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Navigational aids used aboard ships or boats (from top left, clockwise): boat compass, protractor, parallel ruler, sextant, marine chronometer, divider, and the 1996 Philippine Coast Pilot

Hydrography & Navigation

Hydrography refers to the study and charting of the world's oceans, rivers, and other bodies of water. Hydrographic surveys are necessary for the production of nautical charts, which provide information vital to navigation. Considering the archipelagic nature of the Philippines, hydrographic surveying plays a crucial role in ensuring maritime safety in this country.



Above, Cape Bojeador lighthouse, Burgos, Ilocos Norte

Right, Navigational safety measures should strictly be followed to ensure safety aboard ships and similar vessels



EDITORIAL

The recent Gretchen I tragedy which claimed the lives of 50 people focused national attention once more on the perennial problems affecting maritime safety. As with the scores of other sea mishaps which have occurred before it, such an accident could have been prevented by the strict observance and enforcement of existing laws, rules and regulations governing the seaworthiness of vessels, competency of sailors and ship loading capacity.

Such steps should be taken to ensure that similar mishaps are prevented in the future. If no lessons are learned from such tragedies, then it is our fate to experience these misfortunes year after year.

For a country of 7,100 islands, the seas and inland waters are of primordial importance to its economic stability. Official figures reveal that every year, around 20 million people or 29% of the population travel by inter-island routes and about 80% of the country's trade are transported by sea routes. These statistics alone make it imperative for the government to pay more attention to the many problems plaguing maritime safety administration in the country.

With the enforcement of the United Nations Law of the Sea in 1994, the Philippine territorial jurisdiction has expanded by approximately 131,300 sq nm from 520,700 sq nm. This has opened up new opportunities for economic development in terms of the optimal use of our natural and mineral resources. On

the other hand, it has also posed other concerns for protecting the nation's territorial boundary.

There is therefore an urgent need to accelerate the delineation and survey of the country's 200-mile Exclusive Economic Zone or EEZ. The periodic assessment of resources underneath the bodies of water and the implementation of projects which will ensure safe navigation are only some of the major programs which government should prioritize.

As the lead agency for surveying and mapping, NAMRIA has made significant strides in the conduct of hydrographic and oceanographic surveys of vital sea routes, harbors, ports and other bodies of water. Utilizing modern technology, it has established traffic separation schemes in critical straits in order to prevent sea mishaps. Nautical charts, notice to mariners and other publications containing statistical hydrographic and oceanographic data continue to be produced by NAMRIA.

This year, the Tenth Congress has taken a serious look at the NAMRIA Modernization Bill which will enhance the agency's capability in generating comprehensive land and ocean resources information. With provisions for the acquisition and upgrading of equipment for digital map production, a more aggressive staff development policy, and the establishment of a ground receiving station, the modernization bill will enable NAMRIA to provide up-to-date, modernized, reliable and accurate land and ocean resource information to government and private clients.

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NEW PRODUCTS & SERVICES

Listed hereunder are new large scale urban base maps:

- One sheet covering Mactan, map sheet #3821-IV-16-C at scale 1:5,000
- One sheet covering Punta Engaño, map sheet #3821-IV-16-B at scale 1:5,000
- One sheet covering Olongapo City, map sheet #3030-I-16 at scale 1:10,000

The following contour maps of Metro Manila at scale 1:10,000 were revised:

- One sheet covering Baclaran, map sheet #3130-II-25

- One sheet covering Las Piñas, map sheet #3129-I-5
- One sheet covering Malibay, map sheet #3130-III-21
- One sheet covering Sun Valley, map sheet #3229-IV-1
- One sheet covering Manila South, map sheet #3130-II-20
- One sheet covering Mandaluyong, map sheet #3230-III-16
- One sheet covering Pasig, map sheet #3230-III-17

The new provincial map of Sarangani at scale 1:150,000 has also been introduced.

Likewise revised were the following Administrative maps:

- Region IV (4 sheets) at scale 1:250,000
- Occidental Mindoro at scale 1:200,000
- Oriental Mindoro at scale 1:200,000
- Romblon at scale 1:150,000

The following topographic maps of Metro Iloilo at scale 1:5,000 are now available: map sheet numbers 3522-III-7-A, 3522-III-2-B, 3522-III-7-D, and 3522-III-2-C.

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The Essence of Hydrography

by Lt(jg) Rosalino C. delos Reyes

The Philippine archipelago comprises about 652,800 square nautical miles of water, of which 25% is surveyed, 20% is inadequately surveyed, and the remaining 55% remains unsurveyed.

Hydrographic surveying mainly deals with the delineation of the sea bottom topography of navigable waters (lakes, rivers, and harbors) and the identification of water areas safe for navigation. In a much broader sense, it embraces a wide variety of activities, all of which are necessary for the **compilation*** of nautical charts and other related publications designed to provide all information required for safe navigation. It also supplies relevant data for engineering purposes, scientific research and environmental monitoring.

The accuracy of a nautical chart is dependent on the accuracy and adequacy of the hydrographic surveys from which it is compiled; it cannot be more accurate. The increasing draft and size of merchant vessels, growth of submarine activity, and the exploration and exploitation of marine resources, among other factors, combine to make the standards for hydrographic surveying ever more strict.

For the layman, the interpretation of **bottom configuration*** and other information plotted on nautical charts may seem ordinary and easy to determine. However, whereas the user of the topographic map is able to verify by visual inspection the details shown, the sea-floor topography contained in the nautical chart is obscure. Thus, great care is exercised in the execution, depiction and selection of information plotted on nautical charts.

Hydrographic surveying is more costly compared to land survey. A team of land surveyors, for example, might consist of three or more men using a service vehicle and a theodolite, tripod and two stadia rod as survey equipment. For a detached hydrographic survey, on the other hand, a team of four or more is required, as well as a motor launch and its accessories which may cost more than a service vehicle, depending on its size. Further, the motor launch also has greater depreciation and running cost.

The instruments and equipment used in hydrographic surveying are more expensive than their counterparts in land surveying. The vehicle can travel at, say, 50 kph and reach the working site after a few minutes relative to the location of the base camp. The vessel's speed will most likely be around seven to ten knots or about 14 to 18 kph and the survey area is frequently over 150 km from the nearest har-

bor. The logistics, fuel and passage time between base and the survey area, and the effects of weather conditions on the progress of the survey also play a big part in the scheduling and planning of surveying operations.

Plans and Preparation

In the Philippines, the Coast and Geodetic Survey Department (CGSD) of the National Mapping and Resource Information Authority (NAMRIA) is responsible for the delineation, depiction and identification of all dangers to navigation incorporated in the nautical charts.

The field operations of hydrographic survey in a specified area is a combination of operations which can include reconnaissance, topographic, hydrographic, oceanographic, and levelling surveys, as well as the establishment of geodetic controls. Each project is covered by project instructions approved by the CGSD Director or the Administrator of NAMRIA. Project instructions describe in detail the scope of work to be done, project limits, scale, establishment of controls, spacing of sounding lines, tides and current observation, and other relevant information needed as guide in the execution of the project.

One important aspect in the planning of activities is the conduct of a reconnaissance survey of the project area. A reconnaissance survey is a preliminary survey or investigation done in advance to gather necessary information such as for the recovery of old geodetic controls, ideal location to establish additional controls, possible camp site, and coordination with local officials. Aerial photographs are also good sources of reliable information. In the absence of detailed maps or nautical charts, these photographs provide a wealth of information for planning operations. Even when these maps are available, aerial photographs provide additional information in operational planning.

Several factors to be considered in hydrographic operations are the type of **sounding vessel*** to be used, type of echo sounder re-



Depth measurements using echo sounder and skiff with outboard motor

quired, positioning instruments, personnel requirements, and logistics.

Controls

Hydrographic surveys must be guided by a system of geodetic controls established with an accuracy not lower than that prescribed for third order control. This is carried out to determine the position of points which become the fundamental control for hydrographic surveying, as well as those landmarks which are used for navigational purposes. These controls are based on the existing values of triangulation station data, Global Positioning System (GPS)* observation, newly established geodetic controls, and controls set by traverse or any other method acceptable for positioning the survey vessel at sea while the work is in progress.

It is necessary to reduce the water depth to the real time value prevailing in the vicinity of the project area. The reduction of depths is based on the **Mean Lower Low Water (MLLW)*** which is the sounding datum used in the nautical charts produced by NAMRIA. A standard operating procedure for every hydro survey project is the installation of a portable tide gauge to serve as control station if there is no available tide gauge in the area where tidal data can be referred. This station is maintained throughout the duration of the survey and normally requires 30 days of continued observation to ensure reliable tidal measurements.

**Please refer to page 3 of Infomapper Vol. I no. 1 (October 1991) for a more detailed discussion of GPS in the article "Global Positioning System - An Introduction."*

Note:

* Terms in bold type and marked with asterisks are defined in the Glossary of Terms on page 16.

Coastlining

The accurate delineation of the shoreline and other coastal features is essential in hydrographic surveying since the mariner is often required to fix his position by bearings and angles with reference to the shoreline. Except for the application of satellite technology in fixing the vessel's position, which is being used nowadays, the shore is still the best reference for fixing the position using visual or electronic methods when the vessel approaches the coast. It is therefore important that every detail which can be represented based on the scale of the survey is carefully fixed and charted.

Positioning at Sea

A major element of the hydrographic survey is the dynamic positional control of the survey vessel. A great majority of the hydrographer's offshore tasks today require positioning services. Until the method to be used has been chosen, time schedules, costs, and other factors cannot be assessed.

Measuring a survey vessel's position at sea in coastal areas is primarily made on the basis of landmarks, for which either or both the optical or the electronic method is used depending on the equipment selected. Two or more position lines intersect to give a position fix. The accuracy of the fix is dependent on the precision with which the position lines can be determined and on their angle of cut.

For hydrographic work, the required accuracy will usually be defined by the scale of the survey and the limitations of plottable accuracy. For example, if the smallest plottable dimension is taken to be 0.5 mm and the scale of the survey is 1:10,000, the position fixing method is required to resolve distances on the ground of $10,000 \times 0.5/1000$ m, (i.e., 5 m) in order that one fix may be differentiated from another.

The ideal position fixing method provides continuous, precise information of the vessel's track at all ranges, in all weather conditions. This is made possible with the use of GPS technology. GPS is an all-weather, high-precision, global satellite system which transmits radio frequencies for positioning purposes. CGSD is utilizing the method that offers the best compromise within survey requirements without sacrificing the accuracy and adequacy of the survey.

Determination and Plotting of Water Depth

One way to obtain water depth is by using a special kind of instrument installed aboard survey vessels called "echo sounder." All echo sounders operate on the basic principle that a sound produced near the surface of the water will travel to the bottom and will be reflected to the surface as an echo. This echo sounding equipment is designed to produce the sound,

receive and amplify the echo, measure the intervening time interval, convert the interval into units of depth measurements, and record the depths on a moving graph. This is accomplished by running a predetermined system of sounding lines in an area that will delineate the submarine relief in the most thorough and economical manner. These lines should give a methodical representation of the depths and be sufficient enough to give indications, at least, of all banks and dangers present in the area covered by the survey. Nevertheless, a hydrographic survey can only be considered complete and adequate when there is reasonable assurance that all dangers to navigation and shoals existing in the area have been found and their least depth determined by close examination.

