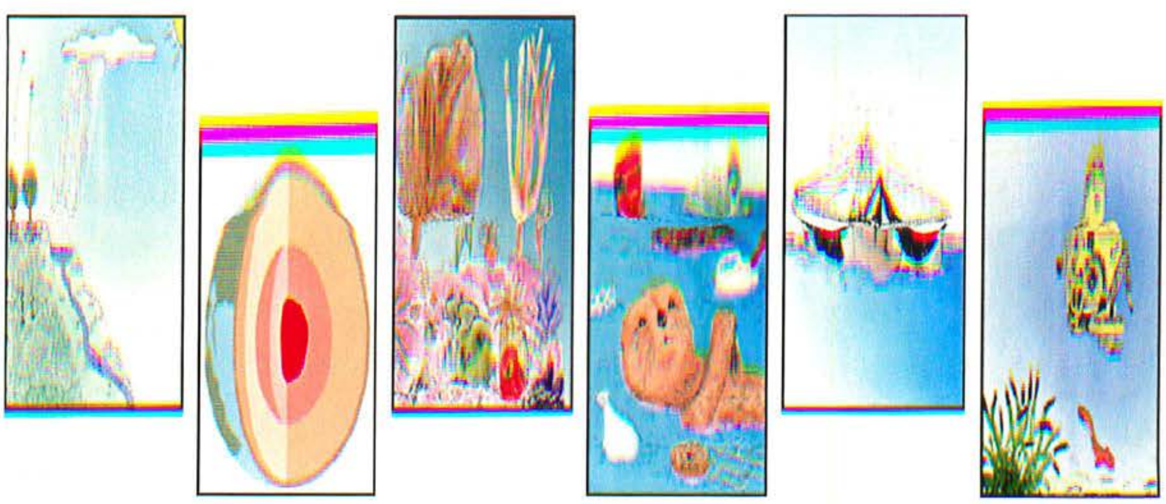
A Resource Guide For
Oceanography and Coastal Processes

Developed for
Elementary, Middle, and High School Teachers



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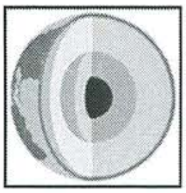


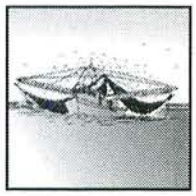


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Project Director

Sharon H. Walker, Ph.D., Institute of Marine Sciences, The University of Southern Mississippi

Senior Editors

Sharon H. Walker, Institute of Marine Sciences, The University of Southern Mississippi
Kimberly Damon-Randall, Institute of Marine Sciences, The University of Southern Mississippi

Associate Editor

Howard D. Walters, Mississippi Gulf Coast Community College, Jefferson Davis Campus

Typists

Johnette D. Bosarge, Institute of Marine Sciences, The University of Southern Mississippi
Catherine L. Seymour, Institute of Marine Sciences, The University of Southern Mississippi

Layout and Design Editor

Catherine L. Seymour, Institute of Marine Sciences, The University of Southern Mississippi

Original Artwork

Rosemary Finley, Harrison County Schools, Gulfport, Mississippi

Consulting Editors, Second Evaluation Team, and 1996 and 1997 Regional Project Directors

Diane Baxter, Scripps Institute of Oceanography/Birch Aquarium at Scripps
Amy Haddow, Connecticut Sea Grant College Program, University of Connecticut
Liz Kumabe, Hawaii Sea Grant College Program, University of Hawaii
Bruce Munson, Minnesota Sea Grant College Program, University of Minnesota
Vicki Osis, OR Sea Grant College Program, Hatfield Marine Science Ctr./OR State University
Sharon Roth-Franks, California Sea Grant College Program, Scripps Institute of Oceanography
Lundie Spence, North Carolina Sea Grant College Program, North Carolina State University
Sharon H. Walker, MS-AL Sea Grant Consortium, the Institute of Marine Sciences/J.L. Scott Marine Education Center and Aquarium, and The University of Southern Mississippi

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Oceanography and Coastal Processes Resource Guide
J.L. Scott Marine Education Center and Aquarium
P.O. Box 7000
Ocean Springs, MS 39566-7000

Phone: (228) 374-5550   Fax: (228) 374-5559   E-mail: shwalker@seahorse.ims.usm.edu

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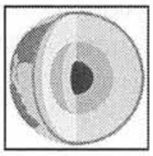



A Resource Guide for Oceanography and Coastal Processes for Elementary, Middle, and High School Teachers

The Earth, for all we know, is a unique planet where a thin blanket of air, a thinner film of water and the thinnest veneer of soil combine to support a web of life of wondrous diversity and continual change. The daily needs of more than five billion people now stress the limits of this naturally regulated system.

National Oceanic and Atmospheric Administration, Global Change Research Program
1991

What science education will be for any one child for any one year, is most dependent on what that child's teacher believes, knows, and does or doesn't believe, doesn't know, and doesn't do. For essentially all of the science learned in the school, the teacher is the enabler, the inspiration and the constraint.

National Science Foundation, 1978

Preface

This *Resource Guide* was developed and funded by the U.S. Navy (Naval Meteorology and Oceanography Command, Naval Oceanographic Office, Office of Naval Research/Naval Research Laboratory, and the Office of the Oceanographer of the Navy), the National Oceanic and Atmospheric Administration (Sea Grant College Program; National Environmental Satellite, Data, and Information System; and Ocean and Coastal Resources Management), the Department of Interior (Office of Territorial and International Affairs), and the National Marine Educators Association. This national educational study has been implemented in cooperation with the Institute of Marine Sciences administered by The University of Southern Mississippi and the Sea Grant College Programs of Mississippi-Alabama, New Jersey, New York, Maine-New Hampshire, Oregon, Connecticut, Washington, California, North Carolina, Hawaii, Minnesota, Wisconsin, and Delaware and universities associated with these Sea Grant College Programs. This partnership of federal agencies and academia recognizes the importance of "bridging-the-gap" between education and scientific research. This cooperative effort resulted in the development of an intellectually rigorous and physically demanding graduate course in Oceanographic and Coastal Processes Education which was implemented and offered to elementary and middle school teachers representing all coastal and Great Lakes states in this country—to include Puerto Rico and the Pacific Island Network during the summers of 1993 through 1997. This program has been expanded for the summers of 1998 and 1999 to include high school teachers, as well as a continuation of participation by elementary and middle school educators. This precollege audience in 1998 and 1999 will also include 30 teachers per region (180 teachers per year), four of whom will be preservice teachers.

Teachers, researchers, and Sea Grant educators converge each summer at a regional, host university for 14-days in June or July. Through lectures, sessions with scientists, field experiences and hands-on activities, precollege teachers will continue to explore issues concerning oceanography and coastal processes. As "homework" for the course, the 1993, 1994, and 1995 teachers developed individual lesson plans for six oceanographic and coastal processes topics. By the conclusion of each institute—over these three summers—the project and associate directors of this teacher enhancement effort recognized the lesson plans of fellow teachers were a valuable resource which should be shared.

During the summers of 1996 and 1997, Operation Pathfinder participants field-tested and evaluated the previously developed elementary and middle school teachers' 1,175 lesson plans and selected the "best-of-the-best" for editing, refining, and compiling into a *Resource Guide* to be used by formal and informal educators from throughout the United States, Puerto Rico, and the Pacific Island Network who may have need for this curricular material.

During the winter of 1997 and spring of 1998, the National Sea Grant College Program, the Office of Naval Research, the National Ocean Partnership Program, the Consortium for Oceanographic Research and Education, and Mississippi's Department of Marine Resources (Tidelands Trust Funds) provided funds for taking the seventy-nine "best-of-the-best" activities—selected by the 1996 and 1997 teachers a step further. The "best-of-the-best" activities were further reviewed and evaluated by the seven-Regional Project Directors for 1996 and 1997. Review criteria in determining the "best-of-the-best" activities included scientific

accuracy and timeliness,
consistency with National Science Education Goals and Standards, clarity, grade-level of potential students, and content appropriateness. The activities being presented in this *Resource Guide* include the following topics:

- Marine and Aquatic Habitats
- Deep Sea Technologies
- Marine and Aquatic Resources
- Marine and Aquatic Pollution
- Physical Parameters
- Plate Tectonics

This *Oceanography and Coastal Processes Resource Guide* is intended as an aid to teachers who wish to infuse these issues in their K-12 curricular materials—even though this book was specifically written for elementary and middle-school levels of understanding. This *Resource Guide* is not intended to be a comprehensive presentation of oceanographic and coastal processes issues; however, it provides teachers with select activities which will aid in framing and clarifying some of the key issues associated with the environment. It has also been recommended that this *Resource Guide* serve as a complementary text for use by informal educational efforts in museums, science centers, aquariums, and other similar facilities as they relate to a diversity of audiences concerning oceanographic and coastal processes.

Program History

This concept of a precollege course was initiated by the U.S. Navy and discussed with Dr. Sharon H. Walker of the J.L. Scott Marine Education Center and Aquarium, in November of 1992 at the Marine Technology Society Conference. The concept was expanded and developed in December 1992 through January and February 1993 as a prototype course, "Oceanography and Coastal Processes for Elementary and Middle School Minority Teachers." This study was implemented during the 1993 summer by Drs. Sharon H. Walker and Shelia A. Brown of the Mississippi-Alabama Sea Grant Consortium and the Gulf Coast Research Laboratory. Seventeen minority teachers from 12 states participated in the three-semester hour graduate course. The 1993 study was expanded to encompass six geographic regions within this country—including the U.S. Territory of Puerto Rico and the Pacific Island Network. A follow-up meeting was conducted in Silver Spring, MD at the National Sea Grant College Office with attendance from the Office of the Oceanographer of the Navy, the Office of Naval Research, the Naval Meteorology and Oceanography Command, as well as personnel from various NOAA Line Offices and the Department of Interior—Office of Territorial and International Affairs. As a result of this meeting, representatives from the Sea Grant National College Program and the Sea Grant Educational network met in November 1993 to refine the successful prototype "Oceanography and Coastal Processes" course. The 1994 proposal authors expanded and revised the original effort; these 1994 authors and the 1994-1999 Regional Project Directors were/are as listed (authors are asterisked):

- Ms. Rachel Salas Didier* (1994) - New Jersey Sea Grant College Program, New Jersey Maine Sciences Consortium
- Drs. Shirley Fiske/Dale Ingmanson, Program Directors - National Sea Grant

College Program

- Drs. Sharon Roth Franks/Diane Baxter (1997)-California Sea Grant College Program, Scripps Institute of Oceanography/Birch Aquarium at Scripps
- Ms. Amy Haddow (1997) - Connecticut Sea Grant College Program, University of Connecticut
- Dr. William R. Hall (1995 and 1998) - Delaware Sea Grant College Program, University of Delaware
- Mr. Robert J. Kent* (1994 and 1998) - New York Sea Grant College Program, Cornell University
- Ms. Elizabeth Kumabe (1994, 1995, 1997, 1998 and 1999) - Hawaii Sea Grant College Program, University of Hawaii
- Ms. Frances Lee Larkin* - Virginia Sea Grant College Program, Virginia Institute of Marine Sciences
- Ms. B. Sharon Meeker* (1995 and 1999) - Maine/New Hampshire Sea Grant College Program, University of New Hampshire
- Mr. Allen H. Miller* and Dr. James Lubner (1995 and 1998) - Wisconsin Sea Grant College Program, University of Wisconsin
- Mr. Bruce Munson (1997 and 1999) - Minnesota Sea Grant College Program, University of Minnesota
- Ms. Vicki J. Osis* (1996 and 1999) - Oregon Sea Grant College Program, Hatfield Marine Science Center/Oregon State University
- Dr. Leslie R. Sautter* - South Carolina Sea Grant College Program, University of South Carolina
- Dr. L. Lundie Spence* (1997) - North Carolina Sea Grant College Program, North Carolina State University
- Mr. Michael Spranger (1995 and 1998) - Washington Sea Grant College Program and University of Washington
- Mr. John A. Tiedemann* (1994) - New Jersey Sea Grant College Program, New Jersey Marine Sciences Consortium
- Dr. Sharon H. Walker* (1993 through 1999) - Mississippi-Alabama Sea Grant Consortium, the Institute of Marine Sciences/J.L. Scott Marine Education Center and Aquarium, and The University of Southern Mississippi
- Dr. Susan E.Yoder (1994) - Southern California Sea Grant College Program University of Southern California

For purposes of the 1994-1997 effort, the authors and Project Directors listed above plus two representatives each from the U.S. Navy, the Department of Interior, and the National Oceanic and Atmospheric Administration and one representative each from the NOAA-National Sea Grant College Program and the National Marine Educators Association comprised the De Facto Executive Committee for the six, regional teacher institutes. The Co-Chairs were Drs. Sharon H. Walker of the Mississippi-Alabama Sea Grant Consortium and the Institute of Marine Sciences administered by The University of Southern Mississippi and Lundie Spence of the North Carolina Sea Grant College Program and North Carolina State University. The responsibility of this Committee was to ensure the program objectives were being achieved in the manner outlined within the proposal narrative; to help in the selection of national speakers; and to meet the

National Educational Goals and Standards, as well as incorporate the highest scientific standards consistent with research findings to date. Meetings of this group convened at the National Sea Grant Week Conference and/or the National Marine Educators Association Annual Conference.

In order to maximize the coordination of resources and ideas within each of the six regions, Regional Steering committees were also organized. The Regional Steering Committees' composition reflected one representative from each state/territory within that region. The Regional Steering Committees were coordinated by the Project Director from that specific region for input into the planning process for collaboration and for the sharing of ideas and resources for the summer institutes. The Regional Steering Committees also provided input to the De Facto Executive Committee. The Regional Steering Committees attempted to convene at the Science Teachers' Annual Conference within each state or territory.

This management structure has served as an exemplary infrastructure and opportunity to evaluate "how well the Operation Pathfinder: Oceanography and Coastal Processes Institutes have worked." The administrative goal was and continues to be—having a management structure which enables participation, coordination, planning, and successful outcomes. The De Facto Executive Committee changed each year, as different institutions rotated their Project Directors for the courses, such that each year the De Facto Executive Committee had a mix of new members. Due to the fact Operation Pathfinder Institutes have achieved national recognition as exemplary precollege teacher models and are expanding during the 1998 and 1999 summers, a National Advisory Committee will be developed for outside consultation and advice.

1998 and Beyond

The "Consortium for Oceanographic Activities for Students and Teachers," or COAST, is a working collaborative designed to effectively deliver oceanographic and coastal processes education to pre- and inservice teachers from kindergarten through the twelfth grade (K-12). Each of the COAST members offers expertise in different areas and through focused efforts at specific educational levels provides depth of knowledge and resources in these areas. As a collaborative, the partners provide the broadest spectrum of means, methods and materials for ocean science education, as well as a nationwide telecommunications infrastructure. The COAST partners include: OPERATION PATHFINDER, a nationally recognized inservice program for elementary and middle school teachers of predominantly minority students and the development of curricular materials; the OCEAN VOYAGERS PROGRAM, a middle school teacher preservice/inservice training system featuring integrated curriculum development, World Wide Web page construction and maintenance, and teachers-to-sea experiences; and STARBORD, a high school level effort combining training with teacher-student research partnerships to leverage computational science tools for ocean science research. Each of these programs individually creates bridges between ongoing Naval research and formal and informal learning environments through focused teacher education. Together, the COAST collaboration fuses the strengths of each partner to provide enhanced, interdisciplinary content knowledge and hands-on activities relative to oceanography and coastal processes for precollege educators. The activities range from hands-on experiences aboard research vessels, to Web-based instruction, to curriculum resources, to videoteleconferencing, and to computational science and visualization of the highest

quality.
This Office of Naval Research funded project involves three COAST components as previously mentioned; their respective institutions and locations are as listed: OPERATION PATHFINDER will be facilitated through The University of Southern Mississippi's Institute of Marine Sciences/ J.L. Scott Marine Education Center and Aquarium located in Biloxi, Mississippi to include ten regional Sea Grant College Programs; the OCEAN VOYAGERS Program is based at St. Norbert College in DePere, Wisconsin; and STARBORD, represented by Mississippi State University is located in Starkville, Mississippi.Other essential partners in this 1998-1999 enhanced collaborative effort include: 1) the Naval Meteorology and Oceanography Command, the Naval Oceanographic Office, the Naval Research Laboratory, and the Office of the Oceanographer of the Navy; 2) the National Marine Educators Association; 3) the National Sea Grant College Program and the State Sea Grant College Programs in select affiliated universities in Mississippi-Alabama, Maine-New Hampshire, Delaware, Washington, Oregon, Wisconsin, Minnesota, New York, Hawaii, and North Carolina; 4) Sea Grant and University researchers; 5) 360 K-12 pre- and inservice teachers from all Great Lakes and coastal states in this country and numerous U. S. territories; 6) 24 high school students (four from each of six regions); and 7) select museums and aquarium within this country.

The 416 former Operation Pathfinder participants combined with the 360 pre- and inservice COAST participants—776 teachers—have the potential, over a minimum of a five-year teaching career, of reaching 385,200 precollege students. All three COAST components' pre- and inservice teachers are required to implement a staff development program in his/her school or school district (this is a commitment required in the selection process). These 360 precollege teachers combined with the 416 former Operation Pathfinder participants have or will directly train approximately 15,520 "fellow" teachers. Consequently, these additional 15,520 "second tier" teachers have the potential of reaching 8,556,000 precollege students over a five-year period.

Lastly, the National Ocean Partnership Act (NOPA) is simply about one thing—preparing our nation for the challenges of the 21st century. From centralized data collection and information sharing to increased education and a more streamlined approach. NOPA is helping us meet its goals for the next century (*Sea Technology*, 1996). COAST will contribute to the enhancement of oceanographic and coastal processes knowledge by cadres of precollege teachers and students. In accomplishing this goal, the National Ocean Partnership Program will have successfully broadened the awareness and understanding of marine and aquatic environments by program participants, and the roles of these fragile areas in the global relationships of sea, soil, and atmosphere. COAST—through this programmatic effort—can and will help shape the future.

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- Rear Admiral Paul E. Tobin, Jr., Oceanographer of the Navy (Retired);
- Rear Admiral George W. Davis, VI, Oceanographer of the Navy (Retired);
- Rear Admiral Geoffrey L. Chesbrough, Oceanographer of the Navy (Retired);
- Rear Admiral Kenneth E. Barbor, Commander, Naval Meteorology and Oceanography Command;
- Rear Admiral Paul G. Gaffney, II, Chief of Naval Research;
- Rear Admiral John E. Chubb, Commander (Retired), Naval Meteorology and Oceanography Command;
- Captain Richard M. Cassidy, Commanding Officer, Naval Research Laboratory (Retired);
- Captain Bruce Buckley, Commanding Officer, Naval Research Laboratory;
- Dr. Richard W. Spinrad, Director, Consortium for Oceanographic Research and Education;
- Dr. Donald L. Durham, Technical Director, Naval Meteorology and Oceanography Command;
- Ms. Gail Cleere, Public Affairs Officer, Staff of the Oceanographer of the Navy;
- Mr. Stephen B. Wilson, Public Affairs Officer, Naval Meteorology and Oceanography Command;
- Mr. Thomas V. Fredian, Public Affairs Officer, Naval Meteorology and Oceanography Command (Retired);
- Mr. Robert S. Winokur, Assistant Administrator for the National Environmental Satellite, Data, and Information Services (NOAA-U.S. Department of Commerce);
- Mr. Robert H. Feden, Special Assistant to the Assistant Administrator for the National Environmental Satellite, Data and Information Services (NOAA-U.S. Department of Commerce);
- Dr. Ned A. Ostenso, Assistant Administrator for Oceanic and Atmospheric Research (Deceased) [NOAA-U.S. Department of Commerce];
- Ms. Stephanie Thornton, Chief, Marine Sanctuaries Division, Office of Coastal Resources Management (NOAA-U.S. Department of Commerce);
- Ms. Maureen Wilmont, Program Planner, Marine Sanctuaries Division, Office of Coastal Resource Management (NOAA-U.S. Department of Commerce);
- Mr. Philip D. Delongchamps, Technical Assistance Advisor, Office of Territorial and International Affairs, U.S. Department of Interior (Retired);
- Mr. Allen P. Stayman, Acting Assistant Secretary, Office of Territorial and International Affairs, U.S. Department of Interior;
- Ms. Darla Knoblock, Office of Insular Affairs, U.S. Department of Interior;
- Dr. Ronald C. Baird, Director for the National Sea Grant College Program (NOAA-U.S. Department of Commerce);
- Dr. Chandrakant Bhumralkar, Acting Director (1994-1996) for the National Sea Grant

College Program (NOAA-U.S. Department of Commerce);

- Dr. David B. Duane (Retired), Director for the National Sea Grant College Program (NOAA-U.S. Department of Commerce);
- Dr. Shirley J. Fiske, Team Leader for Outreach, National Sea Grant College Program (NOAA-U.S. Department of Commerce);
- Dr. Linda Kupfer, Program Officer for Biotechnology National Sea Grant College Program (NOAA-U.S. Department of Commerce);
- Ms. DeShon Carter, Program Assistant, National Sea Grant College Program (NOAA-U.S. Department of Commerce);
- Sea Grant Directors as Listed: Drs. Anders Andren-Wisconsin; Jesús B. Tupaz-Mississippi-Alabama; Michael P. Weinstein-New Jersey; Jack Mattice-New York; Doug Sherman-California; Carolyn Thoroughgood-Delaware; Anne Bucklin-New Hampshire; Louie Echols-Washington; Michael McDonald-Minnesota; Edward Monahan-Connecticut; Robert Malouf-Oregon; Charles Helsley-Hawaii; Ronald Hodson-North Carolina; and James Sullivan-California;
- Dr. Horace W. Fleming, President, The University of Southern Mississippi;
- Dr. Aubrey K, Lucas, President (Retired), The University of Southern Mississippi;
- Dr. Karen M. Yarbrough, Vice President for Research, The University of Southern Mississippi;
- Dr. D. Jay Grimes, Director, Institute of Marine Sciences, Administered by The University of Southern Mississippi;
- Dr. Robert T. van Aller, Interim Director, Institute of Marine Sciences, Administered by The University of Southern Mississippi;
- Dr. Thomas D. McIlwain, Director (Retired), Gulf Coast Research Laboratory, Administered by The University of Southern Mississippi;
- Dr. Martha A. Sager, Coordinator of Educational Programs, Institute of Marine Sciences, Administered by The University of Southern Mississippi;
- Ms. Linda C. Skupien, Public Information Officer, Institute of Marine Sciences, Administered by The University of Southern Mississippi;
- Ms. Johnette D. Bosarge, Administrative Assistant, J.L. Scott Marine Education Center and Aquarium, Institute of Marine Sciences, Administered by The University of Southern Mississippi;
- Catherine L. Seymour, Layout and Design Editor, J.L. Scott Marine Education Center and Aquarium, Institute of Marine Sciences, Administered by The University of Southern Mississippi;
- Ms. Rosemary Finley, Artist and Science Teacher, Harrison County Schools, Gulfport, Mississippi;
- Dr. Shelia A. Brown, Science Department Chair, Mississippi Gulf Coast Community College, Jefferson Davis Campus;
- Mr. Howard D. Walters, Instructor-Developmental Studies, Mississippi Gulf Coast Community College, Jefferson Davis Campus; and
- Ms. Anne C. Switzer, High School Physics Teacher and Graduate Student, North Carolina State University.

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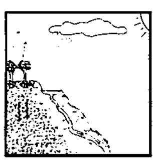

Topic I
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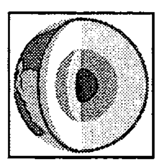

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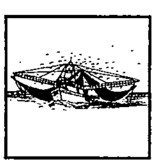

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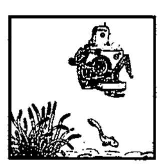

Topic VI
Deep Sea Technology VI-1

References .... R-I

1995 Operation Pathfinder Participants

Great Lakes Region

(These teachers developed the Operation Pathfinder activities.)

Neil Boettcher
7015 N 97th St
Milwaukee WI 53224-4601

Amy Cox
1532 Midvale Ave.
Los Angeles CA 90024

Deloris Donnelly
99 Pine Valley Rd.
Dover DE 19904

Dominic Gregorio
820 S Seaside Ave
San Pedro CA 90731-7330

Ken Kessenich
2559 S 82nd St
West Allis WI 53219-2420

Pam Legdesog
P.O. Box 985
Colonia Yap FSM 96943

Donald Newman
820 S Seaside Ave
San Pedro CA 90731-7330

Cathleen Rosen
829 Ocean View Blvd
Pacific Grove CA 93950-2229

Diane Smith
1635 Plumas Ave
Seaside CA 93955-6126

Lynn Telaak
7654 Hinman Hollow Rd
Little Valley NY 14755-9700

Andrea Cantu
Po Box 1297
Port Aransas TX 78373-1297

Eva Cruz
1907 E 142nd St
E Chicago IN 45312

Dean Gilbert
701 Locust Ave Rm 200a
Long Beach CA 90813-4316

Jodi Jansky
W6094 County Road T
Holmen WI 54636-9017

Judy Larmouth
944 S Quincy St
Green Bay WI 54301-3631

Corinne Multhauf
8908 Douglas Ave
Racine WI 53402-9714

Diane Pothast
1750 W. Julian #3
Chicago IL 60622

Cheryl Smelt
642 Hazel Dell Rd
Corralitos CA 95076-0383

Patricia Stapleton
Rr 2 Box 2387
Manistique MI 49854-9608

1997 Operation Pathfinder Participants

Great Lakes Region

(These teachers evaluated and field-tested the activities developed by the 1993-1995 participants.)

Joan Barle
P.O. Box 232
Coleraine MS 55722

Debra DeYoung
517 Maple Lane
Spring Valley MS 55975

Randy Furman
415 Tenth Street NW
Milaca MN 56353

Sue Glennon
1713 Fulham Street, Unit D
Lauderdale MN 55113

Kathryne Johnson
2653 Rice Creek Rd. #206
New Brighton MN 55112

Deb Las
1842 16th St. NW
Rochester MN 55901

Pamela Lord
1589 E. Appleman Rd.
Kendallville IN 46755

Lori McCadden
W63 N517 Hanover Avenue, #2
Cedarburg WI 53012

Ray Rusnak
1901 Campbell Street
Valparaiso IN 46383

Robert A. Snyder
1212 9th Avenue NW
Rochester MN 55901

Pamela Udelhofen
110 6th Avenue NE
Pine City MN 55063

Stephanie Breidenbach Nelson
6008 Kellogg Avenue
Edina MN 55424

Randee W. Edmundson
1508 Olene Avenue No.
Stillwater MN 55113

Laurel Gast
32 Bayview Rd
Castroville CA 95012-9725

Fred Hellbusch
P.O. Box 608, 6th & Hayward
chappell NE 69129

Jolene Marie Landwer
Rt. 1, Box 201A
Deer River MN 56636

Lars Long
2003 Welsh Drive
Eau Claire WI 54703

Lynne Martin
240 Grandview Ave. W. #206
Roseville MN 55113

Teresa Root
239 3rd Avenue South, Apt. F-7
South St. Paul MN 55075

Marlene A. Schoeneck
20355 Parkers Road NE
Parkers Prairie MN 56361

Jeffrey Theune
1782 Gulden Place
St. Paul MN 55109

1993 Operation Pathfinder Participants

Gulf and South Atlantic Region

(These teachers developed the Operation Pathfinder activities.)

Loreta Antonio
1196 Bay Circle St
Lima OH 45801-2411

Brenda Collum
10515 Mullikin Dr
Clinton MD 20735-3843

Eugene Davis
117 Womrath Ct
North Augusta SC 29841-4366

Patricia Goodnight
13023 Brahms Ter
Silver Spring MD 20904-7107

Sadye Hudson
5725 Green Tree Rd
Mobile AL 36609-2507

Marita Kasey
3110 Cody St
New Port Richey FL 34655-3417

Ruth Nelson-Wright
11221 108th Street Ct Sw
Tacoma WA 98498-1435

Nicholett Pestana
98-410 Kaoauka Loop Apt #33E
Aiea HI 96701-4515

Luz Tellez
607 Beckham Ave
Alice TX 78332-6147

Salvador Ceja
1916 B Ave
National City CA 91950-5632

Deanne Crichton
6018 N 15th St # E-102
Tacoma WA 98406-2405

Ruby Fields
719 College Ave
Grambling LA 71245-2413

Sylvester Hackworth
2455 Oakleigh Dr
Mobile AL 36617-2241

Brenda Jones
5438 85th Ave
New Carrollton MD 20784-3119

Paula Moore
800 Southern Ave Se Apt 927
Washington DC 20032-4804

Lemuel Patterson III
305 Commons Way
Goose Creek SC 29445-5445

Irene Smith
803 Woodrow Ave
Selma AL 36701-4746

1994 Operation Pathfinder Participants

Gulf and South Atlantic Region

(These teachers developed the Operation Pathfinder activities.)

Mary Ellen Alsobrook
126 S Bonham St
San Benito TX 78586-3912

Janice Anderson
Po Box 1423
Escatawpa MS 39552-1423

Barbara Burns
318 Indian Mound Rd
Clinton MS 39056-4904

Carol Bynum
Rr 4 Box 378a
Corinth MS 38834-9459

Lisa Davis
3305 S Harbour Cir
Panama City FL 32405-1640

Gus Hembree
P.O. Box 1
Section AL 35771

Margo King
2400 Magnolia Ave
Pensacola FL 32503-4941

Betty Lewis
3100 Lincoln Dr Apt 8d
Selma AL 36701-6627

Rachel Milstead
219 Warpath Rd
Columbus MS 39702-3105

Lynn Morris
2208 Old Highway 24
Hattiesburg MS 39402-9752

Joe Murphy
RR 11 Box 107M
Florence AL 35630-9343

Anne Rhodes
Rr 2 Box 108
Rienzi MS 38865-9802

Laura Sanders
630 B Alkabama Ave
Selma AL 36701

Teresa Ann Turner
107 Pickwick Ct
Jackson MS 39206-2432

Walter Ware
208 Meadowbrook Rd # 115
Greenwood MS 38930-6931

1995 Operation Pathfinder Participants

Gulf and South Atlantic Region

(These teachers developed the Operation Pathfinder activities.)

Haidee Anthony
509 E Wright St
Baytown TX 77520-5023

Roy Brooks
807 Tarrant Cir
Pharr TX 78577-6025

Cheryl Clinger
Po Box 5309
Biloxi MS 39534-0309

Alice Dubois
Po Box 1586
Albany LA 70711-1586

Georgia Graves
103 S Harbour Oaks Dr
Saint Simons Island GA 31522-4025

Hazel Hearty
114 Charwood St
Pearl River LA 70452-3700

Rodie Higginbotham
2209 Flippen Rd
Stockbridge GA 30281-5165

Marilyn Martinez
C/2 Blq. 2-J-13
Covadonga, ToaBaja PR 00949

Brenda Peterson
4219 Natchez Trace Dr
Saint Cloud FL 34769-6817

Kathy Westerman
125 Naples St
Corpus Christi TX 78404-1828

Margaret Bean
11614 Persuasion Dr
San Antonio TX 78216-2501

Sue Cassidy
7545 Serenity Dr
Hughesville MD 20637-2219

Gloria DelGuadio
14941 SW 297 Terrace
Leisure City FL 33033

Gloria Gonzalez
5307 Cynthia Linn St
San Antonio TX 78223-2214

Dorable Harry
236 Foxbriar Ct
Slidell LA 70461-3314

Trisha Hembree
315 Johnston Cir
Palmetto GA 30268-1529

Kay Hobbs
2301 Sandlewood Pl
Gautier MS 39553-7707

Jim McCurdy
1028 Ridge Ave
Stone Mountain GA 30083-2914

Meg Sullivan
916 Cloverdale Rd
Montgomery AL 36106-2104

1996 Operation Pathfinder Participants

Gulf and South Atlantic Region

(These teachers evaluated and field-tested the activities developed by the 1993-1995 participants.)

Kay Baggett
Po Box 7002
Ocean Springs MS 39566-7002

Hope Brown
2100 Pamela Dr
Gautier MS 39553-6633

Linda Carter
629 Wantoot Blvd
Charleston SC 29407-6630

Alicia Eggemeyer
3839 Dry Creek Dr Apt 139
Austin TX 78731-4860

Florence Furan
1310 White House Blvd Apt B
Charleston SC 29412-9251

Cynthia Gardner
126 Seases Cir
Lexington SC 29072-8973

Jane Harris
305 Mitchell St
Hot Springs National Park AR 71913-5020

Rodney Harris
305 Mitchell St
Hot Springs National Park AR 71913-5020

Donna Jackson
735 Quarry Rd
Tuscumbia AL 35674-5624

Johnetta Jenkins
1543 13th St S
Saint Petersburg FL 33705-2441

Laura Litolff
Po Box 2002
Hammond LA 70404-2002

Maria de Lourdes Lopez Falcon
HC-01 Box 8655
Aquas Buenas PR 00703-9725

Lee Noonan
11254 E Lanoux Rd # 713
Gonzales LA 70737-7847

Melissa Persahau
12148 Jollyville Rd Apt 1515
Austin TX 78759-2241

Maritza Rivera
Po Box 5274
Cayey PR 00737-5274

Carmen Sol Cruz Roman
Calle 4 C-12 Urb San Pedro
Toa Baja PR 00949

1997 Operation Pathfinder Participants

Gulf and South Atlantic Region

(These teachers evaluated and field-tested the activities developed by the 1993-1995 participants.)

Delmaline D. Armstrong
3262 Arkabutta Rd.
Coldwater MS 38618

Blair Heald
201 Grand Ave.
Fairhope AL 36532

Louis M. Lanni
45 Woodcutter lane
Palm Harbor FL 34683

Belinda Matlock
4055 Bailey Acres Circle
Meridian MS 39305

Gracie Lee Page
1604 Beverly Dr.
Clinton MS 39056

Lisa Reid
Rt. 1, Box 82-C
May TX 76857

Yolanda Rivera
AA-19 Artemisa, Urb. Apolo
Guaynabo PT 00934

Rachel Jo Rottier
1511 Mohican Ct.
Green Bay WI 54313

Flora Ann Warren
1270 Yucca Dr.
St. Louis MO 63132

Catherine Zuniga-Wohlfarth
7627 Spanish Wood
San Antonio TX 78249

Jan Bethmann
14040 Lake Tilden Blvd.
Winter Garden FL 34787

Audrey Jones
9511 Perrin Beitel #721
San Antonio TX 78217

Sandra Lopez Guerrios
3 Calle A-Urb. Hnas. Davila
Bayamon PR 00959

Vicki Lynn Morrison
5545 Hanauma St.
Diamondhead MS 39525

Francis Redmon
P.O. Box 102
DePere WI 54115

Abigail Resto Hernandez
251 Calle Violeta San Rafael Estates E-14
Bayamon PR 00959

Migdalia Rodriguez-Acosta
2 A St., #C-43, Urb. Hillside
San Juan PR 00926

Kay Scarbrough
P.O. Box 362
Hurley MS 39555

Monica Williams
4011 Arkabutla Rd.
Coldwater MS 38618

1995 Operation Pathfinder Participants

Mid-Atlantic Region

(These teachers developed the Operation Pathfinder activities.)

Ann Alexander
1206 Steeles Ridge Rd
Camden Wyoming DE 19934-2423

Shannon Buckalew
19 Finney Rd
New Castle DE 19720-3350

Rosemary Buote
1690 Wellington St
Dighton MA 02715-1000

Madelyn Charlton
2 Georgian Circle
Newark DE 19711

Tina Darling
P.O. Box L
Willow Grove PA 19090

Kimberly Demowski
27 Tower Point Rd
Chesapeake City MD 21915-1625

Michael Duffy
Po Box 441
Little Creek DE 19961-0441

Carolyn Elliot
409 Augusta Dr
Statesville NC 28677-4607

Marcia Ellison
201 Weldin Rd
Wilmington DE 19803-4933

Eileen Gray
5300 Glenside Dr Apt 2009
Richmond VA 23228-3977

Rebecca Henderson
325 Spalding Rd
Wilmington DE 19803-2421

Ross Hobbs
401 Lauderdale St
Selma AL 36701-4526

Karen Jardine
84 Ethan Allen Ct.
Newark DE 19711

William Johnson
3741 Hawkhurst Close
Chadds Ford PA 19317

Cynthia Louden
110 Angus Ct
Cary NC 27511-4361

Irene Morgan
Rr 2 Box 278c
Delmar DE 19940-9645

Edward Pasek
2750 Moody Ave
Orange Park FL 32073-5905

Nelda Sharkey
425 Hunters Creek Dr
Goldsboro NC 27534

Janice Trainer
10 Eagle Point Cir
Hockessin DE 19707-1422

Sophronia Wilson-Burwell
3825 Hawthorne Ave # 2
Richmond VA 23222-1048

1996 Operation Pathfinder Participants

Mid-Atlantic Region

(These teachers evaluated and field-tested the activities developed by the 1993-1995 participants.)

Diana Caldarola
726 Rutherford Ave
Lyndhurst NJ 07071-1218

Christine Hernandez
841 Rivanna River Reach
Chesapeake VA 23320-9236

Sophia Jarvis
P.O. Box 248
Swan Quarter NC 27885

Mary Johnson
2120 Cocoa Cir
Virginia Beach VA 23454-2213

Pauline Maniscalki
66 Skyline Dr
Ringwood NJ 07456-2012

Charles Mercer
Po Box 70870
Washington DC 20024-0870

Kathy Porter
72 Box Grove Pl
Somerset NJ 08873-4766

Carlos Smith
Po Box 10
Urbanna VA 23175-0010

Ginny Drennan
1513 Janke Rd
Virginia Beach VA 23455-3417

Penelope Jarvis
101 Ravenwood Apts Apt C
Jacksonville NC 28546-7016

Ceresy Jenkins
205 Holyoke Dr
Washington NC 27889-9221

Wendy Keller
1008 Ferry Plantation Rd
Virginia Beach VA 23455-5404

Jacqueline McDonnough
3220 1st Ave
Richmond VA 23222-3225

Anna Patty
811 Players Ln
Newport News VA 23602-9107

J. Catherine Roberts
3753 Garfield Ave.
Norfolk VA 23502

Melissa Tukey
142 Beechwood Dr
Carrboro NC 27510-2458

1997 Operation Pathfinder Participants

Mid-Atlantic Region

(These teachers evaluated and field-tested the activities developed by the 1993-1995 participants.)

Mary Anna Arnold
670 Knollwood Drive
Mount Airy NC 27030

Alec Bodzin
2067 Pathway Dr.
Sanford NC 27330

Cheryl deLusignan
6294 Mill Creek Trail
Zuni VA 23898

Victoria Harris
2858 Powell Creek Drive
Charlottesville VA 22911

Rose Kelly
P.O. Box 88
Aydlett NC 27916

Jalynn McDonald
2067 Pathway Dr.
Sanford NC 27330

Jennifer Mott
118-O Lofton Dr.
Fayetteville NC 28311

Ellen Thompson
2993 Hourglass Road
Hartly DE 19953

Frankie Vann
119 Henry Vann Farm Road
Clinton NC 28328

Susan Wallace-Carr
513 West Main Street Ext.
Swansboro NC 28584

Robert Wilson
P.O. Box 15883
Acheville NC 28813

Myron Bass
4210 Taylors Bridge Highway
Clinton NC 28328

Clay Campbell
93 Hillcrest Dr.
Chocowinity NC 27817

Joan Gorsuch
40 Green Oak Drive
Coraopolis PA 15108

Scott Jacobs
168 Ramtown-Greenville Rd.
Howell NJ

Arleen Linehan
612 Baden Ave.
Virginia Beach VA 23464

Elizabeth Moore
3232A Park Avenue
Richmond VA 23221

Deborah Orzechowski
788 Old York Road
Somerville NJ 08876

Kathy Tinsley
151 Valley Lane
Franklin NC 28734

Joe Wagner
4300 Fosterdale Lane
Winston-Salem NC 27107-7626

David Wehunt
3304 Windsor Court
Chattanooga TN 37411

1994 Operation Pathfinder Participants

Northeast Region

(These teachers developed the Operation Pathfinder activities.)

Gerald Ahern
35 Woolsey Ave
Glen Cove NY 11542-1912

Evelyn Casdia
22 Fischer Ave
Islip Terrace NY 11752-1510

Chet Dulak, Jr
3448 Greenway Rd
Grand Island NY 14072-1017

Geraldine Erhartic
58 Cedar Dr
Massapequa NY 11758-7525

Sandra Ifill
56 Arthur Ave
Floral Park NY 11001-3502

Evelyn Lein
Po Box 46
Brightwaters NY 11718-0046

Ed Murphy, Jr.
Star Rt Box 276
Lowville NY 13367

Roseann Pellegrino
412 4th Ave
East Northport NY 11731-2807

Christine Schaer
3 Warren St
Norwalk CT 06851-3510

Salvadore Testa
7958 78th Ave
Glendale NY 11385-7508

Maureen Carlos
5 Brigham Hill Rd Apt 8
Grafton MA 01519-1187

Yvonne Coppola
93 Greenbelt Pkwy
Holbrook NY 11741-4439

David Egolf
99 Atlantic Ave
West Sayville NY 11796-1901

Alison Hall
50 Revere Pl
Buffalo NY 14214-1519

Guy Jacob
Po Box 388
West Islip NY 11795-0388

George Linzee
Chapman Parkway
Stony Brook NY 11790

Connie Parise
47 Pine Edge Dr
East Moriches NY 11940-1548

April Pokorny
212a N Country Rd
Wading River NY 11792-9368

Robert Shanley
33 Woodbine St
Coram NY 11727-1140

Karen Zopf
12 Gristmill Dr
Kings Park NY 11754-2819

1995 Operation Pathfinder Participants

Northeast Region

(These teachers developed the Operation Pathfinder activities.)

Ted Albright
17955 Tanleaf Ln
Prunedale CA 93907-8548

Sally Dean
22 Rockwood Ter
Boston MA 02130-2426

Carolyn Hine
279 Cambridge Ave.
Cambridge MA 02138

Karen Jerz
16 Pleasant St.
Methuen MA 01844

Donna Maroon
5 Hillside Rd
Windham NH 03087-1433

Virginia McIver
115 North Rd
Saunderstown RI 02874-3105

Rosemary Rodriguez
74 Pleasant Ter
Leominster MA 01453-3929

Ruth Scheilbenpflug
13 Seavey Dr
Saco ME 04072-9238

Kimberly Spencer
347 State Route 125
Barrington NH 03825-3630

Colleen Wilusz
40 Lantern Ln
Hooksett NH 03106-2149

Elizabeth Young
240 Middle St Apt 5
Portsmouth NH 03801-4355

Shelia Billings
8 Ober St
Salem MA 01970-1346

Gary DiCenso
Po Box 246
Lincoln ME 04457-0246

Rita Houghton
23 Cleveland St.
Sommerville MA 02143

Jacqueline Kupu
44 S Chestnut St
Bradford MA 01835-7446

Paula McDonnell
100 Spring St
Saunderstown RI 02874-3230

Dana Mitchell
Po Box 294
Perry ME 04667-0294

Pamela Santiago
35 1/2 Arnold St
Methuen MA 01844-3625

Ann Smith
340 Hubbard Rd
Berwick ME 03901-2304

Shirley Spencer
86 Steppingstones Rd
Epping NH 03824-6609

Christine Yanco
71 Coburn Woods
Nashua NH 03063-2849

1997 Operation Pathfinder Participants

Northeast Region

(These teachers evaluated and field-tested the activities developed by the 1993-1995 participants.)

Karen Artinger
146-15 25th Drive
Flushing NY 11354

Irene Cruz
875 Olmstead Ave.
Bronx NY 10473

Gina Diaz
221 Winchester St.
Rochester NY 14615

Carol Drejza
174 Quassaic Ave.
New Windsor NY 12553

Laura Elisofon
2552 Young Ave.
Bronx NY 10469

Roxanna Foglia-Horton
29 Crescent Place
Middletown NY 10940

Guido Garbarino
501 Pelham Rd., #2G
New rochelle NY 10805

Louis Giorsos
132-09 80th St.
Ozone Park NY 11417

Cindy Gram
91 Shirley Dr.
Schenectady NY 12304

Elaine Holcombe
354 Abbe Rd. Extension
S. Windsor CT 06074

Gary Klar
95 Hickory Knoll Dr.
Easton CT 06612

Margot Lowell
894 Rossville Ave.
Staten Island NY 10209

David McDonald
30 Heusted Dr.
Old Greenwidh CT 06870

Nancy Mott
65 South Meadow Rd.
Carver MA 02330

Echendu Nwanodi
5 W 107th St., Apt. 4B
New York NY 10025

Rosemary Stewart
24 Log Cabin Rd.
Lynn MA 01904

Louise Taylor
1522 Plimpton Ave.
Bronx NY 10452

Doreen Todorov
105 Dodge Dr.
syracusc NY 13210

Howard Warren
19 Beaver Point Trail
Wharton NY 07885

Wesley Wilhelmsen
52 Hurds Corner Rd. #2
Pawling NY 12564

1994 Operation Pathfinder Participants

Pacific Region

(These teachers developed the Operation Pathfinder activities.)

Kerry Barrow
20415 Bothell-Everett Hwy, B-202
Bothell WA 98012

Paul Costa
21270 S Richard Ct
Oregon City OR 97045-8625

Gary Hafner
6797 Murray Park Dr
San Diego CA 92119-2931

Becki Kilkenny
1500 Sw 201st Ave
Aloha OR 97006-2045

Betty Naidis
2028 Banewood Ct.
Bend OR 97702

Scott Presho
8081 Ravenna NE
Seattle WA 98115

Valerie Seymour
530 Estero
Morro Bay CA 93442

Connie Shundo
67 Via Canada
Rancho Palos Verdes CA 90275

Chris Steinkamp
6033 SW Vermont St.
Portland OR 97219

Colleen Collins
Po Box 6091
Napaskiak AK 99559-6091

Gordon Greenwald
Po Box 231
Hoonah AK 99829-0231

Pat Hawthorne
14649 Se 173rd St
Renton WA 98058-8760

Sherry Matson
HC01 1541-4
Kenai AK 99611

Carol Ponganis
8425 SW Halter Ter
Beaverton OR 97008

Toni Roberts
17273 Caminito Canasto
San Diego CA 92127

Mimi Shawe
P.O. Box 1268
Bethel AK 99559

Terry Snyder
P.O. Box 35478
Los Angeles CA 90035

Elaine To
1558 - 26th Avenue
San Francisco CA 94122

1995 Operation Pathfinder Participants

Pacific Region

(These teachers developed the Operation Pathfinder activities.)

Ann Campbell
820 Wadsworth Ave
Pismo Beach CA 93449-2362

Jill Carell
1107 Monterey Blvd.
Hermosa Beach CA 90254

John Jackson
280 E Mendocino St
Altadena CA 91001-5144

Kathleen Jones
2354 Yale Ave E Apt 201
Seattle WA 98102-3383

Terry Loving
121 Vine St Unit 407
Seattle WA 98121-1453

Cindy Machado
24 Bayview Rd
Castroville CA 95012-9725

Amy Maggio
15733 Victory Blvd
Van Nuys CA 91406-6054

Laura Martin
10734 Rhodesia Ave
Sunland CA 91040-2530

Kathleen Mitchell
Po Box 835
Wrightwood CA 92397-0835

Arlene Mohilner
8801 Stanmoor Dr
Los Angeles CA 90045-3439

Karen Moore-Boich
19431 Rue De Valore Apt 28c
Foothill Ranch CA 92610-2316

Sam Read
Po Box 498
Odessa WA 99159-0498

Thelma Ritchie
7445 86th Ave Se
Mercer Island WA 98040-5738

Alretta Skellenger
950 N Lilac Ave
Rialto CA 92376-4051

Morri Spang
2015 Monterey Blvd
Hermosa Beach CA 90254-2913

Junko Toll
4800 Brookwood St
Eugene OR 97405-3538

David Ulrich
Po Box 18002
Coffman Cove AK 99918-0002

Wendy Ward
26240 Jeanette Rd
Carmel Valley CA 93924-9225

1996 Operation Pathfinder Participants

Pacific Region

(These teachers evaluated and field-tested the activities developed by the 1993-1995 participants.)

Maureen Allen
7139 Coralite St.
Long Beach CA 90808

Ed Austin
902 Normandy Ave. S
Salem OR 97302

Valerie Baker
P.O. Box 24
Gleneden Beach OR 97388

Valorie Brown
790 LaCresta Ct. SE
Salem OR 97306

Jerry Carlson
930 E. Main St.
Hermiston OR 97838

Cammi Charlton
935 Casanove Ave.
Monterey CA 93940

Nancy Conrad
2545 NE 37th Place
Portland OR 97212

Dennis Cowan
710 LaCresta Dr. SE
Salem OR 97306

Liz Cox
3500 Park Rd
Ocean Springs MS 39564-9709

Anastasia Fayne
13426 Huston St. apt. C
Sherman oaks CA 91423

Susan Fountain
7710 S. Taylor Dr.
Tempe AZ 85284

Lynne Hallstrom
1702 Florida St., #22
Huntington Beach CA 92648

Michelle Hansen
78994 N. Loop Rd.
Stanfield OR 97875

Jeannine Housden
960 NW Jones
Albany OR 97321

Michelle Howard
1930 W. Nob Hill St. SE
Salem OR 97302

Robert Ishii
2346 Ewing St.
Los Angeles CA 90039

Rebecca Kelly
P.O. Box 63
Agness OR 97406

Amy Mitchell
14630 SW Grayling Lane
Beaverton OR 97007

Joanne Olson
6759 N. Oak Avenue
Seattle CA 91775

Susan Talaro
1514 Bellevue Ave.
Seattle WA

Roger Warren
29 Palma Ave.
LaSelva CA 95076

Lisa Winter
729 1/2 St. ann's Drive
Laguna Beach CA 92651

1996 Operation Pathfinder Participants

Pacific Region

(These teachers evaluated and field-tested the activities developed by the 1993-1995 participants.)

Audrey Wu
3657 Second Ave.
La Crescenta CA 91214

1997 Operation Pathfinder Participants

Pacific Region

(These teachers evaluated and field-tested the activities developed by the 1993-1995 participants.)

Paul Blake
1336 Piedmont Rd.
Pt. Angeles WA 98363

Marilyn Bridgan
3002 N. Viewmont
Tacoma WA 98407

Laura Carlson
4050 Porte la Paz #43
San Diego CA 92122

Dorothy D. Clater
12110 Via Serrano
El Cajon CA 92019

Kimberly A. Dalton
2303 Belmont Ave.
Long Beach CA 90815

Nancy Dosick
4395 Rous St.
San Diego CA 92122

Lorraine Gerstl
25579 Carmel Knolls Dr.
Carmel CA 93923

Jan Hamilton
335 Trailview Rd.
Encinitas CA 92024

Andy Holleman
14300 Teton Place
Anchorage AK 99516

Cynthia Leah Hoskins
880 Tierra Del Sol Rd.
Booulevard CA 91905

Susan Hustad
217 16th St. #3
Huntington Beach CA 92648

Joyce Irene Johnson
2615 Willowbrook Lane #77
aptos CA 95003

Barbara Lesure
1921 Virginia Rd.
Los Angeles CA 90016

Danan McNamara
7780 Parkway Dr. #1004
LaMesa CA 91942

Sally Movido
9862 Ivy St.
Spring Valley CA 91977

Lori A. Pina
9104 Libra Dr.
San Diego CA 92126

Dawn R. Rucker
4357 Vetter Place
La Mesa CA 91941

Diane Kimiko Saski
1622 West Ave. K-8, Apt. 103
Lancaster CA 93534

Diane Wentzel
7430 Brookmill Rd.
Downey CA 90241

Elizabeth Wieler
2316 Taylor Dr.
Everett WA 98203

Tim K. Williamson
444 Obispo Ave. #302
Long Beach CA 90814

1994 Operation Pathfinder Participants

Pacific Island Network

(These teachers developed the Operation Pathfinder activities.)

Lancine Backer
13104 September Way
Riverside CA 92503-0920

Angie Buniag
Po Box 1511
Saipan MP 96950-1511

George Fagolfleg
Po Box 220
Colonia, Yap FM 96943-0220

Robert Koss
Po Box 24222
Barrigada GU 96921-4222

Peau Peau
Po Box 3629
Pago Pago AS 96799-3629

Hatsuko Sato
Po Box 514
Koror, Palau PW 96940-0514

Owen Yamaguchi
76-6211 Papala St
Kailua Kona HI 96740-3014

Aurelio Buliche
Po Box 460
Chuuk FM 96942-0460

Jeff Erikson
PO Box 77
St Michael AK 99659

Elizabeth Johnathan
Po Box 189
Koror PW 96940

Kevin Nishimura
98-209 Pajoa Pl Apt. L203
Waipahu HI 96797

Maxwell Salik
PO Box AM
Tofol Kosrae FM 96944

Steven Soltysik
1702 Makoi St
Lihue HI 96766-9009

1995 Operation Pathfinder Participants
Pacific Island Network
(These teachers developed the Operation Pathfinder activities.)

Olivia Alcalde
Po Box 1003
Rota MP 96951-1003

Carmen Atalig
Songsong Village
Rota MP 96951-0508

Daisy Atalig
Po Box 979
Rota MP 96951-0979

George Ayuyu
Songsong Village
Rota MP 96951

Carina Miriam Bautisa
Po Box 1136
Rota MP 96951-1136

Pichiosy Billy
Po Box 284
Moen, Chuuk FM 96942-0284

Enterina Calvo
Po Box 1335
Rota MP 96951-1335

Therese Calvo
Po Box 501
Rota MP 96951-0501

Amorvilla Catabas
Po Box 1405
Rota MP 96951-1405

Nita E. Elayda
P.O. Box 998
Rota MP 96951

Alfred Hitchfield
PO Box 5621
Ebeye Marshalls MH 96970

Angel Hocog
Po Box 1105
Rota MP 96951-1105

Tita A. Hocog
P.O. Box 998
Rota MP 96951

Isaac Jackson
Po Box 102
Tofol, Kosrae FM 96944-0102

Stephanie Kamakeeaina
140 Uwapo Rd Apt 5-102
Kihei HI 96753-7409

Karness Kusto
Po Box 3
Majuro MH 96960

Pepine Feao Lauvao
Po Box 3760
Pago Pago AS 96799-3760

Eloise Manglona
Po Box 996
Rota MP 96951-0996

Rizalina Maratita
Po Box 910
Rota MP 96951-0910

Jim Maskie
Po Box 1116
Pohnpei FM 96941-1116

Evangeline Mendiola
Po Box 1375
Rota MP 96951-1375

Magdalena Sn. Mesngon
P.o. Box 1027
Rota MP 96951

1995 Operation Pathfinder Participants
Pacific Island Network
(These teachers developed the Operation Pathfinder activities.)

Delson Pony
Po Box 1468
Kolonia, Pohnpei FM 96941-1468

Evelyn Redrico
Po Box 1169
Rota MP 96951-1169

Conception San Nicholas
Po Box 939
Rota MP 96951-0939

Bismark Sebastian
Po Box 250
Pohnpei FM 96941-0250

Annette Taisacan
Po Box 492
Rota MP 96951-0492

Frances Ulloa
PO Box
Saipan MP 96950

James Priest
Po Box 1005 CK
Saipan MP 96950-1005

Ann Marie Rosario
Po Box 1057
Rota MP 96951-1057

Carmelita Santos
Caller Box Aaa 346
Saipan MP 96950-9999

Tobed Smith
Po Box 2407 CK
Saipan MP 96950-2407

Michael Tenney
1025 Kalo Pl Apt 406
Honolulu HI 96826-1612

Iros Waguk
Po Box 1515
Songing Village, Rota MP 96951-1515

1997 Operation Pathfinder Participants

Pacific Island Network

(These teachers evaluated and field-tested the activities developed by the 1993-1995 participants.)

Jamil Ahmadia
200 West Puainako St.
Hilo HI 96720

Sabastian Amor
P.O. Box 1418
Kolonia, Pohnpe FSM 96943

Sam Baamafel
P.O. Box 220
Colonia Yap 96943

Monroe David
P.O. Box 976
Seinwar, Pohnpei FSM 96941

Juan P. Flores
P.O. Box 384
Agana Guam 96932

Maskie Jim
P.O. Box 1166
Kolonia, Pohmpei FSM 96941

Sobse Jose
P.O. Box 2210
Kolonia, Pohnpei FSM 96941

Rose Lawrence
P.O. Box 705
Kolonia, Pohnpei FSM 96941

Maxon Malarme
P.O. Box 225
Kolonia, Pohnpei FSM 96941

Mike Pacheco
P.O. Box 155
Hakalau HI 96710

Elias Robert
P.O. Box 310
Weno, Chuuk FM 96942

Elisapeta Alaimaleata
P.O. box 5907
Pago Pago AS 96799

Arwelson Arpona
P.O. Box 250
Kolonia, Pohnpei FSM 96941

Seberanio Baranabas
P.O. Box 976
Seinwar, Pohnpei FSM 96941

Henry Donre
P.O. Box 671
Kolonia, Pohnpei FSM 96941

Mason Henry
P.O. Box 1720
Kolonia, Pohmpei FSM 96941

Sohnnis Johnny
P.O. Box 1355
Kolonia, Pohnpei FSM 96941

Antero Latorres
P.O. Box 788
Kolonia, Pohnpei FSM 96941

Salter Lohn
P.O. Box 822
Kolonia, Pohnpei FSM 96941

Augustina Mesubed
P.O. Box 1277
Koror Palau 96940

Lisa Riseling
P.O. Box 1349
Rota MP 96951

Aurelio Sauder
P.O. Box 460
Weno, chuuk FM 96942

1997 Operation Pathfinder Participants

Pacific Island Network

(These teachers evaluated and field-tested the activities developed by the 1993-1995 participants.)

Andrew Shiro
P.O. Box 160
Koror Palau 96940

Jesus Songsong
P.O. Box 1107
Rota MP 96951

Lenson Tauleng
P.O. Box PS97
Palikir, Pohnpei FSM 96941

Martin Weirlangt
P.O. Box 250
Kolonia, Pohnpei FSM 96941

Marino Siver
P.O. Box 310
Weno,Chuuk FSM 96942

Tao Suani
P.O. Box 242
Pago Pago AS 96799

Anna Voigt
P.O. Box 176
Pago Pago AS 96799

Stan Yiluy
P.O. Box 222
Colonia, Yap FSM 96943

Physical Parameters

TOPIC I

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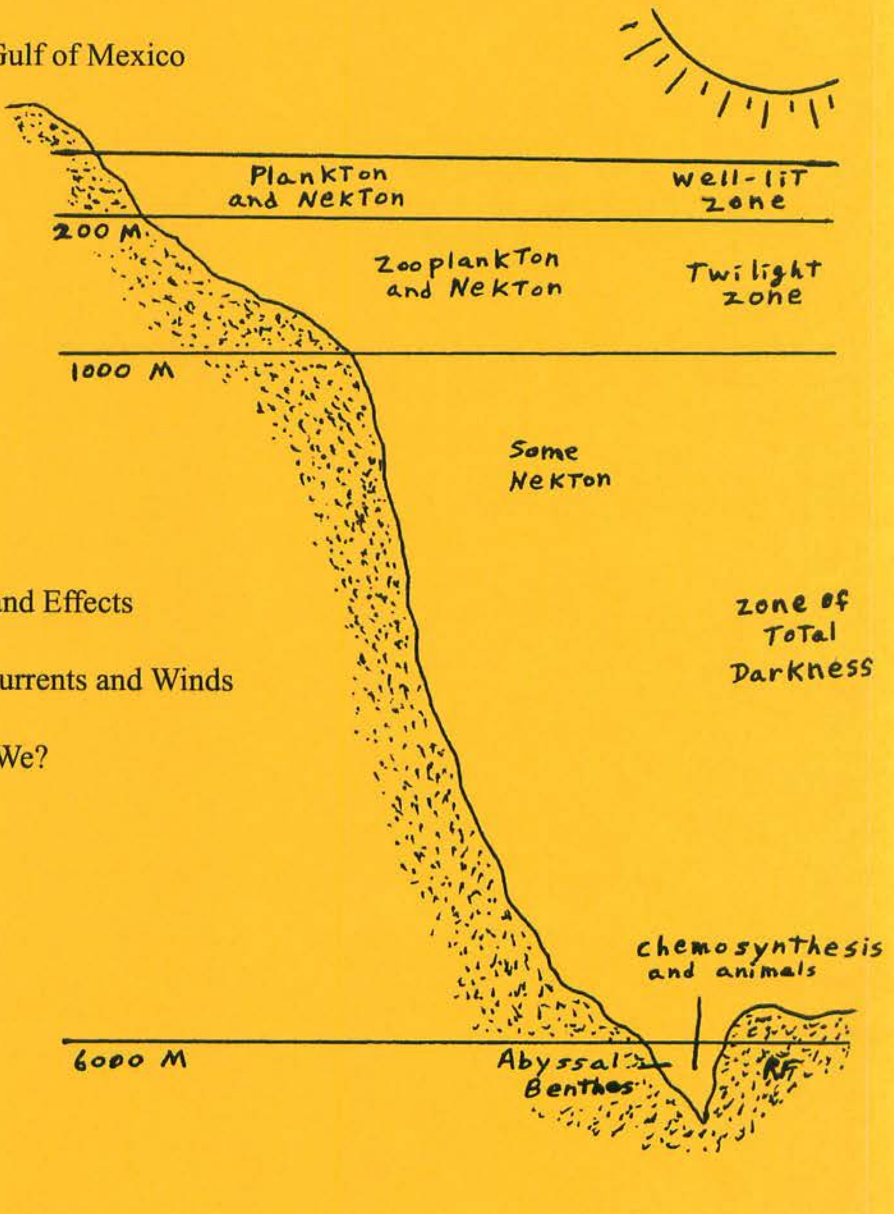
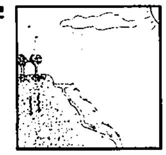


Physical Parameters



INTRODUCTION

Physical Parameters

The Earth's surface is dominated by water. In fact, water accounts for 70.8% of the surface of this planet, the majority of this water is contained in the world's oceans. Without water, there would be no life. There are many physical properties of ocean water which control the distribution and diversity of organisms.

Density of water is an important abiotic factor. Temperature, salinity, and depth are determining factors in the density of seawater. Density increases with *decreasing* temperature (cold water is more dense than warm water), and *increasing* salinity and depth. Much of the ocean is divided into three density zones: the surface zone or mixed layer, the pycnocline—an area where density increases rapidly with increasing depth—and the deep zone where there is little increase in density with increasing depth (Garrison, 1993).

Light is another important factor in the distribution of life in the oceans. Once sunlight passes the ocean surface, it is scattered and absorbed, limiting the depth to which it can penetrate. As a result, there is only a relatively thin layer of lighted surface water, known as the photic zone, within which all food production by photosynthetic marine plants occurs. In the open ocean, the photic zone is generally about 100 meters in depth, although in clear, tropical waters, it may extend to a depth of 200 meters (Garrison, 1993).

The scattering and absorption of light also results in the ocean waters appearing blue. Absorption of visible light in the ocean is greater for longer wavelengths; therefore, red, orange, and yellow light are absorbed quickly. Fifty five percent of the light entering the water is absorbed in the first meter or so of water, and the remaining 45% is mostly comprised of green and blue wavelengths. Clear ocean waters appear blue because blue light penetrates the water far enough to be scattered back through the surface to our eyes (Garrison, 1993).

Ocean currents, which are capable of moving vast quantities of water, are driven by a number of different forces. Primary forces, which start water moving and determine its velocity, include wind stress at the water surface, thermal expansion and contraction, and differences in water density. Secondary factors include the Coriolis effect, the shape and size of ocean basins, gravity, and friction (Garrison, 1993).

Changes in typical atmospheric and oceanic circulation can affect global weather patterns. An example of this is an El Niño event. In normal years, trade winds blow *from east to west* from a region of higher pressure over the eastern Pacific, toward an area of lower pressure in the western Pacific generally centered over Indonesia. As these trade winds blow over the surface of the water, they drag cool water from the South American

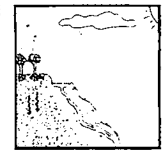
coast westward. Sunlight and the atmosphere heat this water resulting in surface water along the equator which is cooler in the eastern Pacific and warmer in the western Pacific. However, every few years, there is a breakdown in the usual atmospheric pressure patterns. Air pressure decreases in the eastern pacific and increases in the west. This results in the weakening of the trade winds. In strong pressure reversals, the normal easterly winds are replaced by west winds (i.e. winds blow from *west to east.*) As a result, a broad area of warm, nutrient poor, tropical Pacific waters moves eastward toward South America. Large quantities of fish, particulary anchovies, and marine plants which thrived in cold, nutrient rich waters, may die. Birds which feed on the fish may also die, littering the waters and Peruvian beaches with their carcases. The impact on the fishing industry in the area can be catastrophic.

The impact of an El Niño event is not limited to South America. The large area of abnormally warm water fuels the atmosphere with additional moisture and warmth, and can have an effect on global wind patterns. The actual mechanism of this relationship between changes in surface ocean temperatures and wind patterns is not fully understood, but the results can be observed world-wide. The major El Niño in 1982-83 resulted in droughts in Indonesia, southern Africa, and Australia and record rains and flooding in Ecuador and Peru. In the Northern Hemisphere storms pounded areas of the United States from California to the Gulf States. It is estimated than worldwide damage exceeded $8 billion (Ahrens, 1991).

Tides and waves are other factors which move ocean waters. Tides are created by the gravitational attraction between the sun, moon, and Earth. The moon's gravitational pull on the Earth results in water being pulled toward the moon causing a "bulge" in the water. Inertia causes a similar bulge of water on the opposite side of the Earth. These "tidal bulges" are, in essence, the crest of planet sized waves, and are the cause of high tides. Low tides are associated with the troughs.

Twice each month, when the sun, moon, and Earth are in alignment, the gravitational pull combines to produce spring tides or tides with the greatest tidal range (highest high tides and lowest low tides.) When the moon is in its first quarter or third quarter phase, the sun, moon, and Earth form a right angle. The resulting tides, known as neap tides, have a smaller than average tidal range (lowest high tides and highest low tides).

