STUDENT SCIENTISTS

Investigating Marine Debris
Teacher Guide

Aloha Fellow Educators! You are invited on an adventure! That's what working with students as they learn about scientific investigation is – an adventure. You have to learn to be comfortable NOT knowing the outcome of the investigations in advance, having students develop different hypotheses and investigations related to a single issue and serving your students in the capacity of a coach.

Those who have never embarked on an "investigation adventure" with their students are encouraged to help students develop a single hypothesis to investigate or encourage their students to work in groups; this makes the role of coach much easier to manage.

<u>This Module Includes the Following Materials to Assist You</u>:

- CD with several of the module contents – teachers have permission to modify contents to adapt them to their students
- Introductory powerpoint, associated student worksheet and scientific articles
- Teacher Guide with
    - information to assist in standards alignment in the state of Hawaii
    - criteria for assessment
    - activity directions
    - links to related web sites
- A copy of the NOAA Quicktime Northwest Hawaiian Islands slideshow
- Copies of scientific articles about marine debris in the Northwest Hawaiian Islands
- Instructions to help students use Microsoft Excel to graph and analyze data
- A PDF copy of the ICC (beach clean up) data sheet
- PDF copies of concise, colorful brochures about the International Coastal Clean Up and the Marine Debris Research and Reduction Act of 2005

Hawaii Content and Performance Standards Addressed in this Module:

Please note that teachers should review the grade level benchmarks for these standards to better assist students in mastering them.

Science:

Strand	The Scientific Process

Standard 1: The Scientific Process: SCIENTIFIC INVESTIGATION: Discover, invent, and investigate using the skills necessary to engage in the scientific process

Standard 2: The Scientific Process: NATURE OF SCIENCE: Understand that science, technology, and society are interrelated

Strand	Life and Environmental Sciences

Standard 3: Life and Environmental Sciences: ORGANISMS AND THE ENVIRONMENT: Understand the unity, diversity, and interrelationships of organisms, including their relationship to cycles of matter and energy in the environment

Math:

Strand	Data Analysis, Statistics, and Probability

Standard 11: Data Analysis, Statistics, and Probability: FLUENCY WITH DATA: Pose questions and collect, organize, and represent data to answer those questions

Career and Technical Education:

Strand	Technological Design

Standard 1: TECHNOLOGICAL DESIGN-Design, modify, and apply technology to effectively and efficiently solve problems

Language Arts:

Strand	Reading

Standard 1: Reading: CONVENTIONS AND SKILLS: Use knowledge of the conventions of language and texts to construct meaning for a range of literary and informational texts for a variety of purposes

Nā Honua Mauli Ola- Hawaii Guidelines for Culturally Healthy and Responsive Learning Environments Addressed in this Module:

4. Instill a desire for exploration of learning, teaching, leading and reflecting to pursue standards of quality and excellence.

14. Plan for meaningful outcomes that foster the relationship and interaction among people, time, space, places and natural elements around them to enhance one's ability to maintain a "local" disposition with global understandings.

15. Engage in experiences which mālama the entire learning community and the environment to support learning and good practices of stewardship, resource sustainability and spirituality.

Essential Questions Addressed in this Module:

Essential Questions are excellent for use in focusing student attention on the "big ideas" of a unit. They can be used on bulletin boards and for pre-, formative and post assessment.

1. How do scientists investigate mysteries?
2. How does scientific investigation help solve environmental problems?
3. What can you do about environmental problems in your own backyard?

Sample Assessment Criteria for 4th grade

"I can" statements are an excellent way to share criteria for success with elementary and middle school students. Students can use criteria presented in this manner to self and peer assess their progress in developing scientific inquiry and mathematical data analysis skills. The above statements were based on science and math Hawaii Content and Performance Benchmarks for the fourth grade.

I can …..