The results of the survey gathered in the field are checked and verified. These are plotted on a working sheet called "boat sheet" to determine if all the data and information are complete. After careful evaluation of the plotted data, another sheet of the same scale is constructed. In contrast to the boat sheet, this smooth sheet is the final, carefully made plot of the hydrographic survey based on corrected data (i.e., instrument correction, velocity correction, correction due to the effects of tides, etc.) and conforms with more cartographic survey standards.

After verification and review, the smooth sheet becomes the official permanent record of a particular survey and is the principal source of information for the production of a nautical chart.

Importance of Hydrography

Hydrographic surveying is the main function of national hydrographic organizations. The main products of hydrographic surveys are nautical charts. About 90% of the world's cargo are transported by ships which rely on nautical charts in moving their vessels from one port to another. It is easily understandable why developed countries place great importance on hydrography and nautical charting.

The Philippine archipelago comprises about 652,800 square **nautical miles*** of water, of which 25% is surveyed, 20% is inadequately surveyed, and the remaining 55% remains unsurveyed. The 187 charts published by CGSD at various scales cover the country's coastal waters. Most of these charts are products of old hydrographic and geodetic surveys with accuracies which are questionable by current standards. A great number of shoals and other hazards to navigation were undetected because measurement points were sparse. Many off-lying islets in charts may not

be in their true positions by several miles because they were located by conventional methods prevalent at that time.

The inadequate charting of Philippine waters can have an adverse effect on our economy. The citing of Philippine waters as hazardous to navigation because these are inadequately charted could translate into higher insurance premiums due to greater risks. Cargo ships would have to carry a lower volume of goods per trip to allow for uncertainty of charted depths at crucial passages. Also, ships may take longer routes as they confine themselves to familiar, well-traversed sealanes.

The string of sea accidents that happened a few years back has resulted in the loss of close to 4,000 lives and millions of pesos worth of property as in the case of the *Doña Paz* tragedy. Among the problem areas identified are the inadequate aids to navigation, as well as the lack of marine communication, environmental monitoring, and up-to-date nautical charts.

When the United Nations Convention on the Law of the Sea (UNCLOS) came into force in November 1994, it required each country to delimit its maritime boundaries in large-scale charts and deposit all pertinent technical information with the United Nations. These



Conventional plotting of a three-point fix using a three-arm protractor

documents shall serve as basic reference should there be conflicts or overlapping claims with neighboring countries. CGSD plays a crucial role in this aspect as the department is tasked to delimit, through hydrographic, oceanographic and geodetic surveys, the country's baselines, territorial seas, contiguous zone, Exclusive Economic Zone (EEZ), and the continental shelves.

Editor's Note: Due to space constraints, we cannot publish the list of references consulted for this article. Interested individuals may avail of the list from the author or the editors of this publication.

Hydrographic Surveying of the Exclusive Economic and Continental Zones

by Randolph S. Vicente
Mapping and Reprography Department

The Philippines' Exclusive Economic Zone (EEZ) and Continental Shelf (CS) play key roles in the country's economic scenario because it is likely that these contain a significant portion of the country's living and non-living resources that are subject to the different kinds of aggression which threaten the fragile environment vital to our survival.

A significant portion of the 1993-1998 Medium Term Philippine Development Plan deals with the exploitation of land-based resources, but it barely discusses the programs involving the survey, inventory and assessment of available resources of the country in the seas and the oceans.

Determination of the location and quantification of these marine resources remains to be vague as of this time. The absence of information and inadequacy of government programs necessary for the development of the country's territorial waters contribute to the prevailing ignorance of the significance of these areas.

Hydrographic surveying and charting can be utilized to generate ample information concerning these problems. These are indispensable activities that have to be done if we really want to tap offshore wealth to pursue economic development. The few existing nautical charts we have which are products of antiquated survey methods in the early 1900s are lacking in essential details.

Downstream Issues/Areas

To appreciate the significance of hydrographic surveys, it is imperative to discuss six major downstream issues/areas that depend, directly and indirectly, on their result/s. These are:

1. Political and Security Issues

Historical animosities, advancing regional military technology and presence, and overlapping claims all contribute to the uneasy atmosphere in the region. The UNCLOS that took effect last November 1994 expanded the territorial jurisdiction of the country by approximately 131,300 sq nm (from 520,700 sq nm to 652,000 sq nm). This may cause boundary conflicts within neighboring countries like Taiwan, China, Vietnam and Malaysia concerning the Kalayaan Islands (one of the overlapping claims), which are potential sources of oil. Thus, we must delineate the lawful boundary covering the Philippines' EEZ and CS.

2. Shipping, Navigation and Communications

One of the busiest waterways in the region is that of the Philippines. It does not only contain vital routes but acts as the lifeline of the various island provinces of the country. Safe navigation through these routes is of great concern. Oil spills and other disasters that have a catastrophic impact on the country's environment can be some of the possible serious results if we fail to implement safe navigational procedures.

3. Marine Science Research

Marine scientific researches are important in developing a better understanding of the Philippine waters and the impact of human activities. These are very important contributions to the knowledge base. The use of the different data would allow us to draw management plans/strategies, educate the populace about the significant functions of the living and non-living resources, and formulate sensible policies or laws to that effect.

(Continued on p.12)

SAILORSPEAK by Maria Romina B. dR.-Pe Benito

The mariner's language is truly unfamiliar to everyone except, well, the mariner himself.

The average traveler is, of course, more interested in enjoying his trip and getting to his destination safely. It might however be of interest to him to know some of the sailor's nautical terms. Perhaps he will be more observant the next time he boards a ship. Who knows, the information may even come in handy someday!

Ship Ahoy!

Ladders are stairs which the traveler climbs to get on his ship or go aboard. The bow is the forward part of the ship while the stern is its rear. The traveler standing on the ship faces forward when he faces the bow, and aft if he turns around or goes in, near or toward the stern.

As the traveler looks ahead of him, the starboard side of the vessel is the right-hand side while the port side is the left-hand side. The centerline is an imaginary line equidistant from the bow to the stern. The length of the ship is the length of the centerline while the beam is the greatest breadth or width of the vessel.

The traveler stands amidships when he stands in or toward the middle of the ship. He faces outboard when he stands on the imaginary centerline, facing the port or starboard side; and inboard when he stands near the side of the ship, facing the centerline.

Things over his head are above him while things underneath him are below. An object aft of another is abaft the object in front; while an object or line is athwartships when it is across the ship, at right-angles to the centerline.

In the ship, floors are decks, walls are bulkheads, and the ceiling is the overhead. Compartments are made up of the decks and bulkheads and are connected to each other by passageways.

Ports or circular openings in the side of the ship let in light and air; while doors are openings through bulkheads. Hatches, as in cargo hatches, are openings in decks.

The kitchen of the ship is the galley while meals are served on the messdeck. Built-in beds or bunks may be found in the berthing compartment and toilet facilities are in the head.

Aye, aye

Knowledge not only of the major parts of the ship but also of basic nautical terms is very important for all sailors. Sharing in the learning of the world's mariners would not hurt the landlubber. Happy sailing then!

Sources

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Tools for Safe Marine Navigation

by Charmaine Rowena C. Aviquivil
and Maria Romina B. dR.-Pe Benito

Navigation is both a science and an art. In the thousands of years which have elapsed since man first learned the rudiments of navigation, it has evolved as a science, involving the development of scientific navigational instruments and techniques.

Navigation is almost as old as man itself. As man wandered from place to place, he had to learn how to determine where he was, how far an object or place was from another, and what familiar objects could be used as landmarks which can guide him from one place to the next.

Today, navigation can no longer be loosely defined as merely learning how to get from place to place. Strictly speaking, it now refers to "the process of directing the movements of a craft from one point to another" (Bowditch, 1962). It involves methods which can help the traveller determine the distance travelled by, position or location, and course or direction of land vehicles, ships, aircraft and spacecraft.

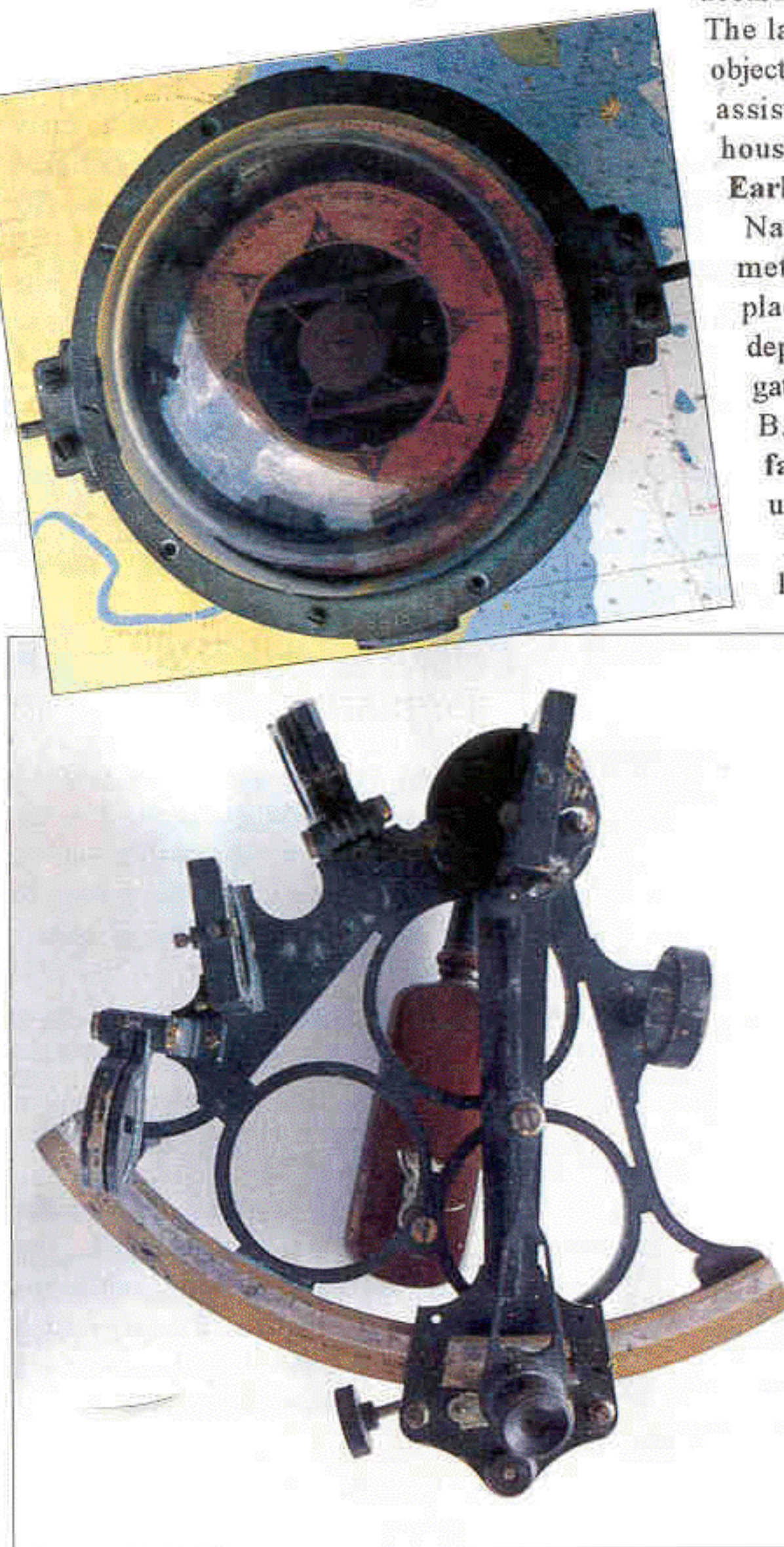
Navigation is both a science and an art. In the thousands of years which have elapsed since man first learned the rudiments of navigation, it has evolved as a science, involving the development of scientific navigational instruments and techniques. On the other hand, the skillful use of these tools, application of these methodologies, and interpretation of data also make navigation an art.