The most familiar type of waves are produced by wind. The size of waves produced depends on wind speed, the length of time the wind is blowing at a particular speed, and the fetch—the unobstructed distance of the sea over which the wind blows (Bearman, 1989). As a wave approaches shore, it encounters shallower water. When the depth of the water is approximately 2 of the wavelength, the wave begins to "feel" the bottom and friction causes the wave to slow and wavelength to decrease (wave period remains the same.) As depth continues to decrease the top of the wave—the wave crest—is moving faster that the wave bottom. The wave will eventually "break." This generally occurs at a 3:4 ratio of wave height to water depth, i.e. a 3-meter wave will break in 4 meters of



water (Garrison, 1993).

The chemical composition and quality of water also dictate which organisms are able to survive in a given region. Salinity or, very simply, the salt content of the water is an important abiotic factor. Salinity is measured in parts per thousand (0/00). The average salinity of ocean water is between 30 and 35 0/00. However, salinity fluctuates with the amount of freshwater influx through precipitation, the melting of snow and/or glaciers, river runoff, and evaporation rate. Salinity generally increases with a decrease in depth. The area of rapidly changing salinity is known as the halocline.

Water temperature is another important component of water quality. Water temperatures vary greatly by region. Water is warmed by solar energy, therefore surface waters are generally warmer than bottom waters. Ocean water is mixed through a variety of mechanisms including currents and wave action. The area where the warmer surface waters meets the colder bottom waters is known as the thermocline. The temperature of the water within the thermocline decreases rapidly with depth.

The pH of water is also an integral factor in the distribution of organisms on this planet. The pH of a solution is determined by measuring the concentration of hydrogen ions and is measured on a scale from zero to 14. A solution with a high concentration of hydrogen ions is acidic with a pH between zero and seven. A solution with a large number of hydroxyl ions is an alkaline or basic solution with a pH ranging from seven to 14 (Greene, 1998). Ocean water generally has a pH between eight and nine and is therefore, basic. Freshwater is typically more acidic. Smaller bodies of water, such as lakes and ponds, are often affected by acid precipitation which causes the pH to become more acidic. The larger volume of water in an ocean helps to dilute the effects of precipitation. Chemicals in the ocean water known as buffers also help to control pH (Greene, 1998). The carbonate radical ($CO_3^{=}$) is an example of one buffer in the ocean. The carbonate radical can accept hydrogen ions, causing pH to increase, or it can release hydrogen ions, causing the water to become more acidic. Photosynthesis and respiration alter the amount of CO_2 in the water, which also affects pH. Photosynthesis removes CO_2 from the water, which forces buffers to remove hydrogen ions, increasing pH. Respiration, at night, when photosynthesis does not occur, adds CO_2 to the water, resulting in an increase in the number of hydrogen ions, thereby lowering the pH (Greene, 1998).

The amount of oxygen dissolved in water also controls the distribution of organisms. The majority of oxygen produced on Earth is the result of photosynthesis by plants and algae living in the upper portions of the water column. The amount of dissolved oxygen (DO) in water is measured in parts per million (ppm). Ocean water is generally between one and nine ppm (Greene, 1998). Dissolved oxygen generally decreases with depth as the plants and algae that produce oxygen require sunlight. Waves and currents help mix surface waters and bring oxygen to the depths of the water column. Areas with very low DO levels are known as hypoxic, while areas with no usable DO are referred to as anoxic.

There are other abiotic factors which control the distribution and abundance of organisms in marine and aquatic environments, such as the availability of nutrients and food. However, in general, the physical parameters described above are the primary factors responsible for maintaining viable ecosystems.

The physical parameters of the ocean are driving forces behind marine biodiversity, zoogeography, global climates, and coastal development. Most people do not realize the impact the oceans of the world have on their day-to-day lives. For thousands of years, the human race has relied on the oceans as a source of food, a crucial mechanism for travel/transportation, the major source of the air we breath, and an integral component of weather patterns.

Over the past several decades, the desire to live near the coast has increased dramatically. It is estimated that three-fourths of all Americans live within 80 km of the coast or Great Lakes (Thurman, 1993). This increased coastal demography by humans has resulted in an increase in habitat loss and degradation which has led to a decline in many coastal marine and aquatic plant and animal populations. This coastal movement by human species has often led to a lessening in water quality due to the sheer numbers of people, without proper infrastructure being in place such as wastewater treatment facilities. Further, increased amounts of run-off from highways, industrial and commercial companies, airports, and golf courses —combined with increased emissions from airborne fossil fuels which may return to the Earth in the form of acid rain—have negative effects on both terrestrial and marine and aquatic plants and animals. Therefore, understanding the various abiotic factors and the role they play in the ocean ecosystem is essential to the conservation, preservation, and responsible management of the ocean and its resources. Controlling point and non-point source pollution and coastal development, as well as educating the general public are integral components in maintaining healthy marine and aquatic environments for future generations.

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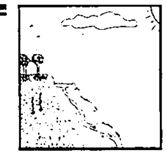
Physical Parameters



TOPIC-TITLE: Physical Parameters - *Erosion Creates a Change in the Landscape*

AUTHOR: Guy Jacob

GRADE SUITABILITY: Middle School

SCOPE: Earth Science

SEQUENCE: Before introducing the topic of erosion, students should be taught about waves. What is a wave? What can it do to the landscape? After students discuss erosion, lead them through a discussion relative to controlling and/or reducing erosion.

BACKGROUND SUMMARY: The ocean is constantly in motion. Currents, tides, and waves which move ocean waters are the result of the Earth's position in the solar system, the rotation of the Earth, and actions which occur between the Earth and its inhabitants.

Waves are generally produced by wind. The wind moves over the surface of the water causing the water to rise. The stronger the wind, the higher the water rises producing larger waves. When the wind is steady, it produces a wave train which is a series of consecutive waves. As waves approach the shore, they move over shallow water. When the bottom of the wave hits the seafloor, the top of the wave moves forward and crashes. This process forms a breaker.

When the incoming tide reaches the mouth of a river, another type of wave is formed. If the seafloor slopes at the mouth of the river and the tidal range at that point is more than five meters, a wave known as a tidal bore would be created (Greene, 1998). Sudden changes in the Earth's crust can lead to another type of wave referred to as a tsunami. According to Greene (1998), an earthquake on the seafloor created a turnami off Japan in 1993.

Currents, tides, and waves not only move the water in the ocean, but also move sediments along the shoreline. The movement of these sediments is called erosion. When the sediments are relocated along a beach, it is termed deposition. When a wave crashes against a beach, sand is suspended into the water and may drift with the current. During storms, waves and currents have more energy; therefore, more sand may be removed.

Governmental agencies attempt to contend with the problem of coastal erosion in a number of ways. One way is to create a barrier. A groin is a rock or wood barrier which extends from the beach into the water. A jetty is another type of barrier. Jetties are designed to trap sand drifting along the shore with the current, to prevent sand accumulations in a channel.

When a large quantity of sand has eroded from a beach, one way in which it can be

replaced is to pump the sand in the water column back to the beach. This process is known as dredging. All of these processes are temporary methods to reduce or control erosion.

Researchers are currently testing a new erosion control theory. This new type of erosion control is a submerged artificial reef. According to Greene (1998), large concrete blocks which interlock are placed approximately 100 meters offshore. As the waves move toward the shore, they reach these concrete blocks and break. The sand then increases between the artificial reef and the shore preventing the shore from eroding. This process may also only be a temporary solution as the sand beneath the reef eventually erodes, compromising the reef. Further studies must be conducted to determine whether this is the best and most natural course of action.

OBJECTIVES: Students will be able to conduct experiments to show evidence of soil erosion.

MATERIALS:
- 20 rulers (4 for each group)
- All purpose sand (70 lb. bag)
- Pencils
- 5 rectangular pans or plastic bins (at least 9" or 12")
- Tap water
- Paper

ACTIVITY:
1. Divide students into five, cooperative learning groups.

2. Provide each group with a pan, sand, water, four rulers, paper, and pencils.

3. Have students place sand in their pan approximately 1 ½" thick on one half of the pan.

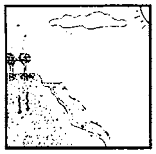
4. Gently add tap water up to ½" deep on the side of the pan.

5. Label the shorter sides of the rectangular pan, east and west.

6. Have student groups draw a diagram of their respective pans.

7. One student in each group should take a ruler and create a "wave" action against the shore in a general east to west movement.

8. Ask the students to make a drawing after creating the wave action—noting the effects of erosion. How has the coastline changed?



9. Following Step 7, have students place two or three rulers into the sand about 4" apart to represent groins. Have them develop a hypothesis for the function of groins. Make a drawing of these groins and shoreline.

10. Use a ruler to create the same east to west wave movement. What happened inbetween the groins? What happened to the shoreline? What happened to the west of the last groin? Make a drawing after the wave action is complete.

POSSIBLE EXTENSION:
1. Obtain a slide of beach groins. Demonstrate beach groins to the class and discuss their thoughts.
2. Compare and contrast jetties with groins. Groins protect barrier beaches. Both jetties and groins can be constructed of rock; however, jetties tend to be longer and protect channel or inlet areas.
3. Humans can modify the landscape as does mother nature. How would you feel if you could not access a beach? Would you want tax dollars spent to have the effects of erosion controlled by human technology?

TEACHER EVALUATION: Have student groups write possible reasons why the sand was eroded to the west of the last groin. Also, have student groups write how the problem could have been prevented. Students may wish to draw a plan demonstrating how shoreline erosion should have been prevented.

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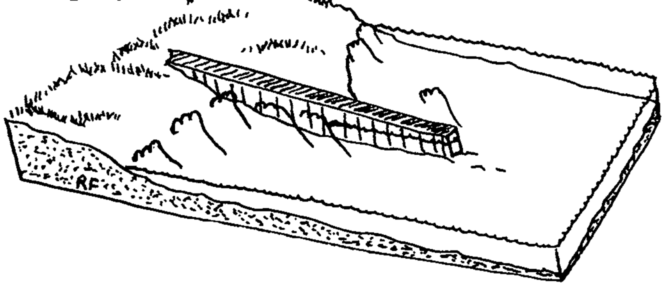


Physical Parameters

TOPIC-TITLE: Physical Parameters - *Where do You Live in The Oceanic Realm?*

AUTHOR: Jodi L. Jansky

GRADE SUITABILITY: Middle School

SCOPE: Earth Science and/or Life Science

SEQUENCE: This unit follows a unit on coral reef communities. To compare and contrast coral reef communities and physical parameters, discuss the areas of the ocean where most life exists. Discuss the technology oceanographers use to explore the ocean floor. Students should be familiar with how sound travels and be familiar with inferring distances by using sound. (See *Jason Curriculum* 1992 pages 99-103 for ideas.) Follow this unit with plate tectonics and thermal vents.

BACKGROUND SUMMARY: Sonar technology is used by oceanographers and topographers to discover the appearance of the sea floor. This information helps us better understand the geologic features of the deep ocean and allows us to travel the oceans more safely.

OBJECTIVES: Students will be able to:
1. Create a map of the Atlantic Ocean floor.
2. Label sea floor features on the map.
3. Label oceanic life zones on the map.
4. Draw pictures of animals found in the different life zones on the map.

MATERIALS:
- Clear tape
- Colored pencils
- Thin line black markers
- Rulers
- Three sheets of graph paper per student team
- Copy of data on page 13 of *Nature Scope* (1992) edition or *Merrill Earth Science* (1995) pages 312-315.

ACTIVITY:
1. Divide class into learning groups of two students each.

2. Provide each team with three sheets of graph paper, several pieces of tape, and a copy of the "Ocean Depth Data" found on page 13 of *Nature Scope* (1992) or page 315 of the *Merrill Earth Science* (1995) Textbook.

3. Use an overhead transparency of a piece of graph paper to demonstrate the numbering of the X and Y axes on the graph paper.

4. Plot the first three to four depths together, then have teams finish plotting all depths.

5. Teams should connect all points using a pencil and ruler.

6. Teams then will trace over plotted points with a thin line black marker.

7. Teams will color the ocean floor using black or brown colored pencils.

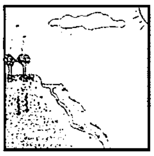
8. Teams will read pages 312-315 in the *Merrill* (1995) text together, then using that information, label the following areas of the ocean floor on the map: continental shelf, continental slope, continental rise, ocean basin, abyssal plain, ocean trench, sea mount, mid-ocean ridge, and rift.

9. Have each team label the life zones of the ocean including the depths.

10. Teams will draw and label two to three animals found in each zone.

POSSIBLE EXTENSION:
1. Investigate the mineral deposits found on the sea floor. Can they be mined? In the event the mineral deposits can be mined, who owns them?
2. Investigate the process of "false coloring" in sonar technology and compare it to the Magnetic Resonance Imaging (MRI) process used in hospitals.
3. Research how or which animals use sound waves for survival.

TEACHER EVALUATION: Have students respond to the following three questions in their journals:
1. Draw a profile of the ocean floor and label the following features: continental shelf, continental slope, abyssal plain, rift zone, mid-ocean ridges, sea mount, and ocean trench.
2. Where do most animals in the ocean live, closer to continents or in deeper water? Justify your answer.
3. Explain how the ocean floor data used for maps were gathered.



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Physical Parameters

TOPIC-TITLE: Physical Parameters – *Ubiquitous Estuaries-Similarities and Differences*

AUTHOR: Roy Brooks, Blair Heald, Sandra Lopez, Belinda Matlock, and Abigail Resto

GRADE SUITABILITY: Middle School

SCOPE: Oceanography, Habitat, and/or Estuaries

SEQUENCE: Students should have prior knowledge and understanding of:

- Hypersaline
- Hyposaline
- Dissolved oxygen
- Salinity
- pH

BACKGROUND SUMMARY: A unique environment known as an estuary develops where freshwater from rivers meets the sea. Estuaries are among the most productive environments on Earth. Along the shores of many estuaries are often found salt-marsh grasses, seaweed, submerged grass beds, and mangroves. Multitudes of worms, clams, and shrimp reside in the muddy bottom; snails and crabs crawl along the shore; and countless species of fish swim in the often turbid, plankton-rich estuarine waters.

Estuaries provide natural nurseries and are also among the environments most affected by humans. This anthropogenic impact has been disastrous to many estuaries. Estuaries are too often filled, dredged, turned into seaports, and used by some humans as sites for garbage disposal. Estuaries are scattered along the shores of the world's oceans and vary greatly in origin, type, and size. Some estuarine environments are called lagoons, such as the Laguna Madre; others are called bays, such as Chesapeake Bay; and some may be referred to as bayous such as Davis Bayou on the Mississippi Sound. Another example is represented by the mangrove swamps in southern Florida. They all share the mixing of fresh water with the sea in a partially enclosed, shallow section of the coast.

Perhaps the most common type of estuary is the drowned river valley or coastal plain estuary. These estuaries were formed when sea level rose at the end of the last "ice age," and the sea invaded lowlands and the mouths of rivers. A good example of this estuary type is the Chesapeake Bay. In a bar-built estuary, an accumulation of sediments along the coast results in sand bars and barrier islands which act as walls between the ocean and the fresh water supply. The Laguna Madre and the Mississippi Sound are examples within the Gulf of Mexico.

Tectonic estuaries, such as San Francisco Bay, were created when land sank or subsided as a result of movement in the Earth's crust. The spectacular estuaries known as

fjords were created when retreating glaciers cut deep valleys along coasts. The valleys were then flooded by the sea, and rivers formed in the valleys and flowed into the sea. These estuaries are common in southeastern Alaska. Estuaries tend to be broader and more well-developed along coasts with flat plains and wide continental shelves, or passive margins. They are less developed where steep coasts and narrow continental shelves have created narrow river mouths along active margins.

Influenced by tides and the mixing fresh and saltwater, estuaries have unique physical and chemical characteristics which impact the lives of the organisms which inhabit them. The characteristics of two estuaries along the Gulf Coast will be compared in this lesson.

OBJECTIVES: Students will be able to:

1 Define the term estuary.
2. Name, describe, and list examples of different types of estuaries.
3. Compare water parameter data for two estuaries.
4. Determine the differences between estuaries by examining maps, charts, graphs, tables, and other relevant data.

MATERIALS:

- Data tables, location maps (acquired from the U.S. Geological Survey Office), charts, graphs, and other teacher-provided handouts (teacher would need to obtain these materials prior to this activity).
- Other classroom resource materials.

ACTIVITY:

1. Introduce the lesson with background information and a review of the terminology used in measuring physical parameters. Students will be required to take notes.
2. Distribute data tables and other teacher-provided materials and remind students to note details, such as date of data collection.
3 Ask students to compare data tables for their estuaries and to locate each estuary and begin recording observations about the similarities and differences of these estuaries.
4. Discuss results. Then have students prepare hypotheses to account for differences between the two estuaries.

POSSIBLE EXTENSION:

1. Have students design and conduct a more thorough investigation into the possible causes of differences between the estuaries studied.
2. If possible, conduct field trips to the estuaries studied to enable students to collect and analyze their own data and compare these data with previous results.

Physcial Parameters

TEACHER EVALUATION:

1. Students will be pretested and posttested on the key concepts.
2. Students will prepare a Venn diagram using the estuarine data.
3. Students will record written hypotheses to explain the differences and similarities between the estuaries.

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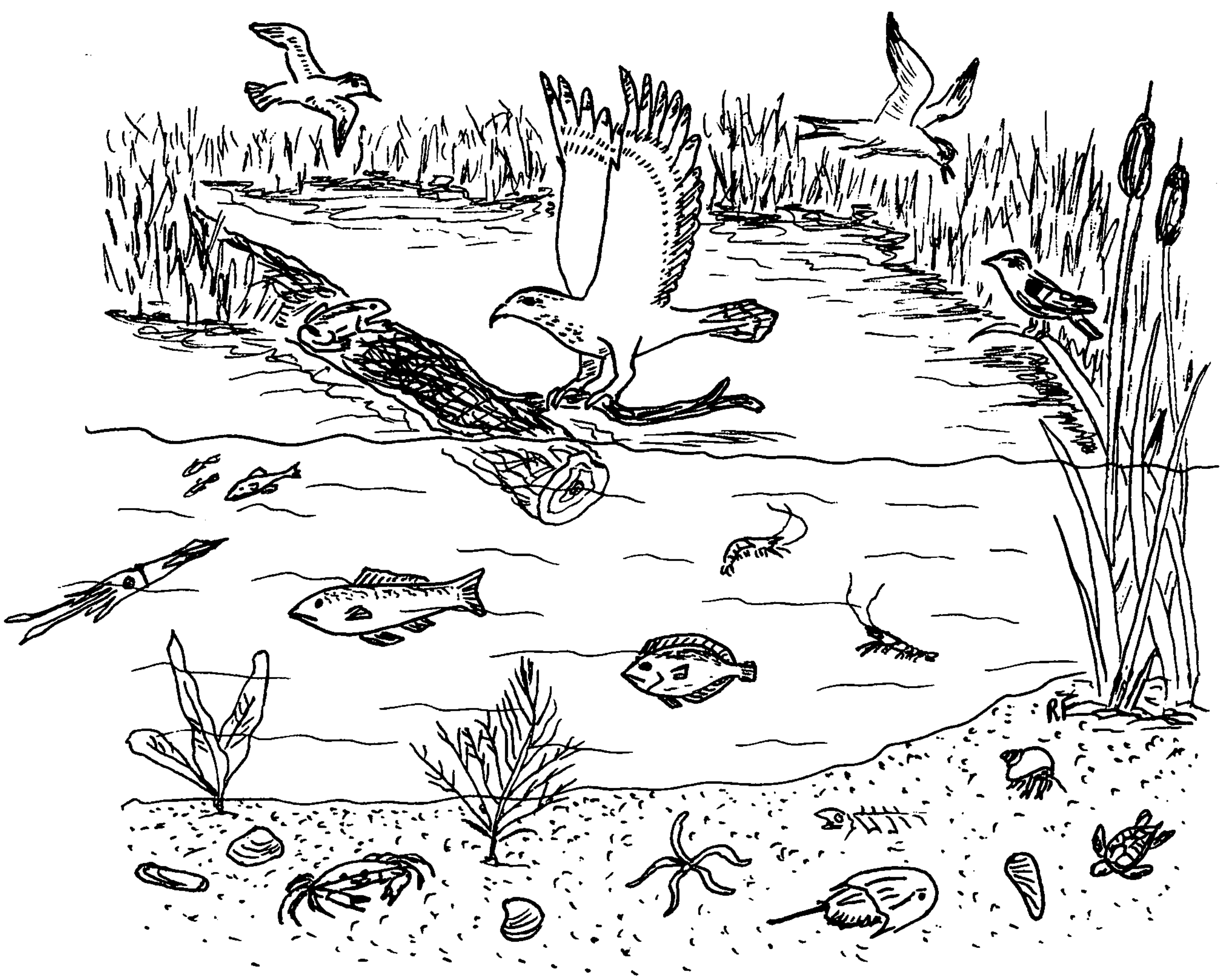


TOPIC-TITLE: Physical Parameters - *Creating and Comparing Various Saline Environments Within the Gulf of Mexico*

AUTHOR: Haidee Anthony

GRADE SUITABILITY: Middle School

SCOPE: Life Science, Marine Science, Ecology, and Environmental Science

SEQUENCE: Students should have an understanding of the following:
- How to use a hydrometer
- The relationship of density and salinity

BACKGROUND SUMMARY: The average salinity of the ocean is 35 parts per thousand (ppt); most of the Gulf of Mexico averages 28 to 32 ppt. However, there are some areas of the Gulf of Mexico which average 36 ppt. There are many influences on the salinity within the Gulf of Mexico. There are more than 30 rivers which contribute freshwater to the Gulf. The Mississippi River makes the greatest contribution, but rivers are not the only contributors of freshwater to the Gulf. Freshwater vents on the southwest shelf of Florida are also notable sources of freshwater to this semi-enclosed body of water.

The fact some areas of the Gulf of Mexico have a slightly higher salinity than the open ocean is a surprising anomaly. This anomaly may be attributed to many things, but perhaps the most interesting is the existence of brine seeps. Brine seeps are often associated with oil pockets and are located in at least two areas of the Gulf of Mexico. One well known brine seep is located near the East Flower Garden Banks and an even larger one is located at the Orca Basin. These seeps have a salinity of 200 ppt and 250 ppt, respectively.

The variation of salinity will influence the ecosystems around them. North of the barrier islands, the freshwater is prevented from completely mixing with the Gulf water, so the salinity is lower from Florida to the upper Texas coast. The mid-Texas coast through much of Mexico has a high salinity north of the barrier islands. The freshwater influx through riverine input and precipitation is less than the evaporation rate. The Laguna Madre is an example of a bay which has a hyper-saline environment. Ecosystems and the life forms which exist in high salinity environments are very different from those found elsewhere. It is interesting to investigate those life forms and their adaptations for survival in such hostile environments.

Physical Parameters

OBJECTIVES: Students will be able to:
1. Predict the amount of salt required to bring a given amount of water to the average salinity level of the Gulf of Mexico.
2. Design and write a testing method to determine whether their hypotheses are correct or incorrect.
3. Perform the testing procedure designed by students and determine how much salt is needed to achieve the desired salinity.

MATERIALS:
- Salt
- Five-gallon bucket
- Hydrometer
- Graduated beaker
- Any other material the students may decide they need for testing

ACTIVITY:
1. Present the problem of the investigation to the students–"How many milliliters of salt are needed to make five gallons of water read 1.020 on the hydrometer?"

2. Allow the students to work in cooperative learning groups to develop the results of their laboratory proposals.

3. Students are required to present their proposals and develop and submit a request for materials to the teacher for approval. (This should take one day of class time.)

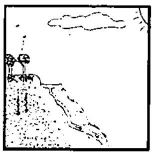
4. Each group will begin the experiment using their proposed testing procedure.

5. Students will record the salinity changes during the experiment on a self-designed data table.

6. Students will then graph the results from the data table in a bar graph.

7. Students will develop and write conclusions for their laboratory investigations using a grammatically correct format (minimum of five sentences in the conclusion). They will predict the amount of salt required to prepare a 20-gallon aquarium for living marine organisms.

POSSIBLE EXTENSION:
1. Discuss how much salt is needed for the closest coastal waters and why the salinity of these waters is so much lower than the Gulf of Mexico.



2. Discuss how much salt is needed for the hypersaline environments and the causes for such conditions.
3. Contrast and compare the differences in a coastal, hypersaline body of water and Gulf of Mexico salinities.

TEACHER EVALUATION:

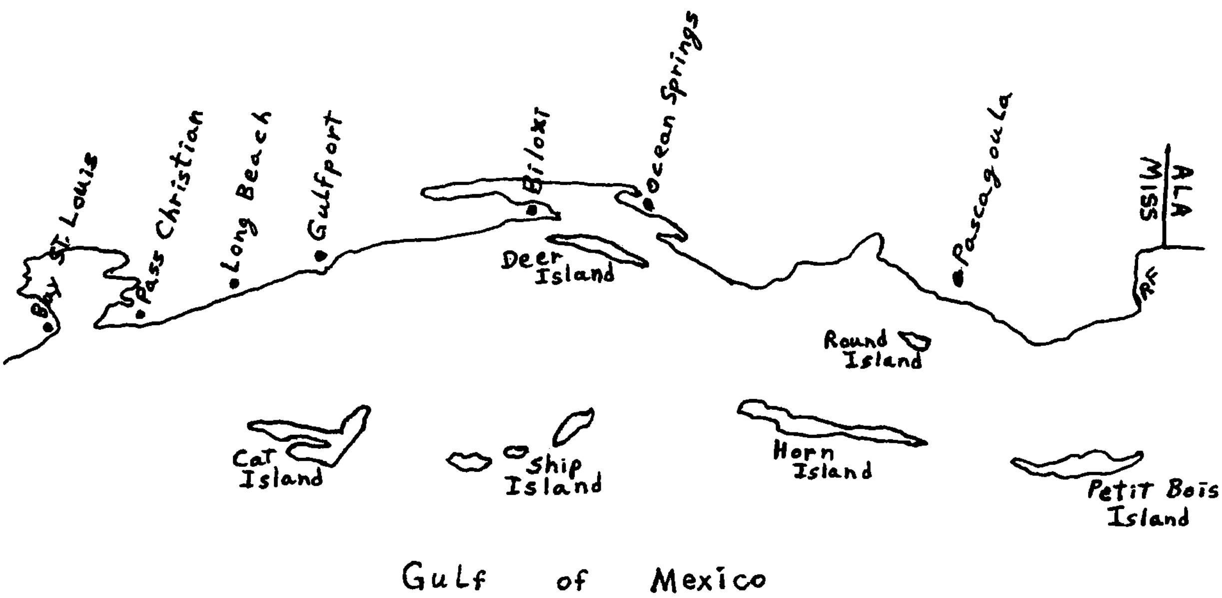
1. Student groups will develop a hypothesis for the problem.
2. Student groups will design a testing procedure to determine whether their hypotheses are correct.
3. Student groups will make a bar graph to show the increased salinity from their test results.
4. Student groups will complete a written laboratory report (from problem to conclusion).
5. Teachers should evaluate the content, accuracy, and conceptual understanding of the graphs and laboratory reports.

REFERENCES:

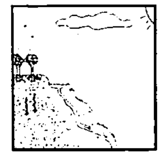
Department of Environmental Protection, Florida Marine Research Institute. 1994. *Florida Salt Marshes.*

Maraniss, Linda. 1991. *The Gulf of Mexico: A Special Place—Creative Learning Activities for the Classroom.* Washington, D. C. Center for Marine Conservation.

Weber, Michael, et. al. 1992. *Environmental Quality in the Gulf of Mexico: A Citizen's Guide.* 2nd Ed. Washington, D. C. Center for Marine Conservation.



Physical Parameters



TOPIC-TITLE: Physical Parameters - *Whale Hang-Out in the Gulf of Mexico*

AUTHOR: Elizabeth Young

GRADE SUITABILITY: Middle School

SCOPE: Oceanography, Environmental Science, and Biology

SEQUENCE: Prior to this activity students should be provided with information about marine mammals and strategies relative to their life history.

BACKGROUND SUMMARY: Whales in the Gulf of Maine region are usually found in relatively shallow areas where up-welling currents carry nutrients into the photic zone. Phytoplankton flourish in this zone and become food for the zooplankton upon which many of the great whales, especially those with baleen, feed. Toothed whales such as the Atlantic whitesided dolphins and harbor porpoises feed upon small fish which gather to eat zooplankton.

OBJECTIVES: Students will be able to:
1. Demonstrate an understanding of bathymetric charts as representations of the ocean floor.
2. Develop hypotheses regarding whale distribution in relation to depth of water, currents and up-wellings.
3. Demonstrate an understanding of how LORAN numbers and global positioning systems are used in navigation and positioning of marine vessels.

MATERIALS:
- Gulf of Maine chart in the form of an overhead transparency showing depth, relation to the Atlantic Ocean, and other related information.
- Navigational chart of the whale watch area duplicated on different colors according to the depth scale used.
- Cardboard, Styrofoam®, foamboard, or other source of filler to use for spacing between depth layers.
- Scissors, Exacto®-knives, rulers, glue, and masking tape. (Note: Students should use extreme care with Exacto®-knives).

ACTIVITY: Note: This activity can precede a whale watch field trip, thereby setting the stage for observations to be made by the students for data acquisition. A whale watch field trip will empower the students to investigate their hypotheses about whale migration patterns.

Physical Parameters

1. The teacher must visit the whale watch tour company to ascertain if there will be naturalists on board, tour the boat, and arrange with the captain a listing of LORAN readings at locations of sightings of marine mammals so these data may be used by the students.

2. Using the navigational chart and the transparency, stress the salient features of the Gulf of Maine, in particular the up-welling along the coast and over the George's Bank. This can be accomplished by an explanation of LORAN numbers and how they are used to indicate position on the chart.

3. View selected portions of the video, *A Sea Beside The Sea.*

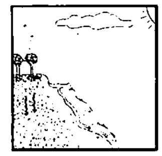
4. In cooperative learning groups, have the students carefully create a three-dimensional scale model of the area of the whale watch. Students may use Styrofoam® or cardboard to demonstrate the depths on the Gulf of Maine chart. For instance, set a width of Styrofoam® or cardboard which is equivalent to a certain depth—1/4" of Styrofoam® = 20 meters of water depth. Construct a scale model according to the depths located on the Gulf of Maine chart. Styrofoam® or cardboard layers should be glued directly to the chart. For added stability, glue the chart to foamboard or thick cardboard.

5. Have each student group develop record sheets which include time, species, and number of marine mammals, behavior (spyhopping, tail-lobbing, flipper flapping, breaching, and other related characteristics) depth of water at sighting, weather, and other pertinent data. These parameters will be used by students to record observations while on the whale watch.

6. Through group discussions, have students develop several hypotheses regarding the relationship between depth, distance from shore, appearance of other boats in the vicinity, and the number and species of marine mammals sighted.

7. On the whale watch, have one student record the depth and LORAN position every 20 minutes, using information from the navigational equipment in the pilot house.

8. Upon return from the trip have students plot the location of whales and dolphins sighted during their trip, on their scale models. They can then test the hypotheses developed in #6 regarding location of marine mammals.



POSSIBLE EXTENSION:

1. Report findings via WHALENET (http://whale.simmons.edu) on the Internet.
2. Use WHALENET to trace the migration of a particular species from beginning to end for the season.

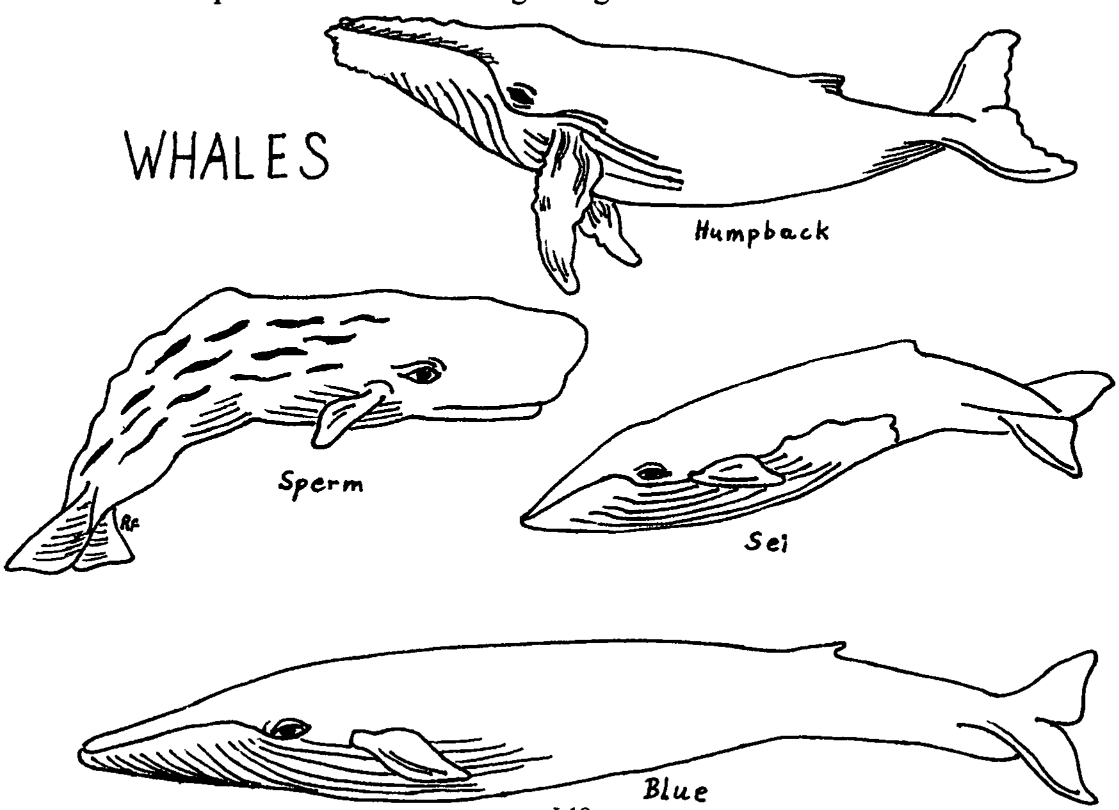
TEACHER EVALUATION:

1. Collect and evaluate record sheets for thoroughness.
2. Have each student write a report based on his/her observations including information to support or deny the hypotheses. Students should also include their thoughts on how pollution from nearby cities affects productivity of shallow waters and thus, marine mammals. Students should also list other factors which affect migration patterns—other than up-welling and depth of water.

REFERENCES:

Cousteau, Jacques. 1985. *The Ocean World.* New York, NY.
Evans, Peter G.H. 1993. *The Natural History of Whales and Dolphins.* London. Academic Press.

Video:
Maine-New Hampshire Sea Grant College Program. 1985. *A Sea Beside the Sea.*



TOPIC-TITLE: Physical Parameters - *The Ocean Floor*

AUTHOR: Patricia Stapleton

GRADE SUITABILITY: Upper Elementary

SCOPE: Science and/or Social Studies

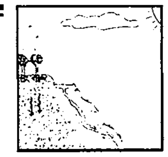
SEQUENCE: This activity may be used to introduce an oceanography unit. Following these activities, the students will learn about the life of the ocean, the shoreline, and wave action.

BACKGROUND SUMMARY: Ocean waters account for approximately 70% of the Earth's surface. There are three major oceanic basins on Earth–the Pacific, Atlantic, and Indian. The Pacific is the largest, holding 52% of the Earth's ocean waters (Sumich, 1984). The bottom of the ocean basins are dominated by mid-ocean ridges, submarine canyons, abyssal hills, volcanic mounts, and trenches. Volcanic eruptions and earthquakes take place under the water and as a result, the ocean floor is constantly changing. Waves, currents, and tides keep the oceans constantly in motion. The organisms which live in the ocean must adapt to these conditions in order to survive in the sea.

OBJECTIVES: Students will be able to:
1. Understand the ocean ecosystem, including concepts such as continental shelf, slope, plains, valleys, mountains, and trenches.
2. Understand that earthquakes, volcanic action, currents, and wave action are all associated with the marine environment.

MATERIALS:
- *Science Grade Four, Silver Burdett,* Unit 10, pg. 200. 1987 Edition.
  Ranger Rick Nature Scope, National Wildlife Federation. 1992. Pages 6, 13, and 56
- Classroom globes
- Shallow boxes (shirt boxes)
- Toilet paper
- Water colors (optional)
- Blue clear wrap (tissue dampened can be used to make land form, no glue needed)

ACTIVITY: Have the students use a globe to make statements about the surface of the Earth. Allow students time to research characteristics of the ocean bottom. Have each student join with a partner to create a model depicting the bottom of the ocean. The



model should include trenches, ocean ridges, abyssal hills, and other related, bottom topography. Have the students label all aspects of their respective models. The students should then develop a scenario of an alteration which takes place on their ocean bottom (i.e. a volcanic eruption, earthquake, deep sea wave, or other similar event). Students should research these occurrences and develop hypotheses of their model.

POSSIBLE EXTENSION:

1. *JASON IV* (1992, pg. 99) 2.3a Activity 1-Sonar Technology
2. *JASON IV* (1992) 2.3f Activity 4-Guaymas Basin Profile
3. Research the *Alvin* submersible

TEACHER EVALUATION:

1. Grade the accuracy of each student group's model.
2. The labeling of all aspects of student groups' models will be evaluated.
3. An explanation will be presented by each student group to the class relative to at least one cause for a change in the ocean floor.

REFERENCES:

DeWall, Marily (Curriculum Director). 1992. *JASON IV Curriculum, Baja California Sur.* National Science Teachers Association. Washington, D.C.

National Wildlife Federation. 1992. *Ranger Rick's Nature Scope.*

Sumich, James L. 1984. *Biology of Marine Life.* 3rd Ed. Dubuque, IA. Wm C. Brown Publishers.

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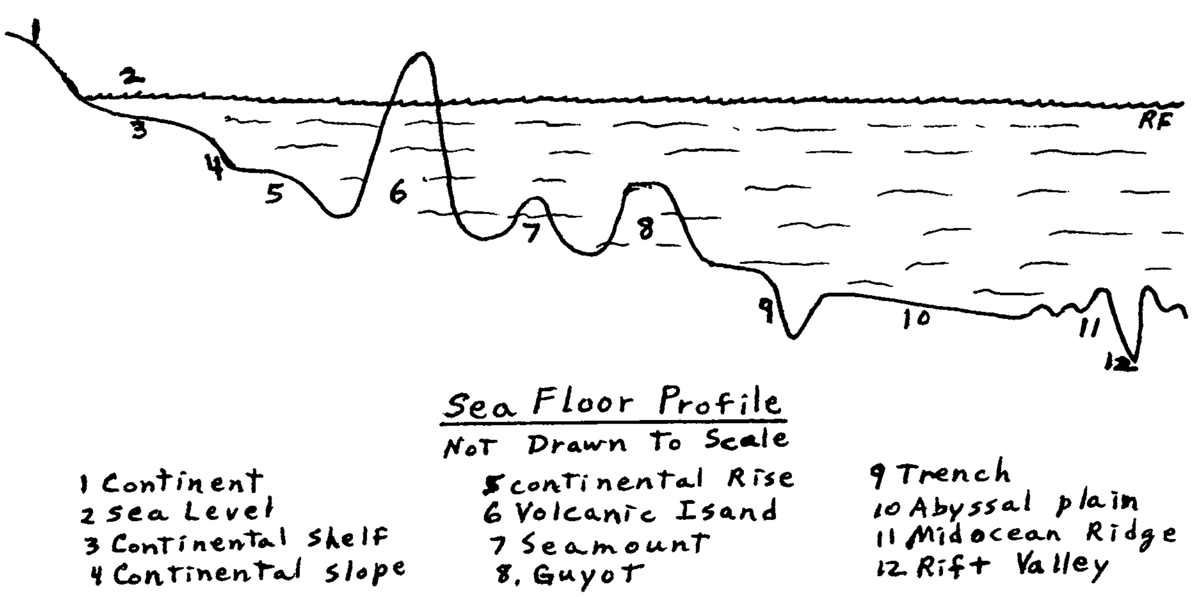


TOPIC-TITLE: Physical Parameters - *The Water Molecule*

AUTHOR: Eileen Gray, Ann Alexander, Tina Darling, and Nelda Sharkey

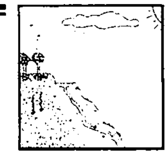
GRADE SUITABILITY: Middle School

SCOPE: Chemical Oceanography

SEQUENCE:
1. Review the previously covered concept of density (the effects and relationships of mass, volume, temperature, and pressure).
2. Introduce water as a molecule that occasionally likes to "bend" these rules and only obeys the rules when you are dealing with differences in pressure.
3. Construct a molecular diagram of a water molecule (containing one atom of oxygen and two atoms of hydrogen). Explain why the molecule is dipolar. The dipolar aspect gives water great dissolving and cleaning powers.
4. Introduce salt and the concept of salinity.

BACKGROUND SUMMARY: Purpose: To demonstrate the various chemical properties of water and how these properties influence the oceans of the Earth. Water is one of the most unusual compounds on Earth. It has a variety of properties not found in any other liquid. A water molecule is formed from two atoms of hydrogen and one atom of oxygen. An oxygen atom has eight protons and eight neutrons in its nucleus and eight electrons surrounding the nucleus. Hydrogen has one proton and no neutrons in its nucleus and one electron surrounding the nucleus. The oxygen atom has more electrons than both hydrogen atoms and, therefore, is more negative than the hydrogen ion. The hydrogen portion of the water molecule is more positive than the oxygen portion. These opposite charges on each portion (side) of the water molecule result in an attraction which forms a weak hydrogen bond between the oxygen atom and each hydrogen atom (Greene, 1998). Because of the two opposite charges of the water molecule, it is known as a dipolar molecule and acts as a magnet. The negative portion attracts positively charged sodium ions while the positive end attracts negatively charged chloride ions. These sodium and chloride ions separate and are surrounded by water molecules, which is why salt is dissolved easily in water (Greene, 1998).

OBJECTIVES: Students will be able to:
1. Recognize how the temperature of water affects density.
2. Define salinity, explain how it is determined, and describe some conditions which cause it to vary.



3. Explain where and how salinity influences the density of oceans.
4. Recognize the manner in which the properties of temperature, density, and salinity interact to create currents.

MATERIALS:

- 500 ml graduated cylinder (one/group)
- Karo® syrup
- Oil
- Candle
- Cotton ball
- Freshwater
- Ice cubes
- Heat lamp
- Journal notebook (one/student)
- Glycerine
- Colored water
- Rock (1/group)
- Cork
- Penny
- Saltwater
- 100 ml beakers (2/group)
- Plastic wine glass

ACTIVITY:

Density Cocktail:

Divide students into cooperative learning groups of three or four. Provide each group with a graduated cylinder and two liters of saltwater (salinity 30-35 ppt). Give each group the following items—glycerine, karo syrup, colored salt water (salinity 40 ppt), oil, a rock, one candle, one cork, one cotton ball, and one penny. Have the students test to see which of these items float and which sink. Students should record observations after each item has been added. The students will need a different volume of saltwater after testing the glycerine, oil, Karo syrup, and colored water. Fill the graduated cylinder with 300 ml of saltwater each time.

Salinity Lab:

Place students into groups of three or four. Provide each group with two beakers. Have each group weigh beaker one and two and record weights. Place 50 ml of freshwater into beaker one. Place 50 ml of saltwater (35 ppt) into beaker two; weigh each beaker again and record weights. Place each beaker under a heat lamp overnight until all the water has evaporated. The following day weigh each beaker and record results. There should be little to no difference in weight for beaker one; determine the weight fraction of salt (salinity) of seawater based on weight differences in beaker two.

Temperature and Density:

Provide each group with a plastic wine glass. Have students place as many ice cubes as possible in a glass full of water until the water level is at the edge of the glass (water looks as if it is about to overflow). Have students hypothesize whether or not the water will overflow if the ice melts completely (note: it should not). Explain that when water freezes, a lattice is formed and the molecules are not as close together as in fluid water; therefore, ice is less dense than water and floats.

POSSIBLE EXTENSION:

1. Create water color paintings. Show designs created by applying different volumes of water and salt to the water color paint to the class.
2. Determine how varying densities (specifically salinity) affect individual cells and entire organisms. Discovery-Method Lab—Experimenting to determine the best salinity to grow brine-shrimp (sea monkey) eggs.
3. Complete a creative writing assignment: "You are a salesman trying to sell water to a planet where the inhabitants have never seen water, but could benefit greatly from it."

TEACHER EVALUATION:

Administer and grade a test on the chemical properties of water.

1. Explain how ice floats.
2. If one swimming pool is filled with freshwater, and another pool is filled with saltwater, in which pool would you be the "better" swimmer? Explain.

Student Performance:

1. Observe student performance in the laboratory setting and review science journals.
2. Observe student responses during class discussions.
3. Test students on concepts.

REFERENCES:

Greene, Thomas F. 1998. *Marine Science.* New York, NY. AMSCO School Publications, Inc.

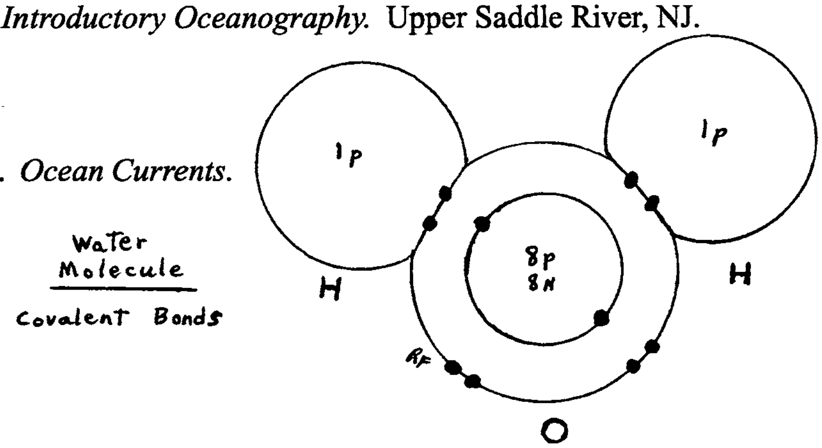
Pickard, G.L. and W. J. Emery. *1995. Descriptive Physical Oceanography,* 4th Ed. Boston, MA. Butterworth Heinermann.

Smithsonian Institution's *Ocean Planet: Souvenir Magazine.* 1995. Washington, D. C.

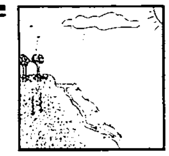
Thurman, Harold V. *1997. Introductory Oceanography.* Upper Saddle River, NJ. Prentice-Hall, Inc.

Video:

Nye, Bill. The Science Guy. *Ocean Currents.*



Physical Parameters



TOPIC-TITLE: Physical Parameters - *Sea Level Rise*

AUTHOR: Michael Duffy, Edward Pasek, Madelyn Charlton, Allen Ross Hobbs, and Rosemarie Buote

GRADE SUITABILITY: Middle School

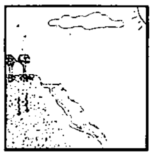
SCOPE: Geology

SEQUENCE: Sea level rise can be presented to students in either 7th grade Life Science or 8th grade Earth Science before or after studies of the greenhouse effect or global warming. Depletion of the ozone layer relative to the greenhouse effect and the periods of glaciation followed by warming trends throughout the Earth's history can be examined.

BACKGROUND SUMMARY: Research has demonstrated a relative rise in sea level in the last century at a number of locations around the globe. This expansion is believed to be the result of the Earth's increased surface temperature due to increased concentrations of carbon dioxide in the atmosphere and other factors. Should temperatures continue to rise, the Antarctic ice sheet would melt and significantly increase the rate of increase in sea level. An accelerated rise in sea level would create problems for low-lying coastal areas. For example, coastal inundation would increase the rate of shoreline erosion, thereby threatening coastal structures and increasing salinity in rivers, bays and aquifers via flooding and the subsequent rise in water tables.

OBJECTIVES: The students will be able to:
1. Interpret visual data and graphs.
2. Present a topic in a debate.

MATERIALS:
- Two large glass beakers
- Two thermometers
- Masking tape
- Waterproof markers
- Aluminum foil
- Goose neck lamp
- Graph paper
- Two meter sticks
- Stop watch
- Two trays of ice cubes
- Water
- Instant Ocean®
- Strainer
- Four cups gravel



Experiment 1. Place one cup gravel and ½ cup of sand in each beaker. Tape a thermometer to the inside of each beaker. Pour salt water (made with Instant Ocean®) into each beaker leaving 10mm of dry rock above the water. Put vertical tape on beakers; mark water levels both inside and outside. Place four ice cubes in each beaker. Place aluminum foil (dull side up) over one container sealing the edges. Place a goose neck lamp over the other and follow with aluminum foil. Seal. Have students develop hypoteses on what they believe will occur to the water level and temperature in the beaker. Record temperatures and water levels every 15 minutes until the ice has melted. Record observations on data sheet. Have students graph data. Analyze data and discuss results in terms of the melting of floating ice masses (Arctic analogies).

Experiment 2. Fill two beakers with salt water (made with Instant Ocean®). In one, add four ice cubes to the water. To the second, place ice cubes in a strainer above the water level. Again, have students develop hypotheses on the results for each experiment. Mark and record the water level on data sheet. When the ice cubes melt, observe how the water level has or has not changed on graph paper. Analyze and discuss in terms of the different impacts of the melting of floating and grounded ice.

POSSIBLE EXTENSION:

1. Research information on rises of sea level throughout Earth's history. Graph these sea level changes.
2. Research and debate the different views on the greenhouse effect and/or global warming.
3. Research the effects of increased salinity in rivers, bays and aquifers. Conduct a salinity test with refractometer or multi-parameter probe.

TEACHER EVALUATION:

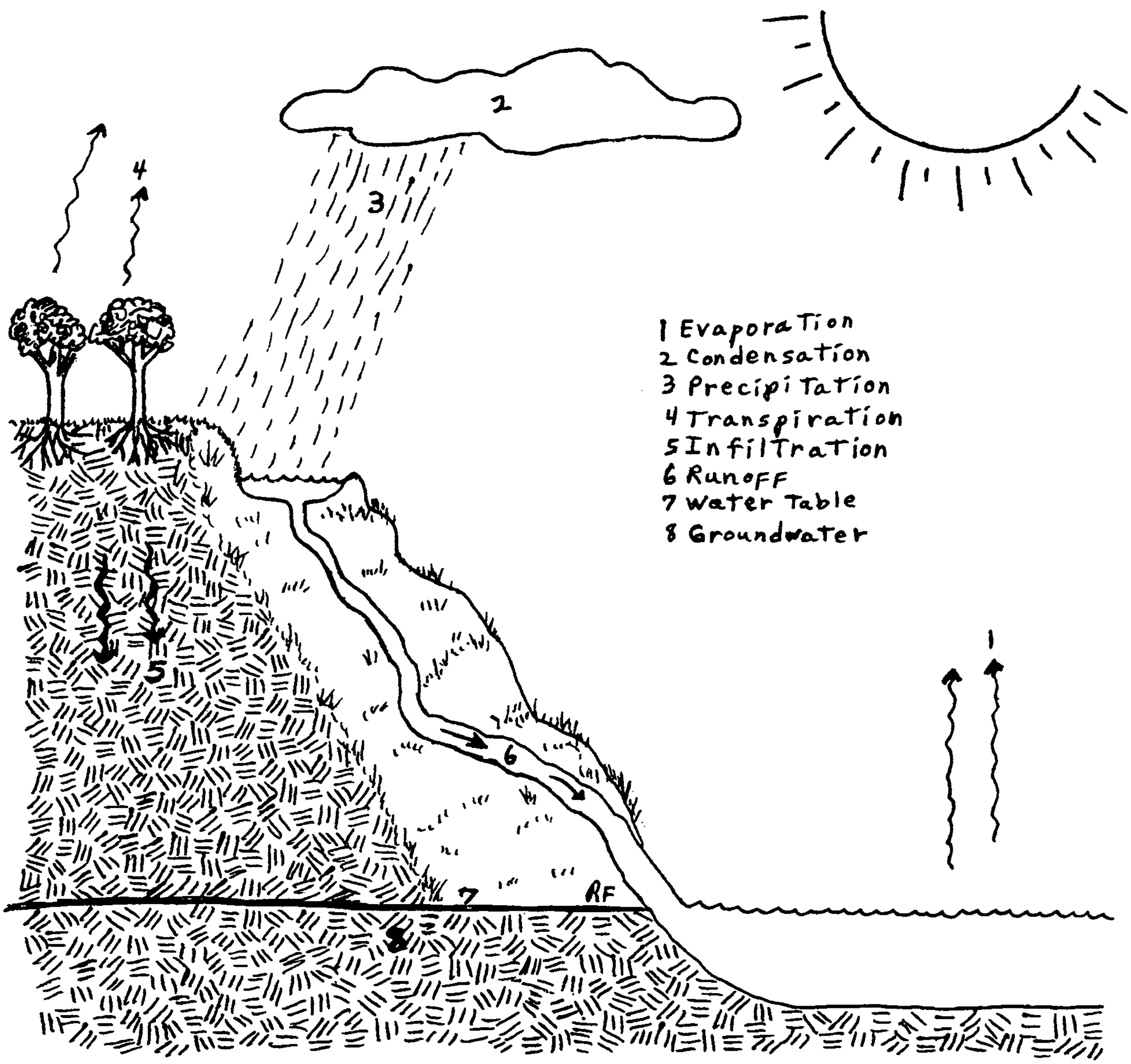
1. Check student's data sheets and graphs for accuracy.
2. Have students write conclusions on experiments.
3. Written assessment (sample questions).
    1. State your view on either the greenhouse effect or global warming; support your view.
    2. Explain why melting of the Arctic ice cap would not affect sea level while melting of the Antarctic ice cap would affect sea level.
    3. Why is the rate or amount of sea level rise not a scientific certainty?

Physical Parameters

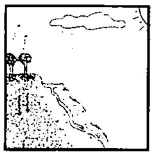
REFERENCES:

Jacobson, Jodi L. "Swept Away," *World Watch.*

Musgrave, Reuben (Curriculum Editor). JASON Foundation for Education. 1994. *JASON Project VI, Hawaii Expedition Curriculum.* Waltham, MA. National Science Teachers Association. Thurman, Harold V. 1991. *Introductory Oceanography.* 6th Ed. New York, NY. Macmillan Publishing Co.



WATER TABLE



TOPIC-TITLE: Physical Parameters - *Nutrients in the Ocean*

AUTHOR: Cynthia Louden, Carolyn Elliott, Karen Jardine, and Kimberly Dernowski

GRADE SUITABILITY: Middle School

SCOPE: Chemical Oceanography and Watershed Management

SEQUENCE: Discuss the following with the students:
1. How do nitrates and phosphates affect water, plants, and animals?
2. How can people help with water management by using environmentally friendly products (phosphate free)?
3. How can people dispose of chemicals properly?
4. How can activities like farming, development, or boating affect watersheds?
5. What is a watershed and how can we map a watershed area?

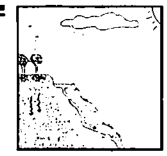
BACKGROUND SUMMARY: Nitrogen and phosphorus are commonly associated with non-point source pollution problems. Excess amounts of nitrogen and phosphorus do not originate from a specific source but enter the ecosystem through a stream or estuary from lawns, fields, human and/or animal wastes, or household cleaners. Excess nitrates and phosphates increase the primary productivity of a water system, leading to the excess growth of algae. As these plants die, the decomposition process uses available dissolved oxygen and creates hypoxic (low dissolved oxygen) conditions.

OBJECTIVES: Students will be able to:
1. Define and explain the functions of a watershed.
2. Determine the effects of NO_3^- and $PO_4^{=}$ on ecosystems.
3. List ten ways to reduce NO_3^- and $PO_4^{=}$.

MATERIALS:
- Beakers
- Saltwater
- Miracle-Gro®
- Graph paper
- Freshwater
- Calgon®
- State or county topographic maps (price varies with state or local agencies)

ACTIVITY: Use a county or state map to trace nearby watersheds. Have students research activities which take place in the area that would affect the watershed and pin-point these locations on the map. Each student can then develop three ways in which these activities can be altered to make them more environmentally friendly.

Physical Parameters



Lab Procedure:
If possible, use natural pond water for the freshwater and estuarine water for the saltwater. If this is not possible, tap water can be used for freshwater and estuarine water can be produced with artificial sea salts. When using this method, you will need to provide a source of algae in the water. Algal sources can be purchased from scientific supply companies. Divide students into cooperative learning groups of three or four. Provide each group with the following:

Control Set-Up:
one beaker with 100 ml freshwater
one beaker with 100 ml saltwater from an estuary

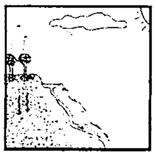
Variables Set-Up:
one beaker with 100 ml freshwater plus one teaspoon Miracle-Gro®
one beaker with 100 ml of 20 ppm salt water plus 1 teaspoon Miracle-Gro®
one beaker with 100 ml freshwater plus one teaspoon Calgon®
one beaker with 100 ml of 20 ppm saltwater plus one teaspoon Calgon®

Note: The control and variable beakers need to receive the same amount of light and be exposed to the same temperatures.

1. Have each group develop a set of hypotheses predicting the results of each beaker.
2. Have one student observe the beakers daily for two weeks and record observations in a laboratory journal.
3. After the two-week period has expired, have each student write a laboratory report presenting observations, results, and conclusions drawn from these experiments.

POSSIBLE EXTENSION:

1. Have students brainstorm ways to reduce NO_3^- and $PO_4^{=}$ wastes.
2. Modify the experiment as outlined in the procedure above to investigate the effect of temperature by using a heat lamp or light on algal growth under nitrate and phosphate-rich conditions.
3. Modify the experiment by varying the amounts of nitrates and phosphates to determine the threshold level needed for these nutrients to impact water systems.
4. Direct students to contact state natural resource officials to determine what actions the state is taking to control excessive nutrient input in rivers. Invite an official to speak to the class.



TEACHER EVALUATION:

1. Students should include in their reports ways in which they can practice environmentally safe procedures at home.
2. The success of the student can be measured by the laboratory reports, journal entries, lists of environmentally safe practices implemented at home, and the mapping of watersheds.

REFERENCES:

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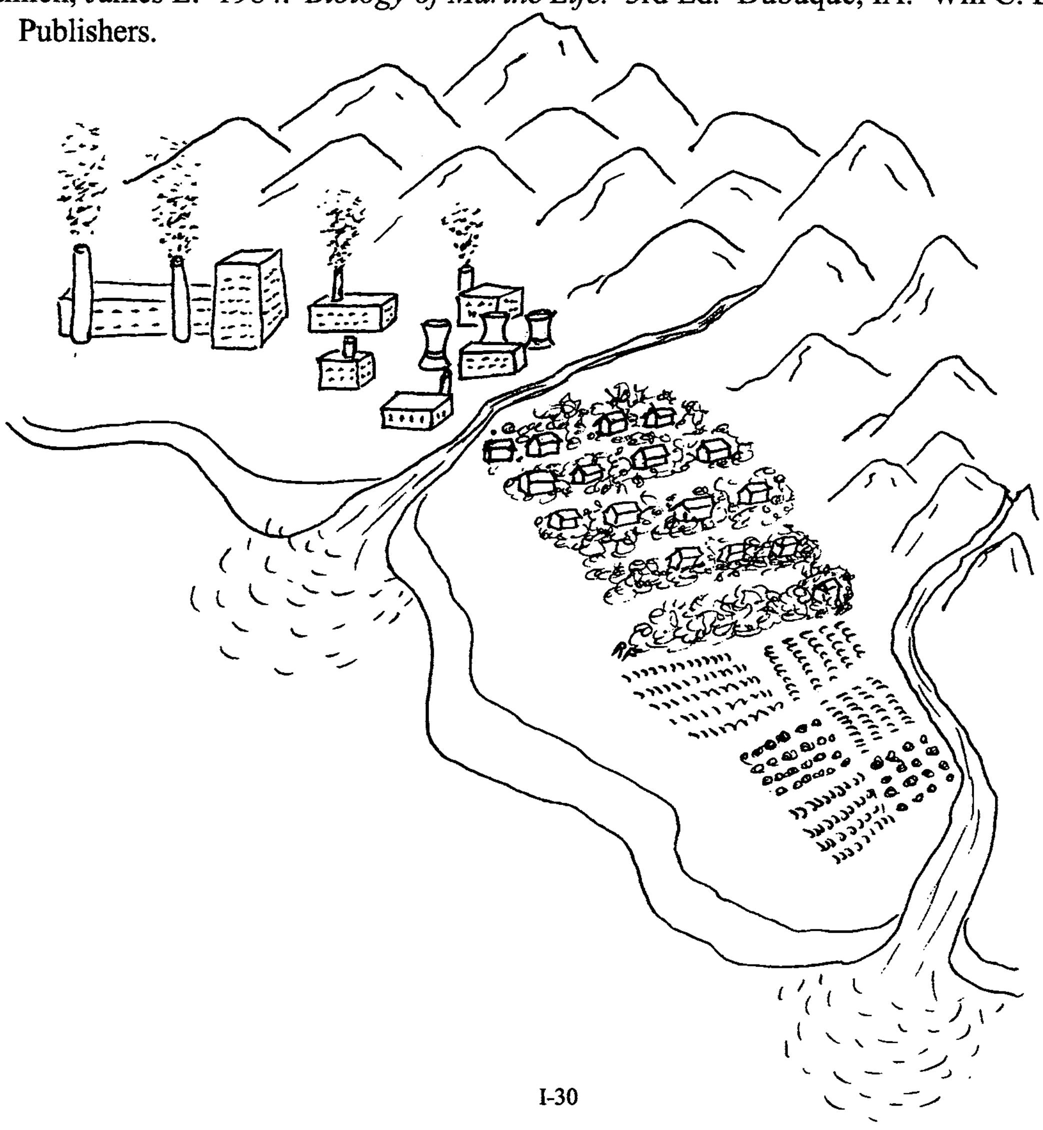


Physical Parameters

TOPIC-TITLE: Physical Parameters - *Tracking Tides*

AUTHOR: Russell C. Read

GRADE SUITABILITY: Middle School

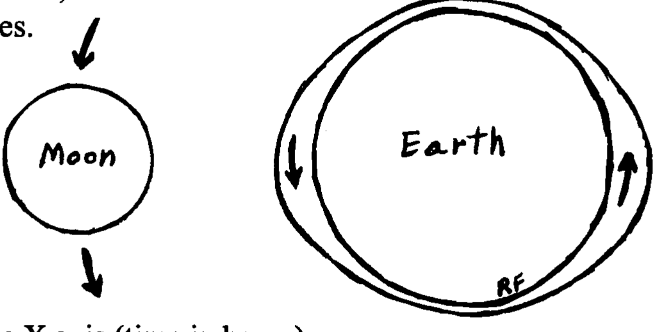
SCOPE: Science

SEQUENCE: This activity would be an excellent precursor to a field trip to a beach environment. Familiarize students with reading and understanding local tides and tide charts.

BACKGROUND SUMMARY: Tides affect most of our coast: marine shipping, fishing industries, commercial development, and marine organisms. As humans, we have had to learn to predict tides so we can better plan for the future.

One source of tidal information is known as a tide table. Tide tables are often published in local newspapers; the United States government also publishes them each year. On the East Coast of the United States, the populace experiences two high tides and two low tides a day. This is known as a semi-diurnal tide. The Gulf Coast experiences only one high and one low tide per day which is called a diurnal tide. The West Coast of the United States experiences two high and two low tides. However, the first set of tides is stronger than the second set; therefore, this tidal pattern is known as mixed tides.

OBJECTIVES: Students will be able to:
1. Plot data on a graph.
2. Understand the terms high and low tides, or +tides and -tides.
3. Describe the general cycle of the tides.



MATERIALS:
- Graph paper
- Pencil
- Local tide chart

ACTIVITY:
1. Label the Y axis (tide height) and the X axis (time in hours).

2. Plot the tide level points on your graph, using the data from the local tide chart for a period of four days.

3. Connect your data points with a smooth, straight line.

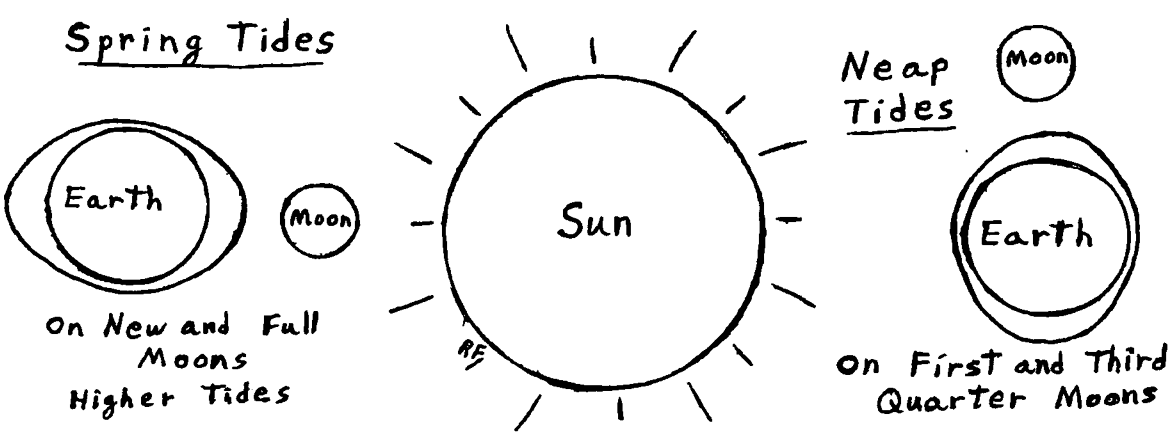
4. Label the high and low tides.

5. Make a prediction on the best time to visit the tidal area.

POSSIBLE EXTENSION:
1. Assign each student to graph a different day of the month. In daily, consecutive order attach all the tide graphs around the wall for a monthly record.
2. Make a scrapbook of news articles on damage from high tides.
3. Report on animals and plants which reproduce using tidal cycles. (There are many examples; a select few including: sea turtles, sand worms, and chitons).
4. Research the cause of the tides.

TEACHER EVALUATION: Teacher should monitor group discussion, read tidal chart and explain positive and negative tides, and ascertain student understanding as documented by journal entries.
1. How do morning and afternoon tides compare?
2. What type of tidal cycle does your graph reveal?
3. What would be the worst time of the month to bring a fully loaded super tanker into port?

REFERENCES:
California State University. 1985. *Exploring the Coastal Environment and Its Resources.* Long Beach, CA. Science and Mathematics Education Institute. School of Natural Sciences. Long Beach, CA.
Green, Thomas F. 1998. *Marine Science.* New York, NY. AMSCO School Publications, Inc.
Gross, M. Grant. 1990. *Oceanography: A View of Earth*, 5th Ed. Englewood Cliffs, NJ. Prentice-Hall, Inc.



