4th & 5th Grade Social Studies

4th Grade – Objectives 7.01, 7.05
5th Grade – Objective 6.02

Technology of the Lighthouse

Warning Mariners throughout History

National Park Service
Cape Lookout National Seashore
Harkers Island, North Carolina

This set of curriculum materials is part of a series of guides developed by staff at Cape Lookout National Seashore and designed to connect classrooms with the seashore.

These materials are based on the 2006 North Carolina Standard Course of Study. Descriptions of the education goals and objectives that can be completed using these materials are included for educators in other locations.

The pre-visit and post-visit activities were created to be used in conjunction with a class visit to the park or a Ranger visit to the classroom. Contact the park for more information on scheduling a Ranger program, at the park or in the classroom.

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Technology of the Lighthouse

Overview

Description:

The learner will be able to:

- Understand how the technology of the lighthouses and lanterns has changed over the past several hundred years.
- Understand how Cape Lookout's lighthouse has changed since the first lighthouse of 1812 was built.
- Be able to build a timeline of the lighthouse and lantern technology and understand how timelines function.

Group Size: 5-30

Time: 60 minutes per class visit for on- and pre-site visit activities

On-site activity covers a one (1) day session

Location: Classroom

Pre-Site Visit Activities: TEACHER COMPLETED

Knowledge Assessment (in post-site materials)

Light House Technology Introduction

- Give each student a copy of "A Brief History of Lighthouses" and have them read it
- Split the class into groups of 4-5
- Have each group create a list of important terms from the reading
- Create a combined list of terms and definitions for the class
- Distribute two (2) copies of the "Traffic Signs of the Sea Glossary" to each group
- Ask the students to tell you one thing about lighthouses they did not know before reading the handout.

On-Site Visit Activities: RANGER COMPLETED

<u>Day 1</u>

Lighthouses: Where and Why?

The Shapes and Sizes of Lighthouses

Lighthouse Technology Timeline Activity

Post-Site Visit Activities: TEACHER COMPLETED

Knowledge Assessment

Design a Lighthouse Activity

- Break the class up into two teams and break each group into three sub-groups
- Each sub-group will take 15 minutes to design and color a portion of their team's lighthouse
- Assemble each team's lighthouse
- Use the discussion points below to guide students through the materials

Discussion Points

- Working on lighthouses has always been a team project.
    - What are some of the jobs which might be required to complete a lighthouse? (Examples: masons, painters, carpenters, iron workers, engineers, etc.)
- What type of lighthouse did you use for inspiration?
    - Why did you pick that style of lighthouse?
    - Does it match the style chosen by your teammates?
- What would happen to lighthouses built on the coast if the workers didn't communicate?
    - Would they be able to build a better lighthouse?

Technology of the Lighthouse

Goals and Objectives

Fourth Grade

NCSCOS Goal 7: The learner will recognize how technology influences change within North Carolina.
Objective 7.01: Cite examples from North Carolina's history of the impact of technology. **Objective 7.05:** Identify the advantages and disadvantages of technology in the lives of North Carolinians.

Fifth Grade

NCSCOS Goal 6: The learner will recognize how technology has influenced change within the United States and other countries in North America.
Objective 6.02: Relate how certain technological discoveries have changed the course of history and reflect on the broader social and environmental changes that can occur from the discovery of such technologies.

Traffic Signs of the Sea

Pre-Site Visit Activity

Description:
Students will learn about the origins and evolution of lighthouse technology.

Materials:
A Brief History of Lighthouses Handout
Traffic Signs of the Sea Glossary
Index Cards – 1 per Student
Sheets of 8 ½ x 11 paper, yellow – 1 per Group
One Large Sheet of Paper

Directions:

1. Split the class into groups of 4-5 members.

2. Give each student a copy of the "A Brief History of Lighthouses" handout and have them read it.

3. Each student should make a list of five (5) words or phrases he/she does not understand.
    - These should be words they don't know and cannot figure out the meaning of from the reading.

4. Group members should compare their lists.
    - If there is a term that no one in the group knows, it should be added to their list (yellow paper).
    - If there is a term that some group members know and others don't, the group members who know it should explain it to their teammates.

5. Once the group is finished, one team member should go to the front of the class and write his/her group's terms on the Class Glossary (large paper).