- …write a clear hypothesis (a testable prediction)
- …come up with a way to test my hypothesis
- …use tools to accurately measure in a variety of ways*
- …make observations without making inferences*
- …organize my measurements and observations in clear tables and graphs
- …explain the conclusions that I get from my measurements, observations and graphs
- …describe how human activities have influenced the environment of Hawaii
- …describe a plan to improve the conditions in the natural environment

*it is recommended that students are taught to understand that measurements and observations are "data"

Sample Assessment Criteria for grades 9-12 Scientific Investigation

Teachers are encouraged to develop rubrics that include columns that describe "below standard", "approaching standard" and "above standard". It is more effective to develop rubrics AFTER assessing a set of student inquiry reports. The following criteria was developed in part by teachers in the science department of Mililani High School. It should also be noted that students can rarely, accurately, self and peer assess using this criteria without instruction and practice. It is also recommended that the following criteria be used throughout the year as it takes significant time and practice to master. Finally, the use of exemplars in the teaching of the criteria is extremely useful even if the teacher has to create them.

	Meets Standard
Identify Problem/Purpose	• Student fully participates in discussion • Student can fully explain the problem/purpose associated with their inquiry
Generating Hypothesis	• Hypothesis testable and clear • Includes logical justification for hypothesis (based on prior knowledge, observations and/or research findings)
Procedure (designing the investigation)	• Write a set of instructions that will test the hypothesis or solve the problem • Write procedure sequentially (step 1, 2, 3…) • Includes list of all materials in a "shopping list" format • Written with enough detail so that the experiment is reproducible • Apply research to determine procedure • Identify the independent and dependent variables • Address things in the procedure that could affect results • Adequate sample size, number of trials, number of observations • Address all safety concerns related to procedure
Data Table	• Data is organized in a table • Table made with a ruler or computer • Use metric measurement only • Columns/rows have labeled headings with units • Consistent significant figures • Clear, detailed observations
Data Calculations	• All units labeled • Accurately performs and labels calculations • Calculates more than average (need range, mean, median, mode • Clearly understands with statistics are necessary to understand data
Graphs	• Has title related to data • X and Y axis labeled • Units are clearly labeled • Appropriate scale (not small, not over gridlines)
Data Analysis	• Discuss data (observations, calculation, and graphs) and explain what it means- what does the data tell you? • Discuss problems that occurred and explain how they affected results
Conclusion	• State whether data supports or refutes hypothesis (must re-state hypothesis in first sentence) • Summarize important findings from the data analysis in 1-3 sentences. • What generalizations (how this applies to other situations) can you make from your data
Revision/Reflection	• Describe how you would address problems/suggest improvement to procedure • How would you apply what you learned in this inquiry? • Can you use this criteria to accurately evaluate your work and/or other's work? • Generate related questions and/or procedures for further study • What did you learn by doing this experiment
Communicates clearly	• Investigation write up is clear to peers • Investigation write up is grammatically correct

Using the Module – Instructions and Suggestions for Teachers

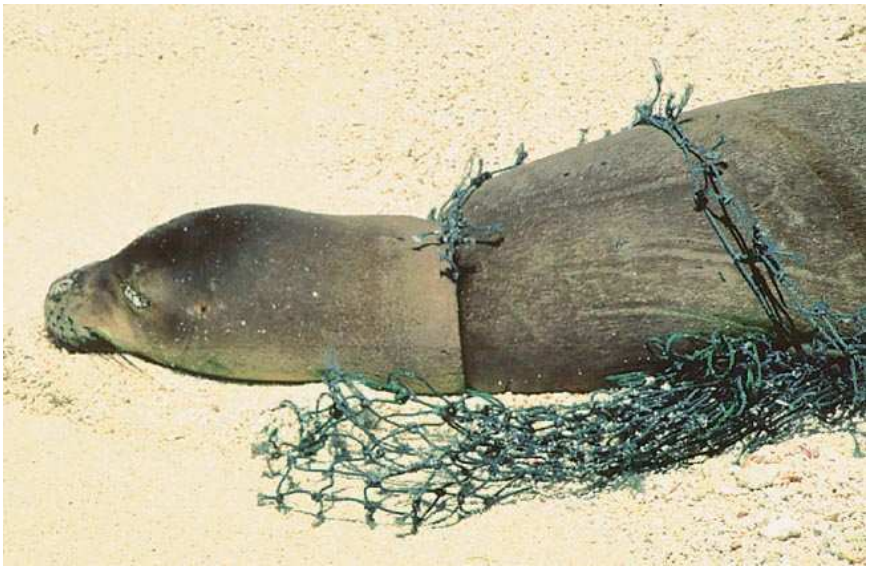
Introductory Lesson Ideas – Fantastic Visuals!

