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United States Department of the Interior
National Park Service

National Register of Historic Places
Multiple Property Documentation Form

This form is used for documenting multiple property groups relating to one or several historic contexts. See instructions in How to Complete the Multiple Property Documentation Form (National Register Bulletin 16B). Complete each item by entering the requested information. For additional space, use continuation sheets (Form 10-900-a). Use a typewriter, word processor, or computer to complete all items.

_X_ New Submission ____ Amended Submission

A. Name of Multiple Property Listing

Light Stations of the United States

B. Associated Historic Contexts

(Name each associated historic context, identifying theme, geographical area, and chronological period for each.)

Federal Administration of Lighthouses, U.S. Lighthouse Service, 1789-1952
Architecture & Engineering, U.S. Lighthouse Construction Types, Station Components, Regional Adaptations and Variations, 1789 -1949
Evolution of Lighthouse Optics, 1789 -1949
Significant Persons, U.S. Lighthouse Service, 1789 -1952

C. Form Prepared by

name/title Edited and formatted by Candace Clifford, NCSHPO Consultant to the NPS National Maritime Initiative, National Register, History and Education Program.
Based on submissions by Ralph Eshelman under cooperative agreement with U.S. Lighthouse Society, and Ross Holland under cooperative agreement with National Trust for Historic Preservation
Also reviewed, reedited, and reformatted by Ms. Kebby Kelley and Mr. David Reese, Office of Civil Engineering, Environmental Management Division, US Coast Guard Headquarters, and Jennifer Perunko, NCSHPO consultant to the NPS National Maritime Initiative, National Register, History and Education Program.

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date February 23, 1999 & February – July 2002

D. Certification

As the designated authority under the National Historic Preservation Act of 1966, as amended, I hereby certify that this documentation form meets the National Register documentation standards and sets forth requirements for the listing of related properties consistent with the National Register criteria. This submission meets the procedural and professional requirements set forth in 36 CFR Part 60 and the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation. (___ See continuation sheet for additional comments.)

, ACTING
Captain, U. S. Coast Guard,
Chief, Office of Civil Engineering — 2/22/02
Signature of certifying official — Date

Department of Transportation, U.S. Coast Guard
State or Federal agency and bureau

I hereby certify that this multiple property documentation form has been approved by the National Register as a basis for evaluating related properties for listing in the National Register.

Beth L. Savage — 12/02/02
Signature of the Keeper — Date

SHPO Concurrence

Maine:

Earle G. Shettleworth Jr. 4/2/02

Signature date

Maryland:

Signature date

Virginia:

Signature date

SHPO Concurrence

Maine:

Signature date

Maryland:

Signature date 5-9-02

Virginia:

Signature date

E. Statement of Historic Contexts

Introduction

> *The lighthouse and lightship appeal to the interests and better instinct of man because they are symbolic of never-ceasing watchfulness, of steadfast endurance in every exposure, of widespread helpfulness. The building and the keeping of the lights is a picturesque and humanitarian work of the nation.*
>
> George Putnam, Commissioner of Lighthouses, 1910-1935

Of the myriad of cultural resources in the United States, for many people, none have more appeal than lighthouses. Lighthouses conjure up feelings of romance, security, humanity, heroism, and beautiful settings. Some lighthouses have dramatic appeal in connection with notable rescues of shipwreck victims by the lighthouse keeper. Some religious hymns refer to the lighthouse beacon as a symbol of trust, moral direction, and even God. It is not surprising that lighthouses have become icons for humanitarian causes such as the Lighthouse for the Blind. This love of lighthouses and fascination with lighthouse keeping has been described by Dennis Hanson who states:

> *Clearly there is something special about lighthouses that goes far beyond their utilitarian purpose. They are perceived as monuments to the country's maritime past, symbols of man's stormy relationship with the sea, beacons of hope and homecoming. They stand for integrity and reliability. The resourceful lighthouse keeper, who endured the tedium, danger and deprivation of his job with heroic stoicism, has become part of our national folklore ....*[1]

Lighthouses, it seems, have always been favorite destinations for visitors. Throughout the history of the lighthouse service, many visitors camped or picnicked at light stations. Tours of the tower were routinely given upon request. The 1858 Instructions and Directions for Light-House and Light-Vessel Keepers of the United States, Third Edition, specified regulations for admitting visitors in the light tower. It stated,

> *The light-keepers are required to be sober and industrious, and orderly in their families. They are expected to be polite to strangers, in showing the premises at such hours as do not interfere with the proper duties of their office, and may, with the approbation of the inspector, place a placard on a conspicuous part of the premises, specifying the hours when visitors will be admitted, it being expressly understood that visitors shall not be admitted to the lantern-room after sunset. No more than three persons shall have access to the lantern-room at one and the same time during the day; and no stranger visiting the light-house can be permitted to handle any part of the machine apparatus. The light-keepers must not on any pretext, admit persons in a state of intoxication into the lighthouse.*

Today nearly 250 lighthouses are accessible to the public. The more popular sites boast visitation in the hundreds of thousands. Lighthouses have become a popular icon in our culture. They are used as logos for restaurants, television production companies, real estate, newspapers and other periodicals, museums, and other such establishments. The lighthouse motif has been used for the exterior design and interior decor of restaurants, churches, banks, hostelries, and other places of business. Individuals have

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[1]Dennis Hanson, "The Tide Is Turning For Old Beacons Adrift At Land's End," *Smithsonian Magazine* (August 1987).

designed their homes to resemble lighthouses. The lighthouse motif can be found on microbrewery labels, jewelry, calendars, knick-knacks, place mats, napkins, note cards, etc. Miniatures of popular lighthouses are common in souvenir and gift shops. Many towns and counties have incorporated a nearby lighthouse into their official seal; many states include local lighthouses on their license plates. Lighthouses are extremely popular with tourists; local restaurants, motels, inns, bars, and other establishments incorporate lighthouses into their name. A popular television soap opera uses the light from a lighthouse in its introductory title; television commercials often use lighthouses as backdrops to their sales pitch.

PART I: FEDERAL ADMINISTRATIVE HISTORY

Lighthouses transferred to the Federal Government (1789-1820)

Prior to 1789, during the colonial period, each colonial government determined the need for a lighthouse in their colony, financed its construction, and oversaw its operation. Twelve colonial lighthouses remained in the hands of the individual states throughout the period of confederation with additional lighthouses being erected. Colonial lighthouses were usually constructed of wood or rubblestone.

On August 7, 1789, President George Washington signed the ninth act of the United States Congress which provided that the states turn over their lighthouses, including those under construction and those proposed, to the central government.[2] In creating the U.S. Lighthouse Establishment, aids to navigation would henceforth be the responsibility of the Secretary of the Treasury. The legislation also provided that a lighthouse would be erected at the entrance to the Chesapeake Bay. Cape Henry Lighthouse (1792) and its associated structures was not only the first light station completed by the Federal government, but also its first public works project.

Secretary of the Treasury Alexander Hamilton reviewed contracts and the appointment of keepers before sending these documents to President Washington for his signature. The president sometimes asked pointed questions and often commented on the salaries of each keeper at the individual lighthouses.[3] In 1792 Hamilton turned over the administration of aids to navigation to the Commissioner of Revenue until Albert Gallatin became Secretary of the Treasury. Gallatin kept control of lighthouses for nearly all of his two terms in office when this responsibility went back to the Commissioner of Revenue.[4] The commissioner retained this duty until the office was abolished in 1820. At that time, Stephen Pleasonton, Fifth Auditor of the Treasury, was assigned the responsibilities of the commissioner. The collector of customs assigned to that district did the administration of lighthouses on the local level. Between 1789 and 1820, the Lighthouse Establishment built about 40 new lighthouses; the towers were generally constructed of brick and cut stone.

Lighthouses under the Fifth Auditor of the Treasury (1820-1852)

For 32 years Pleasonton administered the U.S. Lighthouse Establishment. Little technical progress was made during his administration. Once Pleasonton had adopted a way of operation or a technical

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[2] *The Lighthouse Act of 1789*, U.S. Senate Historical Office, 1791, pp. 1-11.

[3] George R. Putnam, *Lighthouses and Lightships of the United States* (Boston and New York: Houghlin Mifflin Co., 1917), pp. 31-33.

[4] Ibid., p. 33.

development, he actively resisted changes or innovations. For example, when he assumed his new responsibilities, lighthouses were lit with the Argand lamp and parabolic reflector. When French scientist Augustin Fresnel invented a lens in 1822 which produced a light infinitely superior to the system used in American lighthouses, Pleasonton refused to adopt the new lens and actively resisted even testing it until forced to do so by Congress in the 1840s. After the highly successful test, the lens was not adopted in this country until the administration of aids to navigation was taken out of Pleasonton's hands and assigned to the Lighthouse Board. His reasons for rejecting Fresnel's lens were that the lens was too expensive and the lamp inside the lens was too complicated for American lighthouse keepers to operate. It is true the lenses were much more expensive, but these lenses paid for themselves within five years with the savings in oil. Moreover, the lenses have a much longer life, and many are still in use in American lighthouses over 125 years after their adoption. Argand lamps and parabolic reflectors were much more fragile, lasting about a tenth as long. Pleasonton was also a close associate of Winslow Lewis who patented and supplied his modified Argand lamp to American lighthouses. This friendship may have played a factor in Pleasanton's reluctance to replace Lewis lamps with Fresnel lenses.[5]

The number of lighthouses and lightships[6] grew dramatically during Pleasonton's reign as General Superintendent of Lighthouses. In 1820, since maritime activities were concentrated in the northeast, 75% of the nation's lighthouses were from Delaware Bay northward.[7] In 1822 there were 70 lighthouses in the country. By 1842 the number had increased to 256 lighthouses and 30 light vessels. Ten years later that number had increased to 331 lighthouses and 42 lightships.

For the last decade or so of his control of lighthouses, Pleasonton was under near-constant attack by shippers, navigators, chambers of commerce, and the Blunt brothers who issued the *American Coast Pilot,* the navigator's bible for sailing in American waters. They complained of the poor quality of America's lighthouses, especially the lights. In 1837 when Congress questioned the need for funding a large number of new lighthouses, a board of navy commissioners was appointed to examine the sites of proposed lighthouses and see if these aids to navigation were really necessary. After careful study, the commissioners recommended dropping 31 of the proposed lighthouses.

In the following year, Congress divided the country into eight districts including two for the Great Lakes. A naval officer assigned to each district examined the condition of current lighthouses as well as selected sites for new ones. The officers found that the condition of lighthouses ranged from good to terrible. Although they reported much faulty construction, an inadequate lighting system, and that many lighthouses were poorly placed, Congress took no immediate action. In 1838 Congress began to give the Army Corps of Engineers an increasing role in selecting the sites, constructing, and lighting lighthouses. An inventory was published and distributed to mariners in the form of an annual *Light List.*

Finally in 1851, complaints regarding the country's system of aids to navigation grew so intense that Congress ordered a sweeping investigation of the country's aids to navigation, and appointed a panel consisting of distinguished military officers and civilian scientists to conduct the investigation. Their investigation was broad and thorough, not only analyzing and criticizing the current state of aids to

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[5] Holland, *America's Lighthouses*, pp. 14-21.

[6] "Lightship" is a term that comes into use after the Lighthouse Board took over aids to navigation. Pleasonton and others always referred to them as "lightboats" or light vessels.

[7] Holland, *America's Lighthouses*, p. 69.

navigation, but also offering detailed recommendations to cure the problems. Surveys of ship's captains who sailed up and down the coasts were conducted. All findings were compiled into a report that made specific recommendations for improvements.[8]

Establishment of the U.S. Lighthouse Board (1852-1910)

Congress immediately passed legislation to establish a Lighthouse Board that was essentially composed of those who had overseen the investigation. The appointment of these experienced, knowledgeable men to the Board attracted others of similar quality to lighthouse duty, both on the board and in district offices. Since the board members were government employees, they could not be paid for this duty. They squeezed their quarterly meetings into their regular jobs. Day-to-day operation of the Board was the responsibility of a naval secretary and an engineer secretary; both officers on detached duty. The country was organized into 12 lighthouse districts, each having an inspector (a naval officer) who was charged with building the lighthouses and seeing that they remained in good condition and that the lens was in operation. After a few years, the inspectors became overloaded with work and an engineer (an army officer) was appointed to each district to tend to the construction and maintenance of lighthouses.

The Lighthouse Board moved quickly. The Board had to deal with new technology, particularly in purchasing and installing new Fresnel lenses and constructing screwpile lighthouses. The Board also had to oversee the construction of the first lighthouses on the west coast. It was a difficult period for the Lighthouse Board, but it methodically went about getting its program started and underway. By the time of the Civil War, all lighthouses had Fresnel lenses.

The role of the local collectors of custom in connection with lighthouses was slowly declining. In time, all duties regarding aids to navigation were taken from them. The Board demanded that only those who could read were to be appointed as keepers so that they would be able to read their written instructions to them. These instructions were detailed and covered everything possible about the operation of lighthouses, leaving little discretion to the keeper. The Board struggled to eliminate politics from its activities, and slowly the organization became a professional career agency, helped greatly by the Civil Service Reform Acts of 1871 and 1883. Most important, the Board was constantly mindful of advancing technology and took advantage of new types of lighthouses, buoys, or fog signals, as well as improvements in lighthouse optics. Over the next five decades, several advances in lighthouse construction technology took place including the development of the exposed screwpile lighthouses, exoskeleton lighthouses, waveswept interlocking stone lighthouses, iron caisson lighthouses, and breakwater lighthouses.

Several advances in the technology of navigational aids were made during the 1850s. In 1851, an experimental air fog whistle and reed horn was installed at Beavertail Lighthouse at the entrance to Narragansett Bay, Rhode Island. The first installation of this sound signal was powered by a horse-operated treadmill and later by an internal combustion steam engine. Around 1851, mechanically-rung fog bells were introduced. The striking mechanism was governed by a weight attached to a flywheel, and later internally run by clockworks. The strokes of the fog signals were timed deliberately to afford each signal a unique sound characteristic.

In the 1850s, the United States Lighthouse Board prescribed color schemes for the buoys, as well as range lights and day markers; and the buoy system was standardized. Classification systems were also

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[8] See also "Report of the Officers Constituting the Lighthouse Board . . . February 6, 1852," *32nd Congress, 1st Session, Senate Executive Document No . 28* (Serial #617), especially pp. 6-18.

developed to mark the nation's waterways. Iron buoys were introduced to replace the more expensive copper-clad wooden buoys; this was noted in an appropriation specifying an iron can buoy for Little Egg Harbor, New Jersey, in 1855. The Lighthouse Board also began printing changes made in aids to navigation as a *Notice to Mariners*.

The U.S. Lighthouse Board was continually trying to improve the quality of navigational aids technology, from fog signals to lighthouse illuminants. Before this period, whale oil was the primary combustible used to fuel the lights; however, it became more expensive as production decreased. Lard oil became popular in the 1850s, and by 1885, kerosene became the principal illuminant for the lighthouses. Because of the volatile nature of kerosene, Congress issued a series of small appropriations for the construction of separate fireproof oil houses at each lighthouse station. Installation of these structures was finally completed about 1918. Lighthouse illuminants were further refined and experiments in other aids to navigation persisted throughout the decades of the 1860s, 1870s, and 1880s.

In the 1870s great improvements in the technology of fog signals were especially helpful on the often foggy northeastern and western coasts.[9] Colonial use of cannon had given way to bells and horns. The bell signal was gradually replaced by three variations of that instrument. The first was an ordinary locomotive whistle, enlarged and modified and blown by steam from a high-pressured tubular boiler. The second was a reed-trumpet, and in 1866 the third variation, a siren-trumpet. Although the fog bell signal was still used for warning vessels over short distances, other fog signals started to supersede the smaller bell signal. Bells were also used on buoys; later whistling buoys were invented by J. M. Courtenay and were first in use in 1876. The first gas-lighted buoy was installed in 1882. The gong buoy was invented in 1923. The number of lightships increased substantially and by 1882, all lightships were constructed of iron or steel.[10]

In 1886, a new technology[11] was being tested in the illumination of the Statue of Liberty: electricity. The electrical lighting of the Statue, under the Lighthouse Board's care from 1886 to 1902, marks the beginning of the "modern age" in lighthouse illumination. In 1900, the Lighthouse Board began converting lighthouses to electric service; however, because of the lack of direct access to power lines, the conversion came about slowly.

In 1889, the "first wireless messages" were sent and received between ship and shore on the East Coast. This exchange occurred between operators aboard the *S.S. Ponce* and at the Navesink Twin Lights, New Jersey. The first actual wireless message, however, had been staged earlier at San Francisco's lightship when one message was sent repeatedly from ship to shore. The advent of the telegraph ushered in a new type of navigational aid which would improve needed communication between ship and lighthouse stations.

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[9] The evolution of fog signals included cannons, bells, ship's whistles, sirens, reed trumpets, diaphone and electronic bells and horns. (Personal communication, Wayne Wheeler, February 24, 1998.)

[10] George Weiss, *The Lighthouse Service: Its History, Activities and Organization* (Baltimore, Maryland: The John Hopkins Press, 1926) p. 15.

[11] Electricity was first used in lighthouses in England and France in 1865. (Personal communication, Wayne Wheeler, February 23, 1998.)

Lighthouses during the Civil War

One of the most trying periods for the Lighthouse Board was the Civil War, mainly because the southern and Gulf coasts were darkened by the Confederates. Lighthouses and other aids to navigation were of greater importance to navigation for the Union forces, since the southerner blockade-runners were familiar with local waters. Lightships suffered also; Confederate naval raiding parties captured these vessels often hiding them from the federal forces, sinking, or burning them.

Most of the damage to the lighthouses was inflicted by contingents of the Confederate army, sometimes on their own initiative, but mostly on orders. Some local citizens took it upon themselves to put a lighthouse out of operation. Often explosives damaged the top of the tower; thus, not only impairing its use as a navigational aid, but also as a spotting tower for federals. On at least one occasion the military dismantled an iron-plate lighthouse, and apparently melted the plates for military purposes.[12]

As the Civil War drew to a close, only a minuscule number of southern lighthouses remained in operation. They were offshore and under the protection of union troops such as Garden Key Lighthouse on Fort Jefferson and Dry Tortugas Key Lighthouse that is within sight of Fort Jefferson, and the tall towers at Carysfort Reef and on Sand Key.[13] As sections of the coasts were brought back under Federal control, commanders of the area would ask the Lighthouse Board to restore the lighthouses and other navigational aids. Though the Board did what it could to get these aids back into service, the actual work done during the war was spotty and mostly temporary. Consequently, after the conflagration was over, the Lighthouse Board had a major task on its hands. Some lighthouses had to be rebuilt, others repaired before they could go back into service, many lightships had to be constructed, and lenses had to be recovered or obtained.[14] Within a couple of years the work was done, with the last few back in operation in the early 1870s.

The Lighthouse Board looked on this tragedy as an opportunity to implement its policy of replacing, where possible, inside light vessels with screwpile lighthouses. A lighthouse was much less expensive to operate than a lightship.[15] The waters of North Carolina and Chesapeake Bay before the war had a number of lightships, and between 1864 and 1868, screwpile lighthouses replaced at least six lightships in North Carolina sounds and at least another five in Chesapeake Bay waters.[16]

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[12] T. Lindsay Baker, *Lighthouses of Texas* (College Station: Texas A&M University Press, 1991) p. 59.

[13] Kevin M. McCarthy, *Florida's Lighthouses* (Gainesville: University of Florida Press, c.1990), pp. 51, 75.

[14] David L. Cipra, "The Confederate States Light House Bureau: A Portrait in Blue and Gray," *The Keeper's Log*, v. VIII, no. 2, pp. 6-13. Cipra, who has been researching confederate lighthouse records in the National Archives, says he found no indication of a confederate policy to put lighthouses out of operation. He thinks local collectors of custom and/or military units took independent action to darken the lighthouses. See p. 9.

[15] Inside lightships were those in bays, harbors, sounds, and rivers. Those lightvessels in the ocean offshore were considered outside lightships.

[16] Some publications containing substantive information on the impact of the Civil War on individual lighthouses or coastal areas are: David Stick, *North Carolina Lighthouses* (Raleigh: North Carolina Department of Cultural Resources, 1988), pp. 53-61; T. Lindsay Baker, *Lighthouses of Texas* (College Station: Texas A&M University Press, 1991), pp. 3-12, 14-15, 19, 30, 59, 73-74; F. R. Holland, Jr., *The Aransas Pass Light Station: A History* (Corpus Christi, TX: Privately printed [Charles C. Butt], 1976), pp. 39-47; F. Ross Holland, Jr., *A History of Cape Hatteras Light Station, Cape Hatteras National Seashore, North Carolina,* Division of History, National Park Service, September 30, 1968, pp. 66-75, and David Cipra, *Lighthouses, Lightships, and the Gulf of Mexico* (Alexandria, VA: Cypress Communications, 1997), pp. 9-23.

Bureau of Lighthouses or the U.S. Lighthouse Service (1910-1939)

Over its 58 years of service, the Lighthouse Board accomplished all it set out to do, and passed on to its successor a first-rate agency, both in terms of personnel and aids to navigation. The Lighthouse Board presided over an enormous increase in numbers of aids. By 1910, there were 11,713 aids to navigation of all types in the country. At this time, the Lighthouse Board had become cumbersome, and Congress wanting to give a civilian aura to the administration of aids to navigation, abolished the Lighthouse Board and created the Bureau of Lighthouses. The legislation authorizing this step referred to the bureau as the Lighthouse Service, and it is better known by that name.[17]

The Lighthouse Board had hired a number of civilians and many of these experienced people took over the roles that the military officers had been playing. Though most of the engineers and inspectors eventually transferred back to military projects, the legislation establishing the new bureau permitted the use of the inspectors and engineers for a two-year transition period. The new commissioner took advantage of the grace period to carefully and methodically select new civilian inspectors for each district; consequently, the change to a completely civilian bureau evolved with a minimum of trauma. Though initially called inspectors, the civilian heads of the districts changed their titles to superintendent.[18] Also at this time, the placement of aids to navigation along rivers had become the responsibility of the Lighthouse Service, and local citizens called lamplighters and lamp attendants tended many of these aids on a part-time basis.

President Taft selected George R. Putnam to head the new bureau, and he had the title, Commissioner of Lighthouses. Putnam had been a longtime employee of the Coast and Geodetic Survey's Washington office. For 25 years Putnam headed the bureau and during his administration, navigational aids saw a substantial increase and new technology, when appropriate, was incorporated into the bureau's work, particularly in the area of electronics. Though the number of aids to navigation increased substantially during Putnam's reign from 11,713 to 24,000, mostly buoys and small lights, arguably two of his most significant achievements were the passage of the Retirement Act for lighthouse personnel in 1918, and the introduction in 1921 of the radiobeacon as an aid to navigation. This new technology permitted a reduction of over 800 employees during Putnam's 25 years as head of the bureau.[19]

In 1912, under Putnam's leadership, a monthly newsletter, called the *Lighthouse Service Bulletin*, was circulated to Lighthouse Bureau employees and contained events of interest and importance, as well as occasional anecdotes and recipes. In the same year, a system of efficiency stars and pennants was established to promote friendly rivalry among lighthouse keepers.

During World War I and the period following, several technological advances contributed to the automation of lighthouses, rendering human occupancy unnecessary. A device for automatically

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The reference to six screwpile lighthouses replacing former lightships in North Carolina can be found in Holland, *America's Lighthouses*, pp. 128-129; Ralph Eshelman, Light Stations of Maryland, Multiple Property National Register Nomination (Maryland Historical Trust, Crownsville, MD, 1996), lists five for Maryland plus Windmill Point in Virginia.

[17] George R. Putnam, *Sentinel of the Coasts: The Log of a Lighthouse Engineer* (New York: W. W. Norton & Co., 1937), p. 119.

[18] Ibid., p. 126.

[19] Ibid., p. 328.

replacing burned-out electric lamps in lighthouses was developed and placed in several light stations in 1916. A bell alarm warning keepers of fluctuations in the burning efficiency of oil-vapor-lamps was developed in 1917. In the same year, the first experimental radiobeacon was installed in a lighthouse. The first automatic radiobeacon in the United States began service in 1928. Radiobeacons are still in use today, although most have recently been decommissioned as improved electronic navigational aids have become available. Radio compasses were also introduced during this period. An automatic time clock for operating electric range lights came into use in 1926, and by 1933, a photo electric-controlled alarm device had been developed to check the operation of the unwatched electric light. A lightship staffed by remote control was equipped by the Lighthouse Bureau in 1934. It included a light, fog signal, and radiobeacon, all controlled by radio signals. A battery-powered buoy that gradually replaced the older acetylene buoys was introduced in 1935. Due to the technological improvements mentioned above, and in particular the radiobeacon direction finder, the United States rose from sixth in shipping safety in 1920 to second in 1935, with only the Netherlands holding a better safety record.[20]

Improvements in the road and highway systems provided better and more rapid means of transportation during the 1920s and 1930s. As a result of the improved roadways, the Lighthouse Bureau was able to better maintain aids to navigation, benefiting the service economically. The extension of electric lines into remote sections of the country provided a reliable power source for operating aids to navigation. By the 1920s and 1930s, the majority of light stations had electric service, reducing the number of staff necessary to operate the station. As ancillary buildings at many stations, especially shore stations, were rendered useless, the makeup of the light station began to change. Over time, many of the lighthouse buildings, such as oil houses, fog signal buildings, and towers, were demolished or removed.

Lighthouses under the U.S. Coast Guard (1939-present)

In 1935, Putnam was followed in the Commissioner's position by a career Lighthouse Service employee, H. D. King, a former district superintendent. But the new commissioner had but four years to serve, for in 1939 the duties of the Bureau of Lighthouses were amalgamated into the operations of the U.S. Coast Guard. Personnel of the former bureau were given the choice of being brought into the Coast Guard through a military position or remaining as civilian employees. About half chose to remain civilians, and about half went the military route.

During World War II, one of the many war-related jobs of the Coast Guard was to guard the shores of the country. With the help of volunteers and career Coast Guard personnel, the Beach Patrol was formed whose mission was to patrol the shore, guarding against enemy incursion, rescuing victims of German submarine warfare, and retrieving bodies of the dead. The Coast Guard issued directions, that where possible, Coast Guard stations, lifeboat stations, and lighthouse stations be made available to the Beach Patrol. The lifeboat stations were used more often, probably because it was easier to coordinate the lifeboat station activities with the responsibilities of the Beach Patrol. Lighthouses and ancillary structures were also used, especially at stations that had been deactivated. Many were used as spotting stations to view possible enemy land and sea activities. Light towers were also used as temporary radio stations and used portable equipment the height of the tower to improve communication with the unit's beach patrols.[21]

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[20] Holland, Jr., *America's Lighthouses*, p. 204; and Adamson, 1955.

[21] Eleanor C. Bishop, *Prints in the Sand: The U. S. Coast Guard Beach Patrol During World War II* (Missoula: Pictorial Histories Publishing Co., 1989), pp. 30, 33, 38, 41, 56.