Physical Parameters

TOPIC-TITLE: Physical Parameters - *Beach Stratification*

AUTHOR: Karen Moore-Boich

GRADE SUITABILITY: Upper Elementary and Middle School

SCOPE: Science

SEQUENCE: This lesson is designed to establish basic awareness of beach substrate, geologic formations and methods of beach monitoring. Students should be aware of basic geologic formations, tides, and beach substrate. This lesson could be followed by a study of intertidal zones. Data should be collected over time to create a beach history.

BACKGROUND SUMMARY: A single-line transect is a very effective way of studying beach substrate. Transects provide a useful tool to monitor beach activity, health, and geologic formations.

OBJECTIVES: Students will be able to:
1. Hypothesize about beach stratification.
2. Teach how to conduct a beach substrate transect.
3. Record results of the transect.
4. Use results to draw conclusions concerning beach stratification.

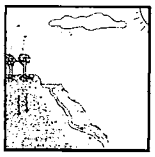
MATERIALS:
- Two 1.5 meter sticks
- Shovels
- Data sheet
- Local tide table
- Watch
- Long tape measure
- Identifiable permanent bench mark
- Graph paper (optional)

ACTIVITY:
1. Have students hypothesize the composition of beach substrate and geologic formations.

2. Practice creating a single-line transect on school grounds.

3. Take a field-trip to the beach and perform a beach transect. Upon arriving at the beach, students should complete a coastal geology data sheet.

4. Have students establish their benchmark (this must be a permanent reference point). Mark the transect line vertically to the shoreline. Using the two-stick method, have



students complete a beach profile.

5. Begin the substrate transect. Students will use the benchmark as a reference point to record location of substrate dig. Students should record water levels, layers of substrate, evidence of plant or animal material, depth at which layers change, and soil type. (Students should refer to *Key to Soil Texture by Feel* to aid in identification.)

6. Students will then compile results and add them to their beach profiles.

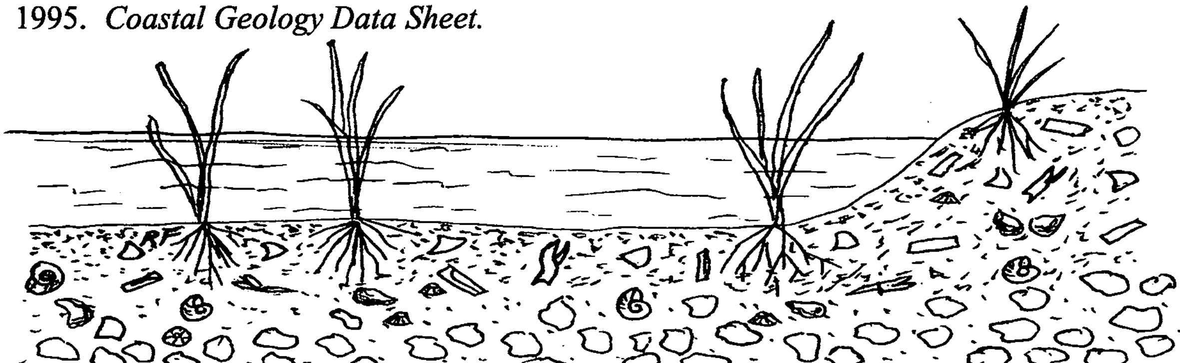
7. Students should create a beach transect log which includes data from the beach profile, substrate transect, and geology data sheet for long-term beach monitoring.

8. Students will develop a conclusion based on the data gathered in large group discussions. They should hypothesize changes which may occur over time.

POSSIBLE EXTENSION:
1. Continue to monitor the same transect line over time to create a beach history.
2. Perform a biological transect by using the same transect line.
3. Correspond with organizations and individuals concerning beach health.

TEACHER EVALUATION:
1. Successful completion of the beach substrate transect will serve as the assessment.
2. Do students exhibit an understanding of the activity?
3. Can students form conclusions about beach stratification based on their data?

REFERENCES:
Johannessen, Jim. 1995. *Beach Profiling Using the Two-Stick Method.*
Ocean Related Curriculum Activities, Pacific Science Center, Washington Sea Grant College Program. 1988. *Beach Profiles and Transects.* Seattle, WA.
Slattery, Britt E. 1995. "Key to Soil Texture by Feel." *Wow! The Wonders of Wetlands.* Environmental Concern, Inc. and The Watercourse.
1995. *Coastal Geology Data Sheet.*



Physical Parameters

TOPIC-TITLE: Physical Parameters - *Currents—Their Causes and Effects*

AUTHOR: George Linzee

GRADE SUITABILITY: Middle School

SCOPE: Earth Science

SEQUENCE: This activity should follow a unit on global air circulation.

BACKGROUND SUMMARY: A current is defined as a large mass of continuously moving oceanic water (Greene, 1998). Surface ocean currents are mainly wind-driven and occur in all of the worlds oceans. Examples of large surface currents which move across vast expanses of ocean are the Gulf Stream, the North Atlantic Current, the California Current, the Atlantic South Equatiorial Current, and the Westwind Drift. Associated with surface currents are counter-surface and underlying currents. Surface ocean currents are deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere due to the Coriolis effect. The Coriolis effect holds that because the Earth is spinning, surface waters move in a clockwise direction in the Northern Hemisphere and in a counterclockwise direction in the Southern Hemisphere. The currents eventually come into contact with the continents which deflect them, creating giant oceanic current circles known as gyres.

Vertical and ocean bottom currents are mainly driven by density differences caused by changes in temperature and salinity. Originating in polar regions, cold, salty waters sink to the ocean bottom and move toward the opposite poles where they again surface. Vertical upwelling currents can also be caused by winds "blowing off" a coastline. The displaced waters are then replaced by underlying bottom waters. Currents are important to marine life as they help to move food and nutrients, making them available for consumption, metabolic requirements, and/or photosynthesis.

OBJECTIVES: Students will be able to:
1. Define ocean currents and understand overall surface circulation.
2. Show the relationship between global air circulation and oceanic currents.
3. Explain how certain coastal and divergent wind patterns can cause up-welling.
4. Demonstrate thermohaline and evaporation density currents and explain their importance to bottom water currents.

MATERIALS:

- Rectangular Pyrex® baking dish
- Small fans or hair dryers which can dispense cool air
- Blue, yellow, and red food coloring
- Wind map

ACTIVITY:

1. Introduction: Open class discussion with the question, "Why do the oceans move?" Make sure the class knows that you are not referring to waves, but actual, massive "rivers" of water moving in definite directions. Give some examples of currents. Discuss the effects of winds on currents.

2. Wind on Water Demo: Set up the Pyrex® dish with water, add red and blue food coloring to opposite ends of the dish and start blowing both hair dryers in opposite directions on opposing sides of the tray. After a gyre has appeared, start this process again. Use new water and dye; this time blow the fans in the same direction on opposing sides and watch as two currents and a counter current occur.

3. Map Exercises: On a world map, have the students draw the prevailing wind currents with black, thin arrows and the related ocean currents with thick, blue or red arrows, depending on the temperature. Have students label the major currents and discuss the Coriolis effect and its effect in causing currents to bend somewhat from the wind currents. As the students work, stress continents have a more dramatic effect on ocean currents than on air currents, causing the five ocean gyres. Also, indicate the different characteristics of eastern and western boundary currents, the Ekman spiral, and geostrophic currents.

4. Homework Question: How can winds create a vertical up-welling current? Give an example of where it happens and how it affects marine life.

5. Homework Answer: Ekman transport is formed when a northern wind parallels a western coast in the northern hemisphere (California) or a southern wind parallels a western coast in the southern hemisphere (Peru). Winds blowing parallel to the coast cause movement of surface water away from the coast and lift bottom water toward the surface. This is known as up-welling. Up-welling brings ample nutrients to the surface which support a wide variety of marine life.

6. Density Current Demo: Perform the density current demonstration on page I-40.

7. Demo follow-up: Perform the thermohaline circulation demonstration on page I-40.

8. Evaporation Density Currents: The Mediterranean is a good example of currents in which evaporation is rapid and causes the more dense saltier water to sink, thereby driving bottom water from the Mediterranean and drawing surface waters from the Atlantic.

9. Homework Problem: If a bottom current were moving around the world at 0.5 miles per hour, calculate an estimate as to how long it would take to complete the trip. Refer to a world map for the distance and remember distance equals rate divided by time.

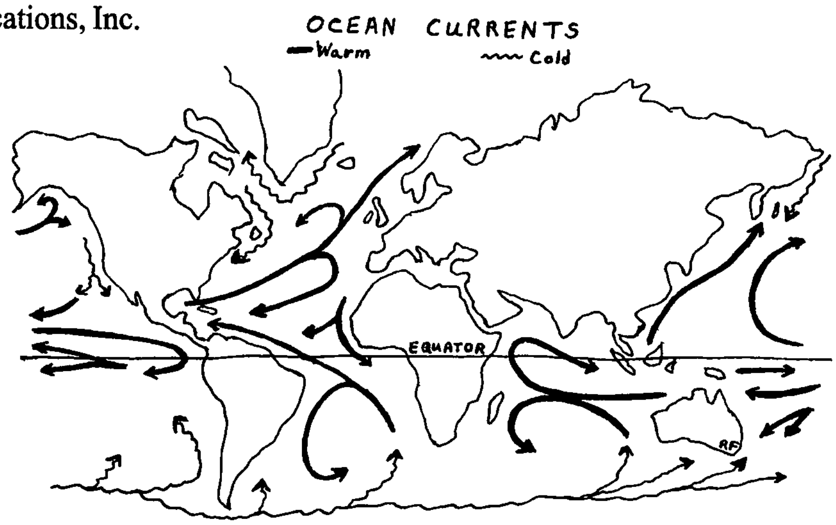
POSSIBLE EXTENSION: Research interesting facts behind the Atlantic Gyre and other ocean currents including information on explorers, submarine incidents, and yacht races which relied on that current.

TEACHER EVALUATION:
1. Each student map and homework would be evaluated.
2. Questions:
   - In the Northern Hemisphere, do the ocean current gyres go clockwise or counterclock wise? Why?
   - How are the processes of both freezing and evaporation similar in the way they both make sea water more dense?
   - Why is the coast off Peru one of the most productive fishing areas in the world?

REFERENCES:

Garrison, Tom. 1995. *Essentials of Oceanography.* Belmont, CA. Wadsworth Publishing Company.

Greene, Thomas F. 1998. *Marine Science.* New York, NY, AMSCO School Publications, Inc.



TOPIC-TITLE: Physical Parameters - *Moving Water—Ocean Currents and Winds*

AUTHOR: Eileen Gray, Ann Alexander, Tina Darling, and Nelda Sharkey

GRADE SUITABILITY: Middle School

SCOPE: Physical Science

SEQUENCE: Introduce the various types of currents and their locations. Describe how these currents affect our daily lives and how these currents are affected by changes in winds, climate, and other related abiotic factors.

BACKGROUND SUMMARY: An ocean current can be defined as any continuous flow of water along a definite path in the ocean. The flow may occur at the surface or far below it. The flow may be vertical or parallel to the surface. The circulation of these water masses in motion can be categorized as either wind driven or thermohaline. Thermohaline currents have a significant vertical component and account for the thorough mixing of the deep masses of ocean water. Wind driven circulation is set into motion by moving air masses with the motion being confined primarily to horizontal movement in the upper waters of the oceans. Currents carry enormous amounts of warm water away from the equator and currents return equal amounts of cold water. Current flow can affect temperatures, biotic systems, and climate.

OBJECTIVES: Students will be able to:
1. Define ocean currents; describe the general pattern of wind-driven and thermohaline currents; and describe the effects of these currents.
2. Discuss the relationship between winds and ocean currents.
3. Locate and describe major ocean currents, their features, and their effects on climate.

MATERIALS:
- Freshwater
- Salt
- Ice
- Fifteen gallon (or larger) fish tank
- Food coloring
- Large heat lamp or two hot plates
- Soup plates (four to six depending on group numbers)
- Two-liter soda bottles (two/group)
- Tygon® tubing
- Silicon sealant

- Blow dryer
- Journal notebook (one per student)

ACTIVITY:

Density Current:
Divide students into cooperative learning groups of five or six. Provide each group with a soup plate with a wide, flat rim. Have each group fill the soup plate with water until the rim is covered. The soup plate will simulate the depths of the ocean while the rim of the plate will simulate the continental shelf. Have one student in each group squirt a few drops of ink (tip: mix solution of salt and ink for increased density) into the water at the very edge of the plate. The ink will form a current which slowly moves over the edge of the rim down the side to the bottom. Ask students whether this kind of movement would be considered a current and why. Lead a discussion relative to the definition of an ocean current. Have students record results in a journal.

Convection Current:
Each group will need two, empty two-liter soda bottles with the tops cut away. Have one student in each group cut two holes into both of the bottles so each bottle has a hole two inches from the bottom and six inches from the bottom. A six inch piece of Tygon® tubing should be siliconed into the holes so the bottom holes of each bottle are connected. The top holes should also be connected by Tygon® tubing. Note: Be sure the tubing is level. Clamp both tubes in the middle. Fill one bottle with cold water dyed blue. Fill the other bottle with hot water dyed red. Remove the clamps. Ask students whether this kind of movement would be considered a current and why. Have students record results and observations in a journal.

Thermohaline Current:
Have students fill a 15-gallon or larger aquarium with freshwater. Prepare large ice blocks made from water dyed blue. Place an ice block in one corner of the tank. Place a rock on top of the block to hold it on the bottom. Place a heat lamp over the opposite side of the tank and turn it on. Prepare 200 ml of a mixed solution of water, concentrated salt, and red food coloring. Pour the saltwater mixture into the tank on the side with the ice. Explain what happens and record observations in the journal.

Wind Driven Current:
Conduct experiment number one again. This time turn on a blow dryer in a "low-cool" setting. Observe the ink now flowing in a horizontal pattern and record results in the journal.

POSSIBLE EXTENSION:

1. LUCKY DUCKS—In January 1992, a Pacific storm caused a box of 29,000 toy ducks to tumble from a container ship and start "bobbing" their way around the Pacific. Oceanographers, Curtis Ebbesmeyer and Jim Ingraham, have tracked the landings of these ducks and charted ocean current routes in order to predict the routes oil will follow in the event of a spill. Write an essay on why this is a "bad situation turned good."
2. Place a few drops of water-color paint on a paper; drop fresh water on the paint using an eyedropper. Blow gently (or use a blow dryer) and create colorful swirl designs.
3. History Discussion—What happened to Columbus? In your journal, write where he wanted to go; what route he attempted; and what currents took him off course.

TEACHER EVALUATION:

1. Have students illustrate the four current types they created.
2. Observe student performance in laboratory exercises and notes made in science journals. Observe student responses during class discussions. Test students on the concepts.
3. Illustrate and label three types of currents.
4. If the Earth were to spin in the opposite direction, diagram or explain what would happen to the Gulf Stream, the Equatorials, and the Canary Currents.

REFERENCES:

Namowitz, Samuel N. and Nancy E. Spaulding. *Earth Science.*

Smithsonian Institution's *Ocean Planet.*

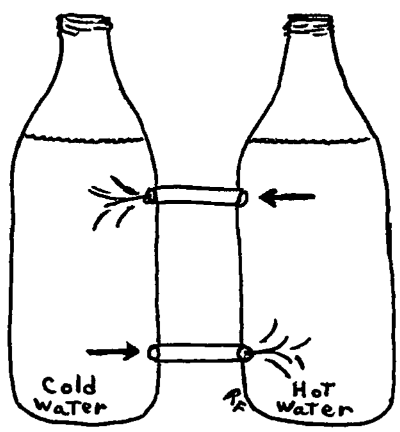
Thurman, Harold V. 1991. *Introductory Oceanography.* 6th Ed. Macmillian Publishing Co. New York, NY.

The National Oceanic and Atmospheric Administration. 1993. *Reports to the Nation.* "El Niño and Climate Prediction." Boulder, Colorado. UCAR office of Intersisciplinary Studio.

Video:

Bill Nye. The Science Guy. *Ocean Currents.*

Finite Ocean



Physical Parameters

TOPIC-TITLE: Physical Parameters - *Where In the World Are We?*

AUTHOR: Anne C. Switzer

GRADE SUITABILITY: Middle School

SCOPE: Physical Science

SEQUENCE: Students should have a basic understanding of what the term latitude and longitude mean before commencing this activity.

BACKGROUND SUMMARY: Latitude and Longitude: These terms refer to a system which has been devised to help locate places on the Earth. Latitude is the angular distance north or south of the Earth's equator (measured in degrees, minutes and seconds), of an arc formed from the center point of the Earth. Lines on a globe or map connecting points of equal latitude are called parallels or lines of latitude. When represented on a globe, they appear as parallel, east-west circles around the Earth. The equator is at zero degrees latitude and the poles are at 90 degrees north and south latitudes.

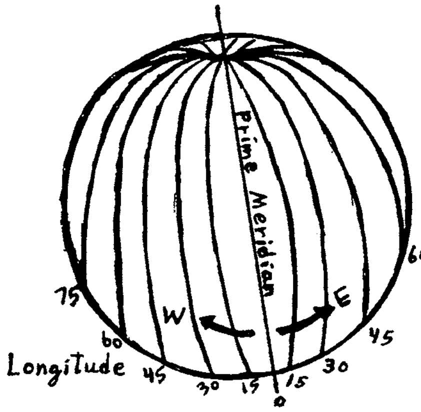
Longitude is the angular east-west distance, measured from the center point of the Earth, referenced to zero longitude, also called the Prime Meridian. Lines of equal longitude form circles that go around the Earth in a north-south direction, all passing through and intersecting at the poles. The Prime Meridian passes through the poles and through Greenwich, England. The longitude of all other locations is measured as being either east or west of this line.

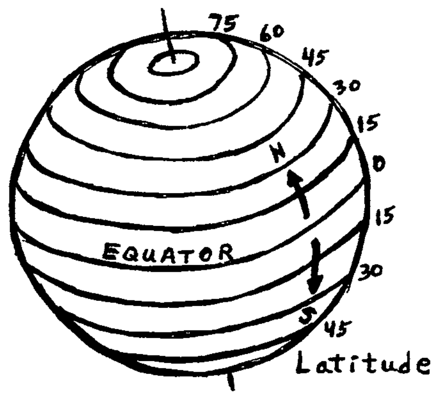
Any place on the Earth can be located exactly by stating an intersection of a latitude line and a longitude line. However, many places do not fall exactly on one of the main lines of latitude and longitude, so degrees have to be divided into smaller units. Any complete circle (line of latitude or longitude in this case) has 360 degrees. Each degree can be broken into 60 smaller units called minutes. Each minute is made of 60 seconds.

Latitude can also be used to determine the distance between points on a map or a chart. On the Earth's surface, one degree of latitude is equal to 111 km (60 nautical miles). Longitude is more difficult because the lines intersect, so one degree of longitude is equal to 111 km of distance at the equator only. The distance between lines of longitude decreases to 0 km at the north and south poles.

Some people say maps, and other people say charts. Who is correct? It's actually possible they both are. A map gives detailed information about areas which are mostly land-covered. Charts, however, give detailed information about areas which are mostly covered with water. When you hike in the mountains or drive across the country, maps are most useful. If you are going fishing in the Gulf of Mexico, a chart would be more suitable.

The following picture shows lines of latitude and longitude on the surface of the Earth. Make sure you understand this picture before moving on to the next part.





Parallels of latitude (horizontal circles around the globe parallel to the equator) and meridian of longitude (vertical circles passing through the poles).

OBJECTIVE: In cooperative learning groups of four students, each group will be able to plot latitude and longitude data on a map or chart.

MATERIALS:

- World map
- Globe
- Data table

ACTIVITY:

1. Listed below are three latitude and longitude intersections which student groups can find on the given map of the eastern United States. Locate them and write the name of each area/city (as close as possible).

Latitude	Longitude	Place Name
42° N	70° N	
44° N	77° N	
24° N	82° N	

2. Listed below are some location to find on this map. Locate each one and then write the latitude and longitude intersection which best describes it.

Place Name	Latitude	Longitude
Center of Lake Huron		
Mouth of Cheseapeake Bay		
Intersection of GA, TN, AL		

POSSIBLE EXTENSION:

1. Have student groups repeat the activities using different locations.
2. Request student groups prepare a similar activity and exchange this activity with another group.

TEACHER EVALUATION:

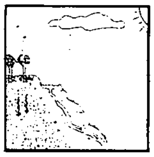
1. Observations in cooperative learning groups of performance by students.
2. Journal notes and class discussions of latitude and longitude.

REFERENCES:

Charton, Barbara, E.H. Immergent, and J.H. Tietjen. 1990. *Dictionary of Marine Science.* Published by Facts on File.

Jones, Norris W. 1998. *Laboratory Manual for Physical Geology*, Chapter 6, Topographic Maps. WCB/McGraw-Hill.

Thurman, Harold V. 1991. *Introductory Oceanography.* 6th Ed. New York, NY. Macmillan Publishing Co.



TOPIC-TITLE: Physical Parameters - *The Race is On!*

AUTHOR: Anne C. Switzer

GRADE SUITABILITY: Middle School

SCOPE: Physical Science

SEQUENCE: Before beginning this activity, a discussion of speed and the various units used to measure speed should take place.

BACKGROUND SUMMARY: The general formula to calculate speed when the distance traveled by something and the time it took to do so is known is represented by the following equation.

$$\text{Speed}=\frac{\text{Distance}}{\text{Time}}$$

Speed can be measured in many different units, according to the measurements used for distance and time. For example, when looking at a train, it might make sense to measure speed in meters per second. When looking at a snail, it might be better to measure in centimeters per hour. Both are appropriate units to measure speed.

OBJECTIVES: In cooperative learning groups of four students, each group will be able to:

1. Understand the methods used to track currents.
2. Calculate the speed of various objects.

MATERIALS:

- Rulers
- Pencils
- Data tables

ACTIVITY:

1. Groups should complete the following table by calculating the speeds of the following objects. Remember to use the appropriate units for each one.

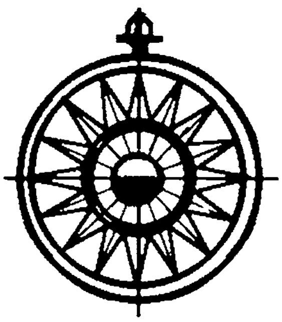
OBJECT	DISTANCE	TIME	SPEED
Airplane	700 km	2 hours	
Snail	125 cm	1.5 hours	
Cheetah	24 km	15 minutes	
Orca Whale	24 km	30 minutes	

2. Draw an arrow to represent the speed of the cheetah and the orca whale. The length of the arrow will be proportional to the speed you calculated above. For a scale use 1 cm = 10 kilometers per hour (6.2 mph).

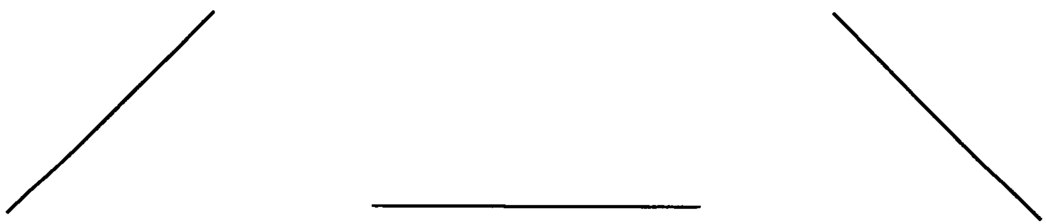
Cheetah	
Orca Whale	

3. Speed is useful when an object is in motion. However, if you also look at the direction of that motion, you will have much more information. In fact, when you have a quantity which is best described by a number and a direction, it is given the special title of a vector quantity. In the case of speed and direction, this vector is called velocity.

   For this exercise use the diagram below (it is called a compass rose) to determine the direction of south, east, and west on your page. If an arrow points in between two of these main directions, then it is called a combination of the two; for example southeast would be between south and east.



For each of the following arrows, cooperative learning groups should write what direction it is pointing.



a. b. c.

4. Each group should draw arrows above each of the following to represent the named direction. The arrows only need to be a approximately two to four of centimeters long.

a. west b. southeast c. northwest

5. For each of the arrows below, each group should measure its length and use a scale of 1 cm = 10 kilometers per hour to determine the speed each one represents. Also, for each arrow name the direction it is pointing. A sample answer would be: 15 kilometers per hour (km/h), northwest.

a. b. c.

6. Reverse this process and draw arrows which represent the given speed and direction.

a. 20 km/h, south b. 30 km/h, southwest

POSSIBLE EXTENSION:

1. Repeat this exercise with students developing various scenarios.
2. Request that each group prepare a similar activity and exchange activity with another group.

TEACHER EVALUATION:

1. Observations of activities conducted by each cooperative learning group.
2. Administer similar mathematical activities to each student for individual grades.

REFERENCES:

Charton, Barbara, E.H. Immergent, and J.H. Tietjen. 1990. *Dictionary of Marine Science.* Published by Facts on File.

Jones, Norris W. 1998. *Laboratory Manual for Physical Geology*, Chapter 6, Topographic Maps. WCB/McGraw-Hill.

Thurman, Harold V. 1991. *Introductory Oceanography.* 6th Ed. New York, NY. Macmillan Publishing Co.

Physical Parameters

TOPIC-TITLE: Physical Parameters - *Track a Drifter*

AUTHOR: Anne C. Switzer

GRADE SUITABILITY: Middle School

SCOPE: Physical Science

SEQUENCE: Prior to plotting drifter positions it is crucial to understand the concepts of latitude and longitude. The activity (*Where In The World Are We?*) is designed to help students plot points on a chart, using latitude and longitude. A complementary activity (*The Race Is On!*) provides guidance for calculating the speed and direction of an object in motion. This activity combines both *Where In The World Are We?* and *The Race Is On!* and allows students to plot actual data from an ocean drifter, calculate its speed and direction of flow, and examine how drifter data are useful. Also, other data which are collected by ocean drifters will be discussed.

BACKGROUND SUMMARY: Ocean drifters are floating in currents throughout the global ocean. In order to make use of the information provided by the drifters, scientists (i.e. oceanographers) must be able to track the where they are and where they have been. You too can track drifters, calculate their velocity, and predict where they may go in the future. By plotting a position reported via satellite technology, you can track a drifter as it is being transported by an ocean current.

Although scientists have been using drifters to track ocean currents since the *Challenger* Expedition in 1872, we are still continually surprised by the paths they follow. Other instruments used to track ocean drifters provide information regarding the temperatures of the surface waters and how temperatures vary from one location to the next. This is important because currents transport heat as well as water. Using drifter tracks, one might be able to predict where floating marine organisms travel, or how pollutants in the sea spread, or even help to forecast climate and weather changes affecting nearby land masses.

OBJECTIVES: Students will be able to:

1. Relate currents to the transport of heat and floating materials.
2. Predict the direction and speed of drifters as they flow in real time with ocean currents from web data.

MATERIALS:

- Data table
- Chart
- World maps

VOCABULARY:

- *Current:* a continuous movement of a fluid, such as water or air.
- *Drift:* to become driven or carried along by a current
- *Plot:* to locate and mark a point by means of coordinates
- *Latitude:* location on Earth's surface based on angular distance north or south of the equator.
- *Longitude:* location on Earth's surface based on angular distance east or west of the Prime Meridian.
- *Speed:* the time rate of change of position.
- *Direction:* the line or course on which something is moving or is aimed.
- *Velocity*: a vector quantity describing speed and direction of an object.
- *Nautical Mile:* length of a minute of arc on the Earth's equator, equivalent to 1,852 meters.

ACTIVITY:

1. Example data from two ocean drifters are provided. Divide students into several groups and have them plot drifter positions; these drifter data may be obtained from the following Year of the Ocean (YOTO) website: drifters.doe.gov. Plot a point for each drifter position and write in the date next to the point.

2. Once each group has completed this task, have students connect the points. There connected points represent the drifter track. For each drifter, calculate the speed of travel between each successive position interval, also recording the direction in which it moved.

3. When analyzing drifter data and ocean currents, it is very important to understand the concept of averaging. Due to the amount of data being produced by these drifters, it is sometimes convenient to only look at (and do calculations from) the data in certain increments rather than ALL of them. For example, if every-other data point is used, the amount of work to be completed is reduced by one-half; however, the result is not as exact. If the speed of a drifter is calculated using data for every other day, it is called a two-day average. Because water movement in the ocean is not necessarily a steady process (having constant speed or direction), the length of time averaging is used can produce very different results.

Physical Parameters

Table One: DATA from 1996 Drifters

Drifter		Date	Latitude	Longitude
Sample	1	3/3/96	11°45'66"	-62°05'46"
	2	3/9/96	12°54'6"	-63°30'6"
	3	3/12/96	13°13'2"	-64°13'8"
	4	3/15/96	13°38'4"	-64°25'2"
	5	3/18/96	13°27'	-64°36'6"
	6	3/21/96	13°39'	-64°20'4"
	7	3/24/96	13°38'4"	-64°36'6"
	8	3/27/96	13°20'4"	-64°31'2"
	9	3/30/96	13°08'4"	-64°27'6"
	10	4/2/96	13°00'6"	-64°15'6"
	11	4/5/96	13°11'4"	-64°13'2"
	12	4/8/96	13°34'8"	-64°12'
	13	4/11/96	13°48'6"	-64°09'
	14	4/14/96	13°48'6"	-63°06'6"
	15	4/17/96	13°36'6"	-64°10'2"
	16	4/20/96	13°22'8"	-64°20'4"
	17	4/23/96	12°58'8"	-64°57'
	18	4/26/96	13°40'2"	-66°16'2"
	19	4/29/96	14°10'8"	-66°26'4"
	20	5/2/96	13°46'2"	-66°17'4"

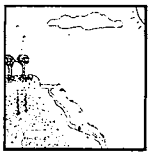
Worksheet 1A: Drifter #1 Data (Table One)
Individual Plot Analysis

Position Interval	Time Interval	Speed	Direction
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Physical Parameters

Table Two: DATA from 1996 Drifters

Drifter		Date	Latitude	Longitude
Sample	1	9/28/96	23°44'46"	-85°10'62"
	2	10/1/96	24°31'92"	-80°48'3"
	3	10/4/96	28°12'24"	-80°00'12"
	4	10/75/96	30°20'7"	-80°02'04"
	5	10/11/96	30°51'6"	-79°49'68"
	6	10/14/96	32°18'78"	-77°55'86"
	7	10/17/96	32°23'1"	-78°01'56"
	8	10/20/96	33°01'32"	-77°06'84"
	9	10/23/96	33°18'48"	-77°03'06"
	10	10/26/96	35°17'94"	-74°53'28"
	11	10/29/96	37°54'36"	-69°54'12"
	12	11/1/96	37°00'18"	-67°27'42"
	13	11/4/96	36°46'08"	-67°39'96"
	14	11/7/96	35°13'02"	-66°39'06"
	15	11/10/96	34°41'88"	-66°30'24"
	16	11/13/96	34°27'3"	-66°35'88"
	17	11/14/96	34°22'86"	-67°09'9"
	18	11/17/96	33°48'6"	-66°10'74"
	19	11/20/96	33°20'34"	-66°54'
	20	11/23/96	34°02'1"	-67°07'2"



Worksheet 2A: Drifter #2 Data (Table two)
Individual Plot Analysis

Position Interval	Time Interval	Speed	Direction
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Physical Parameters

Worksheet 1B: Drifter #1 Data (Table One)

Position Interval	Time Interval	Speed	Direction
1-3			
4-6			
7-9			
10-13			
13-15			
16-18			
19-20			

Worksheet 1C: Drifter #1 Data (Table One)

Position Interval	Time Interval	Speed	Direction
1-5			
6-10			
11-15			
16-20			

Worksheet 2B: Drifter #2 Data (Table Two)

Position Interval	Time Interval	Speed	Direction
1-3			
4-6			
7-9			
10-13			
13-15			
16-18			
19-20			

Worksheet 2C: Drifter #2 Data (Table Two)

Position Interval	Time Interval	Speed	Direction
1-5			
6-10			
11-15			
16-20			

ANALYSIS:

1. What do your group results tell you about the currents in which these two drifters were moving?
2. Did the number of days used to calculate the speed and direction impact your results?
3. Predict where each drifter will be three days after the last known data point.
4. Give one example of why it is important to understand how ocean currents flow.

POSSIBLE EXTENSIONS:

1. Determine what might make the current (i.e. the buoy) speed up or slow down?
2. Determine what might make the current (i.e. the buoy) change direction?
3. Do you think the buoys always provide a completely accurate picture of what the current is doing? Why or why not?
4. Go back to your chart and write down the temperature next to each point. Do you see any changes in temperature as the drifter follows this track? Explain.

REFERENCES:

Charton, Barbara, E.H. Immergent, and J.H. Tietjen. 1990. *Dictionary of Marine Science*. Published by Facts on File.

Jones, Norris W. 1998. *Laboratory Manual for Physical Geology*, Chapter 6, Topographic Maps. WCB/McGraw-Hill.

Thurman, Harold V. 1991. *Introductory Oceanography*, 6th Ed. New York, NY. Macmillan Publishing Co.

Physical Parameters

TOPIC-TITLE: Physical Parameters - *Build Your Own Drifter*

AUTHOR: Anne C. Switzer

GRADE SUITABILITY: Middle School

SCOPE: Physical Science

SEQUENCE: Students should participate in a drifter discussion, identification of the specific parts of a drifter and how drifters are used prior to this activity. This activity will help students become familiar with the devices called ocean drifters. Students will be given the opportunity to consider many of the variables which scientists and engineers have encountered in designing the most appropriate drifters for the specified data needs.

BACKGROUND SUMMARY: During 1998, Year of The Ocean (YOTO), a mass deployment of drifters will take place. The drifters are designed to move with surface ocean currents. The data which will be collected and transmitted via satellite will be available for use by oceanographers, other scientists, and educators to learn more about the way in which the ocean/atmosphere system works. One expectation is that we will better understand some of the global changes which are underway in our global weather and climate—El Niño being one example.

There are many currents on the surface of the ocean as well as currents below the surface. These currents are affected by the land masses of the Earth, the sinking of water masses at the poles, and by the atmospheric changes around the Earth. The currents at the surface also have a great effect on weather patterns around the globe, on the ecology of the ocean water, as well as the ecology of nearby land masses.

Questions we often ask include: How can we gain useful information about these currents? What information do we need to be able to obtain? What is a device which we can build to help us in obtaining this information?

OBJECTIVES: In cooperative learning groups, students will be able to design and build a model drifter.

MATERIALS:

- Activity pages (included)
- Drawing paper
- Pens
- Markers
- Rulers
- Stop watch
- Measuring tape
- Milk-jugs
- Frisbees

VOCABULARY:

- *Data*: facts or measurements obtained by observation or instrument in a research situation and used to make inferences.
- *Drift*: to become driven or carried along by a current.
- *Criteria*: standards on which a decision, judgement, or design may be based.
- *Model*: a representation or simulated version of a working instrument.
- *Current*: the continuous movement of a fluid, such as water or air.
- *Transmit*: to send; to cause to be conveyed through a medium.

ACTIVITY:

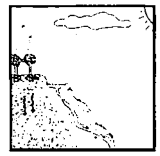
1. Review tracking activity and results. Write one or two special features of the drifters andwhat purpose they serve.

2. Design: Work in small groups for approximately fifteen minutes to discuss the given design aspects or criteria of a drifter and what materials might be useful to build a drifter. Each group should draw a picture of a drifter students think would work well.
   a. Buoyancy/Floatability. Should it float on the surface, midway, or under the surface?
   b. Position Locator. How would it work? Does it need any antennae? Why?
   c. Size. How large should the drifter be? Discuss issues of size and weight.
   d. Construction Materials. What would be best materials for building a drifter? Consider rusting and pounding from waves in storms.
   e. Instrumentation. What information about water in which the buoy floats should each group's drifter buoy be able to measure?
   f. Number. How many of these buoy should be used?

3. Model: Using commonly found household items, each student group should build a small-scale model of the drifter design and present the design to the class. Discuss how each model meets the necessary requirements of an operable drifter.

4. If possible, test the model in a tub or tank which has a hose or some other running water to provide circulation. Conduct a field trip to a local stream. Be sure to deter mine whether the drifter is moved by the current and/or by wind. Student groups should use a stopwatch and measuring tape to calculate the speed of the drifter and also of the current for comparison. Each group should discuss how different materials and models worked during this activity. For example, do different types of drifters move at different speeds?

Physical Parameters



ANALYSIS:

1. What materials were used to build the model drifter? What might be used for the actual drifter?
2. What other criteria (if any) were incorporated in the design?
3. What would be the most difficult criterion to meet in a design for a real life drifter buoy?
4. Below are three other possible ways to gain information about ocean currents. Discuss the advantages and disadvantages of each. Which possibility seems to be the best idea for oceanic investigations? Students should present other ideas and then share them with an oceanographer at the websites.
   a. Pour some sort of identifiable, colored dye in the oceanic location of the lost magic equipment.
   b. Print several cards which could be sealed in bottles and distributed in the water from the point of a large wave. When a drifter "washes up" on shore, whoever finds it could read and return the drifter with information about where it was found.
   d. Other ideas? ______________________________

POSSIBLE EXTENSIONS:

1. Read the following story and discuss what it has to do with ocean drifters.

On your birthday an anonymous friend sends you an amazing gift. The gift is an invitation for you and your friends to go on a small cruise ship down to the Caribbean Sea for a day-long trip and party. After recovering from your astonishment, you and your friends pack your bags and board the ship.

The party and ship are so much fun. There is a wealth of delicious food and several entertainers are performing. One of the entertainers is your favorite magician. However, in the middle of the performance, a huge wave tosses the ship like a small toy, and all of the magician's equipment falls overboard. As you, your friends, and the magician watch from the ship's deck, the equipment floats away, carried by the ocean currents.

Eventually, after days or weeks of drifting, the magicians's equipment becomes water-logged and sinks to the sea floor. Understandably, the magician wants to recover all of the magical things. You want to help.

Questions to Consider

The magician can ascertain from the ship's navigator the exact location (longitude and latitude) of the ship when the large wave hit the ship. As a young scientist, you know these are critical data in order to start your investigation.

   a. What other information would you need to have in order to direct a dive team to the site in order to recover the magical props? Make a list of information you will

Information Needs	Source of Information

need and how you might acquire this information.

b. Discuss this investigation with your classmates. Decide on a question which defines this investigation.

c. Write another story which would help people understand why knowing about ocean currents is so important?

2. Design an experiment in a local body of water (real or fictional) to investigate the speed and direction of water movement. Why would it be important to understand current patterns in this particular body of water? (e.g. dispersal of floating larvae, pollutants, ship traffic and swimming.)

REFERENCES:

Charton, Barbara, E.H. Immergent, and J.H. Tietjen. 1990. *Dictionary of Marine Science*. Published by Facts on File.

Garrison, Tom. 1995. *Essentials of Oceanography*. Belmont, CA. Wadsworth Publishing Company.

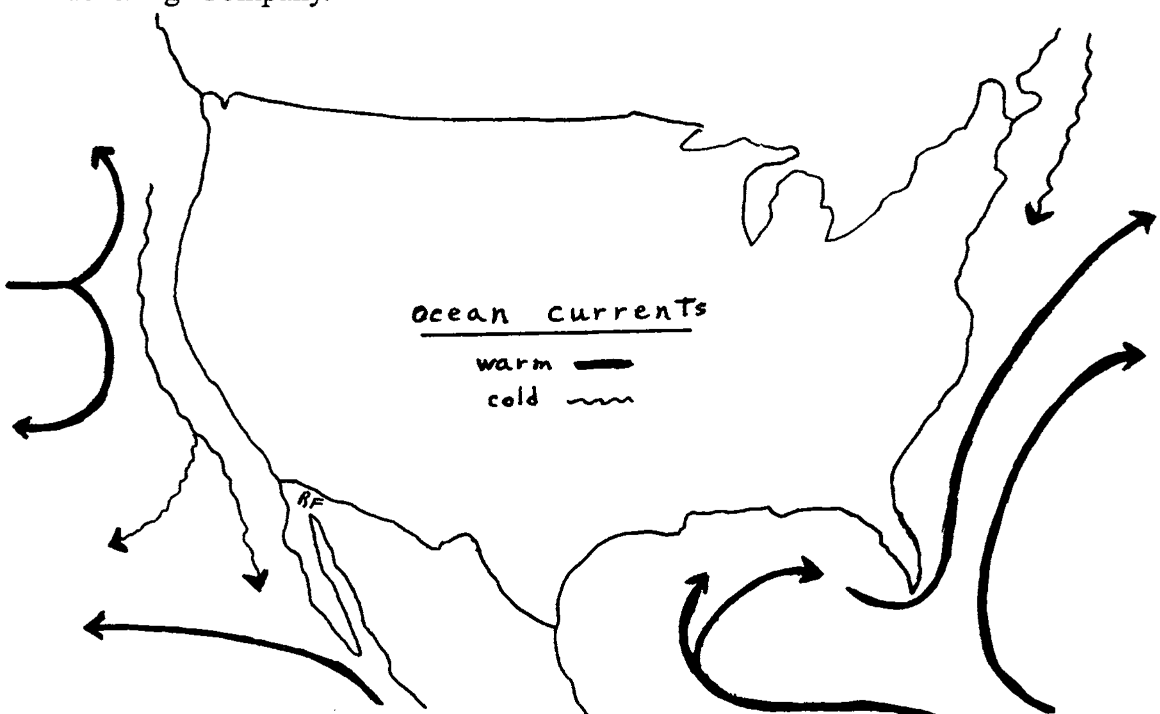
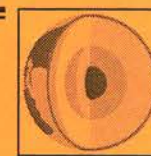


Plate Tectonics



TOPIC II

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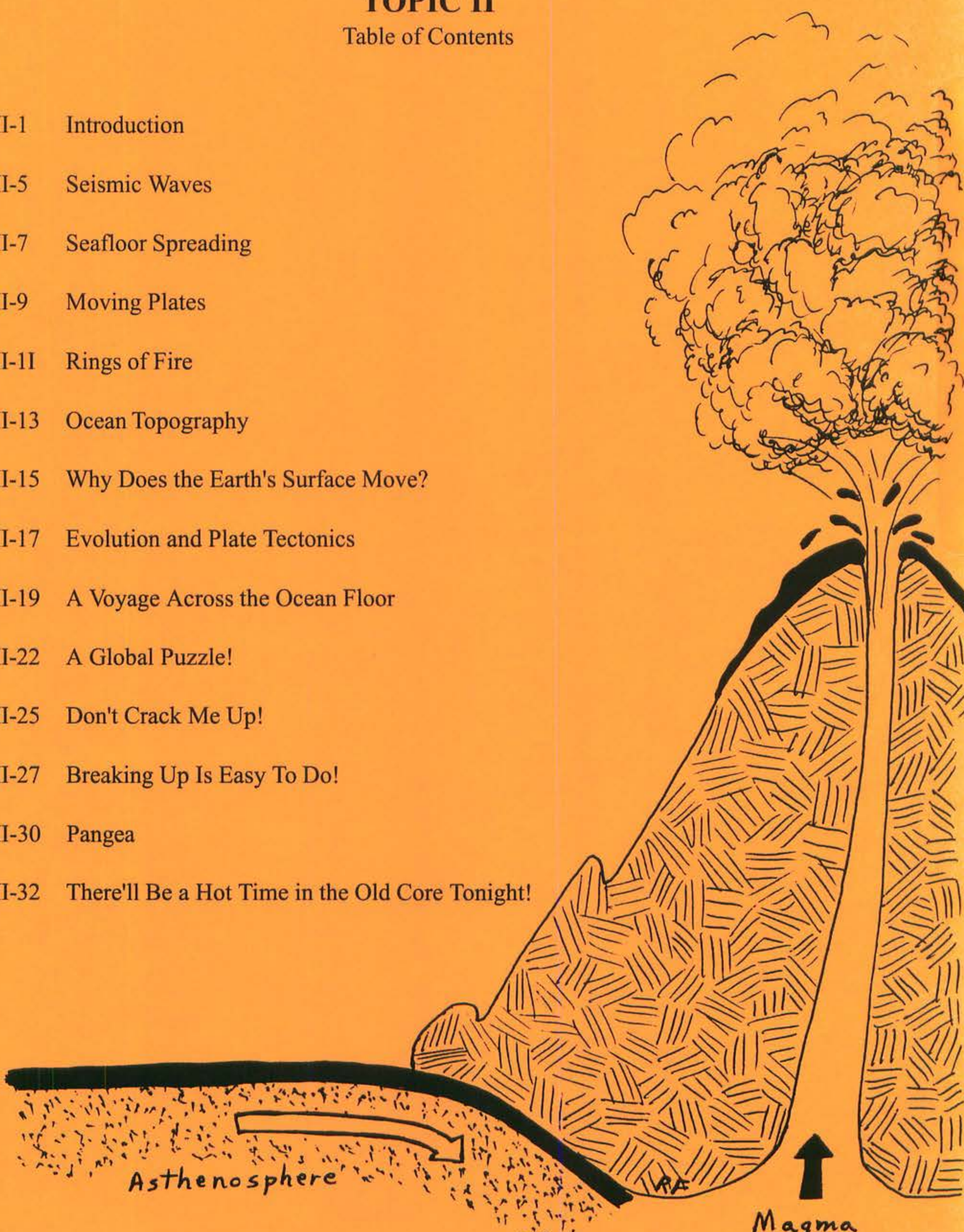

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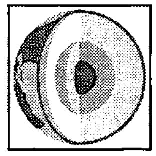


INTRODUCTION

Plate Tectonics

The Earth's Plates

Most earthquakes and volcanoes are caused by large scale movements of the Earth's plates, and occur at the boundaries between the plates. Earth scientists recognize seven to twelve major plates and a number of smaller ones. The plates take their names from continents (the North American Plate), from oceans (Pacific Plate), or from geographic areas (the Arabian Plate).

The plates are in very slow but constant motion, so if seen from above, the Earth's surface might look like a slowly moving, spherical jigsaw puzzle. The plates move at a rate of five to fifteen centimeters (or several inches) a year, or about as fast as our fingernails grow. A faster moving plate will cause a greater geologic impact than a plate which moves at a lesser rate of speed. From a human point of view, this is a rate of movement which only the most sophisticated instrumentation can detect. On the scale of geologic time, it is a dizzying speed. The three-billion-year-old rocks which scientists have dated, could have traveled all the way around the world at this rate.

The result of this slow, steady motion is the opening and closing of ocean basins. At the present time, the Atlantic ocean is opening, causing the North American continent to slowly move Westward, thereby closing the Pacific Ocean. Over the past several million years, the Mediterranean basin has opened and closed as the African and European plates moved toward each other. It is this motion that causes the numerous earthquakes and related volcanoes of the Mediterranean region.

Three Kinds of Plate Movements

The movement of plates relative to one another is generally a result of spreading, colliding, or sliding. When plates are spreading, or separating from each other, scientists call this movement *divergent*. When they are colliding or pushing each other, scientists call the movement *convergent*. Movement in which plates slide past each other is called *lateral* or *transform* plate movement. Earthquakes can accompany each of the three types of movement, but the most forceful quakes result from convergent and lateral movement. Volcanoes are normally associated with divergent and convergent types of movement.

Continental Drift - 1910 to 1960

The theory of plate tectonics originated early in this century, although it did not gain general acceptance until the late 1960s. The German meteorologist, geophysicist, and explorer, Alfred L. Wegener, is now given credit for the first step in understanding the movement of the lithosphere. Between 1910 and 1912, he formulated the theory called Continental Drift and collected evidence from the rocks, fossils, and climate of various continents which had once been joined together. Wegener had little data on the oceanic crust and thought the continents merely moved through that crust.

Plate Tectonics - 1960 to Present

In the early 1960s, oceanographers, Fred Vine and Drummond Matthews, using magnetic data from the seafloor, demonstrated the ocean floor was spreading apart at the mid-ocean ridges. They named the process *seafloor spreading.* As study continued, it was soon realized the continents were also moving. By 1968, a new explanation for the dynamics of the Earth's surface had been devised. It is now referred to as *plate tectonics.*

The discovery of plate tectonics has enabled scientists to better understand earthquakes and volcanoes and have greater respect for the forces which are shaping our Earth. Perhaps one day, researchers will be able to better predict earthquakes and volcanoes, thus lessening the loss of life and property associated with these events.

REFERENCES:

Garrison, Tom. 1995. *Essentials of Oceanography.* Belmont, CA. Wadsworth Publishing Company.

Ingmanson, Dale E. and William J. Walker. 1995. *Oceanography: An Introduction.* Belmont, CA. Wadsworth Publishing Co.

Ross, David A. 1982. *Introduction to Oceanography.* 3rd Ed. Englewood Cliffs, NJ. Prentice-Hall, Inc.

Thurman, Harold V. 1986. *Introductory Oceanography.* The Benjamin Cumming Publishing Company. Maps can be found in Introductory Oceanography or most atlases.

Plate Boundaries

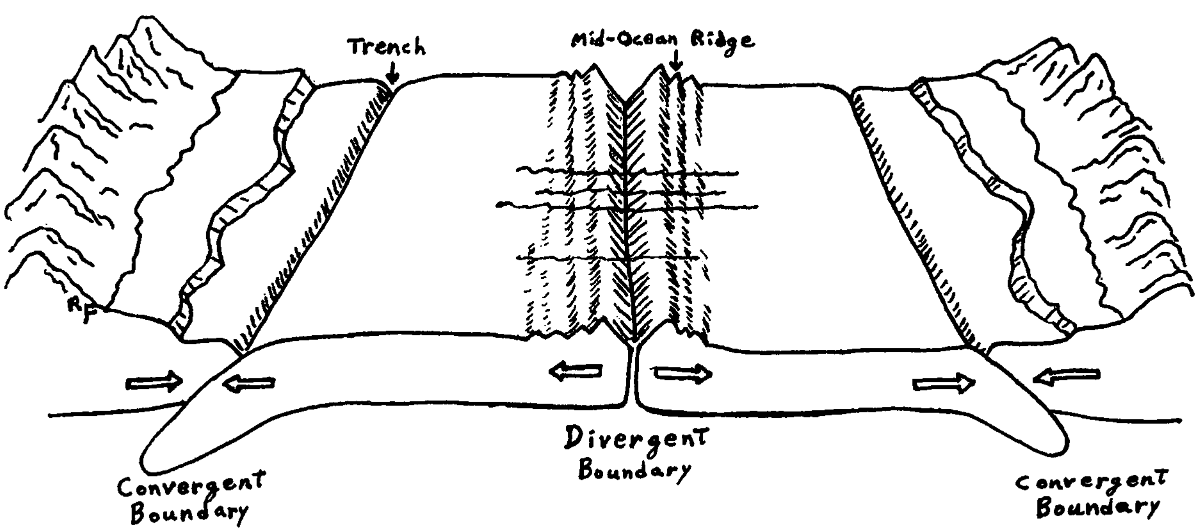
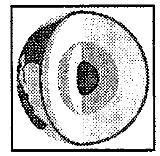


Plate Tectonics



Vocabulary

1. *Asthenosphere:* The layer of the upper mantle under the lithosphere thought to be partly molten.

2. *Continental Drift:* A theory originating in the early 1900s which suggested continents move around the Earth in various directions.

3. *Converging Boundary:* A type of plate boundary where plates move together commonly forming trenches or mountains.

4. *Crust:* The and thin rigid outer layer of Earth above the Moho composed of ocean floor basalt and continental granite.

5. *Diverging Boundary:* A type of plate boundary found at mid-oceanic ridges where plates slowly move apart.

6. *Lithosphere:* The solid rigid layer of the Earth above the asthenosphere composed of the crust and the upper mantle.

7. *Low Velocity Zone:* The zone of the upper mantle where seismic wave speeds are reduced as they move through the partially melted material.

8. *Mantle:* The dense layer of possibly peridotite below the crust and extending to the outer core of the Earth.

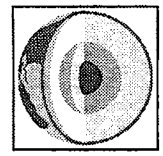
9. *Moho:* The Mohorovicic Discontinuity at the base of the crust where seismic waves increase their speeds as they move into the upper mantle.

10. *P Waves:* The fastest moving seismic waves which pass through both solids and liquids.

11. *S Waves:* The slower moving seismic waves which pass only through solids.

12. *Transform faults:* Faults mostly locate along mid-oceanic ridges with horizontal movement.

Plate Tectonics



TOPIC-TITLE: Plate Tectonics - *Seismic Waves*

AUTHOR: Gloria Gonzalez

GRADE SUITABILITY: Upper Elementary

SCOPE: Students should have some understanding of the following:

- Continental Plates
- Faults
- Epicenter
- Earthquakes

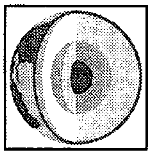
SEQUENCE: An introduction to plate tectonics and sea floor spreading should be provided prior to commencing this activity.

BACKGROUND SUMMARY: Faults are cracks which are found throughout the Earth's crust. Major faults are found around the edges of the continental plates. The movement of any plate is greatly affected at the fault lines because they are lines of weakness.

An earthquake will occur if pressure created by the movement of a continental plate is suddenly released. An earthquake is the shaking and trembling which result from the sudden movement of the Earth's crust. All earthquakes have an epicenter, which is the point directly above the focus. To find the epicenter of an earthquake, you need to time the arrivals of the seismic wave from a distinct point. Earthquakes reach the epicenter first. This is where the most violent shaking takes place. There are three types of seismic waves: primary, secondary, and surface waves. Primary waves are the fastest and can travel through solids, liquids, and gases. Secondary waves can travel through solids but not through liquids or gases. Finally, there are surface waves. Surface waves are the slowest type of wave. This type of wave only travels on the surface of the Earth. When an earthquake affects several cities, Seismologists record the exact time they experience the primary wave and secondary wave. (The primary wave will always arrive first and the secondary wave will always arrive second.) The epicenter can be located by compiling data from several cities. The difference between the arrival of the primary wave and secondary wave indicates the distance you are from the epicenter. When those data are plotted on a map, the intersection of all cities represents the epicenter location.

OBJECTIVES: Students will be able to:

1. Recognize terms concerning an earthquake.
2. Pin-point an epicenter using data from actual earthquakes.



MATERIALS:

- Colored pencils
- Compass
- Xerox copies of U.S. maps
- Data from recent earthquakes

ACTIVITY:

1. Obtain data from recent earthquakes. Record the arrival time of the primary and the secondary waves from two cities which experienced the earthquake.

2. Subtract the time of arrival of the primary wave from the arrival of the secondary wave. Conduct the same function with City A and City B.

3. Obtain a compass and adjust the degrees. The difference between primary and sec ondary waves is represented by the data used to set the compass. An example would be if the difference between the waves is five seconds, the compass would be set to five.

4. Choose a colored pencil and place it in the compass. Place the point of the compass on the city from which the data were obtained.

5. Draw a complete circle around the city.

6. Change colors and repeat steps three to five with City B.

7. The point at which the two circles intersect is the area where the epicenter is located.

8. Have the students review area maps and develop hypotheses as to why the earthquake occurred.

POSSIBLE EXTENSION:

1. Reduce the area of a possible epicenter by increasing the number of cities plotted.
2. Plot differences from cities around the world. Review these data in a broader sense.

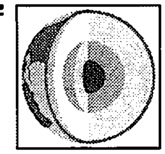
TEACHER EVALUATION: Students will be able to:

1. Observe students in: the compilation of data, mathematical computations, and graphing preparation.
2. Use a compass to narrow the range of the earthquake.
3. Determine the area of the epicenter by observing the points which intersect.

REFERENCES:

1991. *Earth Science*. Englewood Cliffs, NJ. Prentice-Hall Publishing Company.
Garrison, Tom. 1995. *Essentials of Oceanography*. Belmont, CA. Wadsworth Publishing Company.

Plate Tectonics



TOPIC-TITLE: Plate Tectonics - *Seafloor Spreading*

AUTHOR: Russell C. Read

GRADE SUITABILITY: Upper Elementary and Middle School

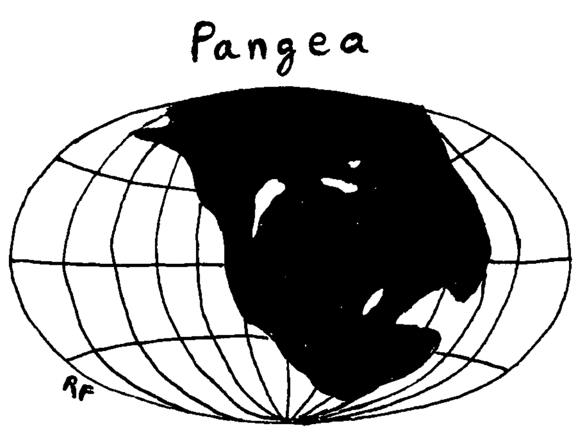
SCOPE: Science

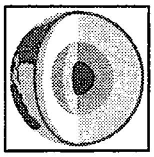
SEQUENCE: These activities can be used to introduce select principles concerning the Earth's internal processes. An introduction to plate tectonics should take place prior to this activity.

BACKGROUND SUMMARY: At the Earth's center is the inner core. Surrounding this is the outer core, the mantle, and the crust. The Earth's crust is divided into seven major and approximately twelve minor plates including: the Pacific, Nazca, North American, South American, Antarctic, African, Eurasian, and Indian. These plates float on top of the Earth's molten interior layer, and the continents "ride" on top of the plates (Greene, 1998). According to Greene (1998), a current is the transfer of heat in either a liquid or a gas which causes magma to rise through the mantle and into the crust and form oceanic ridges. Convection currents are believed to be the result of significant temperature differences between the upper and lower mantles. As magma moves under oceanic ridges, the oceanic plates move apart in a process called *seafloor spreading* (Greene, 1998).

OBJECTIVES: Students will be able to:
1. Observe the close fit of continental margins by cutting and piecing them together.
2. Model the phenomenon of polar reversal with magnets and a compass.
3. Relate the idea of convection currents as the driving force behind plate tectonics.

MATERIALS:
- Tracing paper
- Pencils and pencil shavings
- Small world map
- Paper
- Bar magnets
- Compass
- Felt pens
- Shallow metal pans
- Hot plate
- Scissors





ACTIVITIES: In cooperative learning groups:

1. Students will use a sheet of tracing paper to trace the outline of the continents on a world map. Then, they will carefully cut the traced continents and diligently fit them together into one land mass. Compare results with the other student groups. Which continents seem to fit together best?

2. Students should push two desks or two tables together, pull two sheets of paper in opposite directions through two tables which have been pushed together. Place the (N) poles of two magnets at the top of both papers where they exit the desk. Place a compass on the paper just below the magnets and draw an arrow on each sheet of paper in the direction of the compass needle. Pull the papers through the desktop or tables an inch on each side and reverse the magnets; again draw the direction of the arrows. Repeat this process three or four times. Students should discuss their results.

3. As a demonstration performed very carefully by the teacher wearing goggles and using protective gloves, place a pan of water on a hot plate. Turn on the hot plate; heat the water a few minutes; and then sprinkle pencil shavings in the middle of the pan. Wearing goggles, students should observe the pattern of the shavings as they move out and away from the center of the pan. This is believed to be a result of convection currents. The teachers will add food coloring to the water with a pipette to better observe the movement of the water. Students should record all observations in a journal with a diagram depicting the results of both experiments.

POSSIBLE EXTENSION:

1. Fossil evidence or geologic formations could be integrated into this activity and could then be plotted on maps.
2. The relationship between the rock cycle and plate tectonics could be discussed. Then, draw a plate tectonics diagram.

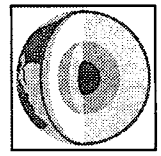
TEACHER EVALUATION: Journal can be graded for content and accuracy. Evaluate class discussion and comprehension of the topic.

REFERENCES:

1993. *Merrill Earth Science.* Fresno, CA. AIMS Education Foundation.

Garrison, Tom. 1995. *Essentials of Oceanography.* Belmont, CA. Wadsworth Publishing Company.

Plate Tectonics



TOPIC-TITLE: Plate Tectonics - *Moving Plates*

AUTHOR: Kathleen Mitchell

GRADE SUITABILITY: Upper Elementary

SCOPE: General Ecology

SEQUENCE: After understanding the "breaking apart" of Pangea through plate movement, students will participate in an interactive demonstration to present the movement of plates.

BACKGROUND SUMMARY: Even though the Earth is 4.5 billion years old, it is still geologically active. Living on a planet which has not yet cooled has a major effect on our lives. Earthquakes have a major economic impact in many parts of the world. Knowing how the Earth moves can help students be more capable of understanding why earthquakes occur.

OBJECTIVES: The students will be able to illustrate plate movement.

MATERIALS: Area in which student can move freely (grassy areas or gym mats would be appropriate).

ACTIVITY:

1. To demonstrate the manner in which plates slide past each other, have students gently place their hands palm to palm at waist level. Then, ask them to slide one hand for ward in a smooth, gentle motion. Next, have them press their hands firmly together and again try to slide one hand forward beyond the other hand. The hand will move forward in a series of jerky motions. Explain when plates are adjacent to each other but are not under pressure, the movement is slow and steady. If pressure builds between the plates, the movement is in a series of jerks or earthquakes. The longer the pressure builds, the more pronounced the movement at each occurrence.

2. To demonstrate plates locking, have the students interlace their fingers, palms together, at waist level. Have students attempt to move their hands past each other with their palms staying close together (it should not be possible to slide the hands past each other). Next, have students fold the last three fingers of one hand toward their palm, keeping the others interlaced, and try again. This time it should be easy for the student to slide their hands past each other. This sliding of students' palms past one another illustrates the current condition of the San Andreas Fault in the San Gabriel Mountains in Southern California. The San Andreas Fault is an example of a

very active transform plate wherein the North American and Pacific plates move laterally past one another.

3. To demonstrate mountain building, have half the students sit back to back in two long lines with their feet in front of them. Each line should interlace elbows with the person sitting next to him/her (not the person at his/her back). Explain the students will attempt to stand by pressing against the back of the person in the other line. The other half the of the class will observe first and then participate in a second round. As the students attempt to stand, the observers will note there is an even distribution of push/ pressures as these seated students begin to stand together (mountain building). In other cases, one person will push over his/her partner (subduction). Have the students observing determine the number of features they can match to the participating students and then students should trade places.

4. Have students research the major earthquakes which have taken place in the United States. Also, have the students describe changes in the construction of buildings and other safety measures which have taken place since the last major earthquake.

POSSIBLE EXTENSION:

1. If possible, take a field trip to an area where fault zones may be observed.
2. Discuss how to secure objects in a house so they are not damaged when the ground moves.
3. Watch a film on earthquakes, faults, and/or volcanoes.

TEACHER EVALUATION:

1. Have the students write a paragraph describing the plate processes they observed.
2. Ask the students to describe differences in the forms of plate tectonics when the Earth's internal pressure is high and when this pressure is low. Why are earthquakes uncommon in certain areas?
3. Have students match pre-existing conditions to final outcomes of the processes.

REFERENCES:

Gross, Grant M. 1993. *Oceanography, A View of Earth.* 5th Ed. Englewood Cliffs, NJ. Prentice-Hall, Inc.

Menard, H.W. 1986. *The Ocean of Truth: A Personal History of Global Tectonics.* Princeton, NJ. Princeton University Press.

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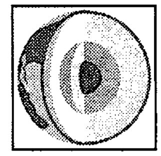
Plate tectonics



TOPIC-TITLE: Plate Tectonics - *Rings of Fire*

AUTHOR: Carina Bautista, Enterina Calro, Angel Hocog, Karness Kusto, Michael Tenny, and Iros Waguk

GRADE SUITABILITY: Middle School

SCOPE: Oceanography

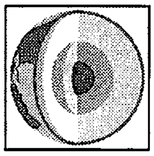
SEQUENCE: Students should already have knowledge of basic mapping skills, including latitude and longitude.

BACKGROUND SUMMARY: Trenches are found at the margins of crustal plates in subduction zones. Island arcs are volcanic islands which form an arc in the ocean and are associated with trenches. Most trenches are located in the Pacific Region. Because many of the volcanoes associated with wetlands are still active, this area is known as the Ring of Fire (Greene, 1998). Further, since islands in this area are in subduction zones, earthquakes occur frequently.

OBJECTIVES: Students will be able to:
1. Describe the theory of plate tectonics, including such concepts as the Ring of Fire, and the three ways the Earth's plates move.
2. Plot earthquakes and volcanoes on a map and explain why they occur at plate boundaries.

MATERIALS:
- Video, *Pacific Ring of Fire,* or any video on Plate Tectonics
- Globe or world map
- Poster paper, and markers
- Student activity sheets (provided from Ohia Project)
- Pacific Region maps (provided from Ohia Project)
- Earth plate maps (provided from Ohia Project)

ACTIVITY:
1. Show the video, *Pacific Ring of Fire* (45 min.), or a video on Plate Tectonics. Students should write two questions each about the video, such as: Why are the Earth's plates moving?



2. Discuss the questions from the video. Review mapping skills. Use latitude and longitude to locate specific points on a globe or world map. Distribute copies of the map of the Pacific region. Explain the points students are to plot on the map represent only a few of the many earthquakes and active volcanoes in the Pacific.

3. Explain scientists believe the Earth's crust is divided into large moving plates and the area of seismic and volcanic activity around the Pacific Ocean is known as the Ring of Fire (the ring outlines the boundaries of moving plates). Using a model (plastic or wood) or illustrations, discuss the theory of plate tectonics. Refer to the Earth Plate map, and use the Pacific Plate as an example to review the three ways the Earth's plates move.

4. Assign groups of four or five students. The Pacific region map will be given to each group as a guide. On poster paper, each group will draw a map of the Pacific region. They will also locate and mark as many active volcanoes and earthquakes as possible. The group members will also discuss the plate tectonic theory as it relates to the Ring of Fire. As a final activity, the groups will illustrate and give a two-minute presentation on three ways the Earth's plates move and the Ring of Fire.

POSSIBLE EXTENSION:

1. Have students make a mural.
2. Divide the class into four groups.
3. Each group will be assigned a role in making the mural. (Draw and color the organisms found on these habitats.)
   a. 1st group: shore
   b. 2nd group: reef
   c. 3rd group: shallow
   d. 4th group: deep
4. From the mural, allow each student to make a story of his/her own. Have students create their own books about marine habitats.