1. Introduce your students in some manner with the Northwestern Hawaiian Islands. Included in this module are several resources that can make this introduction engaging and easy to prepare for. Choose one or more of the following:

- Show the segment of the "Navigating Change" video entitled "The Voyage" (approximately 13 minutes). The videos may be downloaded from the Navigating Change website http://www.hawaiiatolls.org/teachers/NavChange.php
- Show the NOAA video comprised solely of photo images and songs about the NWHI (approximately 7 minutes) – this may be downloaded from http://hawaiireef.noaa.gov/imagery/welcome.html by "right clicking and saving" the link entitled "Quicktime Movie Slideshow"
- Explore the NOAA website http://www.hawaiireef.noaa.gov/

2. **Engage your students!** Use the powerpoint slide show included in this module entitled "Investigating Marine Debris" and the associated worksheet to actively engage your students in the use of scientific inquiry related to marine debris.

- It is recommended that teachers review the entire powerpoint in advance and be prepared to explain some of the vocabulary words – for example, "regurgitate".
- The font and spacing of the worksheet entitled "Investigating Marine Debris" may be modified for younger students as it is included on the module CD
- The powerpoint can be showed to students using an LCD projector, a computer hooked up to a large screen television or to students in small groups using several computers.
- It is estimated that working actively through the entire powerpoint will take approximately one hour but teachers may want to break it up into 2 -3 segments over 2-3 days.
- It is recommended that many of the worksheet questions be answered using a combination of individual reflection, cooperative student pairs/small groups and whole class discussion with teacher guidance.



In Depth Examination of Scientific Investigation – Develop Reading Skills and Learn from the Pros!

Middle and High School students should read at least one of the scientific journal articles referenced in the introductory powerpoint. They are included in electronic and printed form in this module. Review of one article will take approximately one hour.

Articles included in this module (listed in order of difficulty, the first being the easiest):

1. **Occurrence of Plastic Particles in Seabirds from the Eastern North Pacific,** Louise K. Blight and Alan E. Burger

2. **Ghost Net Identification**
   Molly A. Timmers, Christina A. Kister, Mary J. Donahue

3. **A Retrospective Review of Marine Debris Deposition Data from Tern Island, French Frigate Shoals, 1990-2002**,
   Carey Morishige, Christine Woolaway, Christopher Swenson, Mary Donohue

4. **A Comparison of Plastic and Plankton in the North Pacific Central Gyre**
   Charles J. Moore, Shelly L. Moore, Molly K. Leecaster, and Stephen B. Weisberg

Reading strategies include:

- Partnering students and having one student read out loud while the other listens and paraphrases after each paragraph (students should switch roles after every 3 paragraphs)
- Creating a worksheet or graphic organizer that asks students to identify the author's hypothesis, procedure, and conclusion/s. Students may work individually and/or cooperatively to complete the worksheet
- Chose at least one graph and/or table from an article and ask students to interpret it – they will have to read parts of the article to complete this task
- Have students highlight words they do not understand as they read the article for the first time and look up the meaning of these words and write "common language" definitions of them. Have students read the article a second time.
- Low-level readers, SPED students with language processing difficulties and ESLL students should be provided with a copy of the article at least one day in advance that has the main-points highlighted by the teacher.
- Show the video segment from "Navigating Change" entitled "Human Impacts". You do not need to show the entire segment, as marine debris is addressed in the first portions of the segment.
- Show the video entitled "Marine Debris in the Northwest Hawaiian Islands: Ghost Net Identification" Copies of the Ghost Net DVD - it can be ordered for $10 at http://www.soest.hawaii.edu/seagrant/communication/pdf/NWHI.pdfa It is 15 minutes long and is an excellent follow up to having students read the article by Molly A. Timmers et al.

Develop Local Scientific Investigation Projects With Your Students

Develop scientific investigations in your "backyard". Students are often very motivated to do something about marine debris in their area. The following section will describe three types of investigations that you can help the students develop and implement.

Whose Rubbish is This?

Investigation #1 Based on One or More Beach Clean-Ups.

This investigation also involves students in the vital act of "mālama i ka aina, mālama i ke kai" or taking care of the land and sea. Many schools are requiring and encouraging students to get involved in community service or service learning – this project allows students to perform a important service while learning valuable scientific investigation skills.

