An Oceanographic Curriculum for High Schools.

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Abstract

Contained are outlines for 18 one-hour lectures on oceanology. Each outline lists topics to be covered, suggestions on which topics should be covered most thoroughly, and books for further reading and related films. Lecture topics include: oceanographic surveying and research; geology of the oceans; physical properties of seawater; waves, tides and currents; chemistry of seawater; marine biology; food from the sea; air-sea interaction; sea ice; estuaries; man and the sea; the continental shelf; limnology; underwater sound; and conservation. Appendices list various resources: sources of instructional materials, charts, films and bibliographies, organizations and publications which can provide further information, and a selection of relevant Scientific American offprints. (BB)
an oceanographic curriculum for high schools
AN OCEANOGRAPHIC CURRICULUM FOR HIGH SCHOOLS

OUTLINE

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INTRODUCTION

The National Oceanographic Data Center (NODC) has prepared this outline in response to queries from high school instructors interested in oceanography and also as a basis for lectures by members of the NODC staff. Since this outline will be revised on the basis of the experience and ideas of its users, comments are solicited.

At the discretion of the instructor, the 18 suggested one-hour lectures may be rearranged, augmented, or replaced by individual projects, demonstrations, laboratory work, or field trips. The additional readings and films listed may be applicable to more than one area and should be used where the instructor feels they are most appropriate.

Two publications, Questions about the Oceans and Topical Readings in Oceanography, are presently being prepared and will be available from the NODC in August 1968.
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1. INTRODUCTION TO OCEANOGRAPHY

Concepts Covered

Definition of oceanography and the interrelationship of disciplines

Major features of the oceans

Development of oceanography and its related concepts

Unsolved problems

Career opportunities and preparations for a career in oceanography

Preview of course content

Most Thorough Coverage

Development of oceanography and its related concepts

Further Reading


Film

2. OCEANOGRAPHIC SURVEYING AND RESEARCH AT SEA

Concepts Covered

Research projects
Parameters to be measured
Oceanographic vessels
Platforms other than ships
Survey procedures and positioning
Instrumentation

Most Thorough Coverage

Research projects
Survey procedures and positioning
Instrumentation

Further Reading

Naval Oceanographic Office.
Instruction Manual for Oceanographic Observations.

Film

Challenge of the Oceans. 16 mm, black and white or color, sound, 29 minutes, obtainable from McGraw-Hill Text Films, 330 West 42nd Street, New York, N. Y. 10036. Price: black and white, $90.00; color, $165.00.
3. GEOLY OF THE OCEANS

Concepts Covered

Nature of the sea floor--old concepts and recent discoveries

Methods of measuring and representing relief

The mantle and crust under the ocean

Sediments in the ocean

Formation of limestones by shell-building organisms

Geophysical measurements of gravity, magnetism, seismicity, and heat flow

Movement of the sea floor

Weathering of the earth's crust as a source of sea water constituents

Most Thorough Coverage

Nature of the sea floor--old concepts and recent discoveries

Further Reading


Film

The Earth Beneath the Sea, 16 mm, color, sound, 27 minutes. Address inquiries to Lamont Geological Observatory of Columbia University, Palisades, New York 10964.
4. PHYSICAL PROPERTIES OF SEA WATER

Concepts Covered

Properties of pure water

Measured properties: temperature, salinity, and pressure; methods of measurement, units, and range in the sea

Computed properties: specific volume, density, compressibility, specific heat, sound velocity, etc.

Transmission of sound and light

Most Thorough Coverage

Measured properties: temperature, salinity, and pressure; methods of measurement, units, and range in the sea

Further Reading

Von Arx, William Stelling. 

Pickard, G.L.