The term "navigation" was associated mainly with the guidance of ships and similar vessels across the seas until this century, when its meaning was broadened to encompass the guiding of craft on land, air and even space. In fact, navigate comes from the Latin word *navis*, meaning ship, and *agere*, which means, to move or direct. In this article, the term "navigation" will refer to sea or marine navigation.

Maritime Safety

There is hardly a year that passes without news of a sea accident in Philippine waters. The tragic M/V Doña Paz-M/T Vector collision in 1987 which claimed the lives of over 4,000 people is still the worst maritime disaster in 50 years. Statistics from the Philippine Coast Guard (PCG) show that 3,216 ships have been involved in sea mishaps from 1982-1995, with more than 21,000 people killed or declared missing. All these illustrate the need to address the problem of maritime safety.

There are many factors which contribute to the high incidence of maritime accidents in Philippine waters. Apart from human errors,



(Top photo) A portable boat compass, used for determining direction

(Bottom photo) Designed by Tycho Brahe, the sextant is used for measuring angles, primarily the altitude of heavenly bodies

unseaworthy vessels, and the occurrence of tropical cyclones, one contributory factor is the inadequacy of navigational instruments or tools.

Navigational Aids

While laymen commonly use the terms "navigational aids" and "aids to navigation"

interchangeably, there is in fact a difference between these two. The former is the broader term, referring generally to objects which help one navigate a craft, and includes navigational instruments, charts, and other objects found aboard a vessel, as well as aids to navigation. The latter term, on the other hand, refers to objects not found onboard a ship, which can assist navigators. These include lighthouses, beacons and buoys.

Early Navigational Instruments

Navigators in ancient times used simple methods and tools to go from place to place. A pole used to determine water depth was probably the first known navigational aid. As early as the 2nd century B.C., great depths reaching up to 1,000 fathoms* were already being measured using a weight attached to a line.

Early navigators also used meteorological and astronomical clues for guidance. The kinds of winds that blew, for instance, served as directional cues. This was the principle behind the *rosa ventorum* or wind rose, a device invented by the Etruscans, which contained eight equally spaced points corresponding to the eight principal winds and the directions from which they blew. The *astrolabe**, *quadrant** and *octant**, the precursors of the modern-day sextant*, as well as the *cross-staff**, were all ancient instruments used at sea to measure altitude by determining the angle between a celestial body and the horizon.

One of the greatest and earliest navigational aids is the magnetic compass which today's navigators still use. The first compass was simply a magnetized piece of metal placed on a straw or reed, floating in a bowl of water. The lodestone* or a piece of iron mag-

netized by a lodestone, was commonly used in compasses because it aligns itself in a north-south direction. The magnetic compass is the forerunner of the liquid magnetic compass being widely used today together with an azimuth circle* to get bearings.

Other early navigational aids included the following: the *periplus** or pilot book which contained sailing instructions; early marine charts such as the *portolano* which contained information on the coast; *almanacs* and *tables* which contained the day-to-day posi-

tions of celestial bodies and, together with the sextant, made it possible to determine latitude; the **log**^{*} which determined speed; and the **marine chronometer**, a very accurate timekeeper which aided in determining longitude.

Modern Navigational Aids

The emergence of modern navigational aids has made the practice of navigation more systematic and dependable than it was a hundred years ago. Old reliables such as compasses, sextants, and nautical charts are still being used today, complemented with the modern electronic navigational devices which emerged during this century.

* Charts

The nautical chart, which can also be referred to as a marine or hydrographic chart, is one of the most essential tools for navigation. A chart is basically like a map. It represents the water and land areas of a specific part of the earth, drawn to scale. The difference is that it contains information of interest mainly to navigators.

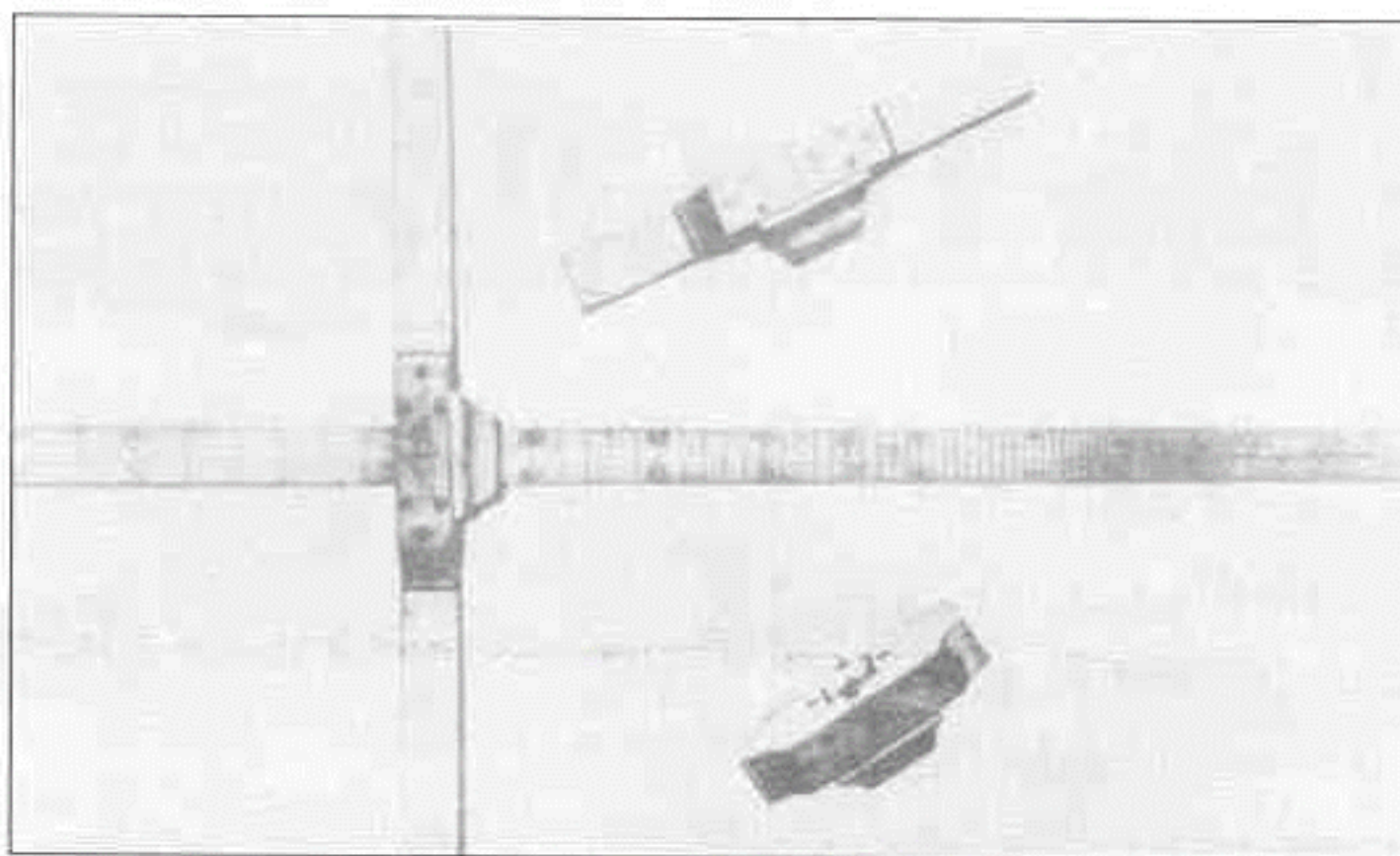
Charts are vital to safe navigation precisely because of the information they contain. These include water depths, currents, bottom topography, elevations, coast characteristics, hazards to navigation such as shoals and reefs, and aids to navigation such as lighthouses and beacons. These basic information help navigators in making crucial decisions about the direction or course to take, and other related matters. Nautical charts are also important in that they serve as work sheets which graphically record a ship's progress, plot its course and position, and measure without calculation the distance it has covered.

* Notice to Mariners and Other Publications

It is important for navigators to be aware of the most recent information on the Philippine coastlines and waters. Hydrographic and coastal conditions change frequently, and it is not possible to immediately update nautical charts to include such frequent changes.

To address this issue, CGSD, as in all hydrographic offices worldwide, publishes a *Notice to Mariners* every two weeks to supplement and update nautical chart information. Through this publication, navigators are advised about matters affecting navigational safety and warned about possible dangers to navigation such as new hydrographic discoveries, changes in channels, non-functioning of lighthouses and other aids to navigation, uncharted shoals, military drills and exercises, and chart corrections.

The information found in the above publication are sourced from the NAMRIA vessels, PCG, the Philippine Ports Authority, the Maritime Industry Authority, hydrographic offices abroad, and other public and private maritime organizations. Copies of this publication are distributed for free to the maritime public. PCG also issues Notices to Mariners based on



The cross-staff, used during the 16th century, was the first instrument which used the visible horizon to make celestial observations (appeared in the *American Practical Navigator* [US Navy Hydrographic Office, 1962] courtesy of the Peabody Museum of Salem)

data from its field staff.

Other publications of interest to navigators which are published by NAMRIA are: the *Coast Pilot*, which contains sailing directions and a description of Philippine coastal features, channels, harbors, ports and their facilities, weather patterns, and dangers and aids to navigation; and the *Philippine List of Lights*, which features detailed information on the country's lighthouses.

