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ΕΠΙΒΛΕΠΩΝ ΚΑΘΗΓΗΤΗΣ: ΠΑΝΑΓΟΠΟΥΛΟΥ Μ.

Special Purpose Ships (SPS)

ΤΩΝ ΣΠΟΥΔΑΣΤΩΝ :
ΝΙΚΟΛΑΪΔΗ ΣΤΥΛΙΑΝΟΥ 3905
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Α/Α	*Ονοματεπώνυμο*	*Ειδικότητα*	*Αξιολόγηση*	*Υπογραφή*
1				
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ΤΕΛΙΚΗ ΑΞΙΟΛΟΓΗΣΗ				

Ο ΔΙΕΥΘΥΝΤΗΣ ΣΧΟΛΗΣ :

Contents

Summary

This study has been developed within our dissertation on the subject Special Purpose Ships. The types of these ships vary and take their name from the purpose they serve. More specifically the ships that are mentioned are: Research Vessels, Reefer Ships, Fishing Vessels, Cable Ships, Light Vessels, Training Ships, Pleasure Crafts.

First of all, the first category we are about to examine is Research Vessels which were used in the past as a way of transportation for scientists to discover new areas to explore. Nowadays they have evolved and acquired more roles and they can be divided in more categories like: Hydrographic research vessels, Oceanographic research vessels, Fishing research vessels, Naval research vessels, Polar research vessels.
In addition, the second category is Reefer Ships, which is another name for Refrigerated Ship. A Reefer Ship is a refrigerated cargo ship used to transport products such as fruits, vegetables, meat, fish and other foods.
The third ship is fishing vessels which as we can understand are used for fishing purposes.Another category is cable ships, ships which have special cable-laying equipment and also ships that control, maintain or repair already mired cables.
Furthermore there are light vessels, which are used as lighthouses and have an auxiliary role on the navigation of adjacent ships for example they are used in waters that are too deep to have a lighthouse construction.
Moreover one other category of ships we are going to describe is training ships. The purpose of these ships is to train students as future officers.
Finally the last category of special purpose ships is the pleasure crafts. Pleasure crafts are used for personal, family and sometimes sportsmanlike recreation. Most common pleasure crafts are yachts which are used mainly for cruising.

1. Code of Safety for SPS

According to IMO, Special Purpose Ship (SPS) means a mechanically self-propelled ship which by reason of its function carries on board more than 12 special personnel

IMO has published a Code for the SPS called "Code of Safety for Special Purpose Ships" which includes 11 chapters. The subjects of each chapter are the following:
Chapter 1 General
Chapter 2 Stability and subdivision
Chapter 3 Machinery installations
Chapter 4 Electrical installations
Chapter 5 Periodically unattended machinery spaces
Chapter 6 Fire protection
Chapter 7 Dangerous goods
Chapter 8 Life-saving appliances
Chapter 9 Radiocommunications
Chapter 10 Safety of navigation
Chapter 11 Security
The purpose of the Code is to recommend design criteria, construction standards and other safety measures for special purpose ships.

1.1 Application of the code

The Code applies to every special purpose ship of not less than 500 gross tonnage certified on or after 13.May 2008. The Administration may also apply these provisions as far as reasonable and practicable to special purpose ships of less than 500 gross tonnage and to special purpose ships constructed before 13 May 2008. This Code does not apply to ships meeting the Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU Code). The Code is not intended for ships used to transport and accommodate industrial personnel that are not working on board.

1.2 Exemptions

A ship which is not normally engaged as a special purpose ship and which undertakes an exceptional single voyage as a special purpose ship may be exempted by the Administration from the provisions of this Code, provided that it complies with safety requirements which in the opinion of the Administration are adequate for the voyage which is to be undertaken by the ship.

1.3 Definitions

Special Personnel:

“Special personnel” means all persons who are not passengers or members of the crew or children of under one year of age and who are carried on board in connection with the special purpose of that ship or because of special work being carried out aboard that ship. Wherever in this Code the number of special personnel appears as a parameter it should include the number of passengers carried on board which may not exceed 12. Special personnel are expected to be able bodied with a fair knowledge of the layout of the ship and to have received some training in safety procedures and the handling of the ship’s safety equipment before leaving port and include the following:

.1 scientists, technicians and expeditionaries on ships engaged in research, non-commercial expeditions and survey;
.2 personnel engaging in training and practical marine experience to develop seafaring skills suitable for a professional career at sea. Such training should be in accordance with a training program approved by the Administration;
.3 personnel who process the catch of fish, whales or other living resources of the sea on factory ships not engaged in catching;
.4 salvage personnel on salvage ships, cable-laying personnel on cable-laying ships, seismic personnel on seismic survey ships, diving personnel on diving support ships, pipe-laying personnel on pipe layers and crane operating personnel on floating cranes;
.5 other personnel similar to those referred to in .1 to .4 who, in the opinion of the Administration, may be referred to this group.