Film

The Restless Sea. 16 mm, color, sound, 1 hour, available free from local Bell System representative or affiliated company.
5. WAVES, TIDES, AND CURRENTS

WAVES

Concepts Covered

Definition
Surface waves: origin and characteristics
Breakers and surf
Destructive waves
Internal waves
Wave prediction
Wave measurement
Seiches in lakes and harbors

Most Thorough Coverage
Surface waves: origin and characteristics

Further Reading

Bascom, W.

Clemens, Elizabeth.

TIDES

Concepts Covered
Tide-producing forces
Astronomical tides
Meteorological tides
Tidal bore
Tide prediction
Tide measurement

Most Thorough Coverage
Tide-producing forces

Further Reading

Darwin, G. H.
_The Tides_, San Francisco: Freeman and Company (paperback).

Defant, A.

CURRENTS

Concepts Covered

Large scale currents
Currents related to the distribution of density
Effects of Coriolis Force
Effects of winds on currents
Tidal currents
Countercurrents
Measurement of currents

Most Thorough Coverage

Currents related to the distribution of density

Further Reading

Munk, Walter.

Stommel, Henry.
Films

Physical Oceanography. Film strip, 35 mm, color, narrated on record, 15 minutes. Address inquiries to Mr. Richard C. Vetter, Committee on Oceanography, National Academy of Sciences, National Research Council, 2101 Constitution Avenue, N. W., Washington, D. C. 20418.

Tides and Currents. 16 mm, color, sound, 15 minutes, available on free loan from ESSA, Washington Science Center, Rockville, Maryland 20852. When requesting, refer to P-1056-24.
6. CHEMISTRY OF SEA WATER

Concepts Covered

Composition of sea water--Dittmar's principle: constancy of composition
Salinity and chlorinity
Dissolved solids
Dissolved gases
Nutrients
CO₂/carbonate system
Oxidation and reduction in the sea water environment
Preparation of artificial sea water
Effects of formation and melting of ice

Most Thorough Coverage

Composition of sea water--Dittmar's principle: constancy of composition

Further Reading


Film

Chemical Oceanography, Film strip, 35 mm, color, narrated on record, 15 minutes. Address inquiries to Mr. Richard C. Vetter, Committee on Oceanography, National Academy of Sciences, National Research Council, 2101 Constitution Avenue, N. W., Washington, D. C. 20418.
7. MARINE BIOLOGY--PART I

Concepts Covered

The food chain
Seaweed
Plankton and productivity
Nekton
Benthos

Most Thorough Coverage

The food chain

Further Reading

Clemens, Elizabeth.
Tide Pools and Beaches. New York: Knopf.

Hardy, Alister Clavering.

Films

Biological Oceanography. Film strip, 35 mm, color, narrated on a record, 15 minutes. Address inquiries to Mr. Richard C. Vetter, Committee on Oceanography, National Academy of Sciences, National Research Council, 2101 Constitution Avenue, N. W., Washington, D. C. 20418.

Survival in the Sea; the Life Cycle. 16 mm, black and white or color, sound, 29 minutes. Obtainable from Audio-Visual Center, Indiana University, Bloomington, Indiana 47405. Price: black and white, $125.00; color, $250.00.

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8. **MARINE BIOLOGY--PART II**

**Concepts Covered**

- Microbiology
- Bioluminescence
- Bioacoustics
- Deep scattering layer
- Dangerous and toxic organisms
- Biodeterioration

**Most Thorough Coverage**

- Biodeterioration
- Dangerous and toxic organisms

**Further Reading**

Film

*Sounds in the Sea*, 16 mm, black and white or color, sound, 16 minutes. Obtainable from Moody Institute of Science, Educational Film Division, 12000 East Washington Boulevard, Whittier, California 90606. Price: black and white, $60.00; color, $120.00.