* Navigational Instruments

Currently in use aboard today's ships are instruments discovered long ago like the log, sextant and chronometer. The **gyrocompass**, which is similar to a magnetic compass, is also used in modern navigation, and is required for use in large seacraft. Other aids include **dividers**^{*}, **parallel rulers**^{*}, **plotters**^{*}, **rolling rules**^{*}, **three-arm protractors**^{*}, **range finders**^{*}, **hand leads**^{*}, and echo sounders, among others.

* Electronic Navigation

Together with the abovementioned instruments, electronic devices are essential to navigation. The more common electronic aids include the **radio direction finder**^{*} which locates bearings of radio beacons onshore; and **radar**^{*}, which shows on a screen the direction and distance of objects (such as other ships) from a vessel. Among the many other electronic navigational devices being used today are the **Loran**^{*}, **Consol**^{*}, **Omega**^{*}, **Decca**^{*}, and lately, Electronic Navigational Charts.

Aids to Marine Navigation

Just as essential to mariners in guiding watercraft safely across the seas are navigational aids external to the ship which are generally referred to as **aids to navigation**.

Buoys, beacons, lighthouses, **lightships**^{*}, and navigation sound and electronic transmitters are man-made structures established mainly to determine the position and direction of vessels and to serve as markers for avoiding obstructions such as hazardous reefs, shoals, and wrecks. Aids to navigation can also be natural landmarks, like mountains and islands.

The different aids to navigation are given particular characteristics in their general use of light, shape, color and even radio and sound waves. Through so-called "**light lists**"^{*} and other invaluable sources of safety information at sea, marine navigators can interpret the characteristics of the various aids to navigation and identify their use.

In the Philippines, the Coast Guard, one of the major units

of the Philippine Navy, is in charge of the development, establishment, operation and maintenance of the various aids to navigation. Aids to navigation found in the Philippines include lighthouses, beacons, buoys, **range lights**^{*}, natural landmarks, and artificial landmarks like the guiding poles placed by fishermen. PCG categorizes lighthouses and beacons as **light stations**, which the maritime agency defines as lighted aids to navigation on fixed structures with personnel assigned to tend the light.

With respect to its total coastline in nautical miles of 18,679, the Philippines has, at present, a total of 435 light stations and 71 buoys. Operational light stations are 328, while 55 buoys are unlighted and 16 are lighted. The country's range lights may be found in Albay, Siquijor, Polilio Island, and San Fernando in La Union.

The least extensively used aids to navigation in the Philippines are buoys and floating beacons. This is due to their being easily blown away during storms which are frequent occurrences in the country.

* Beacons

In marine navigation, beacons are generally known as fixed, conspicuous structures, lighted or not, which are used to give signals for guidance or warning.

Daybeacons are unlighted fixed structures equipped with a **dayboard**^{*} for daytime identification while floating beacons are directly anchored to the sea bed by means of a sinker.

Early beacons were bonfires or fire baskets on hills and beaches. Other than lights, modern beacons also use radio or radar transmitters that emit signals which help ships to determine their position. These radio aids have quite a comprehensive coverage. Modern types of beacons include land-based radar beacons or RACONS and radio beacons. Vessels are able to obtain their approximate **range**^{*} and **bearing**^{*} through transmitted coded responses to their radar signals from the

(Continued on page 13)

PHOTO ESSAY

Philippine Lighthouses

Researched by Celeste Barile

Advancements in marine navigation with the passing of years have served to make travel by water a convenient and secure means of transporting both people and goods.

Early sailors navigated mostly by studying seasonal wind directions and observing different celestial bodies. Important *navigational aids* later developed include the magnetic compass and nautical charts.

Equally essential to sailors, past and present, are the natural landmarks and the likes of buoys, beacons and



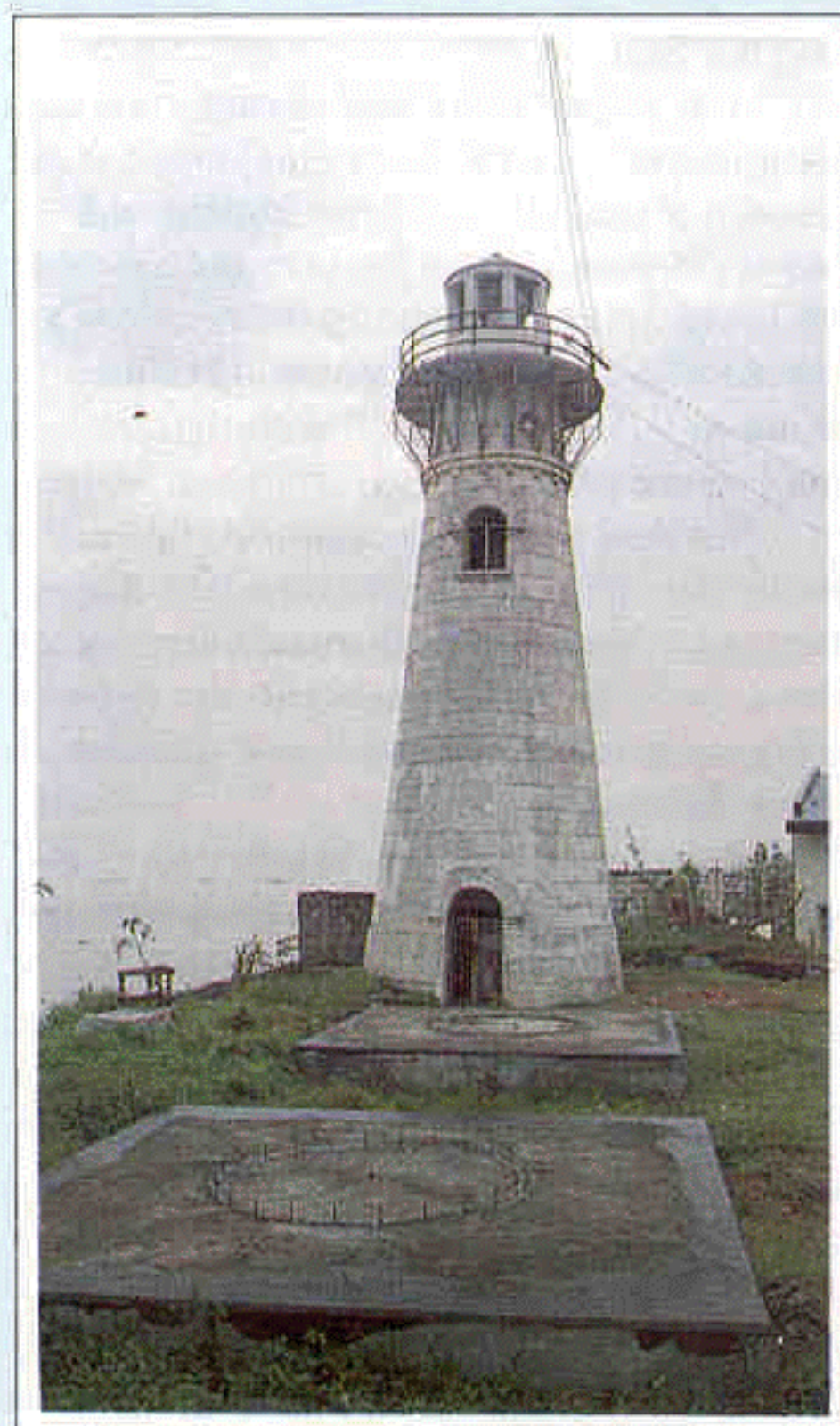
CAPE SANTIAGO

Calatagan, Batangas
 Year Constructed: December 15, 1890
 Year Modernized: May 28, 1978
 Elevation: 15.5 m
 Visibility Range: 15.5 nautical miles
 Structure: Concrete
 Power Source: Solar and Generator
 Light Characteristics: Flashing 3 white every 5 seconds

lighthouses, *aids to navigation* not found on board the ship. Of these, perhaps the best-known are those lighted guiding structures called *lighthouses* whose origin can be traced to ancient times.

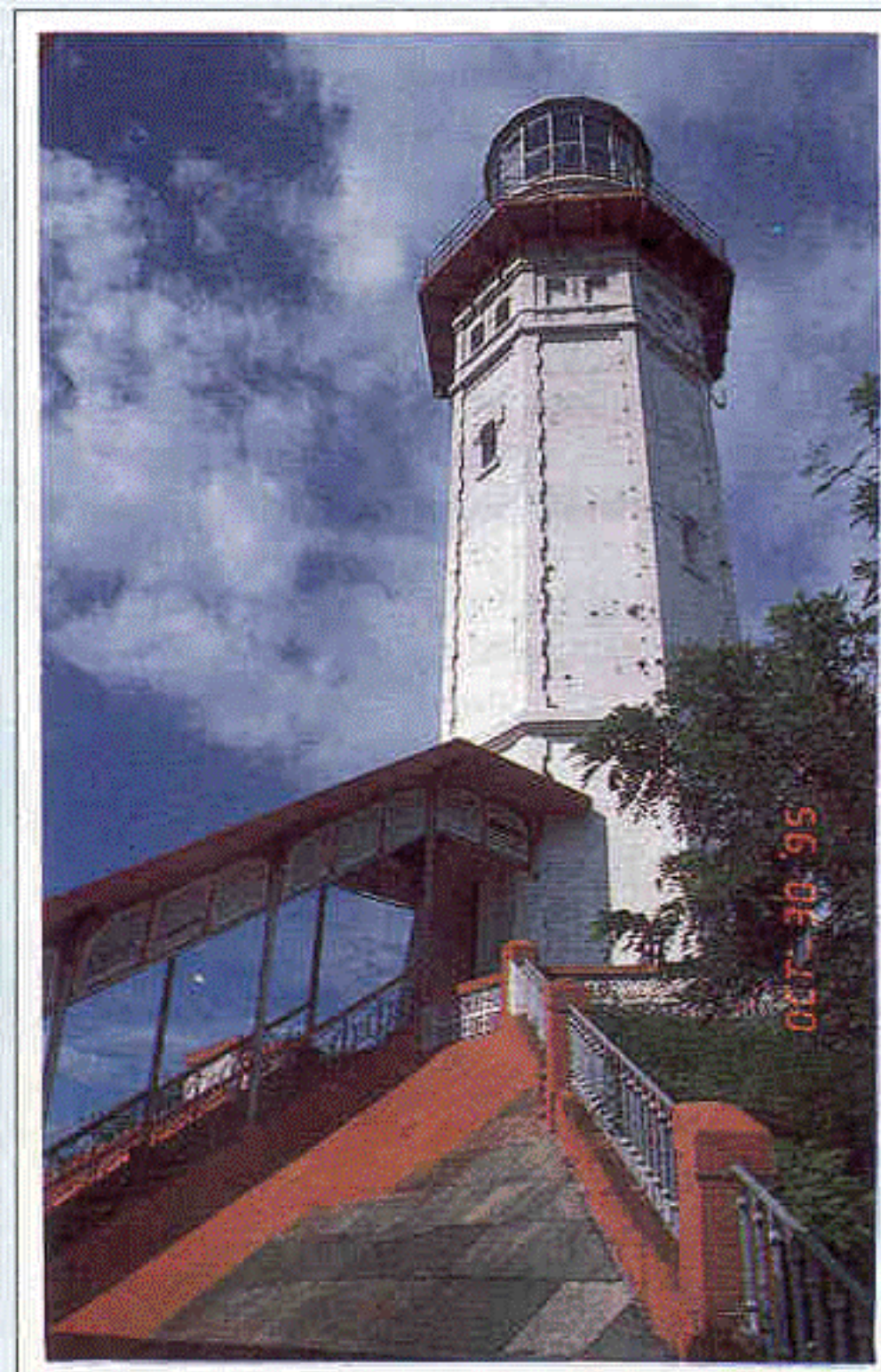
In the Philippines, lighthouses are still important aids to navigation, even if shipboard navigation systems have to a great extent lessened the need for them in other countries. For our country's sailors, lighthouses will remain quite a welcome sight, well directing their course for a safe arrival at their destination.

