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ED 016 619 SE 003 809

A FORMAL COURSE IN OCEANOGRAPHY AT THE SECONDARY SCHOOL LEVEL THROUGH INDEPENDENT STUDY, SUMMARY REPORT AND FINAL REPORT.

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REPORT NUMBER BR-6-8297 PUB DATE 67
CONTRACT OEC-1-6-068297-1734
EDRS PRICE MF-$0.25 HC-$1.52 36P.

DESCRIPTORS- *CURRICULUM DEVELOPMENT, *COURSE DESCRIPTIONS, *COURSE CONTENT, *INDEPENDENT STUDY, *OCEANOLOGY, *REFERENCE MATERIALS, *SECONDARY SCHOOL SCIENCE, BIOLOGY, BIBLIOGRAPHIES, CURRICULUM DEVELOPMENT, COURSE ORGANIZATION, INSTRUCTION, INSTRUCTIONAL MATERIALS, TEACHING METHODS, TEACHING PROCEDURES,

THIS STUDY WAS DESIGNED TO DETERMINE THE FEASIBILITY OF INTRODUCING A COURSE IN OCEANOGRAPHY AT THE SECONDARY LEVEL. SPECIFIC OBJECTIVES WERE (1) TO ORGANIZE, EXAMINE, AND REVISE EXISTING INSTRUCTIONAL MATERIALS SUITABLE FOR USE IN AN INDEPENDENT STUDY COURSE IN OCEANOGRAPHY, (2) TO DEVELOP NEW INSTRUCTIONAL MATERIALS AND EXPERIENCES, (3) TO MEASURE THE EFFECTIVENESS OF THE VARIOUS INSTRUCTIONAL MATERIALS AND MEDIA, (4) TO ASSESS THE FEASIBILITY OF INVOLVING SEVERAL NEIGHBORING SCHOOL DISTRICTS, AND (5) TO ASSESS HOW WELL STUDENTS, PURSUING A COURSE THROUGH INDEPENDENT STUDY, LEARN VOCABULARY AND BASIC CONCEPTS, DEVELOP LABORATORY AND ANALYTICAL SKILLS, AND APPLY KNOWLEDGE FROM PREVIOUS RELATED COURSES. THE PROGRAM INVOLVED 24 STUDENTS CHOSEN FROM VALHALLA HIGH SCHOOL AND FOUR NEIGHBORING HIGH SCHOOLS ON THE BASIS OF THE STUDENTS' SCIENCE AND MATH BACKGROUNDS AS WELL AS THEIR INTEREST IN OCEANOGRAPHY. THE PROGRAM CONSISTED OF 30 THREE-HOUR LECTURES BY OCEANOGRAPHERS ASSOCIATED WITH THE LAMONT GEOLOGICAL OBSERVATORIES. THE LECTURERS PROVIDED OCEANOGRAPHIC EQUIPMENT, SPECIMENS, FILMS, SLIDES AND RECORDS, AND OTHER MATERIALS USED IN THE PROGRAM. LABORATORY EXPERIENCES, PROJECTS, AND FIELD TRIPS WERE CONDUCTED. PRETESTING AND POST-TESTING OF STUDENTS WERE CONDUCTED, AND THE RESULTS ARE INCLUDED IN THE REPORT. THE PROGRAM DIRECTOR IN CONJUNCTION WITH CONSULTANTS FROM LAMONT GEOLOGICAL OBSERVATORY AND WOODS HOLE OCEANOGRAPHIC INSTITUTION DEVELOPED COURSE OUTLINES, A REFERENCE BOOK, AND SCIENTIFIC AMERICAN REPORT LISTS. THESE MATERIALS ALONG WITH OTHER REFERENCE AND RESOURCE MATERIALS, WHICH WERE MADE AVAILABLE TO THE PARTICIPATING SCHOOLS, ARE INCLUDED IN THE REPORT. THE INVESTIGATION INDICATED STUDENTS THROUGH INDEPENDENT STUDY COULD INTERRELATE THE AREAS OF SCIENCE THEY STUDIED. (DS)

FINAL REPORT

"A Formal Course in Oceanography
at the Secondary School Level
Through Independent Study."

Contractor: Valhalla Union Free School No. 5
300 Columbus Avenue
Valhalla, New York

Proposal No. 6-8297
Contract No. OEC 1-6-068297-1734

The prime objective of this present study was to determine the feasibility of introducing a course in Oceanography at the secondary school level. The objectives were set forth in the initial proposal thusly:

Objectives

Phase 1 To organize, examine, and revise existing instructional materials suitable for use in an independent study course in oceanography at the secondary school level. To devise and develop new instructional materials and experiences for a course in oceanography. To obtain some measure of the effectiveness of various instructional materials and media when used by students pursuing an independent study course in oceanography.

Phase 2 To assess the feasibility of involving several neighboring school districts in one particular course of study in order to alleviate the problem of staff limitations in areas requiring unique teacher preparation or experience. To obtain some measure of the degree to which students from several school districts pursuing a formal course of study through independent study can succeed in:

a) learning vocabulary and basic concepts
b) developing laboratory and analytical skills
c) applying knowledge from previous related courses to a new area of study.

This report will point out how the objectives were attained.

First of all, it was determined by the instructors that sufficient and pertinent instructional material did not exist. Therefore, new instructional material aimed at adolescents who would pursue the material through independent study had to be devised. This material follows syllabus added here:

I. Physical Properties of Sea Water
   A. Pure water (hydrogen bonds, isotopes of H^1 and O^{16})
   B. Sea-water composition (particulate and dissolved material)
   C. Salinity
      1. Definition and its empirical nature
      2. History
      3. Density relationship to salinity
      4. Uncertainties
   D. Density
      1. Modes of expression
      2. Equation of state

3. Density relationship to salinity
4. Uncertainties

E. Heat capacity
F. Freezing point and temperature of maximum density
G. Adiabatic lapse rate
H. Stability
I. Sound velocity in sea water
J. Optical properties -
    1. Extinction
    2. Refraction
    3. Sea surface albedo
K. Molecular transports and viscosity