During World War II and postwar periods, the Coast Guard continued to develop new technologies. The effectiveness of radio technology, and an increased dependence on it, decreased the role of the lighthouse stations. SHORAN (short-range navigation aids) or LORAN (long-range navigation aids) were installed at stations and stationary towers; large navigational buoys (LNBs) began replacing lightships in the 1970s. In the mid-1960s, the Lighthouse Automation and Modernization Program (LAMP) began further eliminating the need for lighthouse personnel. By the 1960s, fewer than 60 lighthouses had keepers. By 1990, all lighthouses but one were automated.[22]

In May 1980, the U.S. Coast Guard Short Range Aids to Navigation Division of the Office of Navigation was formed. Under this program, 64 Aids to Navigation Teams (ANTS) were assigned across the country. The Aids to Navigation Teams, each of which comprises about 12 people, are responsible for maintaining the active lighthouses in the United States. Each ANT is assigned responsibility for its area's lighthouses, providing periodic preventive maintenance, and responding immediately to lighthouses if any outages or other discrepancies occur. Under this system, a relatively small number of people are able to look after the approximately 300 active lighthouses administrated by the United States Coast Guard today. In recent years, acrylic "Fresnel-like" lenses have been introduced to replace the classic glass Fresnel lenses and airport-type "aero-beacons" used at some lighthouses. These smaller and less expensive lenses, designed like Fresnel lenses, are visually as effective as the old lenses and require less maintenance.

With modern automated beacons, it is more cost effective to construct and maintain an aid to navigation on a steel structure or buoy, rather than inside the lantern of a traditional lighthouse tower. Thus, in many locations, the traditional lighthouse tower has been found to have little value to the U.S. Coast Guard mission, other than to provide a visual aid to mariners during daylight and good weather.[23] With the wholesale automation of lighthouses, secondary structures at light stations for the most part became obsolete and with the departure of personnel, these structures became subject to vandalism and received little maintenance. The Coast Guard soon encountered a rising grassroots concern for the preservation of these old stations and many, mostly local, historical societies, expressed a strong interest in obtaining an old station to preserve and open to public visitation. The Coast Guard began setting up a process for leasing old light stations to local historical groups and other organizations interested in caring for the structures. More recently, the Coast Guard, with the Department of Transportation, has declared lighthouses to be excess property, allowing the General Services Administration to transfer them to organizations better equipped to preserve their historic nature, while retaining access to the navigation signal.

PART II: ARCHITECTURE & ENGINEERING

U.S. Lighthouse Construction Types

The United States has more lighthouses and diverse architectural and engineering types than any other country in the world. Most lighthouses can be categorized by construction method, shape, building material, or foundation types. A lighthouse can also be classified as terrestrial or aquatic, i.e., onshore or offshore. The majority of today's 600 light stations are land based; close to a fourth have foundations

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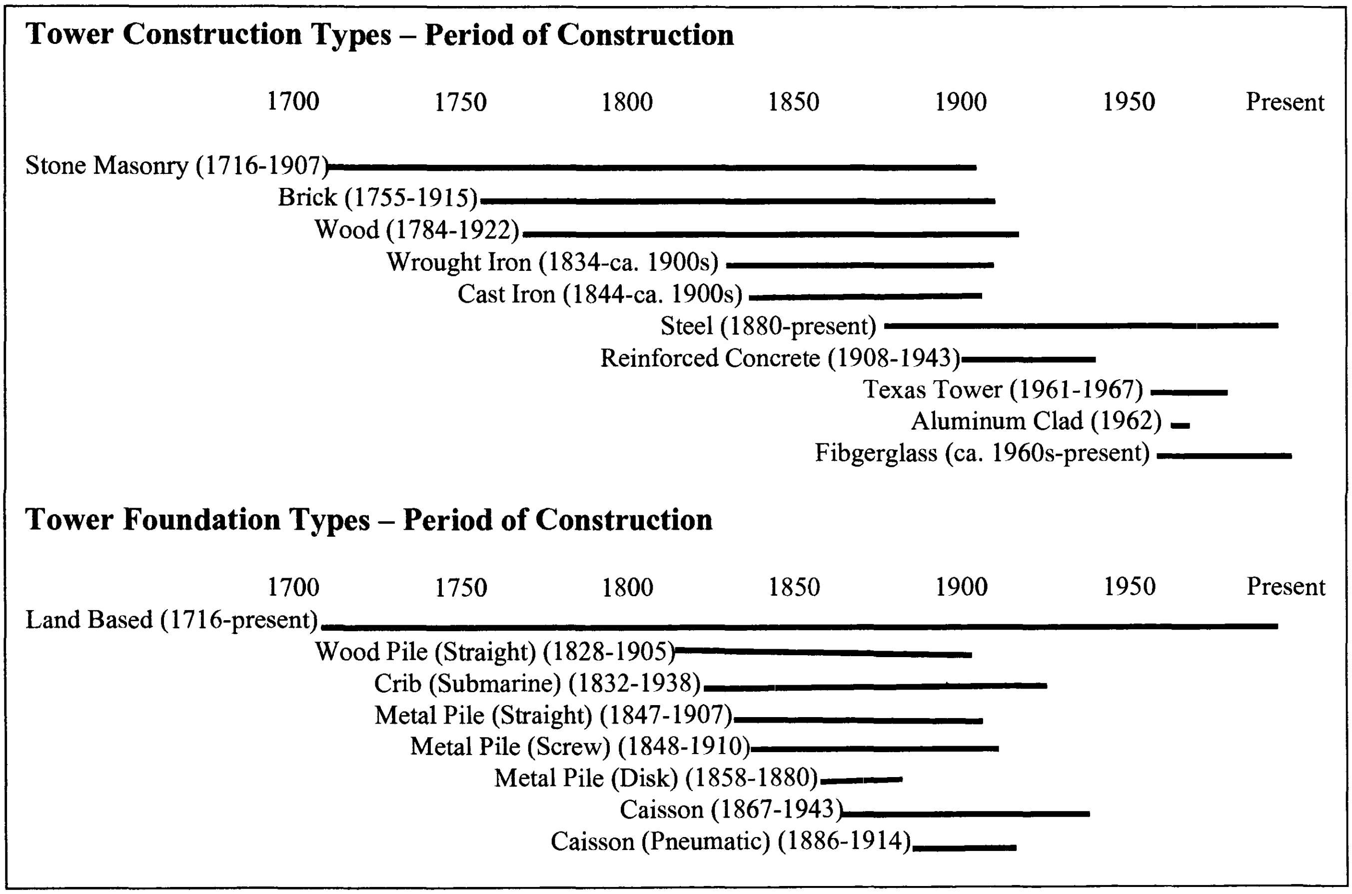
[22] Today the only lighthouse with official keepers is the Boston Harbor Light Station. It will to continue to be staffed per an Act of Congress.

[23] Reese, David, and Robert Browning, "Lighthouse Management: A Balancing Act by the U.S. Coast Guard" *CRM*, Vol. 20, No. 8 (National Park Service, July 1997)

built in the water. The major construction types for lighthouse towers are: wooden, masonry, wave-swept interlocking masonry, concrete, cast-iron plate, skeletal, straightpile, screwpile, crib, caisson, and Texas tower. Lighthouses were built on land, in the water, on islands, on top of ledges and cliffs, on breakwaters and piers, and at least five are on fort walls. Some light towers are stand-alone structures, while others are attached or integral to, a keeper's quarters or, in a few cases, a fog signal building. In addition to a light tower, a land-based light station might consist of a keeper's quarters, oil house, fog signal building, workshop, cisterns, privies, landing wharf, boathouse and ways, barn, roads, walks, and fences (for more information, see Part III, Lighthouse Components).

Politics, need, cost, location, geography of the site, as well as technology available at the time of construction and the popular architecture styles of the era influenced lighthouse designs. Before the mid-nineteenth century, lighthouse construction technology required solid rock or other stable foundation soils; however, onshore towers sometimes proved inadequate to warn ships of a shoal located offshore. Riverine and estuarine environments often had unstable muddy and/or sandy bottoms which could not support the heavy masonry towers then in vogue. In some locations, a lighted buoy or a lightship solved this problem. In areas such as the Carolina Sounds, Chesapeake Bay, Delaware Bay, the Gulf of Mexico, the Mississippi River delta, and the coral reefs of the Florida Keys, the development of new technology using screwpile, caisson, and skeletal tower lighthouse construction was essential to adequately lighting these marine hazards.

U.S. lighthouse typology chronology[24]



[24] This timeline is for United States lighthouses; tower and foundation construction types were sometimes used earlier or later in other countries. The dates are meant only to give relative time, not absolute first and last use of this construction type.

Wooden tower

The earliest lighthouse towers in the original colonies, and subsequently in the United States, were built of wood and/or rubble stone. Of the wooden towers, most were consumed by fire; approximately 11 percent of the historic lighthouse towers in existence today are made of wood.[25]

Masonry tower

Masonry towers were constructed of rubblestone, cut stone (dressed stone), brick, and concrete. Nearly 20 percent of all historic lighthouse towers extant are made of stone and approximately 32 percent are made of brick.[26] The oldest standing masonry light tower in the United States is the 85-foot-tall Sandy Hook Lighthouse (1764), New Jersey, built of cut stone. The preferred foundation for masonry lighthouses was bedrock, but wooden piles driven into the substrate and topped with timbers and/or rubble stone had to be used in regions such as the coastal plain where bedrock was lacking. Towers of stone and brick were typically built in the form of the frustum of a cone (a conical or pyramidal shape left by cutting off the top portion at a plane parallel to the base). Masonry walls of lighthouses are typically several feet thick at the base and decrease in thickness upward, with heights ranging from 30 feet at Piney Point Lighthouse (1836), Maryland, to the tallest lighthouse in the United States, the Cape Hatteras Lighthouse (1870), North Carolina, at 197 feet.[27] The base of the tower was made thicker to support the ever-increasing weight from above and to make it more stable. Cut or dressed stone, and later brick, permitted construction of taller and stronger towers because the weight could be more evenly distributed.[28] The tapering sides were either conical such as Boston Harbor Lighthouse (1789), Massachusetts, or octagonal such as Sandy Hook Lighthouse (1764), New Jersey, and Cape Henry Lighthouse (1792), Virginia.

Some deteriorated masonry towers on the Great Lakes were encased in steel plates and the void between the steel plates and masonry tower filled with grout. Big Sable Point Lighthouse (1867), Michigan, was encased in 1900; and Cana Island Lighthouse (1869), Wisconsin, encased in 1901.[29]

Tall masonry tower

When the Cape Hatteras Lighthouse (1803) tower was heightened to 150 feet in 1854, it was the first of the "tall tower" lights to be built in the United States (this original tower was replaced by an even taller tower in 1870). During the construction of the Ponce de Leon Inlet Lighthouse (originally Mosquito Inlet) in 1887, Lighthouse District Superintendent of Construction Herbert Bamber invented an adjustable, moveable working platform that increased the efficiency and ease of constructing masonry towers. Individual bricks were left out of the exterior tower wall every 10 feet vertically and

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[25] Robert L. Scheina, "The Evolution of the Lighthouse Tower," in U.S. Lighthouse Service Bicentennial, a U.S. Lighthouse Society Event Souvenir Program (Newport, Rhode Island, September 21-24, 1989), p. 18; and Clifford, p. xvii.

[26] Clifford, p. xvii.

[27] According to 1989 HABS documentation, the overall height of the tower at Cape Hatteras is 208 feet including the foundation. The height from ground level was recorded at 197 feet; and "Cape Henry Light Station," U.S. Coast Guard Records, National Archives, Washington, D.C.

[28] Scheina, pp. 18-19.

[29] Barnes, p. 9.

horizontally so that supports for the platform could be set into the resulting slots. Once the tower was completed, the platform was lowered level by level and the gaps filled with bricks.

Waveswept masonry tower

Subjected to the full fury of the sea, the offshore waveswept masonry tower is built on rocks just above or slightly below the ocean surface. John Smeaton, an Englishman, built the first successful masonry waveswept tower in 1759 at Eddystone Rock, in the English Channel, though a waveswept tower was built in 1157 on the shoal of Meloria, near Livorno, Italy. Smeaton's tower was the first interlocking masonry block tower. Later Smeaton developed (using the Roman idea that by mixing lime putty with a fine volcanic ash, it would harden under water forming possibly the first hydraulic cement) cement that would set up in water. These two inventions revolutionized open sea lighthouse construction and remained the principal method for their construction until concrete and steel came into use. The first masonry waveswept tower to be built in the United States was the 114-foot Minots Ledge Lighthouse (1860), Massachusetts, which replaced a pile-type lighthouse destroyed by a storm. It is considered the "most important engineering work" constructed by the Lighthouse Board and "it ranks, by the engineering difficulties surrounding its erection, and by the skill and science shown in the details of its construction, among the chief of the great sea-rock light-houses of the world." It took five years to complete and cost approximately $300,000 to build.[30]

These waveswept towers were built by interlocking large cut stones together, both horizontally and vertically. This integral intertonguing formed a monolith of great weight which combined with their conical shape diverted the energy of the waves away from the tower enabling them to withstand the heavy pounding of the surf. While most waveswept towers were built with interlocking stone, any lighthouse, regardless of material used in construction, but subject to being waveswept, may be so called.

Concrete tower

In 1824 Joseph Asplin was granted a patent for a superior cement which resembled Portland Stone. I. C. Johnson discovered in 1844 the high temperature process of forming Portland Cement clinker. In 1872 Johnson was granted a patent for Improvements in the Manufacture of Portland and Other Cements. The mass production of Portland Cement was made possible by the introduction of the rotary kiln in 1877. Concrete towers began to replace the brick masonry towers in Scotland in the late 19th century and in the United States at the beginning of the 20th century. Use of reinforced concrete in the United States dates from 1860 when S. T. Fowler obtained a patent for a reinforced concrete wall. Concrete did not become generally accepted, however, until the introduction of the horizontal rotary kiln, developed by Ernest L. Ransome in 1880. This type of kiln allowed for the production of cheaper, more uniform and reliable cement. Reinforced concrete became an accepted building method during the 1890s; the first use of reinforced concrete in a lighthouse in the United States was at Tillamook Rock Lighthouse (1881), Oregon, when the original iron roof was replaced with a flat reinforced concrete slab in 1898. The first lighthouse tower constructed of reinforced concrete in the United States was the 115-foot-tall Point Arena Lighthouse (1908), California. The earthquake hazards of the West Coast prompted the

[30] Hague and Christie, p. 12; Ebbe Almqvist and Kenneth Sutton-Jones, "Milestones in Lighthouse Engineering," (no reference), p. 16; and Quote from Arnold Burges Johnson, *The Modern Light-house Service* (Washington, D.C., Government Printing Office, 1890), pp. 30-31.

construction of many reinforced concrete lighthouses in California and Alaska.[31] Unlike the tapered brick and stone towers, reinforced concrete towers typically are cylindrical.

The Navassa Island Lighthouse (1917), Windward Passage, West Indies, at 162-feet in height, was the tallest reinforced concrete tower when built. The newest reinforced concrete lighthouse in the United States is Oak Island Light, North Carolina (ca. 1958). This 155-foot silo-type tower was built using slipforms. The three wide horizontal daymark color bands were incorporated into the concrete so that the tower never needs to be painted.[32]

The first combination of a reinforced concrete tower on a reinforced unprotected concrete pier was built at the Brandywine Shoal Lighthouse (1914), New Jersey. The pier is cylindrical, 35 feet in diameter, weighs 225 tons, and rests in eight feet of water on top of 74 pine piles which were jetted into the shoal within one foot of the bottom. The pier was built on shore, floated to the site, and sunk into position in a manner very similar to cast-iron caisson construction discussed later. Where it differs, however, is that the pier is secured to the wooden piles by 12 precast reinforced concrete piles, each weighing 4 tons passing through sleeves on the outer shell of the pier. This is the first use of precast concrete in the United States. Some modern lighthouses are now made of prestressed-precast rings which are stacked and post-tensioned.[33]

Cast-iron tower

Approximately 20 percent of the historic lighthouse towers extant in the United States are made of iron, however, this percentage includes screwpile and skeletal towers.[34] Cast iron was lighter than stone or brick, relatively inexpensive, capable of being shaped, watertight, and had a slow rate of deterioration.

The first cast-iron lighthouse was an octagonal tower built at Swansea, England, in 1803. The earliest surviving cast-iron lighthouse is believed to be the 1834 slender hollow octagonal lantern built on the south pier of Mayport, Cumberland, England. The first cast-iron lighthouse in the New World was designed by Alexander Gorden, built in England and erected in Jamaica in 1840. This round lighthouse tower built at Morant Point, still stands. Gorden designed at least 10 similar lighthouse structures. The United States was quick to follow Gordens concept when in 1844 it built a cast-iron tower on Long Island Head, Boston Harbor (this tower was replaced by a brick tower in 1900).[35] Another early iron lighthouse was begun in 1847 and completed in 1850 when Captain William H. Swift of the U.S. Topographic Bureau, recommended an iron pile structure for Minots Ledge, an offshore waveswept ledge. The Minots Ledge lighthouse was built with one central and eight periphery 10-inch diameter wrought-iron piles wedged in 5-foot-deep holes drilled into the ledge. Swift recommended this design

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[31] Hague and Christie, p. 107; Belle Isle North East Lighthouse, Newfoundland, Canada, built in 1905, is possibly the first reinforced concrete lighthouse in North America; see Alfie Yip and Ross Anderson, *Canadas Flying Buttress Style Lights*, unidentified Canadian publication.

[32] Clifford, pp. 9, 25, and 337; and Barnes, p. 12.

[33] George R. Putnam, *Lighthouses and Lightships of the United States* (Boston, Houghton Mifflin Company, 1933), pp. 84-85; and Barnes, pp. 11 and 13.

[34] Clifford, p. xvii.

[35] Hague and Christie, pp. 104-105; Patrick Barnes, The Development of Lighthouse Structures, unpublished manuscript, USCG, Cleveland, Ohio, no date, p. 6., copy at National Maritime Initiative Office, National Park Service, Washington, D.C.; and Clifford, p. 149.

because he felt the piles would provide less resistance to the waves than a stone tower. But 15 months later the lighthouse was destroyed in a severe storm. Nevertheless iron lighthouses continued to be built.

Cast-iron-plate tower

Cast-iron plates were prefabricated offsite, numbered, and easily assembled into towers on site. The cast-iron plates were either segments of a cone or a flat surface, depending on the design chosen. The plates have flanges on all four sides which were fastened together by bolts. The interior of the tower was often lined with brick for added stability and insulation. Cast-iron-plate towers were similar to masonry towers in external physical appearance; from the outside, both the Hunting Island Lighthouse (1875), South Carolina, and the second Cape Henry Lighthouse (1881), Virginia, resemble masonry structures. In areas where shifting and eroding beaches were present, cast-iron-plate towers were designed so they could be disassembled and re-erected as needed. Cape Canaveral Lighthouse (1868), Florida, and Hunting Island Lighthouse (1875), South Carolina, are examples of this design - both having been successfully moved.

By varying the size of the plates and number of courses, lighthouses of different heights and dimensions could be made. Architectural features such as door and window openings were cast into the integral part of a plate so when fastened together an attractive, uniform pediment or hood could be produced.[36] This same design was used to build the cast iron cylinders which formed the upper foundation of caisson lighthouses.

Skeletal tower

Skeletal tubular iron towers consisting of a central vertical stairway cylinder and four to eight slanting structural skeletal peripheral columns were especially adapted to locations where a relatively light pile structure was required in mud, sand, swamp, or coral. This type of lighthouse structure was also prefabricated offsite and easily assembled on site.[37]

Some skeletal tubular lighthouses were constructed on foundations not requiring piles. These were usually terrestrial tubular skeletal towers built on rock or sand and made of cast iron or steel. Skeletal towers were often standardized. The most common form was four-legged tapered towers with diagonal bracing available in 10-, 20-, 30-, and 40-foot heights. Skeletal towers built offshore typically used straight or screwpile foundations and are discussed later. Cape Charles Lighthouse (1895), Virginia, is the tallest skeletal lighthouse tower in the United States and at 191 feet is only 17 feet shorter than the brick tower at Cape Hatteras.

Iron proved popular for construction of range lights (pairs of lights that when viewed in a line from a vessel signifies the vessel is within the navigable channel) and breakwater lighthouses (lights established at the ends of protective breakwaters to harbors and waterways) which required small and lightweight structures so as to not stress a small lightweight foundation, yet strong enough to withstand the impact of waves and resultant vibrations. The keepers' quarters were often detached and located onshore, as most breakwater lights were built at port towns. The Great Lakes has the largest number of breakwater

[36] J. G. Barnard, Lighthouse Engineering as Displayed at the Centennial Exhibition, American Society of Civil Engineering Transactions, volume 8, 1879, p. 70.

[37] Almqvist and Sutton-Jones, p. 17; and Scheina, p. 22.

lighthouses in the United States.[38] There are at least two "bottle shaped" cast-iron/boiler plate breakwater lighthouses: South Buffalo North Side Lighthouse (1903) and Buffalo North Breakwater South End Lighthouse (1903), both in New York.[39]

Non-cast-iron tower

It is not always clear whether lighthouses are made of cast iron, wrought iron, or steel. Steel was used in place of iron for skeletal structures as early as 1880 but iron was more common until just before the turn of the century. After 1900 iron was used only in special situations. For example, to take advantage of iron's superior corrosion resistance, iron plates were placed over a steel frame at the St. Joseph North Pier Inner Lighthouse (1907), Michigan; and corrugated iron was placed over a wooden structure at Grand Haven South Pier Entrance Light Station fog signal building (1922), Michigan. Cast-iron lanterns continued to be used even on steel structures up into the 1930s. Steel towers have lapped, riveted, or welded joints. The 1833 Buffalo Lighthouse in New York is built with internal cast-iron supports but non-cast-iron external plates.[40] Gravelly Shoal Lighthouse (1939), Michigan, is a steel-plate tower. At least one dressed stone light was sheathed in iron plate, Destruction Island Lighthouse, (1891), Washington.[41] It was gradually accepted that the cast-iron lighthouses, though cheaper to build than masonry, were not as structurally sound for exposed sites, but rather more acceptable for secured headlands and harbor locations. Steel on the other hand, has greater tension and residual strength than iron making it better for slender truss and frame members resulting in lighter designs. Ductile steel when used as a reinforcement also allowed the use of concrete which lacked tensile properties. Los Angeles Harbor (1913), California, is a steel frame structure with concrete plaster infilled walls.[42]

Foundation Types

Many of the earliest lighthouses in the colonies and the United States were built on natural rock outcrops. Other early lighthouses were built upon sandy soil lying almost at sea level and built on foundations of wood timbers and planks. With the advent of pile-driving technology closely spaced wooden piling also supported such foundations. This grillage was usually placed within an excavation deep enough to keep the wood below the water table. Of the 40 or so brick tower lighthouses constructed in the South between 1820 and 1852 at least 25 were destroyed when eroding foundations caused them to fall down or blow over in storms.

Offshore lighthouses were generally more expensive to build because of exposure to storms, currents, and wave action and because of the high costs of transporting materials and workers to the site. But, their strategic placement afforded better marking of offshore shoals, reefs, rocks, and channels. Many of the first offshore lighthouses replaced light vessels and buoys.

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[38] Scheina, p. 23.

[39] Clifford, pp. 229 and 252.

[40] Barnes, p. 10; Clifford, pp. 174, 201 and 228.

[41] Clifford, p. 327.

[42] John Naish, *Seamarks: Their History and Development* (London, Stanford Maritime, 1985), p. 129; and Barnes, pp. 10 and 13.

In the Great Lakes region, cribs of fastened timbers built in a box-like fashion were floated to a site and filled with stone and/or concrete. Sometimes a steel shell containing cells was built around the wood crib that then was pumped full of concrete and positioned on the bottom. Interlocking steel sheet piling filled with stone and capped with a concrete slab has been used to form foundations in areas where ice is prevalent.
Metal screwpiles were used to form the foundation of many lighthouses built on sandy or muddy bottoms. The helicoidal or screw-like cast-iron flange at the end of the metal pile was augured into the bottom increasing the bearing power of the pile as well as its anchoring properties. Yet lighthouses built with these foundations were found to be vulnerable to ice floes. In areas such as the Florida Keys, where the bottom is soft coral rock, disc pile foundation lighthouses were built. Wrought iron piles were driven through a cast-iron or semi-steel disc that rested on the sea floor until a shoulder on the pile prevented further penetration. The disc diffuses the weight of the tower more evenly over the bottom. In coral reef areas where sand is also prevalent, a cast-steel screw was fitted to the end of the pile to give it more anchoring ability. Cofferdams were used generally in shallow waters where it was not necessary to deeply penetrate the natural bottom. The cofferdam enabled the water inside the dam to be pumped out and the foundation built in the dry.

In areas prone to ice flows, caissons were employed as lighthouse foundations. Caissons were made of fastened cast-iron plates forming a hollow cylinder. At the bottom of the cylinder is fastened a wooden crib. The assemblage is allowed to settle to the bottom and sinks under its own weight as rock and concrete fills the cylinder. Where deeper penetration into the bottom is required, sediments are excavated from the bottom of the crib allowing the assemblage to sink deeper. This later technique is referred to as pneumatic because of the air pressure required to keep water from entering into the assemblage.

Finally, a few lighthouses have been built on breakwaters composed of large quarry rock. Los Angeles Harbor Lighthouse (1913), California, is an example of a breakwater foundation lighthouse. Many of these foundation types are more fully discussed below.[43]

Pile foundation

A Quaker and wealthy Liverpool merchant, John Phillips, erected a lighthouse on Smalls Rock in 1773, in the British Channel off the west coast of Wales. Instead of hiring an engineer to design the structure, he chose a musical instrument maker, Henry Whiteside, who built the lighthouse on piles rather than using the methods for a conventional masonry tower. Phillips' choice and Whiteside's design were to prove revolutionary. Construction began in June 1775 and, when finished, the lighthouse consisted of nine oak posts each 24 inches in diameter and 40 feet in length with a small two-story octagonal wooden cabin built on top. The first floor was where the keepers lived and the top floor housed the light. It stood for 85 years, but more importantly proved the principle of least resistance since waves would tend to pass through as opposed to crash against a foundation built in waveswept locations.[44]

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[43] *Aids to Navigation 1945*, pp. 312-326.

[44] Layne Bergin, "Screwpile Lighthouses: From Britain to the Bay," *The Keeper's Log* (Summer, 1987), p. 11.

Screwpile foundation

Alexander Mitchell invented the screwpile, a major improvement over the standard straight pile construction type. With his son, he patented his wrought-iron screwpile design in the 1830s, which he described as follows,

> *A bar of iron having at its lower extremity a broad plate or disk of metal in a spiral . . . on the principle of a screw, in order that it should enter into the ground with facility, thrusting aside any obstacles to its descent, without materially disturbing the texture of the strata it passed through, and that it should at the same time offer an extended base, either for resisting downward pressure or an upward strain.*[45]

He further stated that his screwpile was a device for "obtaining a much greater holding power than was possible by any pole or mooring then in use." William Johnstone, harbormaster at Glasgow stated in a letter to Mitchell and his son on May 7, 1837,

> *The great strain they bear . . . the safety for vessels grounding above them, the unexpected ease with which they are put down, and their exemption from frequent lifting, to which other moorings are liable, will make me recommend them.*[46]

By 1840, Mitchell combined his wrought-iron screwpile moorings with Whiteside's pile construction technique and built the first screwpile lighthouse at the mouth of the Wyre, an important harbor in Lancashire, England. Mitchell used 36-inch-diameter wooden timbers on whose bottoms were attached his wrought-iron screwpile device. The piles were inclined toward the center as in Whiteside's standard straight pile design.[47]

Mitchell later noted, "by reason of the various descriptions of sea-worms which everywhere infest our coast" wrought-iron piles were necessary. This led to his next and best-remembered achievement, the Maplin Sands Lighthouse. In partnership with James Walker who was responsible for the superstructure, Mitchell contracted with the Trinity Corporation (England's lighthouse authority) to build a lighthouse at the mouth of the Thames River, an area subjected to high winds, strong currents, and consisting of a soft bottom. Completed in 1841, this structure was the first lighthouse to be built upon a screwpile foundation made entirely of iron. The hexagonal dwelling was supported by one central and eight surrounding iron piles, either five or six inches in diameter, each tipped with a 4-foot-diameter flanged screw and each turned 22 feet into the sandy bottom. Unlike the Wyre Lighthouse, these piles were screwed vertically into the bottom, and capped with hollow cast iron columns which not only formed the foundation but supported the dwelling as well. The Maplin Sands Lighthouse became a prototype for other screwpile lighthouses.[48]

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[45] Bergin, p. 11.