Featured in this spread are some Philippine lighthouses, including the "farola" in Del Pan, Manila which has been serving the country's navigators through the centuries.



LIGHTHOUSE STATION PASIG RIVER

Nuele dela Industria, Farola, Manila
 Year Constructed: 1842
 Year Repaired: 1989
 Elevation: 14.5 m
 Visibility Range: 9 nautical miles
 Structure: Concrete
 Power Source: Electricity
 Light Characteristics: Flashing white every 5 seconds



CAPE BOJEADOR

Burgos, Ilocos Norte
 Year Constructed: March 31, 1892
 Elevation: 19.9 m
 Visibility Range: 14 nautical miles
 Structure: Concrete
 Power Source: Battery
 Light Characteristics: Flashing 3 white every 5 seconds



LIGHTHOUSE STATION CORREGIDOR

Cavite
 Year Constructed: 19th Century
 Year Modernized: 1995
 Elevation: 191.8 m

Visibility Range: 22.8 nautical miles
 Structure: Concrete
 Power Source: Generator
 Light Characteristics: Flashing 3 white every 20 seconds



LIGHTHOUSE STATION CAPITANCILLO

Bogo, Cebu
 Year Modernized:
 May 11, 1976
 Elevation: 29.7 m
 Visibility Range:
 15.6 nautical miles
 Structure: Concrete
 Power Source:
 Solar and Generator
 Light Characteristics:
 Flashing white
 every 10 seconds



LIGHTHOUSE STATION CALAPAN

Calapan, Oriental Mindoro
 Year Modernized: November 10, 1976
 Elevation: 10.9 m
 Visibility Range: 9.5 nautical miles
 Structure: Aluminum
 Power Source: Solar and Generator
 Light Characteristics: Flashing white every 10 seconds



LIGHTHOUSE STATION MAGDALENA

Sorsogon
 Year Constructed: April 18, 1995
 Elevation: 30 m
 Visibility Range: 18 miles
 Structure: Glass Reinforced Plastic
 Power Source: Solar
 Light Characteristics: Flashing 2 white
 every 10 seconds

PHOTO CREDITS:
 PHILIPPINE COAST GUARD
 JESUS M. ARCAINA
 RENATO E. EGUIA

NEWS

Land cover, soil classification maps completed for locust research project

The NAMRIA National Remote Sensing Center (NRSC) in coordination with the National Crop Protection Center (NCPC) of the University of the Philippines (UP) - Los Baños completed last October 1995, land cover and soil classification maps in support of a research project on the Identification and Mapping of Potential Breeding Sites of Migratory Locust (*Locusta Migratoria Manilense Mayen*) in Central Luzon.

The land cover maps which were completed using SPOT XS remotely sensed data show the updated land cover in Zambales, Tarlac and Pampanga. The maps also contain data on areas affected by locusts, existing agriculture areas, forest areas, the extent of lahar damage on the agricultural areas, and bare lands.

The soil classification and land cover maps will be used as reference to identify the possible breeding sites of locusts and to check if soil type could be a possible factor for breeding sites.

This research project aims to help farmers and landowners control the migration of locusts that destroy agricultural crops such as rice, vegetables, sugarcane, bananas and other types of vegetation in Central Luzon.

The migration of locusts in Central Luzon has greatly affected the economic situation in

the region resulting in food shortage and less income for the farmers and landowners who are directly dependent on the land.

The Philippine Council for Agriculture, Forestry and Natural Resources Research and Development, as the coordinating agency of the project, has recognized the expertise of NRSC-NAMRIA in the fields of remote sensing (RS) and geographic information system (GIS), and has selected it as one of the implementing agencies to work with NCPC of UP Los Baños.

NRSC-NAMRIA's responsibilities in the implementation of the project are the following: a) acquire and evaluate basic information on migratory locust field-ecology and population dynamics in breeding sites and invaded areas; b) identify and map out potential breeding sites of migratory locust using RS and GIS; and c) develop effective and feasible monitoring and control methods against gregarious locust through the use of RS and GIS.

This project is being undertaken in collaboration with the Department of Agriculture-Region III, Central Luzon local government units, Central Luzon State University, Philippine Atmospheric, Geophysical and Astronomical Services Administration and UP-Diliman.

Elinor C. delos Reyes

CGSD conducts surveys in Mindanao and Subic Bay

The CGSD of NAMRIA has completed a one-week oceanographic survey along the south coast of Mindanao and hydrographic survey of Subic Bay covering a water area of 96 square kilometers.

The oceanographic survey in Mindanao, conducted in cooperation with the Commonwealth Scientific and Industrial Research Organization (CSIRO) of Australia, gathered description of the water properties such as temperature, density, salinity and currents that flow along the south coast of Mindanao, and the Moro and Davao Gulfs. A total of 97 oceanographic stations were observed during the course. The survey activity was done in connection with the Regional Ocean Dynamics Project.

The hydrographic survey in Subic Bay performed in cooperation with the Subic Bay Metropolitan Authority gathered the latest topographic, hydrographic, oceanographic and coast pilot information in the vicinity of the bay. The information will be incorporated in updating nautical chart numbers 4212 and 4213.

NAMRIA's hydrographic vessels RPS Atymba, RPS Arinya and its survey boat RPSB Hizon were used in the execution of the project.

Tidal current observations were conducted at two identified locations inside the bay to determine the current velocity and direction in said areas. RPSB Hizon served as a platform for the 15 days' continuous observation.

Rosalino C. delos Reyes

NAMRIA Modernization Bill introduced in Congress

The Modernization Bill of NAMRIA, introduced as House Bill No. 5516 by Congressman Gilberto M. Duavit and as Senate Bill No. 1361 by Senator Gregorio B. Honasan, is currently being discussed in the appropriate committees at the Lower and Upper Houses of Congress.

The two bills advocate the modernization of NAMRIA in order that the agency can fulfill its mandate as the central surveying and mapping agency providing the government and the private sector with up-to-date, modernized, reliable and accurate land resources and related information which are necessary to produce the comprehensive land use plan of the country. The comprehensive land use plan is a vital tool in propelling the country towards industrialization in the year 2000. It will guide planners, developers and managers in the wise utilization of our resources, thereby ushering the

country towards economic and social development.

The modernization bill seeks to develop NAMRIA's capabilities in digital cartography and mapping, information technology, data acquisition, and remote sensing.

The bill includes the implementation of the National Mapping Program which will enable NAMRIA to expand its capability in providing topographic, hydrographic and oceanographic information for the generation of updated, standardized and reliable quality maps, charts and resource information.

The development and implementation of the Information Technology Strategic Plan (ITSP) will enhance the agency's information technology capability by establishing a one-stop shop of geographically referenced ocean, land and resource database information. The ITSP shall enable NAMRIA to provide a rapid response system to generate maps and charts for disaster management on land and at sea, and floodrisk and volcanic flows management, among others.

Another significant feature of the modern-

ization bill is the establishment of a multi-system, multi-purpose ground receiving station (GRS) which will have the capability to receive data from satellite missions and eventually to subscribe high resolution data from future satellite systems. With the GRS, NAMRIA will be able to provide real-time or near-real time data necessary in natural resources and environmental assessment and monitoring.

The enhanced capability for hydrographic and oceanographic surveys and nautical charting shall enable NAMRIA to produce up-to-date nautical charts of the EEZ, and in coordination with other agencies delineate the different maritime zones and administrative boundaries throughout the country.

Another feature of the bill is the establishment of the NRSC which will enable NAMRIA to establish and operate the GRS. The NRSC will be the archiving, processing and applications center of remotely sensed data in the country.

Concepcion A. Bringas/
Milagros F. Viernes

Marine Outreach Program conducted

NAMRIA together with other agencies participated in the outreach program entitled "Outreach Marine: Palawan" conducted by the National Committee on Marine Science (NCMS) of the UNESCO National Commission of the Philippines (UNACOM), in cooperation with the Palawan Council for Sustainable Development last 06-10 December 1995 in Puerto Princesa City.

The outreach program was the concluding activity of the NCMS and UNACOM for 1995 in line with the committee's objective for environmentally sustainable economic development through marine sciences to support the Philippine Strategy for Sustainable Development.

The resource persons were NAMRIA Deputy Administrator Ricardo T. Biña; NCMS Chair Mr. Miguel D. Fortes; Mines and Geosciences Bureau Assistant Director Salvador G. Martin; Bureau of Fisheries and Aquatics Resources Director Jose Ordoñez; Philippine Council for Aquatic and Marine Research and Development Director Cesario Pagdilao; Vice-President for Planning and Development of Mindanao State University Mr. Ali Macawaris; Chief of the Flood Forecasting Branch, PAGASA, Mr. Rolu Encarnacion; UP Professor and Chair of the Biology Division, NRCP-DOST, Ms. Virginia S. Cariño; Director of NOCOP, Philippine Coast Guard, Commander Ernesto J. Paquiz, and Philippine National Museum representative Mr. Noe Gapas.

The gathering was attended by 47 representatives from the local government, Palawan Council for Sustainable Development, El Nido Foundation, Ulugan Bay Foundation, DA-Inland Sea Ranching Station, State Polytechnic College of Palawan and Palawan National School.

Anna Maria E. Gapuz/Concepcion A. Bringas

NAMRIA draws Albay and Sorsogon boundaries

Albay Governor Al Francis C. Bichara and Sorsogon Governor Raul Lee recently entered into an agreement with NAMRIA Administrator Jose G. Solis for the delineation of the two boundaries of Albay and Sorsogon provinces using Land Classification Map No. 1087.

Under the agreement, NAMRIA will undertake relocation surveys to determine the relative position on the ground of monuments

DENR, NSCB mark 6th Statistics Month



6th National Statistical Month. Sen. Heherson H. Alvarez (middle) cuts the ribbon formally opening the photo exhibit assisted by NAMRIA Adm. Jose G. Solis (left); Dr. Romulo A. Virola, NSCB Sec. General (right); DENR Asst. Secretary Sabado T. Batcagan (2nd from R) and other guests.