6. After all the teams have written down their words, the teacher should eliminate the repeated terms.

7. Give each group two copies of the "Traffic Signs of the Sea Lighthouse Glossary."

8. Go through the Class Glossary and have students define these words based on the handout.

9. With any remaining time, ask students to tell you something they didn't know before they read the booklet about lighthouses.

Traffic Signs of the Sea

Activity Glossary

Aid to navigation – a tool to help a traveler get safely from one place to another

Beacon – the light coming from the lantern in the lighthouse

Buoys – any one of many different kinds of floating containers anchored in place to work as an aid to navigation guiding boats and ships safely from one place to another

Compressed air – lots of air forced into a small, closed space to push water out of the space; for submarine foundations the water had to be pushed out before workmen could work in the closed space building a foundation, otherwise the workmen would have drowned

Design – to draw, to sketch, to make a model

Eliminate – to get rid of something

Exposed waters – open ocean waters covering shallow sand areas or rocks

Increase – to make bigger, to make larger, to make stronger

Lantern – the lamps or lamp inside the top of the lighthouse that actually produces the light

Lard oil – oil from cooking animal fat until it separates into oil and solids

Lens – any piece of glass placed so that the light from the lantern must shine through the glass making the lighter look brighter

Lightship – an anchored floating ship with a bright warning beacon like a lighthouse to warn sailors of danger just like a lighthouse would

Magnify – using a special glass to make something bigger to see

Obtain – to get something

Petroleum product – anything like kerosene or gasoline that is made from dead dinosaurs and plants that have turned into black oil and taken from the earth by drilling oil wells

Prism – a piece of glass you can see through that bends the light beams so they all shine in the same direction

Radiate – to give off, to glow with, to spread out in many directions

Radically – completely, totally, a whole lot

Range of a light – the distance the light can be seen offshore out at sea

Run aground – When ships get stuck in the underwater sand because the water is not deep enough for ships to go through

Shoals – dangerous, shallow areas of water where ships frequently run aground

Stilts – a framework of wood or metal to hold the foundation of the lighthouse up higher in the air over the water's surface

Submarine foundations – any lighthouse foundation built under the water's surface to hold a lighthouse steady in exposed waters

A Brief History of Lighthouses

The First Lighthouses

In the early days a **large bonfire** was lit on the tops of hills near the dangerous areas along the shoreline. This was the warning for mariners. The bonfire was the light and the hill served as the lighthouse. Mariners probably would have been unable to see these fires further than a couple of miles off shore.

This is a 3D reconstruction of what the Pharos Lighthouse in Alexandria would have looked like before it was destroyed. This image is available courtesy of the University of Texas.

Years went by without a change until the ancient Egyptians' remarkable structure. The ancient Egyptians were very good at finding better ways to do things. In 3000 BC, they had dammed rivers, constructed large irrigation systems for crops, built huge buildings, developed a system of advanced math, created a system of writing and, using their construction techniques, built the largest and first lighthouse in recorded history.

Pharos was located in Alexandria, Egypt and built about 280 BC. At 450 feet it was the tallest lighthouse ever built. It used an open fire as a light at night and a column of smoke during the day as a daymark. At night the light could be seen 30 miles out to sea. Using slave labor, it took 20 years to complete. It stood for 1500 years until it was destroyed by an earthquake about 1350. Today, people who study lighthouses are called pharologists: the name comes from this famous first lighthouse.

Lighthouse technology in most of the rest of the world did not match that of the Egyptians. In fact, it would be several hundred years until the next advance in non-Egyptian lighthouse technology: stone towers. It was decided that bonfires on low, flat areas could be seen further if they were built on top of a tower. The **Kopu lighthouse** in Estonia (Eastern Europe) is one of the first stone tower lighthouses. It was built in 1531.

Lighthouse technology pretty much stayed the same—some kind of bonfire on top of a stone tower—through the time of George Washington in 1776.

Lighting Up the American Coast

The first lighthouse in America was built in Boston in **1716**.

Lighthouses were made of whatever local people had on hand. Some were made of stone, others of wood, some of brick, cast iron, or even something called tabby—a mixture of shells, lime, sand, and water used primarily in the south.

Those places with high cliffs near the dangerous rocks or shoals could have bonfires higher above the water. This meant that the light could be seen farther offshore.