II. Instruments

A. The classical hydrographic station
B. Temperature measurements
    1. Reversing thermometers - thermometric depth
    2. Thermistors
    3. Radiation sensors
C. Salinometry
    1. Chemical methods
    2. Electrical conductivity
    3. Inductive coupling
D. Processing hydrographic data
    1. Quality control methods
    2. Interpolation
    3. Validity of quality control
E. In-situ continuous recorders - impact on classical method
F. Current measurements - Eulerian and Lagrangian methods
G. Recording data - analog and digital

III. Heat and Water Budget (Sea-air interaction)

A. Terms of heat and water balance equation
B. Solar radiation
C. Back radiation - skin temperature
D. Direct heat transfer
E. Evaporation - Bowen's ratio
F. Uses of heat budget method
G. Ocean importance to world heat balance
H. Heat budget of the North Atlantic
I. Water budget
J. Relation of heat and water budget

IV. Geographical Distributions of Parameters

A. Introduction to dynamic factors affecting the distribution of properties (eddy diffusion and currents)
B. Major oceanographic divisions
C. Lines of singularities (convergences, divergences and fronts)
D. Vertical distribution of T, S, σ_t, and O_2 in zonal belts
E. Frequence distribution of t_p-S for oceans
F. Surface characteristics
    1. Currents
    2. T, S and O_2
    3. Anomalies and influence of continental climates
    4. Annual variations
    5. Daily variations
    6. Climate - sea surface characteristic relationship for the North Atlantic
G. Sea level - definition and seasonal variations

V. Water Mass and Regional Oceanography

A. T/S diagram and σ_t-S diagram
B. Water types and masses
C. Water mass formation (source) region
    1. Heat and water budget considerations
    2. Major source regions
D. Basic water mass structure of the ocean
E. Relation of North-South T/S curve to T/S curve for vertical column
F. Qualitative methods of studying ocean circulation
G. Water masses of Atlantic cold-water sphere
    1. Formation of water masses
    2. Surfaces and axis of spreading
    3. Influence on world ocean deep and bottom water
    4. Volume transports
H. Cold-water sphere of the Pacific and Indian Oceans
I. Atlantic Ocean warm-water sphere
    1. Sargasso Sea
    2. Equatorial circulation
    3. Gulf Stream
    4. Upwelling
J. Warm-water sphere of Pacific and Indian Oceans
    1. Kuroshio
    2. Monsoon influences
    3. Equatorial systems
K. Interaction of cold and warm-water spheres
    1. Material
    2. Energy

VI. Ocean Dynamics
- A. Introduction to the terms of the equations of motion
- B. The types of ocean flow
  1. Geostrophic
  2. Inertia
  3. Frictional (wind-driven)
  4. Combinations of the above

VII. Waves and Tides
- A. Spectrum of ocean waves
- B. Tide raising potential and the major components
- C. Wind Waves
  1. generation
  2. phase and group velocity
- D. Other waves
  1. Seiche
  2. Tsunami

Biochemistry of the Oceans

- A. Definitions
  1. biochemistry
  2. plankton
     - a. phyto
     - b. zoo
  3. nekton
  4. benthos
- B. Conservative solutes
- C. Non-conservative solutes
- D. Biochemical cycle
  1. exchange of chemical elements between sea water and the biomass
  2. elementary composition of the biomass
  3. preformed nutrients
  4. regeneration of nutrients
  5. fa^tors affecting nutrient distribution
  6. Liebig's law of the minimum
  7. potential fertility
  8. external metabolites in the sea
     - a. exclusion
     - b. attractants
     - c. toxins
  9. Bioassay
- E. Productivity
  1. Primary productivity
     - a. gross
     - b. net

2. Methods of measuring Primary productivity
   a. standing stock
   b. chlorophyll "a" concentration
   c. consumption of CO_2 or nutrient salts
   d. O_2 production in light and dark bottles
   e. C^{14} technique
   f. transparency / color
3. geographic variations
4. seasonal variations

Introduction to Marine Biology

A. History of marine biology
   1. Edward Forbes (1815-54)
   2. Charles Darwin (1809-82)
   3. Challenger Expedition (1872-76)
   4. Wyville Thomson Ridge
   5. Loims and Alexander Agassing (1835-1910)
   6. Victor Hanson - Plankton Expedition 1889

B. Definitions
   1. words
   2. roots
   3. prefixes
   4. importance of above in "decoding" new terms

C. Main divisions of the marine environment
D. Main divisions of marine life
E. Food chain of the sea
F. Description of the marine environment
   1. parameters involved
   2. ranges of these in the world ocean

G. Adaptations to the marine environment
H. Distribution of life in the sea

Description, Classification and Study of Plankton

A. Definitions and terminology
B. Phytoplankton
   1. Diatoms
   2. Flagellates
      a. dinoflagellates
      b. coccolithophorids
      c. silicoflagellates

C. Zooplankton
  1. phylums of the animal kingdom represented
  2. importance of each

D. Vertical migration
  1. history
  2. explanations
  3. points to consider

E. Plankton as food for man
  1. emergency
  2. commercial
    a. difficulties
    b. shrimp industry

Description, Classification, and Study of the Nekton

A. Introduction and definitions

B. Parameters controlling distribution

C. Types of nektonic animals
  1. Fish
    a. cyclostomata
    b. Pisces
      1. chondrichtkyes
      2. osterchthyes
  2. Mamals
    a. cetacea
      1. mystacoceti
      2. odontoceti
    b. pinnipedia
    c. sirenra
  3. Molluscs
    a. cephlapods
      1. squid
      2. cuttlefish
  4. Reptiles
    a. snakes
    b. turtles
  5. Birds (i.e. penquins)

D. Commercial aspects of the nekton
  1. Five most important fish families
  2. fish farming

E. Deep sea adaptations
  1. vision
  2. color
  3. feeding
  4. reproduction

Description, Classification and Study of the Benthos

A. Introduction and definitions

B. Distribution of Benthic Life
   1. abundance
   2. diversity

C. Adaptations
   1. to the littoral zone
   2. to the deep sea

D. Feeding mechanisms
   1. suspension feeders
   2. deposit feeders
   3. carnivores
   4. herbivores

E. Plants of the benthos
   1. Thallophyta
      blue-green)
      green)
      brown) algae
      red)
   2. Spermatophyta