The Department of Environment and Natural Resources (DENR), its bureaus and attached agencies, and the National Statistics Board (NSCB) opened the month-long celebration of the 6th National Statistics Month at the Amorsolo Grand Ballroom of Manila Galleria Suites last 02 October 1995, with the theme "Statistics Towards Sustainable Development: Focus on Environment."

The celebration was in conjunction with Presidential Proclamation No. 64 declaring the month of October as the National Statistics Month. The proclamation aims to promote nationwide awareness and appreciation of the importance of statistics to planning, development, assessment and monitoring in various fields such as environment, agriculture, trade and industry, and health.

The opening day affair was attended by Executive Secretary Ruben Torres, NSCB Secretary General Dr. Romulo A. Virola, DENR Secretary Victor O. Ramos, and DENR Assistant Secretary Sabado T. Batcagan. Also present were Adm. Jose G. Solis, Chairman of

the DENR Executive Committee on Statistical Concerns and Coordination, and other government officials.

During the forum in the afternoon, three papers were presented. These were: "The State of the Philippine Environment and Development" by DENR Undersecretary Delfin J. Ganapin, Jr.; "Environmental and Natural Resources Accounting Project (ENRAP) - Implications of the Philippine Statistical System" by Dr. Marian delos Angeles; and "The Mining Industry" by Dir. Joel Muyco of Mines and Geosciences Bureau.

Sen. Heherson T. Alvarez assisted by DENR officials cut the ceremonial ribbon opening the photo exhibit. The exhibit which was the highlight of the day's affair featured statistics on various subjects in the form of maps, graphs and tables.

The month-long celebration featured several activities such as seminar/workshop, statistical exhibit, film showing, and statistical quiz in the national and regional levels.

Celeste Barile

numbering 7, 8 and 9. These monuments are concrete references in defining the technical description of the boundaries of the two provinces.

Preliminary activities of the project are the gathering of documents and existing data from the Land Management Services - DENR Region V and the preparation of a relocation survey plan. Final output of the project is a boundary map with technical description of the monument numbers 7, 8 and 9.

The boundary map will resolve the territorial boundary problems of the two provinces. It will also serve as a planning tool in determining their land areas for development.

Cezar J. Rebolledo

CONTRIBUTIONS

The Infomapper is accepting contributions for its forthcoming issues. Manuscript should be typed, double-spaced, and must indicate the author's name, position, and office/home address. Photographs and illustrations with captions are also welcome.

The editors reserve the right to edit materials submitted.

Solis elected ICA veep, attends meetings

Administrator Jose G. Solis was elected as one of the seven vice-presidents of the International Cartographic Association (ICA) during its Executive Committee meeting held in Barcelona, Spain on 03 September 1995. He heads the Commissions on Education and Training, and Mapping and Satellite Imagery.

The ICA Executive Committee is headed by President Michael Wood of Scotland. Its officers are elected every four years during the ICA Executive Committee meeting.

Adm. Solis attended the second Executive Committee meeting of the ICA held in Paris, France on 15-17 January 1996. He presented the commission's budget proposal, program and plans of activities to the Executive Committee.

GlobeSAR Workshop

Adm. Solis also participated in the Second Asia Regional GlobeSAR Workshop held at the Continental Grand Hotel in Beijing, China on 09 - 12 October 1995.

The seminar-workshop focused on the results of various research projects and future

activities and goals using GlobeSAR data by the participating countries in the Asia-Pacific region. The participants presented their research achievements using GlobeSAR data, and an assessment of the applicability of the future satellite data for their particular fields of interest.

Adm. Solis presented a country report entitled "Updates on the Use of Radar Technology in the Philippines." The report discussed the recent developments in the field of microwave or radar remote sensing in the Philippines.

The seminar-workshop was attended by representatives from China, Malaysia, Thailand, Vietnam, Philippines, Bangladesh, Cambodia, India, Indonesia, Laos, Mongolia, Nepal, Papua New Guinea and Pakistan. Invited as observers were Brunei, Iran, Kuwait, Korea, Myanmar, Singapore and Taiwan.

The seminar was jointly organized by the Institute of Remote Sensing Applications (IRSA) and the Canada Center for Remote Sensing (CCRS).

Elinor C. delos Reyes/Concepcion A. Bringas

NAMRIA conducts 9th Technical Forum

NAMRIA through the Information Management Department (IMD) conducted its 9th technical forum entitled "Automated Mapping for Enhancing the Services of the Infrastructure and Utilities Sector (IUS)" last 26 October 1995 at the NAMRIA Lecture Hall.

The forum featured projects of the Philippine Long Distance Telephone Co. (PLDT), Computer Information Systems, Inc or CIS (a subsidiary of MERALCO), and Geodata Systems Technologies, all of which utilized GIS technology. These companies shared their experiences and expertise in automated mapping which enhances the delivery and provision of their basic infrastructure and utility services.

The projects presented were the "System for Mapping and Recording Techniques (SMART)" by Fernando Leonor of PLDT and the "Integrated Facilities Management System" by Yolanda Arbis of CIS. Ariel Araza of Geodata discussed various GIS applications on IUS and Emerson Gayban of NAMRIA high-

lighted the role of the agency in providing geographic information for the IUS.

An open forum followed after the presentations. DA Linda Papa, IMD Dir. Virgilio Santos, and the speakers took turns in answering questions and clarifying points raised by the participants.

DA Ricardo Biña delivered the welcome remarks while Dir. Virgilio Santos formally closed the forum. Certificates of Appreciation were given by DA Papa to the resource speakers.

The forum was attended by 74 participants from PLDT, MERALCO, Dept. of Public Works & Highways, Metro Manila Authority, Metro Manila Development Authority, National Irrigation Authority, Local Water Utilities Authority, Dept of Interior & Local Gov't, National Economic & Development Authority, Software Ventures, PACER, United Business Technologies, and Geodata, among others.

Eriberto N. Brillantes/Concepcion A. Bringas

Hydrographic... continued from page 5

4. Marine Living Resource Management

Examples of marine living resources are ducks, corals, fisheries and other flora and fauna which can be found on the water surface and column. Downstream activities that are dependent on hydrographic survey outputs include stock inventory, exploitation assessment, and the establishment of a marine park in a multiple-claim area. The issue here is complicated and addresses the consideration of extra-regional interests involved, like tuna migration.

5. Marine Non-living Resource Management

Marine non-living resources include offshore minerals like polymetallic sulfide, manganese nodules and other minerals found in the water column and subsoil, as well as energy resources in the form of ocean thermal energy conversion, wave energy systems, tidal power systems, petroleum (oil and gas), and other hydrocarbons. The exploration and exploitation of these resources will greatly depend on the data taken from hydrographic surveys.

Along this line of activity, basic information concerning the sea floor are essential for the crew of the RPS Explorer (vessel of the Mines and Geosciences Bureau, DENR) which cannot undertake its marine geological or geophysical surveys without a nautical chart. Likewise, offshore platform construction or pipelaying cannot be done without these data. The same is true with the conduct of a regional seismic survey over offshore areas outside existing contract areas within the EEZ and CS which require another approach.

6. Environmental Protection

In order to avoid the risk of marine accidents and pollution or any major oil spill that will greatly damage the Philippine territory, the need to mitigate these is of paramount importance. Without accurate maps, risks of marine pollution due to grounding and collisions resulting from increased volume of traffic and size of vessels in the area will increase. Environmental disaster contingency plans, the designation of protected areas, the curtailment of land-based sources of marine pollution, the bio-diversity assessment are among the effective undertakings to protect the environment. Unless steps are taken to protect the marine environment, the country's territorial waters could be faced with loss of living resources and tourism industry revenues.

Data Acquisition Platforms

There are three basic types of platforms used in hydrographic surveying. The most commonly used is a survey ship/vessel. The manner by which data are gathered is called *shipborne*. Other remote sensing specialists call it shipborne acoustic remote sensing because of the echo sounder and sonar systems

which are used to acquire bathymetric information. Depending on the type of instrument and the methodology used during observation, it is considered the most precise technique. New equipment have been evolved and are already available in the market. These include four-beam multiscanners, side scan sonars, wide-angle multibeam echo sounders, and many more. They provide more precise information about the sea bottom, are much more precise and offer more sophisticated processing than the conventional hydrographic sounding equipment.

Another type of observation platform is called *airborne* remote sensing whereby scanning lidar scanners are onboard an aircraft. From an altitude of 500 m, infrared and blue/

green laser pulses scan the water's surface and bottom across a 270 m swath width and a depth penetration up to 40 to 50 m. Positioning and navigation components can be referenced. Ground-based microwave systems and GPS are currently used in the hybrid positioning package to achieve positioning for photogrammetric applications and + or -5m for hydrography. Laser airborne depth sounders suitable for hydrographic surveys were also developed to provide 10-m nominal sounding spacing and a rate of 168 soundings per second.

Spaceborne remote sensing is another technique that allows us to generate hydrographic parameters such as wave heights and water circulation pattern.

The information derived from all of these

techniques can enable the acquisition of data and upgrading of the technical database covering our EEZ and CS. With the resource inventory information, these zones are made attractive to private companies who are interested to undertake detailed investigation works and/or development. In this light, foreign or local companies may also take steps to conduct further exploration of known areas and follow up works and development of proven reserves. Seabed minerals, deep sea fishing grounds, and other resources, once discovered and tapped, can bail us out of the economic difficulty we are in.

Editor's Note: Due to space constraints, we cannot publish the list of references consulted for this article. Interested individuals may avail of the list from the author or the editors of this publication.

Tools for... continued from page 7

radar beacon stations. Radio beacons, said to be the first electronic system of navigation, are able to provide mariners with a course or *line of position* through transmitted radio signals picked up by the directional antenna of the vessel's radio direction finder, a kind of radio receiver.

* Buoys

Buoys are floating objects which are anchored to the sea bed by means of chains and sinkers. These have standardized colors and shapes to serve different purposes.

There are two basic types of buoys: mooring buoys and navigational buoys. Mooring buoys, unlike navigational buoys, are not aids to navigation, but anchorages to which vessels may be secured. Navigational buoys named according to shape include can buoys (metal cylinder), nun buoys (truncated cone), spar buoys (upright post), and cask and keg buoys. Some buoys also have bells, gongs and whistles which are sounded by the action of the waves.

Many buoys have lights with definite characteristics for detection and identification during darkness. Some examples of lighting apparatuses are lenses and lightbulbs. Lighted buoys have the distinct advantage of marking the actual location of the danger.

Buoyage systems of buoy coloring, shape, numbering and lighting are used to mark channels and submerged dangers. Philippine buoys conform to the maritime guidelines prescribed by the International Association of Lighthouse Authorities.

* Lighthouses

The aid to navigation said to have been constructed the earliest, the lighthouse is a tower or high cage structure designed to serve as a marker by day and from which a powerful light is projected at night for guiding mariners. Lighthouses are usually erected in certain important areas on coastlines, in the entrances to the major ports, and on dangerous rocks or shoals.