[46] Bergin, p. 11.

[47] Bergin, pp. 11-12.

[48] Bergin, p. 12; Douglas B. Hague and Rosemary Christie, *Lighthouses: Their Architecture, History and Archeology* (Wales: Gamer Press, 1975), and Naish, p. 127. Note, Naish gives the date of completion of the Maplin Sands Lighthouse as 1836 on page 127 and 1848 on page 128, F. Ross Holland, Jr., *Americas Lighthouses: An Illustrated History* (New York, Dover Publications, Inc., 1988 edition) p. 99 gives the date 1838, Bergin gives the date 1841, and Hague and Christie gives the date 1838 on page 221 and 1841 on page 137. These various dates may reflect the experimental nature of several adaptations in the development of the screwpile type lighthouse at Maplin

The first mention of Mitchell's screwpile invention in the United States may be in an 1842 report on buoys written by engineer I. W. P. Lewis,

> *The use of screw moorings are yet unknown in this country, while England has availed herself of this valuable invention . . . as a means of founding lighthouses upon shoals hitherto considered inaccessible to the engineer.*[49]

Congress was willing to give the screwpile technique a try at Flynn's Knoll in New York Harbor but the project died with little support outside of Congress, most people believed nothing more than a buoy was needed. The first screwpile lighthouse type built in the United States was at Brandywine Shoal, Delaware Bay, an area served by a lightship since 1823 and an ordinary straightpile lighthouse which stood briefly there in 1828 but was destroyed by ice. Major Hartman Bache, a distinguished engineer of the Army Corps of Topographical Engineers, began work in 1848 and completed the task in 1850; construction cost $53,317. Alexander Mitchell served as consultant. A 4-foot capstan worked by 30 men turned the screwpiles. To protect the structure from ice floes, an icebreaker consisting of a pier of 30 iron screwpiles 23 feet long and five inches in diameter were screwed down into the bottom and interconnected at their heads above the water reinforcing them together. This cost an additional $11,485.[50]

The screwpile lighthouse is an example of early iron truss technology and became especially popular after the Civil War when the Lighthouse Board adopted a policy to replace inside (bays, sounds, and rivers) light vessels with screwpile lighthouses.[51] This lighthouse type was built in ice-free, shallow, slow moving sheltered waters, where soft bottom shoals stood too far offshore to be protected by the more traditional onshore lighthouse structure. When built in areas prone to ice flow, moving ice occasionally destroyed these relatively lightweight structures. Other enemies of the screwpile lighthouse were fire, fast flowing water that could scour bottoms and undermine foundations, and even collision by vessels.[52]

Screwpile lighthouses were relatively inexpensive, easy to construct, and comparatively quick to build. A temporary platform or stage was constructed to facilitate the work. Most screwpile lighthouses were made with iron piles, though a few were made with wooden piles covered with metal screw sleeves (these sleeves were probably adopted because they were less expensive and easier to insert into the bottom, plus the sleeve protected the wood from marine-boring invertebrates). The typical screwpile lighthouse was hexagonal or octagonal in plan consisting of a central pile which was set first and then the six or eight perimeter piles were screwed in place around it. Occasionally, two additional fender piles were set, one on each of the ebb and flow sides of the structure for additional stability against ice. The York Spit Lighthouse (1870) had two extensions built over these additional piles, one for the

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Sands, but also reflect the tendency for the British to use starting date of construction while Americans use the date of the first lighting.

[49] Bergin, p. 12

[50] Johnson, 26; Holland (1972), p. 99; Bergin, pp. 12-13; and Putnam, p. 84.

[51] Frank N. Schubert, *The Nation Builders: A Sesquicentennial History of the Corps of Topographical Engineers 1838-1863*, Office of History, United States Army Corps of Engineers, Fort Belvoir, Virginia, 1988, p. 30; and Holland (1988), p. 128.

[52] Scheina, p. 19.

placement of a fog signal and the other as a landing deck fitted with davits to accommodate a station boat.

Cottage type screwpile

There are two principal types of screwpile lighthouses: the spider-like, cottage type and the exposed tall skeletal tower type. The spider-like, cottage-type screwpile lighthouse consisted of a screwpile foundation built over open water upon which a wooden cottage for the keeper's quarters was constructed.[53] Initially the cottage was a one-story building surmounted by a lantern room, but later a one-and-one-half-story cottage surmounted by a lantern room became more popular. The first floor was divided into a sitting room, kitchen, storeroom, and sleeping room. A central enclosed spiral staircase connects the first floor to the second half-story where a sleeping room, oil room, and storage area was located. The interior walls and ceilings were of finished tongue-and-groove beaded board paneling. The circular stairwell continued to the cast-iron lantern room which was surrounded by an exterior gallery deck and railing. The lantern room had glass panes set in cast-iron mullions covered with vertical tongue-and-groove wood paneling on the inside and sheet metal on the outside. At least two 2-story square cottages with Mansard roofs were also built; both in Long Island Sound. The cottages were almost uniformly hexagonal in shape though there were at least seventeen exceptions.

Perhaps as many as 100 spider-like, cottage-type (1 and 1/2 story wooden dwelling) screwpile lighthouses were built throughout the Carolina sounds, the Chesapeake Bay, Delaware Bay, along the Gulf of Mexico, at least two in Long Island Sound and one even at Maumee Bay (1855), Lake Erie, Ohio.[54] However, the Chesapeake, with 42, has the distinction of having had the most spider-like, cottage-type screwpile lighthouse structures of any area in the world.[55] At least 15 of this type were built in North Carolina.[56] Seven Foot Knoll Lighthouse is believed to be the oldest surviving screwpile cottage-type lighthouse in the United States, and although moved to shore, its most important feature, the screwpile foundation which survives from the water level up (the portion of the piles below the water are still in place), remains unpreserved and unrestored.

The beginning of the end of screwpile cottage type lighthouses came in 1894 when the Lighthouse Board stated in its annual report,

> *In view of recent damages by ice to screwpile structures in Chesapeake Bay, the Board is now of the opinion that only caisson structures should be used where such dangers exist.*[57]

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[53] The only exceptions known are the Brandywine Shoal Lighthouse (1850), Delaware Bay, and the Seven Foot Knoll Lighthouse (1855) which have a cylindrical iron keepers quarters similar to those used on a caisson foundation.

[54] Scheina, pp. 20-21; and Clifford, p. 372.

[55] Ralph E. Eshelman, *A History of Drum Point Lighthouse* (Solomons, Maryland, Calvert Marine Museum, 1978), p. 1.

[56] David Stick, *North Carolina Lighthouses* (North Carolina Department of Cultural Resources, Division of Archives and History, Raleigh, 1980), pp. 60-61.

[57] U.S. Lighthouse Board, *Annual Report*, 1894 (Washington, Government Printing Office, 1894).

The last spider-like, cottage-type screwpile lighthouse built was Ragged Point Lighthouse (1910), Maryland, constructed in the Potomac River (in waters of Maryland but closer to Virginia shore) near Chesapeake Bay.[58]

Tall skeletal tower type screwpile

An exposed skeletal tower with a screwpile or driven pile foundation was designed specifically for offshore reefs of Florida. They came into use a few years after the cottage screwpile design. Many of these offshore screwpile skeletal towers had large iron footplates or disks that were attached to the pile above the screw tip to diffuse the pressure caused by the weight of their tall towers that were mounted with first-order lenses weighing several tons. Cottage-type screwpile lights were short, squat, and mounted, principally, with small, relatively light, fourth order lenses and needed only to project their light over a few miles of open water in protected bays and sounds. The tall skeletal screwpile tower type was built in exposed open water at major coastal sites where visibility over ten miles was required. Six screwpile skeletal towers were built in Florida; three before and three after the American Civil War, as well as one in the Gulf of Mexico off Louisiana prior to the Civil War.

The first of the screwpile tall skeletal towers to be built was the Carysfort Reef Lighthouse, on the dangerous stretch of reefs between Cape Florida and Key West, Florida.[59] Designed by I. W. P. Lewis, it was started in 1848 and completed in 1852. The entire structure was first erected in Philadelphia "so as to obviate the necessity of fitting parts at its isolated site." It cost $105,069 to complete. Carysfort Reef Lighthouse, with its skeletal foundation, presented relatively little resistance to wind and waves and served as a prototype for the string of lighthouses that now mark these reefs off Florida. Similarly, some onshore lighthouse towers also used an external skeletal support to broaden their foundation on soft sands or other unstable substrate foundations. Skeletal screwpile foundation lighthouses can be classified as a skeletal tower type and/or a screwpile type; thus the type classification used here can and does overlap with other construction types.

Straightpile skeletal type

Non-screwpile (straightpile) tubular skeletal tower lighthouses were built, usually of cast-iron but also of wrought-iron piles, both onshore and offshore, typically on soft bottoms such as mud, sand, and swamp. The method of construction is well described by the Lighthouse Board when it built the Fowey Rock Lighthouse in Florida in 1878:

> *Fowey Rocks . . . is of iron; rests on nine piles driven about 10 feet into the live coral rock . . . A working platform, about 80 feet square, was erected on the site, 12 feet above low water, on iron-shod mangrove piles driven into the coral. The disk for the central iron foundation-pile was then lowered to its place, and through this disk the first iron pile was driven. A perimeter disk was located by a gauge, and then the first perimeter pile was driven through the center of this disk. After every blow of the pile-driver the pile was tested with a plummet, and the slightest*

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[58] Holland (1993), p. 8. Holland gives no name for this lighthouse but Ragged Point is the only lighthouse listed for 1910 in Clifford p. 368 and deGast p. 156.

[59] Johnson, pp. 26-27; and Hans Christian Adamson, *Keepers of the Lights* (New York, Greenberg, Publisher, 1955), p. 180; Holland (1993) p. 43 and (1994), p. 19 states Lt. George G. Meade started work on Carysfort Reef Lighthouse but Johnson, p. 26 states Capt. Howard Stansbury started the work and Maj. Thomas B. Linnard completed it. The 1915 report of the U.S. Lighthouse Service on page 25 indicates the Carysfort Reef Lighthouse was a straight-pile built tower; this is apparently incorrect.

> *deviation from the vertical was rectified. In locating the disk for the next perimeter pile two gauges were used to get the proper distance from the center pile, and to maintain it from the perimeter pile just driven. The disks were dragged along the bottom until their outer edges just touched the free edges of the gauges. Each pile was then driven through the center of its disk. When all were driven their tops were leveled by cutting off each to the line of the lowest. The poles were then capped with their respective sockets; the horizontal girders were inserted, the diagonal tension-rods were placed and screwed up and the foundation series were completed.*

Caisson foundation

The caisson construction method for lighthouses is based on the idea developed by Lawrence Potts, an English physician and inventor, who in 1845 sank a section of hollow tubing from the surface of the ocean to the sea floor. He then attached a powerful pump to the open end extending above the water, and as he pumped air and water from the tube, it drew up sand that allowed the tube to sink by gravity deeper into the sea bottom. Charles Fox, a civil engineer for sinking railroad bridge supports, adopted this idea. The method was then employed in 1850 during the construction of bridge support towers at Rochester, New York. Workmen soon discovered that large rocks obstructed the descent of the tube so the engineer in charge, J. Hughes, reversed Pott's process. He pumped air into the tube forcing the water out so his men could descend into the tube and remove the rocks, sand, and mud, allowing the tube to sink under its own weight into the river. The foundation for the Brooklyn Bridge in New York City, as well as many bridge foundations, were built using this same pneumatic method. Pott's modified method was also used to build caisson lighthouse foundations, particularly in unconsolidated soft-bottomed environments such as mud or sand.[60]

The first application of the caisson technology in the United States for lighthouse-related work was for Waugoshance Lighthouse (1870), Michigan, built on a timber crib. When the crib foundation became damaged, William Sooy-Smith (who was the first to use the pneumatic process in the United States when he built a bridge over the Savannah River in 1859) used a temporary caisson in 1867 to enable his workers to repair the crib foundation with a masonry protection wall. Craighill Channel Lower Front Range Lighthouse (1873), Maryland, built near the Patapsco River and marking the entrance to Baltimore, Maryland, used a permanent caisson and is considered a greater feat of engineering as it was built in deeper water under more difficult conditions.[61] The caisson lighthouse was sturdier and better able to withstand the stresses exerted by ice flow. It is not surprising that caisson lighthouses are numerous from the northern coast of Maine to the Chesapeake Bay. At least one, Rock of Ages Light Station (1908), Michigan, was built on the Great Lakes. Only one caisson lighthouse was built south of the Chesapeake Bay, Sabine Bank Lighthouse (1906), Texas. The last caisson lighthouse built in the United States was the Cleveland East Ledge Lighthouse (1943), Massachusetts, using an art modern style.

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[60] Cohen, p. 17.

[61] Holland (1993), p. 9; *Aids to Navigation 1945*, p. 323; and U.S. Lighthouse Board, *Annual Report, 1873* (Washington, D.C., Government Printing Office, 1873), pp. 45-46. Holland, *Maryland Lighthouses of the Chesapeake Bay* (Maryland Historical Trust Press and Friends of St. Clements Island Museum, Inc., Crownsville, MD, 1997), p. 67. states that the Craighill Channel Lower Front Range Lighthouse is the first caisson built. Almqvist and Sutton-Jones, p. 19 states the "first caisson structure to be constructed ashore, floated and installed out at sea" was at Rothersand, Outer Weser estuary near Bremerhaven, Germany, completed in 1885. Craighill Channel Lower Front Range Lighthouse built in 1873 predates this. Elinor De Wire, Sentinels on Watch - 2, states Major David Heap of the Army Corps of Engineers, designed and completed in 1888 Fourteen Foot Bank, Delaware Bay, the first caisson type lighthouse in the United States.

Of the 100 or so cottage screwpile lighthouses built, only one, Thomas Point Shoal Lighthouse (1875), has survived intact and in its original location. Most have been destroyed or only the foundation remains; four have been moved ashore. Virtually all the caisson type lighthouses have survived, withstanding hurricanes and severe ice conditions.[62]

Caisson foundations for lighthouses were constructed by fabricating the cylinder plates from grey iron and typically cast in the form of 1-to-1 and 1/2-inch-thick plates, 6 feet in height, with 6-inch vertical and horizontal flanges 1 and 1/4-inch thick to insure water tightness. These plates were either totally or partially pre-assembled on shore to ensure proper fitting, then disassembled, shipped to the designed site and re-erected. Depending on bottom conditions and depth of water, the cylinder was either fitted with a temporary watertight bottom or permanent wooden crib, called a caisson, described later. Launched from ways, the cylinder was then towed to its desired location and sunk by controlled flooding of the interior achieved through a valve located in the chamber and/or by ballasting. The cast-iron cylinder was partially filled with stone and trimic concrete to provide the desired ballast during towing.[63]

In some instances the open-ended cylinder was carefully sunk into a muddy bottom under its own weight until it met refusal, and if necessary leveled by placing stone on the inner high side of the cylinder. External water jetting under the high side could also be employed to help level the cylinder. Once the cylinder was leveled, riprap stone was placed around the outside to add stability and prevent bottom scour by currents. Then the sand and mud within the cylinder was pumped out. Water hoses or jets were sometimes used to clear debris around the outer side of the cylinder to assist in the settling of the assembly. More stone and concrete was added to assist in the settling. Additional plates could be added to the cylinder as it settled in order for it to reach the desired height above the water surface. Though not common, this technique was sometimes used on land to sink a cylinder that was then used as a foundation pier. The foundation piers of the 1894 Cape Charles exoskeleton lighthouse used this technique. A 21-foot-diameter cylinder made of boilerplate iron was sunk ten feet into the sand by excavating the sand from within it while pumps kept water from filling the cylinder.

Where bottoms were harder, contained rocks, and/or greater depth of penetration into the substrate was desired, the pneumatic process was used. A wooden open-ended box-like crib contraption called the caisson was attached with the open side of the box facing down from the bottom of the cast-iron-plated cylinder. Typically the timbers forming the caisson were one foot square in dimension. The entire caisson was sheathed and sealed with mineral pitch to make it essentially watertight. In later years the caisson was occasionally made of steel. The lower sides or rim of the caisson were tapered near the bottom to ease the settling of the caisson into the bottom sediments. Water was forced out of the caisson by means of pressurized air. The tubular cylinder fitted on top of the caisson was then partially filled with cement. The added weight further settled the assembly into the substrate.[64]

An airtight shaft built in the center of the assembly (caisson and attached cylinder) was big enough for men to climb up and down. It provided access to the caisson where they would haul out, or suck out with hoses, the debris from inside the bottom of the caisson. Removal of these bottom sediments

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[62] Holland, *Maryland Lighthouses of the Chesapeake Bay* pp. 67 and 101; and Clifford, pp. 143 and 373. Holland refers to Cleveland East Ledge Lighthouse as the "Cleveland Ledge" Light.

[63] "Chesapeake Bay Lighthouses," Gredell & Associates: Structural Engineers (Wilmington, Delaware, 1991), p. 12; file on copy at the National Maritime Initiative Office, National Park Service, Washington, D.C.

[64] Johnson, pp. 37-40.

allowed the assembly to slowly sink further into the bottom, typically about one to two feet a day. The digging continued until the caisson had sunk to the desired depth, usually about 30 feet into the substrate. The contraption was also outfitted with an air lock to maintain the needed air pressure to keep water out of the caisson as well as an air pipe to the surface to maintain fresh air supplies. Once this work was completed the air chamber in the caisson was completely filled with compacted sand and the air and worker access shafts as well as the cylinder were filled with concrete. This type of submarine foundation is called pneumatic. The first pneumatic caisson lighthouse built in the United States was at Fourteen Foot Bank Lighthouse (1887), Delaware.[65]

Eleven pneumatic caisson lighthouses were built in the United States. In some areas where the bottom was unstable even at great depth, timber piling was used to transfer the loads even deeper into more stable strata.[66] Some caisson type lighthouses were built on rocks just above the water.

On average, the caissons were approximately 70 feet in height and 35 feet in diameter and the wooden crib approximately 10 feet high, 40 feet square, and 5 feet thick. This cast iron assembly served as a form for concrete, stone, and/or brick masonry that was added to anchor the caisson to the bottom; the form was not intended to function as a load-bearing element.[67]

On these caisson platforms, the builders erected several different styles of lighthouse towers. In the Chesapeake Bay, two dominated: conical metal lighthouses, often called coffee pots because their configuration suggested such, and brick structures suggestive of the Second Empire style. Elsewhere the superstructure was a slightly conical squat tower. All of these structures had work and storage space, and adequate water storage, as well as living quarters for the keepers.[68]

In the cast-iron structures, the casting was often lined on the interior with double wythe (masonry term for double lining or width) of brick masonry. Floor framing of rough timber was set in the framing bearing pockets formed in the masonry. Floor framing for the cast-iron quarters was often achieved by bolting radial sections of iron plates together to form a circular diaphragm that was supported by the cast iron walls and sometimes a central column.[69]

Depending on the height, caisson lighthouses had different levels. Often within the caisson a cellar was built within the upper 12 feet and enclosed with at least 6 feet of thick masonry or concrete walls. Occasionally recessed windows also were added for lighting purposes. These cellars were often used for fuel storage such as wood or coal bins and often a cistern for collecting water from the roof gutter and downspout system. The first level was usually partitioned into a sitting room, kitchen, and storage area, and completely surrounded by an exterior gallery deck. The main entrance was also located on this level. The second and sometimes third floor was dedicated to sleeping areas and storage. The level

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[65] Scheina, p. 23; and Clifford, p. 43. Johnson pp. 36-40 gives a good description of the construction of this pneumatic caisson lighthouse.

[66] "Chesapeake Bay Lighthouses," Gredell & Associates: Structural Engineers (Wilmington, Delaware, 1991), p. 12; file on copy at the National Maritime Initiative Office, National Park Service, Washington, D.C.

[67] "Chesapeake Bay Lighthouse Foundation Inspection," DTCG83-91-C-3WF269, Han-Pardon Associates (New York, New York, July 1992), p. 1.

[68]Holland, *Maryland Lighthouses of the Chesapeake Bay*, Chapter 4.

[69] "Chesapeake Bay Lighthouses," Gredell & Associates: Structural Engineers (Wilmington, Delaware, 1991), p. 12; file on copy at the National Maritime Initiative Office, National Park Service, Washington, D.C.

directly below the lantern room was the watch or service room. The fog bell operating equipment, if required, was often housed here. The lantern room was usually made of cast iron, surrounded with storm panels, and typically octagonal in shape. The cast-iron quarters usually had a spiral staircase that hugged the brick lining of the cast iron tower while the brick masonry type had a tight winder or straight run staircase between floors.[70]

Caisson lighthouses were more complicated and on average about four to five times more expensive to build than screwpile lighthouses, but they were better able to withstand the pressure of flowing ice. For this reason, many screwpile lighthouses in the Chesapeake and Delaware Bays were replaced with caisson type lighthouses. The Sharps Island (1882) caisson lighthouse, built to replace the 1866 screwpile lighthouse destroyed by ice in 1881, leans from ice damage that occurred in 1897.[71] Twelve caisson lighthouses were built on the Chesapeake Bay. Five of them replaced screwpile type lighthouses in Virginia waters and two in Maryland waters.[72] In all, 47 caisson lighthouses were built in the United States, 11 pneumatic and 36 non-pneumatic.

The caisson lighthouse, though superior to the screwpile lighthouse as far as stability is concerned, especially in northern locations where ice flow conditions exist, did not prove worthy for offshore ocean locations because of severe bottom scouring. For years a lighthouse had been suggested to replace the buoys off Diamond Shoals, 13 miles off the shore from Cape Hatteras, North Carolina. In the late 1880s a pneumatic caisson foundation with a tall steel light tower was designed for this location and $200,000 authorized by Congress in 1889 with the provision that the total sum did not exceed $500,000 an enormous amount of money for a lighthouse at this time. The caisson was 54 feet in diameter and 45 feet in height. It was sunk in 25 feet of water but the current action over the bottom soon scoured the site and tilted it out of level. A few days later, a storm, accompanied by large waves, washed over the top of the caisson and carried off the machinery. The contractors gave up in disgust, as did the Lighthouse Board, after a few more unsuccessful attempts. A lightship and then a Texas tower (discussed below) were finally placed on the shoal.[73]

Crib foundation

Wooden cribs constructed onshore, towed to the site, and then filled with stone to sink them in place was a lighthouse foundation type used extensively in the Great Lakes, many replacing lightships. This foundation type was especially well adapted to hard rock bottoms. Once settled and leveled, the cribs were capped with concrete or some other masonry upon which the lighthouse structure was constructed. Perhaps the two most significant crib foundation type lighthouses are the 93-foot Spectacle Reef Lighthouse (1874), Lake Huron, Michigan, located 10 1/2 miles from the closest land; and the 110-foot

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[70] "Chesapeake Bay Lighthouses," Gredell & Associates: Structural Engineers (Wilmington, Delaware, 1991), p. 12; file on copy at the National Maritime Initiative Office, National Park Service, Washington, D.C.

[71] Clifford, p. 132; and deGast, p. 131.

[72] Cohen, p. 17; and Holland (1993), p. 11.

[73] Johnson, pp. 11 and 40; and Wayne C. Wheeler, "Diamond Shoal Lighthouse: The Lighthouse That Never Was," *Keeper's Log* (1988) 4(3):24-29.

Stannard Rock Lighthouse (1882), Lake Superior, Michigan, located over 30 miles from the nearest land.[74]

Cofferdam and other miscellaneous foundation types

In shallow water, cofferdams were sometimes used to facilitate the construction of foundations providing a dry protected area in which to construct a permanent foundation made of stone or other masonry material. The temporary cofferdam was usually made of wood partially assembled on shore, brought to the site, bolted together, sealed, and the water pumped out. Many of the lighthouses with granite foundations in the Great Lakes were built this way, including Stannard Rock Lighthouse (1882) and Spectacle Reef Lighthouse (1874). Once the foundation was constructed safely above the water level, the cofferdam was dismantled, and the lighthouse tower built on top of the foundation. There were at least three granite and concrete foundation lighthouses which probably made use of cofferdams; the earliest apparently is Craighill Channel Lower Range Rear Lighthouse (1873), Maryland; followed by Hudson-Athens Lighthouse (1874), New York; and Robbins Reef Lighthouse (1883), New York.[75] The Craighill Channel Upper Range Front Lighthouse (1938) is unusual as the tower was built on the granite foundation base of an earlier range light built on land in 1824, but over the years the land has receded around the base so that the 1938 structure built on the earlier foundation is now located several hundred feet offshore. At least three lighthouse foundations were made of stone below the surface of the water without using a cofferdam.

Texas tower

A relatively recent technological development in lighthouse construction is the Texas tower type which replaced lightships in open ocean conditions in waters greater than 30 feet. These so-called Texas towers were modeled after offshore oil drilling platforms first employed along the Texas coast. All the major components of these structures were prefabricated in sections and towed to the site.

The first Texas tower lighthouse in the United States is the Buzzards Bay Lighthouse, located in Buzzards Bay, Massachusetts, and commissioned on November 1, 1961. It is anchored to the ocean bottom by four 33-inch-diameter steel pipes, and cross-braced with 16- and 18-inch-diameter steel pipes both horizontally and diagonally. Through each of the main 33-inch pipes a 30-inch-diameter steel pile was driven to bedrock, a depth of 268 feet below mean low water. The piles were partially filled with concrete. Upon this foundation, 66 feet above the water, is the platform, consisting of two decks. The lower deck houses water and fuel and the upper deck, the living quarters. On top of the top deck is a helicopter landing deck and to one corner are the light and radio tower, foghorn, and radiobeacon. The focal plane of the light is 101 feet above the water, visible 16 miles at sea, with a capacity for 400,000 candlepower under normal conditions and 5,000,000 candlepower under low visibility conditions. The open ocean waves pass under and around the open pile foundation.

Five additional Texas towers have been constructed including: Savannah Lighthouse (1964) off Georgia; Chesapeake Bay Lighthouse (1965), off the mouth of the Chesapeake; Ambrose Channel Lighthouse (1967), off New York City; and Diamond Shoal Lighthouse (1967), replacing a lightship station. These

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[74] Scheina, p. 22; Johnson, pp. 32-34; "Historically Famous Lighthouses", pp. 54-57; and Clifford, pp. 202 and 206. Note Scheina lists Stannard Rock Lighthouse as Standard Rock Lighthouse. Wayne Wheeler, personal communication, February 28, 1998.