F. Animals of the benthos
   1. littoral communities
   2. sublittoral communities
      bottom fish
      coral reefs

Observations and Collections at Sea

A. Plankton sampling problems
   1. Patchiness
   2. Avoidance
   3. Inaccuracy of volume of water filtered measurements
   4. Hydrogynamics
   5. Escapement or extrusion

B. Plankton sampling equipment
   1. Non-closing
      a. tow nets
      b. trawls
   2. Closing devices
   3. High-speed samplers
   4. pumps
   5. filters

C. Fishing gear and techniques
   1. Towed equipment
      a. beam trawl
      b. otter board trawl
      c. Isaaca - Kidd midwater trawl
   2. Harpoon
   3. Passive equipment
      a. handline
      b. longline
      c. weirs / traps
      d. gill nets

D. Benthic equipment
   1. dredges
   2. grabs
   3. traps

Survey of Present Research in the Field of Marine Biology

A. The computer
   1. definition
   2. capabilities
   3. limitations
   4. hardware / software
   5. computer language
   6. computer programs

B. Applications of the computer to zoogeography
   1. date handling
   2. computation
   3. plotting

C. Drugs from the sea

D. Fish protein research

The Floors of the Ocean
   a) Bathymetry of Ocean floor
      1) echo-sounding techniques
         a) Profiles
      2) Features
         a) Oceanic ridges
         b) Types of submarine relief
      3) Major divisions
         a) Continental margins
         b) Ocean basin floor
         c) Mid ocean ridges

Sediments of the World Ocean
   a) Determination age of ocean basins through sediments
   b) Main classes

b) Main classes (ccn't)
  1) Terrigenous sediments
    a) sand and silt grains
    b) volcanic glass
  2) Biogenous
    a) globergerina
    b) diatom and radiolaria oozes
c) Methods of obtaining deep sea sediments
  1) piston corer
d) Mapping thickness of sediments by seismic soundings

The Crust of the Earth Beneath the Sea
  a) Techniques of seismic exploration used to study the crust of the earth
  b) Comparison of igneous rocks from deep sea and continental
    1) Comparison of crystal size
  c) Comparison of thickness of ocean crust and continental crust
  d) Study of composition by velocity of sound

The Structure of the Oceanic Crust from Seismic Refraction
  a) Snells Law
  b) True velocities and apparent velocities
  c) The Idealized ocean Crustal section

Submarine Vulcanism and the Oceanic Rocks
  a) Formation of igneous rocks
    1) granites
    2) bassalts
  b) Processes of consolidation and diagenesis in sediments
  c) Mechanism of reef building and formation of atolls
  d) Contouring

The Mid-ocean Ridge
  a) Topography, structure and origin
  b) Subdivisions of physiographic provinces
    1) rift valley
    2) rift mountains
    3) high fracture plateau
    4) low, middle and upper steps
  c) Linearity of the ridge
  d) Effects of fracture zones
  e) Comparison of profiles of mid-Oceanic Ridge in Atlantic, Indian, Pacific, Artic and Southern oceans
  f) Origin of the ridge by tension as compared to other hypotheses
  g) Magnetic field over ridge
  h) Possibilities and significance of large scale movements of ocean crust

Shaping of the Continental Margin and Origin of Submarine Canyons

a) Origin of the continental margin
   1) micro-topography of the sea floor
b) Provences of continental margin
   1) continental shelf, shelfbreak, continental slope, continental rise
   2) lower continental rise hills and submarine canyons
c) Deep ocean geostrophic currents
   1) study of deep sea photographics
      a) evidence of ocean currents by scour marks and ripple marks
      b) direction of currents

d) Continental shelf
   1) history
   2) origin

Turbidity Currents

a) History and concept of turbidity currents
   1) gradients of the abyssal plains
      a) proximity to continents and to submarine canyons
b) The case of 1929 Grand Banks turbidity current
c) Occurrence and explanation of graded deep-sea sand layers on the abyssal plains
   1) core samples
      a) shallow water forminifera

The Pelagic Record

a) Procedures for dating and studying Stratigraphy of deep sea deposits
   1) Recent advances in geochronology
      a) radio-active isotope dating
      b) paleomagnetic reversals
b) Evaluation of planktonic forminifera
   1) Identification of warm and cold water species - a method of correlating deep sea deposits and for determing past epochs
c) Origin and significance of red clays as tied to calcium carbonate compensation depth and the thickness and depth of the sediments
   1) occurrence and distribution of manganese nodules
      a) economic importance
d) Evidence of Ice Age from deep sea sediments
e) Methods of deep sea stratigraphy used to date glacial events
f) Discoveries and dating ancient tremendous volcanic erruptions

The Distribution of Oceanic Sediments and the Age of the Ocean

a) Principles of stratigraphy applied in conjunction with geophysical seismic techniques to probe questions on age of the oceans

b) Seismic reflection profiling technique to indicate thickness of sediments

   1) Absence of sediments suggest very youthful plans

c) Sediments thickest near continents

   1) supply of tenigenous sediment

Paleomagnetism and Continental Drift

a) Tectonic mechanism in the form of a hypothesis to explain youthful age of ocean basins and the tectonic activity associated with the mid-oceanic ridge

b) Principles of remanent magnetization in rocks

   1) past positions of earth's magnetic pole
   2) ancient pole positions were different for different continents
      a) superimposition of continents to show pole position agreement

c) Continental migration

   1) correction within earth's mantle?
      a) formation of mid-oceanic ridges
      b) conjecture and fact

This material was gathered and collated by the following men in consultation with Mr. Lamie:

Richard G. Lamie, Director of Project.
B.S. math and physics, M.A. Secondary Administration, Teachers College Columbia University
Experience in all math and science - 17 years
N.S.F. - PSSC - solid state - Astronomy
PSCC Area chairman 1960 - 1967
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Sea experience - Indian Ocean aboard Atlantic II
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Education - Lehigh Univ. 1956 B.A. and B.S. in E.P.
Employed by Hazeltine Corp., Little Neck, L.I. as project administrator 1956-1960
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The lecture consultants along with Richard G. Lamie, Project Director, were aided by consultants from Woods Hole Oceanographic Institution: John Shilling - Public Relations Officer; John C. Berkerle PhD Geophysics; Arthur R. Miller - Associate Scientist, Physical Oceanographer; David W. Menzel, Associate Scientist - Biologist.