Flat, shallow places—like the coast of North Carolina—required towers to get the light high enough to see. Unfortunately, towers could only be built so tall before they became unsteady and unstable. They were limited to about 100 feet.

In 1812, the first Cape Lookout Lighthouse was built, it was 107 feet tall. It wasn't until 1857 that new technology made it possible to build a taller lighthouse on the NC coast.

Improving the Lanterns

Once lighthouse builders realized the height limitations of the tower, they felt they had nothing left to do but make the light itself brighter.

Making the lighter brighter meant the top of the tower had to be enclosed with a **lantern room**—fires burn brighter when the wind is not able to blow them out. In England, lantern rooms were created in 1696.

Now, with an enclosed lantern room, technology took another step forward: the bonfires were replaced with **candles**. Sometimes they were arranged in a several candleholders throughout the room or on a frame, or even in a large circular pattern. The first candle powered lighthouse had only 24 candles and they never used more than 60 candles. But no matter what they did, the lights just weren't bright enough.

Did You Know?

Even today we refer to the brightness of a lighthouse by its candlepower, where the amount of light produced is compared to how many candles it would take to achieve the same level of brightness.

Spider lamps were so called because they were made up of a shallow brass pan filled with oil with 4, 8, or more wicks arranged in a circle around the pan. The wicks hung over the edge forming a light that looked like the legs and body of a spider. These lamps produced light by burning oil, a popular choice was the oil make from the blubber (fat) of sperm whales.

After spider lamps, lighthouses began using **pan lamps**. Then, lamps started to look more like something we would recognize today. The **hurricane style lamp** came into use in 1780, but it still wasn't very bright, even when there were several in the lantern room at the same time.

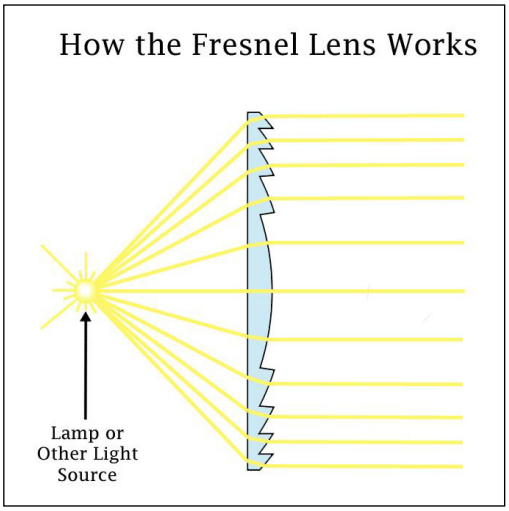
In the late 1700s, two important discoveries were made. **Parabolic reflectors**—rounded metal dishes which helped channel the light into one direction—were added to the hurricane lamps in the 1760s, giving us the first really efficient lights. Even though this made it possible for the lights to shine brighter, it was still not bright enough.

Then in 1780, Aime Argand invented the **Argand lamp** which used a hollow wick. This hollow wick made the light 7 times brighter than a candle or regular wick.

From this point forward, there were no more significant improvements made to lamp design until the invention of electric powered lights. However, there were still improvements being made to the power of lights through the use of mirrors and special lenses.

The Power of Fresnel

The **Fresnel lens** was invented by Augustin Fresnel in 1822. The Fresnel lens can be thought of as a big lampshade made of hundreds of pieces of specially cut glass. Because it is made of glass, the Fresnel lens makes the light brighter just like shining a flashlight through a magnifying glass makes that light brighter.



Normally, light from a lantern will shine in many directions. The Fresnel lens uses specially shaped pieces of glass (prisms) to redirect these beams of light so that they will shine in the same direction. This makes the beam of light produced by the lantern much stronger in the direction the light is shining (for a lighthouse, that would be out to sea to warn sailors). It also allows the light to be seen farther away from the lighthouse than it would be without the lens. A Fresnel lens was first used in the second Cape Lookout lighthouse when the tower was first lit November 1, 1859.

The lighthouse at Cape Lookout began using a first order Fresnel lens when the second tower was opened in 1859. It is the largest lens of that style standing approximately 8 feet high and 6 feet wide.