[75] Clifford, pp. 126, 238 and 246-47; and Holland, *Maryland Lighthouses of the Chesapeake Bay*, p. 90.

Texas towers were built with an expected life span of about 30 years. Buzzards Bay Lighthouse has been extinguished and is scheduled for dismantlement. It is to be replaced by a newer non-Texas type tower which will resemble the tower that marks the entrance to the harbor at Valdez, Alaska. Ambrose Lighthouse is also scheduled to be demolished. These Texas-tower type lighthouses were expensive to construct, and not a large number of them were erected.[76]

Fiberglass towers

In an effort to keep maintenance costs down, the English introduced the concept of the fiberglass (glass-reinforced plastic) light tower which was adopted by the Coast Guard. The color of the tower is molded into the plastic with pigments so painting is not necessary. Little, if any metal, is used to keep saltwater corrosion to a minimum. The light lens is plastic and no storm panes are required for protection. The result is very low maintenance light towers. The first use in the United States of a fiberglass light tower was apparently in northern California in the 1960s. Three were built in New England in the early 1980s: Great Salt Pond Light, Block Island, Rhode Island; Deer Island Light, Boston Harbor, Massachusetts; and Cape Cod Canal Breakwater Light, Massachusetts. The first plastic Deer Island Light, a white tower built in 1982, replaced an iron tower on a caisson. The present red-brown plastic tower replaced the white plastic tower in 1984. The Cape Cod Canal Light is a plastic red tower built in 1986, which replaced a metal skeletal tower, now used for the fog signal.[77]

Light Station Components

The U.S. Lighthouse Service in 1915 regarded lighthouses as stations where resident keepers were employed.[78] With today's automated lights, under this same definition, very few lights would be classified as lighthouses. The 1995 *Light List* defines lighthouse as a lighted beacon of major importance. Buoys and lights housed outside of buildings are not considered lighthouses. The former light at Dutch Gap on the James River near Richmond, Virginia, consisted of a tiny lantern suspended from a 10-foot tripod. It was serviced by the keeper via a small ladder. While this light was considered a minor aid to navigation, it was not a lighthouse.[79]

The concept of the "light station" came into being during the period that the Lighthouse Board administered aids to navigation, 1852-1910. A station consisted of the light tower, a dwelling, a garden site, a place to store oil, and maybe a chicken house and shelter for a milk cow. The increased complexity of operation, with the introduction of the more sophisticated Fresnel lens and fog signal in the 1850s, particularly the steam-operated ones, brought about a need for more personnel, which in turn required additional housing and other support buildings such as fog signal buildings, workshops, cisterns and water catchment basins, storage buildings, garages, radio buildings, boathouses and tramways, among others. By the 1920s and 1930s, however, the majority of light stations had electric service,

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[76] LNBs, large navigational buoys, were often employed instead of Texas towers. These are typically 40 foot in diameter, equipped with a radiobeacon signal, a horn fog signal, a RACON for identification, and a light 42 feet above the water which can be seen 14 miles away.

[77] Robert Fraser, "Plastic Towers," *Lighthouse Digest*, volume 4, number 1 (January, 1995), p. 7; and Barnes, p. 13.

[78] de Gast, p. viii; and *United States Lighthouse Service 1915* (Government Printing Office, Washington, D.C., 1916), p. 18.

[79] Eshelman, "Lighthouse Construction Types," unpublished monograph, 1997.

reducing the number of staff necessary to operate the station. As ancillary buildings at many stations, especially shore stations, were rendered useless, the makeup of the light station began to change. Electrification and automation of many light stations led to the removal or demolition of many obsolete light station buildings.

Light tower

The tower served principally as a support for the lantern that housed the light. The lantern was typically a cast-iron round, square, octagonal, or decagonal-shaped enclosure surrounded by an exterior stone or cast iron gallery with railing. Access to the lantern at the top of the tower was via stone, wood, or cast iron stairs which either wind around a central column or spiral along the interior sides of the tower walls (a few had straight sets of stairs which ran from landings around the tower interior). Windows in the tower were positioned to provide daylight onto the stairs. For taller towers, landings were provided at regular intervals. The top landing ended at the watch room where the keeper on duty ensured the optic was functioning properly. The lantern room above was usually reached via a ladder.

The most recognizable lighthouse type is the stand-alone tower such as Cape Hatteras Lighthouse. Lighthouses of this type come in many shapes including conical, square, octagonal, cylindrical, and even one triangular. Lighthouse towers may also be attached or integral to the keepers' dwellings, and in a few cases, fog signal buildings. Attached towers are those connected to a keeper's quarters to another structure, often by a hyphen; whereas integral towers are those structurally built into the structure with the tower extending through the roof.

Lantern

In the early days, lanterns were made of thin copper frames that held small panes of glass. The glass framing extended from the gallery deck to above the lighting equipment it held. A copper dome topped by a ventilator served as the roof of the lantern. Its design has given it the appearance of a birdcage, and in more recent years, it has been known by that name. In addition to using small panes of glass that were of poor quality, these lanterns were generally not of adequate size to hold Fresnel lenses. Consequently, when the Fresnel lens was introduced wholesale in the 1850s, most of the old style lanterns were replaced with new lanterns designed to hold the larger and heavier Fresnel lenses. Today only a few of the old-style lanterns survive on lighthouses, including Prudence Island Lighthouse in Portsmouth, Rhode Island; Baileys Harbor Lighthouse, Lake Michigan; and Selkirk Lighthouse in Pulaski, New York.

There were four sizes of lanterns created to accommodate the seven standard sizes or orders of Fresnel lenses--a separate design for the first-, second-, and third-orders, and one design for the fourth- through sixth-order lenses. Made of cast iron plate, they were six-, eight-, and ten-sided lanterns, although round and square lanterns were sometimes used for range lights. They had large panes of glass, one pane to a side for the smaller lanterns, and as many as three panes (one over the other) per side for the two largest size lanterns. Typically the section of the lantern slightly below the level of the bottom of the lens was covered with iron plates in the smaller sized lanterns. One of the metal panels was hinged to serve as a doorway providing access to the gallery or walkway on the exterior of the lantern.[80] The roof of the

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[80] On larger lanterns, the glass panes continued to floor level; one pane might be hinged to serve as a doorway. For first and second order lanterns the lantern was usually circular. Also, on these lanterns there was another, narrower, outer gallery walkway at the level of the bottom of the glass which permitted the keepers to reach the glass for cleaning and repair purposes.

lantern, sometimes dome like and at other times a low peaked pyramidal roof, was usually made of copper. A ventilation device often a finial ball on the roof and slots in the parapet wall permitted proper ventilation. A lightning rod surmounted the ventilator device. At the roof's edge small gargoyle heads occasionally served as downspouts.

In the late 19th century, the helical bar lantern was introduced. Rather than having vertical astragals, they had diagonal ones. On the larger lanterns, the astragals crossed. The lighthouse officials believed these types of lanterns gave off a brighter light when housing rotating lenses because the light beam was only partially blocked at any one time by the diagonal astragals versus a split second total eclipse of the light beam by vertical astragals.

Keeper's dwelling

Second in importance to the light tower, dwellings for light keepers and their families were generally, in the early days, simple 1 and 1/2-story wooden or stone structures. Since lighthouses had only one keeper, there was only one dwelling. After 1852 with the coming of the Fresnel lens and the Lighthouse Board, more keepers began to be assigned to light stations, and, of course, it became necessary to have more living accommodations. Keeper's quarters could be single, double, triple, or even quadruple dwellings; they reflected the prevailing architectural styles, adaptations to geographical conditions, or regional tastes. Complaints by keepers concerning lack of privacy for their families finally persuaded the Lighthouse Board not to build tri-plex housing. By 1913, the U.S. Lighthouse Service stressed that a recent practice favors detached houses, insuring greater privacy, and giving better opportunity for yards and gardens.

For all practical purposes, prior to 1852 there were two types of land-based lighthouses: either a detached dwelling or an integral dwelling with the light tower rising out of the roof. The early integral towers had the tower supported by the roof system. As time went on with the lighting apparatus getting heavier, particularly with the advent of the Fresnel lens, the tower was supported from the foundation of the keeper's dwelling. The plans for Blackistone Island Lighthouse in the Potomac River, designed in 1852, clearly shows the support system ascending from the ground. The two-story dwelling had the wood tower rising through its center. Fortunately, this lighthouse needed only one keeper, even after the introduction of the Fresnel lens. In colder climates, such as New England and the Great Lakes, the light tower often was either attached to the dwelling or an enclosed passageway was built between the two structures.

Oil house

During the early days oil was often stored in the lighthouse. The contract to erect the Cape Henry Lighthouse in 1792, however, called for the oil to be stored in an underground vault with a shed built above it.[81] As late as the early 1850s, plans for the first west coast lighthouses called for the oil storage area to be in the basement. Some lighthouse towers were constructed with attached oil room and workroom structures that were generally one-story, constructed of masonry, had gable roofs, and were modest in detailing; examples include Pensacola, Pigeon Point, and Yaquina Head Lighthouses.

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[81] Watson and Henry Associates, *Historic Structure Report for the Old (1792) Cape Henry Lighthouse, Virginia Beach, Virginia*, July 1990, Association for the Preservation of Virginia Antiquities, Richmond Virginia, p. 22. This type structure did not work well at this site which is a sand covered area, for by 1794 the oil was reported as being stored in Norfolk.

By 1890, all except a few lighthouses in the United States were using kerosene. The volatile nature of kerosene necessitated the construction of separate oil houses, which were usually built of fireproof materials such as brick, stone, iron plate and concrete. Congress issued a series of small appropriations for the construction of separate fireproof oil houses at each lighthouse station. Installation of these structures began in 1888 and was completed about 1918. The 1902 *Instructions to Light-Keepers* stated: "All mineral oil belonging to the Light House Service shall be kept in an oil house or a room by itself. The oil house shall be visited daily to detect loss by leakage or otherwise, and every precaution taken for the safe keeping of the oil."

Though they varied in size, lighthouses with smaller lenses had relatively small oil houses and those stations with the large lenses, had relatively larger oil houses. Constructed of stone, brick, cast iron, and concrete, oil houses were small, simple, and functional, usually with a gabled or a pyramid roof. When oil was no longer required, the structures were used for other storage purposes, often paint storage. In some instances, these buildings were torn down after becoming obsolete.

Fog signal building

Fog signals were developed to assist mariners when fog obscured the light. Fog signals included bells, cannons, sirens, diaphragm horns, and trumpets, and were usually housed in separate buildings, which were either attached to the light tower or free-standing. The equipment for large coastal stations was provided in duplicate to guard against breakdowns that might cause an interruption in fog signal operation.

Light stations began to get a little more complex with the introduction of fog signals. The first fog signal was a cannon placed at Boston Harbor light in 1719. Over the years a few other light stations had a cannon to warn seamen. In the 1820s, a bell fog signal was apparently introduced at West Quoddy Head Lighthouse in Maine.[82] Subsequently, other fog bell signals were added around New England and down to Chesapeake Bay; south of the bay, fog occurs much less frequently.

In the very early days, fog bells were rung by striking the bell by hand; the bell installed at Pooles Island Lighthouse, Maryland, in the mid-1820s was operated by mechanical means, using a clockwork system. A tower on which the fog bell hung was built near the shore. A rope ran from a striker to the top of the tower where weights were attached. As those weights slowly fell, they would activate the striker so that it struck the bell periodically. When the weights hit bottom after 45 minutes, sometimes an hour and a half, the keeper cranked the weights back to the top to start the process over again. Later, Daboll, Stevens, and Gamewell invented clockworks that were advertised as good for 10,000 blows of the fog bell with one winding. With a rapid characteristic, i.e., a blow every 10 seconds, a day could pass between windings; with a characteristic of a blow every 30 seconds, four days could pass before another winding. [83] In time, electricity was applied to fog signals that eased the burden of tending them. In the 1920s, a device that turned the bell on automatically came into use. It was a hygroscope measuring moisture in the air that activated the bell.

[82] This statement is based on the correspondence of the fifth auditor when the fog bell was being installed at the Pooles Island Lighthouse in Chesapeake in the 1820s. In this letter the fifth auditor said that the only other fog bell that he was aware of was at Passamaquoddy. See F. R. Holland, *Maryland Lighthouses of the Chesapeake Bay*, p. 16. Obviously the lighthouse he was referring to was the West Quoddy Head light near the Passamaquoddy Bay, for in 1820 Congress authorized an appropriation to install a fog bell at West Quoddy Head lighthouse. See George R. Putnam, *Lighthouses and Lightships of the United States* (Boston and New York: Houghton Mifflin Co., 1917), p. 228.

[83] Personal communication, Wayne Wheeler, February 28, 1998.

The earliest fog signal structures were wooden bell towers; later designs included iron construction.[84] The towers were usually a tapering square shape topped by a pyramidal metal roof. The tower structure was often exposed except for the enclosed upper level area that protected the bell-striking mechanism. These towers were built in exposed marine environments and subjected to heavy vibrations from the striking of the bell. They had to be replaced frequently and few survive. For the most part, the ones that survive are metronome in shape.

On stations built offshore such as caisson and screwpile structures, the fog bell was usually mounted outside the top half-story of the dwelling (just below the lantern) and struck by machinery mounted on the inside. The striker hammer passed through a hole in the wall. In screwpile lighthouses, the weights that drove the striking machinery were usually suspended by wire down through a wooden square shaft and/or in a closet. In many caisson lighthouses, the weights were suspended by wire through a central hollow structural support column. The weights were usually suspended through the first level deck of a screwpile lighthouse or to the cellar level of a caisson lighthouse. When electric fog signal horns began to replace the fog bells, the new devices were often mounted on the deck of the lantern gallery, or in the case of a caisson lighthouse on the deck of the lower gallery, or in the case of a crib lighthouse on the crib foundation platform.

During the latter half of the 19th century, the Lighthouse Board experimented with various types of fog signals, including whistles, trumpets, and sirens. At first, whistles were not successful; mainly, the board later determined, because the tests were run on too small a steam whistle. Some years later, it ran more tests, this time with the largest railroad steam whistle. The tests were successful, and the steam whistle was installed at a number of light stations. These fog signals continued in service into the 20th century. A modified version of this signal continues in use, but operated by compressed air, not steam.

Daboll's trumpet was also experimented with, but it too apparently was not successful for it was not put into general use. This fog signal had a reed that was vibrated by compressed air and the sound came out of a large trumpet, one order measuring 17 feet long and 38 inches across the opening. The siren fog signal was first used in 1868 and was most successful.[85]

Another fog signal used until recently, the diaphone, a Canadian development, gives off a two-tone sound that was made popular in the hey-day of radio by a Lifebuoy soap advertisement. It was available in several sizes and used a single tone, two-tone, and chime signal. These fog signals with their steam or compressed air apparatuses, switchboards, work benches, storage cupboards, generators, engines, air and water tanks, pumps, tools, and signal equipment occupied near barn-like buildings. The sound equipment was usually attached to the waterside of the building. Built of masonry or wood, these structures were usually plain and highly functional, with the interiors being mostly open space until filled with concrete machinery mounts, tools, and equipment. Some fog signal buildings were built integral to the light tower. The Cape Arago Light Station and the octolateral brick stucco fog signal at Coquille River Light Station, Oregon, are examples. In a few instances, a fog signal station was established without a light.

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[84] A few stone fog signal towers were also constructed but none survive.

[85] F. R. Holland, *America's Lighthouses: Their Illustrated History Since 1716* (Brattleboro, VT: Stephen Greene Press, 1972), pp. 204-205.

Today fog signals, for the most part, are intended to aid small vessels and boats that do not have the advanced electronic gear such as radio direction finders, radar, sonar, and satellite guidance. As a result, the fog signal is being downsized. Today, the only fog signal the Coast Guard operates is the electronic horn; the ELG300 and ELG 500 have a three to five mile range and the FA 232 has a 1/4 to one mile range.[86]

Radiobeacon

About 200 radiobeacons located mostly at lighthouses, and formerly on lightships, were established on all ocean coasts and the Great Lakes. Commissioner George R., during his administration of aids to navigation, put the evolving use of the radio as one of his proudest accomplishments; he considered the radiobeacon the definitive guidance during fog for vessels that could afford radio direction finders. A vessel could search out a signal from a radiobeacon and determine his position in relation to that station. This system is considered short range, effective between 10 and 175 miles.[87] The equipment at the station consisted of antennas and transmitters and occupied space on the grounds and in a building. With the advent of new and better technology, the Coast Guard has taken all of their radiobeacons out of service.

Storehouse

Many onshore stations had separate frame or masonry storehouses where provisions, spare parts, and other items could be stored. Offshore stations made use of nearly every available space for storage. Caisson light stations used the cellars for storage of oil, coal, wood, provisions, and other items. Screwpile light stations usually had a wooden secondary landing built into the spider-like foundation below the first-level of the cottage. Here fuel, live animals, and other items could be stored. In times of storms, however, these areas were vulnerable to water damage. For offshore stations, the closets, the watchroom, and the eaves under the upper half-story were used to store necessary materials.

Boat and boathouse

In the early days, the light keeper who tended an offshore lighthouse could justify a boat to go back and forth to the mainland. But if a keeper was responsible for a light on the mainland, he would have to have strong justification, no matter how isolated the lighthouse may be, to be successful in obtaining a locally made boat from the government. These boats usually had a sail and could be rowed. At the lighthouse, these boats were pulled ashore when not in use and left in the open.

The Lighthouse Board was more generous in size and number of boats, partly because of increase in personnel. The Board also began providing boathouses to shelter the boats. The boathouses were simple gabled-roofed sheds with iron rails on which to pull the boat into the shed. Such structures became more important as technology advanced and the engine-powered boat came into use. These early boats were rather cranky, and the engine would often stop running at inopportune times. Boats were supplied to offshore lighthouses such as the screwpile, caisson, waveswept, and crib types as well as the Florida reef lights. Occasionally, isolated shore light stations without road access received boats so keepers could travel to nearby towns. Two boats were usually assigned to each offshore station, and they hung suspended from davits on opposite sides of the station so that the keeper could maintain a lee

[86] Personal communication, Wayne Wheeler, February 28, 1998.

[87] U.S. Coast Guard, *Light List, Gulf of Mexico*, pp. xxiii-xxiv.

for safer leaving and arriving, regardless of wind conditions. Canvas covers supplied protection from the weather.

There were several reasons for justifying two boats at an offshore light station, and one of them was the increase in rescues of fishers and boaters in trouble, and in some sections of the country, pilots of planes forced down in nearby waters. The engine-powered boats, which appeared soon after the turn of the century, could get to an accident quicker. One cannot but be impressed with the number of rescues by keepers that were recorded in the *Lighthouse Service Bulletin*, the internal newsletter of the Lighthouse Service.

Barn and garage

Some of the light stations received government-built barns where horses and perhaps a cow could be sheltered. With the coming of the automobile, light stations began to receive garages. Because they are recent, a number of garages survive; certainly more garages survive than barns. These structures were simple, standard garage structures with up to three bays. Many barns were converted to garages including Pensacola Light Station, Florida and Montauk Point Light Station, New York. The resourcefulness of lighthouse personnel is illustrated by the 1950s conversion of a garage into living quarters at Cove Point Light Station, Maryland. The garage had been moved and remodeled into a dwelling.

Privy

The necessary house for shore stations was generally no different than any other privy. Usually they were simple wooden frame structures, but on occasion they could be fancy, following the style of the dwelling. Currituck Light Station had one that was of Queen Anne design to match the keeper's quarters. Some were made of brick, a material not used for privately constructed privies.
For offshore stations, the privy was usually constructed so it cantilevered over the lower exterior gallery rail. The privy hole dropped directly into the water. They were small, accommodating only one user at a time. Those at screwpile lighthouses were made of wood, while the ones at caisson lighthouses were made of iron plate. On the latter, the privy was sometimes used as part of the electrical grounding system. A metal cable ran from the lightning rod down the roof of the lantern, then from the roof of the dwelling to the top of the privy that was attached to the iron-plated caisson tube. With more stringent environmental laws and newer technology, indoor plumbing came to land-based light stations. By the 1970s, offshore light stations began to convert interior spaces for restrooms. Holding tanks and electric commodes were used. The former privy was sometimes converted for storage or used as a paint locker. With the erection of the Texas tower type lighthouses, indoor plumbing became standard.

Water collection system

All lighthouses needed water. Some stations used wells. At other stations, water was piped in from nearby springs. Often, water collection systems provided water for drinking, washing, and for steam powered fog signals. Rainwater was often collected from the roof of light station structures channeling the water from gutters and downspouts to pipes going to the water reservoirs. Rainwater was usually not collected immediately; rather, the rain was allowed to fall for a while uncollected so the roof would be washed. Periodically the rooves were cleaned by manual means. At other light stations, particularly in drier regions such as California, water was not only caught by roof runoff but also by large catch basins connected to storage cisterns and tanks were used to trap the rainwater. These catch basins were generally constructed of brick, later covered with cement or made only of cement. The Old Point Loma

Lighthouse in San Diego still has the remains of its old brick-lined underground cistern that held 10,000 gallons. Its 2800 square-foot catch basin was attached to it. Other examples of existing catch basins are found at Point Reyes, San Luis Obispo and East Brothers Light Stations, all in California.

Where the underground water level was too high, a light station may have wooden water storage tanks aboveground. The water system for the Anacapa Island Light Station off southern California consists of a 30,000-square-foot concrete rain catchment basin and two round 50,000-gallon redwood tanks housed in a specially built water tank building. As the average rainfall is only eight inches providing only 18,000 gallons of water a year, lighthouse tenders supplied the additional water that was pumped into the storage tanks.

At offshore stations such as screwpile and caisson stations, the gutters and downspouts were attached to a water collection system inside the structure. In screwpile structures, the system was connected to water tanks, usually one in each of three or four rooms of the first-floor of the cottage. The tanks were made either of cypress or metal. A spigot at the base of each tank was positioned over a metal funnel cut into the floor so that any dripping or overflow could be controlled without flooding the cottage floors. These funnels are still intact in the Thomas Point Shoals Light Station (1875), Maryland.

In the caisson light stations, the cisterns were constructed into the concrete fill of the caisson cylinder just below the cellar level. There were usually two cisterns for each caisson light station. Like the screwpile structures, the cisterns were connected to the downspouts. A hand pump in the kitchen, connected to the cellar cistern provided water to the kitchen sink. In times of drought, buoy tenders would provide freshwater to top off the cisterns and other station water storage tanks.

Tramway

A number of light stations had tramway tracks running from landings to the light station. The tramways were principally used to unload supplies and equipment from the lighthouse tender. A few of the tracks survive at a number of light stations, including Point Reyes, California, and Split Rock, Minnesota.

Lighthouse Depot

From the beginning of the service, lighthouses had to be supplied with oil, wicks, extra chimneys for lamps, glass panes for the lantern and other equipment and materials such as brushes, brooms, oil containers, lucernes, clocks, dust pans, feather dusters, cleaning liquids and solids, paint, and wick trimmers. All these items were required to keep these aids to navigation in operation. Fresnel lenses were more complex and with their installation came a substantial increase in required tools and equipment. As the lighthouse service grew, the number of lighthouse depots increased. A tender assigned to each district inspector supplied the light stations, placed and replaced lightships, and positioned and replaced buoys and daymarks.[88] In addition, an inspector would arrive by a tender for his white glove inspection of the light station.

Lighthouse depots came into use in the midst of the Civil War with one per district. At the general depot on Staten Island, oil and lamps and other equipment were tested and often developed. All depots purchased supplies, including oil, and dispersed them to the districts. Those supplies destined for the east and Gulf coasts went largely by water, while those going to the Great Lakes and the west coast

[88] Lighthouse Board, *Instructions to Light-Keepers and Masters of Light-House Vessels, 1902* (Washington: Government Printing Office, 1902), p. 22.

districts went largely by rail.[89] Surviving examples of lighthouse depots include Staten Island Depot, New York (the first and general depot for the service); Detroit Depot, Michigan; and St. Josephs Depot, Michigan.

Some light stations were also used as buoy depots. Point Lookout Light Station, Maryland, became a buoy depot in 1883. Extant structures from the depot include a former coal shed (1884), used to resupply tenders, a buoy repair shed (1883), and remnants of the wharf piles and the concrete shore apron of the former rail delivery system.

Miscellaneous Structures

Other typical station outbuildings might include piers, smokehouses, wood and coal sheds, and carpenters' and blacksmiths' workshops. Relatively newer station buildings exist at some light stations such as signal/radiobeacon/generator buildings.

Regional Adaptations and Variations

Height of tower

The purpose of a light tower is to get a light high enough to be of sufficient aid to the mariner. Consequently, the East Coast from Long Island, New York, southward to the Florida Keys and around the Gulf of Mexico is very low, generally just a few feet above sea level, and requires relatively tall towers for its coastal lights. But in parts of New England and on the west coast, the high coastline requires relatively short towers. For example, the Block Island Southeast tower is 67 feet tall, but the site elevation raises the focal plane height of the light to 201 feet. Cape Cod, or Highland, light tower is 66 feet tall, but the bluff on which it rests lifts the focal plane height of the light to 183 feet. Sankaty Head and Gay Head light towers are relatively short, but the elevation of their sites raise the focal plane height of the lights to well over 160 feet. The light tower on Monhegan Island off the coast of Maine is but 47 feet tall, but the height of the focal plane is 178 feet above sea level. These coastal lights were usually fitted with first- or second-order lens.[90]

On the west coast, sites at high elevations and short towers abound. Indeed, the two lighthouses that have held the "title" of highest lights in the United States are on the California coast. The Old Point Loma Lighthouse in San Diego, a 40-foot tower built on a high promontory supported a third-order lens at a focal plane of 462 feet above sea level. Shortly after being lighted, it was reported as being seen from 25 miles and 39 miles.[91] When the Old Point Loma Lighthouse went out of service in 1891 because low clouds often obscured its light, the Cape Mendocino Lighthouse in northern California, also located on a high cape, became the highest light. Its 43-foot tower held a first-order lens. The focal plane of the light was 422 feet above sea level.[92]

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[89] George R. Putnam, *Lighthouses and Lightships of the United States (*Boston: Houghton Mifflin, 1917), p. 48; F. R. Holland, Jr., *America's Lighthouses: Their Illustrated History Since 1716* (Brattleboro, VT: Stephen Greene Press, 1972), p. 36.

[90] U. S. Coast Guard, *Light List, Atlantic and Gulf Coasts, 1946* (Washington, Government Printing Office, 1946), pp. 100-101; Dept. of Commerce, *Light List, Atlantic and Gulf Coasts, 1933*, pp. 44-45, 50-51, 16-17.

[91] F. Ross Holland, *The Old Point Loma Lighthouse* (San Diego: Cabrillo Historical Assn., 1978), pp. 16, 19.

[92] U.S. Coast Guard, *Light List, Pacific Coast, 1943*, (Washington: Government Printing Office, 1943), pp. 94-95.

Typically, tall towers are coastal towers 150 feet or more in height while harbor, bay, sound, and river lighthouses are typically less than 100 feet in height. Some lighthouses along New England coast did not reach 150 feet but were still considered coastal lights. Cape Elizabeth Lighthouse with a focal plane height of 129 feet above sea level, Petit Manan Lighthouse at 123 feet, and Boon Island Lighthouse at 133 feet are three examples. Each was fitted with second-order lenses.[93]

Though a few lighthouses in the Great Lakes achieved a focal plane height of over 150 feet, this was accomplished by building towers on high elevations. Though important coastal lights were built on the Great Lakes, the towers were only 90 to 110 feet tall. The only lighthouse to exceed that height was the 121-foot tower erected on a crib foundation at White Shoal in Lake Michigan.