The effectiveness of the various instructional materials and media was ascertained through the use of a comprehensive pre and post test in oceanography constructed by the consultants and lecturers.

OCEANOGRAPHY PRE-TEST - POST-TEST

Part I - Match Column II to Column I - ALL answers must be on your answer sheet. DO NOT WRITE ON QUESTION SHEET.

Example: COLUMN I — a. water; COLUMN II — 6. liquid; a. 6

COLUMN I	COLUMN II
a. adiabatic	1. Tsaunami
b. SOFAR	2. $CaCO_3$ compensation depth
c. ocean currents	3. potential temperature
d. tides	4. anaerobic
e. wave	5. erosion
f. coriolis force	6. sound channel
g. reversing thermometer	7. holothurian
h. mid-ocean ridge	8. earth rotation
i. submarine canyon	9. radioactivity
j. ocean trench	10. horizontal density gradients
k. basalt	11. magnetometer
l. Turbidity currents	12. in situ temperature
m. high productivity	13. earliest known ocean bottom material
n. red clays	14. gravitational attraction
o. proton precession	15. deep-sea sands
p. angular momentum	16. rift valley
q. heat flow	17. sima
r. cretaceous	18. conservation
s. presence of H_2S	19. upwelling
t. benthic	20. negative gravity anomaly

OCEANOGRAPHY PRE-TEST - POST-TEST

Part II TRUE OR FALSE

Indicate true or false to each statement on your answer sheet.

1. The areas of the Atlantic and Indian Oceans combined is less than the area of the Pacific Ocean.

2. In situ density is dependant on temperature, salinity.

3. The basis for salinity determination is based on the premise of a constant ratio of the various materials dissolved in sea water.

4. The assumption of Geostrophic flow is that a balance of forces exists between the horizontal pressure gradients and the coriolis force.

5. The wind acting on the ocean surface creates horizontal density gradients which in turn are significant in producting ocean currents.

6. The ancient Greeks attributed the tides observed on the Atlantic Ocean to the action of the moon.

7. The sea surface all over the earth is at the same geopotential.

8. The manimum density of ocean water occurs at a temperature above the freezing point.

9. The average salinity of the Atlantic Ocean is 34.900 o/oo making it the saltiest of the oceans.

10. Submarine volcanoes produce acidic lavas.

11. Shallow focus earth quakes predominate on the oceans along the rift valley.

12. There are canyons on the ocean floor deeper than the Grand Canyon.

13. Tere are deep-sea channels longer than the Mississippi River.

14. The earth's magnetic field closely approximates a quadrapole field.

15. The earth's magnetic field has important applications in measuring surface currents.

16. The average heat flow at the floor of the ocean is the same as that on the continent.

17. OT is the density of sea water corrected to sea level pressure.

18. Globergerenia is the geodetic shape of the earth.

19. Manganese nodules are only found on continental slopes.

20. The vertical oscillations of a vessel at sea due to surface waves introduce an uncertainty in gravity measurements at sea.

Part III - Fill in the blanks to make statement complete on your answer sheet.

1. The oceans cover __________ of the earth's surface with an average depth of approximately ____________ meters.

2. The Atlantic Ocean counterpart of the Kuroshio current is the ____________.

3. The most common element in sea water besides H and O is ___________, while the most common metalic element is ______.

4. In oceanography the quantity called "chlorinity" is found by chemical means and from this __________ is determined.

5. The magnitude of the coriolis force acting on a particle in the ocean depends on the latitude earth's rotation and on the ___________ of the particle.

6. The first systematic physical oceanographic study of any ocean was carried out by the Research Vessel ________ during the late 1920's.

7. The ocean acts as buffer in the world-wide temperatures due to the high _____ ___ _ of sea water.

8. The large anti cyclonic gyre in the north Atlantic Ocean surrounds a calm center called the __________.

9. The Weddel Sea and the area near southern Greenland are responsible for suppling the majority of the world oceans ________ water.

10. The name of the cold current flowing northward along the west coast of South America is called the ________.

11. Anomalies of dynamic height are used to calculate ________.

12. Light waves corresponding to a color ________ have the greatest penetration in seawater.

13. _In situ_ produced minerals on ocean sediments are called ________ minerals.

14. The Blue Whale diet consists of ________ ________.

15. The steep thermal gradient in the ocean called ________.

Part IV - Multiple Choice

1. The East Pacific Rise is characterized by
   a. high productivity
   b. high heat flow
   c. high sedimentation rates
   d. high gravity anomalies
   e. a linear magnetic anomaly

2. Snell's law is used in oceanography
   1. to study the optical properties of sea water
   2. to navigate ships
   3. to study the thickness of the ocean crust by seimic techniques
   4. to settle complaints on fishing and deepsea mining leases.
   5. to compute gravity anomalies

3. The deepest part of the ocean is
   1. in the Artic
   2. 1000 meters
   3. 10,000 meters
   4. 10 miles
   5. in the Rift Valley

4. The dissolved CO_2 in sea water is used:
   1. in diagenises of deepsea sediments
   2. as a buffer in controlling the Ph of the ocean.
   3. by fish in producing their coloring.
   4. for measuring salinity
   5. in the formation of sea ice

5. Deep focus earth quakes are most abundant
   1. beneath the crest of the mid-ocean ridge
   2. under the Greenland and Antarctic ice caps
   3. associated with island arcs
   4. in the earth's core
   5. beneath sea mounts

6. Rayleigh waves are produced
   1. from tropical huricanes
   2. from the tidal influence on ocean islands
   3. by dispersion of sound in a layered medium
   4. as a result of refraction along a straight coastline
   5. by the diurnal changes in the earth's magnetic field

7. Geostrophic currents owe their existence to
   1. the narrow channel at the entrance to a tidal basin
   2. the melting of ice at the poles
   3. the flowage of electricity through the earth's core
   4. the vertical circulation in the ocean basins
   5. the rotation of the earth on its axis.