- Students can hypothesize what types and what proportions of marine debris they will find at a certain beach
- Students can complete beach clean ups that compare the types of marine debris found at different beaches or at different times of the week/year
- Students can learn to use Microsoft Excel to analyze their results. Instructions to help your students use this program are included in this module and are entitled "HELP USING EXCEL"

- Plan your beach clean up using Hawaii DOE water-related fieldtrip guidelines, included in this module. In addition, provide gloves and instruction about handling potentially dangerous debris.

- Have students take digital photos of the debris they find – photo evidence is an excellent data collection procedure used by scientists. Students should develop a photo data collection plan and photo log in advance. Finally students can develop a powerpoint presentation from their photos.

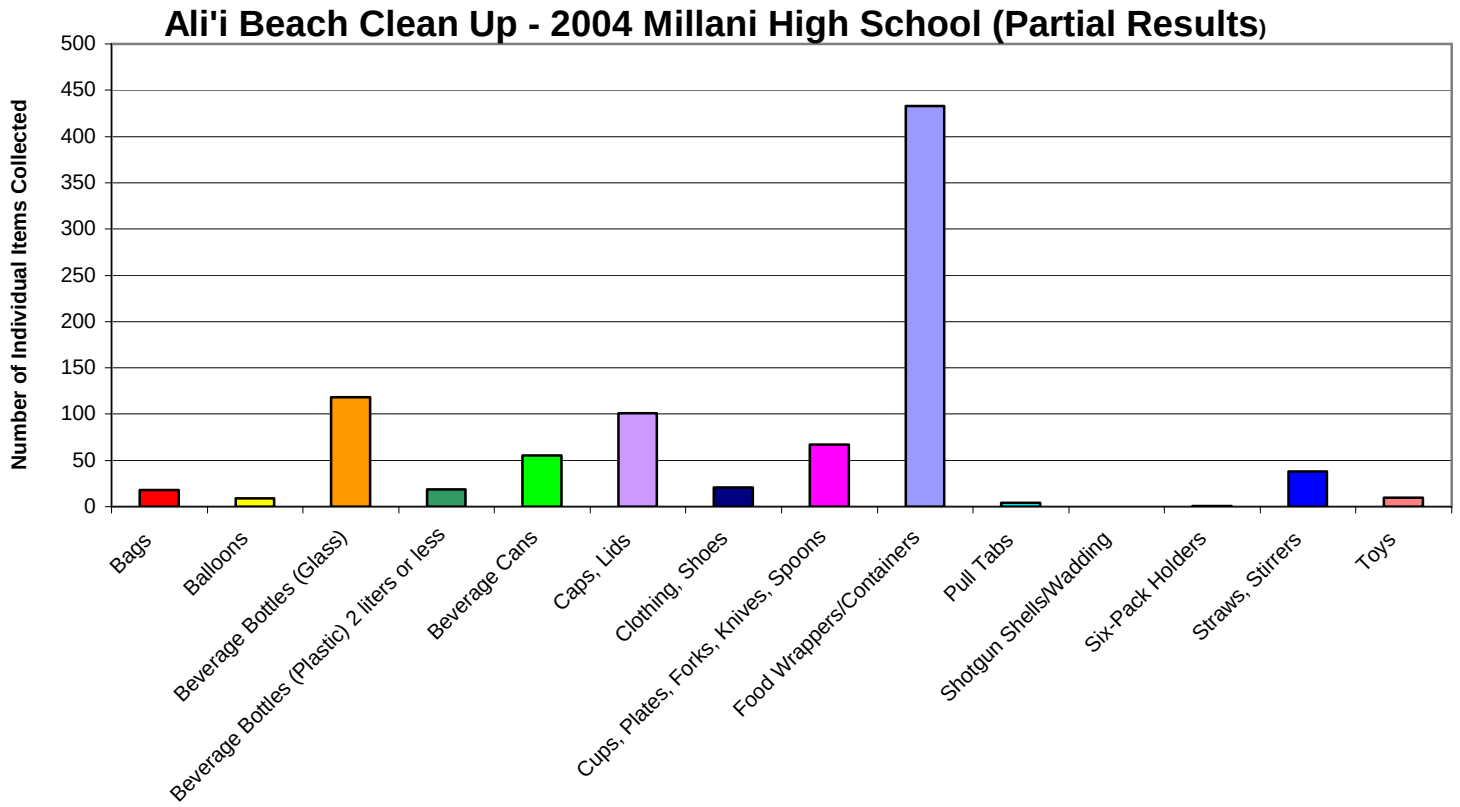
- Participate in the annual "Get the Drift and Bag It" event sponsored by UH SeaGrant. This event occurs in the 3rd week of September and it is part of a world-wide effort called the International Coastal Cleanup. This event is exceptionally well organized, supplies are provided and excellent data sheets (a copy of which is included in this module) have been developed to analyze the types of debris found. The coordinator for this event is Christine Woolaway of Hawaii SeaGrant at woolaway@hawaii.edu

