COASTAL MONITORING & OBSERVATIONS LESSON PLAN

Do You Have Change?

NOS Topic
Coastal Monitoring and Observations

Theme
Coastal Change Analysis

Links to Overview Essays and Resources Needed for Student Research
http://oceanservice.noaa.gov/topics/coasts/monitoring/welcome.html
http://www.csc.noaa.gov/products/sccoasts/html/scmatrix.htm
csc.noaa.gov/crs/lca/ccap.html

Subject Area
Life Science/Earth Science

Grade Level
9-12

Focus Question
How can scientists monitor changes in the ways land is used in coastal areas?

Learning Objectives
- Students will explain how satellite imagery can be used to monitor land use change.
- Students will construct a change table to summarize land cover information.
- Students will use a change table to make inferences about land use changes in a coastal region.

Materials Needed
- (optional) Computers with internet access; if students do not have access to the internet, download copies of materials cited under "Learning Procedure" and provide copies of these materials to each student or student group.

- Copies of "Land Use Change Worksheet," one copy for each student or student group

Audio/Visual Materials Needed

None

Teaching Time

One or two 45-minute class periods

Seating Arrangement

Classroom style or groups of 3-4 students

Maximum Number of Students

30

Key Words

Change table
Landsat Thematic Mapper
Georeferencing
Pixel
Land use
Coastal change
Monitoring

Background Information

Coastal monitoring refers to periodic measurements of physical, chemical, biological, and meteorological factors that may affect the use and quality of coastal resources. For example, such factors may include temperature, salinity, the presence of chemical contaminants, biological species and their life stages (eggs, juveniles, adults, etc.), rainfall, and storm events. NOAA's National Ocean Service (NOS) supports 28 different monitoring systems to provide key pieces of information needed to protect marine resources and control the ways in which they are used.

NOAA's Coastal Change Analysis Program (C-CAP) uses data from Landsat satellites to detect changes in coastal land cover. Often, these changes are the result of human activities such as urban development, forestry, and use conversion (such as converting agricultural land to residential housing). Some changes, though, are the result of natural processes such as erosion or succession (for example, the succession from grassland to shrub vegetation to forest). One of the immediate objectives of C-CAP is to develop a baseline data set that describes land cover throughout the entire coastal zone of the United States. By comparing these data with satellite imagery obtained at a later date, changes in land cover can be detected, and trends can be monitored over time.

It is important to understand the distinction between "land cover" and "land use." Land cover is the visible physical landscape, which includes natural features (forests, water, rocks, etc.) as well as features constructed by humans (buildings, parking lots, etc.). Land use is the economic and cultural activities that take place in a given location (residential, commercial, agricultural, industrial, etc.). Some land uses produce visible land cover features (highways, agricultural fields, etc.), but land cover does not always coincide with a specific land use. A building, for example, might be a school, hotel, retail store, or prison; very different land uses may appear as the same type of land cover. Satellite imagery are most useful for determining land cover. Land use can sometimes be inferred from land cover, but usually requires other survey methods.

The Landsat images used by C-CAP consist of many individual blocks known as "pixels" (a term derived from the phrase "picture element"). Each pixel represents an area of ground, and the size of this area depends upon the characteristics of the sensor used to capture the image. C-CAP uses imagery from the Landsat Thematic Mapper (TM), which collects pixels that each represent a 30 meter x 30 meter area of land. Anything on the landscape that is smaller than 30 meters in diameter will not be distinguishable from other small features in the same area. To detect changes in land use over a specific time period an image obtained at the beginning of the time period is compared with an image obtained at the end of the time period. Different land uses have different spectral characteristics (for example, forested lands reflect more green light than beaches) when viewed by the TM. By knowing the spectral characteristics of different land uses, each pixel in a TM image can be classified as a specific land use. Computer analysis is used to compare the classification of each pixel in the first image with the classification of the corresponding pixel in the later image. The results of this comparison are usually summarized as a "change table." A change table is a matrix of columns and rows similar to a spreadsheet. The first vertical column and first horizontal row list all of the land use categories used in the analysis. The first column represents categories in the first (earlier) image, while the first row represents categories in the later image. Reading the chart from left to right, each cell in the matrix shows the amount of land (typically "acres") that changed from one category in the first image to another category in the second image. The central diagonal cells in the chart represent areas of land whose category is the same in both images (that is, areas of land whose category did not change during the period of time represented by the two images).Visit *http://www.csc.noaa.gov/products/sccoasts/html/scmatrix.htm* for an explanation and example of a change table.