Before the Fresnel lens, the Cape Lookout Lighthouse needed lots of lamps in the lantern room. With the Fresnel lens, the lighthouse only needed one lamp.

Changes to Fuel and Tower Design

By the 1860s, whale oil was scarce, so **animal lard oil** was used instead. But, animal lard oil produced black smoke which meant the lens had to be cleaned constantly so it would remain clear enough for the light to shine.

Around this time, the second Cape Lookout Lighthouse was built using a new technological breakthrough called **double-walled construction**. Because this construction used an inner wall as well as an outer wall, lighthouses could be built taller and were sturdier than they had been before. Cape Lookout's tower, completed in 1859, was the first of this type of tower on the NC coast.

In the 1870s, a new innovative fuel, called **kerosene**, started to be used in lighthouses replacing the animal lard oil previously used. And the Cape Lookout Lighthouse got it's daymark of a diagonal checkerboard. Meanwhile a series of taller lighthouses all using the double-walled construction were being built up the NC coast.

In the late 1880s, **electricity** was first used to light lighthouse lanterns. The first lighthouse to use this technology was the Statue of Liberty in New York City in 1886.

Here at Cape Lookout we used kerosene until 1933 when we switched to a gasoline-powered generator that produced electricity for the lighthouse lamps. We did not become fully automated until 1950. An electric cable was finally run from Harkers Island in 1982 eliminating the need for generators. The combination of lights inside the Fresnel lens was replaced in 1979 by two **airport beacons** providing light in the form of 21,000 watt bulbs—with a candlepower of 1.6 million.

Lighthouse Timeline

On-Site Visit Activity

Description:
Students will examine the advances in lighthouse technology throughout history by building a class timeline of the evolution of lighthouse technology.

Materials:
Assorted Pictures of Lighthouses and Lanterns
Timeline Board
A Brief History of Lighthouses Handout (in pre-site materials)
Team Information Packets

Directions:

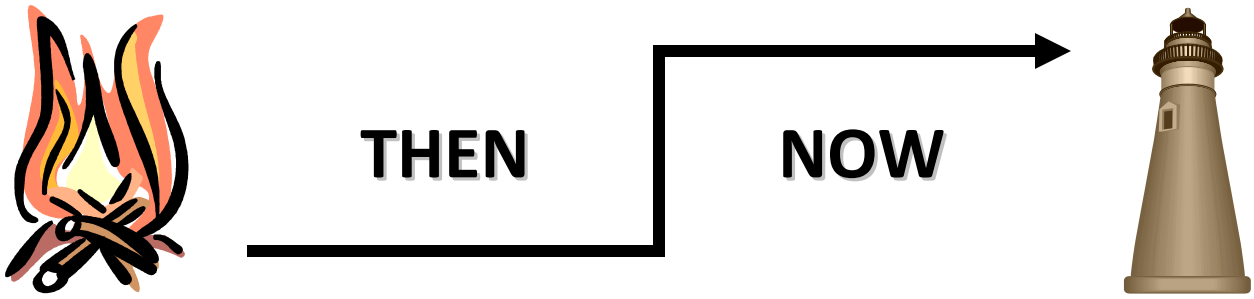
1. Split the class into 6 teams.
    - Give each team an information packet.
    - The packet will include information on the history of lighthouses and which area of the timeline the team is responsible for completing.

2. Students should bring back their copies of the "A Brief History of Lighthouses" handout.

3. The Ranger will give a brief summary of the history of lighthouses.

4. Each team will use their information to complete their section of the timeline.
    - Place the pictures of lantern, lens, and tower modifications on the correct place in the timeline to indicate when it was first used.

5. Once all the teams have completed their section of the timeline, the class will review the timeline and make any corrections necessary.



Technology of the Lighthouse

Circle one answer only. Name _____ Grade _____

1. An **aid to navigation** is any tool that helps a traveler get safely from one place to another.

   True **False**

2. On land, aids to navigation for cars are things like traffic lights, stop signs, and road maps.

   True **False**

3. What is the oldest aid to navigation for ships at sea?

   Lantern on boat **Lighthouse** **Lightship**

4. What did the very first lighthouses use as fuel in the lanterns?

   Wood **Whale oil** **Kerosene** **Gasoline**

5. Where were lighthouses usually built?

   Where ships pass close to land

   Where ships pass dangerous rocks

   Where ships pass dangerous shallow waters

   All of these answers

6. Because North Carolina's coast is flat and our waters are shallow our lighthouses have to be tall so ships at sea can see the lights a long distance off shore.