8. Changes in coiling directions and the relative abundances of marine foraminifera
   1. are noted at various depths on the euphotic zone
   2. indicate temperature fluctuation in the Gulf Stream
   3. are used in a study of poleoclimates
   4. indicate different phases in the evolution of plankton

9. An amphidromic point is
   1. used in computing when evaporation of sea water takes place
   2. A spot with no tidal amplitude
   3. where currents average out to produce a mean current of zero knots
   4. the spot on the seafloor directly above an earthquake
   5. the glaciation of the continents

10. Changes in sea level which account for the major transport of sediment across the continental shelf are caused by
   1. extremely large tides
   2. extensive evaporation during ancient arid climates
   3. the growth of mid ocean ridges and subsidence of trenche
   4. sudden changes in the earth's rate of revolution
   5. the glaciation of the continents

11. The average thickness of sediments in the North American Basin in the North Atlantic is:
   1. 10 meters
   2. 1000 meters
   3. 4 miles
   4. 10 miles
   5. 10,000 meters

12. "Ocean floor spreading"
   1. is a theory on the depostion of sediment by turbidity cirremts
   2. is a theory on the orgin of the oceans by continental drift
   3. is a theory on the circulation of the recently discovered extremely hot and high salinity water
   4. is a theory which explains the origin of the moon
   5. is a theory which explains the behavior of sound waves used in sonar to detect buried mountains

13. Sea water is produced
   1. condensation of volcanic gases
   2. from salt water springs on the early proto continent
   3. from Noah's flood
   4. from the melting of ice
   5. there is no agreement on the origin of the sea water.

14. the density of sea water
   1. varies with temperature
   2. varies with salinity
   3. varies with pressure
   4. varies with amount of suspended material
   5. all of these

16. The pressure at the great depths of the ocean
   1. will cause steel to become bouyant
   2. will crush all living life as we know it
   3. is 10,000 atmospheres
   4. causes an adiabatic increase in temperature of the deep water
   5. prevents underwater volcanic activity apparent

17. The force of gravity as measured by oceanographic vessels
   1. is everywhere the same
   2. changes a measurable amount every year
   3. is less on the seafloor than on the surface of the sea
   4. is aifected by the speed of the vessel
   5. can be used to obtain a rough indication of the depth of the ocean.

18. Internal waves
   a. occur at the Plio-Pleistocene boundary
   b. move much more slowly than surface waved
   c. display inverse dispersion
   d. are created by the coupling of the earth's magnetic and gravity field within the ocean
   e. are used for collection of pelagic fish

19. Plankton are
   a. deep sea fishes
   b. a type of seaweed
   c. the immobile, floating life of the sea
   d. the mobile, swimming life of the sea

20. The fish of the sea are considered to be part of the
   a. plankton
   b. nekton
   c. abyss
   d. benthos

21. The benthic life of the sea lives
   1. on the bottom
   2. in the water
   3. in both (1) and (2)
   4. in the deep sea only

22. There is no life in the sea below
   a. 100 fathoms
   b. 5,000 meters
   c. 30,000 feet
   d. none of these

23. The difference between phytoplankton and zooplankton is one of
   1. kingdom
   2. phylum
   3. genus
   4. method of locomotion

24. abyssal organisms live in the
   a. littoral zone
   b. pelagic zone
   c. enphotic zone
   d. deep sea

25. A community is a
   a. population of organisms
   b. group of various types of organisms living together
   c. type of environment
   d. portion of the neritic zone

The students gained an average of 12.9 points from pre test to post test. The range of gain on an 80 item test was from zero (one student) to an 18 point gain by two students.

The average IQ scores of students in this project was 126. In examining the pre and post test scores of these students no significant differences were found in attempting to correlate the series on the ACE test of critical thinking. The Watson - Glaser test of critical thinking or the Junior Index of Motivation. Two explanations are in order. One the (N) number of students who persisted through the program was not sufficiently high to warrant any confidence in the statistical outcome. Two - the students scored at the ceiling in the pre test administration and even if the N were high enough to warrant confidence, the statistical changes could not be discerned.

Phase 2

This phase poised some problems and a school district (Ardsley) withdrew. This made it necessary to secure another district. Control of the students not attending Valhalla High School was difficult since it was not easy to communicate with this group.

Make up of student population -
The participants in the program were from the following schools:

Valhalla High School - 9 students - 6 seniors
3 Juniors - attendance 59% to 97%
grade distribution 4A, 3B, 2P

Westlake High School - 5 students - 4 seniors
1 junior - attendance 85% to 97%
two drop outs - reason-sports
grade distribution 2A, 1 B

Byram Hill High School - 2 students - advanced
sophmores - attendance 93% - 97%
grade distribution 2A

Rye Neck High School - 8 students - 8 seniors
attendance 59% to 93%
three drop outs - reason - 1 distance to classes (15 miles)
during a bad winter. Two dropped out due to sports.
Grade distribution 1A, 1B, 3P

*The P grade was given when attendance was such that director and consultants felt too many lectures were missed to warrant a better grade.

The average attendance for the entire group of participants, excluding drop outs was 81%.

It was generally agreed that it is possible to offer more courses limited in scope and in student participation jointly with other districts. The formal preparation and orientation of staff and students is of paramount importance.

The a, b, c aspects of Phase 2 were accomplished and can be observed through a comparison of the post and pre test scores as well as through an item analysis of the question in the comprehensive test in oceanography.

Description:

The course in Oceanography as offered at Valhalla High School consisted of a schedules thirty lectures to be given on Wednesday evenings throughout the school for 3 hours per lecture. Students were selected from Valhalla High School and three neighboring school districts (Byram Hills High School, Westlake High School and Rye Neck High School), representing distances up to fifteen miles. Students were selected from those having completed Biology, Chemistry and Physics (or presently taking Physics) plus three years of math. The students were pre tested and post tested.

Some laboratory work and four field trips were offered to participants.

Field Trips:

October 1966 - Open House at the Lamont Geological Observatory. Students toured the installation generally and received a lecture on the electronic computer. Data obtained from sounding charts by students was programed for students.

December 1966 - Visit to the Research Vessel Verra two days before its round the world expedition. Students examined the equipment carried aboard the vessel. Lecture consultants discussed procedures for obtaining samples using different kinds of equipment.