TEACHER EVALUATION:

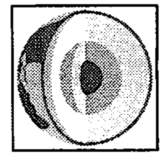
1. Students will be graded according to how many active areas they can accurately mark on their maps. A=12 or more, B=9 to 11, C=6 to 8, and D=5 or less.
2. The groups will be graded on the accuracy of their illustrations, content of their presentation, group members' involvement, and ability to adhere to time restrictions.

REFERENCES:

Garrison, Tom. 1995. *Essentials of Oceanography.* Belmont, CA. Wadsworth Publishing Company.

Greene, Thomas, F. 1998. *Marine Science.* New York, NY. AMSCO School Publications, Inc.

Plate Tectonics



TOPIC-TITLE: Plate Tectonics - *Ocean Topography*

AUTHOR: Cynthia Louden, Carolyn Elliott, Karen Jardine, and Kimberly Dernowski

GRADE SUITABILITY: Middle School

SCOPE: Geological Oceanography

SEQUENCE: This activity should follow a discussion of plate tectonics.

BACKGROUND SUMMARY: The Earth's surface is divided into separate plates which move and influence global topography. Sea floor spreading is responsible for the "breakup" of the super continent, Pangaea, and is responsible for the creation of mountains, earthquakes, and volcanoes.

OBJECTIVES: Students will be able to locate major plate boundaries based on topographic features.

MATERIALS:
- Paper
- Pencil
- Blank world map
- Topographic/physiographic map of the world
- Map of fictitious planet
- Materials for presentations such as transparencies
- Poster board
- Markers

ACTIVITY: Place students into cooperative learning groups (two students per group). Provide each group with a blank map and a physiographic map. The students will then identify plate boundary locations. Next, the students are to research whether these are converging, diverging, or transforming plates based on the information from the topographic map and knowledge of land forms associated with each type of plate boundary. Students should then draw their predicted boundaries on the blank map with converging boundaries in red, diverging boundaries in blue, and transform boundaries in green. Arrows should be drawn on each plate to indicate the direction of plate movement. Each group could then discuss its results with another group and critique each predicted boundary map. At the conclusion of class, the instructor should present the actual map of plate boundaries on an overhead for the students to check the accuracy of their predictions. The class could then engage in a discussion of plate boundaries and the effects of plate configuration on the composition of the Earth in the future. Re-divide students into cooperative learning groups (four students per group). The instructor should then provide each group with a map of a hypothetical planet. The map contains plates with motion speeds and directions. It also contains the boundaries of four countries. Students must draw topographical features which would occur at each plate boundary. The features must correspond to the directions of plate movement of the adjacent plates. Each student must then take one of the four countries and describe the country in a brief report. This description should include topographic and tectonic features of the area. Students must add a paragraph at the conclusion of the paper describing the manner in which the topography affected the development of the political and cultural infrastructure of the inhabitants. Each group must discuss the countries of its planet and improve its report. Each group can then make an oral presentation to the class about its respective country.

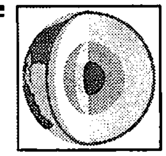
POSSIBLE EXTENSION: Students can prepare a publicity poster and travel brochures for their country and develop a governmental system for their country. The different groups should interact, just as representatives of different governments interact. This interaction could be based on a problem, such as earthquake activity, which might affect all the groups.

TEACHER EVALUATION:
1. The students can be given pre- and posttests. A rubric can be administered in advance, then used as a guide for grading.
2. Student performance can be assessed during oral presentations. An additional rubric can also be administered in advance, then used as a guide for grading.

REFERENCES:
DeWall, Marily (Curriculum Director). 1992. *JASON IV Curriculum, Baja California Sur*. National Science Teachers Association. Washington, D.C.
Dietz R.S., and J.C.Holden. 1970. "The Breakup of Pangea." *Scientific American* 229 (4): 30-41.
Hallam, A.. 1975. "Alfred Wegener and Continental Drift." *Scientific American* 232 (2): 88-97.
Namowitz, Samuel N. and Nancy E. Spaulding, *Earth Science.*
Thurman, Harold V. 1986. *Introductory Oceanography.* The Benjamin Cumming Publishing Company. Maps can be found in *Introductory Oceanography* or most atlases.

Audio Visuals:
The Restless Earth

Plate Tectonics



TOPIC-TITLE: Plate Tectonics - *Why Does the Earth's Surface Move?*

AUTHOR: George Linzee

GRADE SUITABILITY: Middle School

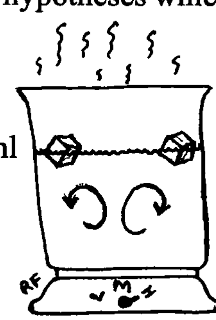
SCOPE: Earth Science

SEQUENCE: This activity is designed to follow a series of lessons which first present the geological features of the Earth's oceans and continents and then teaches the theory of plate tectonics. By presenting a problem or aspect of a scientific theory which scientists are still researching, this activity should stimulate and challenge those students who are creative problem solvers. The teaching strategy includes presenting the problem and allowing students in cooperative learning groups to develop hypotheses. Then, student groups can conduct a demonstration which presents various hypotheses. Finally, challenge the student groups to determine if they can design an experiment which may provide additional evidence for plate movement.

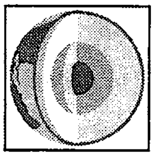
BACKGROUND SUMMARY: The emergence of the plate tectonics theory has accounted for a broad range of geological features and events. While the concepts of plate movement and various boundary types have explained the formation of volcanoes, earthquakes, the construction of ocean mountains, island arc formations, ocean trenches, continental drift, and the rock cycle, the actual cause of the plate movement has not been firmly established. This lesson involves student cooperative learning groups in the consideration of internal convection cells as the driving force behind plate movement, while also further substantiating the need for plate tectonics research.

OBJECTIVES: Students will be able to present and consider possible hypotheses which account for the movements of lithospheric plates in the Earth's crust.

MATERIALS:
- One hot plate
- One tray of ice cubes
- Water source
- Graduated cylinder, 1,000 ml
- Beakers, one and two liters



ACTIVITY:
1. *Overview:* review plate tectonics, describing all the features of the theory and using visual aids, such as maps of the Earth's surface and internal features.



2. *Hypothesis Generation:* Present the questions, "Why do the plates move?" "What force causes the plates to move?" Give the student groups time to write their own ideas about probable causes. Then, allow each group to interact for five minutes. Each group should develop one hypothesis. Then, discuss each hypothesis (note: if convection has not been discussed, ask some leading questions which will allow convection discussion).

3. *Consideration of Convection Hypothesis:* List, with student input, all the conditions necessary for convection to occur: heat source, fluid medium, and boundary conditions. Identify these elements in the structure of the Earth.

4. *Modeling Demonstration:* Very carefully - using safety goggles and appropriate hand protection - pour 500 ml of water into the liter beakers and place them on a hot plate. Place six ice cubes in the middle of each beaker. Allow the convection cell to develop and spread the ice cubes in a manner similar to a divergent plate boundary. Stress that the ice is less dense than liquid water and corresponds to the rigid lithospheric plates floating over the fluid (glass-like) mantle. The hot plate corresponds to the Earth's internal sources of heat such as radioactive decay, pressure, and friction. Then, have students discuss what factors about the model do not account for the Earth's situation, i.e. it is too fast, does not rotate, wobble, or orbit like the Earth does. Further, this model does not have the gravitational effects of the moon or sun affecting it, nor is it receiving heat from the sun. Lastly, this model does not account for any magnetic field.

POSSIBLE EXTENSION: Prepare a grant proposal: Each student can combine his/her final hypothesis and finalize experimental designs and/or research directions into a research grant proposal. The teacher should provide guidelines for grant proposals and be available for individual help.

TEACHER EVALUATION:

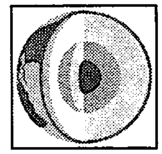
1. Each student will be evaluated on his/her participation in class discussions.
2. Questions:
    a. Are scientists confident that convection drives plate tectonics? Explain your answer.
    b. What internal layer of the Earth's structure has the fluid characteristics which would make convection possible?
    c. Why is it important to learn what makes the Earth's surface move?

REFERENCES:

Greene, Thomas F. 1998. *Marine Science.* New York, NY. AMSCO School Publications, Inc.

Garrison, Tom. 1995. *Essentials of Oceanography.* Belmont, CA. Wadsworth Publishing Company.

Plate Tectonics



TOPIC-TITLE: Plate Tectonics - *Evolution and Plate Tectonics*

AUTHOR: Sheila Billings and Donna Maroon

GRADE SUITABILITY: Upper Elementary

SCOPE: Environmental Science, Geography, and Physical Science

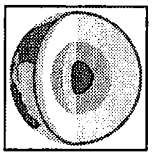
SEQUENCE: This activity should be an introduction to a study of Earth Science or as a part of a beginning Geography unit.

BACKGROUND SUMMARY: Children often believe the Earth is a static, unchanging object in space. Although young children do not yet have a well-developed sense of time, they can understand the Earth is constantly changing.

OBJECTIVES: Students will be able to understand the Earth's crust is composed of a series of moving plates, which will continue to move very slowly throughout its future.

MATERIALS:
- One hard-boiled egg per child and several for demonstration
- Food coloring or Easter egg dyeing solution
- Assorted balls: baseball, volleyball, soccerball, or similar, circular object of comparable size
- World map that shows the Earth's tectonic plates
- Syrup or watery jello
- Laminated puzzle pieces of Pangaea

ACTIVITY:
1. Provide each student with one hard-boiled egg.
2. Have the students gently crack the surface of the eggs.
3. Dip the eggs in Easter egg dyeing solution or food coloring, dry them, and carefully peel the shells. (Instructors may need to assist in removing the eggshell.)
4. Have each student observe his/her egg and record some observations.
5. Show the children a map of the Earth's plates and explain the colored lines on their eggs are similar to the cracks located between these tectonic plates.



6. Take the Pangaea puzzle pieces and place them on top of a viscous substance (syrup or watery jello) and demonstrate to the students the manner in which the continents drifted apart.

POSSIBLE EXTENSION: Have the students write a group letter to a physical oceanographer requesting information on recent geologic events which have taken place in the oceanic basin nearest the students' school.

TEACHER EVALUATION: Develop a concept map on the topic of "what is the Earth's crust like" before and after this activity. Allow the students to provide the content for this plate tectonic concept map.

REFERENCES:

Garrison, Tom. 1995. *Essentials of Oceanography.* Belmont, CA. Wadsworth Publishing Company.
1995. *Map of the World.* Washington, D.C. National Geographic Society.

Video:
Continents in Collision. Time-Life Series. Durham, New Hampshire. Sea Grant Extension. University of New Hampshire.

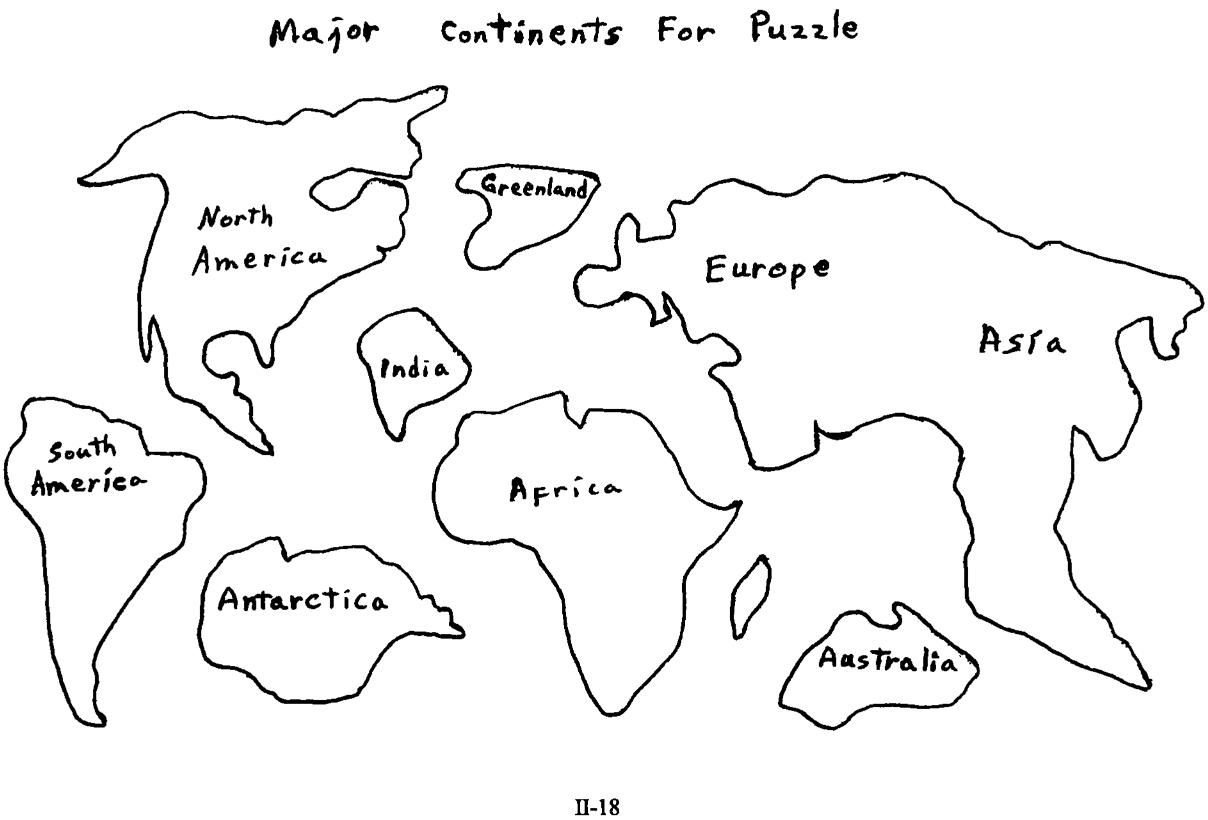
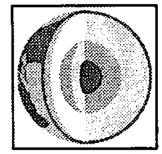


Plate Tectonics



TOPIC-TITLE: Plate Tectonics - *A Voyage Across the Ocean Floor*

AUTHOR: Karen Moore-Boich

GRADE SUITABILITY: Upper Elementary

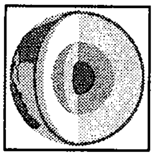
SCOPE: Science

SEQUENCE: Students should be familiar with the theory of continental drift and oceanic basin features. This activity can be used to re-enforce the understanding of the varied topography found in the ocean basin. This lesson could be followed with an introduction to the physical factors of the photic, pelagic, and benthic zones.

BACKGROUND SUMMARY: The Earth's crust is broken into many moving plates of Lithosphere. The crustal plates move on the mantle, which is the semi-fluid layer directly below the lithosphere. As the plates move, they come into contact with other plates. Earthquakes, volcanoes, and mountain building processes occur along the plate boundaries creating varied topographical features including trenches, abyssal plains, and underwater mountains. Geological features found in the ocean basin are very similar to those found on continental plates.

Terms:

a. *Abyssal plain*: region of ocean floor located between the continental rise and oceanic ridge. This area is flat, cold, and covered with sediments; it is more prevalent in the Atlantic and Indian Oceans; and it is very deep.
b. *Oceanic basin*: deep, basaltic ocean floor.
c. *Fracture zone:* region which marks past seismic activity that occurs along a transform fault.
d. *Oceanic ridge*: center of active seafloor spreading which is the boundary between diverging plates, usually found rising above the abyssal plain.
e. *Seamount*: circular rise in the ocean floor with a height of more that one km and steep, sloping sides.
f. *Trench:* arc-shaped depression in the deep-ocean floor with very steep sides, occurring in subduction zones, usually in the Pacific.
g. *Convergent plate boundary*: region where two plate boundaries are pushing together, normally accompanied by seismic or volcanic activity.
h. *Divergent plate boundary*: region where two plates are moving away from each other, creating new oceanic crust.



OBJECTIVES: Students will be able to:

1. Understand the topography of the ocean basin.
2. Complete a travel log.
3. Show the similarities between oceanic plate features and continental plate features.

MATERIALS: Physiographic chart of the ocean floor

ACTIVITY:

1. Review terminology of ocean basin features.

2. Place students into small learning groups.

3. Provide each group with a copy of a physiographic chart of the sea floor. Review longitude and latitude and discuss how to reference them on the chart.

4. Explain that each group will have the task of charting a trip along the ocean basin between two pre-determined points (e.g. Chesapeake Bay and the Cape of Good Hope). Students are to describe any geologic features they encounter such as rises, fractures, ridges, and trenches. Students' descriptions should be as detailed as possible and must reference longitude and latitude. Stress the idea of the trip is to determine the most interesting route, **not** the most direct.

5. Instruct students to create a travel log which must include longitude, latitude, feature name, and description. An additional column could be added for geologic processes.

6. Share travel logs in a large group discussion.

7. Compare ocean basin features to continental plate features.

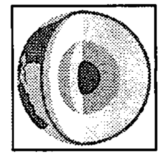
POSSIBLE EXTENSION:

1. Students could create a three-dimensional model of the route explored in the activity.
2. Students could write a story based on their journey.
3. Discuss what marine life may have been encountered along the way.
4. Obtain charts of many of the ocean basins. Have students compare and contrast the ocean bottom features.

TEACHER EVALUATION:

1. Can students explain the features they encountered along their journey?
2. Did students complete their log?
3. Can students recognize the similarities between oceanic and continental plates?

Plate Tectonics



REFERENCES:

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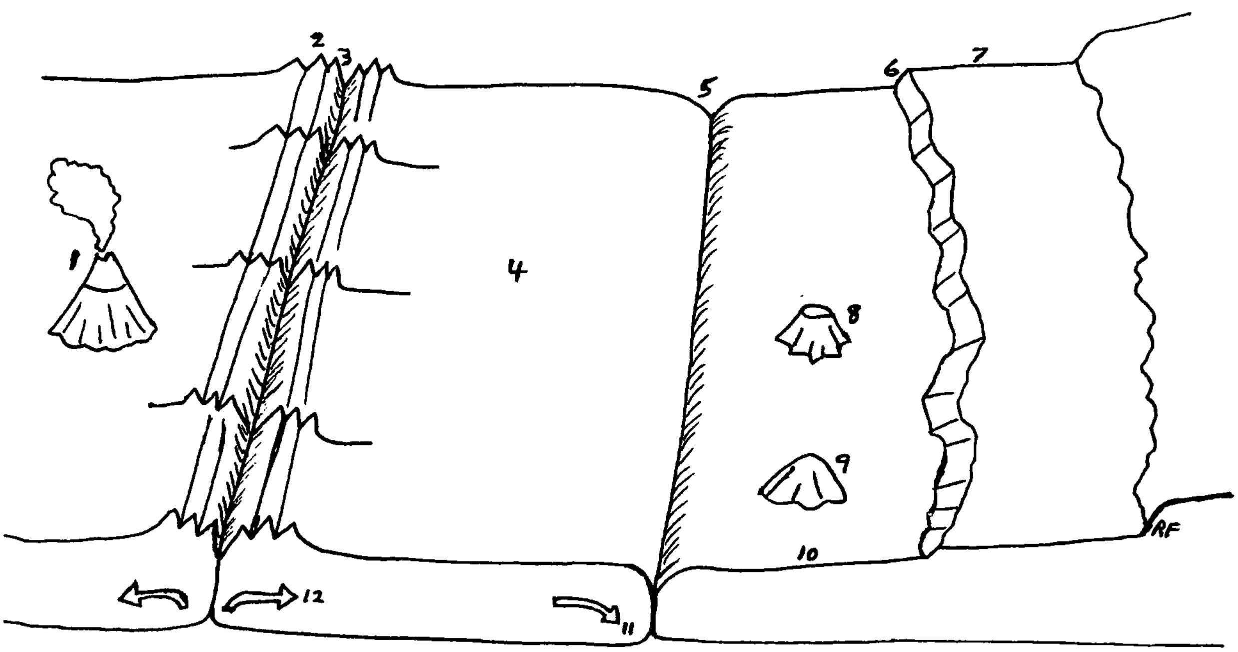
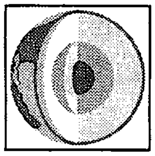


Sea Floor Formations

1. Volcanic Island	7. Continental Shelf
2. Mid-Ocean Ridge	8. Guyot
3. Rift Valley	9. Seamount
4. Abyssal Plain	10. Continental Rise
5. Trench	11. Subduction
6. Continental Slope	12. Divergent or Sea Floor Spreading

Plate Tectonics



TOPIC-TITLE: Plate Tectonics - *A Global Puzzle!*

AUTHOR: Shannon Buckalew, Marcla Sue Ellison, and Rebecca Henderson

GRADE SUITABILITY: Middle School

SCOPE: Geological Oceanography

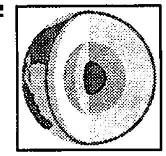
SEQUENCE: This activity should follow a lesson on plate tectonics. Explain the three types of plate boundaries and associated geological formations of each. Photographic and geographic examples (maps) will be demonstrated for each type boundary, conducted with chalkboard drawings of the movement, thereby visually re-enforcing concepts. Locations of boundaries will be shown on a wall map to re-enforce relative locations. Students will list the characteristics of each type boundary.

BACKGROUND SUMMARY: The plates which cover the Earth's surface are constantly in motion. When the plates collide with each other or push toward each other, it is called convergent movement. When the plates are separating from each other, it is called divergence. Movement in which plates slide past each other is called transform or lateral movement.

OBJECTIVES: Students will be able to:
1. Name, explain, and identify the three types of plate boundaries.
2. Create and explain a physical example of each of the three types of plate boundaries.
3. Explain the effects of the three plate boundary types on geological features.

MATERIALS:
- Photographs of examples of geological formations at the three plate boundaries
- Crayola® model magic clay (six, 3" x 5" portions for each group)
- Laboratory question sheets
- Large wall map of the world with plate boundaries and geological topography
- Blank world maps depicting plate boundaries (for each student for extension 1)
- Colored pencils (for extension 1)
- Teacher-made information on cards for student journal report (for extension 2)

ACTIVITY:
1. Student Demonstration: two students will be brought to the front of the class and positioned nose to nose. The class will be asked to explain how the two individuals could move relative to each other while keeping their feet on the floor. Brainstorm. The class should arrive at the conclusion there are three ways for individuals to move: toward each other, away from each other, or along each other. (This class discussion



will be used to relate the three types of plate boundary movement: convergent (toward each other), divergent (away from each other), and transform (beside each other).

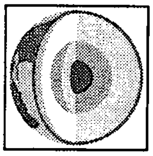
2. Place students into cooperative learning groups of three to four per group. Have one student record observations and answers to the questions.

3. Students will follow the directions and answer the following questions:
   a. (directions) Put two portions of clay together horizontally, long end to long end. Push them toward each other.
   b. (question) Record observations relative to the changes in the clay and include a sketch of the observations. Why do you think this happened?
   c. (question) Name the type of boundary you have just created. Base your answer on your group's observation and class discussion.
   d. (question) In your own words, give a definition for the boundary you just created.
   e. (question) Based on what happened to your clay, what do you think would happen if two crustal plates moved in the same way?
   f. (directions) Put two portions of clay together, long end to long end, and slide them along each other in opposite directions.
   g. (questions) Have students answer questions b-e, pertaining to the experiment.
   h. (directions) Pinch two slabs of clay together, long end to long end. Grasp the outer edges of the clay square you have just formed and pull them in opposite directions.
   i. (questions) Have students answer questions b-e, pertaining to the experiment.

4. At the end of the laboratory exercises, hold a class discussion, calling on the groups' reporters to help explain their observations during these activities. The focus of the discussion should be on similarities and differences of observations between groups.

POSSIBLE EXTENSION:

1. Social Studies: Use a large topographical wall map of the world to identify plate boundaries. Students will label these boundaries (location and type) on individual maps. Six to eight of the photographic examples given in class should also be labeled on the maps. Colored pencils should be used to make a key. How do people adapt to life at tectonically active plate boundaries?
2. Language Arts: The instructor will create situation cards on example boundary locations given in class. Each card will describe a drastic geological phenomenon occurring at the given location. (These may be fictional; however, they must be plausible.) Students will role play as a CNN reporter and write and orally present what is happening and why it is happening at the given location.



3. Science: Preserve the models of plates made in the laboratory exercise to be used later for addition of other topographical features studied in future lessons.

TEACHER EVALUATION: Student performance will be evaluated by:
1. Graded assessment of laboratory sheets.
2. Interaction during experiment (one-on-one questioning by teacher).
3. Participation during discussions.
4. Authentic Assessment: Assign a plate boundary region to each student and, after research, have each student determine the type of relative motion at this boundary. Students should be able to support their conclusions.

REFERENCES:

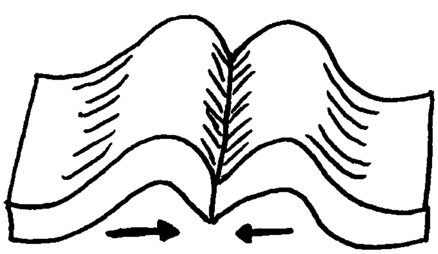
Earth Science. 1989. New York, NY. Prentice-Hall, Inc.

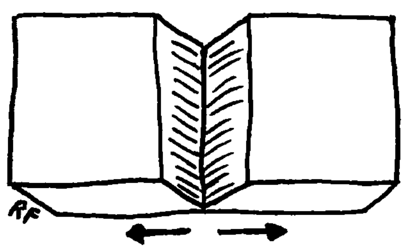
Garrison, Tom. 1995. *Essentials of Oceanography.* Belmont, CA. Wadsworth Publishing Company.

Thurman, Harold V. 1996. *Introductory Oceanography.* 7th Ed. Chapter 3. New York, NY. Macmillian Publishing Company.

Audio-Visuals:

Photographs of examples of geological formations at plate boundaries
Large wall map of world with plate boundaries and geological topography
Chalkboard drawings of plate movement along boundaries





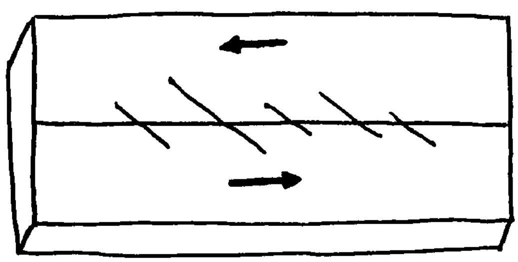
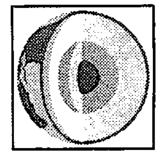


Plate Tectonics



TOPIC-TITLE: Plate Tectonics - *Don't Crack Me Up!*

AUTHOR: Margaret Bean and Meg Sullivan

GRADE SUITABILITY: Middle School

SCOPE: Earth Science and Geography

SEQUENCE: Students should be able to identify the major tectonic plates and have an understanding of the processes involved in sea floor spreading. The teacher should also discuss with the students the different methods of plate interaction.

BACKGROUND SUMMARY: An understanding of the theory of plate tectonics is an integral component leading to a comprehension of the nature of this planet. With understanding comes the possibility of predicting future geologic activity. This may result in minimizing death and destruction during geological events such as earthquakes and volcanoes.

OBJECTIVES: Students will be able to:
1. Determine latitude and longitude and plot locations of various volcanoes and earth quakes on a map using a list provided by the instructor.
2. Compare student group maps with the locations of the Earth's plate boundaries.
3. Discuss the future movements of the plates and the seismic activity which could occur.

MATERIALS:
- Letter size world map with latitude and longitude, one for each student group
- Letter size world map with tectonic boundaries, one for each student group
- Table of volcano and earthquake locations (listed by latitude and longitude-developed by student groups)
- Blank transparencies, one per student group
- Black, red, and blue transparencies and markers for each group of students (students can share if marker quantities are limited)

ACTIVITY: Prior to beginning the activity, students should be placed in cooperative learning groups, research the history of volcanoes and earthquakes, and determine areas which are currently active. Groups should also develop a class list of earthquakes and volcanoes, including the latitude and longitude of these sites.

1. Each student group will plot the positions of each of the earthquakes and volcanoes on a variety of maps. Mark the volcanoes with red dots and earthquakes with blue dots.

2. With a different colored marker, have the students trace the plate boundaries on the transparency sheet with the plate boundary map as a base.

3. Overlay the transparency on the map with the volcanoes and earthquakes. Student groups observe, analyze, and discuss their findings. Each group should prepare a journal of its findings. The journal should contain the following: observations of the correspondence of the seismic activity and the plate boundaries; a paragraph based on respective hypotheses concerning the reasons for this similarity; and conclusions including the importance of knowing geologically active areas.

POSSIBLE EXTENSION:

1. Students may create physical models of plates and their boundaries.
2. Students can research Alfred Wegener and his theory of continental drift.
3. Research aberrations as seen in hot spots or mountain ranges in the middle of continents.

TEACHER EVALUATION:

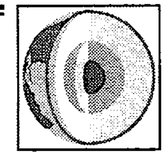
1. Student ability to correctly plot the locations of volcanoes and earthquakes.
2. Evaluate journal entries for content, based on the questions posed during the activity. Students should show evidence of critical thought in the development of group hypotheses.

REFERENCES:

Sherfesee, Lou. 1995. *Plate Tectonics*. Project Pathfinder. Gulf Coast Research Laboratory, J.L. Scott Marine Education Center and Aquarium, Biloxi, MS.

Weyl, Peter K. 1970. *Oceanography, An Introduction to the Marine Environment.* New York, NY. John Wiley and Sons, Inc.

Plate Tectonics



TOPIC-TITLE: Plate Tectonics - *Breaking Up Is Easy to Do!*

AUTHOR: Cheryl A. Clinger

GRADE SUITABILITY: Upper Elementary

SCOPE: Marine Science, Geology, and Earth Science

SEQUENCE: This activity could follow the plate tectonics activity on page II-5 of this book.

BACKGROUND SUMMARY: The Earth is comprised of three basic layers: the crust, mantle, and core. The crust is solid rock. This solid rock is composed of several tectonic plates or sections which float on the layer of the Earth called the mantle. The mantle is composed of dense rock and is mostly solid. The center of the Earth is a hot molten core.

The core heats the mantle and results in it moving slowly in convection currents. These currents push against the crust and cause it to move laterally, very slowly. In fact, the movement of the crust is so slow, it is estimated to be at a rate of four inches per year. At weak points in the crust or along the plate boundaries, hot magma seeps upward from inside the Earth, sometimes causing volcanic mountains.

Along the edge of the tectonic plates there is movement caused by the convection currents and formation of new land or volcanoes. There are three types of movement: away from each other, toward each other, and sideways or lateral movement.

The largest geographic area where plates are moving away from each other is the Mid-Atlantic Ridge. This type of movement allows magma to seep upward from the interior of the Earth causing volcanoes and formation of new Earth.

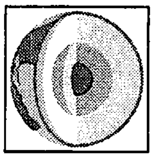
When the plates move toward each other one of two things can happen, either the plates push together and both go upward to form a new mountain chain or one plate slides underneath the other, a process which is called subduction.

Earthquakes are caused when the plates move sideways along each other's boundaries. This is what happens in California along the San Andreas Fault.

An understanding of tectonic plates and their movement is essential in the study of earthquakes and volcanoes. The value in studying and learning about plate movement is that perhaps someday scientists will be able to better predict earthquakes and volcanoes, which could result in a decrease in the loss of life and property.

OBJECTIVES: Students will be able to:

1. Discover, through physical activities, the different types of plate movement.
2. Infer results from these different types of movement.



MATERIALS: No materials are needed except students' appropriate space for physical activities.

ACTIVITY:

1. Have students form two lines (line A and line B) facing each other. Have all of the students in line A join hands.

2. Tell the students in line B (with hands not joined) to run toward the attached hands/ arms of students in line A, one at a time, directly across from where they were standing. They should break through the hands similar to the game "Red Rover." This symbolizes the plates moving away from each other.

3. Discuss with the students the reasons for the line being broken and what this represents.

4. Have the students reform lines and both lines join hands. Now, have students move as close together as they possibly can. This symbolizes movement of the plates toward each other.

5. Discuss what happens.

6. Have the students imagine what would happen if the student across from them ran through, attempting to duck under their legs. This symbolizes subduction.

7. Have both lines move as close as possible to each other.

8. Have lines move sideways in opposite directions. This symbolizes sideways movement.

9. Discuss what happens and difficulties encountered when they are so close.

POSSIBLE EXTENSION:

1. Based upon the students' knowledge of the location of earthquakes and volcanoes, have them list where they think the plate boundaries are, then check the list against actual boundaries.
2. Discuss possible ways of improving earthquake and volcano predictions and the benefits of these improvements.
3. Discuss what the Earth might look like in the future due to plate movement.

Plate Tectonics

TEACHER EVALUATION:

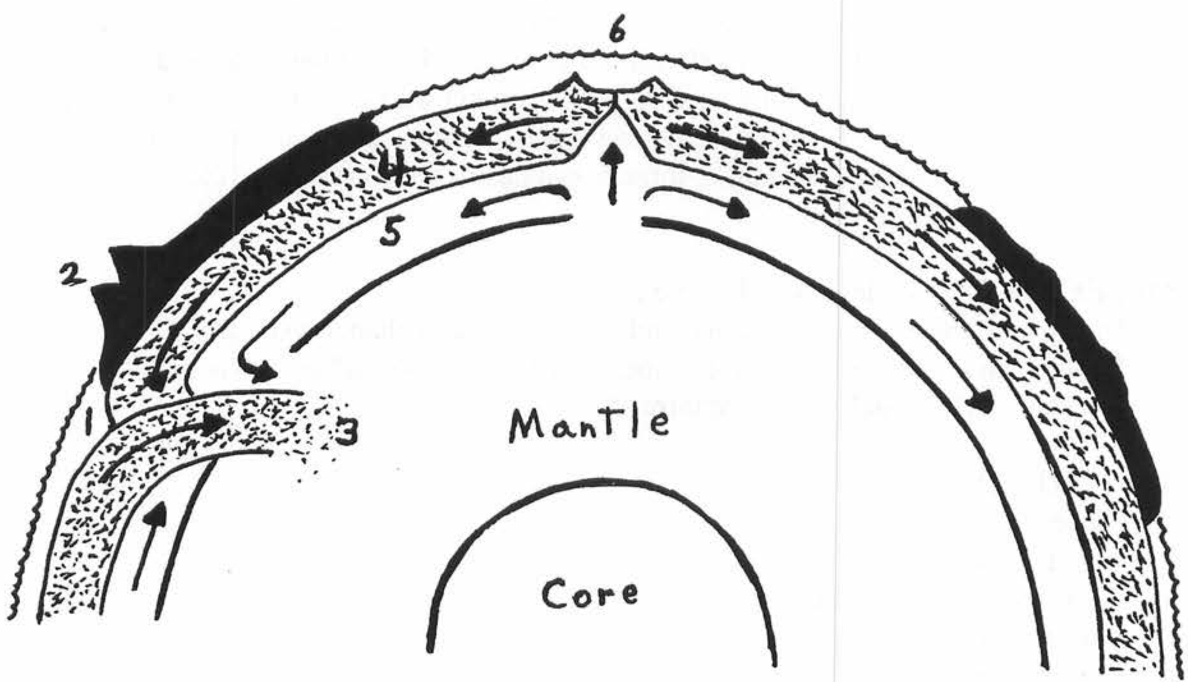
1. Students will record the different types of movements they observed, relating it to tectonic plates.
2. Students will list possible results from the different types of plate movements.

REFERENCES:

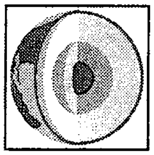
Cromie, William J. 1964. *Why the Mohole Adventures in Inner Space.* Boston, MA. Little, Brown and Company Limited.

Mulfinger, George. 1979. *Earth Science for Christian Schools.* Greenville, SC. Bob Jones University Press.

Thurman, Harold V. 1993. *Essentials of Oceanography.* New York, NY. Macmillian Publishing Company.



1. Ocean Trench
2. Mountains
3. Subduction
4. Lithosphere
5. Asthenosphere
6. Mid-Ocean Ridge



TOPIC-TITLE: Plate Tectonics - *Pangea*

AUTHOR: Ceresy Jenkins

GRADE SUITABILITY: Lower Elementary

SCOPE: Environmental Science, Physical Science, and Social Science

SEQUENCE: The social studies scope and sequence for second graders in North Carolina includes the study of seven continents and four oceans. This activity would complement this course of study.

BACKGROUND SUMMARY: Approximately 225 million years ago, the Earth was composed of a large land mass or supercontinent called Pangea and a single ocean called Pathalassia (Gross, 1990). About 180 million years ago, Pangea began to break apart. The initial breakup created a long, east to west basin known as the Tethys Sea (Gross, 1990). This basin split Pangea into Laurasia and Gondwana and later formed the North and South Atlantic basins. The other three ocean basins were created by the continuation of this initial continental drift.

OBJECTIVES: Students will be able to:
1. Understand the Earth has changed and will continue to change over time.
2. Develop an understanding of the shapes of the continents and oceans and the mechanisms by which they were formed.

MATERIALS:
- Globe
- World maps
- Large cut outs of continents
- Worksheets
- Non-pointed scissors
- Pencils and crayons

ACTIVITY:
1. Introduce this lesson by having seven students hold or wear large continent shapes in a grouping to resemble Pangea.

2. Explain the continents broke apart, thereby creating seven land masses and four oceans. Allow the students to demonstrate this phenomenon.

Plate Tectonics

3. Use a globe and world maps to name continents by matching the shapes. Students should then name the continents and oceans on individual worksheets.

POSSIBLE EXTENSION:

1. Tape continent shapes onto individual air-filled balloons to make globes.
2. Use Styrofoam® cut-outs of Pangea to float in a dish pan to connect and break apart, similar to a puzzle.
3. Use a map of Pangea to infer which continents are represented by each position.

TEACHER EVALUATION:

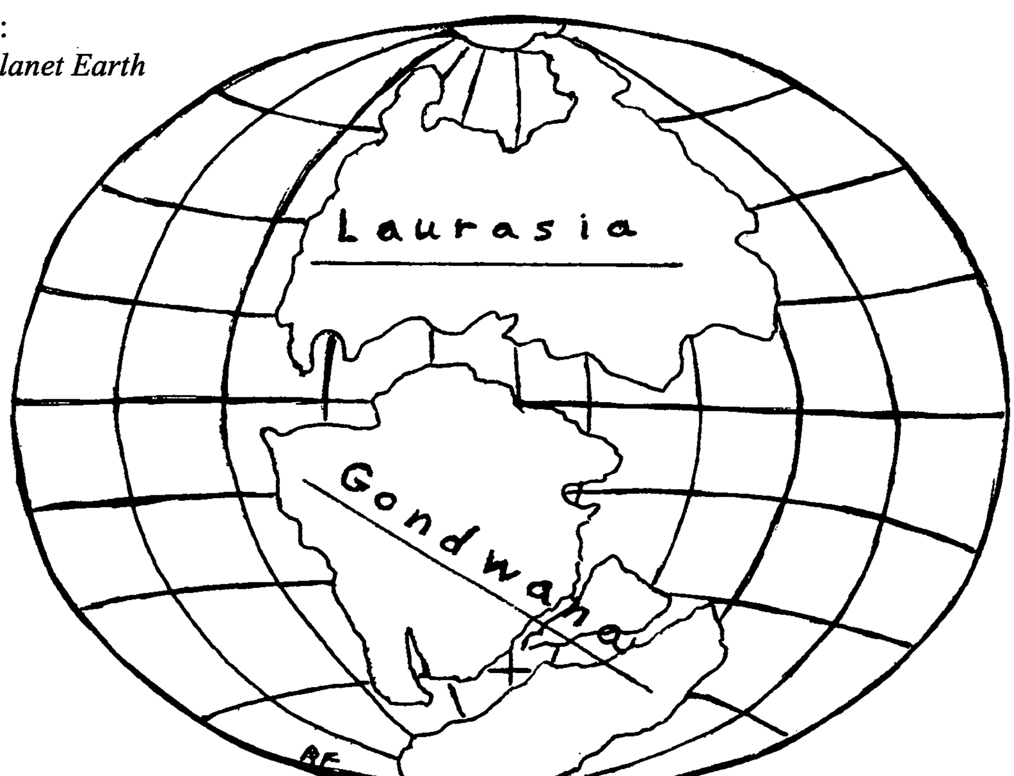
1. Give the students a blank world map that pictures the seven continents and four oceans. Students should be able to provide the correct names.
2. Write at least two ways the Earth is the same as it was 240 million years ago.
3. Write at least two ways the Earth is different than it was 240 million years ago.

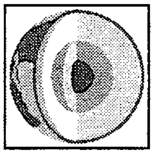
REFERENCES:

Keener-Chavis, Paula and Leslie R. Sautter. *1996. Of Sand and Sea: Teachings from the South Carolina Shoreline.* A South Carolina Sea Grant Publication. SC.

Sautter, Leslie. *Reconstructing Pangea.* Handouts and Worksheets.

Video:
The Planet Earth





TOPIC-TITLE: Plate Tectonics - *There'll Be a Hot Time in the Old Core Tonight!*

AUTHOR: Diane M. Smith

GRADE SUITABILITY: Middle School

SCOPE: Geosciences

SEQUENCE: This lesson could be used as a middle school unit on plate tectonics after the students have learned the size, shape, and position of land, and oceans can change as plates collide, slide, and move apart. The next logical step is for the students to learn the manner in which and reasons why continental and oceanic plates change.

BACKGROUND SUMMARY: The positions of the continental and oceanic plates change over time. These position changes are the result of heat exchanges or convection currents between the Earth's core and mantle. A convection current is an exchange of heat either in a liquid or a gas which results in the rise of magma through the mantle and into the crust, thereby forming an oceanic ridge (Greene, 1998).

OBJECTIVES: Students will be able to:
1. Create a model demonstrating the moving plates in the lithosphere.
2. Draw diagrams explaining plate movements and changes.

MATERIALS: (Per group of four students)
- Beaker, 400 ml
- Hot plate (or Bunsen burner, ring stand with "O" ring and clamp, and wire gauze square)
- Approximately one handful of small paper circles from a hole-hunch
- Water
- A copy of Master 3.1a, *The Inner Earth from Jason VI: Island Earth,, Hawaii Expedition Curriculum*

ACTIVITY: Note: The teacher will very carefully (wearing safety goggles and using appropriate gloves) demonstrate the activity to the students prior the students performing the activity.
Note: Students will also wear safety goggles and use appropriate heat-resistant gloves.

1. Students will fill beakers with 200 ml of water.

2. They will place the hole-punch circles into the water.

3. Then, place the beakers on hot plate or on the gauze squares held in the "O" ring clamps attached to their ring stands.

4. If using Bunsen burners, students will light them and bring the water to near-boiling students should extinguish the flame (turn the gas off).

5. Students will then observe the behavior of the hole-punch circles.

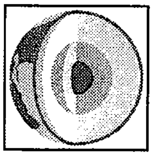
6. Students will draw diagrams to use in their explanations of how the hole-punch circles moved.

POSSIBLE EXTENSION:

1. Using Styrofoam® balls, student groups could construct models of the layers of the Earth by cutting away one quarter of the ball, researching the thickness of each layer, and painting in each layer down to the core. The layers could then be keyed and labeled.
2. Student groups could create charts to accompany the Styrofoam® models in extension They should research the physical layer, the chemical layer, the depth below the sur face, and the temperature and phase of each layer in a manner consistent with the chart given on page 118 of *Jason VI: Island Earth, Hawaii, Expedition Curriculum.*
3. An appropriate extension of this lesson would be the "Hot Spots" lesson which follows the above lesson on convection currents. It is described on pages 126-127 of the *Jason VI Curriculum* and involves passing out Master 3.1b, *Hot Spots*, to each group of students. They are to align the arrows and tape the two pages together as indicated on the master and then cut the three windows. To show the action of the hot spot, they are to place the page with windows on top of the left-hand side of the second sheet. Students should align the submerged volcano so it can be seen clearly in the lower window and then carefully move the window sheet to the right. Stress the hot spot is an area in the Earth's mantle where rock from deep in the mantle is brought to the asthenosphere. Here, it melts, creating magma which rises through the lithosphere, reaching the surface and generating a volcanic eruption. When the plate moves, the hot spot may produce a new volcanic eruption and begin to form a new island.

TEACHER EVALUATION:

1. When the water is near-boiling, what happens to the hole-punch circles? (They move in a circular pattern.)
2. Why does this happen? (As the water is heated, it rises. As it gets further from the heat source, it cools and then sinks. The heat again causes the water to rise and the cycle continues. This movement of heat in currents is called convection. The



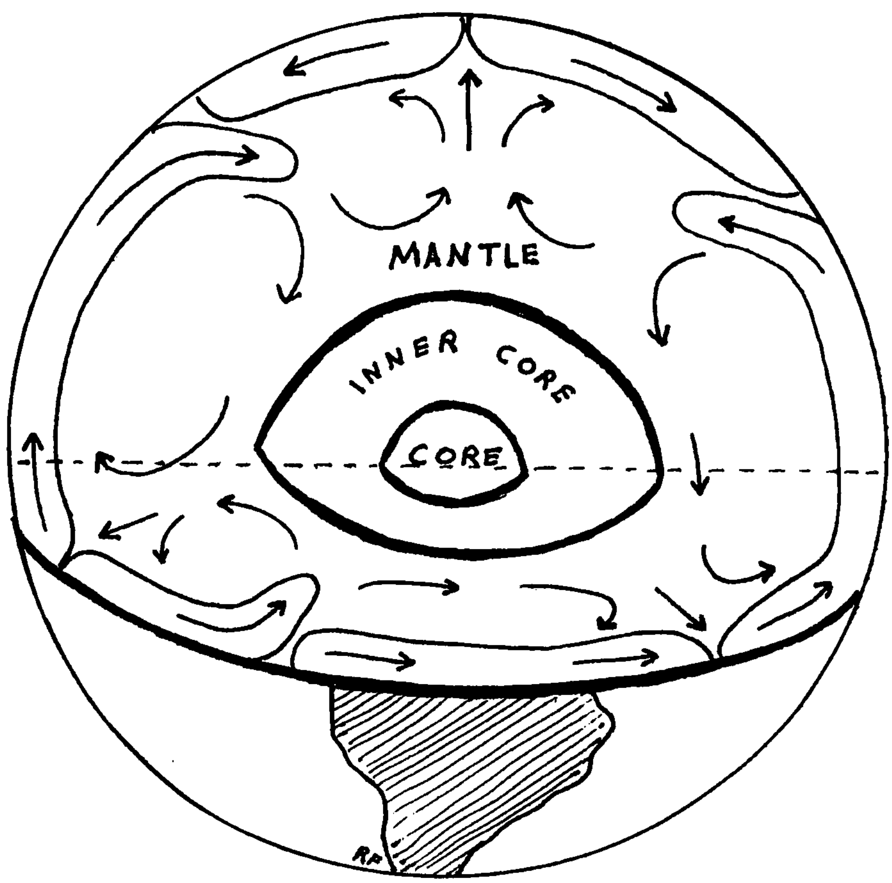
hole-punch circles simply move along with the convection currents as the solid rock does in the mantle.)

3. How does this activity explain what happens within the mantle of the Earth? (This activity shows how heat can create and maintain a convection current.)
4. Have students draw diagrams and make models using index cards to illustrate how the Pacific plate moves. They are to include convection currents and the hot spot under Hawaii.

REFERENCES:

Musgrave, Reuben (Curriculum Editor). JASON Foundation for Education. 1994. *JASON VI: Island Earth, Hawaii Expedition Curriculum.* Pages 117-128. Waltham, MA.

Greene, Thomas F. 1998. *Marine Science.* New York, NY. AMSCO School Publications, Inc.



Earth's Internal Convection Currents

Marine and Aquatic Habitats

TOPIC III

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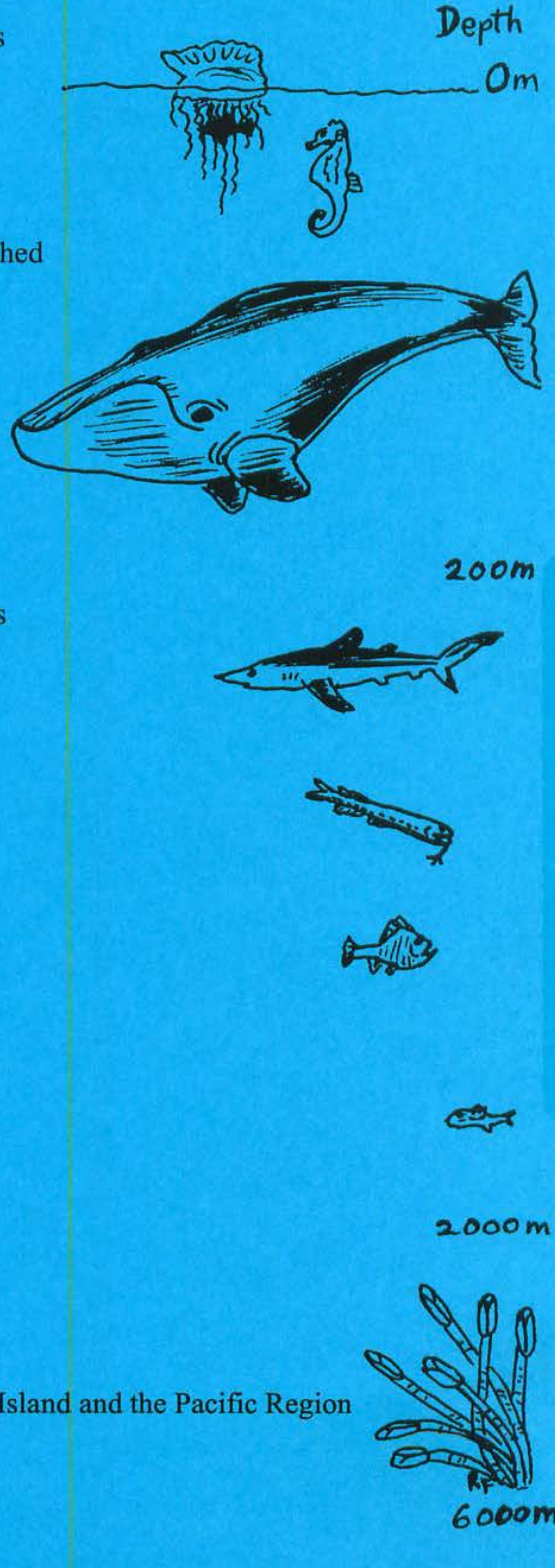

Marine and Aquatic Habitats

INTRODUCTION

Marine and Aquatic Habitats

A habitat is defined as a place where a plant or animal lives, receiving sufficient food, water, and shelter to survive and reproduce. Several factors control the distribution and diversity of organisms in a habitat. These factors may include the amount of light present, the salinity and temperature of the water, food and nutrient availability, and the stability and type of substrate associated with the habitat.

In marine and aquatic ecosystems, there are many varied habitats. However, these habitats may be divided into three general categories: benthic, open water, and shorelines and wetlands. The organisms which inhabit these areas have adapted to avoid predation; to compete for resources; and to survive daily and seasonal stresses occuring from changes in temperature, salinity, and exposure.

The benthic habitat is found at the bottom of a water column. A benthic community may exist in water which is shallow or deep, warm or cold, or dark or illuminated. Benthic habitats include rocky intertidal zones, kelp forests, coral reefs, oyster reefs, deep ocean environments, salt marshes, estuaries, mangrove swamps, and hydrothermal vent communities. The benthos, or bottom dwelling organisms, who live in these habitats have developed certain adaptations to allow them to survive in their respective habitats. For instance, clams, tubeworms, and mussels found in the deep ocean environments have developed a symbiotic relationship with chemosynthetic bacteria. These symbiotic bacteria live inside the host organism and provide it with abundant food in the form of simple sugars in exchange for abundant oxygen, carbon dioxide, hydrogen sulfide, and protection from predators.

Open water is the second general habitat category. Organisms which live suspended in the water column encounter difficulties in maintaining their vertical position in the water, obtaining food and oxygen, and surviving long enough to reproduce. Phytoplankton, tiny one-celled plants, drift near the surface and possess the ability to lift themselves higher in the water column. This elevated position enables them to maximize the amount of sunlight obtained for use in photosynthesis. Phytoplankton form the base for all aquatic and marine food chains. Through photosynthesis, phytoplankton provide 60-70% of the oxygen in the atmosphere, as well as the vast majority of oxygen in the water. Zooplankton feed almost exclusively on phytoplankton and, in turn, are preyed upon by small fish and some large whales and sharks. Fish are the most numerous and diverse of the major vertebrate groups, consisting of over 22,000 species. Whether bony fish such as salmon or flounder, or cartilaginous fish such as sharks or rays, these vertebrates are all dependent upon plankton to turn sunlight into energy for use in their metabolism.

Shorelines and wetlands compose the third habitat category. Rocky shores, sandy beaches or banks along rivers, lakes and oceans, estuaries, mangrove swamps, and salt marshes are all examples of habitats within this category.

The rocky shore proves to be a very harsh environment in which to live. Wave action can dislodge plants and animals clinging to the rocks. Freshwater input from rain, increasing water temperatures, and the effects of desiccation (drying out) in the upper tidepool can result in death or shock to many tidepool inhabitants. However, rocky shores represent one of the most diversely populated habitats as they receive nutrients from both the land and the sea. Abundant food and shelter may be obtained in the rocky shore habitat, making it a desirable place to live for many organisms.

Salt marshes, with their abundant grasses, are among the world's most productive areas. Seventy to eighty percent of all coastal organisms, including many commercially important species, rely upon the salt marsh for some part of their life cycle. Marshes serve as nursery areas for juvenile organisms, as buffers against storms for inland areas, as natural filters for the marine environment, and as resting places for many species of migratory birds.

Mangrove swamps represent the tropical equivalent of temperate salt marshes in that they provide abundant nutrients for resident plants and animals. The root systems trap sediments, provide shelter to many organisms, and build barriers to protect coastal communities.

Freshwater wetlands are dominated by grasses and herbaceous, woody vegetation. Standing surface water or saturated soils are generally present in a wetland, year-round. The wildlife indigenous to a freshwater wetland is quite diverse. For instance, red-winged blackbirds breed and nest in cattail marshes. Wading birds such as bitterns, herrings, rails, and snipes enjoy feeding in freshwater wetlands. Beaver, muskrat, and other small mammals, as well as large numbers of aquatic insects reside in freshwater wetlands. Snakes, fish, and amphibians live in swamps and bayous, feeding on the abundant insects and small mammals.

Habitat loss is a primary concern of scientists, environmental organizations, and many federal and state agencies. Constant encroachment by humans has resulted in the loss of a large percentage of freshwater wetlands and salt marshes. One hundred and five million acres of wetlands exist in the United States today, which represents only one half of the acreage present during the Revolutionary War. By the year 2000, it is estimated that at least 70% of the human population will live close to a body of water.

In order to curb the high rate of habitat loss and degradation, Congress passed the Coastal Zone Management Act (CZMA) in 1972. This Act establishes a national policy to "preserve, protect, develop, and where possible, to restore or enhance the resources of the Nation's Coastal Zone for this and succeeding generations" and to "encourage and assist the states to exercise effectively their responsibilities in the Coastal Zone through the development and implementation of management programs to achieve wise use of the land

and water resources of the Coastal Zone..." [16 U.S. C.1452, sec. 303 (1) and (2)].

Also, in 1972, Congress passed the Clean Water Act (CWA). This act was designed to restore and maintain the quality of United States' waters. The CWA regulates the discharge of pollutants into United States' waters from any point source which includes stormwater drainage systems, industrial facilities and sewage treatment plants. The CWA requires states to develop water quality management plans which regulate nonpoint source pollution. Within the Act are provisions which require oil and hazardous substance spills in or near waterways be reported and cleaned. Permits for activities which might adversely affect wetlands are required under the CWA.

National Parks, wildlife refuges, marine sanctuaries, wilderness areas, nature preserves, and national seashores are designed to protect environmental and natural resources. These areas also set aside and protect important habitats for many organisms.

It is imperative habitat research continue and data be collected and interpreted, thereby enabling managers to develop effective strategies for preserving and protecting these fragile areas. It is also essential that our children learn about the important role these habitats play in the environment and the subsequent effects of the loss of these habitats on ecosystems and their inhabitants.

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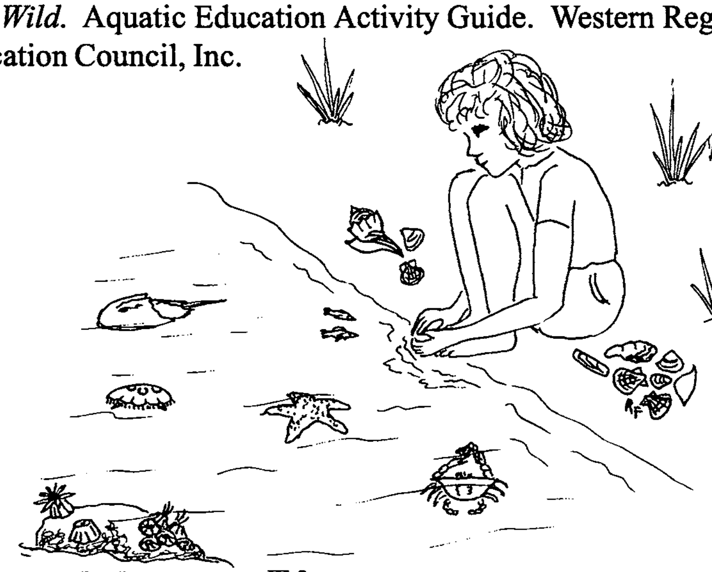


Marine and Aquatic Habitats

TOPIC-TITLE: Marine and Aquatic Habitats - *Benthic BINGO*

AUTHOR: John Jackson

GRADE SUITABILITY: Middle School

SCOPE: Biology

SEQUENCE: Prior to this activity, a lecture on the benthic habitat should be given. The organisms which inhabit the various benthic communities and conditions found in this habitat should also be discussed.

BACKGROUND SUMMARY: The benthic zone is defined as the bottom layer of the ocean. The ocean bottom is home to a diversity of organisms known as the benthos. A benthic community may exist in areas which are shallow or deep, warm or cold, or dark or bright. The organisms found in the benthic zone are directly related to the specific habitat type. Several factors control the distribution and diversity of benthic organisms. These factors include the amount of light, salinity or salt content of the water, temperature, food/ nutrient availability, and the stability and type of substrate associated with the habitat.

Crabs, lobsters, and clams are benthic organisms which may be found in a rocky intertidal habitat. Some near-shore benthic habitats contain seaweeds (non-vascular plants). Kelp is an example of a multicellular seaweed and a representative of the benthic community. This species of seaweed attaches to the bottom via a holdfast, which is a root shaped structure. Other habitats with abundant benthic organisms may include: coral reefs, oyster reefs, deep-ocean environments, salt marshes, estuaries, and mangrove swamps.

OBJECTIVES: Students will be able to:
1. Introduce aquatic organisms of benthic communities.
2. Place marine organisms in the proper community.
3. Define marine terms.

MATERIALS:
- Bingo cards
- Transparency containing a list of terms
- Dry erase markers

ACTIVITY:

1. Give each student one bingo card.

2. Place the transparency containing a list of terms on the overhead projector. Sample terms may include: benthic, wave shock, ahermatypic, red rock crab, barnacles, gulper eels, gas bladders, mangroves, red algae, kelp, kelp crab, tide pool gunnels, and giant kelp.

3. Students will construct their own bingo card by randomly placing words in each block of the bingo card.

4. The instructor will read the definition of each word, and the students will place an "x" or draw a line through the word.

5. Students will use each word only once.

6. a. A bingo occurs when each word is marked out and the words fall diagonally, horizontally, or vertically on the card.

   b. If the words and definitions do not correspond, the line cannot be used again, and the game continues until there is a winner. A winner is the student who accurately matches each definition with its proper term.

POSSIBLE EXTENSION: Using the activity previously described, the instructor could use science bingo as a review for a chapter quiz.

TEACHER EVALUATION: The instructor will evaluate student participation and performance. Each student or cooperative learning group will prepare a journal relative to the concepts and activities learned through Benthic Bingo.

REFERENCES:

Gage, J.D., and Tyler, P.A. 1991. *A Natural History of Organisms at the Deep-Sea Floor*. New York. Cambridge University Press.

Garrison, Tom. 1995. *Essentials of Oceanography*. Belmont, CA. Wadsworth Publishing Company.

Levinton, J.S. 1982. *Marine Ecology*. New York. Prentice-Hall, Inc.

Marine and Aquatic Habitats

TOPIC-TITLE: Marine and Aquatic Habitats - *Journey of a Drop of Water through a Watershed*

AUTHOR: Rita Houghton, Colleen Wilusz, and Christine Yanco

GRADE SUITABILITY: Upper Elementary or Middle School

SCOPE: Environmental Science and Social Studies

SEQUENCE: This activity should follow a discussion on pollution and the hydrologic cycle. A video(s) on pollution and/or water should be viewed prior to implementing this activity.

BACKGROUND SUMMARY: Watersheds are areas of land drained by a stream, river, or river system. Each watershed is separated from another by ridges of high land. Activities by individuals, groups, towns, states, and/or regions affect our supply of water, some of which is the source of our drinking water. Therefore, we must be very careful about what enters our watershed. In New England, town government is the most influential form of government, and town lines often cross watersheds. Often cooperation in the management of watersheds is lacking and we must find ways to clean and/or filter our water before it is consumed.

OBJECTIVES: Students will be able to:
1. Trace the journey of a drop of water through a watershed.
2. Understand why it is important to reduce pollution in an entire watershed, not just the immediate locale.
3. Understand components of a water cleaning system.
4. Identify and understand components of their watershed.

MATERIALS:
- Water in plastic milk jugs
- Spray bottles
- Roller paint trays
- Clay, gravel, charcoal, sand, silt, and small pebbles
- Styrofoam®
- Kool-aid®, used coffee grounds, and powdered chocolate
- Filtering agents: paper towels, coffee filters, fine screening
- Gazeteer® maps of local areas, enlarged and photocopied
- Colored pencils

ACTIVITY:

1. Use a teacher-made model of a watershed to demonstrate the movement of water.

2. With students working as partners or in cooperative learning groups of 3-4, have them trace their journey on a map through a local watershed by locating tributaries, their sources and destinations. (Note: they can outline the watershed, color in the rivers and streams, underline towns, or whatever they deem appropriate).

3. Have students locate high ground and discuss plants, animals, and towns located within the watersheds. Discuss point and non-point (run-off) pollution and where it might occur in the watershed.

4. Have the students construct a model of their watershed (or a portion containing a river or streams) using some of the supplies listed (chocolate for land; kool-aid, soda, and vinegar for chemicals; and coffee grounds for waste).

5. Pour a small amount of water to see how it travels through the watershed. (You can make it rain with one of the spray bottles. Observe erosion and discuss the importance of forests, grasslands, and other ground cover).

POSSIBLE EXTENSIONS:

1. Arrange a visit to the local sewage treatment plant to learn how a combination of settling, filtration, chemical and biological treatment, and composting can assist in making water cleaner.
2. Using LaMotte or other commercial water sampling kits take water samples and test for dissolved oxygen, pH, carbon dioxide, alkalinity, nitrates, and/or other water quality parameters and compare with local, state, or federal records.
3. Write a short story of the progress of a drop of water through the watershed created by the student(s).
4. Choose at least four types of filtering material to test. Devise a simple chart with types of filters on one axis and effectiveness as a filter on the other.
5. Test at least four types of filtering materials placing them so that they filter whatever is "running off" the watershed. Be sure to use the same amount of water to test each filter. Experiment with spray bottle for rain. Graph these results.
6. Have students present their watersheds and filtering results to the class.

TEACHER EVALUATION:

1. Have students create an evaluation card as a group activity, then have the audience use the cards to evaluate the presentations.
2. Pre-and posttests on vocabulary, relationships between plants, animals, soils and water,

effectiveness of filtering materials, and other related differences or similarities.

3. Before making oral presentations, have each cooperative learning group outline its presentation and submit it for comment by the teacher.

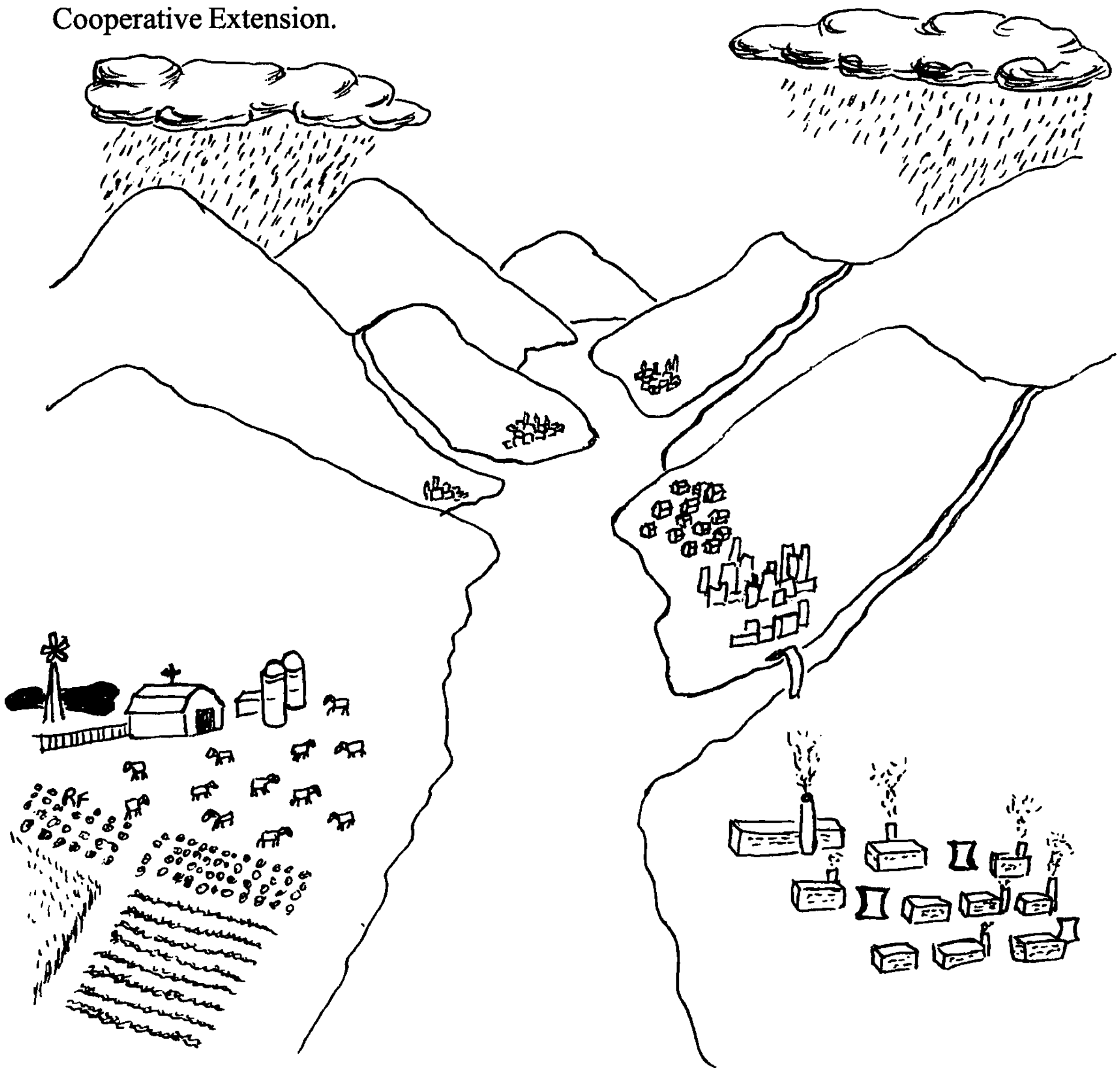
REFERENCES:

Cole, John. 1992. *Magic School Bus Visits the Waterworks.*

Slattery, Britt E. 1995. *WOW! The Wonder of Wetlands.* St. Michaels, MD. Environmental Concern Inc. and The Watercourse.