In this lesson, students will construct a simple change table to become familiar with this concept, and then use an actual change table to make inferences about land use changes in a coastal area.

Learning Procedure

1.

In preparation for this lesson, review the introductory pages on the Coastal Change Analysis Program Web site (*http://www. csc.noaa.gov/crs/lca/ccap.htm*l) and the explanatory materials on change tables cited above, and the "Land Use Change Worksheet."

2.

Lead a brief discussion in which students "brainstorm" events that cause land use changes in coastal areas. This list should include "natural" events as well as human activities. Introduce the concepts of change tables and pixels. Tell students that their first assignment is to construct a change table that summarizes data on land use changes on an imaginary island over a five-year period. Give each student or student group a copy of "Land Use Change Worksheet," and have them complete Part A.

3.

Review students' results for Part A. Tables 1 and 2 should resemble those below:

Table 1

Pixel	1990 Land Cover	1995 Land Cover
A5	GS	GS
A6	BA	BA
B4	GS	GS
B5	GS	BA
B6	GS	BA
C2	DL	DL
C3	DL	DL
C4	DH	DH
C5	DH	DH
C6	WL	BA
C7	WL	GS
D1	AG	AG
D2	DL	DL
D3	DL	DH
D4	DH	DH
D5	DH	DH
D6	AG	BA
D7	AG	AG
E1	AG	AG
E2	AG	DL
E3	DH	DH
E4	DH	DH
E5	DH	DH
E6	BA	BA
E7	BA	BA
F2	AG	DL
F3	BA	BA
F4	WL	DH
F5	GS	DH
F6	GS	GS
G3	MF	MF
G4	MF	DH
G5	MF	DH
G6	GS	GS
H4	MF	MF
H5	MF	MF

Table 2

To 1995 → From 1990 ↓	DH	MF	WL	GS	AG	DL	BA	Total Acres
DH	7	0	0	0	0	0	0	7
MF	2	3	0	0	0	0	0	5
WL	1	0	0	1	0	0	1	3
GS	1	0	0	4	0	0	2	7
AG	0	0	0	0	3	2	1	6
DL	1	0	0	0	0	3	0	4
BA	0	0	0	0	0	0	4	4
Total Acres	12	3	0	5	3	5	8	

Be sure students understand what is represented by the individual cells in the matrix, and that the central diagonal cells represent areas of land whose category did not change during the five-year period. Students' observations about the change table should include:

- All wetlands present in 1990 were converted to other land uses by 1995.
- Pixels with high density development in 1990 did not change.
- Half of the area classified as agricultural in 1990 was converted to other uses by 1995.
- More area was converted to high density development than to any other land use category.

Point out that actual images provided by the Landsat Thematic Mapper include many more pixels than the two images for "Hokey Island," and that computers are used to compare pixels between the images acquired at different times. Be sure students understand the concept of using a coordinate system to identify the location of specific points on Earth (georeferencing).You may also want to discuss some of the coordinate systems used for georeferencing (see page 9 of the Geodesy Discovery Kit at *http://www.oceanservice.noaa.gov/education/kits/geodesy/geo09_gps.html*.

4.

Have students complete Part B of the worksheet, then lead a discussion of their results. The following points should emerge during this discussion:

- Cultivated land, wetlands, and forested land are the top three land cover types in the Mermentau River Basin. Be sure students understand that the "Total Acres" column represents the total acres for each class in the 1990 ("from") data. Total acres for the 1995 ("to") data are given in the "Total Acres" row.
- Students should infer that agriculture, forestry, fisheries and recreational uses might be associated with these types of land cover.
- Grasslands, forested, and scrub/shrub categories had the highest number of acres changed between October 1992 and February 1996.
- These land cover categories are part of the succession from bare earth to mature forest. The sequence is actually a cycle: bare earth, to grasslands, to scrub/shrub, to mature forest, and eventually back to bare earth. There is no specific "starting point"; a snapshot of a single area at one point in time may observe any of these steps, as well as transitions between steps.
- Other evidence of this succession in the change table includes the following: 50,942 acres of scrub/shrub converted to forested land; 81,662 acres of grassland converted to scrub/shrub; 67,769 acres of forested land converted to grassland (presumably the bare earth step took place between October 1992 and February 1996); in fact, all of the largest conversions involved this succession cycle.
- 3.3% of wetlands were converted to other land cover categories (41,033 – 1,213,802.)
- The majority (97%) of wetland conversions were to the "Water" category, so students may infer that the wetlands were not really "lost."