March 1967 - Core Labs - Lamont Geological Observatory - Students received a lecture on coring and then proceeded to study a new core, taking samples to study under microscopes and to run some chemical tests.

April 1967 - Woods Hole Oceanographic Institution - Students were escorted throughout the entire Institution and became involved in informal discussions with oceanographers having specialities in different areas. The new Canadian research vessel, The Prince, hosted the group for a tour and description of their vessel. The library facilities of the Marine Biological Laboratories were visited.

Mr. Lamie, Director of the program and an assistant participated in a cruise aboard the Research Vessel Atlantis II out of Woods Hole Oceanographic Institution December 13-21, 1966. The report of this cruise is included.

December 22, 1966

Report: Woods Hole Oceanographic Institution Conference and Cruise Aboard the Research Vessel Atlantis II by Richard Lamie and Gordon Hall, December 13-21, 1966

Purpose: 1. To investigate all avenues for the development of the course in Oceanography on the secondary level.

2. To provide Director of program and elementary teachers with first hand experiences in both operations at sea and in the laboratory.

3. To collect wherever possible sample specimens, photographs, slides, and literature of a typical oceanographic cruise.

4. To enlist the help and advice of scientists in the various areas of Oceanography.

Dr. Rudolf S. Scheltema, chief scientist on this cruise, was contacted on December 13, 1966. A tour of the Atlantis II was made along with a description of the purpose of the cruise. It was suggested that we use December 14th to speak with various people at WHOI in order to become better acquainted with the functions of the Institution.

Mr. John Schilling, director of Public Relations, was first to be contacted. A discussion on the present Oceanography program at Valhalla produced the following:

1. WHOI picture file was placed at our disposal to choose any picture we considered useful in our program. Twenty-two pictures will be sent to us after the first of the year.

2. An invitation to attend a luncheon meeting of Marine Biologists who were interested in Oceanographic education. We were introduced to the group and at the end of the meeting had many informal talks with a number of scientists.

3. Dr. Dean F. Bumpus who headed other programs was contacted by Mr. Schilling. Dr. Bumpus was unable to see us but recommended that we contact Mr. James Kinney, Director of Oceanographic Education Center of the Falmouth Public School. A preliminary meeting was held with Mr. Kinney. An appointment for a longer meeting on return from the cruise was made.

4. Written materials about WHOI was made available to us.

5. Sources for films, pamphlets, periodicals, were given to us.

Dr. John C. Becherle was next contacted. Since Dr. Becherle has been source of advice in the past, a dexcription of our progress to date was given by him. The early stages of planning for the future was discussed. The problem of teacher training with the cooperation of WHOI was discussed.
Dr. Becherle, as did Mr. Schilling and other scientists, felt that WHOI would find such a task at this time quite difficult due to the demands of their work. They also pointed out the difficulty of housing in Woods Hole and surrounding areas during the summer months. However, Dr. Becherle promised to investigate the possibility of a teacher training institute more carefully. The list of our Oceanography lectures, and lecturers and

reports of the preliminary meeting for further development of the course was left with Dr. Becherle. Arrangements for further discussion was set for our return from the cruise.

****

The cruise began on December 15, 1966. The purpose of the cruise was:

1. To collect deep sea living organisms.
2. To collect larva found in deep sea plankton, many of which were being studied for the first time.
3. To study phosphates and nitrates in sea water at different depths.

The specific area in which we worked was deep sea dredging (1500 to 4500 meters). The dredging sled collected and carried to the surface sediment and animal materials which had to be physically separated in part according to phyla and size. Examination and classification takes place back in the laboratories. When classified, they are forwarded to specialized investigators all over the world.

During free time on board, informal discussions on Oceanography in high school were initiated. Much interest was shown by the scientists. Many useful suggestions were made. As a result of many such discussions, a large number of samples were made available. Dr. Scheltema went so far as to make a plankton tow especially for the use of students in our program. One comment made was "never before have teachers received so many 'goodies' from such a cruise." The many samples, charts, etc. acquired will be organized and made available to students in both Biology and Oceanography.

During one free period, Captain Hiller and the First Mate gave Mr. Lamie a lesson of navigation by the use of Loran. On landing, Captain Hiller presented us with a nautical chart of the cruise.

On return from the cruise, an inspection of the marine biology labs and the water labs was made.

Dr. Roberr R. Hessler, Mr. George R. Hampson, and Miss Susan Erving extended their help whenever needed. Dr. Robert Hessler also promised to send the log of the dredging at station 128. Most of the biological samples we obtained came from this station.

The second meeting with Dr. Becherle was held. Dr. Becherle expressed the feeling that we had an excellent series of lectures with apparently an extremely well qualified staff of lecturers. He agreed with our preliminary planning for future development. As for teacher training, he could not comment on WHOI's involvement.

The cruise along with time spent at WHOI was extremely profitable both personally and for the future of the program. The friends and contacts made, I feel will prove most valuable in the future.

Richard G. Lamie
Oceanography Program Director

Material Obtained for Student Use
In the Oceanography Program

Station 128   December 16, 1966   Depth: 1500 meters

39°46'N   70°46'W

Assortment benthos animals (macro and micro)
Rock assortment
Sediment sample
Fine grit sample plus light sample
Course grit sample
Grit with foramnifera
Water samples: surface, 50 meters 175 meters

******

Enroute to Station 129-130   December 17, 1966

36°40'N   68°45'W

Sargassum weed
Sargassum animals
Portuguese Man of War

****

Station 129-130   December 17-18, 1966   Depth: 4500 meters

36°40'N   68°45'W

Rough pebbles, clay bottom (solid), showing worm holes and tubes along with magnesium deposits

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Special Plankton Tow (for Valhalla H.S.)

December 18, 1966 time in: 0210
time out: 0230

Length of tow, 20 min. Net size, 3/4 meter
Meters of wire out, 200 Mesh size, #6
Wire angle, 65° Surface temperature, 21.5°C

Station No. AII 30-34
36°27.8'N 67°56.4'W

******

Surface water sample

40°34'N 70°45'W

Loran Nautical Chart with course plot of cruise
Test sounding recording
Descriptive material on WHOI

The lectures were designed to be a survey of the total area of Oceanography and not restricted to any one area, i.e. marine biology. The list of lectures along with aims and purposes follow.