    - The results of the 2004 data collection for Hawaii are included in this module (the file is entitled "2004 ICC Results"). They are in the form of an excel spread sheet and can be used to have students learn more about data analysis.
    - This event is part of an International Coastal Cleanup (ICC) sponsored by the Ocean Conservancy, which has an excellent web site. Included in this module are PDF copies colorful, concise brochures about the 20 year history of the ICC effort and The Marine Debris Research and Reduction Act of 2005

- Participate in the National Marine Debris Monitoring Program. A joint effort of the Ocean Conservancy and the Environmental Protection Agency. To learn more about this long term study, go to this web site http://www.oceanconservancy.org/site/PageServer?pagename=mdm_debris Currently, several beaches in Hawaii are part of the study! If this study looks like too much for one teacher/school, partner up with other schools on your island to monitor one beach

- If field trips are not possible, try this: collect marine debris yourself and bring it to your class for analysis, students only need grocery bag sized samples to complete an investigation

- If computers are not readily available for data analysis, have students first create graphs on standard graph paper and then create giant graphs of class results using poster paper. Create a graphing grid with approximately ½ inch squares in advance.



Got Plastic?

Investigation #2 Based on the Analysis of Albatross Bird Boluses.

Albatross regurgitate a bolus of indigestible materials (similar to owl pellets) that can be collected and analyzed for its contents.

- To obtain boluses Call Ann Bell, U.S. Fish and Wildlife Service, 300 Ala Moana Blvd. Room 1-350, Honolulu, HI 96850 808-792-9532, Ann_Bell@fws.gov.

- Obtain enough for students to analyze in groups of 4-5. If you ask enough in advance, boluses from different locations may be obtained for comparison investigations.

- Have your students learn more about Laysan Albatross (currently nesting in greater numbers on Kaena Point, Oahu).

    - http://www.nhptv.org/natureworks/laysan.htm this web page by Natureworks is a colorful, concise summary of their life history – it is also included in this module.
    - An additional resource to use in teaching about boluses is the material entitled "What Are Boluses?" from the Navigating Change curriculum, which is included in this module.
    - To explore more cool ways scientists study these birds, check out this web site! http://www.wfu.edu/albatross/

- Once they know about these wonderful birds, have students hypothesize what they will find in the boluses they analyze.

- Students carefully “dissect the boluses (over newspaper or large kitchen rubbish bags) and sort the contents into piles.

    - Gloves and dissecting tools can be provided as an option but boluses may be dissected by hand as long as students wash their hands thoroughly when they are finished.

- Contents of the boluses may be analyzed by composition, volume and % of total volume. Since plastics float (and your students unfortunately will find plastics in almost every bolus) the displacement method for determining volume will, in this investigation, be somewhat challenging. Students will have to use some implement to push floating components of the bolus beneath the surface of the water in a graduated cylinder (a dissecting probe or large needle works very well)

- Results of bolus content analysis can be graphed by individual subject and class results of bolus composition may also be analyzed and graphed.

- If a teacher uses a sample of 30 boluses among all classes, advanced statistical analysis can be performed using bolus composition. Fairly common and understandable statistical analysis includes the following:

    - Data from one type of bolus composition can be graphed (using Microsoft Excel)
    - Students should use the advanced functions in Excel to determine the central tendencies and the standard distribution of the data
    - Outliers may determined using quartile analysis and you can discuss their affect of central tendencies and the conclusions that can be drawn from the data
    - Results of analysis from bird boluses obtained at different locations on one island can be completed and analyzed

- Boluses obtained from the NWHI and MHI (Main Hawaiian Islands) can be analyzed and compared.