Records

*Sounds of the Sea* and *Sounds of Sea Animals*, 33-1/3 L.P., recorded by W. M. Kellogg, produced by Florida State University Oceanographic Institute, Science Series, FPX 121 and FPX 125, Folkways Records and Service Corporation, 111 W. 46th Street, New York, New York.
9. FOOD FROM THE SEA

Concepts Covered

Fish protein concentrate
Fisheries management
Fish and shellfish farming
Comparison of U.S. with other countries in fish catch and consumption
Other forms of food besides fish

Most Thorough Coverage

Fish protein concentrate

Further Reading

Hull, Seabrook.

Film

Manager of the Sea, 16 mm, black and white, sound, 15 minutes. Available on free loan from Institute of Marine Science, University of Miami, Rickenbacker Causeway, Virginia Key, Miami, Florida 33149.
10. **AIR-SEA INTERACTION**

**Concepts Covered**

- Heat exchange at air-sea interface
- Formation of winds
- Evaporation and condensation
- Exchange of chemical particles
- Exchange of electrical energy
- Hurricanes and typhoons
- Methods of study of air-sea interaction

**Most Thorough Coverage**

- Heat exchange at air-sea interface
- Evaporation and condensation
- Hurricanes and typhoons

**Further Reading**

- Blumenstock, David I.  

- Dunn, Gordon E., and Banner I. Miller.  

**Film**

*Air-Sea Interaction*, Film strip, 35 mm, color, narrated on a record, 15 minutes. Address inquiries to Mr. Richard C. Vetter, Committee on Oceanography, National Academy of Science, National Research Council, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.
11. SEA ICE

Concepts Covered

Ice formation
Stages of ice formation
Ice drift
Ice deformation
Ice decay
Ice prediction
Chemical changes in ice
Areal coverage of ice fields
Methods of charting ice
Icebergs

Most Thorough Coverage

Ice decay
Ice prediction

Further Reading

National Science Foundation

Wittmann, W. I.

Film

Identification of Sea Ice, 16 mm, color, sound, 12 minutes. Available on free loan from Assistant for Public Affairs of local Naval District. When requesting, refer to: MN-7419-B.
12. ESTUARIES

Concepts Covered

Types and examples of estuaries

Fiords

Effect of rivers on estuarine environment

The relationship of organisms to estuarine environments

Sedimentation processes

Development of an estuary

Pollution

Submarine canyons

Surveys and research in estuaries

Most Thorough Coverage

Types and examples of estuaries

The relationship of organisms to estuarine environments

Further Reading

Reid, George K.

Film

Chesapeake Bay. 16mm, black and white, silent, 17 minutes. Obtainable from Audio-Visual Center, Indiana University, Bloomington, Indiana 47405.
13. MAN AND THE SEA

Concepts Covered

Shipping and transportation
Man in the sea
Conservation
Pollution
Energy from the sea
Fresh water from the sea
Recreation
Ocean engineering
Dredging
Extracting natural resources from the sea and sea bottom
Offshore oil production
Legal aspects
Military aspects

Most Thorough Coverage

Conservation

Natural resources from the sea and sea bottom

Further Reading

Caidin, Martin

Carlisle, Norman V.
Deacon, G. E. R.  

Dugan, James, and Richard Vahan, eds.  

Interagency Committee on Oceanography.  


Spiegler, K. S.  

Stewart, Harris B., Jr.  

**Films**

*Marine Resources.* Film strip, 35 mm, color, narrated on a record, 15 minutes. Address inquiries to Mr. Richard C. Vetter, Committee on Oceanography, National Academy of Science, National Research Council, 2101 Constitution Avenue, N. W., Washington, D.C. 20418.