The aim and purposes of these series of lectures are to convey an understanding to the student not only of the ocean but also of the scientific methods which are used by man in studying the ocean. Oceanography is an interdiscipline, i.e. it is a combination of the basics of all science, mathematics and engineering. The understanding of any of the pure sciences is not enough, all must be known and above all, their inter-relation is necessary.

The student will learn to inter-relate the methods and concepts which he learned previously. This would lead to a fuller understanding of these basics and to a more scientific understanding of the oceans.

List of Lectures

1. Introduction to Oceanography
2. The floors of the ocean
3. Sediments of the World Ocean
4. Crust of the Earth beneath the sea
5. Physical Properties of sea water
6. Instruments used to study sea water

7. Geographic distribution of ocean parameters
8. Water masses and regional oceanography
9. Heat and water budget of the world ocean
10. Ocean dynamics - currents and turbulence I
    Ocean dynamics - currents and turbulence II
11. Ocean dynamics - waves and tides
12. Biochemistry of the oceans
13. The structure of the oceanic crust from seismic refraction
14. Submarine vulcanism and the oceanic rocks
15. Measurement of gravity at sea
16. Geomagnetism, heat flow and large scale movements of the earth's crust
17. The mid-oceanic ridge, fracture zones, and ocean flow spreading
18. Island arcs, oceanic trenches and earthquakes
19. The shaping of the continental margin and origin of submarine canyons
20. Turbidity currents
21. Geochronology
22. The Pelagic record in abyssal sedimentation
23. Distribution of oceanic sediments and the age of the oceans
24. Palemagnetism and continental drift
25. Introduction to marine biology
26. Description, classification and study of Plankton
27. Description, classification and study of Nekton
28. Description, classification and study of Benthos
29. Observations and collection at sea
30. Survey of present research in the field of marine biology

Due to the unusual nature of the winter only 27 lectures were given. Three days were lost due to snow days and the inability to reschedule the lost days.

A technical library for the course was acquired for student use. A book list and magazine list was made available to all participants.

VALHALLA HIGH SCHOOL

BOOK LIST
for
Oceanography Program

Deep Challenge, Stewart Jr., Harris B., Van Nostrand, 1963

Ebb and Flow, Albert Defant, University of Michigan Press, 1958 (2)

Frontiers of the Sea, R.C. Cowen, Doubleday & Co., Inc. 1960 (2)

General Oceanography, Dietrid, Interscience, 1963 (1)

How Old is the Earth, P.M. Hurley, Doubleday & Co., Inc., 1959 (2)

Internal Constitution of the Earth, B. Gutenberg, Dover Publications, Inc. 1951 (2)

Life of the Past, George Gaylord Simpson, Yale University Press, 1953 (2)

Oceanography, Warren E. Yasso, Hold, 1965, (1)

Physics and Geology, Jacobs, Russel & Wilson, McGraw Hill Book Co., Inc., 1959, (2)

Principles of Physical Oceanography, Holmes, Arthur, Ronald, 1965, (2)

Principles of Physical Oceanography, Neumann Pierson, Jr., Prentice-Hall, Inc., 1966, (2)

Study of the Earth, J. F. White, Prentice-Hall, Inc., 1962, (2)

Submarine Geology, Shepard, Harper & Row, 1963, (1)

The Earth Sciences, Strahler, Harper & Row, 1963, (2)

The Gulf Stream, H. Stommel, University of California Press, 1965, (2)

The Ocean River, Chapin & F.G.W. Smith, Charles Scribner's Sons, 1952, (2)

The Oceans, Sverdrup, Johnson, Fleming, Prentice-Hall, 1942 (2)

The Physical Geography of the Oceans, Cotter, Charles, Hollis & Carter, 1965, (2) Oceanography book list, continued -

The Sea Around Us, Rachel Carson, The New American Library, Inc., 1961, (2)

The World of Geology, Leet & Leet, McGraw-Hill, 1961, (2)

Time, Life and Man, R.A. Stirton, John Wiley & Sons, Inc., 1959, (2)

Encyclopedia of Oceanography, Rhodes, Reinhold Publishing Corp.

A Preliminary Bibleography with KWIC Index on the Ecology of Esteraries and Coastal Areas of the Eastern United States, U.S. Government Printing Office

Treatise on Marine Ecology and Paleoecology - Volume I Ecology
J.W. Hedgpeth Editor - Geological Society of America

The Sea Volume II, M.N. Hill Ed., John Wiley & Son

Sea Shells of the World, Abbott R. T., Golden

Earth and Its Atmosphere, Bates D. R. Science Editions

Evolution of the Igneons Rocks, Bowen N.S., Golden

The Ocean River, Chapin H. & F. G. Walton, Smith - Scribners

Frontiers of the Sea, Cowen R. C., Bantam Pathfinders

Internal Constitution of the Earth, White J.F., Prentice Hall

How Old is the Earth?, Hurley, P.M., Doubleday

Realms of Water, Kuenen, P.H., Science Editions

The World of Geology, Leet, L.D., McGraw Hill

Fossils, Rhodes, H.S., P.R. Shaffer, R. Pearlman, Golden

Life of the Past, Simpson G.G., Yale University Press

Time, Life, & Man, Sterton R.A., Science Editions

Study of the Earth, White J.F., Prentice Hall

Oceanography book list, continued -

Oceanography - A Study of Inner Space, Yasso W.E., Holt

Rock & Minerals, Zim H.S., P. R. Shaffer & R. Perlman, Golden

Sea Shores, Zim H.S. & L. Ingle, Golden

Introduction to Physical Oceanography, W.S. Von Arx, Addison Wesley

MAGAZINE ARTICLES
on
Oceanography

The magazine Scientific American is a most valuable reference. Articles on many aspects of the marine sciences have been published there in recent years.