Tell students that most of the conversion from "Wetlands" to "Water" was the result of changes in the amount of floating aquatic vegetation, which varies seasonally and from year to year. For this reason, wetland loss is not considered to be a serious problem in the Mermentau River Basin. Be sure students understand that this is only because most of the wetlands were not really lost, and that the loss of 41,000 acres of wetland would be considered very significant and serious in most areas.

The Bridge Connection

http://www.vims.edu/bridge/ – In the "Site Navigation" menu on the left, click on "Data Port," then "On-Line Data," then "Use & Management" for links to real-time data sets that can be incorporated into your lesson plans, as well as pointers on how to use real-time data.

The Me Connection

Have students write a brief essay describing why the ability to detect changes and trends in land cover could be of personal importance, and how they might use this information. For example, how could a downward trend in wetland acreage be personally significant; and if such a trend were detected, what could anyone do about it? If students have difficulty with this, you may want to brainstorm some of the functions or benefits of the resources that are changing. Wetlands, for example provide buffers against erosion and storms, wildlife habitat, etc.

Extensions

Visit *http://www.csc.noaa.gov/crs/lca/locate.html* for access to the C-CAP Data Map Server and *http://www.csc.noaa.gov/products/datasites/* for links to examples of Internet resources for coastal geospatial information.

Resources

http://www.csc.noaa.gov/crs/lca/ccap.html – NOAA Coastal Services Center Web page for the Coastal Change Analysis Program

http://www.csc.noaa.gov/crs/ – NOAA Coastal Services Center Web page for the Coastal Remote Sensing Program

www.geographynetwork.com – Web site for the Geography Network, which is a global network of geographic information users and providers that supports sharing of geographic information and provides access to many types of geographic content including dynamic maps, downloadable data, and more advanced Web services.

http://ltp-education.gsfc.nasa.gov/ – Education and Outreach website for NASA's Laboratory for Terrestrial Physics *http://landsat.usgs.gov/educational.html* – Educational Links page of USGS's Landsat Web site

National Science Education Standards

Content Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard D: Earth and Space Science
- Geochemical cycles

Content Standard E: Science and Technology
- Abilities of technological design

Content Standard F: Science in Personal and Social Perspectives
- Population growth
- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

Links to AAAS "Oceans Map" (aka benchmarks)

5D/H1 – Ecosystems can be reasonably stable over hundreds or thousands of years. As any population of organisms grows, it is held in check by one or more environmental factors: depletion of food or nesting sites, increased loss to increased numbers of predators, or parasites. If a disaster such as flood or fire occurs, the damaged ecosystem is likely to recover in stages that eventually results in a system similar to the original one.

5D/H2 – Like many complex systems, ecosystems tend to have cyclic fluctuations around a state of rough equilibrium. In the long run, however, ecosystems always change when climate changes or when one or more new species appear as a result of migration or local evolution.

5D/H3 – Human beings are part of the Earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.

COASTAL MONITORING & OBSERVATIONS REVIEW

Land Use Change Worksheet

Part A

A major responsibility of NOAA's Coastal Change Analysis Program (C-CAP) is to document how land cover in coastal areas changes from one time period to the next. To do this, C-CAP uses satellite images (primarily the Landsat Thematic Mapper) to categorize land cover in coastal wetland habitats and adjacent upland areas. Extensive ground checks are used to verify that interpretations of satellite images are accurate with respect to land cover. By comparing images of the same area acquired at different times, it is possible to detect changes in land cover and make inferences about land uses that account for observed changes.

Data on changes in land use are often summarized in change tables. To get an idea of what a change table means, let's analyze two images of land use on a fictitious island in 1990 (Figure 1) and 1995 (Figure 2). Land use images consist of many individual blocks known as "pixels." Each pixel represents an area of ground, and the size of the pixel depends upon the characteristics of the sensor used to capture the image. To keep things simple, the data for Hokey Island consist of very large pixels, so there aren't very many of them. In reality, images obtained by the Landsat Thematic Mapper consist of pixels that are 30 meters x 30 meters, so there are many more pixels in these images (and a lot more data to analyze!).