- As suggested in the Navigating Change curriculum, students can make a display of the contents of their boluses by gluing them to a strong background. These displays for very intriguing and can be shared with other classes or in school showcases with student commentary and analysis.

- To obtain copies of the entire Navigating Change Curriculum and/or attend a teacher workshop to learn more about this excellent curriculum go to this web site http://www.hawaiiatolls.org/teachers/NavChange.php Please note that a new web site for this curriculum is currently in development

It's Right Under Your Feet!

Investigation #3 Analysis of Micro-Marine Debris as a Component of Sand

Students can design their investigation to compare the amount of plastic marine debris present in samples of sand from different beaches and/or different sites at the same beach. For example, is there a greater amount of plastic debris near the location of public rubbish cans or near the edge of the water?

- Students can put a sample of sand in a graduated cylinder full of water – lava and coral components will sink while plastics will float. Rough estimates of volume may be obtained. The plastic pieces may then be skimmed off the top, dried and measured for volume in a separate, dry, small graduated cylinder.
- Another way to determine composition is to spread a thin layer of the sand sample over a petri dish and place it on top of a piece of paper with an equally sized circle divided into 10 pie shaped sections. Using a dissecting microscope or magnifying lens and a needle or dissecting probe, students can sort the plastic pieces into one area of the petri dish and use the pie grid to estimate the percent of the sample that contains plastic.
- Results of plastic content analysis can be graphed by individual sample. Class results of plastic composition may also be analyzed and graphed.
- If a teacher uses a sample of 30 sand sample in all classes, advanced statistical analysis can be performed using bolus composition. Fairly common and understandable statistical analysis includes the following:
    - Data from percent plastic composition can be graphed (using excel) in a histogram
    - Students can easily determine the standard deviation.
    - Using t- and z-score analysis, students can identify outliers
    - Once outliers are eliminated, students can determine central tendencies (mean, median and mode)

Extensions – You and Your Students Can Go Further!!

1. For **younger students** consider working with the Bishop Museums' Holoholo Science program. Staff from the museum visit your classroom and they have a program about marine debris described on their web site as follows:

> Tales of Trash: Northwestern Hawaiian Islands Grades K-3
> Discover what marine debris is, where it comes from, and how it affects the birds and marine life in the Northwestern Hawaiian Islands (NWHI) through storytelling, puppets, and hands-on activities. Examine real marine debris and bird boluses from the NWHI, and then identify ways you can help solve the marine debris problem
>
> Go to http://www.bishopmuseum.org/education/holoholo/classroom.html to learn more about this excellent program and it is quite possible that the Bishop Museum staff can work with you to modify it for older students.

2. Develop a **social studies** lesson that addressed the HCPSIII Standard 5: Political Science/Civics: PARTICIPATION AND CITIZENSHIP-Understand roles, rights (personal, economic, political), and responsibilities of American citizens and exercise them in civic action.

- Students can research how the Marine Debris Research and Reduction Act of 2005, new federal legislation sponsored by Hawaii's Senator Daniel Inouye, was passed. A PDF file entitled "the marine debris reduction act" or the printed version, both of which are included in this module is an excellent way to get students started on their research.

- Students can communicate their findings from any of the investigations in this module to local government agencies and officials. Addresses and contact information for the governor, state legislators, The Department of Land and Natural Resources, the City and Count of Honolulu and other agencies involved in the protection of our coastal and marine environment are easy to find.

3. Use marine debris can be used to **create pieces of art**. This addresses the HCPSIII Fine Arts Standard 1: VISUAL ARTS-Understand and apply art materials, techniques, and processes in the creation of works of art and understand how the visual arts communicate a variety of ideas, feelings, and experiences

Liberty Bell by Lee Sewell

4. Ask students **create a video** that teaches others about the marine debris. This addresses HCPSIII Standard 1: TECHNOLOGICAL DESIGN-Design, modify, and apply technology to effectively and efficiently solve problems.