Harbor entrances and bay or river traffic were marked with short towers no matter what the elevation. Chesapeake Bay, Delaware Bay, Hudson River, and Puget Sound are large bodies of water that had numerous lighthouses that were relatively short towers. Like the tall towers, these short towers came in many shapes, including conical, round, multi-sided, and square and were built of a variety of materials, brick, stone, wood, and metal predominating. They included the 36-foot Eastern Point Lighthouse at the entrance to Gloucester Harbor in Massachusetts, the 35-foot Pass Manchac Lighthouse at Lake Pontchartrain in Louisiana, the 27-foot square Point No Point Lighthouse in the Puget Sound, and the 43-foot conical Concord Point Lighthouse at Havre de Grace, Maryland, in upper Chesapeake Bay.

Placement of lighthouses

As aids to navigation, lighthouses serve to assist the mariner in fixing his position; warn the mariner of hazards or danger; and/or indicate a harbor entrance. The placement of lighthouses may also be affected by political and public pressure or building technology present at time of construction. Some lighthouses are located at significant landfalls. For example, transatlantic steamers bound for New York aim for the Fire Island Lighthouse, generally the first lighthouse this traffic sees. Kilauea Point Lighthouse is the landfall light for traffic bound to Hawaii from the Orient.

The most important reason for the location of a lighthouse is to mark dangerous shoals and reefs. Cape Hatteras Lighthouse marks the dangerous offshore Diamond Shoals and Minots Ledge Lighthouse marks a dangerous, hard to detect, submarine reef. Lighthouses were also built to mark the entrance to a river, bay, or harbor. These entrances often have two lighthouses, one for each side of the entrance. Cape Charles Lighthouse marks the northern and Cape Henry Lighthouse the southern entrance to Chesapeake Bay. Inside the Chesapeake Bay some of the tributaries have two lights, others just one, marking an entrance. The mouth of the Potomac River has Point Lookout Lighthouse on the Maryland side and Smith Point Lighthouse on the Virginia side. Delaware Bay is marked on the north by Cape May Lighthouse and on the south by Delaware Breakwater Lighthouse. (Cape Henlopen Lighthouse was the first and only lighthouse to mark the Bay's entrance when first built; it eroded into the ocean in 1926.) No less than five lighthouses mark San Francisco Bay entrance.

Range lights consist of a pair of towers, a lower front range and a taller rear range. When the lights are lined up one above the other, they assist the mariner in keeping their vessel in the channel, navigating twisting rivers, staying in channels running through shallow waters, and entering narrow harbors.

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[93]Ibid.,pp. 22-23, 10-11, 24-25.

Sometimes the entrance to a very busy harbor such as Baltimore, Maryland, has multiple aids to navigation.[94]

Architectural styles

The United States has the most diverse collection of lighthouse architecture than any other country in the world. A number of well-known styles of architecture are reflected in the structures at light stations. A sampling of many of these architectural styles follows.

The Cape Cod style consists of a 1 1/2-story Cape Cod style dwelling constructed around an integral light tower. This style was used often in the Chesapeake Bay and in New England as well as among the first lighthouses built on the west coast. Examples include the now-demolished Greenbury Point Lighthouse (1848), Maryland; and Point Pinos Lighthouse (1855), California. A non-integral Cape Cod style is represented by the keeper's quarters at Scituate Lighthouse (1811), Massachusetts; and Burnt Coat Harbor (1872), Maine.

The Gothic Revival style is represented by Block Island Southeast Lighthouse (1873), Rhode Island; keeper's quarters at Eastern Point Lighthouse (1879), Massachusetts; keeper's quarters at Nauset Beach Lighthouse (1875), Massachusetts; keeper's quarters at Straitsmouth Island Lighthouse (1835), Massachusetts; Sand Island Lighthouse (1881) in the Apostles Islands, Wisconsin; keeper's quarters at Yerba Buena Island Light Station (1873), California; and the Dunkirk Light Station keeper's quarters (1875) in upstate New York. Variations of the Gothic style include the Gothic Victorian style found in the keeper's quarters at Point Montara Lighthouse (1875), California. The Carpenter Gothic style is found in the keeper's quarters at Stratford Point Lighthouse (1881), Connecticut; and keeper's quarters at Sandy Neck Light Station (1880), Massachusetts. The Stick Gothic style is found in the keeper's quarters at Mispillion Lighthouse (1873), Delaware; and keeper's quarters at Fenwick Island Light Station, Delaware. The Norman Gothic style is represented by the keeper's quarters at Passage Island Light Station (1882), Michigan; and keeper's quarters at Sand Island Light Station (1881), Wisconsin.

The Queen Anne style is present in the keeper's quarters at Cape Cod Lighthouse (1857), Massachusetts; keeper's quarters at Fort Niagara Light Station (1897), New York; and the keeper's quarters at Hospital Point Light Station (1871), Massachusetts.

Eastern Stick style is illustrated by the keeper's quarters at Tybee Island Light Station (1881), Georgia; integral tower and keeper's quarters at Hereford Inlet (1874), New Jersey; keeper's quarters at Currituck Beach Light Station (1876), North Carolina; and keeper's quarters at Boston Harbor Light Station (1884), Massachusetts.

Elements of the Second Empire can be seen at New London Ledge Light Station (1909), Connecticut; keeper's quarters at Barbers Point Light Station (1873), New York; Southwest Ledge Light Station (1877), Connecticut; Esopus Meadows Light Station (1872), Hudson River, New York; and caisson lighthouses in Chesapeake Bay such as Sandy Point (1883), Point No Point (1905), and Baltimore (1908).

The Romanesque Revival style is exhibited by the Toledo Harbor Lighthouse (1904), built on a submarine crib foundation in Lake Erie, Ohio; and the fog signal building (1889) at Point Sur Light

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[94]An interesting article on range lights is Wayne Wheeler, "Range Lights," *The Keeper's Log*, v. II, no. 1, pp. 9-10.

Station, California. The Neo-Classical style is represented by keepers' quarters at the following Puerto Rico light stations: Arecibo (1898); Cape Rojo (1882); Cape San Juan (1880); Cardona Island (1889); Guanica (1893); and Muertos Island (1887); and the quarters at Browns Point Lighthouse (1903), Washington.

The Craftsman/Colonial Revival style is represented by the keeper's quarters (1902) converted from the 1889 engine house at Point Sur Light Station, California; keeper's quarters at Marcus Hook Range Rear Light (1918), Delaware; Marshall Point keeper's quarters (1896), Maine; and keeper's quarters at Reedy Island Range Rear Light (1906), Delaware. The Dutch Colonial style is illustrated by the keeper's quarters at Wood Island (1857, remodeled 1906), Maine; and keeper's quarters at Presque Isle Light Station (1870), Michigan.

The Spanish Revival style can be seen in structures at Point Conception (1882), Point Vicente (1926), near Los Angeles, and Anacapa Light Station (1932), Anacapa Island, all in California.

The Greek Revival style is illustrated by the keeper's quarters at Liston Range Rear Light (1907), Delaware; keeper's quarters at Ida Lewis Rock Light Station (1856), Rhode Island; and integral tower and dwelling at Patos Island (1898), Washington. The Egyptian Revival style is represented by the Southwest Reef Lighthouse tower and keeper's quarters (1858), Louisiana. The Moorish Revival style is found in the integral tower at Port San Juan (1908), Puerto Rico.

The Victorian style is found in many light stations including the integral keeper's quarters at San Luis Obispo Light Station (1890), California; Cape Elizabeth keeper's quarters (1878), Maine; Cape Neddick keeper's quarters (1879), Maine; and Great Captain Island Lighthouse (1868), Connecticut. The Italianate Victorian style is found at Point Fermin Lighthouse (1874), California; and keeper's quarters at Block Island Lighthouse (1867), Rhode Island. The Italianate style is illustrated by the Grosse Point Lighthouse keeper's quarters (1873), Illinois; and the keeper's quarters at Saugerties Lighthouse (1869), New York.

The Mission Revival style is represented by the keeper's quarters at Point Loma (new) Light Station (1891) in California. The Flemish Revival style is illustrated by the keeper's quarters at Grand Traverse Light Station (1899), Michigan. The Federal Revival style is found in the keeper's quarters of Bristol Ferry Lighthouse (1855), Rhode Island.

The Art Deco style is represented by the keeper's quarters at Milwaukee Breakwater Lighthouse (1926), Wisconsin; and several Alaska light stations such as Cape Decision (1932), Cape Hinchinbrook (1934), Cape Spencer (1925), Cape St. Elias (1916), Five Finger Islands (1935), Point Retreat (1923), Sentinel Island (1935) and Tree Point (1935). The Art Modern style is represented by the last caisson lighthouse built in the United States, Cleveland East Ledge Lighthouse (1943), Massachusetts; and Huron Harbor Lighthouse (1936), Ohio. The Beaux Art style is found in the Huntington Harbor (Lloyds Harbor) Lighthouse (1912), New York.

Many dwellings at light stations are plain structures and quite functional. The Bungalow and Ranch style of keepers houses can be found in a number of light stations around the country. Bungalow-style living quarter examples include Pigeon Point (1960), California; Dry Tortugas (1922), Florida; Boca Grande (1890), Florida; Molokai (1909), Hawaii; New Canal (1901), Louisiana; Ship Shoal (1859), Louisiana; and Diamond Head (1921), Hawaii. Ranch style living quarter examples include Piedras Blancas (1960), California; Plymouth (1963), Massachusetts; and Egmont Key (date unknown), Florida. The Rambler style is represented by the keeper's quarters at Sankaty Head (1960), Massachusetts. The

Cottage style is represented by the keeper's quarters at Owls Head (1854), Maine; and the Dutch Colonial Cottage style by the keeper's quarters at Whitlocks Mill (1909), Maine.

Duplication of lighthouse designs

George Putnam stated that the early lighthouses are representative of some of the best architecture in this country (simple, honest, dignified and strikingly located).[95] Early on there was no uniformity in lighthouse design although architects tended to use similar plans when they designed more than one lighthouse. For example, the first Cape Henry Lighthouse (1792) was designed by the John McComb, Jr., the same architect who later planned Montauk Point (1796) on the tip of Long Island and Eatons Neck (1799), also on Long Island, New York. All were built in the 1790s; all are still standing and similar in design.

The fifth auditor used contracts and specifications from recently built lighthouses to prepare contracts and specifications for newly authorized lighthouses. With the coming of the Lighthouse Board, which did complete detailed specifications and construction plans for each light station built, duplication of lighthouses became just a matter of taking a plan off the shelf, making changes to meet local conditions and sending them out for bid. Light stations under the Lighthouse Board were either designed at headquarters or in the district offices; in some instances, designs were bid out to contractors.

In the Long Island Sound and Connecticut area, the two-story keepers' quarters with attached light tower at one end were used at least eight times. Plans for screwpile and caisson lighthouses were used over and over again. The slightly modified plans for the screwpile Hooper Strait Lighthouse were used to build several other screwpile lighthouses in the Chesapeake Bay including Drum Point, Janes Island, as well as Laurel Point, a lighthouse apparently never built. The original Hooper Strait Lighthouse plans contain the hand written name of all of these screwpiles. The caisson lighthouse with the squat, slightly conical tower called by some a spark plug or coffee pot lighthouse is another example. It is found in New England, the Long Island Sound, Chesapeake Bay and the Hudson River. Smith Point and Wolf Trap caisson lighthouses were built from the same plans, as were the Bloody Point Bar and Sharp Island caisson lighthouses, all on the Chesapeake Bay.

There was duplication in the tall towers as well. The original drawings for Yaquina Head (1873), Oregon, were titled Bodie Island Lighthouse - North Carolina; Bodie Island (1872), was crossed out and Cape Foulweather (Yaquina Head) transcribed above the original title. While Bodie Island Lighthouse is taller than Yaquina Head Lighthouse, the details are virtually identical. Heceta Head Lighthouse (1894), Oregon, and Umpqua River Lighthouse (1894), Oregon, are nearly identical. The plans drawn in 1891 are titled Umpqua River, later the title is crossed out and Heceta Head penciled above it.

Lighthouses built of similar design are found in large areas with similar topography or site conditions. The depth of the water, solidity of the bottom, tendency for ice, availability of certain building materials, or other such environmental factors influenced the design chosen.

New England

Most of the lighthouses built in the colonies were concentrated in New England because of its relatively larger population center and because of its heavy involvement in the shipping industry. Its rocky coastline with its offshore islands and shoals was more hazardous to navigation than the rock free coast

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[95] Quote given in de Gast without source.

further to the south. The earliest lighthouses were constructed principally of stone and built on rocky outcrops. The first lighthouse built, in what today is the United States, was the Boston Harbor Lighthouse (1716), a stone light tower built on Little Brewster Island, marking the entrance to Boston Harbor. Destroyed by the British during the Revolutionary War, the present rubblestone tower was constructed in 1789, the second oldest standing operational tower in the United States after Sandy Hook Lighthouse (1764), New Jersey. Boston Harbor Lighthouse is also the only officially manned light station in the United States. The first waveswept lighthouse tower in the United States was built on Minots Ledge in 1860, replacing an earlier unsuccessful pile foundation lighthouse. This stone tower is considered a feat of American lighthouse engineering.

Portland Head Lighthouse (1791), Maine, is considered one of, if not the most, photogenic of American lighthouses. It exemplifies the typical New England light station; a stone tower built on a rocky promontory. New England, however, possesses nearly every major lighthouse construction type. While Brant Point Lighthouse (1746), Nantucket, Massachusetts, was the first wooden light tower built, the oldest surviving wooden tower is generally considered to be the Plymouth (Gurnet) Lighthouse (1843), Massachusetts. The Boston Harbor Lighthouse (1716) was the first rubblestone light tower built, and the 89-foot New London Harbor light tower (1801), Connecticut, is built of cut brownstone with brick lining as is the 46-foot Faulker Island light tower (1802), Connecticut. While New England possesses numerous masonry towers, none are considered tall towers, that is, towers over 150 feet in height. Nor are any concrete masonry towers represented in New England.

Other examples of New England wave swept towers include Halfway Rock Lighthouse (1871), Maine; Whaleback Ledge Lighthouse (1872), Maine; Stratford Shoal Lighthouse (1877), Connecticut; Ram Island Lighthouse (1883), Maine; Graves Lighthouse (1905), Massachusetts; and New London Ledge Lighthouse (1909), Connecticut. Examples of cast-iron-plate lighthouse construction include Monomoy Point Lighthouse (1855), Massachusetts, with brick lining; Sandy Neck Lighthouse (1857), Massachusetts; Cape Elizabeth Lighthouse (1874), Maine; Edgartown Lighthouse (1875), Massachusetts; Nobska Point Lighthouse (1876), Massachusetts, with brick lining; Race Point Lighthouse (1876), Massachusetts, with brick lining; Chatham Lighthouse (1877), Massachusetts, with brick lining; East Chop Lighthouse (1877), Massachusetts; and Portsmouth Harbor Lighthouse (1877), New Hampshire.

Marblehead Lighthouse (1896), Massachusetts is the only known skeletal metal tower in New England. Only one screwpile lighthouse was built in New England, the Narrows (1856). It was built in Boston Harbor, Massachusetts, burned in 1929, and replaced with an automated light. New England does not possess any straightpile or disk-pile-type lighthouses.

Because of the colder climate and associated problems of ice flow damage, most offshore New England lighthouses built in protected waters such as harbors and bays are caisson types. Caisson lighthouses in New England include Duxbury Lighthouse (1871), Massachusetts; Southwest Ledge (New Haven Breakwater) Lighthouse (1877), Connecticut; Borden Flats Lighthouse (1881), Massachusetts; Stamford Harbor (Chatham Rock) Lighthouse (1881), Massachusetts; Stamford Harbor Lighthouse (1882), Connecticut; Conimicut Shoal Lighthouse (1883), Rhode Island (cast iron and granite); Latimer Reef Lighthouse (1884), Connecticut; Sakonnet Lighthouse (1884), Rhode Island; Saybrook Breakwater Lighthouse (1886), Connecticut; Hog Island Shoal Lighthouse (1886), Rhode Island (cast iron and granite); Goose Rocks Lighthouse (1890), Maine; Lubec Channel Lighthouse (1890), Maine. The last caisson lighthouse built in the United States was the Cleveland East Ledge Lighthouse (1943), Massachusetts, which was built in an art modern style. Of the eleven pneumatic caisson lighthouses built in the U.S., Plum Beach Lighthouse (1899), Rhode Island is the only New England example.

Granite and concrete caisson lighthouses made with cofferdams in New England include Penfield Lighthouse (1874), Connecticut, a granite caisson; Portland Breakwater Lighthouse (1875), Maine; Stratford Shoal Lighthouse (1877), Connecticut, granite ashlar caisson; Ram Island Lighthouse (1883), Maine; Doubling Point Lighthouse (1899), Maine; and New London Ledge Lighthouse (1909), Connecticut. A submarine caisson foundation type lighthouse is Cleveland East Ledge Lighthouse (1943), Massachusetts, made of reinforced concrete. The first Texas tower lighthouse in the United States is the Buzzards Bay Lighthouse (1961), located in Buzzards Bay, Massachusetts.

Hudson River

The Hudson River, with its maintained 30-foot-deep channel, is navigable to commercial vessels from New York City north over 150 miles to above Albany, New York. The Erie Canal (1825) and Delaware and Hudson Canal (1825-1828) provided important connections to the interior of the United States. Existing lighthouses along the Hudson River include Stony Point (1826), deactivated in 1925; Saugerties (1869), station first established in 1836; Esopus Meadows (1872), station first established in 1839; Hudson-Athens (1874); Tarrytown (1883), deactivated in 1961; Roundout Creek II (1915), station first established in 1835; and Jeffreys Hook (1921), station first established in 1889, located under George Washington Bridge and made famous by the children's book *The Little Red Lighthouse and the Great Gray Bridge.*

Delaware River and Bay[96]

The Delaware River has one of the most extensive range light systems in the world dating back to at least 1876. Range lights were being used in Great Britain by the early 1800s, and apparently were first introduced to the United States at Wolf's Island Range (1882), Georgia. The adoption of range lights, however, was slow to develop in the United States until their use on the Delaware River in 1876 when the Deepwater Point and New Castle Ranges were first placed in operation. Port Penn and Finns Point Ranges were added to the Delaware River range system in 1877, followed with the construction of the Cherry Island, Schooner Ledge, Tinicum Island, and Mifflin Bar Cut Ranges in 1880. The Horseshoe East Group and West Group Ranges were added to the Delaware River range system in 1881, and finally a pair of range lights called the Delaware Breakwater Range was added in 1885 near Lewes, Delaware.

As improvements to the Delaware River channel, or changes in alignment of the channel, were made, ranges were either added, abandoned, or moved. The Marcus Hook Rear Range Light (1920) Wilmington, Delaware, was the last manned lighthouse built along the Delaware River. The addition of the Marcus Hook Range completed the chain of high-powered ranges guiding ships from the Ship John Shoal Light Station (1874) in the Upper Delaware Bay to the port cities of Philadelphia and Camden. A series of minor ranges continues on from there to take shipping traffic upriver to a point just below Trenton, New Jersey.

The only remaining older exoskeletal tower rear range lights include Liston Range (1877), Delaware; Finns Point Range (1878), New Jersey; Tinicum Island Range (1880), New Jersey; Bellevue Range (1909), Delaware; Reedy Island Range (1910), Delaware; and Marcus Hook Range (1918)(reinforced concrete tower), Delaware. The only remaining older type front range lighthouse is Liston Front Range Lighthouse (1877) which became a private residence in the 1950s. All of the ranges have either red or

[96] This section taken from Jim Gowdy, *Guiding Lights of the Delaware River and Bay* (privately printed, Mizpah, New Jersey, 1990).

green lights except the Liston Range, which has white lights (white is easier to see over long distances). The Liston Range is the longest of the Delaware River ranges, and one of the longest in the entire world. All turns from range to range are made near turn buoys that are lit with rapidly flashing lights.

The Delaware Bay is relatively shallow and full of shoals. A lighthouse established at Cape Henlopen, Delaware, in 1767, lighted the entrance to Delaware Bay. Buoys were also used to mark the Bay at this date. Cape Henlopen Lighthouse survived until 1926 when the tower was destroyed by erosion. The north side of the Bay is lit by Cape May Lighthouse (1859), New Jersey. The first lighthouse at Cape May was established in 1823; while the present tower dates from 1859. From the entrance through the bay to the Delaware River, the channel is marked by caisson lighthouses such as Delaware Breakwater (1926), Delaware; Brandywine Shoal (1914), New Jersey; Fourteen Foot Bank (1888), Delaware; Miah Maull Shoal (1913), New Jersey; and Ship John Shoal (1877), New Jersey. Many of these caissons replaced earlier screwpile lighthouses.

Chesapeake Bay[97]

During the height of America's maritime commerce early in the 19th century, the Chesapeake Bay served as a major commercial waterway for the shipment of raw materials and finished goods between the Piedmont and Mid-Atlantic States.[98] Light stations played an important role in the economic development of the Chesapeake Bay region. The opening of the Chesapeake and Delaware Canal in 1829, the opening of the Susquehanna and Tidewater Canal in 1839, and associated aids to navigation on the Chesapeake Bay, played an important role in the economic development of southeastern Pennsylvania and Delaware as well.
Prior to the 1770s, there were no known publicly sponsored aids to navigation in the Chesapeake Bay, and from the 1770s until Cape Henry Lighthouse was first lit in 1792, there were only six buoys in the entire Chesapeake Bay, and those marked shoals at the entrance to the Bay.[99] Individuals, plantations, and some ports, no doubt used simple poles and/or branches to mark shoals and other hazards to navigation but these were not regulated and largely only understood by locals. The first buoys provided by the federal government in Maryland waters are believed to be those authorized by Congress in an act dated March 3, 1819 for marking the Patapsco River. The first lightship in the United States was placed at Willoughby Spit at the entrance to Elizabeth River, Chesapeake Bay, Virginia, in 1820.

The Chesapeake Bay with its soft bottom muds and sands was ideally suited for cottage-type screwpile lighthouse technology. No less than 49 such structures were built in the Chesapeake, more than any other body of water in the world. Many of these structures replaced lightships. Most cottage-type screwpile lighthouses have since been destroyed by ice, demolished and/or replaced by caisson lighthouses. The oldest standing cottage-type lighthouse remaining in its original location is Thomas Point Shoals Lighthouse (1875). Three cottage-type lighthouses have been moved to museum settings: Seven Foot Knoll Lighthouse (1855), Hooper Strait Lighthouse (1879) and Drum Point Lighthouse (1883). The only nuclear powered lighthouse in the United States was Baltimore Lighthouse (1908), a caisson lighthouse.

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[97]This section is derived from Ralph Eshelman's draft multiple property documentation form for Maryland Lighthouses.

[98] Ralph D. Gary, *The National Waterway: A History of the Chesapeake and Delaware Canal, 1769-1965*, University of Illinois Press, 1967.

[99] Morrison and Hanson, pp. 9, 19, 25, 47, 62.

The entrance to the Chesapeake Bay is marked on the north side by Cape Charles Lighthouse (1895); at 191 feet in height, it is the tallest exoskeletal tower lighthouse in the United States. The present tower is the third built at this site, the first dating from 1828. The southern entrance to the Bay is marked by the Cape Henry Lighthouse (1881); at 163 feet in the height, it is the tallest cast-iron lighthouse in the United States. The first tower, constructed in 1792, represents the first federal works project and still stands.

Mid Atlantic

The mid and South Atlantic coast is low and sandy, requiring tall light towers to raise the light at a height that mariners could identify at great distances out to sea. The tallest light tower in the United States, Cape Hatteras (1870); the tallest cast iron light tower in the United States, Cape Henry (1881); and the largest concentration of tall coastal towers in the United States (150 feet or taller), are all located along this stretch of the coast. Because the topography was generally uniform and undistinguished, day marks were especially important along this section of the coast as well. The unique black and white diamond pattern on Cape Lookout Lighthouse (1859), black and white spiral pattern on Cape Hatteras Lighthouse (1870), black and white vertical rectangular pattern on Cape Henry Lighthouse (1881), the black and white horizontal bands on Bodie Island Lighthouse (1872), and the red and white horizontal bands on Assateague Lighthouse (1867), make the mid Atlantic coast line the most diverse collection of daymarks in the country and possibly the world.

South Atlantic

By the end of the American Revolution, the southeastern coast was marked by only two lighthouses: the Charleston Lighthouse (1767) on Morris Island, South Carolina, and Tybee Lighthouse (1773) near Savannah, Georgia.[100] The entire coastline south of the Tybee Lighthouse remained unmarked for the next 50 years, as the Spanish government had done nothing to mark the harbors or the coastline of Florida. The United States established harbor lighthouses at St. Augustine (1824) and St. Johns River (1830), but both were not adequate for coastal navigation until St. Johns River Lighthouse was rebuilt in 1859 and St. Augustine Lighthouse in 1874.

No initial action was taken to achieve a system of lights along the southeastern coast of the United States until a lighthouse was constructed at Mosquito Inlet (Ponce de Leon Inlet) in 1835. However, this light never functioned as oil for the lamps was not delivered when the light was completed or before a storm undermined the tower's foundation, and it collapsed. A new lighthouse was not established at that site until 1887, in part because of the Seminole Indian Wars. Cape Canaveral Lighthouse (1848) was so ineffectual that many vessels ran up on the surrounding shoals as they searched for the light. The Jupiter Inlet Lighthouse (1860) was the most effective seacoast lighthouse in Florida outside of the Keys.

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[100]Tybee Island was the site of an early daymark tower 90 feet in height dating from 1736. The tower also served as a rear range for the Wolf Island Range in 1822. The present 1867 tower is built on the base of the third 1773 tower. The daymark was not lit until 1790.

Florida Keys[101]

Sailing southwest and westward along the Florida Keys at night could be dangerous because vessels must hug the treacherous coral reefs lying offshore to avoid the strong current of the Gulf Stream flowing in the opposite direction. In daylight and in clear weather, navigation was easier because of the distinct color contrasts in these waters. Shallow water over the reefs is light green, mottled with brown. The deep waters of the Gulf Stream are dark blue. At night and in storms, these color guides disappear.

When the United States acquired the Louisiana Territory in 1803, new ports along the Gulf Coast developed, and the Florida Straits became one of the busiest shipping routes in the world. Flatboats carrying lumber, livestock, and farm produce from inland states down the Mississippi River to New Orleans unloaded their cargo onto sailing vessels to be shipped to eastern seacoast ports and to Europe. All the ships sailed along the dangerous coast of the Florida Keys, vulnerable to piracy and to the navigational hazards of the reefs. Wrecks abounded. Salvaging, referred to as "wrecking," became almost as lucrative as piracy.

In 1819, Spain ceded all of Spanish Florida to the United States. Lighthouses were established at Cape Florida (1825), Key West harbor (1825), Sand Key (1826), and Garden Key (1825) in the Dry Tortugas; a beacon and buoys were placed between the Dry Tortugas and the Florida coast; and a lightship was stationed at Carysfort Reef (1825).