The first step in this analysis is to identify the exact location of each pixel so that pixels representing the same location in the two images can be compared. One way to do this is to identify each pixel with the the latitude and longitude of the area it covers. Other systems commonly used include the Universal Transverse Mercator system and State Plane Coordinate System. Again, to keep things simple, we'll just use letters and numbers to identify the row and column corresponding to each pixel.

Figure 1
Hokey Island Land Use, 1990

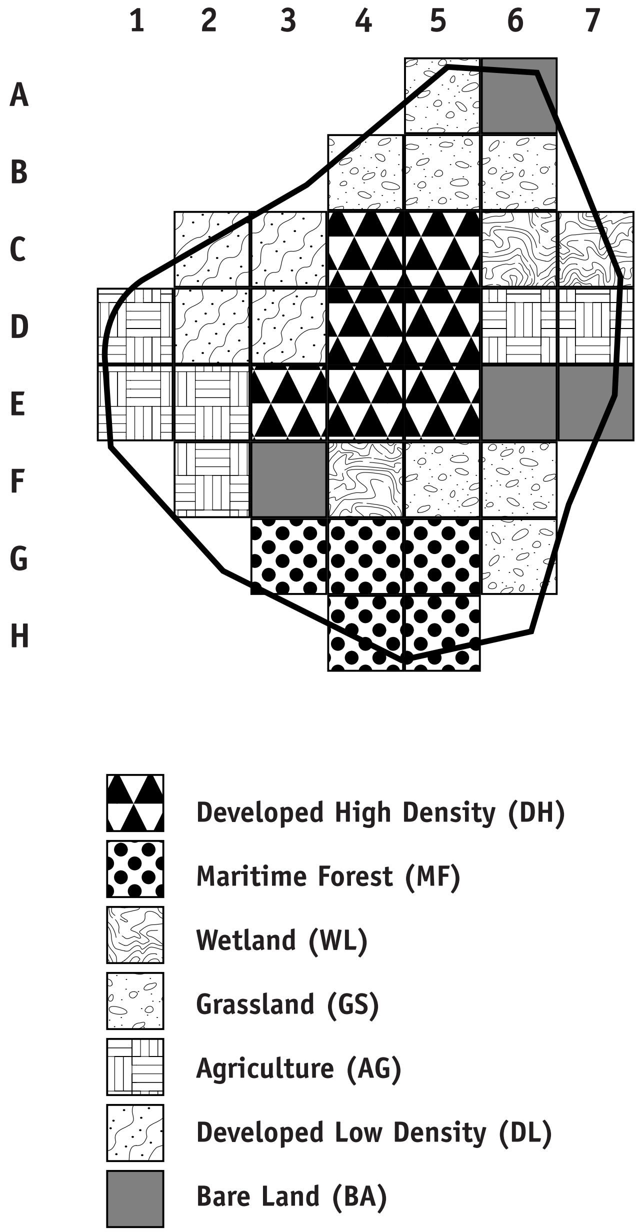
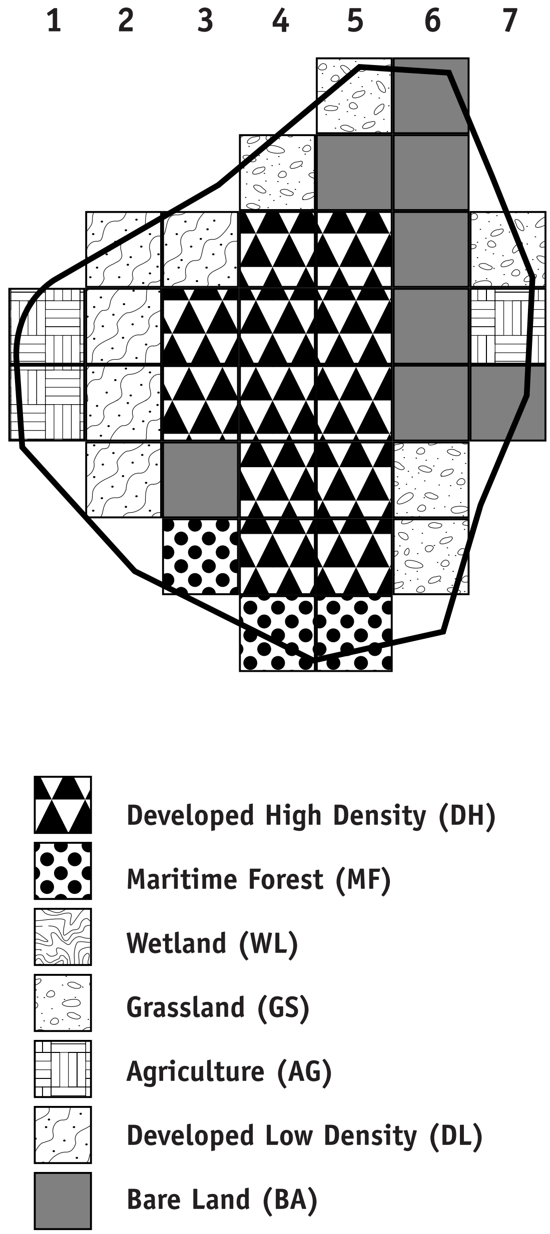