Lighthouses originated from the fires lighted on hilltops along the shore to guide early navigators. The first known true lighthouse is the 85-meter tower designed about 280 B.C. by Sostratus of Cnidos and built on the Island of Pharos at the entrance of Alexandria Bay in Egypt. This landmark is considered as one of the so-called "Seven Wonders of the World."

Lighthouses differ a great deal from each other in terms of appearance and construction. This is due to factors like the structure's location (whether in the water or on land), the relative importance of the light, the distance at which the light should be seen, and the frequency of violent storms. Some examples of principal construction materials of lighthouses are masonry, concrete and steel.

Their being painted in distinctive patterns enables lighthouses to be identifiable by day. By night, lighthouses emit light signals of different color and duration. The colors can be white, red, or green. Aside from fixed lights that burn steadily, among the kinds of lights showing different patterns of intervals of light and darkness are the **flashing light***, the occulting light, the quick-flashing light, lights which flash Morse code characters, and others which show alternating color variations.

Visibility of all lights often decreases as a result of fog, rain, snow, haze and smoke. Installed at lighthouses situated in areas of fog or low visibility are sound fog signal stations which are aids to navigation that use sound waves. Fog signals may be horns, sirens, whistles, or bells. These are either mechanically or electrically operated and may be identified through characteristics like the number of times the sound is made.

At present, almost all lighthouses are powered by electricity while the incandescent and powerful electric lamp is the standard illuminant in lighthouses.

Like beacons, lighthouses also serve as sites for other important supplementary signaling equipment such as radio beacons and radar beacons, and as shore-based transmitting sta-

tions for the long-range navigation (Loran) electronic signals which have a signalling range of 1,500 miles.

In some countries like the United States, developments in the automation of electronic equipment like shipboard navigation systems (radar, Loran, etc.) have made it possible for manned lighthouses to be maintained on or near the shore.

In the Philippines, the first permanent lighthouse is the *farola* which was built in 1842 by the Spaniards at the entrance to the Pasig River. Battery-powered and in good condition, it is operating up to the present.

Philippine lighthouses are located mostly along the major routes and solar energy is now the power source in nearly all Philippine lighthouses. PCG also issues List of Lights by request.

Lighthouses are the most widely used aids to navigation in the Philippines. Ongoing is the Maritime Safety Improvement Project of the Coast Guard for the rehabilitation of lighthouses along the Manila to Cebu route and the construction of new lighthouses. As of the present, some 35 lighthouses have been rehabilitated while 106 new lighthouses have been constructed.

Navigational Aids for Maritime Safety

The presence of navigational aids aboard a ship, and aids to navigation external to a vessel, is required by law in order that navigators may be assisted in guiding their craft safely across the world's seas and oceans. The issue lies in whether these aids are taken for granted or not. Too often, ship crew are either poorly trained in the proper use of these aids, or are indifferent regarding their maintenance. The need for these people to realize that these instruments exist to promote maritime safety must be addressed. This may make the difference between life or death at sea.

Sources: PCG & info. materials (avail of a list from authors/eds.)

TECHNICAL PAPER

Electronic Navigational Chart¹

by Lt(jg) Rosalino C. delos Reyes

I. Introduction

Since the early ages, the paper chart has been a fundamental and indispensable tool used by mariners sailing in domestic and international waters. In recent years, trends in navigation have changed rapidly. The automated operation of equipment onboard a vessel greatly contributed to the improvement of its safety and operational efficiency. The development of modern technology such as the GPS and Electronic Chart Display and Information System (ECDIS) expanded the horizon and overcame limitations to the classic approach in navigation.

The ECDIS is an integrated system for displaying all hydrographic information relevant to safe navigation and plotting a ship's position along a pre-planned route. Its primary function is to reduce the navigational workload associated with the use of paper charts. The Electronic Navigational Chart (ENC), which is often described as just a digital copy of an existing paper chart, carries with it much nautical and hydrographic information compiled from existing charts and other authorized sources. Compared to the paper chart, the ENC is an integrated part of a real-time navigation system and is used on computer-assisted navigation systems aboard seagoing vessels. The International Maritime Organization (IMO) is pushing for the production of regional ENCs to boost the safety of navigation.

II. Selection of Information & Compilation

The following information which are of importance to inshore and offshore navigation as well as navigation along the coast should primarily be considered: coastlines, land areas, drying lines, drying areas, depth contour lines, depth digits, isolated dangers, shoals, rocks, fixed and floating aids to navigation, routing system, fairways and channels, prohibited, restricted, cautionary areas, anchorages, and others.

In principle, all the information set out in "INT 1" (International Chart 1), International Hydrographic Organization (IHO) Standards for Symbols and Abbreviations, should be available in an ENC. The ECDIS will ideally

allow for a choice of different types of information to be presented to the navigator. IHO is establishing a set of rules governing which information is compulsory and which information may be omitted on the ECDIS display for the sake of clarity. The essential point to consider with an ECDIS is the display by color separation or by other means to distinguish between safe and unsafe waters.

At one time there was some thought that the distinction between safe and unsafe waters might be the basic survey data and that the ECDIS would operate on this data to produce a compiled chart with information provided at an appropriate scale. This idea was subsequently shown to be too complicated; most hydrographic offices have instead chosen to digitize information from existing paper charts. It is also important to know the accuracy of the information coming from different sources obtained for use in the ENC. It may happen that in certain areas or charts, information might not be provided to assure the correctness of the transformation from the local datum to the internationally standard horizontal datum - WGS84.

According to IMO Provisional Performance Standards (PPS), chart contents, media, formats, datums, etc. should be internationally standardized. Special Publication No. 52 of the IHO states that only the horizontal datum, WGS84, should be used. Inaccuracies in the various survey methods used through the ages make it highly possible that not all dangerous features have been found. Ideally, the ECDIS should provide some information on the quality of the basic data used in compiling the ENC.

III. ENC Production

The production of an ENC along the intended route of the vessel is very demanding and needs much experience and expertise. The development of several modules to produce an ENC are based on careful studies and research done by experts in this field.

Data Capture - There are many ways to capture data for use in the production of ENCs. Simply put, it is the process of collecting relevant field data through scanning, point digitizing, field surveys, etc. The laborious task of compiling the survey data follows, thereby producing the information to be presented in

the ENC. Some of the problems related to the production process especially in data capture are the connection between lines and the determination of optimal gap tolerances for the line connection process. Independent of method, the normal output is called spaghetti data — that is, vector data in which no spatial relationships are established between features. If the digitized lines do not form closed polygons, the task of area definition becomes complicated because no topology information is established. In this case, a separate line connection process is required before initiating further processing of data.

Cell Division - For the production of ENCs, much of the data and materials come from paper charts. All of these data are digitized and stored in a computer. Paper charts are independent of cells but there should be an overlapping of features to provide continuity. For this reason, the digital data is divided into the proposed cell structure to form the finite data sets prepared for further processing.

IHO Special Publication No. 52 has proposed a unique worldwide cell numbering system to provide a solution to the difficulties and inadequacies associated with the inconsistency of chart data bases. It is important to notice that cells in the same layer do not overlap. Codes are given on each cell based on the geographical position of the cell's lower left corner. The cells are identified by a letter designating chart scale and a seven-digit number. If there are problems concerning boundaries, the ECDIS has the software to determine and manage such problems. However, the ECDIS can not be expected to solve problems where features of two adjacent charts do not match, perhaps due to different standards of surveying (e.g., one based on a 100-year-old survey, the adjacent chart based on a ten-year-old survey). This is also true for two adjacent mercator-based charts with different construction parallels. The lesson is this: when using paper charts for an ENC, care must be exercised to ensure uniformity in the joints between charts.

Line Connection - Line information for the production of an ENC are enormous and for this reason contribute much to processing of data and information. Hydrographic offices involved in the production of ENCs have developed softwares that will eliminate errors or detect the possibility of erroneous connection of lines and unconnected end points.

¹ This paper is a condensed and modified version submitted by the author to the Norwegian Institute of Technology, University of Trondheim, Norway in partial fulfillment of the requirements for a Post Graduate degree in Port and Coastal Engineering.

Area Definition - Hydrographic offices involved in the production of ENC's have created programs capable of determining with a high degree of accuracy the appearance of areas along cell borders. They can also distinguish which side of the coastline is land by looking at the lines and determining their spatial and topological relationship. The purpose of defining an area is for color identification (e.g., color filling).

Object Cross Reference - An ECDIS is not only an electronic chart, but an information system as well. A possible use of this kind of information system is the inclusion of information on tides, currents, weather forecasts, sailing directions, and others. A person in charge of navigating a vessel can therefore automatically relate all information (e.g., dangers, surrounding waters, offshore structures). The ECDIS developed by companies in this field is made in such a way that it can define this kind of relationship and encode it in the ENC. By this process, the ECDIS can select and display the components and complex objects in separate windows, thereby avoiding cluttering information on the display. The information for the ENC must be supplied by the different hydrographic offices around the globe.

Compression of Information in an ENC - The IMOPPS states that the change from one cell to another on an ECDIS display should be immediate. For areas with inadequate line information and data volume, this task is deemed reasonably easy, likewise with the immediate display of an image. But for areas with a vast amount of coordinates used to represent line information, advanced and expensive computers are required. However, an ECDIS can be designed in a manner that can be affordable to a large extent without sacrificing its accuracy and quality. The complexity of the topology decides the amount of line information in a cell. The production time for the ENC is also dependent upon the amount of information that can be covered for the cell. Finding and using an efficient method for data compression in line information is the responsibility of the different hydrographic offices. In the future, work might be concentrated on adopting and implementing the best compression method on different line features, thus assuring that accuracy requirements for ENC's are met.

IV. Updating the ENC

The IHO Committee on ECDIS (COE) working group on updating the electronic chart has proposed the automatic broadcasting of chart corrections using recommended maritime satellite communications. These chart corrections have been broadcast using the International Maritime Satellite (INMARSAT). The INMARSAT Organization is operating an international satellite system with national tele-administration in member

countries. The satellites operate 24 hours a day and have a global coverage between 70°N and 70°S, excluding the polar areas. The INMARSAT Organization is providing text and data transmissions to and from ships and terrestrial subscribers at an information rate of 600 bit per second. The INMARSAT Coast Earth Station serves as a gateway to and from the space segment, while the shipboard Ship Earth Station acts as the interface to the satellite network.

V. Advantages of the ECDIS

Continuous position display - The navigator always has the ship's position in view. There are no distractions from maintaining the watch due to the traditional taking of bearings and plotting of fixes. Constant knowledge of the ship's position during turns and other close quarters maneuvering allows more precise navigation.

Combined display of both radar and chart information - Since the radar display is depicted relative to the ship's position and the electronic chart display is positioned externally by GPS and other positioning systems, when a navigation aid such as a buoy is not in its charted position, the combined display will show any difference between the charted and actual position. Also, the display of selected information with the radar image such as channel limits, aids to navigation, land areas, etc. will make it highly possible to enhance the decision-making capability of a navigator.