In 1848, Stephen Mallory, the collector of customs at Key West, emphasized in his report to Congress that three-fifths of the cargoes lost on the Florida reef had come down the Mississippi River, and three-fourths of the vessels salvaged were owned in the northern and eastern states. He urged Congress to appropriate funds for a survey of the Florida reef for the purpose of compiling up-to-date hydrographic charts of the area. Mallory called the passage along the Florida Keys "a great highway of commerce," and pointed out that along this sea route "property of every section of our Union is afloat." He urged Congress to make every effort to make the route thoroughly safe and to "remove every excuse for shipwrecks." In addition, appropriations were approved in 1847 for rebuilding the lighthouses at Key West and Sand Key, which had been destroyed in an 1846 hurricane, and for erecting a lighthouse at Carysfort Reef. Further appropriations for lighthouses were made during the next four decades.

Difficult as it was to build lighthouses on land, the task was even more demanding in the Florida Keys, where eight submarine sites were chosen. Of the original lighthouses built from Cape Florida to the Dry Tortugas, six still stand and are functioning today: Carysfort Reef (1852), Sombrero Key (1858), Dry Tortugas (on Loggerhead Key) (1858), Alligator Reef (1873), Fowey Rocks (1878), and American Shoal (1880). The Sand Key Lighthouse (1853), another exoskeletal tall tower screwpile lighthouse, was extensively damaged by fire in 1989, but not destroyed. The lighthouses built at Cape Florida and at Key West to replace the ones destroyed by storms have both been discontinued, but the sea route between Cape Florida and the Dry Tortugas is well marked by daymarks and lighted beacons.

Caribbean

Through the years, the United States has acquired territories that had ongoing or incipient lighthouse systems. The most advanced of these foreign systems was in Puerto Rico. In 1853, the Spanish erected the first lighthouse in Puerto Rico atop the old fortification of El Morro at the entrance to San Juan

[101] Taken from Love Dean, *Lighthouses of The Florida Keys* (Historic Florida Keys Foundation, Inc. Key West, Florida, 1992).

Harbor. Other lighthouses were placed around the island as marks into harbors and as warnings to hazards. These were complete light stations with quarters for the keepers and their families, and the towers were equipped with Fresnel lenses. With 13 light stations in place and two under construction, only a single lighthouse had to be added when the U.S. Lighthouse Board took over administration of Puerto Rico's aids to navigation.[102]

The Virgin Islands, while under rule by Denmark, had five lighthouses erected, most in the early part of the twentieth century. As in Puerto Rico, these lights were satisfactorily placed, and over the years, the United States has had only to add small lights, such as harbor, range and buoy lights.[103] The Navassa Island Lighthouse (1917), Windward Passage, West Indies, at 162-feet in height, was the tallest reinforced concrete tower when built.

Gulf of Mexico[104]

When the French owned the Louisiana Territory, there is some evidence that a lighthouse existed at "The Balize" which is a French word for beacon. Reportedly, a light tower had been built at the mouth of the Mississippi River by 1721, perhaps earlier.[105] The first lighthouse in the U.S., built outside the 13 original English colonies, was completed at Bayou St. John on August 5, 1811. The first U.S. lighthouses built along the Gulf of Mexico were copies of the proven New England brick towers; however, the softer soil of the Gulf Coast could not support the weight of these towers. Of the 40 or more constructed, 25 sank into the bottom or blew over, having no solid footing. By the 1840s, integral lighthouses, consisting of frame dwellings with the lantern mounted on top, were used. These could be moved to escape erosion. Iron screwpile lighthouses appeared along the coast prior to the Civil War. These offered a more stable foundation and were built either according to the cottage style used in the Chesapeake Bay or as tall iron skeletal towers.[106]

The opening up of the Midwest spurred a boom in commercial activity. Ports handling outbound cotton and inbound consumer goods grew rapidly. By the 1830s, the small ports along the Gulf were shipping as much cotton as the entire state of South Carolina; within 30 years, cotton accounted for 57 percent of all U.S. exports -- virtually all of it shipped out of the Gulf. The cotton trade spurred the lighthouse-building boom in the 1830s. Steam-powered riverboats were becoming increasingly common. The rivers became the "interstate highways" of the first half of the 19th century. Initially, the surge of railroads throughout the heartland increased trade flowing into and out of the Gulf. As the century progressed, the United States spent less and less on the construction of canals and toll roads (turnpikes) and more and more on the improvement of aids to navigation, especially lighthouses. The introduction and perfection of steam dredging permitted the Corps of Topographical Engineers to deepen the Gulf's shallow harbors. The federal government scrambled to light up the waterways and the new ports that

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[102] Wayne Wheeler, personal communication, February 28, 1998.

[103] Holland, *America's Lighthouses*, pp. 200-201; Lighthouse Service, *Light List, Atlantic and Gulf Coasts, 1933*, pp. 528-530.

[104] Taken from David L. Cipra, *Lighthouses, Lightships, and the Gulf of Mexico* (Cypress Communication, Alexandria, Virginia, 1997).

[105] David L. Cipra, *Lighthouse and Lightships of the Northern Gulf of Mexico* ([Washington]: Government Printing Office, c1983), p. 32.

[106] David Cipra, *Lighthouses, Lightships, and the Gulf of Mexico*, pp. 7-8.

were drawing in so much foreign income -- St. Marks, Apalachicola, St. Joseph, Pensacola, Mobile, Mississippi Sound, Lake Pontchartrain, the Mississippi River, and Atchafalaya Bay.

By the 1850s, technology had a direct impact on lighthouse construction. The new screwpile foundation was introduced into the Gulf, permitting, for the first time, the erection of lightweight structures (compared to stone and brick) in shallow, slow-moving water, on a mud, sand, or coral bottom. Three screwpile lighthouses were built in Galveston Bay in 1854.

The next lighthouse construction technology to be introduced in the Gulf was that of cast iron towers. Like the screwpile, a few had been built before the Civil War, but none in the South. Cast iron tower construction offered numerous advantages over the classic stone and brick towers. First, it was lighter and could be made watertight. Second, it could be produced and prefabricated in the convenience of a workshop and then transported to the building site. Third, a cast iron tower was strong and allowed for the standardization of designs. Fourth, it could be dismantled and moved if threatened by erosion. The first tall, skeleton tower lighthouse to be built in the Gulf was completed at Southwest Pass, Louisiana, in 1873. This design possessed the same advantages as the conical cast iron tower but was lighter.

In 1851, a provisional lighthouse board surveyed the Gulf and recommended that 14 new lights be added. The goal was to place a light every 50 miles along the coast. Lighthouses were built at 10 of the sites, and the others were marked by unmanned, minor lighted aids. At the turn of the decade before the Civil War, with commerce still booming, the potential for additional lighthouse construction in the Gulf looked bright. New Orleans was the fifth largest city in the United States; bumper crops of cotton were carried out of Gulf ports in both 1859 and 1860. The saga of lighthouses in the Gulf radically changed on July 8, 1861, when Confederates seized Ship Island, renamed it Fort Twiggs, and extinguished the light in the lighthouse. With the beginning of the Civil War, other lighthouses were extinguished one by one, and darkness fell on the Gulf Coast that would last for over five years.

Without economic recovery in the South following the Civil War, new lighthouses would not have been built in the Gulf. And recovery was not easy. Many in the North, which controlled the federal purse strings, held ill will towards the recently defeated South. Also, the rapidly expanding railroads were challenging the cost-effectiveness of waterborne transportation. Although the number of steamboats using the river system which drained into the Gulf dramatically declined during the second half of the 19th century, the volume of goods carried by water increased as powerful towboats pushed and pulled barges, each one doing the work of several side-wheel steamers. By the 1880s, barges carried one-third of all cargo on the lower Mississippi, and the percentage continued to increase. Waterborne trade on the upper Mississippi and its tributaries declined as new railroad lines increasingly made Chicago the hub of the Midwest. Also, cotton gave way to coal as the most important cargo, and that, in turn, gave way to petroleum produced during the second half of the 20th century. Although these new trade patterns had a negative impact on the shipbuilding industry in the Gulf, the need for lighthouses and other navigational aids to guide the barge traffic increased. Also, Louisiana had once again become the state through which the most waterborne traffic passed.

Great Lakes

The Great Lakes "offer more variety of dangers than any other ocean. Their violent storms, including winter gales, as well as fog and ice, match anything found on the seven seas. The Lakes' many narrow and shallow passages, combined with the great volume of traffic, have produced another set of dangers."[107]

Completion of the Erie Canal in 1825 that linked New York City with Buffalo on Lake Erie, marked the start of explosive growth in the Great Lakes region.[108] The canal provided a direct cheap route between the Middle West and the Atlantic Coast. Within a few years, shipments of grain, lumber, and coal, increased from West to East, and manufactured goods from East to West. In 1855, the opening of the St. Mary's Falls Ship Canal at Sault Ste. Marie touched off the rapid development of the enormous iron ore and copper deposits found on Lake Superior. The Great Lakes linked the natural resources and agricultural lands of the Middle West with the industrialized East Coast and the rest of the world.[109]

The development of a system of lights on the Great Lakes came with the expansion of shipping and settlement. The construction of lighthouses was not only parallel to the growth in commerce, but a prerequisite. Forty-three lights were in operation by 1840 including 17 on Lake Erie, 11 on Lake Michigan, nine on Lake Ontario, four on Lake Huron, one on Lake St. Clair, and one on the Detroit River. Thirty-three more were introduced from 1841 to 1852 with Lake Superior receiving six. In 1852, 76 of the 331 lights operating nationally were in the Great Lakes. In 1860, the lights numbered 102. At the turn of the century, the Great Lakes had 334 major aids, 67 fog signals, and 563 buoys.[110] Virtually all the light stations in use today on the Great Lakes were built by 1925.[111]

Total shipments on the Great Lakes increased from 4 million tons in 1852 to 80 million tons in 1910. Tonnage reached 169 million tons in 1941, and by the early 1970s, shipments averaged more than 200 million tons per annum with iron ore making up half the total. Through the 1870s, lumber and grain accounted for three-quarters of the total shipments, and by 1910, iron ore accounted for half the tonnage, with coal making up another quarter. Iron mines in the Lake Superior region produced three-quarters of American ore after the turn of the century, and it was transported by water to major iron and steel plants. During the 1888 navigation season, the port of Chicago had approximately 20,000 arrivals and departures of major vessels in an eight-month period compared with 23,000 in New York City. In 1910, the Great Lakes fleet made up more than one-third of the tonnage of the entire American merchant fleet.[112]

For the most part, the light stations in the Great Lakes were made of masonry (some of stone but the great majority of brick). Wooden ones were built such as Mission Point (1870), Michigan, and the half wood-half brick Michigan City Lighthouse (1858), Indiana, on Lake Michigan, the Round Island Lighthouse (1895), on St. Mary's River, Michigan, and some of the range lights. A few were made of metal plates or towers covered with metal plates to protect the brick under them. Pierhead lights erected

[107]Charles K. Hyde, *The Northern Lights: Lighthouses of The Upper Great Lakes* (Detroit: Wayne State University Press, reprint 1995), p.194.

[108] Hyde, p. 15.

[109]National Register Nomination, "United States Coast Guard Lighthouses and Light Stations on the Great Lakes" 1983.

[110] Hyde, pp. 15-16, 20.

[111] National Register Nomination, "United States Coast Guard Lighthouses and Light Stations on the Great Lakes" 1983; Hyde, p. 38.

[112] Hyde, pp. 15-16, 20; National Register Nomination, "United States Coast Guard Lighthouses and Light Stations on the Great Lakes" 1983.

on piers projecting out into the lakes served to guide vessels into the harbors along the coasts. Pierhead lights are occasionally used on the east coast, but normally there is only one at the head of the pier. Also, the lights guiding vessels into east coast harbors are usually lighthouses erected on land. On the Great Lakes, pier head lights often come in pairs, an outer light and an inner light to help guide vessels through the harbor entrance, and are normally made of metal plates. They come in several different forms. Some have the configuration of a house with a light tower on it such as the Holland Harbor Lighthouse (South Pierhead) (1936), Michigan, which is actually a structure that has been covered with metal to help preserve and protect the original fabric. Others are typical lighthouse towers, some round, some square. Another type that is common is a metal clad square structure with an octagonal metal tower rising out of the center of the pyramid roof. The Michigan City (1858), Indiana, pierhead is typical of this type. Breakwater lights are first cousins to the pierhead lights. They are usually at the head of the breakwater and are single lights. They can be different shapes, but, generally, they are tower-like.[113]

Many lighthouses on the Great Lakes were built to the same designs. Most variation was between harbor and coast lights. Before 1870, the most common design consisted of a frame or brickkeeper's dwelling with the lantern mounted directly atop the dwelling or on an attached 25- to 40-foot square tower. Taller coastal towers were conical masonry (generally brick), often connected to the keeper's dwelling by a covered passageway. A few large skeletal towers were built before 1870. Few tall towers were built after the turn of the century, and those that were utilized steel skeletal frames.[114]

After the Civil War, the Lighthouse Board moved most harbor lights from the mainland onto newly built piers and breakwaters. Pier lights were generally simple wooden or metal towers manned by a keeper who lived in an onshore residence. Few of the early pier and breakwater lights survive because of numerous pier extensions and the destructive effects of storms and ice. In the first two decades of this century, most of the harbor lights were replaced with steel-framed structures encased in cast-iron or steel plates.[115]

Offshore lights were designed with the assistance of U.S. Army Corps of Engineers personnel. Most challenging to construct were those with a submarine crib foundation beginning with Waugoshance Shoal Lighthouse (1851). The Great Lakes, with its hard rocky bottoms, has the largest number of crib foundation lighthouses in the United States. Before the use of crib foundation, lightships were used in extremely hazardous locations where lighthouses were considered too costly to build.[116]

West Coast[117]

Prior to the building of the transcontinental railroad in 1869, the west coast of the United States was dependent upon maritime transportation for its connection to the rest of the world. North-south railroad links were not completed until 1887. Even road networks were not sufficiently developed until well into

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[113]Holland, Chapter 1, 1993 draft National Historic Landmark context study on lighthouses.

[114] Hyde, p. 23; National Register Nomination, "United States Coast Guard Lighthouses and Light Stations on the Great Lakes" 1983.

[115] Ibid.

[116] Hyde, pp. 23-24.

[117] Holland

the 20th century. With this heavy dependence on water shipping, it is not surprising lighthouses were relatively early developments for the west coast.

Francis A. Gibbons of Baltimore, in addition to building Love Point Lighthouse (1872), and repair work on Point Lookout (1830) and Sharps Island (1838) lighthouses in Maryland, also built Bodie Island Lighthouse (1847), North Carolina, and Egmont Key Lighthouse (1848), Florida. Pleasonton said, Gibbons "has done some work very faithfully for us." Gibbons most ambitious lighthouse endeavor, however, was obtaining a contract in partnership with Francis X. Kelly in 1852 to construct the first eight lighthouses on the West Coast of the United States. They obtained a bark appropriately named *Oriole*, acquired materials and laborers, and sailed for the West Coast. Despite the wrecking of *Oriole* at the mouth of the Columbia River, these two Marylanders completed all eight lighthouses by 1856.[118]

The first lighthouses on the west coast, designed at about the same time as the one at Blackistone Island (1851), Maryland, were intended to use the Argand lamp and parabolic reflector lighting system. The masonry tower rose from the foundation, through the center of the dwelling and through the roof. The towers of the eight lighthouses were each substantial enough to stand by themselves. The lanterns were not, however, of a proper size to support the recently adopted Fresnel lens. The District Inspector, Major Hartman Bache, was a pragmatic person, and solved the problems in different ways. At Farallon Islands, he tore down and rebuilt the lighthouse to receive a first-order lens. At the Point Loma Lighthouse (1855) in San Diego, California, he decided to use the smaller third-order lens. But even with the smaller and lighter lens, he had to have the tower strengthened by increasing the thickness of the domical arch (the ceiling of the tower) to support a third order lens.[119] Many later West Coast light towers were integral to the fog signal building. Examples include Point Sur Lighthouse (1889), California; and Coquille River Lighthouse (1896) and Cape Arago Lighthouse (1934), both in Oregon.

Steel, in concrete structures, provides the tensile properties concrete lacks. Most major reinforced concrete towers are found on the West Coast where they are best adapted to the dangers of earthquake damage. Examples include Point Arena (1908) and Point Arguello Lighthouse (1934), both California. A series of art-moderne reinforced concrete lighthouses were built along the Alaska coast in the 1920s and 1930s, replacing earlier deteriorated wooden structures.[120] Examples include Cape Decision (1932), Cape Hinchinbrook (1934), Cape Spencer (1925), Cape St. Elias (1916), Five Finger Islands (1935), Point Retreat (1923), Sentinel Island (1935) and Tree Point (1935).

On the west coast, a number of lighthouses have been placed where coasting traffic makes a course change or leaves the coast. These are major lights, usually of the first order. Cape Mendocino (1868) in northern California was a turning point for both north and southbound traffic. This light was particularly important because it also guards vessels against nearby dangerous waters. Point Sur (1889) and Piedras Blancas (1879) are two lighthouses marking the point for departure or return to the coast, depending on the direction in which the vessel is traveling.

The west coast has several lighthouses built just offshore on rocks that are serious hazards to navigation. Tillamook (1881), Oregon, and St. George (1892), California, are two such lighthouses, and they were

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118 Holland, chapter 3, p. 24.

119 F. Ross Holland, *The Old Point Loma Lighthouse* (San Diego: Cabrillo Historical Assn., 1978), pp. 16-19.

120 Clifford, pp. 3, 4, 5, and 6; and Jack Bookwalter, Light Stations of California, Multiple Property National Register Nomination, 1989, p. F. II 5.

difficult and expensive to build because of their offshore location and rough seas. Tillamook served as a warning of the rock and as a guide to the Columbia River. St. George, on an offshore reef, guarded ships against a larger area of rocks and shoals.

Hawaii

The first Hawaiian lighthouse was a 9-foot wooden tower built in 1840 at Lahaina, a prosperous whaling port. Built by Kamehameha III, this light was also the first lighthouse constructed in the Pacific. The U.S. Lighthouse Board assumed responsibility for navigational aids in Hawaii in 1904. By 1917, there were 58-lighted aids, and that number tripled by the 1980s. Three of the most prominent ones were the Molokai Lighthouse (1909) on the north shore of Molokai Island, Makapuu Point Lighthouse (1909) on the eastern end of Oahu Island to guide traffic from the east, and Kilauea Point Lighthouse (1913), another coastal light serving traffic from the west. Makapuu Point Lighthouse exhibits a hyper-radiant lens, the largest of the Fresnel type, and the only one ever used in an American lighthouse. The lack of fog allowed lighthouses to be built at elevations not practical at other sites. The Lehua Rock lighted aid is 704 feet above sea level, and the Kaena Point Lighthouse on Oahu is 931 feet above sea level. [121]

PART III. EVOLUTION OF LIGHTHOUSE OPTICS

Early lights

The most important advances in lighthouse technology over the years concerned the light. The earliest lights were primitive -- consisting of a flame at night and smoke during the day. The first navigational aids were probably fires on a hillside or hilltop. When the first known lighthouse structure, the Pharos of Alexandria, was erected, the fuel -- animal dung, bundles of reeds or fiber such as cotton soaked in oil -- was transported to the top of the structure, which may have had some sort of covering that kept rain from dampening the flames. Constructed at the entrance of the Egyptian harbor near the mouth of the Nile around 280 B.C., this lighthouse was estimated to have a height of 450 feet. Out of service by 800 A.D., an earthquake destroyed the tower in 1340. Later towers that were erected used open fires, but some began to use torches.[122] The use of the open fire, fueled by coal and wood, continued on some light towers until well into the 19th century in Britain, Sweden, and Norway.[123]

There is no evidence that American colonial lighthouses used open fires on their towers. Rather, candles were used in American lighthouses until after the Revolution. Spider lamps came into use in the 1790s. These flat bowls of oil had four or more protruding wicks, which when seen from a distance appeared as a single light source. The use of several wicks and/or lamps was necessary because the candlepower of a single lamp, even with a reflector, was insufficient to provide adequate navigation light at great distances. Acrid smoke from these spider lamps irritated the eyes and nose of the keepers. Nevertheless, these lamps were the principal means of illuminating lighthouses in this country until the

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[121] A comprehensive and excellent book on Hawaii's lighthouses is Love Dean, *The Lighthouses of Hawaii* (Honolulu: University of Hawaii Press, c.1991); see pages 1-2. Ross R. Aikin, *Kilauea Point Lighthouse: Landfall Beacon on the Orient Run* (Kilauea Point Natural History Assn., c.1988) is a similarly fine book on an individual Hawaii lighthouse.

[122] D. Alan Stevenson, *The World's Lighthouses Before 1820* (London: Oxford University Press, 1959), pp. 5, 8.

[123] Douglas B. Hague and Rosemary Christie, *Lighthouses: Their Architecture, History and Archeology* (Wales: Gomer Press, 1975), p. 150.

introduction of a version of the Argand lamp and parabolic reflector system by Winslow Lewis, an unemployed sea captain and New England businessman.[124]

Argand lamps and parabolic reflectors

The Argand lamp, developed in 1781 by Ami Argand of Switzerland, was unique because it had a round hollow wick. Such a wick permitted oxygen to flow up both the outer and inner sides of the wick, giving off a brighter, relatively smoke-free light. One lamp was equivalent to the brightness of seven candles. A metal reflector, purportedly parabolic in form, was placed behind the lamp, and in front of it was a lens. The lens was relatively worthless, since its greenish tint actually diminished the light, but many years passed before they were removed from active lights.

The tests of Lewis's new lighting system were conducted at the Cape Ann, Massachusetts, twin lights established in 1771. In addition to giving a brighter light, the new lamps also burned about half the oil of the spider lamps. Boston Collector of Customs, Henry Dearborn, observed the test and was so impressed that he convinced the Secretary of the Treasury to acquire Lewis's patent.[125]

In 1815, Winslow completed the installation of his new lighting system in all the country's lighthouses. The Lewis lighting apparatus installed in the Thomas Point Shoals Light Station in 1825 consisted of 13 Argand lamps backed by 16-inch-diameter reflectors. From the beginning, these lights were under nearly constant criticism. Part of the problem was caused by the optics themselves and the rest by the lack of training for keepers at that time. The reflectors were supposed to be parabolic, but one lighthouse historian, who worked for the Lighthouse Board and wrote a history of the lighthouse service, said the reflectors approached the paraboloid about as closely as did a barber's basin.[126] Moreover, the keepers generally did not keep the lamps, reflectors, and lantern glass panes clean. The powder given to them to clean the reflectors, when used, was abrasive and tended to wear the silvered coating off the reflectors.[127] Many mariners objected to the lighting system and urged that the United States adopt the Fresnel lens in the country's lighthouses. But Pleasonton, who was influenced by his friend Lewis, felt the new lenses were too expensive and too difficult for the keepers to tend.[128]

The Fresnel lens

The Fresnel lens, developed in the 1820s by Augustin Fresnel, a French physicist, is made up of a collection of glass prisms set in a brass frame in a beehive or clamshell shape. The prisms are mathematically arranged to capture 65 to 70% of the light emitting from the central light source or lamp. The light rays are bent by the prisms into one horizontal sheet of light that in a fixed lens shows a steady light and in a revolving produces a flash or a characteristic. Fresnel lenses were eventually produced in seven standard orders or sizes, numbered one through six. Orders one through three, the largest, were

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[124] F. R. Holland, Jr., *America's Lighthouses; Their Illustrated History Since 1716* (Brattleboro, VT: Stephen Greene Press, 1972), p. 14.

[125] Holland, *America's Lighthouses*, p. 15.

[126] Johnson, p. 23 .

[127] Holland, *America's Lighthouses*, p. 16.

[128] Ibid., p. 18.

used in coastal lights, while four through six were used in harbor or bay lights. Later a three-and-a half order lens was developed, which were used most often on the Gulf coast and the Great Lakes.[129]

Sizes of Fresnel Lenses

Order	Inside Diameter	Height
1st	72 7/16-inches	7-foot, 10-inches
2nd	55 1/8-inches	6-foot, 1-inches
3rd	39 3/8-inches	4-foot, 8-inches
3 1/2	29 1/2-inches	3-foot, 8-inches
4th	19 11/16-inches	2-foot, 4-inches
5th	14 3/4-inches	1-foot, 8-inches
6th	11 3/4-inches	1-foot, 5-inches

In March 1851, Congress prescribed that lens lights be installed in all new lighthouses and all lighthouses not having illuminating apparatuses.[130] With the legislation establishing the Lighthouse Board to manage the country's aids to navigation, came authorization to install Fresnel lenses in all lighthouses. By the Civil War, all lighthouses had been fitted with Fresnel lenses.[131]

Fresnel lenses were illuminated by one lamp, and the lamps were of varying sizes and had one to five concentric wicks (technology borrowed from Argand's lamp). The size of the lamp used depended upon the size of the lens. A sixth order lens had a lamp with one wick, while a first order lens had a lamp with five circular wicks, one inside the other.[132]

Modern lenses

Many lighthouses still have their classic Fresnel lenses; in others, large aerobeacons or small plastic-type lenses have replaced the glass lenses. Coastal light towers use aerobeacon-style lenses which can be seen 25 miles, while lighthouses needing a smaller range are equipped with small acrylic lenses (generally, 250 mm which can be seen for 17 miles); 300 mm lights are used in backup systems in major coastal lights.[133] Now that larger vessels usually have more sophisticated equipment such as GPS, radar, radiobeacons, and electronics gear that can communicate with the navigation satellite, it is the smaller vessels without this equipment that rely on lighthouses for navigation.

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[129] Two larger orders or sizes were developed later: the meso-radial (none in the U.S.) and hyper-radial (one at Makapuu Light, HI). Personal communication, Wayne Wheeler, President, U.S. Lighthouse Society, February 28, 1998.

[130] *Report of the Officers Constituting the Lighthouse Board*, Feb. 5 1852, *32nd Congress, 1st Session, Senate Executive Document No. 28* (Serial #617), p. 125.

[131] Holland, *America's Lighthouses*, p. 21.

[132] U.S. Lighthouse Board, *Instructions to Light-Keepers and Masters of Light-House Vessels, 1902* (Washington: Government Printing Office, 1902), plates 1-8. (Photo reproduction by the Great Lakes Lighthouse Keepers Assn., Allen Park, MI, 1989).

[133] Wayne Wheeler, personal communication, February 28, 1998.

The acrylic-type Fresnel lenses contain small bulbs or lamps that are about the size of a Christmas tree bulb. Two to six of these lamps are attached to a rotary so when one burns out, another moves into position automatically. These lights are often powered by solar batteries. The teams that check these lights could probably visit a lighthouse once a year and expect to find everything working normally, but Aids to Navigation teams visit more frequently for safety reasons.

Visibility

The focal height is the height of the lens' focal plane above high water. The theoretical visibility of a light under good conditions depends on the focal height of the light, the intensity of the light source, the strength of the lens, the clarity of the atmosphere, and the height of the observer. The geographical range of a light is determined by the height while the luminous range is determined by the intensity. In general, the luminous range is greater than the geographical range. Heights above 250 feet gain little advantage due to the curvature of the earth. Theoretically, the focal plane of a light at 100 feet above sea level has a geographical range of 11.5 nautical miles; a light at 250 feet has a geographical range of 18.2 nautical miles, and a light at 350 feet a range of 21.5 nautical miles. The most powerful lenses today have the capacity to be seen up to 26 miles but would need to be placed in towers over 500 feet in height. However, the *Light List* indicates the 193-foot tall focal plane for the Cape Hatteras Lighthouse, North Carolina, has a range of 20 miles and the Makapuu Point Lighthouse, Hawaii, with a focal plane of 420 feet, has a range of 28 miles.