   True **False**

7. Until a French Scientist discovered a way to increase the intensity of the light, just having a tall lighthouse didn't mean the light from the lantern could be seen. This famous scientist made the coasts safer. What was his name?

   Augustin Fresnel **Andre Agassy** **Pierre Buhler**

8. The first lighthouses were just bonfires on top of hills near dangerous rocks, or shallows.

   True **False**

9. Why did lighthouse keepers stop using whale oil as fuel for lanterns?

   So many whales had been killed it was hard to catch the survivors

   Whale oil got to be really expensive

   Both of these answers

   Neither of these answers

10. What do we use today to light Cape Lookout's lantern?

    Electricity **Kerosene** **Candles**

11. Cape Lookout's lighthouse used a lens that was about 12 feet high and 6 feet wide to magnify the light so it could be seen for up to 20 miles offshore.

    True **False**

12. The dangerous area marked by Cape Lookout lighthouse is called Cape Lookout Shoals.

    True **False**

13. What change in technology allowed Cape Lookout Lighthouse to be built so tall?

    Spiral stairs **Double-wall construction** **Gasoline powered cranes**

14. Did changes in technology put the lighthouse keepers out of business?

    Yes **No**

Design a Lighthouse

Post-Site Visit Activity

Description:

This guide is designed to be used as students are watching the NPS screening version (56 minutes) of "The National Parks: America's Best Idea" by Ken Burns.

Materials:

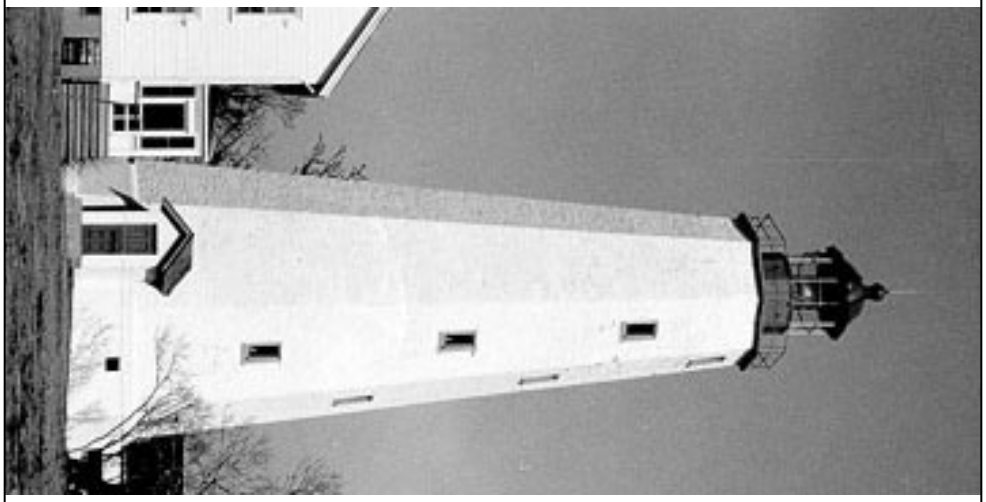
2 Lighthouse Envelopes
OR 6 Sets of Lighthouse Style Cards
2 Large Pieces of White Paper – cut into three pieces
Packing Tape
Colored Pencils, Pens, or Crayons

Directions:

1. Split the class into two teams: Team Wind and Team Waves.
2. Break each team into three groups.
   - Wind will be composed of Group Red, Group, Orange, and Group Blue.
     - Red will design and color the top, Orange the middle, and Blue the bottom
   - Waves will be composed of Group Black, Group Purple, and Group Green.
     - Black will design and color the top, Purple the middle, and Green the bottom
3. Have Team Waves and Team Wind sit on opposite sides of the room.
   - Group members should sit together.
4. Give each group the envelope with their group name on it or a set of Lighthouse Style Cards.
5. Each group has 15 minutes to design and color their portion of the lighthouse.
   - Note: students should color all the way to the edges of the top and bottom of the paper
6. When the time is up, have both groups assemble their lighthouses
7. Use the following discussion points to guide students through the lesson