Sumich, James L. 1984. *Biology of Marine Life.* 3rd Ed. Dubuque, IA. Wm C. Brown Publishers.

Watershed Education Notebook. 1995. Durham, NH. University of New Hampshire Cooperative Extension.



Marine and Aquatic Habitats

TOPIC-TITLE: Marine and Aquatic Habitats - *Aquatic Animals*

AUTHOR: Yvonne Coppola

GRADE SUITABILITY: Upper Elementary

SCOPE: Biology

SEQUENCE: This activity should follow a discussion on the various marine and aquatic habitats. A video(s) on several of these habitats would enhance this discussion, allowing students to actually view the important aspects of these habitats.

BACKGROUND SUMMARY: While many students are curious about marine and aquatic animals, very few are knowledgeable about the components of habitats which are essential for survival. There are certain physical requirements that must be met for each life form. These conditions may include food and nutrient availability, salinity, pH, dissolved oxygen, shelter, aquatic space, and temperature.

OBJECTIVES: Students will be able to:
1. Understand the importance of marine or aquatic habitats.
2. Investigate habitat characteristics and conditions required by various organisms to ensure survival.
3. Conduct library research and introduce students in the use of field guides and other resource materials.

MATERIALS:
- Index cards with of animals names
- Art supplies (paints, brushes, and colored construction paper)
- Field guides and other reference materials
- Clay
- Cardboard
- Boxes
- Pan
- Sponges

Marine and Aquatic Habitats

ACTIVITY: The class will be divided into cooperative learning groups of two. Each group will select an animal to study and will design an artificial habitat in which this animal could live. They will be expected to conduct library research or consult reference materials to determine the requirements of their life form. They must investigate and establish the characteristics of the natural habitat of the animal. When the research is complete, each student team will build a model of the animal's habitat. Once the models are complete, each team will report to the class. Each report should include a description of the basic biological needs of the animal, as well as a description of the characteristics of its natural habitat. Each group will be asked to summarize the habitat components that seem to be necessary for the survival of the aquatic animal they studied (food, shelter, and space).

POSSIBLE EXTENSION:

1. Visit an aquarium or pet shop to observe habitats and basic requirements to sustain animals in healthy environments.
2. Have a discussion of the reasons for and against keeping wildlife in captivity.
3. Have a lesson on endangered species of your area.
4. Discuss the ramifications to each student's animal if the conditions of its natural habitat were altered.

TEACHER EVALUATION: Students' projects and oral reports will be evaluated for presentation, content, originality, and accuracy.

REFERENCES:

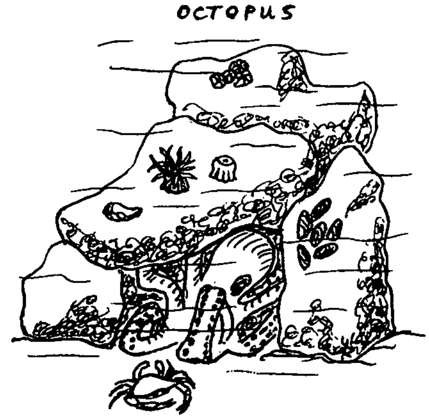
Castro, Peter and Michael E. 1992. *Marine Biology*. Dubuque, IA. Wm C. Brown Publishers.

Greene, Thomas F. 1998. *Marine Science*. New York, NY. AMSCO School Publications, Inc.

United States Environmental Protection Agency. 1993. *Earth Day Teacher's Kit.*

Manatee or Seacow

OCTOPUS



TOPIC-TITLE: Marine and Aquatic Habitats - *Critters of the Water*

AUTHOR: Eileen Gray, Ann Alexander, Tina Darling, and Nelda Sharkey

GRADE SUITABILITY: Middle School

SCOPE: Biological Oceanography

SEQUENCE: A lecture regarding marine and aquatic organisms should be given prior to this activity. A video of marine ecosystems may be shown to enhance the information provided in the lecture. Students will then create an imaginary organism capable of surviving in a marine or aquatic habitat.

BACKGROUND SUMMARY: Immense diversity and variation occur among life forms inhabiting the marine and aquatic habitats of this planet. Since the beginning of life three billion years ago, oceans have provided a variety of habitats for many organisms. Location of habitat (benthic, pelagic, abyssal, mid-depth, or euphotic), type of life style (planktonic, nektonic, benthic/burrowers), and type of feeder (autotrophs or heterotrophs, such as filter feeders, herbivores/grazers, or carnivores/predators) have effects on the physical composition of organisms. Water communities include: freshwater (streams, lakes, ponds, rivers, wetlands- swamps, and marshes); brackish water (estuaries, wetlands, mangroves, swamps, and marshes); and marine waters (oceans and seas). Man's manipulation of environments including pollution, alteration of habitat, and introduction of exotic species causes stress and changes in these biological communities.

OBJECTIVES: Students will be able to:
1. Study different organisms in various aquatic/marine habitats.
2. Investigate what adaptations have been acquired to allow these organisms to survive in their respective habitats. Adaptations may include: method of feeding, location within the water column, type of locomotion, predation avoidance, and life styles.
3. Create an imaginary organism and describe its life cycle and ecological niche.

MATERIALS:
- Paper and pencil
- Scissors
- Rulers
- Knife
- Glue
- Glue gun
- Rubber bands
- String, assorted
- Tape
- Clay
- Recyclable materials such as: fabric scraps, colored paper, cardboard, shoeboxes or smaller boxes, yarn, , ribbons, buttons, and marking pens

Marine and Aquatic Habitats

ACTIVITY: After having researched different marine and aquatic organisms and their habitats, student teams will design and build an imaginary marine organism using the materials listed and describe how it has adapted to its niche. Teams will present their organism to the class and explain how it survives in its environment.

POSSIBLE EXTENSION:

1. Develop a ***Go Fish*** card game following these instructions: students can make a set of index cards with pictures of actual marine organisms (plant and animal) which fit in the different life-styles, methods of feeding, and habitat location within the marine environment. Each team should have 48 cards. Students will play ***Go Fish***. However, when asking for an organism, they will describe a trait unique to certain organisms (habitat location, feeding method, or life style). Note: If time is critical, then the instructor can have sets of cards pre-made. Have enough sets for four-member teams within one class.
2. A ***Marine Bingo*** game can be created by adapting the instructions given in ***Benthic Bingo***.
3. Use ***Go Fish*** cards and play Concentration. You should have two identical cards within the deck for each organism selected. Use 36 cards (18 different organisms).
4. Create an imaginary habitat or build one to fit the imaginary organism you designed.
5. Videotape the presentations and show to the class after all teams have given their oral presentations.

TEACHER EVALUATION: Anecdotal records of student enthusiasm and participation (observe percent involvement of class). Note any modifications (both student and teacher) that should be made for future presentations. Use of several different teaching methods will meet the needs of all learning styles.

Student Performance:

1. The cooperative learning group's imaginary organism presentation will be evaluated for creative design and description of the appropriate adaptation to niche.
2. Interaction of students within cooperative teams will be self-evaluated by the team and by the teacher.
3. The student's ability to follow instructions of the game and to cooperatively play with good sportsmanship will also be evaluated.

REFERENCES:

Gosner, Kenneth L. 1978. *A Field Guide to the Atlantic Seashore.* Boston, MA. Houghton Mufflin Publishers.

Kells, Valerie. 1991. *Sea Life Stickers in Full Color.* New York, NY. Dover Publications, Inc.

Lippson, Alice Jane and Robert L. Lippson. 1997. *Life in the Chesapeake Bay.* 2nd Ed. Baltimore, MD. John Hopkins University Press.

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Musgrave, Reuben (Curriculum Editor). JASON Foundation for Education. 1991. *JASON VI Island Earth Hawaii Expedition Curriculum.* Waltham, MA.

Slattery, Britt E. 1995. The Wetland Community in Wow! *The Wonders of Wetlands.* St. Michaels, MD. Environmental Concerns, Inc. and The Watercourse.

Smith, Deboyd L. 1977. *A Guide to Marine Coastal Plankton and Marine Invertebrate Larvae.* Dubuque, Iowa. Kendall/Hunt Publishing Co.

Thurman, Harold P. 1991. *Introduction to Oceanography, 6th edition.* New York, NY. Macmillan Publishing Co.

Virginia Sea Grant Advisory Program. *Invasion of Exotic Species Stop the Zebra Mussels.* Activities and Resources; Grades 8-12. Gloucester Point, VA.

Zim, Herbert S. 1991. Golden Book Field Guide Series. *Life in the Seashore.*

Zim, Herbert S. 1962. Golden Book Field Guide Series. *Life in the Shells.*

Zim, Herbert S. 1987. Golden Book Field Guide Series. *Birds.*

Zim, Herbert S. 1987. Golden Book Field Guide Series. *Saltwater Fishes.*

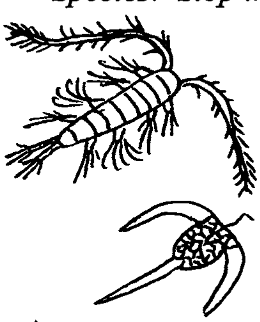
Audio-Visuals:

Videos: *Coral Reef*

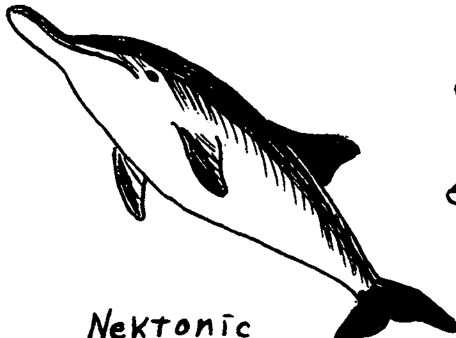
Videos: Craig Carey. Actual *Alvin* tapes and tapes on hydrothermal vents. College of Marine Studies. University of Delaware.

Video: Delaware Sea Grant Program. *The Horseshoe Crab.* University of Delaware.

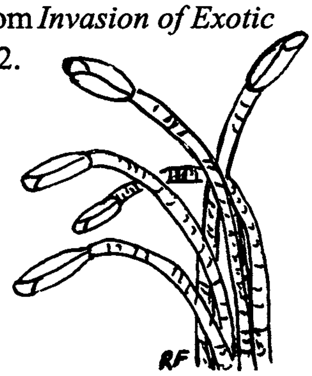
Videos: Virginia Sea Grant Advisory Program. Zebra Mussel from *Invasion of Exotic Species: Stop the Zebra Mussel.* Gloucester Point, VA 23062.



Planktonic



Nektonic



Benthic

Marine and Aquatic Habitats

TOPIC-TITLE: Marine and Aquatic Habitats - *How About a Little Give and Take?*

AUTHOR: Eileen Gray, Ann Alexander, Tina Darling, and Nelda Sharkey

GRADE SUITABILITY: Middle School

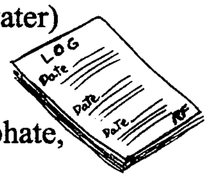
SCOPE: Chemical and Biological Oceanography

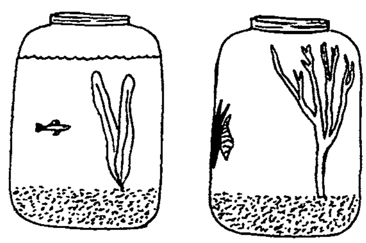
SEQUENCE: Photosynthesis and respiration including the overall chemical reactions and organisms involved in these processes will be introduced. Discussion will include how organisms impact one another and utilize the abiotic elements such as phosphates, nitrates, carbonates, carbon dioxide, and oxygen. Interactions between marine and terrestrial systems will also be discussed. (Be sure to include coral reefs).

BACKGROUND SUMMARY: Abiotic or non-living factors of a marine or aquatic ecosystem may include nutrients such as nitrogen and phosphorus, dissolved oxygen, and carbon dioxide. Unbalanced systems only include plants, such as algae, or animals. Balanced systems include both plant and animal components. Balanced ecosystems require equilibrium between reactions of photosynthesis and respiration. Interactions between the various components of a balanced system are examples of biotic factors.

OBJECTIVES: Students will be able to:
1. Design a closed system to test the relationships between plants and animals.
2. Use a chemical test kit to monitor abiotic fluctuations within this living system.
3. Observe how living organisms respond to fluctuations in abiotic factors.

MATERIALS:
- Quart or gallon jars (all same size, preferably with lids)
- Algae and/or aquatic plant
- Fish or water snail
- Phosphorus and nitrogen fertilizer and an analytical balance (if solid fertilizer is used)
- Sand or gravel
- Unchlorinated, aged water (stream, lake, or estuarine water or stabilized aquarium water)
- Graduated cylinder
- Bromothymol blue
- Hach or LaMotte test kit (nitrate, phosphate, dissolved oxygen, pH)
- Thermometer





ACTIVITY: The tasks of the cooperative learning groups will be to design a closed system and research and discuss the viability of such a system using the scientific method of inquiry.

During a 10-14 day period students will:

1. Monitor, observe and record in a journal fluctuations of one biotic factor.

2. Monitor, observe and record in a journal changes of one abiotic factor.

3. Measure and record initial and final levels of abiotic factors.

4. Illustrate the research and results by sketching and labeling the setup (control and experimental).

5. Design and use a chart to record daily observations.

POSSIBLE EXTENSION:

1. Investigate and discuss the design of the Biosphere Project.
2. Investigate and discuss the requirements and design of a space station.
3. Investigate and discuss the requirements and design of a long-term underwater habitat.
4. Investigate and discuss the requirements and design of futuristic, closed-domed cities.
5. Investigate and discuss the requirements and design of aquaculture.

TEACHER EVALUATION:

- Were objectives accomplished?
- Did students stay on task and work cooperatively? (Students should work in cooperative teams).
- System setup and testing procedure. Journal of events.

REFERENCES:

Castro, Peter and Michael E. 1992. *Marine Biology.* Dubuque, IA. Wm. C. Brown Publishers.

Ross, David A. 1982. *Introduction to Oceanography.* 3rd Ed. Englewood Cliffs, NJ. Prentice-Hall, Inc.

Thurman, Harold V. 1991. *Introduction to Oceanography,* 6th Ed. New York, NY. Macmillan Publishing Co.

Marine and Aquatic Habitats

TOPIC-TITLE: Marine and Aquatic Habitats - *Collecting Field Trip*

AUTHOR: Joan Barle and Jolene Landner

GRADE SUITABILITY: Middle School

SCOPE: Marine Habitats

SEQUENCE: A discussion of local marine habitats and some of the inhabitants should take place before this activity initiates. Information on marine habitats not found in the local area may be given to allow students to compare and contrast all the marine habitats. Students should be given directions relative to the collecting procedures they should follow and the information needed before the field trip is taken.

BACKGROUND SUMMARY: There are many different types of marine habitats such as coral reefs, oyster reefs, deep-ocean environments (hydrothermal vents and cold seeps), salt marshes, wetlands, rocky shores, and/or mangrove swamps. The organisms which inhabit these environments have adaptations which enable them to occupy a particular niche and often survive competition. The increase in human population has led to the degradation and alteration of many organisms' habitats throughout the world. In order to protect and conserve these fragile areas, students must be informed of the functions and importance of habitats and the organisms therein.

OBJECTIVES: Students will be able to:
1. Identify and describe each marine habitat.
2. Name some of the organisms that are found within each marine habitat.
3. Gain an awareness of protecting marine habitats.

MATERIALS:
- Journal or notebook
- Pencils
- Field guides and other reference materials
- Zip-lock® bags to collect non-living specimens

ACTIVITY:
1. Students will research select marine habitats and associated flora and fauna located near the area in which they live.

2. Students will then go on a field trip to one of these habitats. While in the field, students will be grouped into cooperative learning teams. Each team will describe the area and record observations in a journal. Students will collect at least three specimens (keeping only non-living specimens). They will identify, classify, and describe the physical characteristics of each specimen. Description and classifications should also be recorded in students' journals. If possible, drawings or pictures of living specimens should be included.

3. Each group will meet after the field trip to consolidate their data and discuss what they have collected.

4. Each group will then present their results to the class.

5. In each group's presentation, students should address the following questions:
   a. What type of habitat did you visit?
   b. What organisms did you find?
   c. Would you find these same organisms in another type of habitat?
   d. If transported to a different environment, would the organisms survive- describe why or why not?
   e. What type of human actions would affect these organisms and habitats?
   f. Describe the effects of these human actions on the organisms. (For example, dredging of channels, point and non-point source pollution, or the filling of salt marshes).
   g. What can be done to preserve and protect these organisms' habitats?

POSSIBLE EXTENSION:

1. Have students visit a different habitat and compare and contrast this habitat and its associated flora/fauna with the habitat they researched.
2. Have students visit an aquarium and describe the environments they observe and the interaction between the organisms and the simulated environment.

TEACHER EVALUATION: The instructor will evaluate the oral presentations and students' journal. Evaluations of the oral presentations should consider the number of questions addressed, the accuracy of content, and the presentation style.

REFERENCES:

Greene, Thomas F. 1998. *Marine Science.* New York, NY. AMSCO School Publications, Inc.

Castro, Peter and Michael E. 1992. *Marine Biology.* Dubuque, IA. Wm. C. Brown Publishers.

Marine and Aquatic Habitats

TOPIC-TITLE: Marine and Aquatic Habitats - *Estuaries, Estuarine Habitats, and Adaptations*

AUTHOR: Eileen Gray, Ann Alexander, Tina Darling, and Nelda Sharkey

GRADE SUITABILITY: Middle School

SCOPE: Earth Science and Management and Biological Oceanography

SEQUENCE: As part of a unit on habitats, a lecture focusing on estuaries may be developed. Videotapes such as *"Finite Ocean"* can be shown to enhance the lecture and inspire students' enthusiasm. Students will have the opportunity to augment their knowledge regarding estuaries through research, discussion, and by building a model illustrating estuaries and the role they play in our environment.

BACKGROUND SUMMARY: An estuary is an area where fresh water mixed with salt water acts as a transition zone between these two ecosystems. In contrast to other transitional areas, estuaries have a limited number of permanent residents due to the physical and chemical characteristics of this habitat. Although few different species exist permanently in estuaries, they are among the most productive ecosystems on the planet. For example, in some estuaries, one acre of estuary can annually produce ten tons of plant and animal life.

OBJECTIVES: Students will be able to:
1. Illustrate an estuary by designing and building models.
2. Explain how the physical characteristics of estuaries can create a stressful environment for organisms.
3. Create a diagram to illustrate an estuarine food web.

MATERIALS:
- Clear loaf pan
- Blue and yellow food coloring
- Masking tape
- Pencil
- Sand
- Plastic aquarium
- Plants (to represent vegetation)

ACTIVITY:

1. Cooperative learning groups of four to five students each will be involved in this activity and each group will be responsible for one of the following topics:
   - Estuarine organisms and their adaptations to estuarine life (tolerances to this environment).
   - Ecology of estuaries to include productivity, organic matter, food sources, and an example of a food web.
   - Environmental characteristics-include estuarine circulation, mixing fresh and salt waters (stratification and homogeneous mixing) and upwellings (develop a laboratory exercise to illustrate upwellings).
   - Physical characteristics of estuaries-salinity, wave actions and currents, substrate, turbidity, temperature, and oxygen.

2. Each of the topics listed in #1 will be researched within a group and the results will be incorporated in each group presentation.

3. Each group will work together to design and build a model using the materials listed which illustrates an estuarine environment.

4. Groups will develop and demonstrate a method to show how fresh and marine waters mix.

5. Each group will complete the following:
   - List and define several different types of estuarine ecosystems.
   - Explain how environmental changes can quickly alter an estuary.
   - Explain the importance of estuaries as nursery grounds.

POSSIBLE EXTENSION:

1. Determine sources of pollution and their effects on the estuarine environment.
2. Investigate the work of Ducks Unlimited, the Sierra Club, or other land or ocean trust organizations in preserving the estuarine systems.
3. Investigate whether your state or local area has any laws designed to protect estuaries.
4. Investigate an estuary either by visiting it or by computer-World Wide Web.
5. Using the following idea, discuss how everyone can be involved in improving environmental conditions: Ocean Heroes-The California Based Surfer Foundation is no ordinary bunch of surfing dudes. They include lawyers and professors who got the EPA to require pulp mills to prove discharges are safe to marine life without using dioxin to produce chlorine. Research how this may have happened.

6. Play "Hydropoly-The Game of Wetlands Management and Economics" (pp. 129-132, Wow! The Wonders of Wetlands) and the Role Playing Game.
7. Develop a model comparing paved surfaces versus marshes. In two pneumatic troughs, put solid, nonporous substrate in first and astroturf to represent spongy material in second. Measure the muddy water (200ml) which is to be put into the system at top of slope and measure the amount of liquid which comes through the substrate, as well as the turbidity of the liquid which has passed through the substrate.

TEACHER EVALUATION: Determine if all teaching objectives were met by the cooperative learning groups.
1. Did all students contribute to group activities?
2. Were students able to accomplish lesson goals?
3. Based on Student Performance:
   - Observe student groups as they work.
   - Grade model of estuary by determining if all components have been included, such as biotic and abiotic interactions and the food web.
   - Observe students' remarks in the model demonstrations and presentations.
   - Test students on concepts.

REFERENCES:

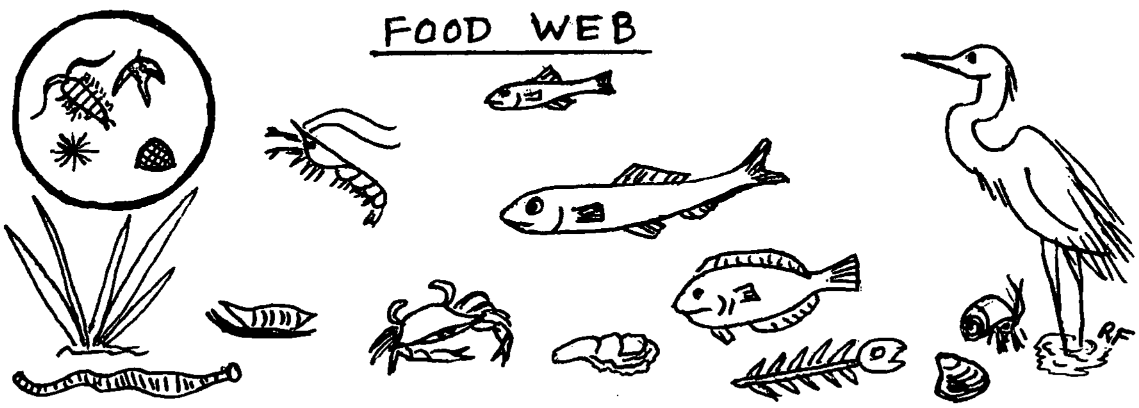
National Science Teachers Association. *Physical Oceanography* (Project Earth Science).

Nybakken, James W. 1988. *Marine Biology An Ecological Approach.* 2nd Ed. New York, NY. Harper and Row.

Slattery, Britt Eckhardt. 1995. *Wow! The Wonders of Wetlands.* Environmental Concern Inc. and The Watercourse. pp. 123-128.

Thurman, Harold V. 1991. *Introduction to Oceanography*, 6th Ed. New York. Macmillan Publishing, Co.

Video:
Finite Oceans.



TOPIC-TITLE: Marine and Aquatic Habitats - *Diversity and Adaptations*

AUTHOR: Cynthia Louden, Carolyn Elliott, Karen Jardine and Kimberly Dernowski

GRADE SUITABILITY: Middle School

SCOPE: Biological Oceanography

SEQUENCE: This activity could be used to introduce biodiversity in the oceans or marine life and the relationship of biodiversity to environmental conditions. The instructor may want to introduce the unit by showing the students some pictures of different organisms which live in the ocean. Instructors could also provide students with live or preserved specimens. If a video is available, the instructor may choose to show it to enhance the unit. The teacher will need to explain the directions and offer guidance to the students. The teacher should give a pretest to determine the knowledge of the students. The classroom should be divided into cooperative learning groups. The students who have some prior knowledge about the subject should be distributed among different cooperative groups.

BACKGROUND SUMMARY: Open ocean or pelagic organisms live in four major biozones known as the epipelagic, mesopelagic, bathypelagic, and abyssopelagic zones. Several scientists define these zones with the following depths: the epipelagic zone (0-100 meters) is the zone in which sufficient light penetrates to allow photosynthesis. The mesopelagic zone extends from depths of approximately 200 meters to 1000 meters. The bathypelagic zone extends from 1000 meters to 3000 meters and the abyssopelagic zone extends from 3000 meters to the bottom. The physical environment of these zones varies with the availability of light, oxygen and food resources, pressure levels, and temperature. These physical factors allow a great diversity of organisms. Some organisms may be found in only one zone, while others inhabit more than one zone.

Under these varying conditions, marine organisms have adapted and survived. To survive, these organisms must secure food, avoid predation, and successfully reproduce. Adaptive features may include size, coloration, defensive and reproductive strategies, bioluminescence, and specialized teeth and jaws. Due to the limited amount of food in the lower zones, larger organisms tend to live in the upper zones, while those organisms living in deep water tend to be smaller in size.

Marine and Aquatic Habitats

OBJECTIVES: Students will be able to:

1. Identify and diagram the biozones.
2. Discover that organisms have adapted to different biozones.
3. Identify some features that help organisms adapt to certain biozones.
4. Design and manufacture either in a two or three-dimensional model, an organism which lives in one of the biozones.

MATERIALS:

- Paper
- Pencils
- Poster board
- Markers
- Reference material
- Field guide
- Resources for research
- Colored pictures of different organisms (best if laminated so they can be used for more than one class)
- Post-it® glue (so students can change locations)

You may want to include organisms which are not found in the ocean.

ACTIVITY:

1. Divide students into cooperative learning groups of approximately five students.

2. Provide each group with a large poster board or sheet of paper, markers, research material, field guide, or textbook.

3. The students will draw a large diagram of the biozones in their cooperative groups and continue their research and description of the characteristics of each zone.

4. If time permits, allow the different groups to exchange their diagrams and information.

5. The instructor will give each group a variety of organisms based on the organisms's adaptation to the biozones. The groups will discuss the zone in which each organism could live and then place the organism within the correct zone (or zones). Near the end of the period, cooperative groups should discuss their choices with the other groups. Each group will design and construct a replica of its organism including the adaptations the organism has evolved to survive in its environment.

POSSIBLE EXTENSION:

1. The two or three-dimensional organisms the students created could be displayed as an ocean museum.
2. The students could write a story about each of the organisms.
3. The students could design a costume for their imaginary sea organism and have a fashion show with "sea" music. Students could give their organism a scientific name, a biome, and state what it eats.
4. Students could study the origins and meanings of scientific words and names.

TEACHER EVALUATION:

1. Relative to the activity, students could be evaluated by: time on task, feedback, and interest of the students.
2. The teacher should administer a pretest to assess background knowledge and a posttest to assess knowledge gained through the exercise. The pretests and posttests could also be used as components of student performance assessment if desired.
3. The student will design an organism that would live in a certain zone and give it to another student to see if that student can name the biozone in which the organism would live.
4. A rubric can be given in advance and then used as a guide for grading.

REFERENCES:

Text Materials (for both teachers and their students):

Burchett, Michael. 1996. *Biology of Marine Environments, in Sea Life.* (Waker and Geoffrey, Editors). Washington, D.C. Smithsonian University Press.

Nines, Thomas. 1986. *Marine Biology Coloring Book.* The Benjamin Cumming Publishing Company.

Robin, R. C., G. C. Ray, and J. Douglas. 1986. *Peterson Field Guide - Atlantic Coast Fishes.* Boston, MA. Houghton Mifflin Company.

Sumich, James L. 1988. *Biology of Marine Life.* Dubuque, IA. Wm. C. Brown.

Thurman, Harold V. 1986. *Introductory Oceanography.* The Benjamin Cumming Publishing Company.

Zim, Herbert and Hurst H. Shoemaker. 1987. *The Golden Guide - Fishes.* NJ. Golden Press.

Other Resources:

CD-ROM, *Grolier Encyclopedia, Oceans, Fish* (visual).

Marine and Aquatic Habitats

TOPIC-TITLE: Marine and Aquatic Habitats - *Habitats and Deep Sea Environments*

AUTHOR: Penelope Jarvis

GRADE SUITABILITY: Lower Elementary

SCOPE: Environmental Science and Life Science

SEQUENCE: Before teaching the deep ocean environment activities, a unit on coastal processes and barrier island beach dynamics should be completed. A marine and estuarine pollution discussion would follow the deep ocean environment activities.

BACKGROUND SUMMARY: The ocean consists of four zones: the epipelagic (sunlight zone), the mesopelagic (twilight zone), the bathypelagic (midnight zone), and abyssopelagic (bottom zone). Organisms have developed various adaptations enabling them to survive in their respective zones.

OBJECTIVES: Students will be able to:
1. Differentiate between the four zones of the ocean.
2. Understand the diversity.

MATERIALS:
- *The Magic School Bus on the Ocean Floor*
- Copies of the ocean zones view strip (*Nature Scope*)
- Crayons
- Non-pointed scissors
- Clear tape
- Glue

ACTIVITY: Introduce the two week deep ocean environment unit by reading *The Magic School Bus on the Ocean Floor.*
1. Next, the students would participate individually in assembling a view strip of the ocean zones. The view strip should depict different depths and temperatures at which marine plants and animals live. Each marine plant and animal is coded by a number. By looking at a key, children can locate the name or label.

2. After taping or gluing the strip vertically, the students should color each plant and

animal appropriately, following a description of the given organism.

3. The view strips should then be displayed in the classroom and/or placed in each child's desk as a reference throughout the deep ocean environment and marine habitat units.

Note: To enhance the students' experience, Pachabel's *Canon in D* (accompanied by ocean waves) could be played while the students are working.

POSSIBLE EXTENSION:

Students would:

1. Keep a daily oceanographer journal, recording topics of interest, new ideas learned, or questions to investigate as additional research.
2. Create individual or group ocean life murals using watercolors or tempera paint, poster board or construction paper, and materials such as macaroni shells and cereal (Cheerio® and Shredded Wheat®) to provide texture. (The sea animals could be stuffed with newspaper to create a three-dimensional effect.) Each item should be correctly labeled. The murals would serve as a display in the room or as a hallway bulletin board.

TEACHER EVALUATION:

1. Students should be able to correctly identify three to five plants and animals which live in the four zones of the ocean.
2. Creation of the interactive ocean bulletin board with Velcro®-attached creatures could be used as an assessment tool.

REFERENCES:

Sumich, James L. 1988. *Biology of Marine Life.* Dubuque, IA. Wm. C. Brown Pubishers.

DeWall, Marily (Curriculum Director). 1992. *JASON IV Curriculum, Baja California Sur.* National Science Teachers Association. Washington, D.C.

Audio-Visuals:

The Little Mermaid. Pachabel's *Canon in D* accompanied by ocean waves cassette tape (The Nature Company).

Marine and Aquatic Habitats

TOPIC-TITLE: Marine and Aquatic Habitats - *Understanding Estuaries*

AUTHOR: Alice DuBois

GRADE SUITABILITY: Middle School

SCOPE: Life Science and Environmental Science

SEQUENCE: Prior to this activity students should be familiar with identifying and collecting estuarine plants and animals. Students should also understand and be familiar with measurements of turbidity, dissolved oxygen, and pH.

BACKGROUND SUMMARY: Estuaries are nursery grounds for many species including fish, oysters, crabs, and shrimp, and they are some of the most productive ecosystems in the world. Approximately 92 to 98% of the Gulf of Mexico's commercial fish and shellfish rely on the estuarine area for habitat, protection, and food. Today, our estuaries are being destroyed due to natural processes such as erosion, and man-made or anthropogenic causes such as dredging of channels and point and non-point source pollution. The hope for these estuaries rests in educating and fostering stewardship in students regarding the value of these natural treasures.

OBJECTIVES: Students will be able to:
1. Create an estuarine ecosystem in an aquarium.
2. Record daily observations in an aquarium log book.
3. Discuss the interaction of organisms in the ecosystem.

MATERIALS:

Per Group:
- Aquarium (20-gallon)
- Sand
- Gravel, rocks, and larger stones
- Aquarium filter
- Pump
- Aquarium light and lid
- Seine
- Water
- Salt packet
- Two buckets for collection
- Dip net
- Student constructed turbidity chart
- Refractometer
- pH meter or litmus paper

ACTIVITY:

1. The cooperative learning groups will begin constructing their own estuarine ecosystem in aquariums.

2. The students will place sand and gravel on the bottom of the aquariums.

3. After these materials are in place, the students will add water to fill the aquarium to one and a half inches from the top. (Note: this water should have a salinity equal to an estuarine habitat. This salinity can be created by adding pre-packaged salts, pur chased at the pet store, to tap water which has been allowed to stand in plastic buckets for at least two days to eliminate the chlorine. Chlorine levels may be depleted more rapidly and completely by aerating the water in the buckets).

4. The aquarium should be allowed to stabilize for two weeks before adding any plants or animals.

5. The class will take a field trip to an environmental research station to collect live species of plants and animals for their ecosystem. The teachers should stress that students are trying to duplicate in their classroom what they had observed in nature.

6. Review proper collection procedures with the students and note that even though they are collecting specimens, they should take care to do as little harm to the environment as possible.

7. Plant species should be collected from the wetland area and the water. Dip nets and seines should be used as methods to capture fish and various organisms. Driftwood, shells, rocks, and other items can also be collected and placed in the aquariums. Be sure the bucket which contains plants has enough water to keep them moist. The animals collected should be placed in buckets containing water from the environmental research station. If possible, field aerators should be used to increase the survival rate. Caution students to maintain collected water as free of sediment as possible.

8. Upon returning to class, students should gently place organisms in their respective aquariums and make their initial data entries in their aquarium logs.

9. Daily observations should be recorded by students in their aquarium logs to include the following:
   - Description of plants (growth and loss)
   - Number and condition of animals
   - Turbidity (using student-constructed turbidity measurement chart)

- Dissolved oxygen measurements
- pH measurements
- Interactions between plants and animals

POSSIBLE EXTENSION:

1. Graph the data from the aquarium log.
2. Write a story about your estuarine ecosystem.
3. Choose one organism in your aquarium and discuss its role in the ecosystem and how it interacts with other organisms.

TEACHER EVALUATION:

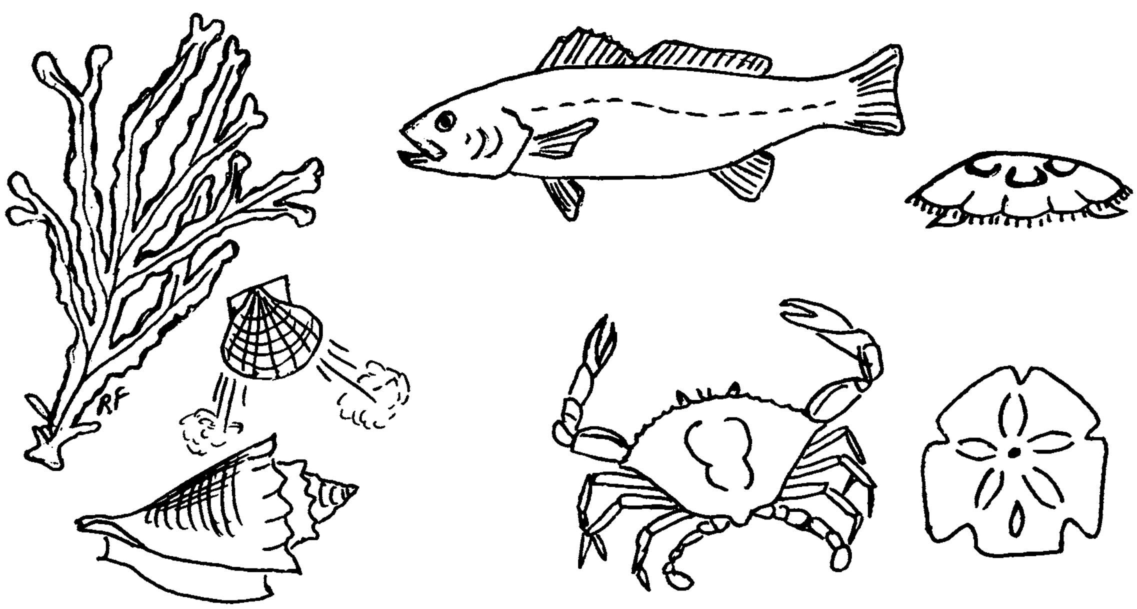
1. The teacher will observe each group's aquarium noting individual student participation and procedures.
2. The student's aquarium log will be graded for adherence to directions and completeness.

REFERENCES:

Greene, Thomas F. 1998. *Marine Science.* New York, NY. AMSCO School Publications, Inc.

U.S. Environmental Protection Agency. 1990. *Gulf of Mexico Program.* GMP-FS-005.

Veal, D. 1993. *Starting and Maintaining a Marine Aquarium.* Mississippi-Alabama Sea Grant Consortium, Mississippi State University. Publication 1287.



TOPIC-TITLE: Marine and Aquatic Habitats - *Marine Ecology*

AUTHOR: Trisha Hembree

GRADE SUITABILITY: Middle School

SCOPE: Marine Ecology - Habitats

SEQUENCE: The students should have completed a brief introduction concerning the diversity and abundance of flora and fauna associated with the marine ecosystem. This activity is intended to be an introduction to a detailed study of the various habitats, as well as the advantages and disadvantages of each habitat. External influences, including human impact, should be included.

BACKGROUND SUMMARY: All organisms on Earth have their own unique specifications and adaptations necessary to live in a specific biological and physical niche. Because these parameters sometimes overlap, competition for space between members of the same and differing species can exist. One result of this competition is the need to increase adaptability to a specific zone.

Animals which are sessile spend part or all of their lives secured to some type natural or man-made substrate (surface). These creatures rely on the sea to bring them food, nutrients, and sufficient oxygen. The food upon which most of these animals depend is plankton (phytoplankton and zooplankton) which is comprised of free-floating, microscopic plants and animals. In the plankton-rich waters of the Gulf of Mexico and the southeastern Atlantic, additional stresses exist such as silting, which smothers the animal; currents, which can remove food sources; submarine lithification, which includes the deposition of carbonate cement grains on the aperture; encrustation by competing organisms; toxic emission of mesenterial filaments from the gut of nearby competing colonies; pollution; over exposure to the sun; eutrophication; algal mats; and/or grazing by larger, swimming organisms.

OBJECTIVES: Students will be able to:
1. Enact the life cycle of a sessile animal.
2. Quantify the possibility of survival under the conditions given.
3. Propose only one, new adaptation in order to increase the chance of survival for each student's animal.
4. Defend that adaptation to the class.

Marine and Aquatic Habitats

MATERIALS:
- Food cards made of 3" x 5" laminated cards to represent the different foods necessary for each animal's survival. Students exhibiting an artistic talent could draw the major plankton.
- A jar or box
- Several handkerchiefs of various colors

ACTIVITY:
1. Prepare the class for this activity by lecturing on all topics listed in the background summary.

2. Have each student select a card from the jar or box which lists the animal he/she should imitate, what that animal eats, what defense mechanisms the animal possesses, and other important aspects of the animal.

3. Position each student according to the animal's position in the ecosystem.

4. With the bag of "food," distribute food at random intervals within the classroom. Be sure to talk to the students at this time, informing them of such alterations as current changes, siltation, or other limiting factors.

5. Organisms who do not obtain sufficient food or who are impacted by an alteration in their habitat will "die." Death of the organism is simulated by placing a handkerchief on the appropriate student's head.

6. Have students evaluate their "health" quantitatively.

7. Have students present their results to the class.

POSSIBLE EXTENSION:
1. Students could research and simulate other sessile animals.
2. Students could research and define the types and amounts of food necessary for certain sessile animals and make the food cards themselves.
3. Students can use their talents to draw or trace their own animals.

TEACHER EVALUATION:

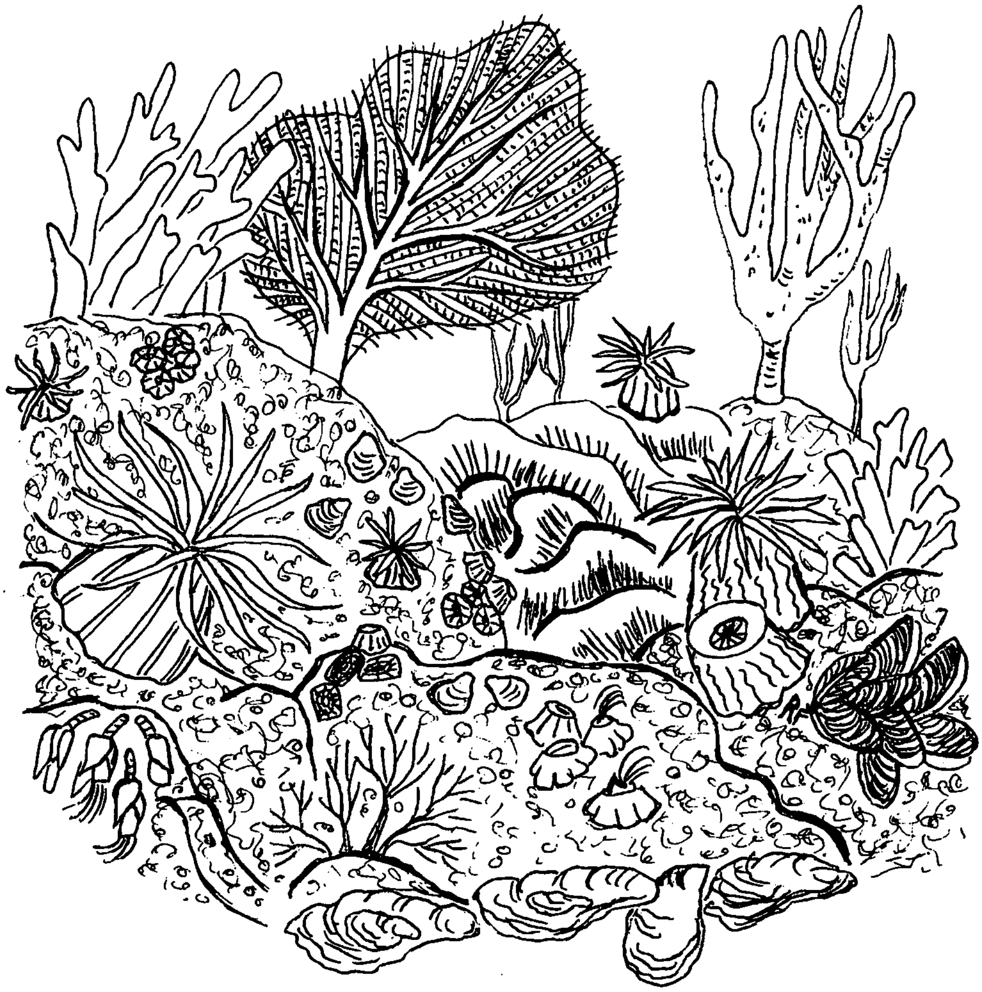
1. Students should be able to present a mathematical evaluation of the usable vs. the nonusable food which they received.
2. Students should be able to propose a probability of survival and defend their results.
3. Students should use correct vocabulary with their defense and present their choice of one additional adaptation.

REFERENCES:

Goreau, T.F; Goreau, N.I.; and Goreau, T.J. *Corals and Coral Reefs.* (This is a copy of an article which the author had for a long time.)

Irby, B.N., McEwen, M.K., Brown, S.A., and Meek, E.M. 1984. *Man and The Gulf of Mexico Series: Marine Habitats.* Mississippi-Alabama Sea Grant Consortium. University Press of Mississippi.

The Puffin Report; Vol 4, No. 2. Baltimore, MD. Department of Education and Interpretation of the National Aquarium.



Marine and Aquatic Habitats

TOPIC-TITLE: Marine and Aquatic Habitats - *Tidal Pools*

AUTHOR: Carina Bautista, Enterina Calro, Angel Hocog, Karness Kusto, Michael Tenny, and Iros Waguk

GRADE SUITABILITY: Middle School

SCOPE: Earth Science - Ecology and Diversity

SEQUENCE: Before teaching this tide pool lesson, students should have an understanding of the importance of the shoreline and the type of habitats which exist adjacent to the coast. They should also have the ability to use thermometers, magnifying lenses, measuring tapes, and maps.

BACKGROUND SUMMARY: The rocky coast habitat is comprised of rocks and can be found in coastal states such as Maine, California, Washington, Alaska, and Hawaii. There are four zones of life in a rocky coast habitat: the upper intertidal, mid-intertidal, lower intertidal, and subtidal (Greene, 1998).

When the tide recedes during a low tide, depressions between rocks may retain water. These areas are known as tide pools. Tide pools contain a variety of organisms such as crabs, small fish, snails, and many types of algae.

The organisms which reside in a tide pool may be subjected to drastic salinity changes due to evaporation or precipitation, changes in temperature from sunlight or precipitation, and desiccation (drying out) when the available water evaporates. The organisms which are found in tide pools are, therefore, uniquely adapted to survive under the harsh conditions of this habitat.

OBJECTIVES: Students will be able to:
1. Gain an understanding and appreciation for the living environments and the interdependence of life, the survival needs of different organisms, and the conditions in a particular area which can affect survival rates.
2. Design and conduct a scientific investigation using appropriate tools and technologies to gather and interpret data.
3. Communicate ideas effectively, using keen observation, measurement, recording, reporting, and active critical thinking and problem solving to ascertain answers concerning tide pools and their inhabitants.

4. Report their observations in an oral presentation.

MATERIALS:

- Thermometers
- Measuring tapes
- Magnifying lenses
- Data sheet for each group
- Reference sources about tide pools
- Pictures of tide pools and marine life

Videos on Tidal Pools:

- *Let's Explore Seashore* (16 min.)
- *Coastline* (28min.).

ACTIVITY:

1. Provide students with background information on the various aspects of the shoreline including tide pools through videos, reference materials, and class discussion.

2. Distribute a data sheet for students to record observations from the video. (See page 36 for a sample data sheet).

3. Explain to the students what exercises they will need to perform when they visit the tide pools. Include information on safety rules and conservation tips for the tide pools.

4. Assign five students to cooperative learning groups. Each member of the group will be given a specific task. Each group requires a leader, two observers, a recorder, and a reporter.

5. Each cooperative learning group should prepare for the field trip by compiling a kit with materials which will be needed for research (thermometer, magnifying lens, and tape measure).

6. While in the field, each group will identify and record various tide pool observations to include the following:
   a. Average depth
   b. Size of the tide pool (length at longest point and average width)
   c. Temperature

Note: All observations will be recorded on the data sheet provided. *(See examples on page 36.)*

7. Students will report their findings to the class in an oral presentation. Oral presentations should include a comparison between the tide pools studied and the organisms present. A description of why tide pools are important habitats and the hardships and/or benefits organisms endure or receive when living in a tide pool should also be included.

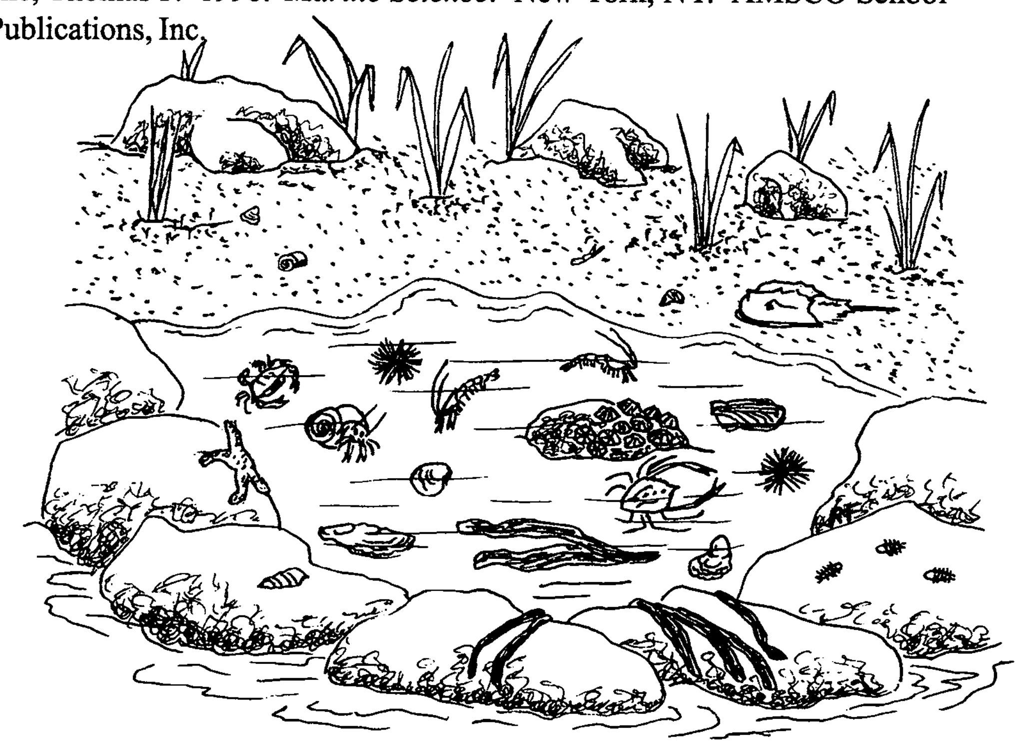
POSSIBLE EXTENSION:

1. Have the students develop a list of conservation tips for tide pools and other marine habitats.
2. As a class, create a tide pool mural incorporating the observations made by each group when in the field.
3. Have students create a mobile or collage of animals and plants they found in the field using drawings or pictures cut from magazines.

TEACHER EVALUATION: Students should be graded on the content of the oral presentations and their ability to work together in a cooperative learning group. Students can rate themselves on what they learned from this experience. (See examples on page 36).

REFERENCES:

Greene, Thomas F. 1998. *Marine Science.* New York, NY. AMSCO School Publications, Inc.



DATA SHEET SAMPLE:

Name:______________________________ Grade:______ Date:__________

Describe the tidal pools as shown in the video.

Description (tidal pools)

1. Draw the different tidal pools you saw on the video.

2. List the various organisms found in the tidal pools.

DATA INFORMATION SHEET

Description of Tidal Pool	Tidal Pool 1	Tidal Pool 2	Tidal Pool 3
Temperature: F_____ C_____			
Depth of water: _____in ____cm Size cm and inches			
Draw the shapes			
Kinds of organisms present 1. 2. 3.			

RATE YOURSELF 5=Excellent 4=Very Good 3=Good 2=Fair 1=Needs Improvement

Check the column of your rating					
1. Identify - describe tidal pools	5	4	3	2	1
2. Conserve tidal pools	5	4	3	2	1
3. Appreciate tidal pools	5	4	3	2	1
4. Exhibit scientific skills	5	4	3	2	1
a. Five senses in observation	5	4	3	2	1
b. Comparing	5	4	3	2	1
5. Record measuring report findings	5	4	3	2	1

Marine and Aquatic Habitats

TOPIC-TITLE: Marine and Aquatic Habitats - *Estuaries are for the Birds!*

AUTHOR: Rodie Higginbotham

GRADE SUITABILITY: Elementary School

SCOPE: Gifted Resources Ornithology Curriculum/Primary

SEQUENCE: Prior to this lesson the students should have completed the following:

- "What Makes a Bird a Bird?"
- "What Kind of Beak is That?"
- "How to Read a Bird," and "Why , Where, and How Do Birds Migrate?"

BACKGROUND SUMMARY: Coastal estuaries perform many functions. Among these functions is the fact that they provide essential habitat for about 75 percent of all the waterfowl which migrate across the United States. Although migratory birds cannot call the brackish water habitat their permanent home, it provides nourishment for their continued existence. Estuaries support large populations of shorebirds, colonial nesting seabirds, and many other bird species.

Southern estuaries supply about half of all the fish and shellfish produced in the United States. Most of these species of fish, shrimp, oysters, and other shellfish spend part or all of their lives in these brackish environments. Many marine species use estuaries as nurseries. These species depend on the different levels of salt concentrations to guide them to and from the nursery areas. Due to the abundance of small fish and other prey, many waterfowl and shorebirds can be found feeding in estuaries.

Freshwater inflow is a critical element in the health of estuaries. Freshwater brings essential nutrients which support the first level (microscopic phytoplankton) of the estuarine food chain. However, too many nutrients can be harmful. Nutrients are found in fertilizers, detergents, sewage, and other substances. Nutrients are carried by rivers, streams, and rainwater into the estuaries. This influx of water can also carry toxic substances and pesticides which can cause immediate death, or these toxins can accumulate in animal tissues. Therefore, some of these toxic substances can place future generations as risk. The effects of this bioaccumlation may be spread throughout the food chain, as predators may consume contaminated food and pass the harmful effects of the contaminant to their offspring.

OBJECTIVES: Students will be able to:

1. Recognize that birds act as indicators of pollution due to their sensitivity to environ mental change.
2. Role play the manner in which marine debris can be hazardous to waterfowl. (This is for the extension activity.)

MATERIALS:

- A small plastic swimming pool
- Gummie® fish (Goldfish® crackers or "Snorklers")
- Drinking straws
- White poster board - cut 3" x 24"
- A hole punch
- Brass fasteners

ACTIVITY:

1. Inform the students who are going to imitate a Great Blue Heron.

2. Explain to the students the Great Blue is a solitary hunter; therefore, there can only be three birds in the estuary feeding at any one time. (This is due to the size of the plastic pool.)

3. Give these three students the rigid drinking straws. Explain that the straw is the Great Blue Heron's beak. Students must spear their food in order to eat. It has been recorded that Great Blues can thrust their beak into the water so fast that it will blur a photograph taken at 1/1000 second shutter speed.

4. Tell the three Great Blue Herons (with beaks) to remove their shoes and place the straw in their mouths.

5. The Great Blue Herons (students) are to step into the plastic pool. They are wading birds so they should stay near the side, which represents the shallow edge of the estuary.

6. Next, place Gummie® fish in the center of the pool.

7. When a sound is made, the Great Blue Herons should begin to feed.

8. The first student to spear a fish with the straw must step out of the pool and say, "yum yum."

9. This student may eat his/her catch (note: provide this and subsequent Great Blue Herons with new, fresh Gummie® fish rather than those Gummie® fish extracted with straws). The other herons must put their food back into the water.

10. This is repeated until one student "catches" three fish.

11. This game can then be played again with three new students until each student has had the opportunity to participate.

POSSIBLE EXTENSION:

1. The students will become Cormorants for the next activity. Give half of the group a brass brad, a hole punch, and a strip of 3" x 24" poster board. Assign partners.
2. Have Commorants (students) secure the strip around their partner's neck with the fastener. (Remember birds do **not** have hands.)
3. At the signal, instruct each Cormorant to remove the plastic debris from their necks. No hands are allowed.
4. After five to eight minutes, repeat the activity with the other half of the class. (It is important to have parental and student permission prior to conducting this activity).
5. Students may research the effects of toxic substances and pesticides used in their homes and report to the class ways in which people can monitor and reduce the use of these substances.

TEACHER EVALUATION:

1. Place the students into three separate groups, those who caught three fish, two fish, and zero or one fish.
2. Give the students who caught three a short eulogy. Tell them they died quickly. Tell the group that caught two fish which contain toxic substances that had accumulated in their tissues so their eggs did not hatch; therefore, their future generations are at risk. No other explanations are necessary. Allow the students to create the script.

REFERENCES:

Fletcher. April. *Freshwater Survival in a Sea of Salt Inflow.* Texas A&M University. Texas Sea Grant College Program.

Williams, Winston. 1987. *Florida's Fabulous Waterbirds.* Tampa, FL. National Art Services.

Marine and Aquatic Habitats

TOPIC-TITLE: Marine and Aquatic Habitats - *Terrestrial Forests vs. Kelp Forests*

AUTHOR: Jim McCurdy

GRADE SUITABILITY: Middle School

SCOPE: Life Science, Marine Science, Ecology, and Environmental Science

SEQUENCE: Students should have some knowledge of the following:

- Habitats
- Niche
- Adaptation
- Zonation
- Food Webs

BACKGROUND SUMMARY: The marine ecosystem known as the kelp forest can be found in cold, coastal waters around the globe. Giant kelp represents brown algae (Phaeophyta) which can reach lengths in excess of 35 meters. Massed strands of these plants have been described as being similar to terrestrial forests, since they provide habitats for species from the benthic zone through the euphotic zone and throughout the canopy at the surface.

Comparing terrestrial forests with kelp forests, in terms of habitats provided for organisms, is a thought-provoking exercise. Starting below the substrate surface in both systems, there are anaerobic conditions, with well adapted bacterial colonies. In the upper layers, there are aerobic bacteria, annelids, and arthropods. At the soil level and up through the plant stems, gastropods are abundant. There are isopods in both environments. There are few marine insects, but crustaceans occupy many parallel niches and habitats in the marine system. In both ecosystems, the dominant plant form provides structure and creates differing light intensities utilized by other plant types, primarily algae on the kelp and mosses, and algae and ferns on large trees.

The main differences in the dominant plant species in these two ecosystems are primarily results of adaptations to the medium (air or water) in which they live. Trees have developed woody trunks to support their weight and resist wind motions. Trees also have vascular tissues to move water and nutrients to their various structural parts. Kelp species, on the other hand, have air bladder floats to support themselves in the water column. Neither system is as productive in terms of biomass production as other systems such as grasslands, salt marshes, and phytoplankton communities. However, larger plants are a concentrated source of nutrients directly preyed upon by many species.

The vertebrate groups in both systems have modified limbs and body shapes (fins and wings) to move through the media associated with these habitats. For instance, bottom

Marine and Aquatic Habitats

dwelling fish have less powerful fins and tails and less streamlined bodies than those which actively move and feed throughout the water column. Ground dwelling birds are another example. They are typically weak flyers and not as streamlined as stronger flying birds such as raptors which feed throughout the terrestrial forests.

OBJECTIVES: Students will be able to:
1. Discuss the concept of habitats and the specificity of habitats, both marine and terrestrial.
2. List similarities and differences in the habitats of a kelp forest and a terrestrial forest.
3. Compare the types of organisms which occupy corresponding types of habitats of the two ecosystems.

MATERIALS:
- Two open top boxes (2' x 2' x 2" work well)
- Modeling clay or Play-Doh®
- Different colors of construction paper
- Glue
- Name tags or labels (may be made from white paper)
- Drawings or pictures of resident species of each ecosystem

ACTIVITY:
1. Inform the students they will be creating two different habitats (kelp forest and terrestrial forest).

2. Have the students begin this activity by removing one side or two adjacent sides of their boxes.

3. Using clay, or a substitute, have the students create a substrate in each box.

4. Have the students cut several paper kelp plants. They should then label and indicate some of the kelps' structural parts (holdfasts, stipes, air bladders, and blades). They should then embed their kelp into the substrate of one box.

5. Now, the students should cut several paper trees. Students need to label and share some of the trees' structural parts (roots, trunks, limbs, and leaves). Students should then embed the artificial trees into the substrate of the other box.

6. A variety of drawings and pictures of different organisms from each habitat should be given to the students.

7. The students will need to identify to which habitat each organism belongs and the ecological zone in which it lives. The students can put these organisms in their models.

POSSIBLE EXTENSION:

1. Discuss the importance of biodiversity in an ecosystem.
2. Discuss the effects of removing a key species from an ecosystem, such as kelp harvesting or clear-cutting forests.
3. Discuss the effects of pollution on these two different habitats.

TEACHER EVALUATION:

1. Students should recognize there are similar habitats and organisms in different environments.
2. The teacher will evaluate individual participation in this activity.

REFERENCES:

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Moore, Hilary B. 1966. *Marine Ecology.* New York, NY. John Wiley & Sons, Inc.

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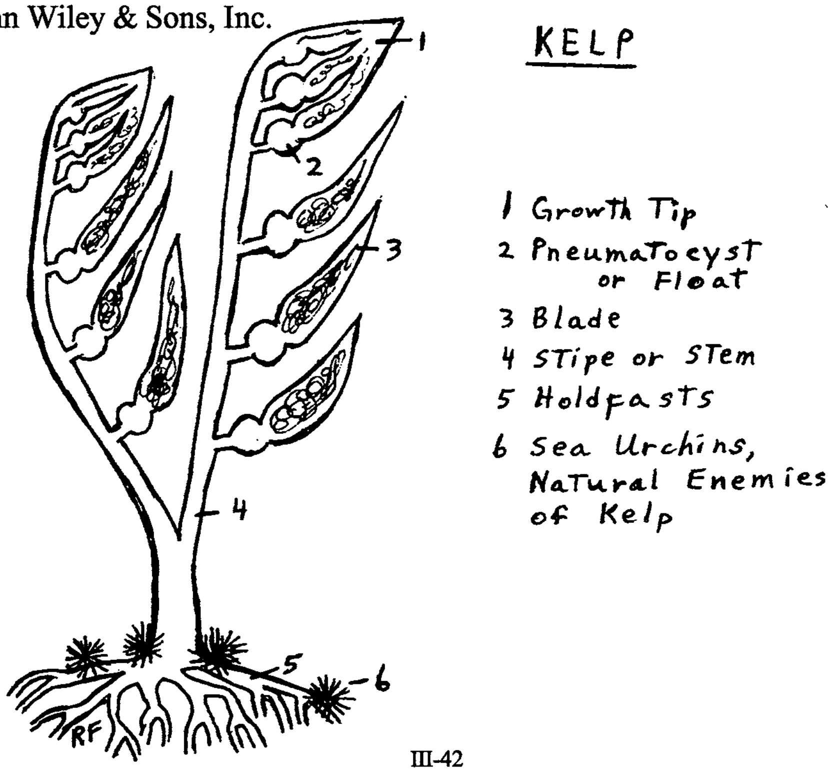


Marine and Aquatic Habitats

TOPIC-TITLE: Marine and Aquatic Habitats - *Walk in the Wetlands*

AUTHOR: Judy Ann Larmouth

GRADE SUITABILITY: Upper Elementary and Middle School

SCOPE: Environmental Education - Habitat Study

SEQUENCE: The students should have completed units on plant and animal life and the "Operation Pathfinder" units on marine and Aquatic Resources and Pollution. A unit on salt water wetlands and life in the oceans should follow this activity.

BACKGROUND SUMMARY: During the earlier part of the 20th century, wetlands were often viewed as a hindrance to expansion and construction. They were perceived as insect infested wastelands which needed to be drained, filled, and covered. Only recently has the public been made aware of the value of wetlands as a means of flood control, nursery areas, and feeding and resting areas for migrating animals, as a means for retaining sediment, and as natural filters.

OBJECTIVES: Students will be able to:

1. Identify the various types of fresh water wetlands.
2. Identify the common animal and plant life in these ecosystems.
3. Understand and appreciate the varied uses of wetlands and the need to protect them.

MATERIALS:

- Modeling clay
- Plastic trays
- Science notebooks
- Florist foam
- Grass and other natural materials
- Field guides, encyclopedias, and other reference materials

ACTIVITY:

1. The class will be divided into cooperative learning groups.

2. The students will conduct research on the four major types of fresh water wetlands.

3. One student in each cooperative learning group will be assigned to become the "expert" on one type of wetland (for example: a marsh expert).

4. All experts representing the same wetland will form a new, temporary group. Students will use the resources listed, encyclopedias, dictionaries, and other media center resources to learn about their wetland.

5. Each member of the temporary group will share their findings with each other and each member will record the information in order to help them remember important facts about the other members' soil, water, plants, animals, and uses of their wetlands.

6. At home, the students will use their notes to prepare a short presentation for their original group. Visual aids such as wetland models may be used.

7. The following day, each group will listen to the presentations by each member of the group.

8. The teacher will circulate among the groups and with them select a representative speaker on each wetland. Students selected will share their presentations with the entire class or other classes.

POSSIBLE EXTENSION:
1. The students will visit a local wetlands and conduct field research.
2. The students will conduct a mock trial similar to the one found in *Nature Scope,* "The Great Swamp Debate."

TEACHER EVALUATION:
1. The students will take pre-and posttests. They will be evaluated on what they have learned.
2. The teacher will evaluate group participation and cooperation.
3. The student will write a letter to a local, state, or federal legislator expressing the need for conservation and responsible management of wetlands and why the student believes this is important.

REFERENCES:
Aquatic Project Wild. 1992. Western Regional Environmental Council.

Challand, Helen J. 1992. *Disappearing Wetlands.* Chicago, IL. Children's Press.

Edelstein, Karen. *Pond and Stream Safari: 4-H Leader's Guide.* Cornell, NY. Cornell Cooperative Extension.

Lepthien, Emilie U. and Kalbacken, Joan. 1993. *A New True Book: Wetlands.* Chicago, IL. Children's Press.

Ranger Rick's Nature Scope: Wading into Wetlands. 1989. Washington, D.C. National Wildlife Federation.

Reid, George K. 1967. *Pond Life.* New York, NY. Western Publishing Company.

Marine and Aquatic Habitats

TOPIC-TITLE: Marine and Aquatic Habitats - *Creatures in the Coral*

AUTHOR: Diane E. Pothast

GRADE SUITABILITY: Upper Elementary and Middle School

SCOPE: Environmental Science and Life Science

SEQUENCE: The unit on coral reefs should be taught as a portion of an ocean habitats theme. The unit will be taught after a background on oceanic characteristics has been established. Each portion of the ocean habitat theme will continue to strengthen previously discussed concepts.