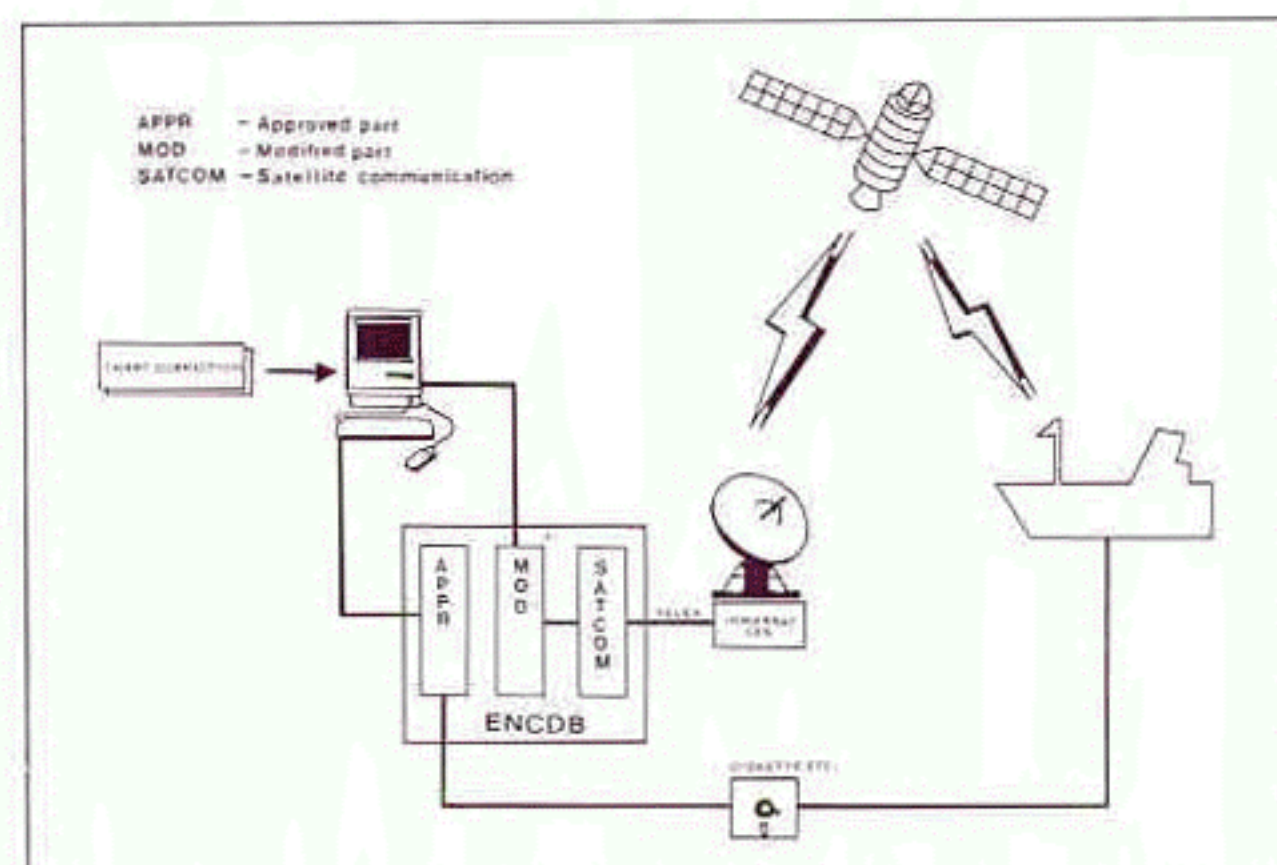
Information alerts - Navigators and route planners could be automatically advised when the route being planned or navigator underway is about to enter designated or regulated areas, (i.e., a Traffic Separation Scheme, an Economic Zone, or Territorial Sea) where fishing, dumping or other activities are prohibited or otherwise controlled.

Hazardous warnings - An ENC supported by a vector data base can include expert systems applications which, when provided with certain ship characteristics information (i.e., stopping distance, turning radius, etc.), can warn the route planner prior to the voyage and the navigator while underway of approaching hazards.

Automatic chart updating - Chart information can be automatically updated, thereby eliminating a burdensome and time-consuming task. Since only major shipping lines are typically required to maintain up-to-date charts, many mariners do not update their charts and merely accept the associated risks. The electronic chart with automatic updating will improve safety for a large number of mari-

ners. Plotters that print out electronic chart data bases will make current information available for hard copy use and provide a backup to the ECDIS.

ECDIS as a marine GIS - Multiple layers of information which could not be shown on a paper chart due to chart clutter and the limitations of scale may now be included in the data available from an ECDIS. It will now be possible to provide mariners with access to significant information that previously was not possible to display or even include in the sailing directions. Access to information will improve through the ability to search for information by digital methods. Details about pipelines and cables in an area planned for anchoring might now be displayed, as well as berthing information, including large-scale depiction of the berth and details such as facilities available, and multitudes of other important information.



Information flow and overview of ENC updating responsibility

VI. Conclusion

A series of maritime accidents have occurred with navigational errors causing considerable damage, and loss of life and property. There is consequently a growing awareness of the need for safer means of navigation. Consistently up-to-date charts will make navigation safer for all mariners. Once the chart becomes digital, there are numerous possibilities for additional layers of information to be made available through hydrographic offices, hence the need for an ENC data base. Information which could not be shown on the paper chart due to chart limitations on scale may now be included in the data available from an ECDIS. Access to information will improve through the ability to search for information by digital method. For example, the ECDIS might provide local data on tide and current information and provide a picture of specified navigational aids, areas of marine vegetation, marine information to provide a listing of available groceries, water, fuel, sanitary tank dumping, etc. The possibilities are tremendous and will serve to both increase safety and improve our environment.

GLOSSARY

- **Astrolabe** - derived from the Greek word *astrolabos* (which combines the words "star" and "to take") and invented in the third century B.C., this instrument was used to determine accurate astronomical position ashore. It consisted of a metal disk, graduated in degrees, with a movable sight vane attached to it which navigators adjusted in reference to a celestial body to obtain the zenith distance reading.
- **Azimuth Circle** - commonly attached to a compass, this refers to an instrument used to determine bearings and azimuths.
- **Bearing** - the horizontal direction of one terrestrial point from another.
- **Bottom** - any ground covered by water.
- **Bottom configuration** - bottom contour, portrayed in nautical charts as depth contours and selected soundings.
- **Compilation** - production of a new or improved map or chart from existing maps or charts, aerial photographs, surveys, new data, and other sources.
- **Consol** - a long-range electronic navigational aid, with each station transmitting a rotating pattern of electronic signals consisting of a series of dots and dashes in alternate sectors.
- **Cross-staff** - the first instrument to utilize the visible horizon in making celestial observations. It was a fairly simple instrument which consisted of a staff about a yard long upon which a sliding crosspiece was mounted perpendicularly.
- **Dayboard** - daytime identifier of an aid to navigation consisting of several standard shapes and colors.
- **Decca** - a long-range electronic navigational aid which uses different frequencies to determine distance. It was named after the British company which introduced it in 1946.
- **Divider** - a drafting instrument consisting of two pointed legs joined by a pivot. It is used to plot or measure distances or coordinates on charts and plotting sheets.
- **Fathom** - a nautical unit of length or depth equal to six feet.
- **Fix** - refers to a relatively accurate position determined without referring to any previous position.
- **Flashing Light** - a light characterized by one or more flashes at regular intervals, in which the total duration of light in each period is shorter than the total duration of darkness.

- **Hand Lead** - a lead weight (weighing 3 to 6 kg) attached to a line of not more than 40-50 m and used for determining depth of water.
- **Light List** - publication generally containing detailed information on the aids to navigation: type, location, description of structure, and operating characteristics.
- **Lightships** - anchored ships with lights at the masthead and serving as lighthouses where such fixed towers cannot be built.
- **Lodestone** - a strongly magnetic iron ore.
- **Log** - an instrument used for measuring a vessel's speed or distance travelled, or both.
- **Loran** - short for "long-range navigation," it is used to guide ships and planes as they approach an area's coastline from the sea. First introduced during World War II, it has two types of stations (called "master" and "slave") that send low- or medium-frequency signals received by special equipment aboard ships or planes.
- **Mean Lower Low Water (MLLW)** - the average height of the Lower Low Waters (LLW) at a place over a 19-year period. LLW refers to the lower of two low waters occurring during a tidal day.
- **Nautical Mile** - a unit of distance equal to 1.852 meters exactly or about 6,076.1 feet. It is used by navigators to indicate distance.
- **Octant** - refers to a double-reflecting instrument used for measuring angles. It is similar to a sextant, but has an arc of 45°.
- **Omega** - a navigation system for ships and planes used globally, it has eight transmitters located throughout the world which send radio signals received by special electronic equipment aboard a vehicle.
- **Parallel Rulers** - a device consisting of two rulers joined together, with the edges of each remaining parallel at all times. It is used for transferring lines of direction from one portion of a chart to another.
- **Periplus** - considered as the first written aid to coastal navigation, this is a book of sailing instructions describing routes, landmarks, anchorages, port entrances, currents, hazards to navigation, and other related information.
- **Plotter** - an instrument for measuring angles and plotting straight lines on a chart or plotting sheet.
- **Quadrant** - when referring to a device, a navigational instrument similar to a sextant

but with an arc of 90°. This is a double-reflecting device used for angle measurement.

- **Radar** - acronym for Radio Detection And Ranging. Invented sometime before World War II, this refers to a method or technique which uses beamed, reflected and timed radio waves to detect, track, or locate objects. These radio signals are reflected from an object along their path and the return signals create an image on a screen, showing the direction and distance of an object from the vessel.

- **Radio direction finder** - a device consisting of a radio receiver and a directional antenna, used to determine the direction of radio transmitting stations.

- **Range** - in navigation, a predetermined line along which a ship moves while certain data are recorded.

- **Range finder** - an optical device which measures the distance of a vessel to an object.

- **Range lights** - two lights placed some distance apart that can be seen in only one direction.

- **Rolling Rules** - invented in 1771, this instrument consists of a ruler attached to the axis of a cylinder in such a way that the working edge remains parallel to the axis as the cylinder is rolled across a chart. It is used in navigation for the same purpose as parallel rulers.

- **Sextant** - a double-reflecting instrument for measuring altitude or the angular distance of a celestial body above the horizon. It has an arc of 60° and a range of 120°.

- **Sounding Vessel** - a ship or craft containing an instrument for measuring depth of water.

- **Three-arm Protractor** - invented in 1801 by Captain Joseph Huddart, this instrument is used for plotting two angles taken simultaneously. It consists of a circle graduated in degrees, upon which a fixed arm and two movable arms are attached. The latter can be pivoted and set at any angle relative to the fixed arm.

* Note:

Sources include the following:

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