Animal Life:

- The physiology of whales, July '49
- Food from the sea, October '49
- The eelgrass catastrophe, January '51
- The deep-sea layer of life, August '51
- Animals of the bottom, July '52
- Whale cardiogram, October '52
- Oysters, November '53
- Biological clocks and the fiddler crab, April, '54
- The life of an estuary, May '54
- The return of the Gray whale, January '55
- The sea lamprey, April '55
- The coelacanth, December '55
- The homing salmon, August '55
- Animal sounds in the sea, April '56
- The blue whale, December '56
- The wonderful net, April '57
- Sharks vs men, June '57
- How fishes swim, August '57
- Animals of the abyss, November '57
- Whales, plankton and man, January '58
- The ecosphere, April '58
- Poisonous tides, August '58
- The Portuguese man-o-war, March '60
- The buoyancy of marine animals, July '60
- Electric fishes, October '60
- The teredo, February '61
- The oceanic life of the Antarctic, September '61

Magazine Articles on Oceanography - continued

The schooling of fishes, June '62
Electric location by fishes, March '63

Sea Bottom:

Submarine canyons, April '49
Exploring the ocean floor, August '50
The Pacific floor, April '52
The origin of earth, October '52
The continental shelf, March '55
Fractures in the Pacific floor, July '55
The origin of continents, September '55
The interior of the earth, September '55
The earth's magnetism, September '55
The trenches of the Pacific, November '55
The origin of submarine canyons, August '56
The Mohole, April '59
Sand, April '60
Beaches, August '60
The rift in the ocean floor, October '60
Minerals on the ocean floor, December '60
The East Pacific Rise, December '61
The magnetism of the ocean floor, October '61
Continental Drift, April '63

Currents:

The Peru current, March '54
The anatomy of the Atlantic, January '55
The circulation of the ocean, September '55
The circulation of the abyss, July '58
The Cromwell current, April '61

Waves:

Ocean waves, August '59
Tsunamis ("tidal" waves), August '54

Weather:

Volcanoes and world climate, April '52
Carbon dioxide and climate, July '59
The earth's electricity, April '53
Trade wind clouds, November '53
Hurricanes, June '54
The general circulation of the atmosphere, December '56
Salt and rain, October '57
The origin of hurricanes, August '57

Magazine Articles on Oceanography - continued

General:
- The Arctic Ocean, May '61
- The green flash, January '60
- The Antarctic Ocean, September '62

Others:
- Louis Agassiz, July '49
- The age of science, 1900-1950, September '50
- The coriolis effect, May '52
- The voyage of the Challenger, May '53
- Underwater television, June '53
- Algae as a food, October '53
- The earth's gravity, September '55
- The Sargasso Sea, January '56
- The Lamont Geological Observatory, December '56
- Fresh water from salt, March '57
- The Bathyscaphe, April '58
- Long earthquake waves, March '59
- The changing level of the sea, May '60

Oceanography Program
Valhalla High School
Valhalla, New York

Many publications have been acquired from:
- American Littoral Society
- Woods Hole Oceanographic Institution
- Lamont Geological Observatory
- Institute of Marine Science, University of Miami
- National Academy of Sciences
- National Research Council
- United States Naval Institute
- Oceanology International
- U. S. Department of Commerce
- Interagency Committee on Oceanography
- National Oceanographic Data Center

In addition to meeting the objectives of this project, it is expected that this procedure will reveal additional information to correlate with other studies in this area concerning:

a) student, teacher and parental attitudes toward independent study
b) criteria for determining the adaptability of a particular course to independent study

c) methods for implementing independent study programs in schools with different population and different socio-academic climates
d) the possibility of involving students of lesser academic ability in independent study programs
e) efficient and effective methods for involving resource people, outside of the teaching profession, in the process of curriculum development.

Part a) Through interviews conducted with students, teachers and some parents, it was concluded that the attitudes toward independent study were generally positive and that there were no strong misgivings concerning the role of independent study in the learning careers of students.

b) The criteria for determining the adaptability of a particular course in independent study were not developed nor were methods for implementing independent study programs with other socio academic populations explored. Resource people drawn from areas other than education, provided they were scheduled at times not to conflict with their prime committments, were absorbed into the educational enterprise smoothly and effectively.

Limitations

The prime limitation of the pilot project was in the fact that the personnel involved were unable to develop laboratory materials and manuals more completely. It was felt that the development of the manuals could further enhance this study and guarantee even more striking conclusions.

Summary

It was felt by all personnel involved, students and staff, that the experience was beneficial as well as a good introduction to oceanography. At the same time, the science courses previously taken by these students were seen in a more integrated fashion.

Francis J. Lodato, Ph.D.
Sponsor

Richard G. Lamie
Director
Oceanography Program

6-8297

SUMMARY REPORT

"A Formal Course in Oceanography
at the Secondary School Level
Through Independent Study."

Contractor: Valhalla Union Free School No. 5
300 Columbus Avenue
Valhalla, New York

Proposal No. 6-8297
Contract No. OEC 1-6-068297-1734

The prime objective was to determine the feasibility of introducing a course in oceanography at the secondary level.

The program involved twenty-four students chosen from Valhalla High School and four neighboring high schools on the basis of science and math backgrounds as well as interest in oceanography.

The program consisted of thirty lectures given by oceanographers associated with the Lamont Geological Observatories. All areas of oceanography were covered in the lectures. Limited laboratory experiences as well as projects were conducted. Four field trips to Lamont Geological Observatory and Woods Hole Oceanographic Institution were offered.

Pre testing and post testing of students was conducted by Dr. Lodato of Manhattan College, the results of which are found in the final report.

Mr. Lamie, Director of the program, in conjunction with consultants from the Lamont Geological Observatory and Woods Hole Oceanographic Institution, developed course outlines, reference book and Scientific American report lists. Reference and resource materials were offered from various sources dealing with Oceanography and made available to any school district interested. (These are to be found in the final report.)

Materials used in the program, oceanographic equipment, specimens, films, slides and records, were provided by the lecturers and as a result of participation of the director in an oceanographic course aboard the Atlantis II.

The program indicated that resource people drawn from areas other than education could be absorbed into an educational enterprise to the benefit of students. The program further indicated that students, through independent studies, could inter-relate the areas of science previously studied in their regular high school sciences.

The prime limitation of the pilot project was that personnel were unable to develop laboratory materials and manuals more completely. It was felt that further development of manuals would enhance this study.