BACKGROUND SUMMARY: Coral reefs are unique habitats as they are constructed entirely by biological activity. Coral reefs are highly productive environments with great diversity. Due to limited space and food, competition in a coral reef is usually intense. Many species have developed symbiotic or commensal relationships with other residents of the coral reef to ensure continued survival. Coral reefs are found in warm, shallow, clear marine waters. Reefs extend to depths of 70 meters in the Caribbean and 150 meters in the Pacific. Depth is limited as the zooxanthellae, living in the stomach lining of the coral polyp, require light. Zooxanthellae are dinoflagellates which coexist in a symbiotic relationship with the coral polyps. The zooxanthellae use the carbon dioxide and nitrogen, produced by the coral polyp as metabolic wastes, for photosynthesis and in exchange, provide the polyp with oxygen and nutrients needed for the coral skeleton.

OBJECTIVES: Students will be able to:

1. Name and describe unique adaptations of organisms which live in the coral reef habitat.
2. Construct a wheel demonstrating the relationships between certain coral reef inhabitants.
3. Read various books pertaining to coral reefs and ocean life.

MATERIALS:

- Construction paper
- Scissors
- Pencils
- Glue
- Paper plates
- Brass Fasteners
- Tape
- Pictures of coral reefs and inhabitant creatures

- Ruler
- Markers
- Dried samples of coral (if available)
- Various books on oceans/coral reefs

ACTIVITY:

1. Introduce coral reefs as habitats by showing pictures and samples of various reefs and their inhabitants to students.

2. In order to build interest and provide background information on a coral reef which is threatened by poisonous waste, read and discuss *The Sign of the Seahorse.* Students may want to role-play their favorite scenes.

3. Introduce the characteristics of coral reefs, creatures, and adaptations which ensure survival. Introduce the concept of "symbiosis," in which some living organisms in the coral reef depend on other living organisms in a very close relationship (food, protection, or shelter). Discuss ways in which people assist each other and relate that to how creatures of the reef help each other.

4. Discuss the characteristics of coral reefs, including symbiotic organsisms living within or on the reef, and their adaptations which enable them to survival.

5. Divide students into cooperative learning groups and distribute task cards.

6. Distribute art supplies and have the students begin constructing a wheel by creating two circles. Circles must be of unequal size, one large and the other small.

7. On the outside of the small wheel have the students draw, cut, or write the names of the following animals:
   a. Clown fish
   b. Zooxanthellae
   c. Coral polyp
   d. Shrimp fish
   e. Clam

8. Utilizing resource books and the textbook, have students determine the symbiotic and predatory relationships of these organisms. Have students place their names on the larger wheel, with the predator/symbiotic pair placed together. Write the name of the symbiotic organism in red and the predator in blue.

9. Place a brass fastener in the center of both wheels. Students can now rotate wheels to match the organism's symbiotic or predatory relationship.

POSSIBLE EXTENSION:

1. Visit an aquarium and research a specific species of coral inhabitant.
2. Make a word search using words related to the coral reef habitat.
3. Write a poem or storybook about coral reef inhabitants, including illustrations.

* Answer key (if needed).

	RELATIONSHIPS	
	SYMBIOTIC	PREDATORY
1. Clown fish	Anemone	Barracuda
2. Zooxanthellae	Coral polyp	Sea stars
3. Coral polyp	Zooxanthellae	Nurse shark
4. Shrimp fish	Sea urchin	
5. Clam	Algae	

TEACHER EVALUATION:

Group:

Students can demonstrate and verbally explain the relationships in the wheel. A group report could be presented to the class.

Self:

Students can complete the following information:

I learned ____

____

I made a wheel which showed the relationship between______________________

____

I read ____

I wrote ____

The best thing about studying coral reef habitats was ______________________

____

Something I still want to learn in this habitats unit is ______________________

____

REFERENCES:

Cole, Joanne. 1992. *The Magic School Bus Visits The Waterworks.*

Coulombe, Deborah. 1992. *The SeaSide Naturalist.* New York, NY. Simon and Schuster.

George, Michael. 1992. *Coral Reef.*

Graeme, Base. 1992. *The Sign of the Seahorse.*

Gross, Grant M. 1996. *Oceanography, A View of Earth.* 6th Ed. NJ. Prentice-Hall, Inc.

Kalman, B. 1997. *Life in the Coral Reef.*

Kulman, Dietrich. 1985. *Living Coral Reefs of the World.*

Orr, Katherine. 1988. *The Coral Reef Coloring Book.*
Roessler, Carl. 1986. *Coral Kingdoms.*
Thurman, Harold V. 1991. *Introduction to Oceanography.* 6th Ed. New York, NY. Macmillan Publishing Co.
Watts, Franklin. 1991. *Night Reef.*

Marine and Aquatic Habitats

TOPIC-TITLE: Marine and Aquatic Habitats - *Coastal Development*

AUTHOR: Daisy Atalig, Isacc Jackson, Pepine Lauvao, Stephie Kamakeeaina, Eloise Manglona, and Bismark Febastian

GRADE SUITABILITY: Middle and High School

SCOPE: Coastal Environmental Changes: Coastal Development

SEQUENCE: This activity focuses on the anthropogenic practices which affect wetland ecology. Prior to this activity, the following concepts and content areas need to be addressed.

I. What is a wetland?
   a. Definition
   b. Types of organisms living in a wetland
II. Types of wetlands (focus on those in your area)
   a. Mangroves
   b. Estuaries
   c. Saline wetlands
III. Functions
   a. Nurseries
   b. Migration/Rest areas
   c. Food providers
   d. Breeding
   e. Protection
   f. Flood control

BACKGROUND SUMMARY: A wetland is defined as a landform characterized by hydric soils, hydrophytic vegetation, and the presence of water. Wetlands are often the transition zones between upland meadows and forests and aquatic and marine environments (Slattery, 1995). There are a number of different wetland types: estuaries, mangroves, and freshwater swamps or bogs. Many different organisms utilize wetlands. Migrating birds often rest in wetland areas due to the vegetative cover and abundance of food. Small fish and crabs utilize the shallow waters characteristic of wetlands and the vegetative cover to avoid predation and because of the availability of abundant food sources. Raccoons, snakes, skunks, nutria, and other predators feed on many of the organisms found in a wetland. Unfortunately, wetlands are being lost at an alarming rate due to coastal development and habitat degradation.

Marine and Aquatic Habitats

OBJECTIVES: Students will be able to: Illustrate the changes which occur from a non-developed area to a developed area through a Wall Story.

MATERIALS:
- Video/slides of area before and after development
- Pictures of area (old and new)
- Paper
- Markers
- Crayons
- Cameras
- Glue
- Paint and paint brushes
- Resource person
- VCR/TV
- Film
- Reference books

Activities:
1. Discuss what the students know about the local area (also, any myths or stories associated with the area).

2. Invite a guest speaker to discuss coastal development in the area and participate in a question and answer period with the students.

3. Have a class discussion, focusing on the reactions to the information from the guest speaker.

4. Creating the Wall Story: have the class choose a local wetland area to study. Divide the students into the following assignments:
   a. Reporters: Create a questionnaire to obtain information from people in the area.
   b. Researchers: Go to the library and obtain old pictures and information about the area and research information on past and current indigenous species.
   c. Artists: Start on the wall background; add pictures and information.
   d. Photographers: Take pictures of the study area, of indigenous flora and fauna, and of activities.
   e. Editors: Responsible for collating the information and writing the information for the Wall Story.

(Note: Teacher must be actively involved with the students on this project.)

POSSIBLE EXTENSION: Have the students write a paper from a plant's or animal's perspective about the development and destruction of its habitat.

TEACHER EVALUATION:

1. Finished Wall Story (40%)
2. Portfolio: students maintain a record of all the information gathered (10%)
3. Participation: teacher monitors participation on a daily basis (10%)
4. Reaction paper: includes what the student learned and his/her feelings about the changes (40%).

REFERENCES:

Slattery, Brett E. 1995. *WOW! The Wonders of Wetlands.* St. Michaels, MD. Environmental Concern, Inc. and The Watercourse.

Marine and Aquatic Habitats

TOPIC-TITLE: Marine and Aquatic Habitats - *Habitats of Birds, Fish, and Mammals on the Island and the Pacific Region*

AUTHOR: Carmen Atalig, George Ayuyu, Pichiosy Billy, Theresa Calro, Evelyn Redrico, and Annette Taisacan

GRADE SUITABILITY: Lower Elementary

SCOPE: Biology

SEQUENCE: This unit may be used after a unit on food relationships and prior to a unit on animal adaptations.

BACKGROUND SUMMARY: Every living organism has a place to live. The place in which a plant or animal lives and receives shelter and food is known as a habitat. There are many different types of habitats: forests, meadows, coral reefs, rocky shores, salt marshes, and mangroves. All organisms are uniquely adapted to survive in a particular habitat. By creating a habitat in a jar, students are able to understand some of the integral aspects some plants' and animals' habitats.

OBJECTIVES: Students will be able to:
1. Understand that every living thing needs a place to live.
2. Explain some of the elements of habitats.
3. Describe how animals live in groups.
4. Build a land habitat terrarium.

MATERIALS:
- Nonfiction book about animals
- Potting soil
- Jars
- Plants
- Water dish
- Small animal (turtle, lizard or frog)
- Animal food
- *National Geographic* Magazines
- Rocks
- Pencil/paper
- Metric ruler
- Teacher resource book
- Textbook
- Paper cups
- Gravel

Marine and Aquatic Habitats

ACTIVITY:

1. Encourage students to work in small cooperative learning groups in order to discuss plants and animals indigenous to local habitats. Different types of local habitats should also be discussed and written on large pieces of posterboard. These pieces of posterboard should then be spread over the floor. Students should then write the names of several plants or animals on pieces of paper and place them in the habitats in which they do not occur. Then, have another student explain why the plant or animal would not be able to survive in that habitat.

2. Arrange a visit to a place where plants and animals—insects, fish, amphibians, reptiles, birds, and mammals—are seen in their natural habitats.
   a. Discuss the meaning of habitat, adaptation, and shelter.
   b. Have the students list all the items they found in a particular habitat which enable plants and animals to live in that system.
3. Provide copies of *National Geographic* for students to view. Have them select a habitat of interest, then devise a plan for the construction of the model habitat in the jar.

4. Create the land terrarium. Initially, complete day 1 chart. After two weeks, complete questions in chart 2.

Performance assessment: Build a terrarium in a large container/jar		
Chart 1 Questions	**Yes**	**No**
1. Is the potting soil of good quality?		
2. Are there enough animals?		
3. Are there enough plants?		
4. Is there enough space for animals to move around?		
5. Is there enough air and water for the animals to live?		
6. Is the jar well covered?		
7. Is the jar in a well secured stand?		

Performance assessment: Build a terrarium in a large container/jar		
Chart 2 (14 Day) Questions	**Yes**	**No**
1. Have the plants grown?		
2. Are the animals still living?		
3. Does the terrarium appear healthy?		

POSSIBLE EXTENSION:

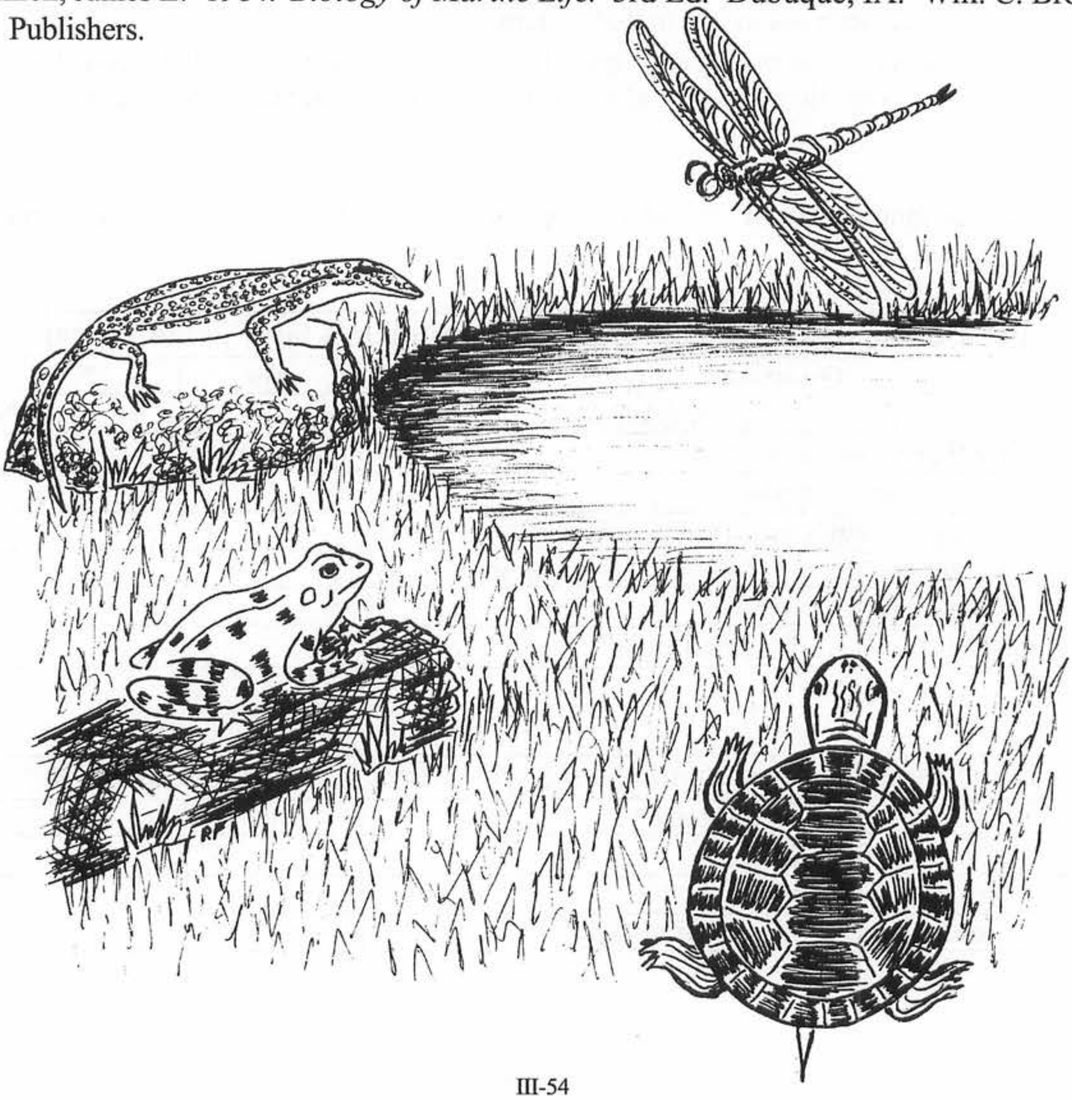
1. If the system appears unhealthy, lead students in a discussion of possible reasons for this status.
2. Lead students in a comparison of their closed system with a natural ecosystem.

TEACHER EVALUATION: The quality of the terrarium should be evaluated by the following: Excellent: 8 out of 10; Very Satisfactory: 6 out of 10; Satisfactory: 5 out of 10; Needs Improvement: 4 or below out of 10.

REFERENCES:

Castro, Peter and Michael E. 1992. *Marine Biology*. Dubuque, IA. Wm. C. Brown Publishers.

Sumich, James L. 1984. *Biology of Marine Life*. 3rd Ed. Dubuque, IA. Wm. C. Brown Publishers.



Marine and Aquatic Pollution

TOPIC IV

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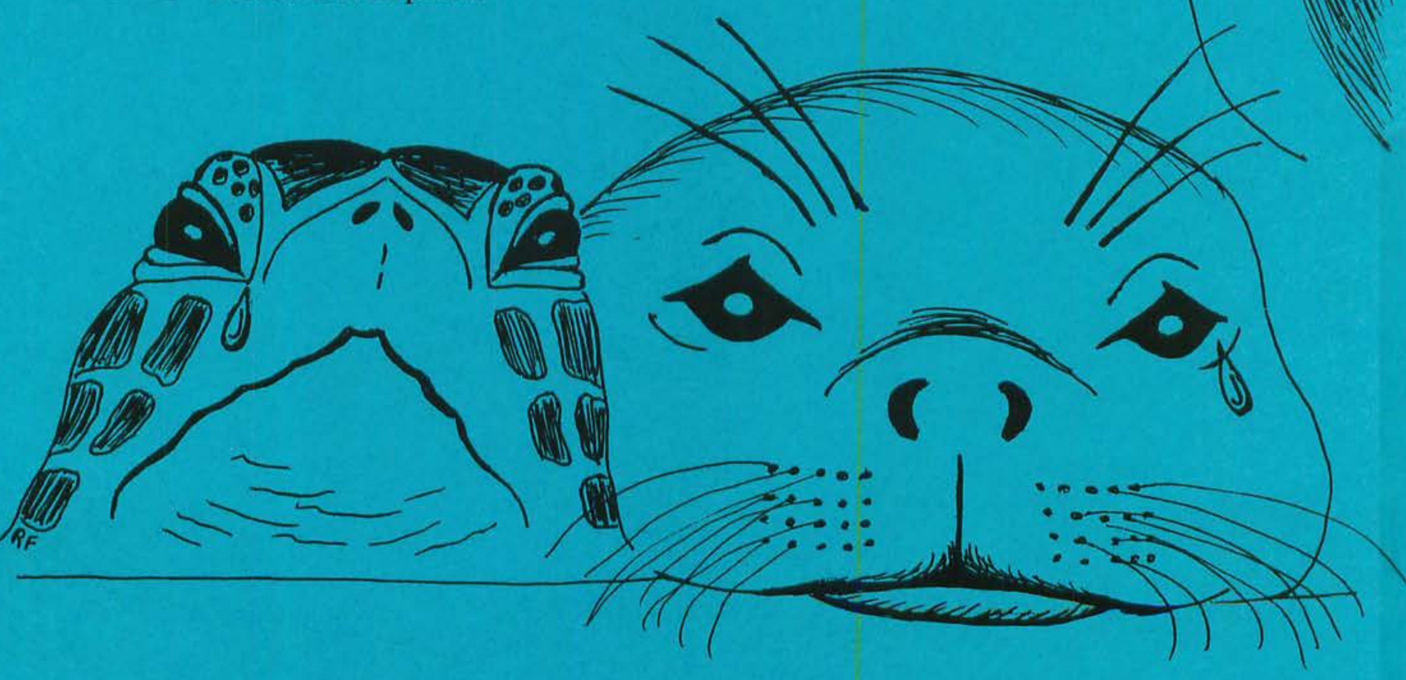

Marine and Aquatic Pollution

INTRODUCTION

Marine and Aquatic Pollution

What makes the Earth different from other planets? The answer is water. For existence of life, as we know it, water is the most precious of substances. Marine and aquatic environments are the homes for a diverse array of organisms. Without water, these organisms would not survive. The ocean and aquatic habitats are often exploited for these resources. However, neither habitat is limitless in its ability to absorb negative impacts.

All the waters in the world are affected in some way by pollution. The highest mountain streams have been impacted by acid rain. Pollutants are added from these mountains' starting points and spread throughout the watershed to areas where the rivers flow into the sea. Lakes, groundwater, and wetlands are all affected by either point or nonpoint source pollution. Litter left behind or carelessly tossed away, chemicals such as pesticides and fertilizers, oil-based products seeping into the watersheds from industry and pleasure vehicles, all impact marine and aquatic environments. Runoff from highways, parking lots, city streets, bridges, and heavily populated coastal areas is washed into nearby watersheds and adds its detrimental effects to the ecosystem.

Until approximately fifty years ago, most pollution was not seen in our oceans, as it was comprised mainly of metal and glass, which sink, and paper and cloth, which decay. Today, pollution is more visible as many of the manufactured objects are made of plastics, which are light-weight, strong, and very durable. Not only do plastics as they are commonly produced degrade slowly, but some animals see plastics as food and ingest them, or they become entangled in them. In either case, the result is usually death.

The following are the lengths of time it takes several forms of litter to biodegrade:

Tin cans - 50 years
Painted wood - 13 years
Newspaper - 6 weeks
Paper towels - 2 to 4 weeks
Disposable diapers - 450 years
Polystyrene foam - indefinite
Cardboard - 2 months
Wool - 1 year
Plastic six pack rings - 400 + years
Plastic bottles - 450 years
Aluminum cans - 200 years
Cotton - 1 to 5 months
Monofilament line - 600 years

Wetlands are an integral part of the ecosystem. Estuaries serve as an important habitat for many organisms including fish, shellfish, various reptiles, and birds. Marine and aquatic habitats serve as nursery areas, a source of food, and shelter from predators. Plants have the ability to filter impurities; hold substrate and the shoreline, in place; absorb

the force of storms; and release flood waters from the land. Wetlands are also directly affected by runoff filled with chemicals and trash.

As the human population rapidly increases, the world has become more industrialized, and chemical wastes have increased to dangerously high levels in some areas. The ocean, because it is so vast, is capable of neutralizing some chemical wastes; however, as the amounts of chemicals increase, toxins begin to accumulate. Chemical pollution originates from factories, farms, lawns, or almost anywhere there are people. Chemical pollutants can cause an increase in algae, which in turn leads to a reduction in the oxygen available for other life forms, often resulting in death. Some marine organisms absorb the toxins, and these toxins become more concentrated in animals higher in the food chain. This adversely affects the animals at the top of the food chain and may cause a decline in their populations. Other toxins may kill the organisms which come in contact with them.

Oil pollution is another major source of environmental damage to the ocean. The thick, sticky oil coats the feathers on birds, inhibiting flight and the ability of those feathers to insulate the bird. The gills of fish become clogged with oil, and the fish suffocate. Marine mammals' bodies become coated in oil, and they are unable to maintain their body temperatures. Oil coated marine plants cannot obtain energy from the sun for photosynthesis. Oil may also become trapped in sediments for many years and may become resuspended during storms or dredging.

To further compound this situation, humans in general desire to live near the water. Water provides recreation, a means of transportation, a source of food, and other resources. Groundwater aquifers, rivers, and streams supply the world with drinking water. These water bodies are too often utilized in sewage disposal. Access to the water has always been an important consideration. However, as more people inhabit coastal areas, the problems of water pollution increase. Ports or harbors require maintenance dredging which may resuspend pollutants which were originally trapped in the sediment below the water column. Untreated sewage may spill into the water during storms. Commercial and recreational vehicles compete for space and resources on and the water. Gas and oil from these vessels may inadvertently spill into the water. People crowd beaches and many leave litter behind. Increased construction along the coast leads to increased erosion, loss of habitat, and more damage to the coast during storms as the natural buffer zone has been degraded.

To rescue marine and aquatic habitats from the devastating effects of pollution will take cooperation and education. More people need to understand the interconnectedness of the role humans play in the ecosystem. Pollution is a global problem. Since this is a recognized fact, many governments and organizations are working together to develop solutions in combating pollution. Most of these efforts are concentrated in the marine environment.

In 1973, The International Maritime Organization, an agency within the United Nations, developed an agreement known as MARPOL (Marine Pollution). This agreement

regulates the disposal of trash, sewage and hazardous chemicals from ships at sea (Greene, 1998). According to Greene (1998), as of 1992, fifty nations had ratified the MARPOL Treaty. In 1972, the U.S. Congress passed the Clean Water Act which prevents toxins from being released directly into the water. In 1990, the Environmental Protection Agency established the National Pollutant Discharge Elimination System (NPES). This act requires industry and municipalities to obtain permits to discharge pollutants directly from point sources into surface waters. Direct discharging includes industrial and commercial wastewater and industrial stormwater.

Private industry, environmental organizations, and individuals are working on ways to reduce the amount of litter which is improperly discarded. Beach cleanups, recycling programs, and lobbying for more strict regulations and enforcement are all ways in which individuals and corporations can help combat the global pollution problem.

REFERENCES:

Greene, Thomas F. 1998. *Marine Science.* New York, New York. AMSCO School Publications.

Gross, Grant M. 1990. *Oceanography: A View of the Earth.* Englewood Cliffs, NJ. Prentice-Hall, Inc.

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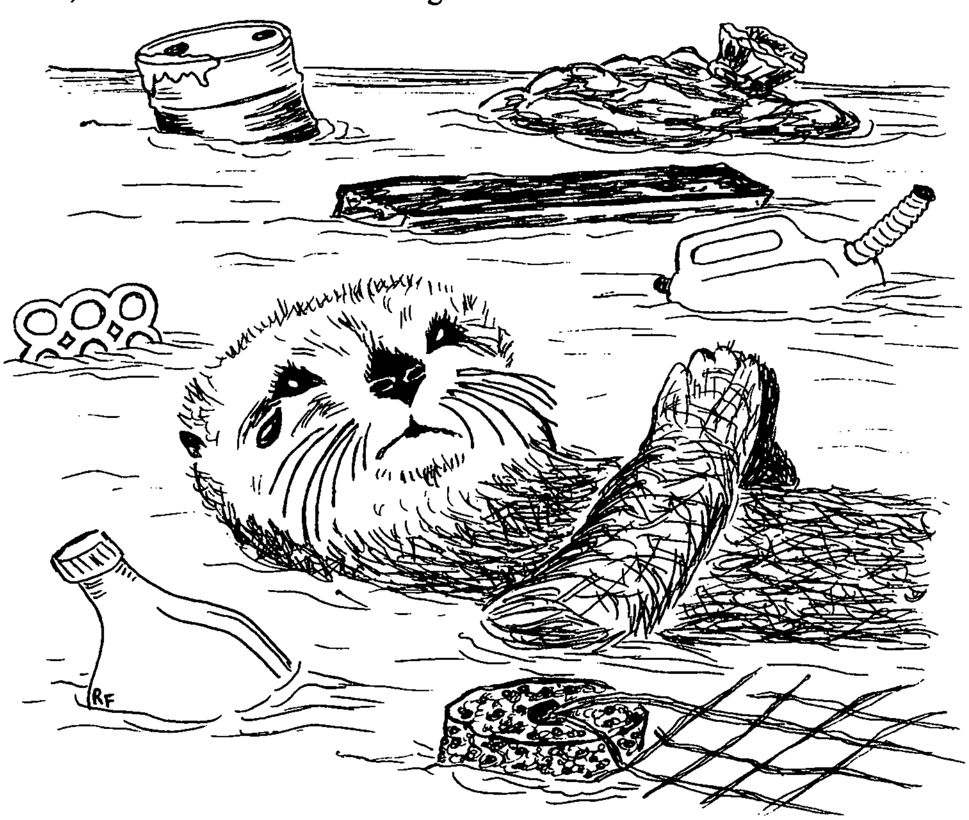


Marine and Aquatic Pollution

TOPIC-TITLE: Marine and Aquatic Pollution - *Marine and Estuarine Pollution*

AUTHOR: Kathy Porter

GRADE SUITABILITY: Lower Elementary

SCOPE: Environmental Science and Life Science

SEQUENCE: This activity should follow a discussion on litter and pollution and their effects on the environment. A videotape such as "*Saving Inky*" (which may be obtained from the Center for Marine Conservation) may be shown to students to help them understand the devastating effects litter may have on marine life and ways in which marine biologists cope with this problem.

BACKGROUND SUMMARY: Pollution and litter are derived from a variety of sources. A piece of trash not properly disposed in Iowa may later make its way into the ocean. Various forms of litter may have devastating effects on marine, aquatic, and terrestrial organisms. Plastic bags and balloons may be mistakenly ingested by sea turtles. Birds such as pelicans may become entangled in discarded fishing line. Plastic six-pack rings may get caught on the shells of turtles or may damage fish. Everyone must be made aware of the impacts of litter and pollution on our environment and actions individuals can take to help remedy this problem.

OBJECTIVES: Students will be able to:
1. Understand how they, as individuals, can make a difference in our world.
2. Identify the most appropriate and safest mechanisms for use in cleaning an oil spill.
3. Create and package an "environmentally friendly" lunch.

MATERIALS:
- Paper grocery bags
- Plastic gloves

ACTIVITY:
1. Ask the custodian not to sweep or pick up litter or trash from the floor of your class room or empty your garbage can for a pre-determined amount of time (two to five days). Without mentioning this to the class, see how long it takes for students to "notice" that their room is getting dirty. When the effects are being seen and felt, discuss the "secret experiment" with the class. Compare this project to littering and polluting our world. How did the class feel being in this environment?

Attempt to stress the idea that living in a polluted world is unsanitary and uncomfortable. Elicit ways in which we can help. Have the students perform the custodian's job for the next day or two in your classroom in an attempt to develop a "sense of pride" regarding their class and school environment.

2. "Pollution Patrol"- divide students into teams of "Pollution Pals" and provide each student with gloves and a trash bag. Design a check list from which the students can work in the school yard or an adjacent "green" area. Before taking the students outside, each team should predict which category or type of litter will be most common (plastics, foams, metals, and papers). Be sure the students wear gloves and are aware of the necessary safety rules when collecting litter. Groups should simultaneously patrol designated areas of the school grounds for 15-20 minutes. All items collected should be recorded on the check list before disposing in the trash bag. Return to class and discuss findings. Sort recyclables and discard trash.

POSSIBLE EXTENSION:

1. As an extra credit project (or occasionally as homework) provide additional pollution clean-up check lists and allow students or groups to patrol a park, a favorite vacation spot, their yard, or the area they walk to/from school for litter. Emphasize the idea if others see them helping to clean the environment, they may follow suit. Encourage them to elicit help from onlookers. Also encourage the idea of leaving a place as neat or neater than it was found (especially useful on trips).
2. Environmentally Friendly Lunch Contest: challenge students to bring lunch in wrap pings which result in the least amount of trash. Compare results. Implement ideas.
3. Save your waste materials at home for one week (e.g., containers, packaging, or junk mail). Have a contest to see who can create the best "junk" project(s). Consider giving students a theme (i.e., animal, space creature, school supply holder, or game).
4. Have the students create bar graphs of the amounts and different types of litter collected.

TEACHER EVALUATION:

1. Class discussion or individual essay: if you had to keep all your family's trash in your home, how would your habitat change?
2. Class discussion or individual essay: what do you think is the best reason for controlling pollution? Justify your answer.

REFERENCES:

Center for Marine Conservation. 1993. *Save Our Seas: A Curriculum Guide for K-12.* San Francisco, CA. California Coastal Commission.

Undated. *Pointless Pollution Curriculum.* Clean Ocean Action. Sandy Hook, NJ.

Marine and Aquatic Pollution

TOPIC-TITLE: Marine and Aquatic Pollution - *Environmental Change*

AUTHOR: Amorilla Catabas, Nita Elayda, Alfred L. Hitchfield, Rizalina Maratita, and Evangelina Mendiola

GRADE SUITABILITY: Lower Elementary

SCOPE: Environmental Science

SEQUENCE: This lesson should follow a discussion of pollution and its impacts. A videotape on the effects of pollution should enhance this discussion.

BACKGROUND SUMMARY: Many changes in the environment are a direct result of peoples' actions. Some of these alterations have had and continue to have a detrimental impact on the environment and its inhabitants. Contaminated water from industry and agriculture often directly kills organisms or accumulates in various organisms and, therefore, travels through the food chain. The filling of salt marshes and wetlands for development affects flood control, the natural filtering process, and destroys valuable nursery and feeding areas for juvenile fish, crabs, birds, and shellfish. There are numerous anthropogenic impacts which have resulted in habitat loss and degradation. These practices need to be controlled and managed in order to ensure the continued existence of many aquatic and marine populations.

OBJECTIVES: Students will be able to:
1. Define pollution.
2. Create a list of the changes people make in the environment which can be harmful.
3. Develop several different ways to prevent pollution in the environment.

MATERIALS:
- Maps
- Pictures
- Books
- Chart
- Markers
- Crayons
- Non-pointed Scissors
- Glue
- Journal or notebook
- Rubber gloves
- Octa® paper
- Water colors

ACTIVITY:

1. Have students research and discuss the impact of pollutants on their immediate environments starting in their schools and then their community. Each student should write his/her definition of pollution. Discuss these definitions.

2. Take the class on a field trip (e.g. to the beach or area adjacent to the school grounds). Observe actual pollution along the shorelines, roads, or in the immediate surroundings. Have students record the different types of pollution they observed in a journal. Students should also hypothesize on each pollutant source. Each student should collect three different types of litter to take back to the classroom. (Gloves should be worn and instructors should review with students all safety precautions before going on the field trip).

3. Divide students into three groups.
   a. Group A: group should draw pictures demonstrating habitats, fish, other animals, and plants which are affected by pollution. Students should also include, in their drawing/poster, some of the causes of pollution and ways to prevent pollution.
   b. Group B: group should illustrate comparisons/contrasts between clean and polluted water sources. Effects of pollution should be included.
   c. Group C: group should create an art project from the materials collected on the field trip.

4. Students will write a summary of their findings and report to the class. Summaries will include alterations people have made in the environment which have created problems, each student's own definition of pollution, and ways in which they would help prevent pollution in their own environment. The illustrations and projects students created will be used during their oral reports. After the oral presentation, projects can be displayed in the classroom.

POSSIBLE EXTENSION:

1. Students could organize an area clean-up of a beach, park or school grounds.
2. Students could display their art projects in a public area such as a park or beach, in order to convey an anti-litter message.

TEACHER EVALUATION: Students will be evaluated on the content of their definitions of pollution, the art project, and oral report presentations.

REFERENCES:

Center for Marine Conservation. 1993. *Save Our Seas: A Curriculum Guide for K-12.* San Francisco, CA. California Coastal Commission.

Marine and Aquatic Pollution

TOPIC-TITLE: Marine and Aquatic Pollution - *Global Warming: Action Plans to Fight Global Warming*

AUTHOR: Yvonne Coppola

GRADE SUITABILITY: Middle School

SCOPE: Social Studies

SEQUENCE: Students should be introduced to the term global warming, its causes, and the ways in which it affects the environment.

BACKGROUND SUMMARY: Scientists have determined that the planet's mean global temperature has increased 1°C over the past 100 years (Greene, 1998). This warming trend is referred to as global warming. Global warming has resulted in the melting of some of the polar ice caps, which has resulted in an increase in sea level.

Greenhouse gases such as carbon dioxide, methane, chlorofluorocarbons (CFCs), oxides of sulfur and nitrogen, and water vapor, which are released during the burning of fossil fuels, agriculture, and manufacturing, cause an alteration in the composition of the Earth's atmosphere. The addition of these gases into the Earth's atmosphere changes the rates of absorption and energy transmission from the sun.

Carbon dioxide transmits shorter wavelengths of solar radiation while it absorbs infrared (longer) wavelengths which are emitted by the Earth's surface, resulting in a warming of the Earth's surface. As people become more aware of the dangers and consequences of global warming, they also become aware that immediate steps need to be taken in order to prevent additional damage to the environment. People of all ages can help to prevent damage to the environment. Many students are unaware that there are many steps which they can take to help prevent global warming. By instructing students on actions they can take, educators are reinforcing the principles of responsible citizenship. These students may then serve as role models for other youth.

OBJECTIVES: Students will be able to:

1. Identify methods of conserving energy.
2. Develop ideas for combating global warming.
3. Expand these ideas.

MATERIALS:
- Paper
- Pencils
- List of environmental organizations and their addresses (such as the Nature Conservancy, World Wildlife Fund, and the Audubon Society). This list can be developed from various websites such as www.consultces.com/envory.htm and www.consultces.com/ceslinks.htm.

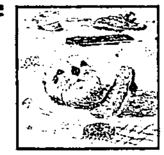
ACTIVITY: The class will be divided into cooperative learning groups who will research and develop environmental action plans for one or more of the following topics: energy use, recycling, transportation, trees, shopping, CFCs, home, and/or politics. While the students are researching these topics, they should write to several environmental groups or political organizations for additional information on their subject of study, to include respective organizations' views on the topic. (Note: Instructors should allow at least two weeks for this information to be received.) These data should be compiled and proactive action plans to combat global warming should be developed, discussed, and implemented. Student research groups should report their findings and the recommendations they have developed to the class.

In order for the students to understand their contribution to the problem of global warming, they should research energy use and recycling programs, which take place in their own homes. To accomplish this task, students should sketch the rooms in their homes depicting only the divisions of the rooms. They will use this sketch to record observations which will enable them to determine what actions they can take to conserve energy in their home. Each of the rooms sketched by students should contain at least three recommendations.

POSSIBLE EXTENSION:
1. Plant a tree on the school grounds.
2. Start a recycling club or program in school.
3. Contact representatives for conservation organizations who are willing to visit the school or conservation facilities which the class can visit.

TEACHER EVALUATION: Student projects will be evaluated for content, originality, and practicality. Student homework will also be evaluated in the same manner.
Test Questions:
1. Why are people so concerned with global warming?
2. Why is recycling so important?
3. Name three things anyone can do in his/her home to conserve energy?

Marine and Aquatic Pollution



REFERENCES:

Greene, Thomas. 1998. *Marine Science.* Brooklyn, New York. AMSCO School Publications, Inc.

Gross, Grant M. 1990. *Oceanography: A View of the Earth.* Englewood Cliffs, NJ. Prentice-Hall, Inc.

Mortenson, Lynn L. 1994. *Global Change Resource Guide.* National Oceanographic and Atmospheric Administration-Office of Global Programs. Silver Spring, MD.

TOPIC-TITLE: Marine and Aquatic Pollution - *Marine Debris: Collection and Impact*

AUTHOR: Elizabeth Young

GRADE SUITABILITY: Upper Elementary and Middle School

SCOPE: Environmental Science, Ecology, Social Studies, and Mathematics

SEQUENCE: This activity could be used at any stage of a specific environmental study.

BACKGROUND SUMMARY: According to Greene (1998), during the summer of 1988, a mass of solid wastes including hypodermic syringes and other medical debris washed ashore on beaches from Massachusetts to Maryland. Litter has been found on other beaches, including remote Islands in the South Pacific. Much of the garbage is derived from ships which dump their waste overboard. However, other trash may be transported, via rivers, from landlocked states to the ocean.

Most of this litter is comprised of plastic, glass, and metal (Greene, 1998). This litter is not only aesthetically displeasing but can pose a threat to many organisms. For instance, sea turtles consume large numbers of jellyfish and often mistake plastic bags for jellyfish. These bags may lodge in the esophagus of the turtle, thereby suffocating it. If the plastic bags do not get lodged in the esophagus and are passed into the stomach, the turtle is unable to digest plastic and, therefore, does not feel the need to eat. This can result in the sea turtle dying of starvation.

The U.S. discards more trash than any other nation in the world (Greene, 1998). Approximately 75% of all trash is disposed in landfills (Greene, 1998). However, many landfills in the U.S. are filled to capacity. Recycling and incineration of trash may aid in the waste disposal problem. However, it should be noted that incineration may result in atmospheric pollution. Recycling and rethinking our use of marine debris should be everyone's concern and responsibility.

OBJECTIVES: Students will be able to:
1. Understand marine debris and its sources.
2. Describe the adverse effects of marine debris on organisms.
3. Determine distribution and predominant types of marine debris within their own region.
4. List potential solutions and select one action item to be conducted by a student environmental organization.

Marine and Aquatic Pollution

MATERIALS:
- Official "Beach Clean up Data Card" (Obtained from the Center for Marine Conservation)
- Trash bags (two colors are helpful for separating recyclables)
- Clipboards and pencils for each group
- Gloves
- First aid kit
- Rope, stakes, tide chart, permission slip

ACTIVITY:
1. Show the *Coastal Clean Up* slide program available from the Center for Marine Conservation and, following the presentation, allow the students to discuss the content.

2. Make a list of sources of marine debris (ships, sewers, commercial and recreational boaters, landfill runoff, parking lot runoff, and storm drains).

3. Have students determine pollution sources which are common in their area and list, beside each source, ways to prevent the associated form of pollution.

4. Circle in red all methods of pollution prevention which students can directly accomplish. Circle in black those methods which students can accomplish indirectly through letter writing, interviews, and offers to assist companies.

5. Have students volunteer to obtain special materials (data cards and gloves) and make arrangements to participate in the state's official coastal clean up.

6. Introduce students to the Data Card safety measures, such as being sure they all wear gloves, what students should do in the event syringes or glass are found during the clean up and what prizes are available for the most unusual item found.

7. Assist students in making arrangements for the clean up of a nearby beach or lakeshore.

8. During the clean up, have students categorize the types of litter they find according to the categories listed on the Data Card; award prizes for the most litter "picked up;" discuss impressions; and hypothesize where the litter originated.

9. When students return to the classroom, arrange for those with computer skills to collect and input the data on a spread sheet. Another cooperative learning group can

analyze the data and create a report which would include most common types of debris and perceived origins of debris. A third group can research ways in which debris affects animal and plant life on the beach and in the water. A fourth group could present the information collected to the appropriate officials. A fifth group could investigate the "Adopt a Beach" program and make recommendations as to whether that would be an appropriate action for the class.

POSSIBLE EXTENSION:

1. Access the Marine Debris World Wide Web home page through the following URL address: http://www2.ncsu.edu/unity/lockers/project/marinedebris/index.html to learn about other debris collecting programs.
2. Create an Earth Day or science fair booth display with methods and results of the clean up.

TEACHER EVALUATION:

1. Check completeness of record card data.
2. Evaluate the group activities which culminated the project with criteria the class helps develop.
3. Create a short test based on what was learned from the coastal clean up experience.

REFERENCES:

Maraniss, Linda. 1992. *The Gulf of Mexico: A Special Place.* The Center for Marine Conservation.

1990. *Coastal Clean Up* slide program. Washington, D.C. Center for Marine Conservation.

1987. *Hawaii Marine Science Studies.* Honolulu, University of Hawaii.

1993. *Save Our Seas: Curriculum Guide K-12.* Center for Marine Conservation. Washington, D.C.

1990. *Waste, A Hidden Treasure.* Keep America Beautiful Foundation, Inc.

Marine and Aquatic Pollution

TOPIC-TITLE: Marine and Aquatic Pollution - *Bioaccumulation*

AUTHOR: Gloria Gonzales

GRADE SUITABILITY: Upper Elementary

SCOPE: General Science, Life Science, Marine Science, Environmental Science, and Biology

SEQUENCE: Prior to this activity, students will have studied the ecology of an estuary and its importance, including the limiting factors. Students will also have an understanding of a food chain.

BACKGROUND SUMMARY: Estuaries are extremely productive environments. The marsh plants found in an estuary are producers, as they are capable of making their own food. Some of the fish and clams are primary consumers. They are unable to make their own food, and therefore, feed on the plants. The birds and other marsh predators are secondary consumers, feeding on the smaller organisms. Bioaccumulation occurs when toxic substances accumulate in higher and higher concentrations from one level of a food chain to the next.

OBJECTIVES: Students will be able to:
1. Identify limiting factors.
2. Demonstrate bioaccumulation.

MATERIALS:
- A simplified diagram of a food chain (instructions given during activity)
- Easel and flip chart
- Green marker for plants, fish, and gull
- Red marker for pollutant

ACTIVITY:
1. Using the green marker, make a diagram on the flip chart, overhead, or chalkboard of the three levels of a simple food chain. The producers are marsh grasses; the teacher should draw several thick blades of grass. The primary consumers are the fish; the teachers should draw six fish at level two. The secondary consumers are the gulls; the teachers should draw one large gull at level three. Display the diagram on the easel so everyone may view it.

2. Explain to the students what has been drawn and what the animal shapes represent.

3. Divide the class so eighteen students represent the marsh grass; six students represent fish, and one student will be the gull.

4. Explain that an unknown pollutant has been deposited in the salt marsh. This pollutant has been absorbed by the marsh grass. Plants cannot metabolize/decompose some chemicals so they store them. The plants have absorbed a small amount of the pollutant.

5. Have the students representing the marsh grass come to the front of the room. Use a red marker to draw a small circle on one of the grass blades in the diagram. Each circle represents a small amount of the pollutant.

6. Then, ask the students representing fish to come to the front of the room. Use the red marker to draw a circle around every blade of grass which is eaten (three blades of grass per fish).

7. Finally, point to the gull on the diagram and ask the student representing it to come forward and, using the red marker, draw circles in the gull. The gull will consume all of the fish in the diagram. A total of eighteen circles will be drawn in the gull by the end of the activity.

POSSIBLE EXTENSION:

1. The students will list possible pollutants in the estuary.
2. The students will investigate possible ways to prevent, reduce, or eliminate chemical pollutants.
3. Research the effects of bioaccumulation in several species (eagles and alligators). Students should report, make a bumper sticker, or write an eco-poem about the animal.

TEACHER EVALUATION:

1. Students will role play the concept of bioaccumulation.
2. Students will identify and explain limiting factors of the estuary.
3. Students will write a report on what bioaccumulation is and how it affects humans.

REFERENCES:

Bierce, Townsend, Weber. 1992. *Environmental Quality in the Gulf of Mexico: A Citizen's Guide*. Center for Marine Conservation. Washington, D.C.

Irly, Bobby N., Malcolm K. McEwen, Shelia A. Brown, and Elizabeth M. Meek. 1984. *Man and the Gulf of Mexico Series: Marine and Estuarine Ecology*. Jackson, MS. University Press of Mississippi.

1987. *Aquatic Project Wild*. Western Regional Environmental Education Council, Inc.

Marine and Aquatic Pollution

TOPIC-TITLE: Marine and Aquatic Pollution - *Are We Just Fouling Ourselves?*

AUTHOR: Eva Cruz

GRADE SUITABILITY: Middle School

SCOPE: Life Sciences and Earth Science

SEQUENCE: The primary objective of this activity is to focus on the types of pollution which are derived from the three major types of land use and their effects on aquatic organisms. This activity should follow a unit on land use and pollution and how pollutants travel through a watershed affecting various members of the food chain.

BACKGROUND SUMMARY: A watershed is defined as the entire land area which contributes surface runoff to a given drainage system (Slattery, 1995). Various types of land use, including agriculture and industry, contribute pollutants through runoff which eventually may travel through an entire watershed. As a pollutant travels through a watershed, it may come into contact with many organisms in a food chain. A food chain is a relationship in which one organism serves as food for another organism. The first stage of a food chain is referred to as the producer - the plants. Producers are eaten by primary consumers; primary consumers are eaten by secondary consumers; this food web continues to the apex predators which represent the top of the food chain. If one stage of the food chain is contaminated, the next stage will often consume large quantities of the organism, in turn becoming contaminated. This is known as bioaccumulation, in which an increase in the concentrations of a chemical (or toxin) takes place as one moves up the food chain (Greene, 1998).

OBJECTIVES: Students will be able to:
1. Identify three major uses of land, and pollutants derived from these land based activities.
2. Explain the ways in which pollutants move through the food chain and become more concentrated in some members of the food chain.

MATERIALS:
- Pen/pencil
- Poster board
- Paper
- Maps
- Crayons/markers
- Scissors

ACTIVITY:
1. Divide students into cooperative learning groups of five or six. Provide each group with sufficient time to research the land uses of a certain area adjacent to a local watershed.

2. Each group will then construct a map of the watershed and surrounding area, indentifying and marking the types of land use in that area (a cow will represent agriculture, a smoke stack will represent industry, and a tree will represent forest).

3. Student groups will then research the types of pollutants typically associated with the land use in their watershed.

4. Groups will also research the effects of these pollutants on the organisms indigenous to their watershed.

5. Each student will construct a food chain from the organisms found in their watershed and develop a report on ways in which he/she believes the pollutants found in their area will affect this food chain. Students will present their food chains and reports to the class.

POSSIBLE EXTENSION:

1. Draw a fish native to a local watershed. Provide information including size, coloration, predators and prey, and discuss the fish's position in the food chain.
2. Draw a poster illustrating aquatic life found in the local watershed and write a slogan/ environmental message.

TEACHER EVALUATION: Students should be evaluated on their ability to work in cooperative learning groups, to develop food chain models, and to make class presentations.

REFERENCES:

Downs, Warren. 1986. *Fish of Lake Michigan.* University of Wisconsin Sea Grant Institute.

Mitchell, Mark K., William B. Stapp. 1995. *Field Manual for Water Quality Monitoring.* Dexter, MI. Thomson-Shore Printers.

Greene, Thomas F. 1998. *Marine Science.* New York, NY. AMSCO School Publications, Inc.

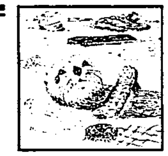
Slattery, Britt E. 1995. *Wow! The Wonders of Wetlands.* St. Michaels, MD. Environmental Concern, Inc. and The Watercourse.

1989. *The Great Lakes in My World.* Chicago, IL. Lake Michigan Federation.

1985. *Water: We Can't Live Without It.*

Audio-Visual:
Great Lakes People

Marine and Aquatic Pollution



TOPIC-TITLE: Marine and Aquatic Pollution - *Affecting Growth*

AUTHOR: Morri Spang

GRADE SUITABILITY: Upper Elementary

SCOPE: Chemistry and Biology

SEQUENCE: This lesson will follow the classification of point and non-point source pollution lessons and will precede a regular classroom assignment on the problem and possible solutions.

BACKGROUND SUMMARY: There are a number of ways in which the global water supply can be impacted by human activities. Four general impact categories have been identified by Day et al. (1989). These categories include enrichment, physical alterations, introduction of toxic materials, and direct changes in the community structure due to overfishing or the introduction of exotic species.

Enrichment is an increase of substances or heat, which occurs naturally in an ecosystem, to a level which is not toxic but leads to changes in the system. For example, agricultural runoff can result in nutrient enrichment in an aquatic system which often leads to excessive algal blooms. Excessive algal growth leads to further alterations in the system. This condition is referred to as eutrophication.

Heavy metals, pesticides, and insecticides are toxins which are introduced into aquatic and marine ecosystems through runoff. Pesticides, such as DDT, have in the past led to many problems. For instance, DDT accumulated in fish who in turn were eaten by brown pelicans. The DDT was transferred to the pelicans at nonlethal levels. The female pelicans then laid eggs and attempted to incubate them. Due to the DDT bioaccumulation, the eggshells were extremely thin and were crushed during incubation attempts. This resulted in a rapid decline in the brown pelican population. Physical alterations in environments through channelization of streams, dredging of channels, and the building of dams also impact the quality of the water and its inhabitants.

Overfishing and the introduction of exotic or non-native species impact the species of fish, plants, and insects, present in a system. Local, state, and federal management regulations to prevent overfishing and introduction of non-native species are in the process of being developed in many areas. Many people are aware of the impacts of enrichment, toxic materials being introduced into a system, physical alterations, and overfishing. However, too many people are unaware the actions they take everyday also have an impact on our environment.

Marine and Aquatic Pollution

OBJECTIVES: Students will be able to:
1. Test the effects of several common household chemicals which are often poured down the drain and eventually enter marine and aquatic environments.
2. Classify pollutant sources.

MATERIALS:
- Safety goggles
- Seven clear, one quart jars of the same shape
- Water (with algae) from a pond
- Aged tap water
- Good light source, indirect sunlight or artificial grow light (can be purchased at a discount or variety store)
- Six pollutants to be chosen by students
- *Elodea* plants (purchased from a biological supply company)

ACTIVITY:

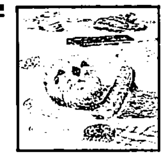
Two weeks before class:

Prepare the jars by filling 7/8 full with aged tap water. Add as much pond water as possible. Put the jars near a window where they will receive indirect light or provide them with strong artificial light. Do not place them in a location which is exposed to cold temperatures.

Class day:

1. Review classification of pollution sources, using the pollutants the students brought to class. Explain to the students that they are going to test some pollutants on model water environments. Students may also ask: *why don't we test the pollutants by dumping them in a natural environment?* Show the students the jars with the algae growing in them. Explain that all the jars have been established using the same mea surement of tap and pond water. Students may inquire *why is this important?* Continue with this line of thinking and have the students design an appropriate experiment to test the effects of their pollutants on algal growth and *Elodea* growth. (Some suggestions: make observations at the same time each day; observe the same things for the same length of time. These observations can be interesting for students, as they may ascertain interesting variables, such as how much clear water is visible at the surface from a top view).

2. Students may also ask *why do we have six pollutants, but seven jars?* Divide students into seven groups. Wearing safety goggles, students should add a reasonable amount of each pollutant, one to a jar: two tablespoons of detergent; enough motor oil to cover the surface of the water; 1/4-1/2 cup of vinegar. Leave the jars in the light as before. Label the jars without obstructing the visibility of the contents. Have students



the contents of jostle the jars at any time. If a plant dies, it should not be removed. Re-enforce the importance of observational dedication and accuracy. Help students develop.

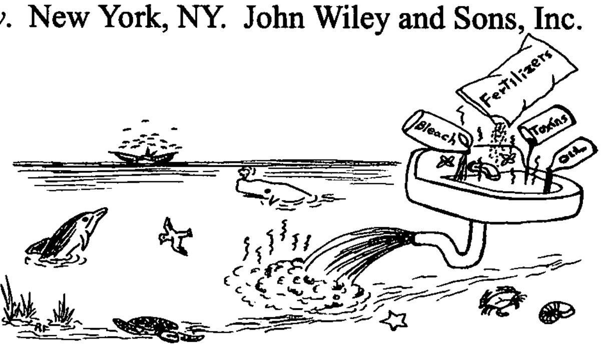
3. Each cooperative learning group will be responsible for the observations of its respective jar. No one should touch the contents or shake the jars at any time. If a plant dies, it should not be removed. Re-enforce the importance of observational dedication and accuracy. Help students develop alternate plans for absent observers.

After at least one week
The class will decide mechanisms to best display their data. Student groups need to reach a consensus relative to the data table or graph. Assign a "conclusions" paper which compares students' predictions with the actual results.

POSSIBLE EXTENSION:
1. Oil spills may be "mopped up" with straw, feathers, or cotton. Can student groups skim the oil off the surface? Insert a new plant and compare its life span in the newly "cleaned" jar.
2. Add baking soda to acid jars (e.g. vinegar) to reach neutrality. Use litmus paper to test for pH. Add new plants and compare results.

TEACHER EVALUATION: Teacher observations of experiment design, thoroughness of data collection, and the conclusions paper will serve as an evaluative assessment.

REFERENCES:
Chase, Valerie (Project Director). *Living in Water.* (Curriculum Guide). Baltimore, MD. National Baltimore Aquarium.
Garrison, Tom. 1995. *Essentials of Oceanography.* Belmont, CA. Wadsworth Publishing Company.
Day, John W., Charles A.S. Hall, Michael Kemp, and Alejáñdro Yanez-Arancibia. 1989. *Estuarine Ecology.* New York, NY. John Wiley and Sons, Inc.



TOPIC-TITLE: Marine and Aquatic Pollution - *Oil Spills*

AUTHOR: Kathy Porter

GRADE SUITABILITY: Middle School

SCOPE: Environmental Science and Life Science

SEQUENCE: This activity should follow a discussion of various forms of pollution, particularly oil spills. Background information should include a discussion on various oil spills which have occurred throughout the world in the last several decades.

BACKGROUND SUMMARY: On March 24, 1989, the *Exxon Valdez* hit a shoal in Prince William Sound and spilled 50,000 tons of crude oil into the surrounding waters (Greene, 1998). This crude oil had an immediate and lasting impact on the residents of this habitat and surrounding areas. Crude oil sank to the bottom and covered shellfish. It coated the feathers on birds, inhibiting flight and preventing the feathers from insulating the birds against the cold. Oil covered the gills and bodies of fish, causing them to suffocate. The oil also killed vast quantities of plankton, which form the base of the oceanic food chain (Greene, 1998).

Oil spills such as the *Amaco Cadiz* in France and the *Sea Empress* off the coast of Wales have had similar and long lasting impacts on the surrounding environment and its inhabitants. Oil remains in the water column and trapped around and within the sediment particles of the substrate. Storms and practices such as dredging may resuspend oil which has been buried under the sediments.

Oil also enters marine and aquatic environments through nonpoint sources such as sewer systems from homes and businesses in which oil products have been improperly disposed. Runoff from roads and bridges may also contain oil from motor vehicles.

In time, oil dissipates from the environment as it is metabolized ("broken down") by bacteria and dissipated by wave action (Greene, 1998). Scientists have identified some oil-eating bacteria which may assist in "clean up" of oil spills.

OBJECTIVES: Students will be able to:
1. Describe some effects of oil spills on resident flora and fauna.
2. Identify various methods of cleaning oil spills.
3. Identify some of the major oil spills which have taken place in the last several decades.

Marine and Aquatic Pollution

MATERIALS:
- One, 1000 ml plastic beaker for every four students
- Vegetable oil
- Blue food coloring

Oil spill clean up materials:
- Sponge cut into small cubes (1 cube/group)
- Cotton swabs (10/group)
- Plastic spoons (1/group)
- Cloth swatches (1/group)
- Forceps (1/group)
- Pipette (1/group)
- Other clean up tools

ACTIVITY:
1. Divide students into cooperative learning groups of four students per group.

2. Have students conduct library/computer research on the various oil spills which have occurred throughout the world. Have each group list the ways in which the oil was cleaned, the spill effects, and the condition of the environment today. Discuss the results.

3. Provide each cooperative learning group with a biome in a beaker (biomes should be prepared prior to beginning this activity. See the attached page for ideas for your biomes). Each biome should consist of an environment with blue water created with f food coloring. Choose an amount of oil and pre-measure it for each group. Have the students pour oil into the biome and observe and record the results. Each group has a full complement of "clean up" tools and a recovery jar for the oil. Each group must discuss each of the tools for cleaning the oil and decide which tools they believe will work the best in their particular biome. Students should record results and measure the volume of oil recovered from the biome. Groups will then report the results of their experiments to the other students.

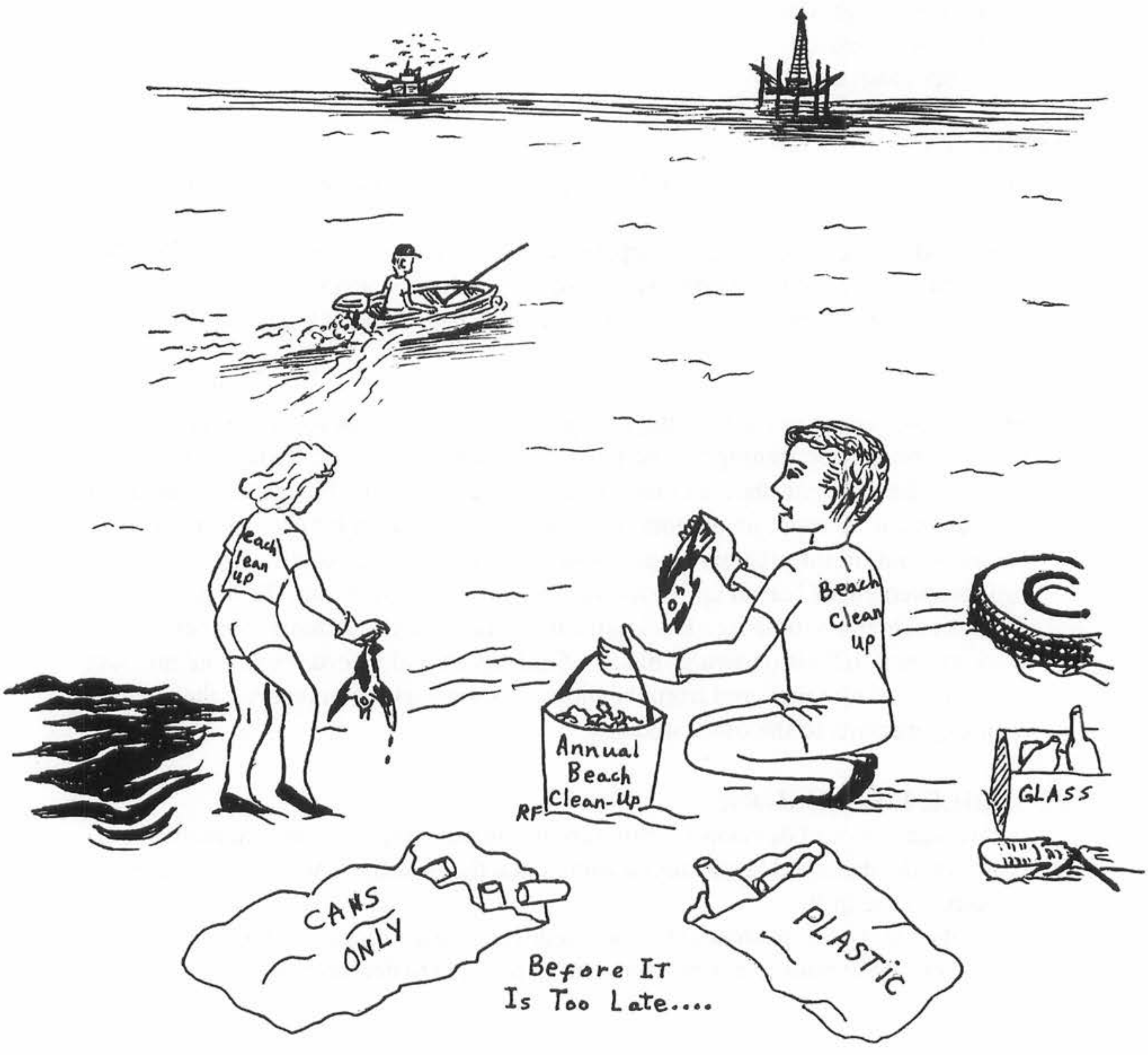
POSSIBLE EXTENSION:
1. Each student should develop a written environmental impact statement including a report on the damaged or destroyed habitat and the organisms which were adversely affected by the spill.
2. Students could paint posters of the environment, in their biome, including as many organisms indigenous to the environment as possible to demonstrate biodiversity.

TEACHER EVALUATION: Group presentations should be evaluated on content and scientific methodologies used.

REFERENCES:

Greene, Thomas F. 1998. *Marine Science.* New York, NY. AMSCO School Publications, Inc.

Wright, R. 1995. *Oil Spill!* An Event-Based Science Module. Rockville, MD. Addwin-Wesly Event-Based Science Project.



Marine and Aquatic Pollution

TOPIC-TITLE: Marine and Aquatic Pollution - *The Coastal Town: Scientific Design and Planning*

AUTHOR: Cynthia Louden, Carolyn Elliott, Karen Jardine, and Kimberly Dernowski

GRADE SUITABILITY: Middle School

SCOPE: Marine Policy/Management

SEQUENCE: This lesson would complement the completion of a unit on oceanography. It could be used to review a multitude of concepts. The problem cards can be modified for classroom appropriateness.

BACKGROUND SUMMARY: Citizens of coastal towns often need to plan for problems which people from landlocked towns can ignore. Biological, geological, physical, chemical and political considerations must be addressed to plan for the future of a coastal town. Economically, the success or demise of coastal towns are linked to the environment. This activity provides an opportunity for students to develop a plan to solve various problems for a hypothetical coastal town.

OBJECTIVES: Students will be able to:
1. Formulate a written plan for the future of a town based on their own interpretation of typical coastal problems and solutions.
2. Define their plan in an oral presentation to the other students in class.

MATERIALS:
The following biological, geological, physical, chemical and political cards must be constructed by cooperative learning student teams:

1. Biological Considerations:
   a. A fishing industry, based on menhaden, thrived in your area during the 1950s and 1960s. Due to a lack of fishing restrictions and regulations, the menhaden population decreased dramatically, which forced the closure of the processing plant in 1967. Since 1967, the menhaden population has increased to healthy levels.
   b. Your area is one of only six locations worldwide where an endangered species of fish, *Hall ullmanensis*, is found.
   c. A European (exotic) species of algae, with little food value, was transported in the bilge water of a ship and established itself in the water column adjacent to your town. It has now "out-competed" many local species of algae and is the primary producer in the water column.

d. Farmers want to have regulations changed to enable them to use sludge from the sewage treatment plants to fertilize their tomato fields. Other citizens are concerned that scientists do not know as much as they should about viruses derived from sewage sludge. These citizens are worried that unknown viruses, able to infect humans, could live through the sewage processing. The virus would be in the sludge, and tomatoes grown with the sludge could transmit the virus to unsuspecting humans.
e. Water craft are the latest fad among teenagers in your town. People are beginning to notice damage to subaquatic vegetation. This damage was most likely caused by water craft.
f. A storm recently destroyed dune grass along the dunes in your town. Citizens are interested in beginning a program to re-establish the dune grass.

2. Geological Considerations:
   a. Some of the homes along the oceanfront of your town are in danger of falling into the ocean due to beach erosion.
   b. Last year, your town spent $2 million replenishing the beach with sand from the continental shelf area. Geologists predict the replenished beach will only last three years because the grain size of the offshore sand is different from the grain size of the natural sand.
   c. Some of the homes along the beachfront of your town have seawalls to protect them from erosion. These sea walls were built long ago. More current regulations prohibit the construction of seawalls because they focus the wave energy and can cause larger problems than they solve. Some citizens are requesting removal of the seawalls to comply with the more current regulations. However, homeowners with seawalls are concerned about erosion destroying their homes if the seawalls are removed.
   d. Business owners have proposed a new boardwalk for the town. Other citizens are concerned the boardwalk will increase beach erosion.
   e. A local group of beachfront homeowners wants to build groins to protect their property. Other beachfront homeowners are against this action because the structures could increase beach erosion on their property.
   f. The Army Corps of Engineers proposes construction of a jetty at the inlet to your town's harbor. This proposal originated because they wish to stabilize the inlet, thereby enabling boats to pass in and out of the small harbor. Many citizens are concerned the jetty will cause erosional and depositional problems elsewhere.

3. Physical Considerations:
   a. Your town is close to the Gulf Stream. This location supports a thriving tourism industry for your town.

b. Longshore currents in the region of your town flow toward the south.
c. State officials are proposing a tidal power generation system to be placed in a local estuary.
d. An oil spill has just occurred fifty miles offshore to the northeast of the coast of your town.
e. Town officials want to close the beach for several days because there is a violent storm at sea. Town officials are worried that swells and rip currents enlarged by the storm present a hazard to coastal property.

4. Chemical Considerations:
   a. Your new sewage treatment plant has improved the quality of treated water flowing into the adjacent inlet. However, nitrogen and phosphorous contents in the effluent are still high.
   b. Your sewage treatment plant is now operating at 80 percent capacity. Federal law states when a plant is that close to 100 percent capacity, the municipality must begin to plan for increasing the capacity or building a new plant with a larger capacity.
   c. A local factory is releasing mercury (a toxic metal) into a creek which flows to the sea.
   d. Salt water intrusion occurs in the aquifer which provides drinking water for your town.
   e. High levels of pesticides have recently been detected in the estuarine waters of your town.