In the early days of lighthouse development, there were very few lighthouses making it relatively easy to distinguish one light from another. Multiple lights, generally twin towers, were an early means to distinguish lights. Among the more well known in the United States are the Three Sisters Lights (1838), consisting of three separate towers on Cape Cod, Massachusetts; Navesink Twin Lights (1862), consisting of two attached towers at Highlands, New Jersey; and Cape Ann (Thachers Island) twin towers, Massachusetts. As lighthouses increased in numbers and the possibility of lighthouse lights being confused with other bridge, tower, city, street, and other lights, variations in lighthouse light characteristics were developed to distinguish them apart. Flashing lights with various periods of eclipses enabled lights to be better distinguished from one another. Perhaps the most famous is Minots Ledge Light which flashes one-four-three pattern or I LOVE YOU, every 30 seconds. Red and green glass was also used to distinguish one side of the harbor channel from another. Prudence Lighthouse, (1852), Rhode Island, had maintained a green colored light since 1939. Red panes of ruby glass, and later red acrylic plates, are used to indicate dangerous sectors of a light. A vessel observing a red sector knew it had to move in a different direction to get into the white, or safe, sector of the light upon approaching or passing the lighthouse. Coast Pilots and *Light Lists* contain light characteristic information for each lighthouse.

Illuminants

When first introduced in this country, lamps burned whale oil, specifically head or case oil from the sperm whale. When the Fresnel lens was introduced into this country, the sperm whale fishery was on a decline and sperm oil, the finest oil known at the time, was increasing in price. In 1851, it was $1.30 to $1.50 per gallon. Four years later, it was $2.25 per gallon. The investigating committee, recognizing that the price would continue to rise, asked Professors Morfit and Alexander, of the University of Maryland, to study the problem. They conducted a set of experiments utilizing several grades and combinations of whale, shark, fish, seal, colza, lard, and mineral oils. They recommended colza oil, feeling it had the greatest potential since it was in use in the French lighthouse service, and testing by distinguished lighthouse engineers and scientists, such as Fresnel and Robert Stevenson, established it to be better than sperm oil. Moreover, it was less expensive than sperm, having been obtained recently from France at about 60 cents a gallon. The board recognized that colza oil came from rape seed and rape, or wild cabbage, not grown in this country. The board dismissed this factor with the thought that rape is suitable for growing in nearly all sections of the United States, and if a market were created, farmers would start planting rape.[134] Farmers did not respond as the board had anticipated and did not cultivate enough rape to supply the needs of the lighthouses.

Gas was also experimented with. The first gas tests were in 1818 when David Melville ran tests on the use of gas made from resin at Beavertail Lighthouse in Rhode Island. Apparently successful, the government nevertheless did not want to adopt gas because of the negative impact it might cause to the whalefishing industry.[135] In 1841, Pleasonton installed a furnace and retort at Christiana Lighthouse in Delaware Bay and conducted a test on the use of gas made from resin. It would appear he was not familiar with the Beavertail Lighthouse experiment. In the late 1840s, three other lighthouses were equipped with furnaces and retorts. These tests were not successful because Pleasonton believed, "the keepers were averse to making and burning gas, but preferred the oil lamps." Though the gas was produced cheaply, he recommended the experiment cease.[136] The Jones Point Lighthouse in Alexandria, Virginia used gas from a local supplier from the end of the Civil War until 1900 when it was changed to an oil lamp. In 1919, it was converted to acetylene.[137]

The Lighthouse Board turned to other potential fuels for the lighthouse lamps. Joseph Henry, a member of the board, resumed experiments on the use of lard oil. Previous tests had not been successful, because the oil did not burn satisfactorily. But from the renewed testing, Henry found out that the lard oil burned quite well if heated to a high enough temperature. The board was delighted and quickly began using that oil in the lamps of the larger lenses, and by 1867, lard oil was in use in all the lighthouses.[138]

A few years later, the board began experimenting to find other fuels and focused on mineral oil, or kerosene. Kerosene had been known as a fuel for some years previous to these tests, but a serious accident in 1864 in a Great Lakes lighthouse made the Lighthouse Board suspicious of this fuel. The new tests showed that it could burn quite well and safely. It would, however, be necessary to alter the lamps to use the oil. The conversion to mineral oil began in the smaller lamps in 1878 and ended with the converting of the lamps in first order lenses, completing this work in 1885.[139]

The next step, and an important one, was the development in France in 1898 of the incandescent oil vapor (IOV) lamp. The principle of this lamp is the same as the Coleman lantern so popular with today's campers. "In this lamp," said Commissioner Putnam, "the kerosene, forced into the vaporizer by air pressure, is heated and vaporized, and is burned mixed with air under a mantle, which is then brought to a brilliant incandescence." The light from this lamp was far brighter than that from the oil lamp. The

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[134] *Report of the Officers Constituting the Lighthouse Board*, pp. 119-120.

[135] Sarah C. Gleason, *Kindly Lights: A History of the Lighthouses of Southern New England* (Boston: Beacon Press, c.1991), pp. 61-77, has a full and interesting discussion of this experiment and the opposition to it.

[136] *Report of the Officers Constituting the Lighthouse Board, 1852*, pp. 273-274.

[137] F. Ross Holland, Jr., *Great American Lighthouses* (Washington: The Preservation Press, c.1989), pp. 157-158.

[138] Holland, *America's Lighthouses*, p. 23.

[139] Putnam, *Lighthouses and Lightships of the United States*, pp. 185-186.

candlepower of the Cape Hatteras light went from 27,000 to 80,000 after the IOV lamp was installed. Furthermore, the consumption of oil dropped dramatically. It was first used in an American lighthouse in 1904 at the North Hook beacon on Sandy Hook, New Jersey.[140]

The next step, and one that led to the wholesale automating of lighthouses, was the introduction of electricity. Electricity was first used in an American lighthouse in 1886 with the completion of the Statue of Liberty. The light emanated from panels cut in the flame of the torch. The statue was not satisfactory as a lighthouse, and after 17 years, the lighting equipment was removed. Other experiments were conducted over the years, but there was little movement toward electrifying lighthouses. As late as 1915/ the Lighthouse Service felt that the IOV lamp was the illuminant of choice in lighthouses, and the only primary lighthouse using electricity at that time was the Twin Lights of the Navesink.[141]

The Service thought electricity too expensive to install. But as power lines spread over the country, the cost of installing electricity began to drop, and in the 1920s and 1930s more and more lighthouses became electrified. Some lighthouses used electricity from generators. In time, automation of some of these lights began to occur. A timer would be placed in the light tower to turn the light on a little before sunset and off shortly after sunrise. In the center of the lens where there was once the oil lamp, a small stand held a rotary lamp changer that held two 1,000-watt bulbs or lamps as they are officially called. When a bulb burnt out, the rotary lamp changer automatically moved another lamp into place. About once a week, Coast Guard personnel checked the light tower to be sure everything was functioning properly, and at that time changed any burned out lamps.

Acetylene was first used in this country in 1902 and has since served usefully. It was used in automating several lighthouses, but it was primarily used to light buoys and small beacons, some of which were equipped with sun valves or sun relay, a temperature-sensitive device, activated by the heat of the sun. When the device cooled at night, the fuel valve opened fully, providing adequate fuel to illuminate the light. When the sun came up, the device was heated, closing the fuel valve so that only the pilot light was lit. The electric relay switch was a similar device that turned the light on and off. These devices began the automation process of light stations in earnest.

Automation has been a main theme in lighthouse history for nearly 100 years. The government has felt that if a lighthouse could be automated successfully, then considerable money, in personnel costs as well as support costs, could be saved. During the developing days of automation, citizens complained about keepers not being in the area with eyes to seaward to spot boaters in trouble or ships in distress. The government contended that with this modern age of electronics there were many forms of communication over which distress messages could travel and alert the Coast Guard to dispatch help.

In the 1960s, the Coast Guard experimented with using nuclear power to light a lighthouse. The test station was Baltimore Lighthouse in Chesapeake Bay. The test ran for a year, after which the nuclear equipment was removed from the lighthouse. The Coast Guard has not attempted to use nuclear power since.

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[140] Ibid., p. 187.

[141] Ibid., pp. 188-187.

PART IV: EXAMPLES OF SIGNIFICANT PERSONS

Architects, Engineers, and Contractors

From the colonial period to the advent of the Lighthouse Board, contractors who bid on the projects built lighthouses. The person who supervised the contractor was the local collector of customs who also served as superintendent of lighthouses for his region. Some of the collectors were conscientious about their responsibilities; others were not. The important factor in getting a good lighthouse for the government's money seemed to be the quality of the builder and not necessarily the construction supervisor. The Treasury Department usually advertised in newspapers when it was looking for a contractor to build a lighthouse. The local superintendent of lighthouses arranged for advertising and had general specifications printed in the newspaper. Usually, these specifications guided the successful bidder in the construction. He reviewed the bids and rejected the ones he felt could not satisfactorily complete the work. He notified the fifth auditor of his rejections, selection, and the reasons for his decision. The reasons for rejection were varied: the contractor would not be able to make bond; he was too inexperienced as a builder; he had done faulty work in the past, etc. These, of course, are subjective reasons, and one wonders whether the superintendent may at times have been trying to eliminate lower bidders to get a contractor who was a political friend. Though the final selection of a contractor was made in Washington, more often than not, the superintendent's recommendation was accepted, and the contract, including specifications, was approved and let by the superintendent of lighthouses.

John McComb, Jr., a famous architect-builder, erected several lighthouses, including the one at Cape Henry (1792) at the entrance to Chesapeake Bay, Virginia; at Montauk Point (1796) on the tip of Long Island; and at Eatons Neck (1799), also on Long Island, New York. All were built in the 1790s, and all are still standing.

Alexander Parris, a noted architect-engineer (1780-1852), erected several lighthouses, including ones on Mount Desert Rock (1847), Libby Island (1848), Monhegan Island (1851), Matinicus Rock (1857), and Saddleback Ledge (1839). Parris probably also built Whitehead Lighthouse (1848). All of these waveswept lighthouses, erected in the middle part of the last century off the coast of Maine, were made of local granite and are still standing. Benjamin Latrobe, the nation's first professional architect, in 1788, unsuccessfully bid on the construction of Old Point Comfort Lighthouse (1802), Virginia. In 1805, Latrobe designed a lighthouse for the mouth of the Mississippi River at the request of Albert Gallatin, Secretary of the Treasury. Latrobe's son Henry and pupil William Strickland went on to design lighthouses; the latter built the first lighthouse at Brandywine Shoal (1828), Delaware Bay.

John Donahoo, a commercial fisherman and builder, erected 12 of the first 17 lighthouses in Maryland. He was the low bidder on all the contracts on which he bid, and he was a favorite of Stephen Pleasonton. Donahoo built very well, for all of his lighthouses, except five, still stand. Of the five, two were lost to erosion, one to a winter storm when it was well over 100 years old, one to demolition, and one to fire 24 years after it had gone out of service. Lighthouses built by Donahoo include Pooles Island (1825), Thomas Point (1825), Fog Point (1827), Concord Point (1827), Cove Point (1828), Point Lookout (1830), Lazaretto Point (1831), Clay Island (1832), Turkey Point (1833), Piney Point (1836), Blackistone Island (1851), and Fishing Battery (1853).

Winslow Lewis, a Boston ropemaker, inventor, and chandler who supplied inferior patented reflector-lamps and sperm oil to lighthouses on the Atlantic coast, became in the eyes of at least one historian a premier lighthouse builder in America and perhaps in the world.[142] Lewis, who had a special relationship with the fifth auditor, received contracts to erect about 24 lighthouses, some using the Latrobe design, but few of his lighthouses remain standing today. This is, in part, because of the early period in which he worked, the lack of modern technology, and the difficulty of the soft eroding muds of the Mississippi delta on which he built most of his lighthouses. Lewis built the three short lighthouse towers on Cape Cod that came to be called the "Three Sisters" (1838), the only tri-tower lighthouse station in the United States. The government's supervisor for the project found the work on the three structures to be shoddy, and refused to sign off on the work. He was directed to do so by the Boston collector of customs. The fifth auditor had already accepted the work. Other government officials later complained about these three towers, but Lewis and the fifth auditor seemed little bothered by the criticism.[143] Other lighthouses built by Winslow Lewis include Franks Island (1818 and 1822), Louisiana; Pensacola (1825), Florida; St. Marks (1831), Florida; Southwest Pass (1832), Louisiana; South Pass (1831 and 1842), Louisiana; Pass Christian (1831), Mississippi; Choctaw Point (1830), Alabama; Cat Island (1831), Mississippi; St. George Island (1833), Florida; Sand Island (1838), Alabama; Dog Island (1838), Florida; and St. Josephs Bay (1838), Florida. Lewis subcontracted most of his lighthouse work. He also conducted the first survey for the location of the Romer Shoals day-beacon (1838), New York, which was later determined to be built about a mile from its correct position.[144]

Isaiah William Penn Lewis, better known as I.W.P. Lewis, civil engineer, nephew and severe critic of Winslow Lewis, was directed by the Treasury Department in 1843 to inspect and report on most of the lighthouses of the New England coast. This was apparently the first instance in which an engineer had been employed with any important capacity in the Lighthouse Establishment. Lewis also designed the Carysfort Lighthouse (1852), and Sand Key Lighthouse (1853), both in the Florida Keys, both exoskeletal tall tower screwpile lighthouses.

Francis A. Gibbons of Baltimore erected a number of lighthouses. His early lighthouses exhibited faulty construction, but it may not have been his fault. Before Gibbons had begun to build the Bodie Island Lighthouse (1848), North Carolina, Pleasonton had directed the collector of customs to use piles for the foundation if mud were found at the site. When Gibbons found a viscous substance he thought to be quicksand, the collector of customs directed him to lay a foundation of bricks two layers high. Pleasonton was not pleased with the collector's decision, but by the time he found out what had happened, the work on the lighthouse was completed. Lighted in 1848, the lighthouse had to be rebuilt in 1859, apparently because of foundation problems.[145] In 1848, Gibbons erected the Egmont Key Lighthouse (1848), Florida, but within ten years shifting sand, induced by two hurricanes virtually back to back, undermined the tower, and it had to be replaced in 1858. Gibbon's next foray into lighthouse construction was in the early 1850s when he went into partnership with Francis X. Kelly of Baltimore to build the first eight lighthouses on the west coast.

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[142] Robert G. Bachand, *Northeast Lights: Lighthouses and Lightships Rhode Island to Cape May*, New Jersey (Sea Sports Publications, Norwalk, Connecticut, 1989), p. 137.

[143] A. Berle Clemensen, et al., *Historic Structure Report: Three Sisters Lighthouses, Cape Cod National Seashore, Massachusetts*, Department of the Interior, National Park Service, January 1986, pp. 11-14, 17. The brick sisters served for over 50 years before being replaced by wooden structures.

[144] Bachand, p. 301.

[145] Kevin M. McCarthy, *Florida Lighthouses* (Gainesville: University of Florida Press, c.1990), p. 93; Holland, *Great American Lighthouses*, p. 202.

After taking over aids to navigation, the Lighthouse Board initially erected many lighthouses with their own crews. Contractors built the others with close supervision by the district engineer. When the plans and specifications, which were much more extensive and detailed than those previously prepared by the fifth auditor, were completed and approved, the project was issued for bid. With the exception of screwpile lighthouses that were built in the district depots, lighthouses after the 1870s were usually erected by contract. The Lighthouse Board did not scrimp on construction costs; consequently, their lighthouses have lasted far longer than those erected in the first part of the 19th century.

Working with lighthouses attracted a number of government officials. Lt. George G. Mead, who later achieved fame as the commander of union forces at the battle of Gettysburg, assisted Maj. Hartman Bache in the construction of the Brandywine Shoal screwpile lighthouse (1850), Delaware Bay, and went on to complete the construction of the Carysfort Reef Lighthouse (1852), the first of the tall lighthouses on the Florida reefs, and subsequently constructed the Sombrero Key (1858) and Sand Key (1853) lighthouses in the same vicinity. Mead supervised the construction of Absecon Lighthouse (1957), New Jersey, and surveyed and recommended the replacement of the Barnegat Lighthouse (1857), New Jersey, with a first-order tower. He designed Jupiter Lighthouse (1860), and assisted in designing Seahorse Key Lighthouse (1854), both in Florida. Mead also invented a five-wick, first order, hydraulic lamp used in Fresnel lenses.

Hartman Bache, a distinguished engineer of the Army Corps of Topographical Engineers, built the second screwpile lighthouse in the United States, the Pungoteague River Lighthouse (1854) in Chesapeake Bay. Major George H. Elliot, who in the early 1870s served as Engineer/Secretary of the Lighthouse Board, designed the conical cast iron tower for Hunting Island (1875), South Carolina. Curved iron plates of identical dimensions were cast with flanges extending along each edge on the inner surface of the curve and knees were cast inside the curve for support. At the site, the plates could be connected by wrought iron bolts through holes in the flanges, forming rings. The rings could be bolted together vertically with the lower rim of each course overlapping the one below it which fit into a half-round cast ridge. By varying the size of the plates and number of courses, lighthouses of different heights and dimensions could be made. Architectural features, such as door and window openings, were cast into the integral part of a plate so when fastened together an attractive, uniform pediment or hood could be produced.[146]

During the construction of the Ponce de Leon Inlet Lighthouse (originally Mosquito Inlet) (1887), Florida Lighthouse District Superintendent of Construction, Herbert Bamber, invented an adjustable, moveable Working Platform that increased the efficiency and ease of constructing masonry towers. Individual bricks were left out of the exterior tower wall every 10 feet vertically and horizontally so that supports for the platform could be set into the holes. Once the tower was complete, the holes were filled as the platform was lowered.

Keepers as Heroes

Some lighthouse personnel over the years became heroes. In 1856, Abbie Burgess Grant tended the Matinicus Rock Lighthouse, Maine, when her father, the keeper, was caught ashore when a storm came up. She also cared for an ailing mother in that memorable storm. Much has been written about her, especially in children's books. Ida Lewis, daughter of a lighthouse keeper and keeper herself at Lime Rock, Rhode Island from 1879 to 1903, is the most famous of light keepers for the 18 to possibly 25

[146] J. G. Barnard, "Lighthouse Engineering as Displayed at the Centennial Exhibition," American Society of Civil Engineering Transactions, volume 8, 1879, p. 70.

lives she saved. In 1881, she received a gold lifesaving medal. Much was written about her, and she became so famous that former president Ulysses S. Grant, Admiral George Dewey, and other notables visited the Lime Rock Lighthouse to pay homage to her. When she retired, the Rhode Island legislature officially changed the name of the island on which the light station stood to Ida Lewis Rock. The Lighthouse Service then changed the name of the light station to Ida Lewis Lighthouse, the only such honor ever given to a lighthouse keeper. Deactivated in 1963, the structure now serves the Ida Lewis Yacht Club.

Another admirable light keeper is Kate Walker. Her husband, keeper of the Robbins Reef Lighthouse in New York Inner Harbor, was taken ill and had to go to the hospital. On departing he said, "Mind the light, Katie." He died in the hospital, and Mrs. Walker was eventually made keeper of the light. The quintessential working mother, each morning rowed one mile to Staten Island with her two children so they could go to school, and retrieved them in the afternoon. She continued to keep the light until reaching age 73 when she retired. She lived at the lighthouse for 33 years -- 23 of them as keeper. She estimated she rescued, over the years, 50 people, mostly fishers who, caught in storms, either had their boats overturned or crashed on Robbin's Reef.[147]

Gold and silver lifesaving medals were given to keepers who displayed extraordinary heroism in rescuing victims of the sea. Mark A. Hanna, keeper of the Cape Elizabeth Lighthouses, Maine, was awarded a gold medal for rescuing two seamen from a wrecked schooner in a snowstorm. Thomas J. Steinhise, keeper of the Seven Foot Knoll Lighthouse in Chesapeake Bay, Maryland, was awarded a silver medal for rescuing six members of the crew of a sinking tug in a northeast storm. The waves were crashing over the light station's small boat as he struggled to pull the men aboard.[148]

[147] Cliff Gallant, "Mind the Light, Katie," *The Keeper's Log*, v. III, no 3, pp.16-18.

[148] Holland, *America's Lighthouses*, p. 52; Seven Foot Knoll file, Lighthouse files, Maryland Historical Trust.

Description

The U.S. Lighthouse Service in 1915 regarded lighthouses as lights where resident keepers were employed.[1] There are many aids to navigation that were never manned; these are not included in our definition of a light station. In addition to the tower and keeper's quarters, a light station might also consist of an assistant keeper's quarters, fog signal building, oil house, workshops, cisterns and water catchment basins, storage buildings, barns/garages, boathouse, tramways, docks, and other support structures (see Lighthouse Components, page 32). As of 2002, the National Park Service's computerized inventory of historic light stations included 584 lighthouse towers that are 50 years old or older. Of these, the Coast Guard managed approximately 312, 214 of which have already been listed in or determined eligible for listing in the National Register of Historic Places.[2]

Significance

Lighthouses are one of, if not the most, romantic symbols of our maritime heritage. By preserving lighthouses, we preserve for everyone a symbol of that chapter in American history when maritime shipping was the lifeblood of the nation, tying isolated coastal towns and headlands through trade to distant ports of the world.[3] Historic and cultural resources represent our nations patrimony. Their owners have an entrusted legal and moral responsibility to care for them. Each lighthouse is special in the context of its geographic location, architectural style, and history. Where the historic integrity of the light station remains intact, the visitor can experience this aspect of our maritime heritage.

Registration Requirements

What makes a lighthouse historic? Identifying historic lighthouses

Not all lighthouses or all structures at light stations are historic nor do all warrant preservation. But how does one determine historic significance of light station properties? How can one be certain that a light station or portion of a light station (only one or more structures of a light station versus a entire light station) warrant preservation? Perhaps the best method for determination, and the method required by the National Historic Preservation Act, is the criteria established for inclusion of properties in the National Register of Historic Places. Nearly 70 percent of all lighthouses in the United States (Coast Guard owned and otherwise) over 50 years old are either listed in the National Register of Historic Places or are determined eligible for listing, and the number is climbing as lighthouses and other light station structures are added to the list.

The National Historic Preservation Act of 1966 authorizes the Department of Interior to establish, maintain, and expand a National Register of Historic Places. This list is considered the official list of

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[1] de Gast, p. viii; and *United States Lighthouse Service 1915* (Government Printing Office, Washington, D.C., 1916), p. 18.

[2] Figures derived from the National Maritime Initiative computerized inventory of historic light stations, February 2002.

[3] Deborah Davis, Keeping the Light: A Handbook for Adaptive Re-use of Island Lighthouse Stations (Rockland, Maine, Island Institute, 1987), p. 2.

the Nations cultural resources worthy of preservation and is maintained by the National Park Service. The Register includes over 68,000 properties that have been recognized as having historic, architectural, archeological, engineering or cultural significance, at the national, state, or local level; this list grows steadily as more properties are identified and nominated each year. The nominations are maintained both on paper and in a computerized database.

Hierarchy of character-defining features

The many structures and features of a light station should be considered cumulatively in accessing its integrity. The tower is vital to defining the station. Keeper's quarters are universal to light stations; sound signal buildings are not. The secondary structures that support the operation of the aid to navigation are significant but their exclusion does not necessarily preclude eligibility for listing in the National Register. The following is a priority listing of the physical elements to consider.

1. *Tower*: Minimum consideration is daymark feature, i.e., shape and color to identify it to mariners. Does the tower still have its daymark characteristic? Daymark does not necessarily include presence of a lantern. For example, Bald Head Lighthouse meets only that minimum requirement.

a. *Lantern*: Ideally the light tower should have a lantern used during its period of significance. Lanterns did change over some lights' operational history to accommodate different lenses and operational requirements. An accurate replica lantern made of suitable materials is better than no lantern. A lighthouse without a lantern, Piedras Blancas Light or Egmont Key Light, for example, are eligible, however they should not be considered significant for architecture or engineering under Criterion C, but could qualify as significant for transportation under Criterion A.

b. *Lens*: Ideally, the light tower should have an operational lens that was used during its period of significance. The next preference would be a non-operational lens used during its period of significance. A replacement Fresnel lens for a lens of the same order and characteristics is next in order of preference and then a Fresnel lens replacement lens of a different order or characteristic. This order of preference takes into account the historical practice of replacing lenses damaged in operation with a spare lens of the same order and characteristic from the inventory in storage. The damaged lens was then repaired and placed in storage until needed elsewhere. Also, the signal characteristics were modified as needed, to better serve the needs of the mariner.

c. *Interior*: Original access to the lantern should be intact, including original stairway, ladderways, and service room. Original interior detailing, such as molding, doors, door hardware, cabinetry also contribute to integrity.

d. *Operational Features*: Mechanisms for rotating the lens, lens pedestal, and ventilators.

e. *Attached Structures*: Towers were often built with attached work rooms, oil rooms, keeper's quarters, and fog signal buildings. It is preferable that these attached structures remain in place.

2. *Keepers' Quarters*: The presence of a keeper's quarters is preferable to a station without its keeper's quarters. A keeper's quarters that retains its configuration from the period of significance is preferable to one that does not. This also applies to assistant keeper's quarters.

3. *Sound Signal and Sound Signal Building:* Its presence, if part of the operational history, is preferable to none at all. The presence of the sound signal equipment is extremely rare and, therefore, especially significant.

4. *Oil house, generator house, fuel tanks, workshop*, which support the operation of an aid to navigation add to the completeness of a station.

5. Other subsidiary structures which add to the completeness of a station:

   a. boathouse, garage/barns, pier, tramways, elevated walkways (transportation related)

   b. cisterns/wells, storage buildings, privies (support keeper)

6. Architectural features, such as gargoyles, finials, architectural detailing

Assessing integrity

The National Register traditionally recognizes a property's integrity through seven aspects or qualities: location, design, setting, materials, workmanship, feeling, and association.

Location

Location is the place where the historic property was constructed or the place where the historic event took place. Integrity of location refers to whether the property has been moved or relocated since its construction. A property is considered to have integrity of location if it was moved before or during its period of significance. Relocation of a light station during its active career, if the move enhanced or continued its function, is not a significant loss of integrity. Aids to navigation relocated to serve new purposes after being decommissioned, suffer a serious loss of integrity of location, but are not automatically precluded from eligibility.

Relocation of lighthouses: Lighthouses have been moved historically in order to better serve the mariner. For example, in 1877, the 1855 Point Bonita Lighthouse was relocated from a high bluff to a rocky promontory to improve its visibility to mariners. Often lighthouses were designed to be moved, especially in areas where the shoreline was changing. When the Lighthouse Establishment approved the first Sharps Island Lighthouse, built in 1837 in Chesapeake Bay, the plans called for a small wooden keeper's house surmounted with a lantern and designed with wheels so it could be easily moved in the event that erosion threatened the structure. The lighthouse was so moved in 1848, presumably on these wheels. Later, cast-iron-plate towers were designed so they could be disassembled and re-erected as needed. This was relatively easy to accomplish as the prefabricated curved cast iron panels were bolted together. Cape Canaveral Lighthouse (1868), Florida, and Hunting Island Lighthouse (1875), South Carolina, are examples of this design; both being successfully moved.