Figure 2
Hokey Island Land Use, 1995



Next, fill in Table 1 to summarize land cover for each pixel in 1990 and 1995. Notice that the images exclude pixels that cover less than half of Hokey Island, and that some pixels (on the edges) also include areas that are not part of Hokey Island. This is why smaller (and therefore more numerous) pixels give a more accurate estimate of land cover.

Table 1

Pixel	1990 Land Cover	1995 Land Cover
A5		
A6		
B4		
B5		
B6		
C2		
C3		
C4		
C5		
C6		
C7		
D1		
D2		
D3		
D4		
D5		
D6		
D7		
E1		
E2		
E3		
E4		
E5		
E6		
E7		
F2		
F3		
F4		
F5		
F6		
G3		
G4		
G5		
G6		
H4		
H5		

Now it's time to construct a change table. Table 2 is a matrix with land use categories for 1990 in the first column, and land use categories for 1995 in the first row. Reading the chart from left to right should show how many pixels for each land use category in 1990 changed to another category in 1995. Use Table 1 to fill in Table 2. The central diagonal cells with bold outlines show how many pixels for each category did not change between 1990 and 1995. What trends does the change table reveal?

Table 2

To 1995 → From 1990 ↓	DH	MF	WL	GS	AG	DL	BA	Total Acres
DH								
MF								
WL								
GS								
AG								
DL								
BA								
Total Acres								

Part B

Table 3 is a change table documenting changes in the Mermentau River Basin, Louisiana, between October 1992 and February 1996. Use this table to answer the following questions:

1. What are the top three land cover types in the Mermentau River Basin?

____

____

____

2. What uses might be associated with the dominant land cover types?

____

____

____

3. Which three land cover categories had the highest number of acres changed between October 1992 and February 1996?

4. Describe the steps in an ecological succession that includes these land cover categories.

5. Is there other evidence of this succession in the change table?

6. What percentage of wetlands were converted to other land cover categories?

7. Which land cover category accounts for the majority of wetland conversions in this change table? How serious is the loss of wetlands in the Mermentau River Basin?

Table 3

From/To	Developed	Cultivated	Grassland	Forested	Scrub/ Shrub	Wetlands	Bare	Water	Total Acres	Changed
Developed	71,033	0	2	0	0	0	0	9	71,044	11
Cultivated	6	1,631,330	4,408	175	5,873	60	98	759	1,642,710	11,380
Grassland	107	961	339,795	17,775	81,662	66	103	424	440,893	101,098
Forested	49	1,559	67,769	866,990	16,230	107	324	2,006	955,033	88,044
Scrub/Shrub	46	1,362	20,961	50,942	105,770	3,371	274	53	182,781	77,010
Welands	2	37	146	143	65	1,172,769	837	39,803	1,213,802	41,033
Bare	46	17	120	7	11	157	4,326	1,836	6,519	2,193
Water	2	125	120	102	8	6,508	4,262	790,347	801,474	11,127
Total Acres	142,532	1,635,391	433,321	936,134	209,619	1,183,038	10,224	835,228		