5. Political Considerations:
   a. The state has decided to shift environmental regulation to local regions. Block grants totaling $1 million have been provided for your town to finance a study of the environment within town limits and the adjacent ocean region. A plan for regulating environmental quality needs to be produced within this project.
   b. A developer friend of the mayor has purchased seafront property and is requesting rezoning to construct condominiums. The present zoning allows for single-family homes only.
   c. The Republicans have just gained seats in Congress. They intend to decrease the federal subsidies to your town by $10 million.
   d. The local military base is on the government's list of bases to be closed.
   e. The state plans to build a new aquarium and natural history museum in your town. Tourism officials project the combined attractions will draw one million additional visitors to your town each year.
   f. When levels of *Escherichia coli* become high, the law requires beach closure, because this bacterium indicates human feces are present and that other pathogenic bacteria may also be present. Beaches have been closed. The state responded by increasing the quantity of bacteria allowed before beach closure. Many citizens are disturbed by this decision since they believe their children may become sick.

ACTIVITY: Divide students into cooperative learning groups of five students per group. Each group of five is a town council from a coastal town. The mission of the town council is to develop a future plan for their town which addresses and, hopefully, solves existing problems. The students can choose a name for their town. Five stacks of cards should be prepared prior to the arrival of the students.

Each stack contains problem scenarios. The stacks are based on the following categories:

a. Biological considerations
b. Geological considerations
c. Physical considerations
d. Chemical considerations
e. Political considerations.

Each group must pick one card from each stack. These cards contain information on the problems which must be addressed in the future plans of the town. Each group must take their set of five considerations and design a coastal town which complies with the considerations. The students must then collaborate to create a plan which will best serve the interests of the town. Each group must then present the plan in an oral presentation to the rest of the class. Students not in the group presenting will serve as the citizens of the town. While the group is presenting, the teacher will evaluate the group based on a pre-desired rubric. The students serving as citizens will then complete a questionnaire designed as an election form. This will keep the citizens on task and provide feedback to the students presenting.

POSSIBLE EXTENSION:

1. The students could videotape the presentations and then complete a written critique of their own presentation.
2. Students could attend an actual council meeting for their own town.
3. The students could create maps of their hypothetical town. Students could also create pictures and a computer simulation.

TEACHER EVALUATION: Student performance can be assessed when making their oral presentations. A rubric can be administered in advance then used as a guide for grading. The pre- and posttests can also be used as a component of student performance assessment if desired.

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Marine and Aquatic Pollution

TOPIC-TITLE: Marine and Aquatic Pollution - *Landfills*

AUTHOR: Daisy Atalig, Isacc Jackson, Pepine Laurao, Stephanie Kama Keeaina, Eloise Manglona, and Bismarck Sebastian

GRADE SUITABILITY: Middle School

SCOPE: Coastal Ecology

SEQUENCE: This activity should follow a discussion on landfills and the impacts that landfills have on a watershed. Prior watershed knowledge is also important.

BACKGROUND SUMMARY: According to Greene (1998), the United States disposes of more garbage than any other nation in the world. Approximately 75% of all trash is buried in landfills. However, many cities and states are running out of areas to dispose their wastes. Incineration is one alternative to landfills. However, incinerators can be expensive and can add to air pollution. The best alternative is recycling. In order to make recycling programs effective, public participation is essential.

OBJECTIVES: Students will be able to

1. Describe the advantages and disadvantages of landfill practices.
2. Develop an awareness of the impact of landfills on local ecology.

MATERIALS:

- Video on landfill development
- Old and new pictures of the island areas
- Crayons/markers
- Reference books
- VCR/TV
- Slides
- Paper

ACTIVITIES:

1. Initiate a class discussion in order to gather information about students' knowledge of landfill practices. What is a landfill? Where do they occur in your area? Show slides or a video about landfill practices.

2. Separate students into cooperative learning groups. Have groups develop a list of what they believe are advantages and disadvantages of landfill practices. Each group should present its list to the class. Have the class combine all the information into a master list of advantages and disadvantages. A town official can be invited to talk to the students about the different types of landfills and to answer questions. This will also help the students decide a focus area for their work. The town official can provide a list of the local landfill areas.

3. Each group should choose a landfill area to research. Student groups will use the resource materials and pictures to create a book illustrating the advantages and disadvantages of landfills which will be used as a reference for other students.

POSSIBLE EXTENSION:

1. The students could write a letter to local, state or federal representatives relative to specific views on landfill practices in their town or state.
2. Students could research their town's recycling programs and organize a campaign to recycle in their schools and in their homes (if this has not already been accomplished).

TEACHER EVALUATION:

1. A leader will be selected for each group.
2. The students will create a list of jobs for each member of the group.
3. Each member must sign on a daily work card. This verifies student participation. The group leader will sign the card and verify each student has performed his/her job for the day. These cards are submitted to the teacher on a daily bases.
4. The grade is based on the daily participation of each student and the completed book let.

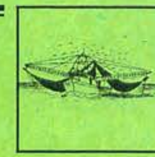
Each book should include:

a. Title page (cover sheet)
b. Table of contents
c. Author page (students write about themselves)
d. Contents (includes in-depth information and pictures or illustration. Eighty percent of the grade is based on this section)
e. Bibliography

REFERENCES:

Greene, Thomas F. 1998. *Marine Science.* New York, New York. AMSCO School Publications, Inc.

Marine and Aquatic Resources



TOPIC V

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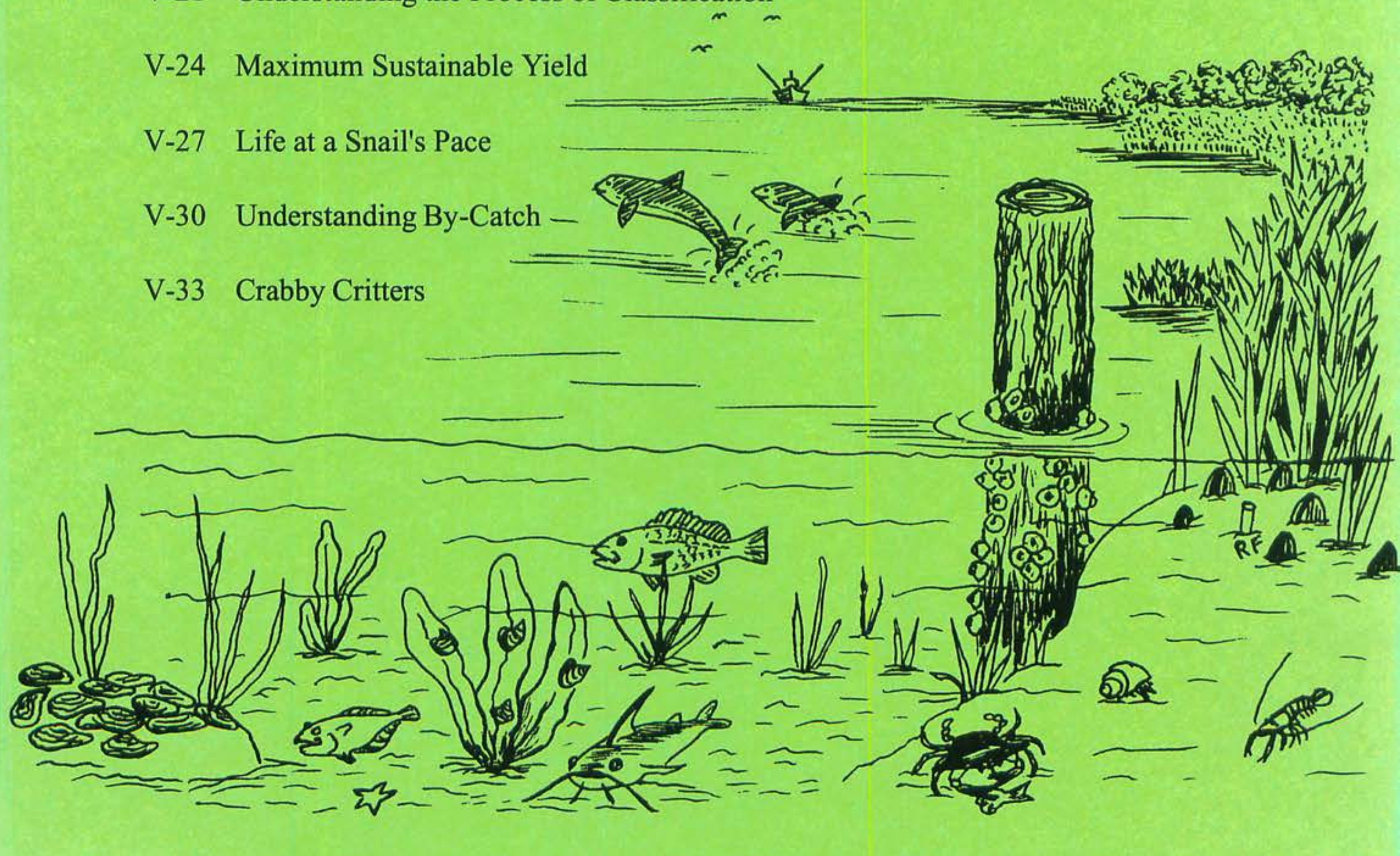
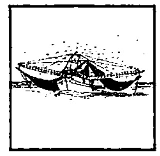


Marine and Aquatic Resources



INTRODUCTION

Marine and Aquatic Resources

The marine environment provides abundant resources. Coastal waters within 200 miles of land contain more than half of the ocean's total biological productivity and supply nearly all the world's fish catch. The seafood industry helps to supply developing nations with food and represents a $10 billion industry in the United States alone. The ocean also provides mineral resources, a potential energy source, a future supply of drinkable water, and may possibly prove to be a richer resource than the rainforest as new materials are discovered.

One of the most utilized resources we obtain from the ocean is seafood. For many people around the world, seafood is their main source of protein. An average serving of fish contains more protein than a serving of beef and provides consumers with Vitamins A, B, and D. Iron and copper may be obtained from shrimp and oysters, and other seafood gives us more magnesium and phosphorus than milk. Fish meal is an important ingredient in food for poultry, cattle, dogs, and cats. Fish are also used as fertilizers for plants.

Wetlands provide a vital contribution to the commercial fishing industry. Coastal wetlands serve as nursery areas for one-half to two-thirds of all sport fish. Shellfish life cycles are also integrally related to salt marshes. Wetlands are important in controlling flooding, preventing storm damage, and trapping sediments and pollutants.

The ocean provides plant resources which are beneficial to humans. Kelp beds are prolific in many of the Earth's oceans and support a wide diversity of organisms. Kelp and other species of algae contain a chemical called algin, which is a stabilizer used in ice cream, other dairy products, many processed foods, beverages, and medicines. Algin is also used in paper production, cosmetics, ceramics, paint, and insecticides. In Japan, seaweed is an important food product and is harvested from the sea.

Most of our energy needs are met by fossil fuels. As we deplete our oil and natural gas stocks on land, we have become more dependent upon the ocean to provide these resources. The ocean floor is currently being mined for minerals, such as phosphates, heavy metals, and manganese nodules.

In the future, the oceans could be a source of even more resources. Once a cost effective method of desalination is developed, a new source of freshwater will be available. Scientists are making new discoveries every day, and no one knows what other resources the sea contains. Our oceans and wetlands provide us with a wealth of resources, and therefore, these areas must be protected from pollution, encroachment by man, and any other factors which are destructive to this valuable ecosystem.

One way in which marine organisms are being conserved is through the establishment of marine sanctuaries and government legislation such as the Endangered Species Act and Marine Mammal Protection Act. According to Green (1998), there are currently nine

designated marine sanctuaries within the United States. Eight other areas are proposed marine sanctuaries. These areas are protected, and no commercial activities are permitted within sanctuary boundaries. The National Marine Sanctuary Program is under the direction of the National Oceanic and Atmospheric Administration.

The Endangered Species Act was established in 1973 and was designed to protect animals from extinction. Animals are listed as threatened or endangered according to their immediate risk. Under the Act, it is illegal to harass, take or transport any animal or plant on the list. It is also illegal to import a listed organism or any of its parts into the United States.

The Marine Mammal Protection Act was passed in 1972, and it specifically protects animals such as whales, dolphins, manatees, otters, seals, sea lions, and walruses. Many populations of marine mammals have been decimated by whaling, fishing, or hunting (Green, 1998). However, due to Acts such as these, many of these populations are beginning to recover in the United States. For example, the California Gray Whale population was reduced to only 5,000 animals in 1910 (Greene, 1998). Since the gray whale was listed as an endangered species, the population has increased to approximately 22,000 individuals.

While these regulations protect and are often helping to rebuild populations within United States boundaries, many resources still require further protection. The organisms and other ocean resources do not respect governmental boundaries. Therefore, protecting the vast resources contained in the world's oceans is a global struggle. Cooperation with other nations and educating people to respect the ecosystem as a whole are integral components of global conservation and preservation of resources.

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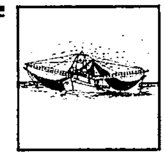
Marine and Aquatic Resources



TOPIC-TITLE: Marine and Aquatic Resources - *The Effects of Salinity, Temperature, and Pollutants on Brine Shrimp Eggs*

AUTHOR: John Jackson

GRADE SUITABILITY: Middle School

SCOPE: Biology and Ecology

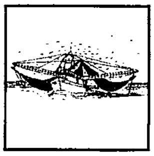
SEQUENCE: This lesson should follow a unit on the different types of habitats and the important role they play in the ecosystem.

BACKGROUND SUMMARY: Where and the means in which plants and animals can live are governed by abiotic (non-living) and biotic (living) factors. Examples of abiotic factors for marine habitats may include nutrients, pressure, temperature, pH, salinity, substrate type, circulation patterns, and dissolved oxygen. Biotic factors may encompass, predation, availability of food, and genetics.

Marine organisms born and reared in estuaries must survive daily changes in salinity, temperature and, often, dissolved oxygen. Since humans often live in close proximity to estuaries, many pollutants may be flushed into the water. Estuaries are highly productive environments and important habitats for a diversity of organisms due to the presence of abundant food, vegetation, and shelter.

OBJECTIVES: Students will be able to:
1. Explain the importance of preserving estuaries.
2. Discuss limiting factors.
3. Develop experiments to test the effects of salinity and temperature on brine shrimp eggs.

MATERIALS:
- Nine baby food jars per cooperative learning group
- Celsius thermometer
- Hand lens
- Marking pens
- Eye dropper
- Brine shrimp eggs
- Three liters of 3% salt water
- Two liters of 10% salt water
- Two liters of fresh water



- Air pump
- Salt
- Bleach
- Oil
- Detergent

ACTIVITY: Students should be placed into cooperative learning groups of four students each. Each group should research the role of estuaries within the environment. Each research group will then perform the following experiment.

1. Label nine baby food jars with numbers one to nine using marking pens.

2. Fill each jar 3/4 full with the following solutions: jar #1—freshwater, jar #2—10% saltwater, jars #3-9—3% salt water.

3. Place equal amounts (20-40) of brine shrimp eggs in each jar with an eye dropper. Retain 20-40 brine shrimp eggs in the original jar as a control. This jar should be stored at room temperature.

4. Store jars #1-3 at room temperature (an air pump will oxygenate the water and should provide improved results).

5. Store jars #4-6 at the following temperatures: jar #4—at room temperature, jar #5—in a refrigerator at approximately 4°C and jar #6—in an incubator/light box at approximately 35°C.

6. Add a few drops of the following pollutants to each jar and store at room temperature. Jar #7—bleach, jar #8—detergent, and jar #9—oil.

7. Record the following data for each jar: exact temperature, salinity, and type of pollutant.

8. Observe each jar daily with a hand lens. Estimate the percentage of eggs which hatch after three days. Sketch eggs and hatched larva.

9. Record the results of these experiments in a laboratory journal and identify the limiting factors observed for each jar. Each student group should develop conclusions based on its results. Each group should present its results and conclusions of the experiment to the class. After each group has presented its re search results, the class should compare and contrast these results and conclusions. A new list of limiting factors should then beidentified.

POSSIBLE EXTENSION:
1. Repeat the experiment using eggs of other estuarine species.
2. Visit an estuary.
3. Research a particular estuary and make a list of endangered species which may reside in the estuary.

TEACHER EVALUATION: Have the student groups write a report on the importance of estuaries and marshes. The laboratory journal can be evaluated on the basis of results of the experiments and conclusions drawn from the results. Student reports and involvement in class discussions should also be evaluated.

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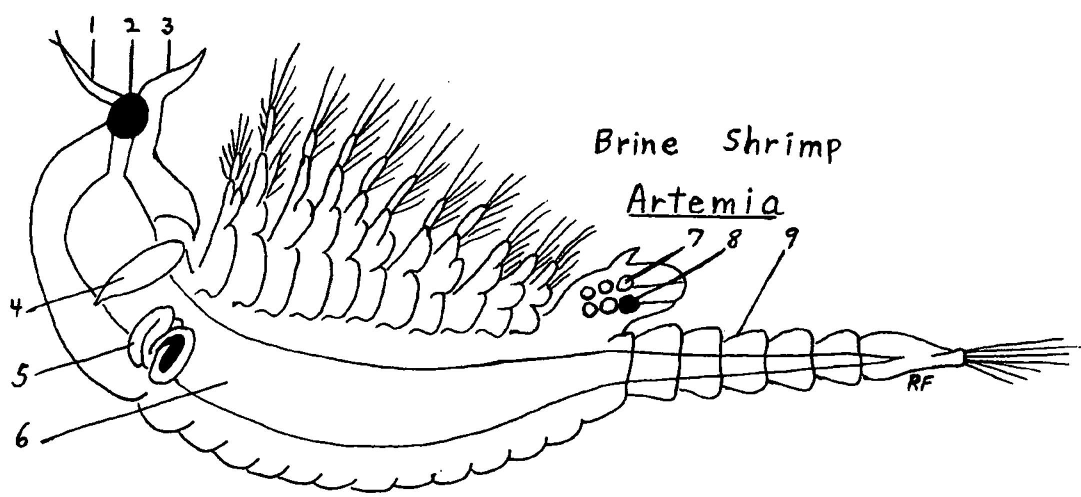
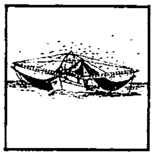


1 Antennule
2 Compound Eye
3 Antenna
4 Mandible
5 Excretory Organ
6 Intestine
7 Brood Pouch
8 Shell gland
9 Abdomen

May be reproduced as a hand-out or a transparency.



TOPIC-TITLE: Marine and Aquatic Resources - *Hide and Seek—The Benefits of Camouflage*

AUTHOR: Laura Martin

GRADE SUITABILITY: Lower Elementary

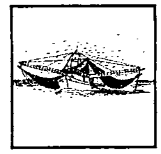
SCOPE: Ecology and Biological Oceanography

SEQUENCE: This activity would be introduced within the fish unit of the biological section of oceanography. Marine mammals could be studied next and comparisons and contrasts between fish and marine mammals could be made.

BACKGROUND SUMMARY: In order to maintain nature's balance, all species of plants and animals develop a means of protection to ensure the continuation of their species. For example, angel fish have coloring which protect them from predators. The vertical stripes along their bodies provide camouflage and allow them to hide among seaweed, avoiding detection. A vertical stripe across their eyes hides the face. Shape also protects the angel fish. The lateral or side view shows the length of the body with stripes and a tail. When the angel fish turns to face the enemy, its profile is drastically reduced, and the fish seems to disappear. Angel fish often swim in schools and move and turn as one. Other fish, such as the butterfly fish, employ other means of camouflage such as an eye spot. Eye spots are designed to confuse predators, leading the attack away from the more vulnerable regions of the fish.

OBJECTIVES: Students will be able to:
1. Apply their understanding of the body parts of fish as they construct their fish with specific adaptations.
2. Demonstrate an understanding of the movement of a school of fish by their dramatic presentation.
3. Design an environment for their fish based on its coloration, providing students with an introduction to the advantages of camouflage.

MATERIALS:
- Two paper plates (not Styrofoam) per student
- Tongue depressors (one per student)
- Glue
- Crayons and markers
- Reproduced page of caudal area and fins
- Various drawings of fish and/or preserved fish specimens (preserved only in Carosafe® or alcohol)



- 11 x 18 white or light blue paper (one sheet per student)
- Several staplers

ACTIVITY: Discuss fish shapes, coloration patterns, and the external anatomy of fish as illustrated by various drawings or by viewing preserved specimens. Be sure to identify the fins (dorsal, caudal, pectoral, pelvic, anal, and adipose). Provide each student with the materials previously discussed. Staple the paper plates together around the edges so they bulge slightly. Cut and paste different body parts onto the paper plate. Draw the eye, stripes, and eyespot, and then color the fish. Glue a tongue depressor between the two paper plates to make a handle with the fish on top. Let the glue dry. The following day, designate a school of fish. Students should practice holding their fish in the same direction and moving in unison. Choose a predator to appear at different intervals and have the school of angel fish respond by turning toward the predator. Allow other students to be the predators. Other models could be aspects of the habitat (examples: seaweed or rock).

POSSIBLE EXTENSION:

1. Create a background mural for fish.
2. Research different kinds of angel fish. Contrast and compare various angel fish.
3. Create a new species of fish, construct an environment, and describe the adaptations which allow it to successfully live in its habitat.

TEACHER EVALUATION: Evaluate the model (are the body parts where they should be, and did they include stripes?) Observe whether or not the students understand the movement of the school as one fish by their presentation.

1. How does the angel fish's body shape help to protect it?
2. How does coloration protect it?
3. What are these features called?

REFERENCES:

Castro, Peter and Michael E. 1992. *Marine Biology*. Dubuque, IA. Wm. C. Brown Publishers.

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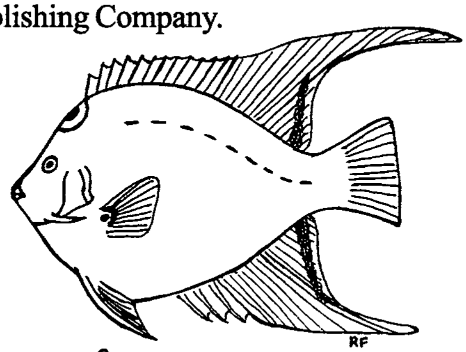
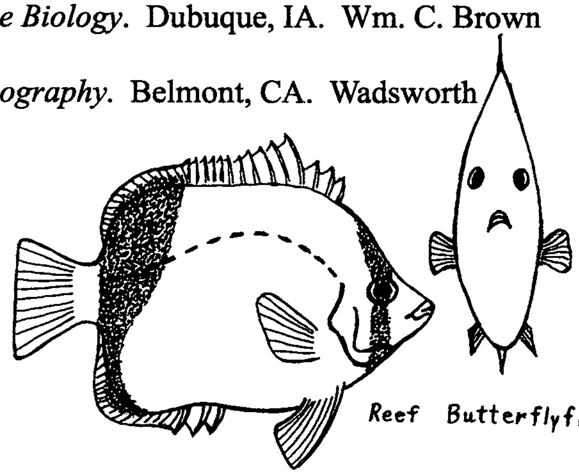
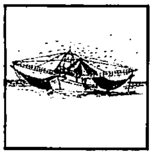


Queen Angelfish



Reef Butterflyfish



TOPIC-TITLE: Marine and Aquatic Resources - *Where Does a Clam Like to Live?*

AUTHOR: Pamela Albright, Ted Albright, Karen Jerz, and Dana Mitchell

GRADE SUITABILITY: Upper Elementary and Middle School

SCOPE: Environmental Science, Social Studies, and Biology

SEQUENCE: Prior to this activity, students should have been introduced to clamming as a viable occupation. Students should also have an understanding of various clamming instruments.

BACKGROUND SUMMARY: Clams are a common item on most seafood menus. However, because clams live buried in the substrate, most people know little about them. Clams are one of the most commercially valuable marine organisms harvested and are very sensitive to sediment type, water quality, and availability of food. Clams are filter-feeders and burrow into sediments and siphon nutrients and oxygen from the water column.

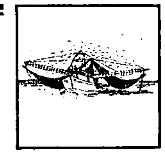
OBJECTIVES: Students will be able to:
1. Identify seven sediment types which are common to the intertidal and benthic zone.
2. Identify the type substrate a clam prefers to inhabit.
3. Recognize and identify the adaptations clams have developed, thereby, enabling them to survive in a given habitat.

MATERIALS:
- 14 small live clams (soft-shell or cherrystone clams)
- Seven different sediment samples: clay, gravel, sand, mud, silt, pebbles, or larger rocks
- Seven to eight small aquaria or clear containers improvised from two- or three-liter clear soda bottles
- Several gallons of sea water or Instant Ocean®
- Pint size Ziplock® plastic bags or clear containers
- Permanent magic markers

ACTIVITY:
1. Place the students into cooperative learning teams of four studens per group.

2. Distribute samples of different substrate types to student teams.

3. Have the student groups identify each type sediment they are given and mark the substrates appropriately.



4. Ask the students in which sediments would the clam prefer to live. Have the student teams record their ideas in the form of hypotheses.

5. Ask each team to develop a simple experiment to determine which of at least two different sediment types clams prefer. Example:
   a. Place two different sediments in a container. The sediments should be approximately the same thickness.
   b. Cover sediments with at least two inches of seawater.
   c. Place one or two clams of equal size into each container.
   d. Observe the clams to ascertain into which sediment they burrow. Do they both prefer the same one? Do they burrow equally fast?

6. Record observations, including adaptations which clams have enabling them to live in the sediment of their choice. Repeat this process and compare results.

7. Have student teams compare their results with those of other groups. Discuss with the students why certain sediments seem to be preferred; what effect polluted waters have on clams and humans; and what laws are enacted to protect humans from "tainted" clams.

POSSIBLE EXTENSION:

1. Encourage students to observe the clam's two siphons and to identify which one takes in food and which siphon releases waste.
2. Dissect a clam and trace, in a diagram, the progress of food from the water column through the clam's digestive track to the waste material.
3. Build a "larger-than-life" model of a clam with recycled materials collected on a beach clean-up excursion.
4. Conduct research and write a history of the clamming industry.

TEACHER EVALUATION:

1. Evaluate the quality of group hypotheses and experimental design.
2. Evaluate the organization of the research teams. Did everyone participate equally?

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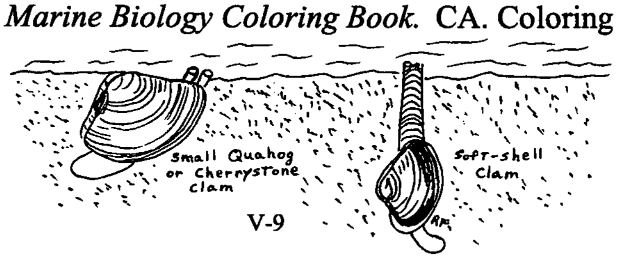


TOPIC-TITLE: Marine and Aquatic Resources - *Exotics in the Local Food Chain*

AUTHOR: Neil Boettcher

GRADE SUITABILITY: Middle School

SCOPE: Life Sciences and Environmental Science

SEQUENCE: Prior to this lesson, students will have studied the water flow patterns of local watersheds, and the students will also have viewed videos focusing on local flora and fauna.

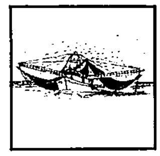
BACKGROUND SUMMARY: The introduction of exotic species has had a dramatic effect on the native fish populations in many marine and aquatic environments including the Great Lakes. The introduction of organic and inorganic substances, such as PCBs and DDT, has affected the reproductive processes of fish populations. The rise and fall of the fish populations have had dramatic effects on animal and bird populations, as well as an economic impact on the humans who depend on these resources for their incomes and recreational enjoyment.

OBJECTIVES: Students will be able to:
1. Understand the role of the food chain.
2. Identify many of the native species endemic to their area.
3. Understand the predator/prey relationship and its effects on local fish populations.
4. Identify exotic species and understand their relationship to native fish populations in their area.

MATERIALS:
- Scissors
- Drawing (construction) paper
- Ruler
- Colored pencils, crayons, and markers
- String
- Video equipment

ACTIVITY:
Note: A list of species from recent sampling nets by a local natural resources conservation agency such as the Department of Natural Resources may be helpful for this activity.

1. Begin with a fish parts matching game using anatomical parts from drawings of native species.



2. Students will assemble their fish and then proceed to draw and color them for display.
3. Using available resources, students will compile brief "biographies" on their fish for a presentation to the class. Each presentation will include habitat, size, preferred food, reproduction, and diagnostic characteristics.
4. Students will construct a food web for their fish and participate in "role-play" based on their food webs.
5. Students will research if exotic species have been introduced in their area.
6. A discussion and "role-play" will then add the exotic species to the food web.
7. Students will analyze the effects of exotics found in their area on the native populations.
8. Students will develop predictions regarding the future of the local ecosystem with respect to overfishing or other environmental concerns.

POSSIBLE EXTENSION:

1. Math students could calculate the ppm of toxic chemicals in fish species based on the bio-magnification principle.
2. Students could research possible aquaculture careers.
3. Students could examine industries which rely on local watersheds for cooling, water dilution, or manufacturing. A field trip could be arranged to one of these industries for observations of its effects. Prepare a presentation of your findings. Are these indus tries harmful to fish, water, birds, humans, or the environment?
4. Students could research the affects of exotic species on other ecosystems (i.e. zebra mussels in the Great Lakes). Students could compare and contrast the effects.

TEACHER EVALUATION:

1. Students will be graded for participation in the activities.
2. A short essay exam will be used, including questions such as:
   - Can we stop the parade of exotics into the environment?
   - How do toxins in fish affect various bird populations?
   - How will the United States fisheries change in the future?
3. The completed fish models will be displayed.

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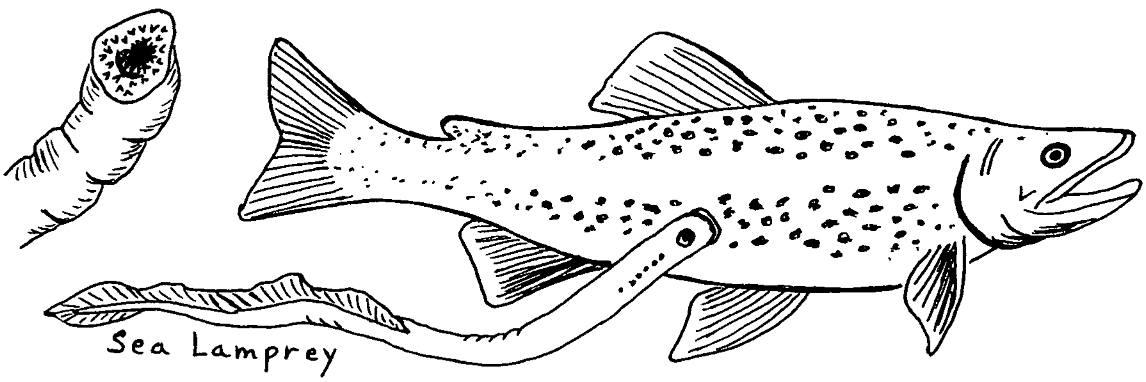
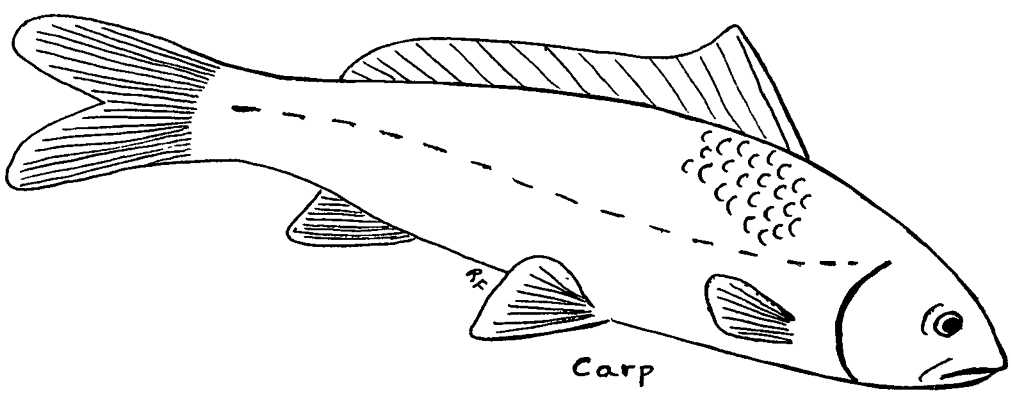
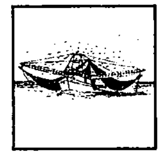




Marine and Aquatic Resources



TOPIC-TITLE: Marine and Aquatic Resources - *Mangrove Swamps-A Wealth of Resources*

AUTHOR: Trisha Hembree

GRADE SUITABILITY: Middle School

SCOPE: Marine Ecology-Marine Resources: Sport Fishing

SEQUENCE: The students should have completed an introduction to the abundant flora and fauna associated with the marine ecosystem. This activity is intended to be an introduction to a detailed study of marine habitats and possible resources available to humans. This activity would complement either Christmas activities or the first day of spring activities.

BACKGROUND SUMMARY: Sport fishing is a growing form of recreation in the United States. The associated economic impact of this sport, including motels, bait shops, restaurants, license fees, parks services, and boat manufacturing, has made sport fishing a viable economic resource for coastal communities. One of the most challenging and richest fishing areas can be found in the mangrove swamps, which host a wealth of marine vertebrates, invertebrates and mammals. Mangrove swamps are transition zones between marine and terrestrial environments.

Mangrove thickets are usually found in low energy, tropical and subtropical coastal zones. Mangroves are the only trees in the world which can survive in salt water. Mangroves are found in areas rich in deposits of peat from accumulated vegetation, black carbonate mud, and sand. Some of these particles are carried in the water column by tides or storms and trapped by the thick tangle of mangrove roots. Mangrove thickets are important stabilizers within their niche just as sea oats are important stabilizers of sand dunes. In the United States, many mangrove swamps can be found on the southern coasts of Florida and Texas. Mangrove thickets are also abundant throughout the Caribbean.

There are three types of mangroves:

1. Red mangroves are located furthest offshore; they have an extensive "intertwining" system of prop roots; they extract oxygen from the salt water; and they provide a complex micro-environment for marine organisms. Red mangroves are considered prime sport fishing areas because of the diversity associated with this habitat.
2. Black mangroves have a black trunk; they have vertical roots which protrude from the ground to extract oxygen; and they provide a great nursery for many organisms due to the shallow water and the cover offered by the maze of roots.

3. White mangroves are located above the high water level on more firm substrate. Their roots firmly adhere to the ground. They provide the shoreline with protection from storms due to their strong root system. White mangroves also are used as rookeries for many species of birds.

Due to the location of mangroves at the edge of the sea, a ladder-like effect in biological diversity can be noted on and in the root system. The leaves which fall from the trees settle to the bottom where microscopic bacteria and fungi begin their jobs as decomposers. Feasting upon the decomposers are the larval forms of many marine organisms. Feeding upon the larvae are the next organisms in the food web; this process continues until the apex predator or top of the food chain is reached. The majority of the larger predators tantalizes many sport fishermen, including many species of salt water fish such as snook, tarpon, redfish, and sea bass.

OBJECTIVES: Students will be able to:
1. Construct a model of a mangrove swamp.
2. Identify and construct models of the organisms associated with a mangrove swamp food web.
3. Simulate fishing and test the effects of overfishing the system.
4. Determine the results of improper fishing practices.

MATERIALS:
- Meter sticks—at least six for each cooperative learning group
- Old blanket, sheet, or towel
- Multiple cut-outs of marine organisms which are associated with this system
- String and tape
- A fishing pole with a pipe cleaner hook

ACTIVITY:
1. Allow the student groups (four students per group) to use the blanket, sheet, or towels to simulate the bottom sediment.

2. Student groups should construct the root system of the mangrove tree upon this base using the meter sticks.

3. Student groups should tape and tie their assemblage of organisms to the roots and bottom sediments in appropriate locations.

4. When finished, students should "go fishing" to test the integrity of the system. One student should sit among the "roots" to place the catch on the hook. Students should simulate all possible combinations of success and degradation.

5. When the students have had their "fill of fishing," they should brainstorm and record a list of actions/reactions to the environmental stresses they simulated.

POSSIBLE EXTENSION:

1. Students can research the current fishing regulations as they pertain to this system.
2. Students could take their ecosystem and teach the students in an elementary school about the balance of this system and the importance this balance plays in our lives.
3. Students can use their own talents to draw or trace their animals.

TEACHER EVALUATION:

1. Students should be able to construct a mangrove swamp model in a sturdy, appropriate manner.
2. Students will be able to list factors and results which lead to instability within this bioeconomic system.

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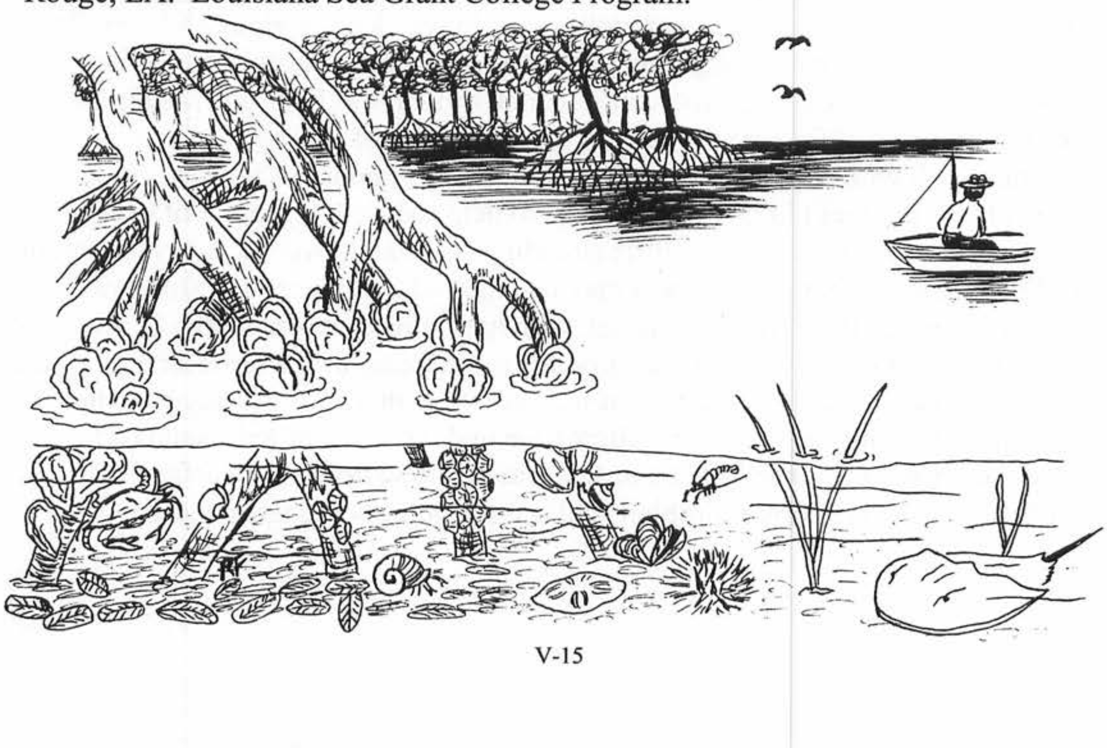
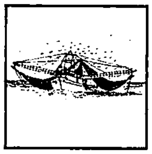




TOPIC-TITLE: Marine and Aquatic Resources - *Sustainable Food From the Sea*

AUTHOR: Georgia Graves

GRADE SUITABILITY: Lower Elementary

SCOPE: Marine Science and Social Studies

SEQUENCE: This activity will be conducted following a unit of study on the ocean and coastal estuaries. The students should have the knowledge of fisheries as critical economic resources.

BACKGROUND SUMMARY: In 1976, the world catch of cod, herring, tuna, oysters, crabs, scallops, lobsters and clams was approximately 162 billion pounds. U.S. fishermen caught 5.4 billion pounds of fish and shellfish (including shells), which was a third of Japan's catch. Approximately one half of United States seafood is used as animal feed and in industrial products.

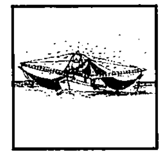
Food from the sea is a highly valuable source of nutrition, and fish are a good source of protein. Unfortunately, when compared to Japan, only one-seventh of a fish is utilized by the average American. Fish and shellfish supply valuable vitamins such as A, B, and D. Shrimp and oysters are high in magnesium, phosphorus, iron and copper, which are important components of blood. Seafood has as much as 200 times the iodine needed for proper thyroid function when compared to other food sources.

Shrimping in the Gulf of Mexico is an extremely valuable economic resource. The primary shrimp caught are generally the brown and the white. Even though commercial fishing and shrimping are of high economic value, by-catch is a serious problem. Trawl mesh sizes need to be small enough to catch the shrimp; unfortunately, trawls catch other organisms of equal or larger size including sharks, finfish, shellfish, and sea turtles. It is estimated 10 pounds of finfish are caught for every pound of shrimp.

Although met with strong opposition by shrimpers, regulations now require the use of Turtle Excluder Devices (TEDs) in trawl nets to help reduce the capture of sea turtles and other by-catch. Unfortunately, sea turtle strandings escalated over the last year, forcing the TEDs issue into debate. Shrimpers may be required to replace their soft trawls, which expel turtles through the bottom of the net, with hard trawls, reversing the expulsion to the top of the net. One possible explanation for the increase in sea turtle strandings may be that turtles are forced to the bottom of the net where they are "pounded" on the substrate prior to expulsion. Another alternative under consideration would be to "flip-flop" the trawl net, expelling the turtle from the trawl nearer the surface.

Finfish by-catch is a serious problem and is threatening some fish populations.

Marine and Aquatic Resources



By-catch Reduction Devices (BRD) are currently under research and development. These BRDs will be attached to shrimp trawls, allowing fish to escape the nets.

The increasing desire for shark steaks in the United States and shark fins in Asia has prompted rapidly growing fisheries for sharks. Federal regulations for shark fishing are now enforced in the Atlantic, Caribbean, and Gulf of Mexico, due to the high rate of shark landings over the past decade. Many fish and shellfish which are caught rely on the quality of estuarine and marsh habitats for propagation and nutrition. These habitats are being rapidly lost due to chemical and physical pollution, development, and dredging—all of which have a negative impact on the future of sustainable fisheries in the United States.

OBJECTIVES: Students will be able to:

1. State the need for regulations limiting the amount of fish harvested.
2. Compare each student learning group's catch and make inferences regarding the results of each group activity as it relates to the fishing industry.

MATERIALS:

- Large fish bowl
- Two, 3-gallon container of Pepperidge Farm® Goldfish Crackers (per 25 students)
- One to two packages Gummie® sharks—one bag for each student

ACTIVITY: Prior to beginning this activity, place the children into two, cooperative learning groups and tell them they will be going on an imaginary fishing trip. Let each group select a name for their boat.

1. Fill a large fish bowl with goldfish crackers.

2. Tell the students they will be fishing by using their hands to catch as many fish as they can from the fish bowl.

3. Choose a student from the first group to catch as many fish as he/she can and take them back to the boat where the other students can help count the fish. The other group will quickly see they are not going to get as many fish as the first group. At this point, the teacher can remind the students that most fish lay eggs and can add more goldfish to the bowl. The students should understand if there are fewer fish in the ecosystem, fewer offspring will be produced.

4. Repeat the procedure for the second group. Do not add any more goldfish after the second group has "gone fishing."

5. Add some of the Gummie® sharks to the bowl to act as predators. The teacher should remove some goldfish which have been "consumed" by the predators.

6. Continue the procedure until the fish bowl is empty.

7. Have each group count their fish. Discuss what happened to the fish population due to over harvesting and predation.

POSSIBLE EXTENSION:

1. Make a class book of regulations with the children's illustrations. Send it, along with student letters, to the U.S. Fish and Wildlife Service.
2. Set up a wading pool, using small plastic fish and different sizes of kitchen sieves (to represent fish nets). The students can catch the fish, then compare the amount caught in the different "net" sizes.
3. Add a pollutant such as an oil spill to the fish bowl and discuss the effects. Pollutants may be simulated by adding bits of colored paper.

TEACHER EVALUATION:

1. Make a class graph showing the number of fish caught by each group. The students will compare what each group caught and tell why the first group made the largest catch.
2. In their same groups, the students will discuss three commercial fishing regulations which help protect fish species from depletion. Each group will share its regulations and tell why it chose them.

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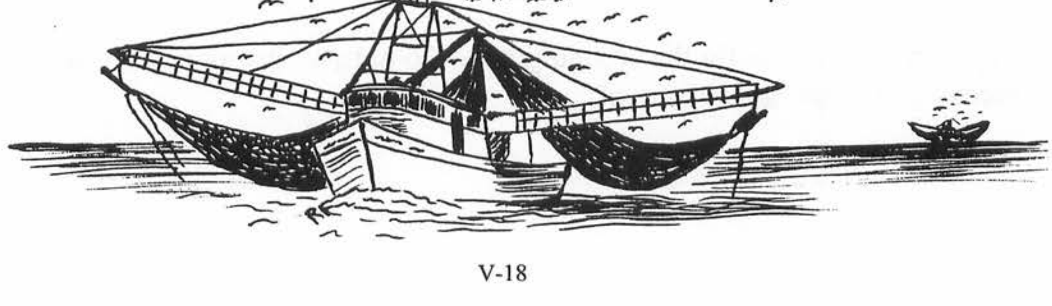
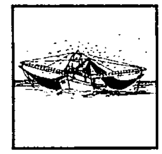


Marine and Aquatic Resources



TOPIC-TITLE: Marine and Aquatic Resources - *The Key to Survival*

AUTHOR: Amorilla Catabas, Nita Elayda, Alfred L. Hitchfield, Rizalina Maratita, and Evangeline Mendiola

GRADE SUITABILITY: Middle School

SCOPE: Coastal Ecology

SEQUENCE: This activity should follow a discussion on the ocean and the zones in the ocean. Students should become familiar with some of the organisms which inhabit each zone. A videotape depicting the various zones would enhance this unit.

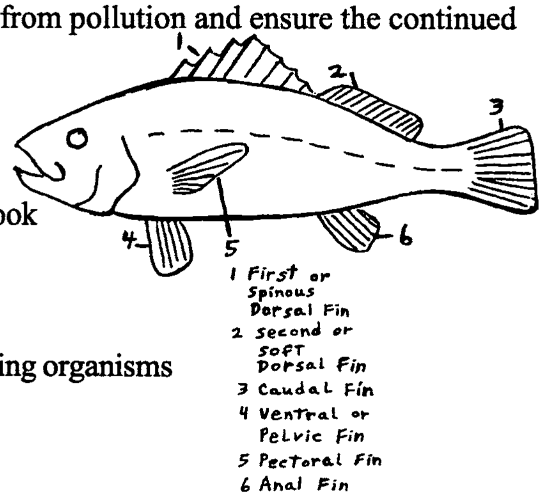
BACKGROUND SUMMARY: Living organisms float or swim on the top layer of the ocean, reside on or within the ocean floor, or swim freely in the open ocean. Each animal or plant is uniquely adapted to the environment in which it lives. These adaptations allow many organisms to survive in very harsh environments. Understanding how these organisms survive in their habitats is important to the management and conservation of each species.

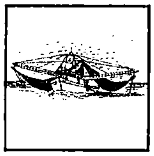
OBJECTIVES: Students will be able to:

1. Identify a variety of living organisms which can be found in the ocean such as fish and plants.
2. Compare and contrast characteristics of these organisms which enable them to survive in the ocean.
3. Observe various behaviors of these organisms and why these behaviors enable them to survive.
4. Comprise a list of ideas to protect the ocean from pollution and ensure the continued survival of these organisms.

MATERIALS:

- Seines
- Dipnets
- Videotape
- Overhead projector
- Pictures
- Magnifying lens
- Television
- Sieves
- Journal notebook
- VCR
- Transparency
- Aquarium
- Samples of living organisms



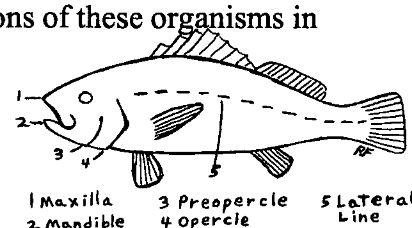


ACTIVITY:

1. A field trip to a local beach or lake should be taken to enable students to view several organisms in their natural environment.

2. If possible, students will investigate and collect some of these organisms via seines, sieves and dipnets. Students should record observations of these organisms in combination with drawings in a journal.

3. Place students into three cooperative learning groups.



First group:

Have students draw or cut out pictures of a variety of organisms which live at the shoreline and on the ocean or lake bottom. Have students place their drawings and pictures on an appropriate collage or diorama and label them. Students should write a short story regarding the manner in which the organisms in their collage interact and coexist in the environment which the students have created.

Second group:

Have the students write a song/poem/rhyme which compares and contrasts the different behaviors and characteristics of the organisms which reside in the ocean.

Third group:

Have the students draw posters depicting their concerns relative to protecting and conserving the environment, particularly the ocean or a lake, and the indigenous species. (Note: Safety precautions/standards should be followed when in the field.)

POSSIBLE EXTENSION:

1. Have the students develop a skit re-enacting the relationships they observed between organisms while at the beach or lake.
2. Have students create food webs given the organisms observed during the field trip.

TEACHER EVALUATION: Students should be evaluated on the content of their group projects, teamwork, and journals.

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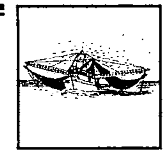
Marine and Aquatic Resources



TOPIC-TITLE: Marine and Aquatic Resources - *Understanding the Process of Classification*

AUTHOR: Roseann Pellegrino

GRADE SUITABILITY: Middle School

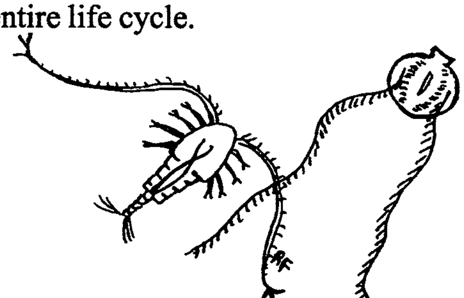
SCOPE: Biology and Marine Biology

SEQUENCE: This lesson could be infused in the marine sciences class when studying life in the water. Later discussions could encompass benthic classification. These lectures could follow a unit on the means in which whales eat and what they prefer to consume.

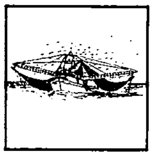
BACKGROUND SUMMARY: In marine and aquatic environments, several different food chains exist. These food chains are often interconnected, resulting in complex food webs. The base of all food chains begins with a producer. In the marine environment, the producers are phytoplankton. The next organisms in a food chain are the primary consumers which are often different species of zooplankton. According to Greene (1998), zooplankton are animals and animal-like organisms which float and drift on the surface of the ocean.

The term zooplankton refers to a great diversity of animal plankton, and therefore, zooplankton have been divided into two groups. The group referred to as meroplankton or temporary plankton is composed of larvae of fish, crabs, lobsters, oysters, clams and other species of invertebrates. The larvae of these organisms remain at the surface only during the early part of their life cycle. As they grow and mature, these organisms will settle at the bottom and become part of the benthos or will swim in the nektonic level of the water column. The second group, holoplankton, is composed of the organisms which remain as part of the planktonic population their entire life cycle.

OBJECTIVES: Students will be able to:
1. Construct their own plankton net.
2. Collect a sample of zooplankton.
3. Classify and analyze the zooplankton sample.



MATERIALS:
- Pantyhose
- Wire hanger
- Rope
- Labels
- Petri® dish
- One quart plastic soda bottle (cleaned)
- Wire cutters
- Four collecting bottles with caps
- Microscopes (compound and dissecting)
- Glass slide



- Medicine dropper
- Thermometer
- Plastic tie wrap
- "Crazy"® glue
- Needle and thread

ACTIVITY: Construction of the plankton net: With the materials listed above, students working in pairs will carefully construct their own plankton net.

1. Carefully using a wire cutter, snip off the hook portion of a hangar. Bend the remaining part of the hangar into a circle and tape the ends of the wire together with electrical tape, covering the exposed ends.

2. Cut one leg from a pair of pantyhose at the upper leg and snip off the toe so that you are left with a pantyhose tube. Save the other leg for later.

3. Carefully cut two holes, one on each side of the one quart plastic bottle, approximately one-third of the way down from the bottle's mouth. Each hole should be 3 cm in diameter.

4. Using the other leg of the pantyhose, cut two 4 cm x 4 cm squares of pantyhose.

5. Using "Crazy"® glue, glue one 4 cm x 4 cm square piece of pantyhose to each hole in the bottle. Make sure the seams are glued completely and that there are no openings.

6. Around the mouth of the bottle, place one end of the pantyhose tube you cut in the second procedure. Secure the pantyhose tube around the mouth of the bottle with a tie wrap, making sure it is very tight.

7. Cut three pieces of rope, each measuring 30 cm in length, and tie each piece to the wire circle at equal distances away from each other. Tie the other ends together, making a bridle. Tie a four meter piece of rope to that end.

8. Using a needle and thread, sew the other end of the pantyhose tube around the wire circle so that the tube is now open all the way down to the bottle.

Hypothesis: Without having collected the plankton, predict the purpose of each part of the plankton net, in as much detail as possible.

Take students to several different collecting locations. Students should collect their samples using their plankton nets and should pour each sample into an appropriately labeled collecting bottle with a cap. Students are to record the water's surface temperature at each location and tape to the collecting bottle. Students should also record, in a field notebook, observations of each location, including weather, physical composition of the sampling area, and surface conditions. All samples are to be brought back to the classroom for further study.

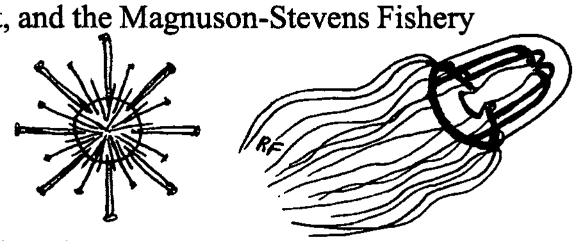
In the lab notebook, students should describe and sketch individual organisms from each sample viewed under the microscope. Keep the descriptions/sketches for each location separate. Using these descriptions, group/classify the organisms observed. Compare each location's classification. After completing all location classifications, compare them to the actual scientific classifications provided by the teacher.

Students should discuss the following questions:

1. Regarding your own classification system, how did each location differ or how were they the same? Were there greater numbers of one type of organism in a particular location?
2. Describe the other factors which might explain the variation of organisms in one location.
3. Compare the similarities and differences between your classification system and the scientific classification system.
4. What kinds of information might using a plankton net, observation, and classification provide?

POSSIBLE EXTENSION:

1. Have students construct a food web using the plankton they identified as a base.
2. Discuss the effects on the food web if a plant or animal is removed. Concepts such as endangered and threatened species, natural balance in a food web, and conservation and management should be included in this discussion.
3. Students could research various local, state, and federal acts which pertain to the conservation and management of plants and animals, such as the Endangered Species Act, the Marine Mammal Protection Act, and the Magnuson-Stevens Fishery Conservation and Management Act.



TEACHER EVALUATION:

1. Laboratory Notebook Check
2. Laboratory Quiz/Practical

Test Question #1: Viewing the slide under the microscope and using your laboratory notes, describe the organism in the field of view, and identify its scientific classification.

Test Question #2: Describe in detail why it is important for scientists to know functions and purposes of their equipment when using it.

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TOPIC-TITLE: Marine and Aquatic Resources - *Maximum Sustainable Yield*

AUTHOR: Brenda Peterson

GRADE SUITABILITY: Upper Elementary

SCOPE: History and Biology

SEQUENCE: Students should be introduced to the concept of overfishing and the under utilization of the ocean's resources.

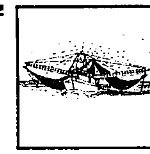
BACKGROUND SUMMARY: All over the world, people are dependent upon natural resources whether derived from the land or the sea. For many years, the resources obtained from the ocean were thought to be infinite. Fish, shellfish, plants, and minerals were extracted or harvested without thought to the ability of that resource to renew itself. Because they are utilized worldwide as a food source, fish are one of the most important resources humans derive from the sea. Approximately two thirds of the fish caught and sold worldwide are consumed by people. The remainder of the fish catch is used as feed for animals or in other products.

During the last several decades, fishing fleets from across the globe have dramatically increased their catch. Although there are thousands of species of marine fish , only about thirty percent of those species account for most of the fish that are caught intentionally (Greene, 1998).

The increase in worldwide fish catch has resulted in the decline of many species of marine fish. All organisms which are harvested must be given sufficient time to grow and reproduce. Also, the amount of fish which can be removed from a population, without having a negative effect on the size of that population, must be determined. This is known as the maximum sustainable yield (MSY). The federal government of the United States is currently in the process of determining the MSY for many of the large fisheries. This will enable the government to manage many fish stocks. Hopefully, this will provide populations with time to stabilize or rebuild, ensuring viable stocks for the future.

OBJECTIVES: Students will be able to:
1. Become aware of the problems of overfishing the oceans.
2. Generate possible solutions or extensions to aid in solving the problem of over-utilization of the ocean's resources.

MATERIALS:
- Ten-gallon aquarium
- One bottle of food coloring (for looks only)

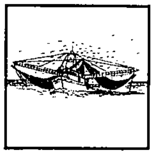


- One glass or clear container
- Two measuring cups-one to accommodate 8oz. and 16oz., respectively
- Reference materials

Note: The search engines on the Internet would provide students with the opportunity to use computers and would provide pertinent information to complement this activity.

ACTIVITY: Divide the students into cooperative learning groups. Have each group research fisheries management practices in the United States. Allow the groups to choose one example of a resource from the ocean which has been over-harvested and a resource which has not been fully utilized. Have the students develop hypotheses on ways in which the over-utilized resource can be managed more fully and how the under-utilized resource could be put to a more productive use.

1. Set up the ten-gallon aquarium and add the bottle of food coloring to the water.
2. Have one student volunteer to be the fisherman and one student volunteer to be the fish.
3. Provide the student who is the fisherman with the one-cup measure and the student who is the fish with the two-cup measure.
4. Have students predict the outcome of who will be able to remove more from the system, the fisherman or the fish.
5. Have the fisherman remove one cup of water from the aquarium and place it into the glass bowl.
6. Have the fish remove two cups from the glass bowl and place it into the aquarium.
7. Repeat steps five and six at least ten times.
8. Stop. Ask the students what they have observed.
9. Discuss what will happen if the fisherman and the fish trade places.
10. Switch the roles of the fisherman and the fish.
11. Repeat steps five and six at least ten times.
12. Discuss the results as a class.
13. Compare and contrast the results as a class.



14. Discuss what human interventions could be enacted to gain a more balanced harvest.

15. Students should list other solutions to harvesting the ocean.

POSSIBLE EXTENSION: Repeat the above procedure, this time modifying the fisherman's catch due to more strict fishing regulations.

TEACHER EVALUATION:

1. Students will have to justify their predictions in writing.
2. Class participation.
3. Discussion of findings.

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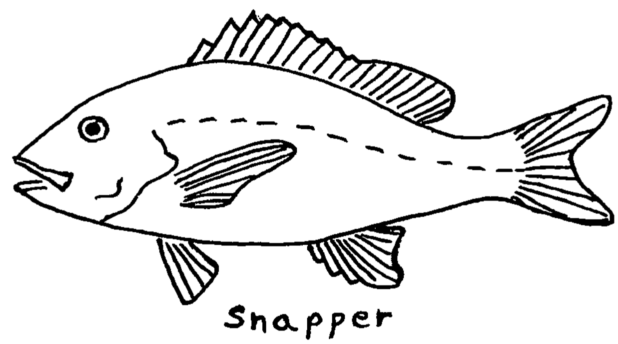
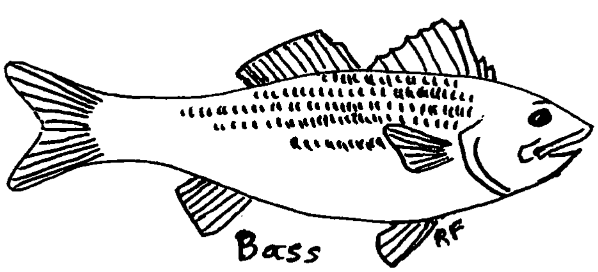
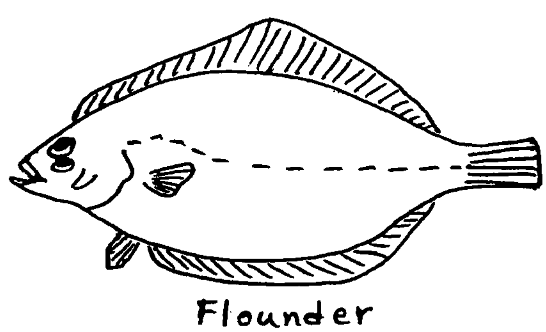
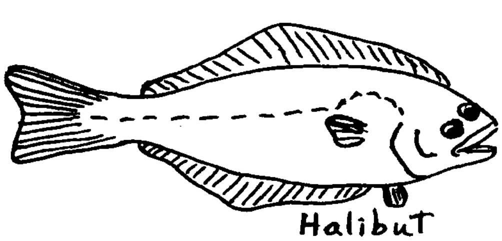








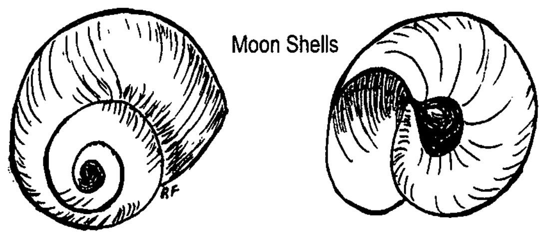
Marine and Aquatic Resources

TOPIC-TITLE: Marine and Aquatic Resources - *Life at a Snail's Pace*

AUTHOR: Ceresy Jenkins

GRADE SUITABILITY: Lower Elementary

SCOPE: Mathematics and Biology



SEQUENCE: Science should not be an isolated subject in elementary school but rather integrated with math, language arts, and social studies. Students have a greater understanding when a subject is relevant to their daily lives. It is educationally fun to spend a day (Example: Moon Snail Day) learning as much as possible about a subject. On Moon Snail Day, everything students do relates to moon snails. The activity described below complements a study of mollusks, an important component of the living resources in marine and estuarine environments.

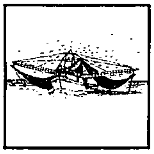
BACKGROUND SUMMARY: Mollusks are defined by Greene (1998) as soft, bilaterally symmetrical animals with a head and brain, foot region, coelomic cavity, coiled visceral mass, and usually an external or internal shell. Examples of bivalve mollusks include mussels, oysters, clams, and scallops. Examples of gastropod mollusks (univalves) are mud snails, periwinkles, and moon snails. Cephalopods such as squid, octopi, and nautilus are also mollusks. Some lesser known mollusks include chiton and scaphopods, which are tusk shells.

The shark's eye moon snail is a common gastropod found from Massachusetts to Florida, to include all Gulf States. This moon snail preys on bivalves such as clams which live in the sand. The moon snail secretes chemicals from its foot which soften the shell of the clam and then the moon snail uses its radula (tongue-like structure) to drill a hole in the clam's valve or hinge. The moon snail then inserts its radula into the hole and consumes the soft tissues. These snails are between 2.2 and 7.6 cm in thickness (height) and somewhat wider.

In moon snails, eggs develop into what is known as a sand collar which is attached to the shell. The sand collar is composed of sand grains cemented together by mucus which the snail secretes.

OBJECTIVES: Students will be able to:

1. Describe characteristics of moon snails (habitat, diet, predators and prey, size, shape, body parts, and other related characteristics).
2. Make and read a pie chart by identifying various attributes of moon snails.



MATERIALS:

- Posters and charts of mollusks
- Books on shells and other reference materials
- Moon snail shells or pictures of moon snail shells (eight for each child)
- Graph worksheet
- Pencils, markers, crayons, and non-pointed scissors

ACTIVITY: The students should be exposed to books, poems, songs and stories of mollusks, shells, oceans, beaches, and other appropriate subjects. Students should research the life history of moon snails and write a report.

1. If using pictures of moon snails, instruct students to color and carefully cut out eight of the pictures (show them pictures or actual shells to give ideas on coloration, but allow student originality).

2. If using actual shells, instruct students to select eight moon snail shells. Next, students sort the shells into as many or as few groups as they choose using any one characteristic (for example: color, shape, size, odor, broken/not broken, and with drill holes/without drill holes).

3. The students then need to make a key on the bottom of the graph worksheet. (If they have four categories, then their key should have four parts. For example, they may have sorted by size and put their eight shells into four size groups. They should name the four groups on their key, maybe giant size, large, medium, and small).

4. The students should next assign a color to each size category. (If they have four size categories, they should choose four colors).

5. Next, the students should color in the correct number of spaces on the pie chart to represent the key (if the student has two giant size shells and has assigned this size category the color blue, then she/he should color in two blue spaces on the pie chart). All spaces should be colored since the students have eight shells and therefore, the graph has eight spaces.

6. Finally, the student should write a conclusion to his/her graph (it could be something similar to, "My graph has two blue spaces colored; therefore, I had two giant size shells").

Note: The conclusion could possibly be about what is not on the graph. Example: "I did not have any super size moon snails." The conclusion could be a relationship statement. Example: "I had more giant size shells than small shells," or "I had an equal number of medium and small shells." The students also need to title their graphs and present them to the class.

POSSIBLE EXTENSION:

1. Do the same activity using different types of shells, a different number of shells, different characteristics, and different kinds of graphs.
2. Draw what the moon snail looks like when removed from its shell. Write several sentences about moon snails.
3. Use the moon snail shells to create "fossils." Coat the shell with Vaseline, press into modeling clay, pour plaster of Paris into imprint, let dry, and peel off the clay.
4. Measure a row of shells or see how many you would need to make a line as long as your body.
5. Use the pie chart for a lesson on fractions.

TEACHER EVALUATION:

1. Ongoing during graph making.
2. Teacher might ask each student to explain what he/she is doing and why, or how he/she is accomplishing a particular task.