*Ocean Engineering.* Film strip, 35 mm, color, narrated on a record, 15 minutes. Address inquiries to Mr. Richard C. Vetter, Committee on Oceanography, National Academy of Sciences, National Research Council, 2101 Constitution Avenue, N. W., Washington, D. C. 20418.
14. INDIVIDUAL PROJECTS

Each student will present the highlights of an individual report or project that has been underway since the beginning of the course. If optional sessions are included, these presentations may be scheduled at the end of the course.
15. THE CONTINENTAL SHELF

Concepts Covered

World distribution of continental shelves
Relief and slope of shelves
Sediments of continental shelves
Life on the continental shelf
Turbidity currents and submarine canyons
Seasonal changes
The continental slope
Island shelves and slopes

Most Thorough Coverage

Relief and slope of shelves
Life on the continental shelf

Further Reading


Film

Geological Oceanography. Film strip, 35mm, color, narrated on record, 15 minutes. Address inquiries to Mr. Richard C. Vetter, Committee on Oceanography, National Academy of Sciences, National Research Council, 2101 Constitution Avenue, N. W., Washington, D. C. 20418.
16. LIMNOLOGY

Concepts Covered

- Origin and development of lakes, ponds, and streams
- Physical and chemical properties and processes
- Geological aspects
- Organisms and their relationship to the environment
- Recreation
- Pollution
- Conservation

Most Thorough Coverage

- Organisms and their relationship to the environment

Further Reading

Frey, David G.

Gordon, Bernard L.

Film

17. UNDERWATER SOUND

Concepts Covered

Principles of underwater sound: transmission, reflection, refraction

Environmental factors that affect speed and path of sound in sea water

Uses of underwater sound

Underwater noises

Sound-reflecting organisms

Instruments for producing and recording sounds

Most Thorough Coverage

Environmental factors that affect speed and path of sound in sea water

Further Reading

U. S. Naval Oceanographic Office

Swanson, Bernard K. (U.S. Naval Oceanographic Office)

Film

Introduction to Underwater Sound, 16 mm, black and white, sound, 20 minutes. Available on free loan from Assistant for Public Affairs, local Naval District. When requesting, refer to: MN-8857.
18. CONSERVATION

Concepts Covered

Problem areas:

- Overfishing
- Pollution
- Radioactivity
- Protection of harbors and beaches

Possible solutions:

- International agreements
- Fishery management
- Fish and shellfish farming
- Control of pollution and radioactive waste disposal

Most Thorough Coverage

Pollution

Further Reading


Film

*The Management of Fisheries*, 16 mm, black and white, 14 minutes. Obtainable from University of Miami, Institute of Marine Science, Rickenbacker Causeway, Virginia Key, Miami, Florida 33149.
19. ORIGIN OF THE OCEANS AND ORIGIN OF LIFE

Concepts Covered

Various theories of formation of the ocean basins
Geologic history of sea water
Theories of how life started
Development of life in the sea
Adaptation to land
Return to the sea

Most Thorough Coverage

Development of life in the sea

Further Reading

Carrington, Richard.  

Rubey, W. W.  

Film

_History Layer by Layer_, 16 mm, color, sound, 23 minutes. Address inquiries to Lamont Geological Observatory of Columbia University, Palisades, New York, 10964.
APPENDIX A

SOURCES OF MATERIALS

Earth Science Curriculum Project. This project is developing new earth science teaching materials for use in secondary schools. Combined text, lab investigations, and teacher’s guide (Investigating the Earth, Houghton Mifflin Company, 1967), reference pamphlets (Reference Series, Prentice Hall) have been published, and laboratory equipment is available (Damon Educational, Inc., Hubbard Scientific Company, and Macalaster Scientific Corporation). These have been tested at selected schools over a three-year period. Further investigations and equipment, visual aids, pamphlets, and films are being prepared. A quarterly newsletter will be sent free on request to: Earth Science Curriculum Project, P. O. Box 1559, Boulder, Colorado 80302.

Oceanography Information Kit. Available free to members of the National Oceanographic Association, Suite 301, 1900 L Street, Washington, D. C. 20036. Individual memberships in the Association are $10.00; student memberships, $3.00.

Student’s Ocean Science Study Kit. Sample charts, list of references, career information, and an 80-page book on science and the sea. Price: $1.60. (Address below.)