Discussion:

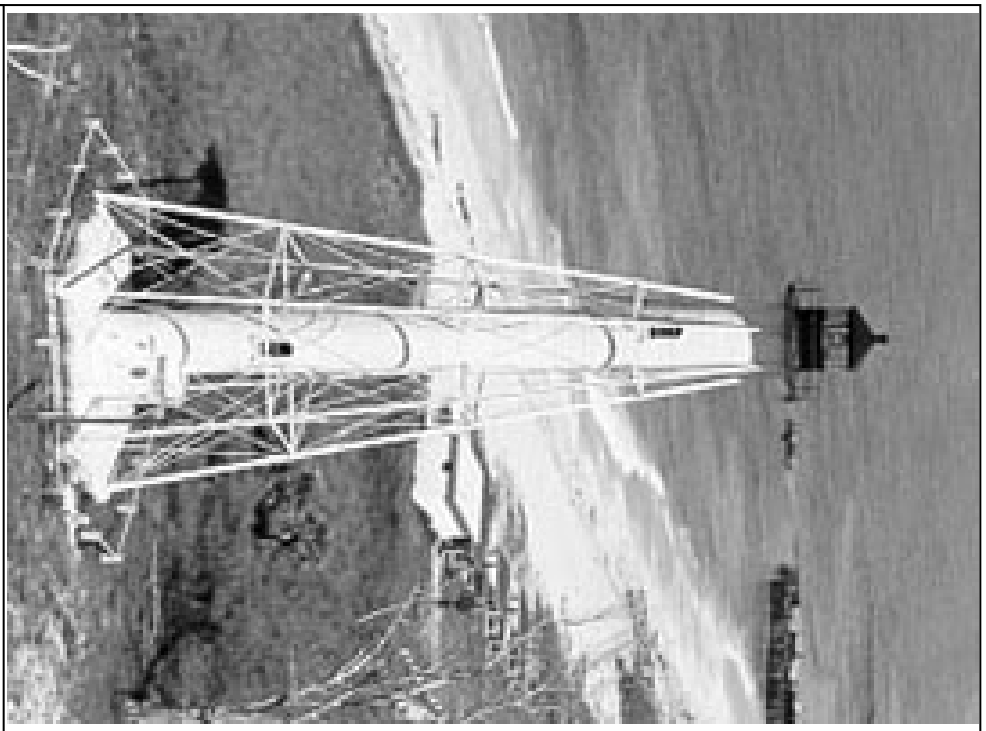
- Working on lighthouses has always been a team project.
  - What are some of the jobs which might be required to complete a lighthouse? (Examples: masons, painters, carpenters, iron workers, engineers, etc.)
- What type of lighthouse did you use for inspiration?
  - Why did you pick that style of lighthouse?
  - Does it match the style chosen by your teammates?
- What would happen to lighthouses built on the coast if the workers didn't communicate?
  - Would they be able to build a better lighthouse?