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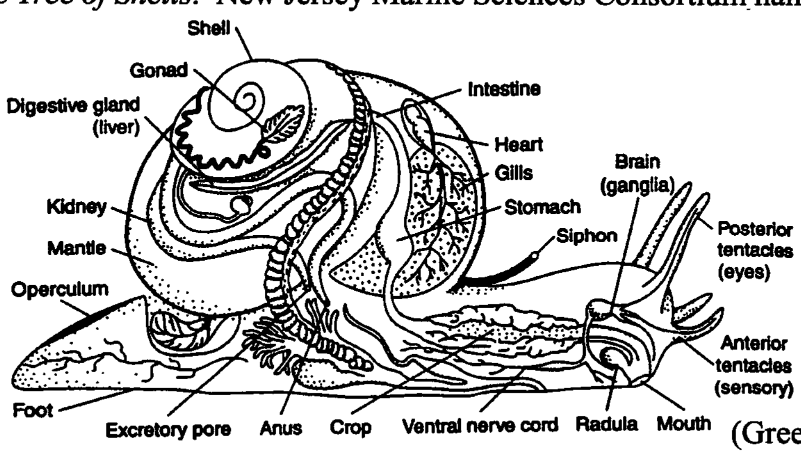


(Greene, 1998)

TOPIC-TITLE: Marine and Aquatic Resources - *Understanding By-Catch*

AUTHOR: Kathy Westerman

GRADE SUITABILITY: Middle School

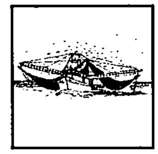
SCOPE: Life Science

SEQUENCE: This activity should follow a unit on commercial and recreational fisheries in the United States. Concepts of maximum sustainable yield, by-catch, and reduction of by-catch should be introduced. Students need to be provided with background information on shrimp and sea turtles. Students should also be familiar with food webs and the concept of natural balance within an ecosystem. This background information may be enhanced by showing students videos such as *Magnificent Fish* by the New England Aquarium.

BACKGROUND SUMMARY: There are many resources which are derived from the sea, both living and nonliving. Examples of some nonliving resources are oil and gas. Examples of utilizing living resources include recreational fishing, commercial fishing/ shrimping, and SCUBA diving. The oceans produce the largest amount of organic matter on Earth. Food from the sea, however, only amounts to one percent of the world's total food consumption. Even with the small percentage of consumption, finfish and shellfish provide ten percent of the protein to the world's population. Consumption of seafood in the United States is dramatically increasing.

Shrimping is the most economically viable fishery in the Gulf of Mexico. The type of shrimp harvested from these waters are the penaeid shrimp which include white, brown, and pink species. Shrimping is such a rapidly growing industry that many fishermen use two trawl nets to increase their catch. These trawls must have a fairly small mesh size in order to capture these organisms. Due to the small mesh size, many other types of marine organisms such as finfish and sharks become trapped in these nets. Anything which is caught and perceived to be of no value to the fishermen is considered by-catch. This by-catch is merely removed from the nets and thrown into the water. Most of these by-catch species die because of the stress caused from the trawl. Often the amount of by-catch will be greater than the amount of shrimp caught. In fact, the ratio of by-catch to shrimp in the Gulf is 5.25:1. This can have an adverse effect on the populations of species being caught as by-catch.

Another animal which is threatened by the shrimp fishery is the sea turtle. All eight species of sea turtles, are currently endangered or threatened in the United States. In the Gulf of Mexico, the Kemp's Ridley sea turtle is severely affected by shrimping trawls. It is the most endangered of the sea turtles. The United States government recently passed



regulations 97% effective. Some shrimpers complain that they lose too much of their catch when using the TEDs. The TED law is difficult to enforce because the ocean is so vast and there are too few enforcement officers. Hopefully, the turtle populations will replenish with time. Research has recently been completed for the development of a By-catch Reduction Device (BRD). Many of our marine resources are being negatively impacted by shrimp trawls. The shrimping industry is important to the economy. However, adequate care must be taken to ensure the conservation and preservation of other resources taken during shrimping activities.

OBJECTIVES: Students will be able to:
1. Calculate the percentage of shrimp caught during the shrimp trawling.
2. Calculate the percentage of by-catch caught during the shrimp trawling.
3. Calculate the percentage of sea turtles caught during the shrimp trawling.
4. Suggest several (at least three) ways in which the by-catch and turtle death rate may be reduced.

MATERIALS: Each cooperative learning group of students will need the following:
- Paper bag containing a mixture of beans prepared by the teacher (100 split peas, three lima beans, 500 pinto beans)
- Small aquarium net

The 100 split pea beans represent the shrimp (desirable harvest). The three lima beans represent the sea turtles and the 500 pinto beans represent the by-catch.

ACTIVITY: Have the students create hypotheses which they believe will happen when they go "fishing."
1. Obtain a paper bag with a mixture of beans from the teacher.

2. Dip the aquarium net into the bag.

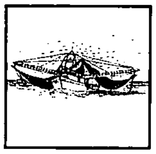
3. Count and record the number of split pea beans (representing the shrimp).

4. Count and record the number of lima beans (representing the turtles).

5. Count and record the number of pinto beans (representing the by-catch).

6. Determine the percentage of shrimp caught (# of shrimp divided by # of total beans) x 100.

7. Determine the percentage of by-catch caught (# of by catch divided by # of total beans) x 100.



8. Determine the percentage of turtles caught (# of turtles divided by # of total beans) x 100.

POSSIBLE EXTENSION:
1. Design your own turtle excluder device for "trawling."
2. Design your own by-catch reduction device for "trawling."
3. This activity could be accomplished with a different species of live fish representing the shrimp, turtles, and by-catch.

TEACHER EVALUATION: Students should be able to answer the following:
1. Calculate the percentages of each type organism caught (shrimp, by-catch, and turtles).
2. Make several (at least three) suggestions relative to ways in which by-catch might be reduced.
3. How might the turtle death rate be decreased?
4. How do you think the by-catch and turtle deaths are affecting the rest of the marine ecosystem?

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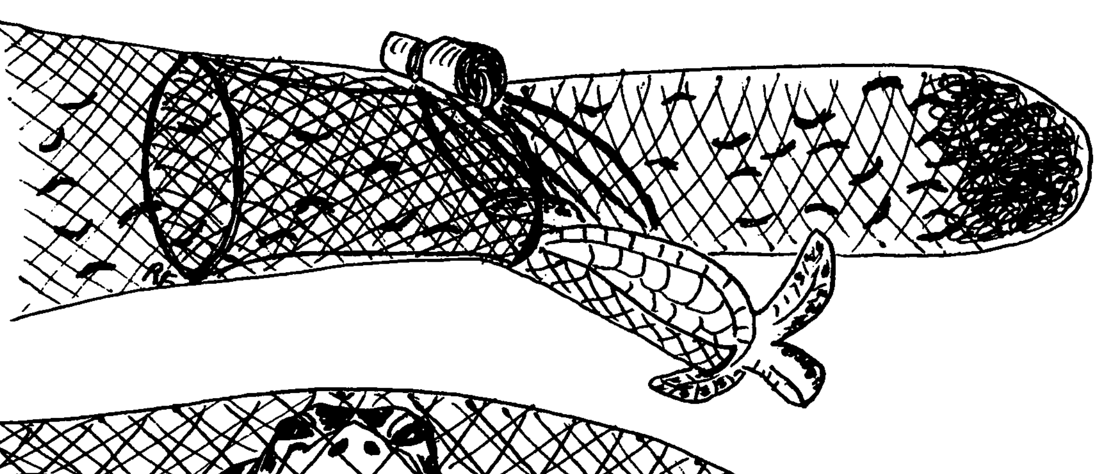
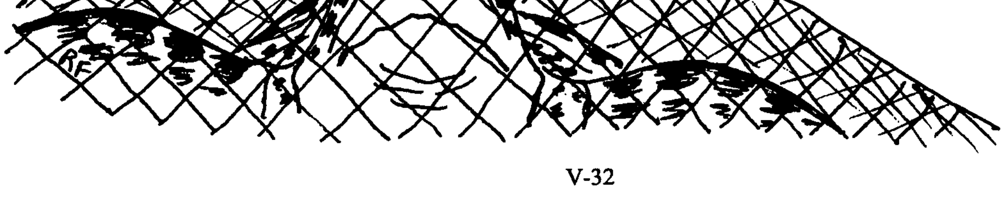
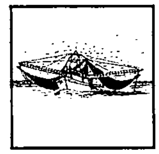




Marine and Aquatic Resources



TOPIC-TITLE: Marine and Aquatic Resources - *Crabby Critters*

AUTHOR: Dorable Harry

GRADE SUITABILITY: Lower Elementary

SCOPE: Earth Science

SEQUENCE: This lesson should follow a unit on estuaries and their role as a nursery area and breeding ground for many marine species. Background information about the importance of blue crabs both environmentally and economically should be provided prior to this activity. Books such as *Crabby and Nabby, A Tale of Two Blue Crabs* can enhance the background information.

BACKGROUND SUMMARY: Crabs can be a delicious food item; therefore, they are an important fishery resource. Crabs belong to the phylum Arthropoda, and are animals with hard exoskeletons and jointed legs. They live both on land and in water. There are many species of crabs. These include blue crabs, ghost crabs, fiddler crabs, green crabs, rock crabs, spider crabs, hermit crabs, mole crabs, elbow crabs, and many others. This activity will focus on blue crabs.

Crabs in the Portunidae family, such as the blue crab, have paddles on the end of their last pair of legs, enabling them to swim rapidly. Crabs can swim forward, backward, or sideways. On the beach they can only move sideways. Other external body parts include claws, mandibles and antenae. Blue crabs are scavengers. In the summer, they form a kind of natural cleanup crew along beaches and in shallow water. In the winter, they move to deeper, warmer waters.

The blue crab is armed with an array of protective devices. For example, blue crabs are completely covered with an armor-like shell which scientists call an "exoskeleton." Sharp spines occur on many parts of the exoskeleton, especially the leading front edge of the broad, top carapace. In addition, blue crabs are equipped with powerful pincers. They are capable of manipulating their pincers quite quickly and efficiently.

The sex of the blue crab is easy to determine. The quickest and easiest way, when dealing with live crabs, is to note the color of the pincers. Female crabs nearly always have pincers with bright red-orange tips, whereas those of the male crabs are blue and white. The abdomen of immature females is triangular. The female may produce as many as four million eggs. The eggs remain under her carapace and abdomen in what is referred to as a sponge. The eggs later hatch into tiny larvae which swim to the surface to feed.

Blue crabs are available to consumers in several forms. Some consumers prefer to catch their crabs or purchase them from a seafood market. More often, consumers purchase

"pre-picked" and packaged crab meat. Regardless of how obtained, crab meat requires special consideration in its handling and preparation.

OBJECTIVES: Students will be able to:
1. Become familiar with the four basic parts of the crab.
2. Create their own male or female crab.
3. Distinguish between male and female crabs.

MATERIALS:
- Overhead projector
- Overhead transparency with male and female blue crab with legs, claws, carapace and appendages identified
- Index cards
- Art supplies such as blue construction paper, markers, crayons, non-pointed scissors, glue, and tape
- Consent form to determine whether or not students are allergic to crabs
- Foods made from crab meat such as crab salad, boiled crabs, fried crab fingers and others may be added or substituted
- Newspaper
- Paper plates
- Napkins
- Ten blue crabs (five male and five female)
- Forks
- Flip chart with an outline of a graph

ACTIVITY:
1. Read the story *Crabby and Nabby, A Tale of Two Blue Crabs* to your class.

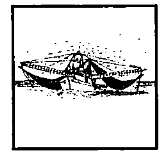
2. Display overhead pictures of crabs. Identify crabs and include the function of specific structural parts (leg-enables them to swim fast, shell-covered with sharp spines, and claws-pincers used for protection).

3. Compare and contrast the claws and abdomen to distinguish the male and female. Show where the female carries her eggs.

4. Disseminate art supplies for the students to make a male or female crab and label the parts. Use newspaper to stuff crab shells.

5. Send home a form to determine whether or not any student is allergic to crabs.

6. Divide your class into five cooperative learning groups. Give each group a male and female crab. Let them explore to find parts and distinguish between male and female crab.



7. Teacher should assist and help establish a food tasting station.

8. Next, let students sample the variety of foods made available.

9. Last, provide each student with an index card. After tasting the foods, have the students write the name of the food they like best on the card . Use cards to finish graph outline. See which food won the taste test.

10. If possible, show the students a live male crab and a live female crab. Display the crabs in separate aquariums to show students how they feed and other types of behaviors.

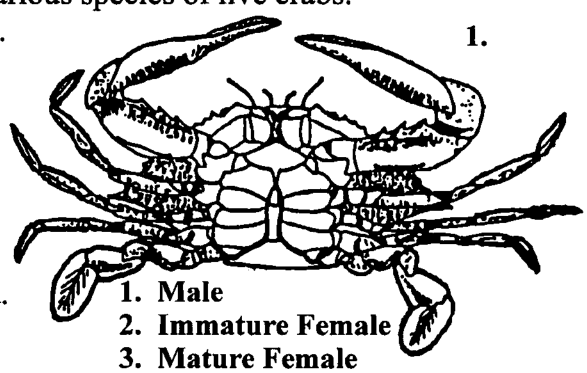
POSSIBLE EXTENSION:

1. Take a trip to a seafood market to view various species of live crabs.
2. Locate places where blue crabs are found.
3. Prepare a crab meal in class.
4. Discuss other crabs and their body parts.

TEACHER EVALUATION:

1. Student participation in activities.
2. The crabs the students constructed.
3. Journal writing of activities demonstrated.

1.



1. Male
2. Immature Female
3. Mature Female

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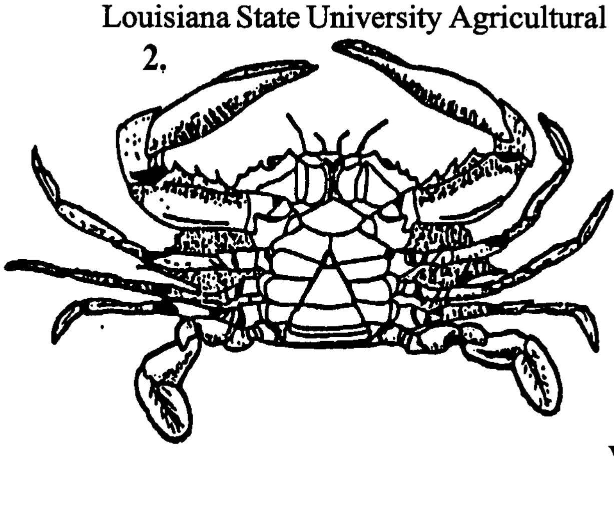

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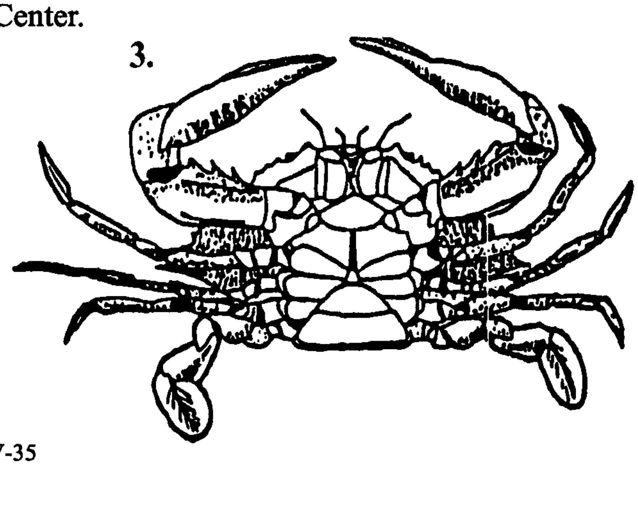

Deep Sea Technology

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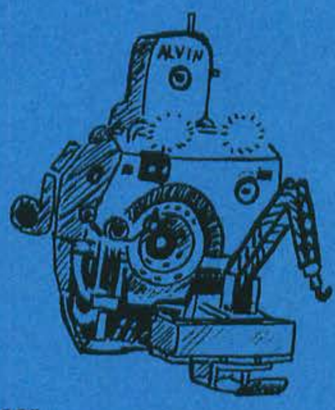
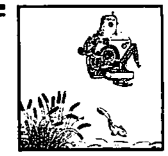


Deep Sea Technology



INTRODUCTION

Deep Sea Technology

The deep sea retains an air of mystery as many portions of the deep have not yet been explored. Scientists have discovered the deep is an inhospitable environment for man. The lack of sunlight makes the temperatures drop quickly as the pressure increases steadily with depth.

In 1872, the British government began an intensive investigation of the organisms found in the ocean. This investigation was performed on the ship known as the H.M.S. *Challenger* and was, therefore, titled the *Challenger* Expedition. For nearly four years, the H.M.S. *Challenger* explored the world's oceans, discovering 715 new genera and 4,417 new species. Their discoveries initiated an interest in some of the creatures found in the deepest parts of the world's oceans.

In order to explore the resources of the deep, specialized equipment is needed. In 1934, Dr. William Beebe and Otis Barton were the first humans to descend to depths of greater than 900 meters. They accomplished this monumental task in a piece of equipment known as a bathysphere. The bathysphere was relatively simple, composed of a steel sphere with small viewports made of quartz. Beebe described creatures, via a telephone wire, which had not been seen or described by any other human being. However, the bathysphere was limited in its capacity for exploration. It could only be raised and lowered by a cable attached to a ship and could not move of its own accord. Deep sea technology continued to develop and in 1954, the Swiss physicist, Auguste Piccard, descended to 4000 meters in his bathyscaphe. The bathyscaphe was a navigable deep sea vessel composed of a pressurized sphere which retained buoyancy due to a gas filled float. The deep sea submersibles used today are even more advanced and are equipped with underwater lights, cameras, television systems, mechanical manipulator arms to collect samples, and computer systems which relay information from the submersible to surface vessels. Robotic submersibles known as ROVs (Remotely Operated Vehicles) are unmanned and can generally descend to depths greater than the manned submersibles. ROVs relay information to the surface vessels via a feedback loop. A feedback loop is essential to the navigational systems of a ROV and allows information about an ongoing task to be continually transmitted to the person controlling the research.

Another technique used for deep sea exploration is echo sounding, which allows surface vessels to determine the depth of the ocean bottom without the use of a submersible. Sound waves or acoustic pulses are sent from the ship, bouncing off the bottom and back to the ship. Scientists then calculate the time it took the sound wave to travel to and from the object, thereby determining the distance from that object. This

process is known as sonar, which stands for sound navigation and ranging.

Other instruments used in deep sea exploration include high-resolution television cameras, thermometers, pressure and flow meters, and seismographs. Deep sea currents are monitored by floats which carry ultrasonic sound which enable research vessels to follow and monitor the rate of flow.

Investigations of the deep sea have demonstrated that many varied and unique creatures thrive under the harsh conditions associated with a lack of sunlight and great depths. Giant squid, six and seven gill sharks, large tubeworms, vampire squid, and a host of other creatures inhabit the deep sea. As man continues to explore the oceans, more discoveries are being made which assist researchers in better understanding the manner in which marine creatures can and do affect the lives of human beings. Not only are marine organisms used as food but the medicinal values of many of these creatures are just being realized. The cures for many human diseases may lie in the deep. While the anthropogenic impacts on the depths of the oceans are most likely less than those on shallower waters, disposing of hazardous chemicals, the mining of minerals, and other human activities can have a negative impact on this undiscovered and untapped resource. It is imperative that the deep ocean environment and its resources be managed properly in order to ensure the conservation and preservation of this vast, relatively unexplored area of our planet.

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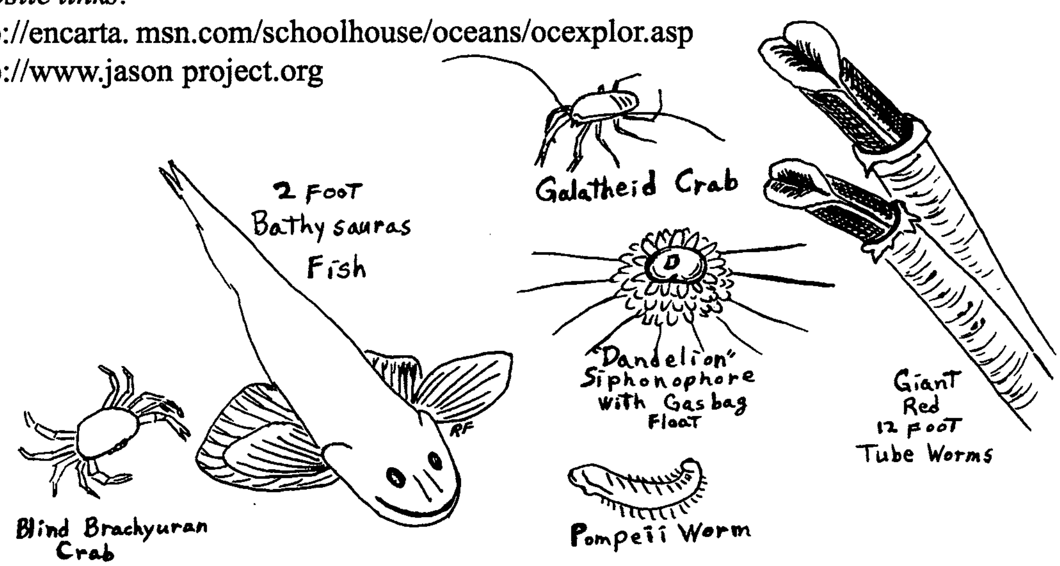
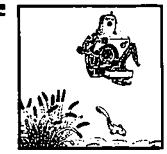
Website links:
http://encarta. msn.com/schoolhouse/oceans/ocexplor.asp
http://www.jason project.org



Deep Sea Technology



TOPIC-TITLE: Deep Sea Technology - *Remotely Operated Vehicle (ROV) Manipulator Arm*

AUTHOR: Laurel R. Gast and Junko Toll

GRADE SUITABILITY: Middle School

SCOPE: Earth Science, Life Science, and Physics

SEQUENCE: This is an introductory lesson in deep sea exploration and research. After the students learn about remotely operated vehicles (ROVs), they will participate in an inter-disciplinary project which revolves around deep sea exploration.

BACKGROUND SUMMARY: In the study of deep sea life and substrata, specialized equipment and instruments are needed. The *Alvin* research submersible allows a scientist to view deep oceanic environments. However, scientists are unable to leave the submarine to gather substrata samples or organisms. In order to accomplish this task, a manipulator arm is attached to the submersible to allow scientists to collect samples. This kind of arm is useful in any environment which is not conducive to human exploration.

OBJECTIVES: Students will be able to:
1. Define ROV and submersible.
2. Describe the type of work accomplished by ROVs.
3. Assemble a model of a manipulator arm.
4. Demonstrate an understanding of the manner in which ROVs manipulate objects and take samples.

MATERIALS:
- *JASON IV Project Core Curriculum,* 2.2 Activity four
- Overhead projector
- Overhead transparencies
- Scissors
- Rulers
- Hole punch
- Poster board
- Paper fasteners
- Video on ROV or submersible
- Small objects of varying size and weight such as candy, cereal, marbles, or blocks

ACTIVITY:

1. Ask students to discuss and develop hypotheses regarding what a submersible or ROV might look like.

2. Place transparencies of submersibles and ROVs on the overhead and have students compare and contrast the actual image with the one imagined.

3. Provide definitions of ROVs and submersible to the class. Have the students take journal notes.

4. Then students should answer the question: "Discuss why scientists would use a ROV instead of a submersible?" Discuss the pros and cons of each.

5. Show actual footage taken by a ROV. Why would a ROV be necessary for some re search efforts when compared to the use of submersible for these same research efforts?

6. Have students work in groups to make a ROV manipulator arm as described in the *JASON IV Core Curriculum*, 2.2 Activity four (pages 94-95).

7. Have students grasp items, such as candy, cereal, marbles, and blocks with the manipulator arm constructed by each group.

8. Discuss difficulties and successes.

9. After each student has had an opportunity to use the manipulator arm, have the students reflect on this process in their journals. Possible prompts: "How is the manipulator arm similar to your own hand and arm? Why are manipulator tools valuable?"

POSSIBLE EXTENSION: Students could build a manipulator arm of their own design.

TEACHER EVALUATION:

1. Define ROV and submersible. Compare and contrast the two.
2. What creatures would you find with the ROV which you might not with the submersible?
3. How has this technology impacted marine exploration?
4. Students may be asked to chart their results; however, observation and practice are sufficient.
5. What was the best technique used to maneuver the arm?

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DeWall, Marily (Curriculum Director). 1992. *JASON IV Curriculum, Baja California Sur.* National Science Teachers Association. Washington, D.C.

Deep Sea Technology

TOPIC-TITLE: Deep Sea Technology - *Telepresence*

AUTHOR: Migdalia Rodriguez, Lisa Reid, and Grace Page

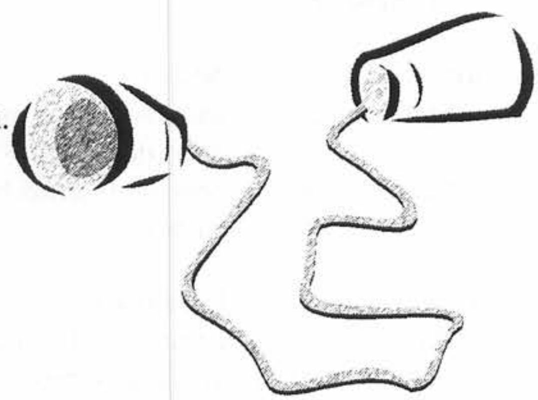
GRADE SUITABILITY: Lower Elementary

SCOPE: Earth Science, Physics, and Technology

SEQUENCE: This is an introductory lesson on deep sea technology and subsequent communication which makes it possible for everyone to benefit from that technology.

BACKGROUND SUMMARY: In deep sea technology studies, it is important to stress the value of telepresence. Telepresence, the sense of "being there" conveyed by real-time video transmission, is valuable from several viewpoints: historical, educational, and scientific.

OBJECTIVES: Students will be able to:
1. Model and compare methods of communication.
2. Explain the importance of telepresence.



MATERIALS:
- Copies of "message" to be communicated
- Stop watch
- Posterboard

ACTIVITY:
1. Students will model three forms of communication representing: "Pony Express," "Telephone," and "Telepresence."

2. "Pony Express:" have students stand in a circle about an arm's length apart.

3. Be prepared to time the passage of the message, then hand the message to the first student. Each student must read the message, then hand the message to the next student. The student must read the message, then pass it to the adjacent student until the rotation has been completed. Stop the watch when the last student has read the message. Write the time on the board.

4. "Telephone:" Students may remain in the circle. This time give each student a "message" which he/she should not read until it is his/her turn.

5. Begin timing this activity when the first student begins reading his/her message. That

student then turns to the next student and holds his/her message for the student to read. This student reads the message, then turns to the next student and holds his/her message for the next student to read. Continue around the room until the last student has read the message, which will be made known by the last student raising his/her hand. Stop timing this activity. Write this time on the board.

6. "Telepresence:" students remain in the circle. Have the same message as before; however, have it printed on a large posterboard. Begin timing this activity when you hold the message for the entire class to read. Have students indicate to you, by raising their hands, when they have finished reading, stop timing this activity, and write the time on the board.

7. After students return to their desks, discuss the time required for each method of communication. Have the students contrast and compare the time needed to receive the messages.

POSSIBLE EXTENSION:

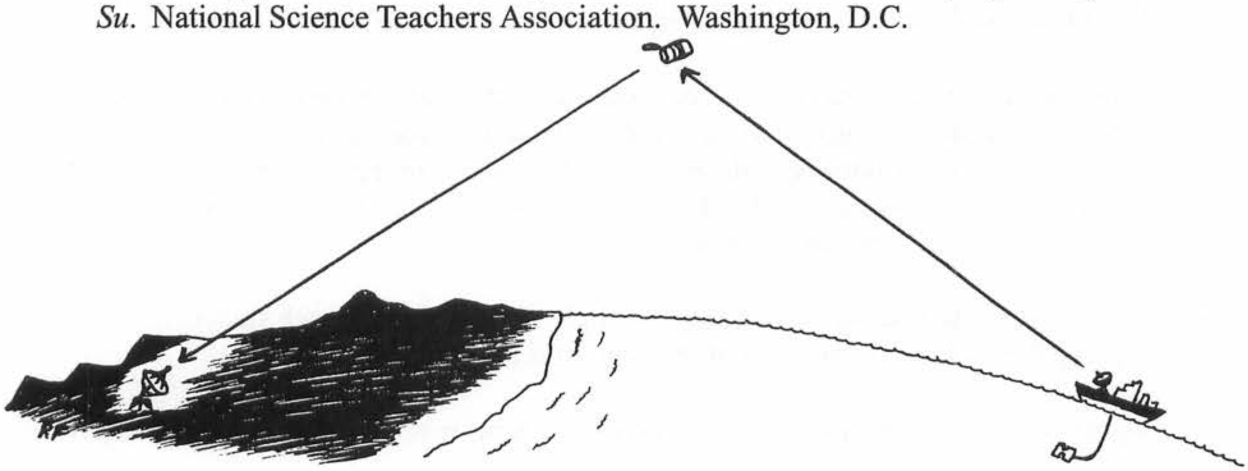
1. Students could research other forms of communication and expand the model by creating new scenarios designed to illustrate what they have discovered.
2. Students could access the Internet to view telepresence in action, specifically in the area of deep sea technology.

TEACHER EVALUATION:

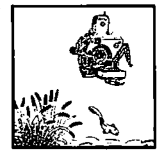
1. Have students make bar graphs of the times required to convey the messages.
2. Discuss why telepresence is important to scientific and educational research.
3. Have students give other examples of telepresence uses.

REFERENCES:

DeWall, Marily (Curriculum Director). 1992. *JASON IV Curriculum, Baja California Su*. National Science Teachers Association. Washington, D.C.



Deep Sea Technology



TOPIC-TITLE: Deep Sea Technology - *Seeing By Sound*

AUTHOR: Gary DiCenso, Paula McDonnel, and Virginia McIver

GRADE SUITABILITY: Middle School

SCOPE: Earth Science, Biology, Physics, and Mathematics

SEQUENCE: Prior to this activity, students should understand how sound travels through different media.

BACKGROUND SUMMARY: Underwater environments are often too distant and too dark to permit visual observation. Frequently, oceanographers use SONAR (sound navigation and ranging) which depends on sound energy to provide pictures of the deep sea environment. SONAR sends sound waves through water which bounce back to the source after they hit an object. Scientists can calculate how long it takes the sound wave to travel to and return from an object on the ocean floor. Therefore, they know how far the object is from the SONAR source. According to Greene (1998), the following formula is helpful in calculating ocean depth employing sonar: Depth (D) = 1,454 meters/ second x time (t) /2 (note: 1,454 m are used because sound travels this distance per second and the time is divided in half because the sound waves must travel to and return from an object). Researchers use this information to develop three-dimensional models of an object on the ocean floor.

OBJECTIVES: Students will able to:
1. Demonstrate understanding of SONAR.
2. Determine the distance from an object by creating a model.
3. Use the model to draw and label a diagram in an oceanic floor profile.

MATERIALS:
- Overhead transparency of oceanic bottom features
- Books
- Graph paper
- Super balls
- Meter stick
- Stop watch

ACTIVITY:

1. Discuss sound waves, and how they travel at different speeds in different media. Focus on how sound travels through seawater and write the speed (1,454 meters per second) on the board. Use a transparency of the ocean floor demonstrating different forms beneath the surface: sea mounts, ridges, trenches, the continental shelf, the continental slope, and abyssal plains. The average depth of the ocean is 3,790 meters; however, the deepest trench is the Mariana Trench in the Pacific at 11,022 meters. Also, if possible, have students access the website at http://www.tritontech.com (steps to follow: cool links, Klein, then hot maritime group). This will provide visual images and additional background information.

2. Divide the students into groups of four. Have them construct a random profile of the ocean floor in a straight line using stacks of books.

3. Have each group prepare an observation chart and an oceanic profile chart. The data observation chart will include students' measurements in seconds every half meter. The oceanic profile chart will be used by students in taking data from the observation chart and converting these data from seconds to meters (1,454 meters per second.) The conversion to meters will then be plotted on the vertical (y axis) and the distance in half-meter intervals will be placed on the horizontal (x axis).

4. Have one student release the super ball stabilizing his wrist on the meter stick. A second student will hold the meter stick steady. The third student will time the re lease. The fourth student should be the recorder.

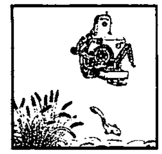
5. Set the stop watch and synchronize the release of the super ball over the first stack of books.

6. Record the time from when the ball is released until it returns to the starting height. Repeat this three to five times and average the time. (Be sure the students understand the bouncing ball represents a sound wave bouncing off the ocean floor).

7. Repeat the procedure every half-meter distance across the simulated oceanic floor profile, recording measurements.

8. Have the group create a bar graph to represent the oceanic profile, labeling bottom forms as necessary.

9. Provide each group an opportunity to present its respective graph in relationship to the simulated profile and those presented by other student groups. Include a discussion of possible ocean forms illustrated by the presented profiles.



10. Explain how SONAR technology plays a part in animal adaptations, commercial fishing, and echoes.

POSSIBLE EXTENSION:

1. Investigate satellite imagery and make a comparison to SONAR.
2. On a field trip to a lake or quarry, where one can obtain an echo, use real sound travel formulas to calculate the length of the quarry or lake.
3. Build a model of the ocean floor using the student oceanic bottom profiles.

TEACHER EVALUATION:

1. After the simulated ocean floor has been cleared, have groups exchange graphs and reconstruct the oceanic profile which was indicated by the graph.
2. Pre-and posttest which includes questions such as:
   a. Explain how dolphins locate objects in the ocean.
   b. If you were an oceanographer, describe two situations in which you would use SONAR and what information you would gain from its use.

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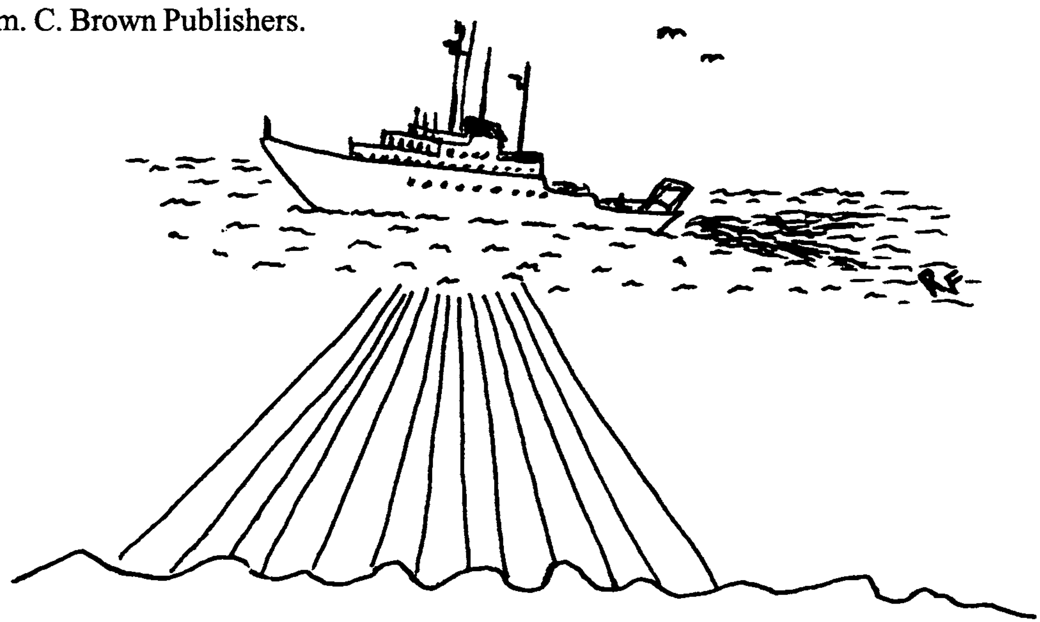


TOPIC-TITLE: Deep Sea Technology - *Robots and Submersibles*

AUTHOR: Michael DiSpezio and Roger Torda (*JASON IV-Deep Sea Technology* Authors)

GRADE SUITABILITY: Middle and High School

SCOPE: Oceanography

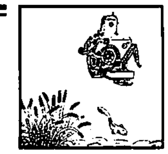
SEQUENCE: Ask students if they have ever seen a robot. (Even if no one has seen a robot at close range, students will certainly have seen robots in books, in movies, and on TV. Allow them to describe what they have seen.) Ask: Do all robots look like mechanical human beings? Why do people make robots? Might there be a design that would be better for some projects than the shape of a human being? For example, can human beings move quickly through water and stay under for long periods of time? Explain that remotely operated vehicles (ROVs) like JASON and Medea are robots, but do not look humanoid because their function calls for another kind of design.

BACKGROUND SUMMARY: Robots are able to do some things that humans cannot do. Human beings can work with robots to accomplish tasks that would not otherwise be possible. Today's robotic technology even makes it possible for humans to conduct activities without being physically present. The JASON Project uses robots to explore the deep water environment.

OBJECTIVES: Students will be able to:
1. Define robot and ROV.
2. Identify suitable work for robots and ROVs.
3. Describe work JASON is expected to do.

MATERIALS:
- Transparency made from Master 1.1j, JASON Transmission System
- Transparencies made from Master 1.1g, JASON and Medea
- Transparency of Master 2.1a, Kinds of Robots
- Overhead projector

ACTIVITY:
1. Project Master 1.1j, JASON Transmission System, and point out JASON. Project Master 1.1g, JASON and Medea. Explain that JASON and Medea together form a two-vehicle team able to do both wide-area and detailed surveys of the sea floor, as



well as detailed sampling. Medea stays higher than JASON (about 15 to 25 meters—or 50 to 80 feet—off the bottom) and JASON works on the sea floor. Neither carries a passenger. Medea has no propulsion, but JASON is equipped with thrusters that allow very accurate movement. JASON can be "flown" manually by a pilot in the command center or can be operated in closed-loop control. In closed-loop mode, JASON is given a set of commands to follow (such as to fly a 100-meter [328-foot] grid pattern at 10 meters [33 feet] off the bottom) and through a sophisticated computer control system is able to do so.

Ask: Why use JASON instead of, for example, a submersible and crew? Time at s sea is very costly—tens of thousands of dollars per day. A typical day on a submarine expedition begins at about 4 a.m. with the engineering team preparing the submarine. At 8 a.m. the three-person dive team enters the submersible, the hatch is closed, and the sub is lowered into the water. By about 9 a.m., the sub begins its descent. Usually it takes about three hours and can cover about five kilometers (about three miles). Visibility from the sub is very poor (less than five meters or 16 feet) and only three people (two scientists and one pilot) share the experience. After three hours, the submersible begins the two and-a-half-hour trip back to the surface. By about 7 p.m. the submersible is back on board, and the day's submarine activities are over. The net result is ten hours for every three hours of direct observation of the seafloor.

In the case of Medea/JASON, the system is deployed and left in the water for days. A team of up to ten people can comfortably experience real-time observation in the control center. A wider area can be imaged, since Medea has a bird's-eye view that includes JASON and JASON's viewing area. The real-time satellite transmission enlarges the direct observation audience to the total capacity of the downlink viewing sites. These ROVs and their human operators are good examples of humans using technology to overcome human limitations.

2. Project Master 2.1B. Kinds of Robots, and explain that it's hard to define all robots by what they do, because they perform such a wide range of tasks. Remind students of their earlier ideas about why people might want to build robots. Students may think of robots as playthings or mechanical butlers, but working robots are usually designed to perform tasks too tedious, too precise, or too dangerous for human beings. In space, at the bottom of the ocean, or in a paint booth engulfed in toxic fumes, robotic machines can keep going without oxygen and at temperatures too high or too low for humans. Robots can be sent into dangerous places and controlled from a safe distance by a human operator. Robots can fight fires and can be used for bomb disposal work or for sweeping mine fields.

   Some robots are programmed to vary their motions autonomously, by means of special "teach units" that move each joint of the robot in the desired direction. Some robots (called "bang-bang" robots) have their mechanical movement stopped at either end of their range by fixed blocks. They bang the fixed block at one end of their path and then bang the fixed block at the other end. The data center tape cartridge robot "sees" the correct cartridge by means of a camera and two lights mounted on each "hand." The robot takes the cartridge from its slot on the rack, moves it to the tape reader, and mounts it—all in 11 seconds.

JASON uses similar technology, and takes its commands from human operators who are able to see by way of TV cameras as if they were inside JASON looking out. The joystick commands are sent from a shipboard computer through a fiber-optic cable to the computer on JASON, which responds by turning on JASON's thrusters. Sensor information (water depth, heading, and position, among other things) is sent from JASON's computer back to the computers aboard the ship, which display the information to the operators and store it for later use. The information links between the computers make up a local area network, which is similar to the local area net works many business and universities use to pass information between computers.

The local area network must pass information very quickly, or the pilot will be hampered by the delay between the joystick commands and JASON's response. The network used on JASON will eventually be able to send information at the rate of ten million bits per second. This is comparable to sending the contents of a 750-page book every second. In reality much less data are actually sent, but the speed capability is very important to controlling JASON well. The shipboard computers are split into separate tasks; individual computers control JASON, acoustically determine Medea's and JASON's positions, and store and display the data coming from the sea floor. JASON's computers accept commands from scientists aboard the ship.

POSSIBLE EXTENSION:

TEACHER EVALUATION: Pose the question: Why are ROVs so important to exploration? Remind students that JASON will be operating at a depth of about 1,135 meters (3,722 feet). JASON is capable of working at 6,000 meters, or almost four miles down. Remote operation is ideal for work beneath the sea, where darkness, high pressure, and low temperatures permit only brief, dangerous trips by humans. Robots designed to be used underwater are called submersible ROVs.

REFERENCES:

DeWall, Marily (Curriculum Director). 1992. *JASON IV Curriculum, Baja California Sur*. National Science Teachers Association. Washington, D.C. (This activity has been reprinted with permission.)

Deep Sea Technology

TOPIC-TITLE: Deep Sea Technology - *JASON Simulation*

AUTHOR: Michael DiSpezio and Roger Torda (*JASON IV-Deep Sea Technology* Authors)

GRADE SUITABILITY: Middle and High School

SCOPE: Oceanography

SEQUENCE: Ask: How will JASON be controlled? (JASON's operator will direct its movements from the shipboard control panel by maneuvering a joystick for accelerating, tilting, and turning). What will the operator have JASON do when they find the hydrothermal vents and tubeworms? What will the other scientists do? If they find something they want to see again, how will they know where to look or know where to tell someone else to look? (Students will learn the answers from this activity.)

BACKGROUND SUMMARY: Cameras mounted on JASON allow students, scientists, and other observers at downlink sites to experience live exploration almost firsthand. A simulation of the JASON imaging system will promote student understanding of telepresence.

OBJECTIVES: Students will be able to:
1. Construct a floor grid for tracking movements and discoveries.
2. Take part in a simulation of exploring the ocean floor with JASON, playing the roles of the control crew and various parts of the JASON Project technology.
3. Relate the concept of telepresence to the interaction of the ROV and the operator and to their own downlink site experience.

MATERIALS:
- Movable partition
- Copies of Master 2.1b, Vent Field Grid, redrawn if necessary to fit space available, one for every student except JASON operators
- Masking tape
- Meter sticks
- Index cards for floor grid location codes
- Video camera with display monitor and long connecting cable
- Walkie-talkie
- Traffic cones, funnels, or other items to simulate hydrothermal vents
- Cardboard cylinders and other items to represent tubeworms and other vent organisms.

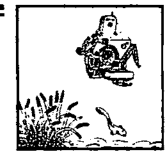
ACTIVITY: (teacher preparation)

1. Partition classroom into two areas. One area will be the vent field (VF) that JASON explores; the other will be the command center (CC).

2. Mark the floor of the exploration space with masking tape to form a grid of squares. Squares 0.5 meter x 0.5 meter are ideal. Use a 4-square x 6-square area as in the pattern on Master 2.1b, or redraw the pattern to fit the space available. In either case, be sure the paper grid matches the floor grid. Label columns A, B, C, and D across, and 1, 2, 3, 4, 5, and 6 down. Each grid square now has a location code—A1, A2, and so on. The pattern is a map of the vent field. Mark one index card with each location code and place a card in the lower right hand corner of each square so it can be observed by the camera.

3. Prepare the vent field. Furniture and objects should remain in the room, but rearranging the room so the explorers will encounter new objects or usual objects in unexpected places will heighten suspense and create more focused observation. Place cones or funnels and items representing organisms in one of the grids in such a way that the command center operators and observers will recognize them as a target of the exploration.

4. Set up the monitor in the command center. Be sure that students in this area cannot see into the vent field. Designate students to play the following roles:
   - Site Coordinator (CC): directs the command center
   - Assistant Site Coordinator (CC): Marks areas on the paper grid as they are explored
   - Command Operator (CC): views the display screen and issues directions to JASON over the walkie-talkie
   - JASON (VF): is controlled by operators and manipulators
   - JASON's "Ears" Operator (VF): holds the other walkie-talkie so the JASON operator can respond to direction
   - JASON Manipulator 1 (VF): moves JASON as directed by "Ears"
   - JASON Manipulator 2 (VF): walks behind JASON and uses his/her arms and hands as the command center directs (This student should have a bag or box in one hand to store objects collected.)
   - JASON Camera Operator (VF): operates the video camera in close-up mode
   - Command Center Crew (All remaining students—CC): mark locations of all objects on their vent field grids and trace JASON's movements.



5. Instruct JASON Manipulator 1 to begin anywhere on the vent field grid and turn on the camera. Command center turns on the display. Using the walkie-talkie, the Command Operator directs JASON around the room. The Assistant Site Coordinator traces JASON's movement on the paper grid and the command center team speculates on what they see and decides where JASON should go next. If the Command Team members want JASON to pick up something for closer observation or to bring it back, they must direct JASON's Ears and he or she must direct the manipulators: move right, move left, move up, open fingers, close fingers, put in box, and so on. The simulation continues until the vents are found or only ten minutes remain in the class period.

6. Reinforce the concept of telepresence. Observe the command center group and watch for a point at which the students get so involved in the task in the command area that they appear to feel more "present" in the vent field than at the command center. The control (changing JASON's direction) and feedback (watching the picture change as JASON is moved) begin to convey a sense of "being there," as the operator concen trates on taking part in the scene. Stimulate discussion of that sensation. It is what Dr. Ballard calls telepresence, and what he hopes students will experience during their visit to the downlink site.

POSSIBLE EXTENSION:

TEACHER EVALUATION:

1. Discuss the simulation with the class. Ask: How was it similar to working with the real JASON? How was it different? What kinds of improvements would have made it easier? (For instance, an ROV with greater "intelligence." One that could respond directly to voice commands. One with sonar that could combine a picture transmitted back to command center with an image of the terrain so CC could make quick decisions about whether to continue or abandon the site.)
2. Tell students that the grid they used is similar to the one the JASON scientists use. What purpose does the grid serve? (Because the command center can view only a small area, it would be difficult to relate to the larger scene without a grid for reference. Imagine doing a 5,000 piece jigsaw puzzle without the picture on the box! The expedition is very costly, and the scientists can't afford to waste time going over the same ground more than once unnecessarily.)

REFERENCES:

DeWall, Marily (Curriculum Director). 1992. *JASON IV Curriculum, Baja California Sur*. National Science Teachers Association. Washington, D.C. (This activity has been reprinted with permission.)

TOPIC-TITLE: Deep Sea Technology - *Feedback Loops*

AUTHOR: Michael DiSpezio and Roger Torda (*JASON IV-Deep Sea Technology* Authors)

GRADE SUITABILITY: Upper Elementary

SCOPE: Oceanography

SEQUENCE: Explain to students that JASON's maneuverability depends upon feedback or the transmission of signals between the ROV and its surface vessel. An array of sensors determines the ROV's exact location and relays this information to a navigational computer system. The computer processes these data and determines if the ROV is on course. Adjustments to the ROV's position are made automatically through the transmission of commands to the vehicle's thrusters.

Explain that in order to supervise JASON's programmed navigation, this shipboard operator closely monitors the information displayed by JASON's sensors. This feedback information supplies the operator with precise details about the position and movement of the ROV.

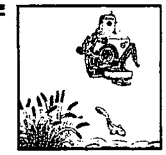
The human operator can use a joystick to modify the programmed ROV path. But all human input, or supervisory control, must first be processed and integrated by the computer system. If the system "approves" of the course input, the new commands are transmitted to the thrusters.

JASON's navigational system is so precise it can track JASON plus or minus two centimeters of actual location. Computers on the ship established a detailed "no-go" envelope around the vent site. The computers prevent JASON from entering the "no-go" envelope by overriding an operator's controls.

BACKGROUND SUMMARY: JASON's navigational system depends upon feedback loops. In a feedback loop, information about an ongoing task is continually relayed to the task controller. The controller uses this feedback to determine how to complete the task.

OBJECTIVES: Students will be able to:
1. Remotely operate a vehicle.
2. Use a feedback loop to modify the vehicle's movements.

MATERIALS:
- Radio-controlled vehicle
- Ten dominoes
- Tape
- Meter stick
- Stopwatch



ACTIVITY:

1. Assign students to cooperative groups. In each group of four, have Student A use a meter stick and tape to mark off a square area of the floor about two meters on each side. Explain that the taped area represents the ROV's field, or "envelope of operation."

2. Have Student B place 10 dominoes in a random pattern within the marked-off square.

3. Tell Student C that his or her role will be to knock over as many dominoes as possible with the radio-controlled vehicle. Give students time to examine the placement of dominoes. Then have Student B place the vehicle anywhere within the square.

4. Have Student C stand about a meter from the square facing away from the dominoes and the car. Students A and B should take positions on opposite sides of the square.

5. Student D will use a watch to keep time. On Student D's signal, Student C will use the controls to drive the car without watching its movement. (NOTE: if the car travels out of the square, Student A or Student B is to return it to its starting location.)

6. At the end of two minutes, Student D will stop the activity and students will count and record the number of fallen dominoes.

7. Now repeat steps 2 through 6. On this second run, however, permit operators to watch the movements of their radio-controlled vehicles.

8. Exchange roles so that every student gets a chance to control the car with and without a feedback loop mechanism (with and without watching and responding to its movements).

POSSIBLE EXTENSION: Request that students "brainstorm" extensions for this activity.

TEACHER EVALUATION: Discuss the difference between the motion of the unwatched car and its purposeful movement when the operator is able to observe its course and make corrections. Explain that the second kind of operation illustrates a feedback loop—the operator provides data to the machine; the machine provides data (or feedback) to the observing operator; and the operator supplies more data (further feedback) in response. Without feedback it would be unlikely for the car to strike all ten dominoes within a short period of time.

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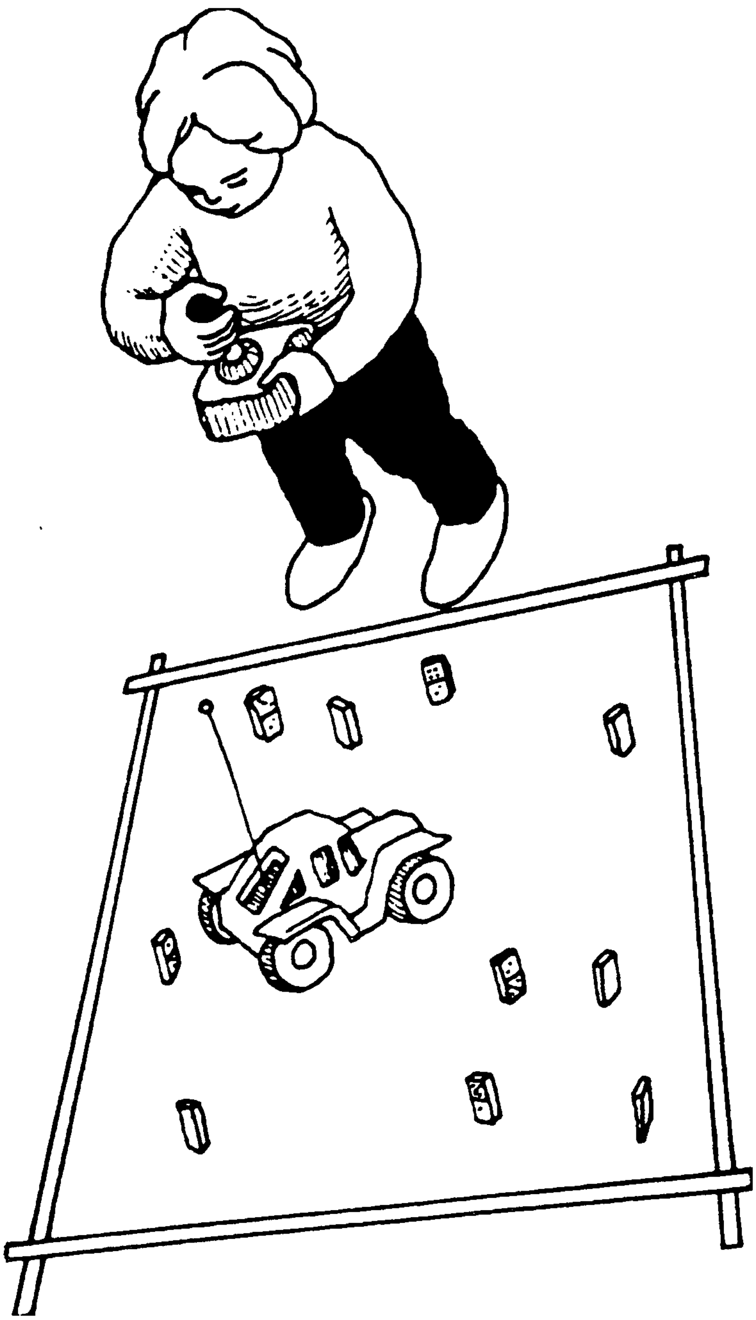

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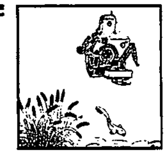

TOPIC-TITLE: Deep Sea Technology - *Slurp Guns*

AUTHOR: Michael DiSpezio and Roger Torda (*JASON IV-Deep Sea Technology* Authors)

GRADE SUITABILITY: Middle and High School

SCOPE: Oceanography

SEQUENCE: Explain that although much information can be gathered remotely through the use of probes and cameras, it is often desirable to retrieve actual samples and examine them topside. Devices such as slurp guns and elevators allow scientists to collect and retrieve samples for further observation and testing.

BACKGROUND SUMMARY: Scientists use several types of collection devices to retrieve samples from the ocean depths. One such device, the "slurp gun," produces a vacuum to pull up samples. The JASON scientists will use a slurp gun to gather samples of the algal mats that are unique to the hydrothermal vent in the Guaymas Basin.

OBJECTIVES: Students will be able to:
1. Construct a classroom slurp gun device.
2. Use their slurp gun to obtain samples from a simulated sea bottom.

MATERIALS:
- An aquarium or other large wide-mouthed container filled with water
- Sand or fine aquarium gravel to cover the bottom of the bowl. (Multiple colors can be used to represent different kinds of bottom features.)
- Newspapers to cover the work surface

For each student team
  - Small Erlenmeyer® flask
  - Two-hole stopper with glass tubing inserted
  - Two sections of plastic tubing
  - Large plastic syringe which can fit the plastic tubing
  - Waterproof clear tape

ACTIVITY:
1. Set up the aquarium and put it in a central place. Sprinkle gravel on the bottom. Follow the directions in VI-20 (next page) to test the plunger assembly, then remove

the tape, syringe, and tubing so a student can complete the process. Leave the glass tubing connected to the holes of the stopper, since this is a risky procedure for students to do on their own. Connect glass tubing in advance to as many stoppers as your class will use.

2. Divide the class into teams or small groups.

3. Distribute materials. Have one student in each team place the two-hole stopper with glass tubing into an Erlenmeyer® flask. Emphasize safe handling of the equipment. Within each team, students can take turns assembling, disassembling, and testing the device.

4. Give these instructions for the construction of the slurp gun:
   a. Carefully connect a length of plastic tubing to each of the stopper's glass tubes.
   b. Carefully fit the syringe opening to the free end of one of the plastic tubes. Make sure that the connection is airtight by wrapping it with sufficient tape, then place the free end of the other plastic tube into the aquarium. The syringe plunger should be pushed all the way in.
   c. Pull back on the syringe plunger. Water should be drawn into the Erlenmeyer flask.

5. Challenge the students to take turns slurping up samples from the simulated bottom materials.

POSSIBLE EXTENSION:

For younger students

Instead of constructing a slurp gun from tubing and a flask, have students obtain samples with a large dropper-like oven baster.

For Older students

1. Supply students with different types of targets and challenge the groups to develop the skills needed to collect "pure" samples, with as little extraneous material as possible.
2. Challenge students to collect samples by remote control. One student will guide the syringe while another gives directions, as in the robotics activity in the last lesson (2.1, Activity two).

TEACHER EVALUATION: Help students draw conclusions about the operation and use of "slurp" sampling devices. Ask the following questions:

1. What does a slurp gun do? (It uses pressure to force a sample into a collection chamber. In this year's JASON expedition, the slurp gun will be used to collect samples of bacteria and other life forms.)

2. How was the suction produced in your model slurp gun? (When the plunger was pulled back, it created a partial vacuum, so that the greater outside pressure pushed the sample into the chamber.)
3. Do you think a slurp gun could be used to obtain rock samples? (Probably not. Rocks and other hard materials are more easily collected with corers and dredges.)

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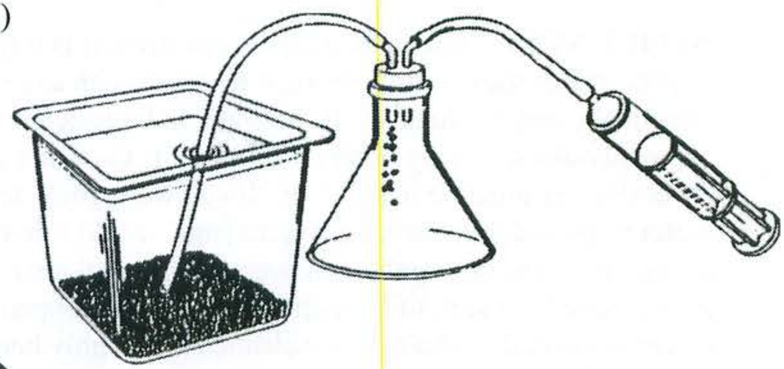

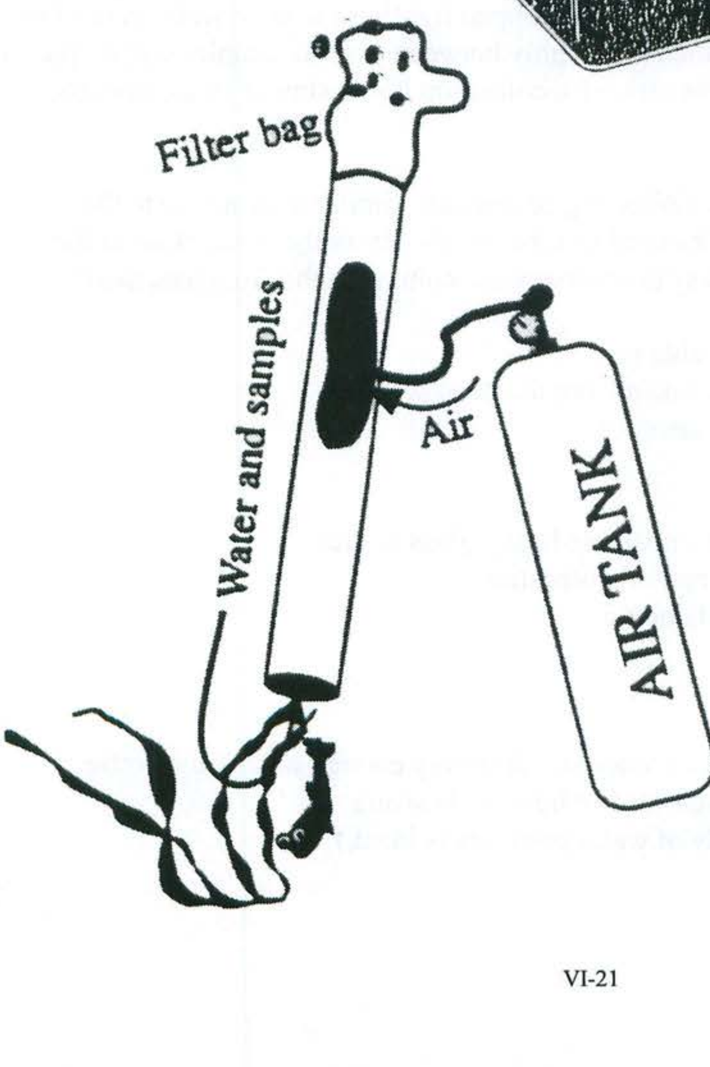

TOPIC-TITLE: Deep Sea Technology - *Testing the Water*

AUTHOR: Michael DiSpezio and Roger Torda (*JASON IV-Deep Sea Technology* Authors)

GRADE SUITABILITY: Middle and High School

SCOPE: Oceanography

SEQUENCE: Explain to students that often it is important to collect water at varying depths so that some of the physical features, such as temperature, salinity, or dissolved chemicals, may be studied. If the water to be tested is close to the surface, it can be sampled quite easily by divers. However, if the water is to be collected at greater depths, other devices must be used. Ask: If you were going to design a bottle for collecting water at great depths, what characteristics would it have? Brainstorm with students for several minutes, noting their answers on the chalkboard. (Answers will probably include: heavy enough to sink to the bottom, able to be stopped tightly so sample water is not lost or contaminated, and able to be cleaned thoroughly between uses so samples will be pure.) Tell the class that they are going to be making a collection bottle similar to the ones the JASON Project scientists will use.

BACKGROUND SUMMARY: Collecting equipment, similar in principle to the water collector described here, will be used to take samples from the areas close to the vents and at varying depths all the way down the water column in the Guaymas Basin.

OBJECTIVES: Students will be able to:
1. Describe how water samples are taken from the deep sea.
2. Follow procedures to test water samples.

MATERIALS:
- One small glass soda bottle (or comparable heavy glass bottle)
- 3-5 m (10-15 ft) cotton rope or cotton clothesline
- One rubber stopper to fit the soda bottle
- One screw about 2.5 cm long
- Metric ruler
- Waterproof marker
- One 500-g (1-lb) fishing weight, or other weight heavy enough to sink the bottle
- Approximately 30 cm (1 ft) mason cord or household string
- Water for testing (A natural body of water outdoors is ideal.)
- Celsius thermometers

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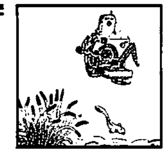

ACTIVITY:

1. Divide the class into small groups and provide each group with materials. Give these directions:
   a. Tie one end of the rope around the neck of the bottle, making sure that it is securely knotted. Cut off the short end as close to the bottle as possible.
   b. Carefully force the screw through the center of the rope at a distance of eight centimeters (3 inches) from the knot, then screw it into the center top of the stopper.
   c. Using knots and waterproof marker, mark off the line from the top of the stopper to the end of the line in equal increments (centimeters).
   d. Use the string to fasten the fishing weight to the bottom of the bottle.

2. Take students with their bottles to a body of water for testing. Give students these directions:
   a. Put the stopper in carefully and securely, but not too tight for easy removal.
   b. Decide which mark on the line the bottle will descend to, then gently lower the bottle to the desired depth.
   c. Give the line a quick jerk to pull the stopper from the bottle.
   d. Large bubbles will rise to the surface as the bottle fills. When the bubbles stop, the bottle is full. Pull it quickly to the surface.
   e. Take the temperature of the sample immediately and record it.

POSSIBLE EXTENSION:

1. The sample can be carefully poured into labeled bottles to be tested back in the lab for salinity, dissolved oxygen, or other dissolved chemicals.
2. Samples can be taken at different depths and comparisons can be made.

TEACHER EVALUATION: Build a discussion around these questions;

1. Why is it necessary to place a weight on the bottom of the bottle? (Otherwise the air inside would make the bottle float.)
2. Why doesn't water from other depths get into the bottle as it is being pulled to the top? (The bottle is already full, and it is pulled straight up to the top.)
3. Why is it necessary to test the temperature as soon as the bottle is pulled up? (The temperature will soon change to that of the surrounding air.)

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TOPIC-TITLE: Deep Sea Technology - *Making an Image*

AUTHOR: Michael DiSpezio and Roger Torda (*JASON IV-Deep Sea Technology* Authors)

GRADE SUITABILITY: Upper and High Elementary

SCOPE: Oceanography

SEQUENCE: Review the basics of sonar as presented in the previous activity. Explain that by "sweeping" the sound across an object, modern SONAR technology can produce extremely accurate three-dimensional views of underwater objects. Sometimes an image-enhancing technique called *false coloration* is applied to acquired data. To produce a false color image, sonar return times are sent to a computer. The computer processes this information and uses it to "paint" an image of the target with bright, distinct colors.

BACKGROUND SUMMARY: SONAR equipment provides accurate imaging and measurement of subsurface features that are not easily accessible. By comparing and contrasting the times required for echo detection, computers can compile a precise three-dimensional profile of an underwater target.

OBJECTIVES: Students will be able to:
1. Learn how SONAR used to construct images.
2. Construct a profile of a vent chimney.

MATERIALS:
- Overhead projector
- Transparency made from Master 2.3b, SONAR Imaging (used in previous activity)
- Transparency and student copies made from Master 2.3c, Profile Grid of a Hydrothermal Vent Chimney
- Erasable transparency markers for teacher demonstration
- Crayons or markers for student use

ACTIVITY:
1. Project Master 2.3b, SONAR Imaging. Review how this master was used to illustrate the previous activity. Then, use overhead markers to color in the image's blank boxes. Explain that this type of false coloration helps scientists identify details of the SONAR image.

2. Distribute student copies of Master 2.3c, Profile Grid of a Hydrothermal Vent Chimney, and project the transparency made from the same master. Use colored markers to fill in the key at the bottom of the master. Then color in several grid boxes for each time range. When you are confident that the class understands the activity, have students color in their own grids accordingly.

3. When students have finished coloring their grids, have them compare their completed false color representations. Ask the class:
   a. Does the revealed image appear similar to the illustration on the master? (Yes, it should.)
   b. What do the different colors represent? (Parts of the vent chimney at different distances.)
   c. Why is it advantageous to use false coloration? (It brings out details that would be lost in a plain black-and-white image.)

POSSIBLE EXTENSION:

For younger students

Supply students with crayons or markers and have them compile false color images of familiar shapes such as cones, cubes, and cylinders.

For older students

1. Have students select a familiar classroom object and produce a false color image of the object as it might be detected by SONAR.
2. Explain that false coloring is frequently used in a high technology medical scanning technique called Magnetic Resonance Imaging (MRI). MRI images of internal body parts allow physicians to study internal tissues without invasive surgery. If possible, obtain several false color images from a local hospital or laboratory.

TEACHER EVALUATION: Review how false color images are produced and used to illustrate three-dimensional features. Describe the role of the computer in producing this high technology display.

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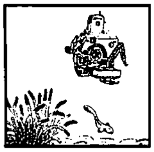

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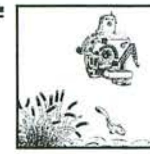

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