While any historic structure is best located in its original location, it is better to have a historic structure in a non-original location than to have no historic structure at all. If a move is necessary to save the structure, every effort should be made to maintain as much of the original station integrity as possible. The lighthouse tower should normally have the same orientation to the water as it had before the move. Other station structures should be similarly moved to demonstrate the same relationship of one structure to the other. Landscaping can also be used to help restore the original impression of the station.

Several moved lighthouses have been placed in the National Register. Examples include: Drum Point Lighthouse (1883), Maryland, moved to a museum setting in 1975; Seven Foot Knoll (1855), Maryland, moved to the Inner Harbor of Baltimore in 1987; Hooper Strait Lighthouse (1879), Maryland, moved to a museum setting in 1967. Though it is more desirable for these properties to remain in their original locations; they are primarily significant for architecture and engineering rather than transportation; therefore relocation did not cause them to be delisted. Block Island (1875), Rhode Island, was moved back from a bluff in 1993; and Cape Canaveral Lighthouse (1868), Florida, was moved about one and a third mile inland in 1894 because of the threat of erosion. These properties have retained their original relationship to the water and retained their approximate historical environment and function.

Design

Design is the composition of elements that constitute the form, plan, space, structure, and style of a property. But properties change through time. Lighthouses may be raised or shortened; lanterns may be replaced; buildings may be added or removed from a light station; sound signal equipment and optics may change to reflect advancing technology. Changes made to continue the function of the light station during its career such as placement of a new lantern to accommodate a Fresnel lens may acquire significance in their own right. These changes do not necessarily constitute a loss of integrity of design. However, the removal of equipment that served as the actual light station such as a fog signal, or lens and lamp, or the removal of distinctive day markings on a tower, has a considerable impact on the property. Removal of an optic from a lighthouse, a foghorn or bell from its building, or painting over a historic lighthouse's day mark pattern, has a serious adverse effect on its design integrity.

The design integrity of light stations is also reflected by the survival of ancillary buildings and structures. The decision to nominate a light station should include an assessment of the design integrity of the property as a complex. The loss or substantial alteration of ancillary resources, such as keepers' quarters, oil houses, cisterns, and tramways, for example, may constitute a loss of design integrity.

Setting

Setting is the physical environment of a historic property that illustrates the character of the place. Integrity of setting remains when the surroundings of a light station have not been subjected to radical change. Integrity of setting of an isolated lighthouse would be compromised, for example, if it were now completely surrounded by modern development. The historic Eatons Neck Lighthouse (1799), New York, is immediately surrounded by five modern two-story dwellings built to provide housing for Coast Guard personnel at the station. The setting for this otherwise historic structure has been compromised.

Materials

Materials are the physical elements combined in a particular pattern or configuration to form the light station during a period in the past. Integrity of materials determines whether or not an authentic historic resource still exists. Materials should be replaced in kind. Many offshore light stations in the Chesapeake Bay have had their interiors inappropriately covered with plywood and/or particleboard. The roofs of many structures have been covered with asphalt shingles when slate, wood, or standing seam metal was the original roof covering. Work should meet the Secretary of the Interior's Standards which require all treatments to not only be neat and professionally done, but be reversible, that is, materials could be removed without causing harm to any historic fabric.

Workmanship

Workmanship is the physical evidence of the crafts of a particular culture or people during any given period of history. Workmanship is important because it can furnish evidence of the technology of the craft, illustrate the aesthetic principles of a historic period, and reveal individual, local, regional, or national applications of both technological practices and aesthetic principles.

Feeling

Feeling is the quality that a historic property has in evoking the aesthetic or historic sense of a past period of time. Although it is itself intangible, feeling is dependent upon the light station's significant physical characteristics that convey its historic qualities. Integrity of feeling is enhanced by the continued use of a historic optic or sound signal at a light station. Likewise a lit tower is preferred to a non-lit tower, even if lit by a modern optic. While sounds themselves, such as the "Beeoooohhh" of a diaphone, cannot be nominated to the National Register, they enhance the integrity of feeling. The mournful call of foghorns on San Francisco Bay is an integral part of experiencing life there.

Association

Association is the direct link between property and the event or person for which the property is significant. A period appearance or setting for a historic light station is desirable; integrity of setting, location, design, workmanship, materials and feeling combine to convey integrity of association.

Reconstructions

Reconstructed light station structures are not generally eligible for the National Register because they are not authentic historic resources. In rare instances, reconstructions at a historic light station can be contributing elements of a National Register property if: 1) the reconstruction is based on scholarly analysis of graphic, written, and archeological sources; 2) the reconstruction is accurately executed, using appropriate period materials and construction techniques; or 3) the reconstruction is presented in a historically appropriate manner as an integral part of, or as part of a group of properties, such as a light station, which together constitute a historic district. Reconstructed light station structures must be part of an overall restoration plan for the entire resource.

The following examples are given to illustrate instances when reconstructions may be acceptable: The deteriorated watch room and lantern of Minots Ledge Lighthouse (1860), Massachusetts, was removed and replaced with a replica. This lighthouse is noted as America's first wave swept lighthouse and is important as one of the U.S. Lighthouse Service's top ten engineering feats. The reconstructed watchroom and lantern do not detract from the structure's integrity as the workmanship and materials match the original. The Key West Light Station (1848), Florida, has an accurate and historically appropriate replica oil house and cistern that help to restore the original historic setting of the station. Both light stations are listed on the National Register.

Criteria for determining significance[4]

Properties eligible for listing in the National Register may be districts, sites, buildings, structures, and objects. The criteria include significance of a property in American history, architecture, archeology, engineering, and culture.

The National Register nomination process uses the following criteria to determine the historic significance of sites, buildings, structures, and objects:

A) association with *events* that have made a significant contribution to the broad pattern of our history; or

B) association with the lives of *persons* significant in our past; or

C) embody the *distinctive characteristics* of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D) yield, or may be likely to yield, *information* important in prehistory or history.

Criterion A

Under Criterion A, association with events that have made a significant contribution to the broad patten of history, a light station may qualify for listing in the National Register through its association with historic themes. Applicable areas of significance would include the obvious maritime history themes such as transportation, as well as several other categories such as architecture and engineering. Therefore, background information must be provided to explain the significance of the light station. Areas of significance to consider may include art, commerce, communication, engineering, entertainment/recreation, government, invention, literature, military, social/humanitarian, and transportation.

Criterion B

Under Criterion B, association with persons significant in our past, a light station will possess significance if a person's historical prominence is tied directly to the aid. These persons should have a strong tie to the property, such as keepers or politicians who lobbied for the establishment of the light station. This significance would not, for example, relate to visits to the light station by important people. National Register Bulletin 32, *Guidelines for Evaluating and Documenting Properties Associated with Significant Persons*, provides further guidance on Criterion B and its application.

Criterion C

Under Criterion C, an aid to navigation possesses significance if it embodies the distinctive characteristics of a type, period, or method of construction, or represents the work of a master, possesses high artistic values, or represents a significant and distinguishable entity whose components may lack

[4] Much of this section taken from James P. Delgado and Kevin J. Foster, Guidelines for Evaluating and Documenting Historic Aids to Navigation (National Register Bulletin 34, National Park Service, Interagency Resources Division, no date).

individual distinction. A light station must possess certain features to be a good representative of its type, period, or method of construction. These features vary. For example, in analyzing an early 20th century caisson lighthouse, a researcher would look for the characteristic sparkplug shape with a circular steel tower rising up from a submerged circular cylinder foundation, and boat falls mounted around the lower gallery deck. A caisson lighthouse reconfigured when automated, with the top stories of the tower replaced by a small modern beacon, might still be identifiable as a caisson lighthouse because the caisson cylinder foundation itself remains, but it is no longer a good representative of the type. Light stations are usually found to be eligible for National Register listing under Criterion C within the following categories:

Architecture: Light station may be significant if it is: 1) a good representative of a specific style of architecture, such as a Cape Cod style lighthouse; 2) a good representative of a specific type, such as a screwpile, caisson, or octagonal stone tower; or 3) a good example of the work of a master architect or builder.

Art: A light station may be significant for artistic works incorporated into the structure, such as stations with decorative sculpture reliefs or murals.

Engineering: A light station may be significant because of the engineering required for its construction, such as Minots Ledge Lighthouse or the tall skeletal tower screwpile lighthouses in the Florida Keys. Some light stations may be significant for their optics and sound signals, such as light stations that retain their clockwork mechanisms for revolving lenses or bell-strikers. Engineering achievements that are no longer extant do not impart significance in this area.

Criterion D

Under Criterion D, a light station is significant if archeological research at the site has yielded or is likely to yield information important to history. These data might include: design information, methods of construction, operation, and life at no longer extent light stations. Examples of sites that might possess significance under Criterion D include archeological remains of earlier light stations on the site or missing components of an extant light station. For example, if only the tower of a light station survives, archeological study of the foundation remains of the outbuildings, keeper's quarters, trash pits, and other structures may provide a detailed picture of the light station and life there and enhance an otherwise sketchy or largely undocumented historic record.

Archeological documentation

Archeological significance is determined by the assessment that the archeological resource, and the scientific analysis of it, will add to or revise the understanding of history. This is done by documenting the poorly recorded or undocumented aspects of a light station, such as the layout and construction of the earliest Colonial lights. The nomination should clearly demonstrate that the archeological information obtained from the site would significantly supplement or revise current historical or archeological knowledge or understanding.

When documenting the archeological features of a light station, the nomination should stress how the site is known to possess archeological remains, such as through remote sensing or archeological test excavation. The documentation of light station sites, including missing or earlier buildings and structures at existing light stations, should include descriptions and characteristics determined through archival research that are then assessed, verified, or contrasted with the actual physical, archeological record. Archeological documentation should include a site plan showing where excavation units were placed, recorded drawings of exposed features (such as a lighthouse foundation or a deposit of material culture in a trash pit), and photographs of archeological features or significant artifacts.

Criteria considerations

Certain types of historic light stations as a general rule do not qualify for the National Register. These would include 1) aids less than 50 years of age; 2) reconstructed light station structures; 3) lighthouses moved from their original sites; and 4) collections of artifacts from light stations, including large artifacts such as lenses, fog signal equipment, and other parts of light stations removed from their setting. Some of these properties may qualify for National Register listing, however, if they meet certain exceptions.

Resources less than 50 years old: A light station achieving significance within the last 50 years can be listed in the National Register if it is of exceptional significance. To qualify, a light station must be associated with important but recent themes or developments (such as representing the first or best example of new technology, architecture, experimentation, and engineering) which scholarly or professional research has recognized as significant in the history of light station engineering, construction, or operation. Light stations potentially eligible under these circumstances would include the first Texas Tower type lighthouse, Buzzards Bay Lighthouse (1961), located in Buzzards Bay, Massachusetts; or the last tall lighthouse tower built in the United States, the 163-foot New Charleston Lighthouse (1962) on Sullivan's Island, South Carolina. This masonry tower is unusual in that it is the only triangular-shaped, aluminum-clad, elevator-accessed lighthouse in the United States. Such a light station must be compared with other light stations of its type (if any) that have similar associations and qualities to establish exceptional significance.

Levels of significance: local, state, and national

Historic contexts are found at a variety of geographical levels or scales. The geographic scale selected may relate to a pattern of historic development, a political division, or a cultural area. Regardless of the scale, the historic context establishes the framework from which decisions about the significance of related properties can be made.

Local significance

A local historic context represents the relationship of a light station to an aspect of the history of a harbor, town, city, county, cultural area, or local region. It is defined by the importance of the light station, not necessarily the physical location of the light station. For instance, if a property is of a type of light station found throughout a State, or the distribution of the light station type extends over two or more States, but its importance relates only to a particular site, harbor, relatively small body of water, cultural area, or local region, the light station would be considered of local significance.

State significance

Light stations are evaluated in a statewide context when they represent an aspect of the history of the State or territory. The light station does not necessarily have to belong to a light station type found throughout the entire State; the type may be located in only a portion of the State's present political boundary. It is the light station's historic context that must be important statewide. For example, the once numerous Chesapeake Bay cottage-type screwpile lighthouses were located only in the tidewater portion of Maryland and Virginia, yet its historical development in the mid to late 19th century enabled shoals to be more accurately marked by building lighthouses directly in the water on the shoal instead of on nearby points of land. In effect, this lighthouse technology made passage of vessels in the tidewater areas safer and helped to increase the commerce of the entire State. These State historic contexts may have associated properties that are statewide or locally significant representations. A fifth or fourth order harbor caisson type light station in a small port town might be a locally significant representation of the caisson type, while a fifth, fourth or third order caisson light station marking a major harbor might be of State significance. Both caissons, however, are representative of the type.

A light station whose historic associations or information potential appears to extend beyond a single local area might be significant at the State level. A light station can be significant to more than one community or local area, however, without having achieved State significance. A light station type that overlaps several State boundaries can possibly be significant to the State or local history of each of the States. Such a light station type is not necessarily of national significance, however, nor is it necessarily significant to all of the States in which it is located.

National significance

Light stations are evaluated in a national context when they represent an aspect of the history of the United States and its territories as a whole. These national historic contexts may have associated light stations that are locally or statewide significant representations, as well as those of national significance.

Light stations designated as nationally significant and listed in the National Register are those properties which may potentially be designated National Historic Landmarks. The National Historic Landmark criteria are the standards for nationally significant properties; they are found in the *Code of Federal Regulations, Title 36, Part 65* and are summarized in *National Register Bulletin Number 15 Part IX: Summary of National Historic Landmarks Criteria for Evaluation.*

A light station property with national significance helps us understand the history of the nation by illustrating the nationwide impact of events or persons associated with the light station, its architectural type or style, or information potential. It must be of exceptional value in representing or illustrating an important theme in the history of the nation.

Nationally significant light station properties do not necessarily have to belong to a property type found throughout the entire country; they can be located in only a portion of the present political boundaries. It is their historic context that must be important nationwide. For example, the first Cape Henry Lighthouse served only the Chesapeake Bay and the mid Atlantic coast of the United States, yet as the nations first public works project it had a significant impact nationwide. Our elected officials realized the importance of lighthouses for aiding commerce between states and with other nations. It was the beginning of our federal program to provide safe navigation along the waterways of the United States. A pierhead light station at a small harbor might be a locally significant representation of this national context, while a set of range lights into a major harbor or river might be a statewide significant representation of the national context.

Statement of significance

The significance of a light station is based on its representation of a type, its association with significant themes in American history, and its comparison with similar light stations. The evaluation of a light station must include thorough historical research into its construction and modifications, including changes to sites, equipment, additions, and operation. Rather than offering just a chronological discussion of a light stations career, the historical narrative included in the Statement of Significance, Section 8 of the registration form should document a light station's significance or role in social, political, economic, architectural, or technological history. This might include a discussion of the following subjects:

- development of humanitarian concern for mariners
- the protection of commerce and transportation
- the assumption of and increasing responsibility of the federal government in operating light
- stations
- American maritime trade, engineering, and commerce
- the various designs of American lighthouses, lenses, lamps, and sound signals

Specific historic contexts might involve a lighthouse's place in the development of Colonial lights in North America; the construction, organization, and operation of lights under the Fifth Auditor of the Treasury or the Lighthouse Board; or the changes wrought by the introduction of the Fresnel lens. The historical discussion should enumerate the reasons for establishing the light station, such as numerous shipwrecks or political pressure, as well as factors influencing the selection of a site and construction method, such as logistical or funding problems, and adverse natural conditions.

The significance statement should be concise and well-developed. The information in the nomination will vary according to the light stations level of significance. The development of light stations on Chesapeake Bay, for example, may be of less significance to a particular lighthouse than its place in the national development of screwpile type lighthouses.

In discussing significance, link the light station to international, national, regional, and local historic contexts, as appropriate. Convey the specific association of a light station to specific historic events. If Criterion B is applicable, a light station's association with the significant individual(s) should be discussed. Assess the light station's relation to similar properties with similar associations. Derive statements of significance from primary sources and scholarly secondary historical or professional engineering assessments. Thorough historical research is recommended in preparing National Register registration forms so that the best available information is analyzed and presented.

In the Statement of Significance, assess and justify the period during which the property achieved historic significance. The period of significance relates to the date that the current light station was built or to the dates of significant associations. The period of significance may include the date that the light station site was established if significant historic resources with integrity from that period survive. For example:

Lighthouse X, important as a good example of a screwpile light, was built in 1886 on the site of former Lighthouse A, built in 1770. An appropriate period of significance for Lighthouse X would be its date of construction or 1886, not 1770. The period of significance could include the earlier period only if archeological information obtained on the site of Lighthouse A would significantly supplement or revise current historical or archeological knowledge or understanding.

The close of the period of significance might be the deactivation, automation, or transfer of a site to new owners as these dates often reflect an important change in the historic function of the light station. If however, none of these events occurred or failed to alter the significance of the light station or if the events occurred less than 50 years ago, then the close of the period of significance should be fifty years prior to the current year unless the light station has achieved exceptional significance within the past 50 years (refer to page 69).

Examples of light stations which obviously meet National Register criteria:

National significance

- Cape Henry (first tower) Lighthouse, Virginia, is the first lighthouse built by United States Government and the first public works project. It is significant for its role in American history. This light station qualifies under Criterion A, Commerce, Government, and Transportation; Criterion B, association with President George Washington and our first national government; and Criterion C, Architecture, John McComb, Jr.

- Thomas Point Shoals Light Station, Maryland, built in 1875, is the last largely unaltered spider foundation cottage-type screwpile lighthouse in the United States. As such, it is significant for American architecture and engineering. This light station qualifies under Criterion A, Commerce, Government, Engineering, and Transportation; and Criterion C, construction type, oldest cottage-type screwpile lighthouse in the United States remaining in its original location.

- Minots Ledge Light Station, Massachusetts, built in 1860, was the first, and most exposed waveswept lighthouse built in the United States and is considered one of the top ten engineering feats of the U.S. Lighthouse Service. It is also significant for American engineering. This light station qualifies under Criterion A, Commerce, Government, Engineering, and Transportation; and Criterion C, construction type, first wave swept lighthouse built in the United States, and engineering as one of America's greatest lighthouse engineering feats.

- Makapuu Point Light Station, Hawaii, built in 1909, houses a hyper-radiant Fresnel lens and is the landfall light for vessels coming from the West Coast to Honolulu. This light station qualifies under Criterion A, Commerce, Government, and Transportation; and Criterion C, construction type. The 1909 tower was designed to house the largest Fresnel lens ever installed in a light station in the United States. The lens is still functioning in its original setting.

- Sandy Hook Lighthouse, New Jersey, built in 1764, is oldest extant lighthouse in the United States. As such, it is a significant property in American history. This light station qualifies under Criterion A, Commerce, Government, and Transportation; and Criterion C, construction type, oldest octagonal masonry tower and oldest operational lighthouse in the United States.

State significance

- Pooles Island Light Station fog-signal building, Maryland, built in 1825, now demolished with its foundation ruins eroding from the banks of the island, was the site of one of the earliest mechanized fog signal stations in the United States. This light station qualifies under Criterion A, Commerce, Government, Invention, and Transportation; Criterion B, built by John Donahoo, a prominent lighthouse contractor in the Chesapeake Bay region; Criterion C, construction type; and Criterion D, archeology. Only the light tower is standing but the foundations of the fog signal building, one of Americas first and only stone fog building structures survives. The plans for this structure apparently do not survive; the archeological information from this site could prove useful to documenting this rare structure.

- Jones Point Lighthouse (1856), Potomac River, Alexandria, Virginia, is a one-and-one-half-story frame structure with integral tower surmounting its roof. The light station was automated in 1919 and deactivated in 1926. This light station qualifies under Criterion A, Commerce, Government, and Transportation; and Criterion C, construction type, integral wood frame. This is the only wood frame integral type lighthouse surviving in Virginia and, as such, possesses state significance.

Local significance

- Ludington North Breakwater Lighthouse (1924), Ludington, Michigan, is a fourth order pier light marking the entrance to Ludington harbor off Lake Michigan. This light station qualifies under Criterion A, Commerce, Government, and Transportation; and Criterion C, construction type, steel square pyramidal tower. This light station possesses historic integrity and is of local significance.

- Wood End Lighthouse (1873), Massachusetts, is a square brick tower marking the entrance to Cape Cod harbor. The light station's fog signal building and keeper's quarters have been demolished. A brick oil house survives. This light station qualifies under Criterion A, Commerce, Government, and Transportation; and Criterion C, construction type, harbor brick tower. This light station has lost much of its historic integrity due to demolition of associated light station structures but possesses local significance.

As illustrated above, those light stations which qualify for listing in the National Register will usually qualify because of their significant contribution to the broad pattern of American history, embody a distinctive characteristic of a type, period, or construction method, and/or that represent the work of a master. As such, nearly any lighthouse 50 years or older possessing site and historic integrity may qualify for listing at least on the local level. Thus, the following justifications may be used for most lighthouses: "Lighthouse X is significant for its association with federal governmental efforts to provide an integrated system of navigational aids and to provide for safe maritime transportation (specify region such as Chesapeake Bay, west coast, etc.) (Criterion A). Lighthouse X embodies a distinctive design and method of construction that was typical of (specify specific construction type such as screwpile, caisson, etc.) lighthouse construction on the (specify specific geographic region in which this construction method exemplifies such as Carolina sounds, Chesapeake and Delaware bays, etc.) during the (specify the time span when this construction method was used such as last quarter of the nineteenth century and first quarter of the twentieth century, etc.) (Criteria C)."

Examples of light stations that may not meet National Register criteria:

- Lime Point Fog Station, California, built in 1883 and outfitted with a post light in 1900, is significant as a working fog signal station and one of five light stations which served the entrance to San Francisco Bay. However, this station does not qualify for listing on the National Register due to lack of historic integrity of site. The Lime Point Fog Signal Station consisted of a fog signal building (1883), keeper's quarters (1883), boiler shed (1883), coal house (1883), wood shed (1883), various water tanks (1883, 1889, 1897, 1907), various fuel tanks (1094, 1907), oil house (1900), and storehouse (1907). About 1910, a rectangular concrete addition was added to the northwest corner of the fog signal station for the mounting of a search light by the U.S. Army. All of these structures have been demolished except for the fog signal building and search light addition. The integrity of the site and sole existing structure has been compromised beyond acceptable tolerance. Furthermore, while the foundations for the demolished structures survive, they provide little additional information to that which is already documented in plans, photographs and plats of the station that are preserved in the National Archives.

- Mile Rocks Lighthouse, California, built in 1906 near the entrance to San Francisco Harbor, was considered one of the great American engineering feats due to unusually strong currents and the open waveswept nature of the site. However, the lighthouse was automated, the upper two tiers of the tower removed, and a helicopter landing pad erected on top. The historic integrity of this otherwise important structure has been compromised beyond acceptable standards. The light station could qualify for listing on the National Register as an example of a caisson light station and for its engineering feat, but it is, nevertheless, a poor example of a lighthouse due to lack of integrity.

Subjectivity versus objectivity

Over time the interpretation of the National Register eligibility criteria for lighthouses has varied. For example, Piedras Blancas Lighthouse (1879), California, is listed on the National Register despite its lantern being removed in 1949 because of storm damage. It could be argued that the architecture of this broad tower, with its rounded pedimented windows and arched pedimented door, make the tower unique enough to warrant listing despite lacking one of its significant features, the lantern room. Furthermore, the historic keeper's quarters have all been demolished and replaced with ranch-style 1960s living quarters. The shell of the fog signal structure built in 1906 is extant and presently used for storage; all of the fog signal equipment has been removed. On the ground level interior of the light tower is a unique and an unusually large built-in wooden storage cabinet. The space of this unusually broad tower base was used as a workroom area, unusual for lighthouse towers. While this station retains some unique features, in general, the historic integrity of the site has been compromised and, therefore, it makes listing it in the National Register questionable.

This somewhat subjective process has resulted in some resources being listed that are questionable, while other resources that should be listed have not been listed. It is for this reason that the nomination form has specific check offs in Section 8 "Statement of Significance." The nominator must check all "applicable" criteria, as well as provide "areas of significance," "period of significance," "significant dates," "significant persons," "cultural affiliation," and "architect/builder," as well as a narrative describing the significance of the nomination. The nomination then goes to the State Historic Preservation Officer in the state within which the resource is located, who makes a recommendation with final authority resting with the Keeper of the Register.

What does listing on the National Register mean?

For any federal agency, it means the lighthouse and any other associated structures so listed such as keeper's quarters, fog signal building, oil house, etc., cannot be altered, neglected, or demolished without going through Section 106 review as required by the National Historic Preservation Act.

The National Historic Preservation Act (NHPA) requires a federal agency head with jurisdiction over a federal, federally assisted, or federally licensed undertaking, to take into account the effects of the agency's undertakings on *all* properties included in or eligible for the National Register of Historic Places and, prior to approval of an undertaking, to afford the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment on the undertaking.

G. Geographical Data

Any state along the coasts and Great Lakes that contain light stations -- Alabama, Alaska, California, Connecticut, Delaware, Florida, Georgia, Hawaii, Illinois, Indiana, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Puerto Rico, Rhode Island, South Carolina, Texas, U.S. Virgin Islands, Vermont, Virginia, Washington, and Wisconsin.

H. Summary of Identification and Evaluation Method

The U.S. Coast Guard is currently evaluating light stations under their jurisdiction that have not been previously evaluated for the National Register as part of their cultural resource management responsibilities under Section 106 and Section 110 of the National Historic Preservation Act of 1966, as amended. In 1997, the Coast Guard contracted with the National Park Services National Maritime Initiative to complete a multiple property documentation form as a vehicle for evaluating these properties for listing in the National Register. The Initiative gained considerable knowledge of lighthouses around the United States after conducting a national comprehensive survey, which was published in 1994. The Initiative has also evaluated light stations through preparation of several National Historic Landmark nominations for light stations and other maritime properties.

The historical contexts for this nomination were derived from two comprehensive draft studies on lighthouses. The first, completed by lighthouse historian Ross Holland in 1993, focused primarily on the administrative history of the lighthouse service. The second, completed by lighthouse consultant, Ralph Eshelman in 1997, developed a typology of lighthouse construction types. Registration requirements were developed using National Register criteria. Assessments of integrity are based on a hierarchy of structures and features composing a light station. Assistance, review, and comments were provided by Wayne Wheeler, president, U.S. Lighthouse Society; Beth Savage, architectural historian, National Register of Historic Places; and Kevin Foster, Chief, National Maritime Initiative.

Site visits were initially made to light stations owned by the U.S. Coast Guard in Maine and Virginia that had not previously been evaluated for listing in the National Register of Historic Places. Site visits, Ralph Eshelman conducted additional archival research, and initial preparation of the forms through a cooperative agreement with the U.S. Lighthouse Society. Also in the first submission, nominations for Maryland lighthouses under Coast Guard jurisdiction that were initially prepared by Ralph Eshelman for the Maryland Historical Trust have been reformatted and appended. As funding becomes available, more individual property nominations in other states will be prepared and appended to this study. Non-U.S. Coast Guard owners of light stations may also use this multiple property nomination as a vehicle for listing their properties in the National Register.

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