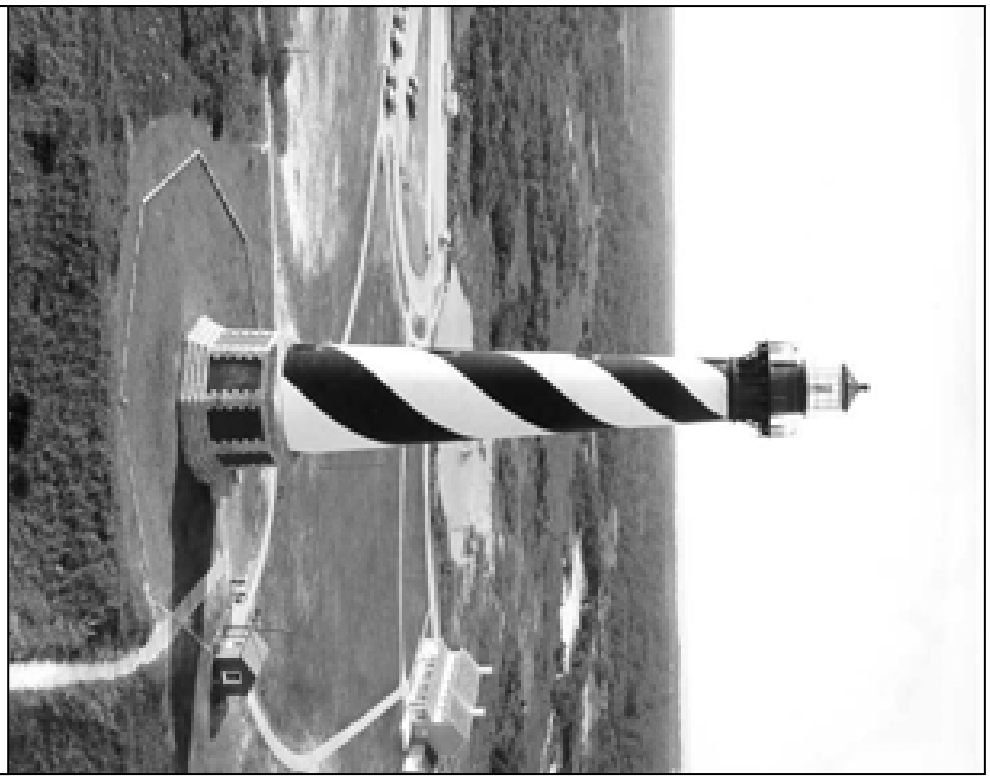
Octagonal Style

Screwpile Style

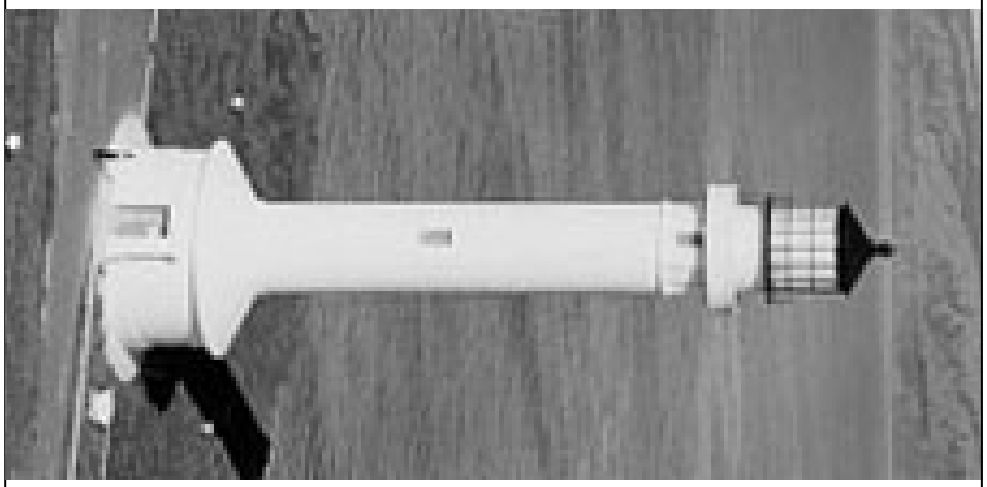
Spark Plug Style



Skeletal Style



Conical Style



Cylindrical Style

Additional Resources:

Cape Lookout National Seashore brochures

http://www.nps.gov/calo/planyourvisit/brochures.htm

Particularly, the Cape Lookout Lighthouse, Beacons of the Coast, and Lightkeepers brochures.

Michigan Lights Conservancy webpage

http://www.michiganlights.com/

Contains informational pages on Fresnel lenses and lighthouse design.

"Traffic Signs of the Sea." by By Robert L. Scheina

In *Cobblestone* II (June 1981), pp. 16-20.

Information on the evolution of sailing signals.

"Fresnel Lens" by Academic Kids Encyclopedia

http://academickids.com/encyclopedia/index.php/Fresnel_lens

Information on the form, function, and history of the Fresnel lens.

"Lighthouse Theme Page" by Jerrie S. Cheek of Kennesaw State University

http://webtech.kennesaw.edu/jcheek3/lighthouses.htm

Lighthouse information and activities.

"The Pharos of Alexandria, the First Lighthouse of the World" by Michael Lahanas

http://www.mlahanas.de/Greeks/Pharos.htm

A little history of the Pharos lighthouse.

"The Great Lighthouse at Alexandria" by Lee Krystek

http://www.unmuseum.org/pharos.htm

A more in-depth history of the lighthouse at Alexandria.