Teacher’s Ocean Science Study Kit. Contains the same items as the students’ kits and in addition several booklets on hydrography and catalogs of films, charts, and publications as well as material relating to the study of oceanography by the Navy. Price: $3.20. Make check or money order payable to Naval Oceanographic Distribution Office, 3801 Tabor Avenue, Philadelphia, Pennsylvania 19120. Mail orders for purchases west of the Mississippi should be forwarded to the Naval Oceanographic Distribution Office, Clearfield, Utah.
APPENDIX B

SOURCES OF CHARTS

Geographical Society of America
429 West 117th Street
New York, New York 10027
(bottom charts of the Atlantic and Pacific Oceans)

National Geographic Society
Washington, D. C. 20036
(atlas of the world and special oceanographic charts)

U. S. Army Engineering District, Lake Survey
630 Federal Building
Detroit, Michigan 48226

U. S. Coast and Geodetic Survey
Environmental Science Services Administration
Washington Science Center
Rockville, Maryland 20852
(coastal charts off the U. S. with soundings)

U. S. Geological Survey
Interior Department
Washington, D. C. 20242
(topographic maps and geological structure)

U. S. Naval Oceanographic Office
Washington, D. C. 20390
(bathymetric charts of world oceans)
APPENDIX C

SOURCES OF MOVIES

Audio Visual Center
Indiana University
Bloomington, Indiana 47405

Bell System
Local representative or
affiliated company

Encyclopedia Britannica Films, Inc.
1150 Wilmette Avenue
Wilmette, Illinois 60091

McGraw-Hill Text Films
330 West 42nd Street
New York, New York 10036

Naval District
Local Assistant for Public Affairs

Films on Oceanography,
Publication C-4, 1966
National Oceanographic Data Center
Washington, D.C. 20390
APPENDIX D

SOURCES OF BIBLIOGRAPHIES

American Meteorological Society.

Emery, K. O., and Evelyn Sinha.

Gordon, Bernard L.
Aquatic Sciences Paperback Reference List. Boston, Northeastern University, September 1967.

Hahn, Jan.

Interagency Committee on Oceanography.

National Oceanographic Data Center

Sinha, Evelyn, and Lynda Strauss,
A Selected Bibliography of Oceanography Books Published between 1959 and 1966. La Jolla, California, Oceanic Library and Information Center, 1967.
APPENDIX E

SOURCES OF FURTHER INFORMATION

Organizations

Bureau of Commercial Fisheries
Fish and Wildlife Service
Department of the Interior
Washington, D. C. 20240

Coast Guard Headquarters
Commandant (CPI)
1300 E. Street, N. W.
Washington, D. C. 20004

Environmental Science Services Administration
Institute for Oceanography
901 South Miami Avenue
Miami, Florida 33130

Mission Bay Research Foundation
7730 Herschel Avenue
La Jolla, California 92037

National Oceanographic Data Center
Washington, D. C. 20390

Oregon State University
Marine Science Center
Newport, Oregon 97365

Superintendent of Documents
Washington, D. C. 20402

Texas University
Institute of Marine Science
Port Aransas, Texas 78373

University of Rhode Island
Graduate School of Oceanography
Kingston, Rhode Island
Publications


APPENDIX F

SCIENTIFIC AMERICAN OFFPRINTS--A SELECTED LIST*


Willard Bascom, "Ocean Waves," August 1959 (Lecture 5).


Herbert S. Bailey, Jr., "The Voyage of the Challenger," May 1953 (Lectures 1, 13).

James E. McDonald, "The Coriolis Effect," May 1952 (Lecture 5).

Willard Bascom, "Beaches," August 1960 (Lecture 1).


Robert Cushman Murphy, "The Oceanic Life of the Antarctic," September 1962 (Lecture 7).


*These and other Scientific American "Offprints" may be obtained for $0.20 each from W. H. Freeman and Company, 660 Market Street, San Francisco, California 94104.