5. Students may **research** the role of the Environmental Protection Agency monitoring marine debris by using this web site
http://www.epa.gov/owow/oceans/debris/floatingdebris/pdf.html

6. Students can organize and improve efforts to **recycle, reuse and reduce rubbish** at their home and school. This website is an excellence resource to assist with this goal:
http://www.opala.org/

7. Develop an **earth science** lesson address the HCPS III Science Standard 8:
Physical, Earth, and Space Sciences: EARTH AND SPACE SCIENCE: Understand the Earth and its processes, the solar system, and the universe and its contents, Benchmark 8-6: Describe how winds and ocean currents are produced on the Earth's surface

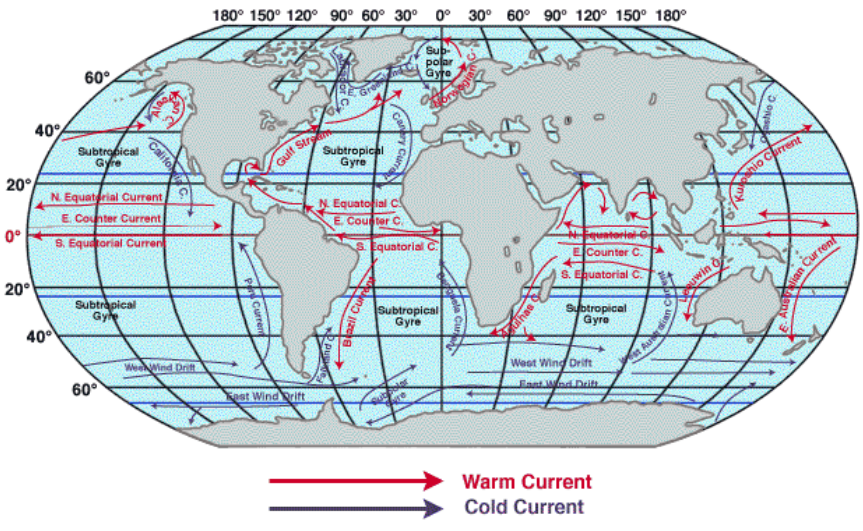
Surface ocean currents are the mechanism that moves marine debris around the world. Use the following web sites to develop an introduction to the topic. It is quite easy to use images from these web sites to develop a powerpoint slide show customized to your grade level or use the to enable students to complete research on their own.

- http://facs.scripps.edu/surf/sepa.html - This site shows a complex animation of currents in the Pacific Ocean – it's a good attention getter and you can ask students to hypothesize what creates such currents.
- http://oceancurrents.rsmas.miami.edu/ - although this site is currently under construction is will allow students to view surface ocean currents around the world
- http://www.windows.ucar.edu/tour/link=/earth/Water/ocean_currents.html - this site has a concise clear explanation of ocean currents, has interactive elements and good clear graphics.
- http://mbgnet.mobot.org/salt/sandy/currents.htm - this site explains all types of ocean currents but has concise explanations and catchy graphics
- http://earth.usc.edu/~stott/Catalina/Oceans.html - this site is for older students and explores some of the more complex aspects of surface ocean currents but does so in a clear manner.
- http://www.oar.noaa.gov/spotlite/archive/spot_marinedebris.html - this site explains more about how a specially equipped airplane is being used in relation to ocean currents to predict where marine debris is likely to accumulate – it's cutting edge science!

Almost every earth science textbook has copy masters of the world's surface ocean currents and global wind patterns. Have students analyze both images to develop a better understanding of their relationship. It is also recommended that students create their own diagrams of these global phenomena.

Once students have a better understanding of surface ocean currents, have them predict where the marine debris dumped at one location will end up. Ask them to justify their predictions.

Students can also model ocean currents moving marine debris in a hands-on activity. Create a mini ocean and continents using a large pan of water (turkey roasting pans work and are inexpensive) and large rocks. Small pieces of debris can be placed in the pans and students can create prevailing winds with fans or by blowing in a certain direction through straws along the surface of the water.



8. An excellent basis for an interdisciplinary unit would be to set up a marine debris study with students living in another city across the North Pacific. Students in both cities could set up communication through their teachers, get to know more about each other's cultures AND conduct simultaneous marine debris studies. By performing beach clean ups, analyzing and sharing their results; students could gain an even better understanding of marine debris, scientific investigation and another culture. The web sites http://www.epals.com/ and http://www.iecc.org/ are two of several sites available to assist educators in setting up classroom exchanges. Marine science in now more than ever a global venture and nations will have to cooperate to solve the problems affecting the world's oceans - why not start with kids!