Special purpose ships carrying more than 240 persons on board should be specially considered by the Administration as to whether or not their machinery spaces may be periodically unattended, and, if so, whether additional requirements to those stipulated in this chapter are necessary to achieve equivalent safety to that of normally attended machinery spaces.

1.4 Dangerous cargo carried by SPS

Special purpose ships sometimes carry a wide range of dangerous goods classified in accordance with the IMDG Code for use in scientific or survey work which are carried as ships’ stores and are used on board and they are not subject to the provisions of the IMDG Code. Dangerous goods that are carried on board for shipment as cargo and are not used on board, are clearly subject to the provisions of the IMDG Code.

The following are the Special Purpose Ships mentioned in this diploma thesis :
.1 Research Vessels
.2 Reefer Ships
.3 Fishing Vessels
.4 Cable Ships
.5 Light Ships
.6 Training Ships
.7 Pleasure Crafts

2. Research Vessels

A **research vessel** is a ship or craft designed, modified and equipped to conduct research at sea.
Research vessels began in the 18th century and were practical cruise ships for the discovery of new areas and / or a means of transportation of scientists of the time to areas they wanted to explore. A typical example is in the UK, used by Charles Darwin to travel all over the world.

2.1 Early Research Vessels

The modern research ship takes its origins from the early exploration voyages such as HMS Endeavour and HMS Challenger, both of which were converted vessels, fitted with a range of research facilities to sample and measure across a range of disciplines in extreme environments.

HMS Challenger

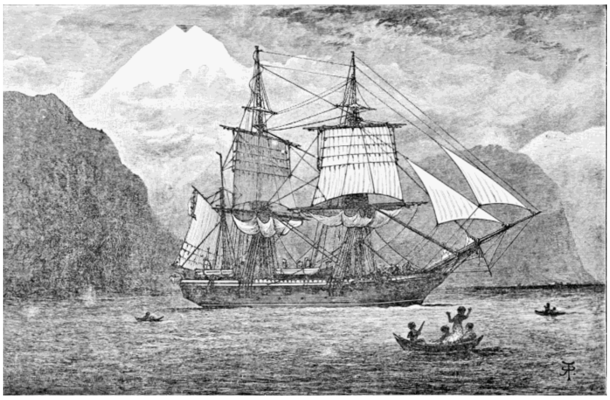
Early research vessels were fairly basic and simplistic compared to the start of the art ships we see being developed today. As time went on, the trend of converting other vessels into research ships was challenged by the challenging demands of investigating increasingly complex areas of oceanographic research, such as physical, biological and chemical oceanography; marine geology and geophysics; ocean engineering and atmospheric science in one expedition. In order to carry out multi-disciplinary research in extreme environments, specially designed research vessels became a requirement. Research ships are the primary source of oceanographic observations and will remain so for the foreseeable future. As time goes on, science is likely to be conducted in increasingly remote and environmentally challenging areas so the ability to operate with minimal interruptions from the natural elements remains unchanged from the days of the HMS Challenger .

2.2 Historical Research Vessels

2.2.1 HMS Beagle

HMS Beagle was a Cherokee-class brig-sloop, one of more than 100 ships of this class. The vessel, constructed at a cost of £7,803 (£613,000 in today's currency), was launched on 11 May 1820

The HMS Beagle is notable for carrying the naturalist Charles Darwin around the world. While the survey work was carried out, Darwin travelled and researched geology, natural history and ethnology onshore. The voyage began on 27 December 1831; it lasted almost five years .Darwin spent most of that time on land investigating geology and making natural history collections, while HMS Beagle surveyed and charted coasts. She also set sail on 22 May 1826 s to accompany the larger ship HMS Adventure on a hydrographic survey of Patagonia and Tierra del Fuego and on the 5th of July 1837she sailed to survey large parts of the coast of Australia with stops for observations at Tenerife, Bahia and Cape Town



HMS Beagle

2.2.2 Terra Nova

Terra Nova was a wooden-hulled barque , with 1 funnel and 3 masts , reinforced from bow to stern with seven feet of oak to protect against the Antarctic ice pack, built in 1884. Her length was 57m and she was manned with 65 crewmembers.

She is best known for carrying the 1910 British Antarctic Expedition Robert Falcon Scott's last expedition on 15 June 1910. The main objective of this expedition was to reach the South Pole. There were other objectives, both scientific and geographical.

Terra Nova

The scientific contributions of the expedition were long overshadowed by the deaths of Scott and his party. However, the 12 scientists who participated the largest Antarctic scientific team of its time made notable discoveries in zoology, botany, geology, glaciology, and meteorology. The Terra Nova returned to England with over 2,100 plants, animals, and fossils, over 400 of which were new to science. The meteorological data collected was the longest unbroken weather record in the early twentieth century, providing baselines for current assessments of climate change.

2.3 Research Vessels' Role

Research vessels perform several roles. Some of these roles can be combined on a single boat, but others require a special boat. The nature of the task that these vehicles are required to perform is demanding and for this, some research vessels are often built around an icebreaker, allowing them to be used even in polar waters.
At present, the phrase "research vessel" refers the listener-reader to the ventures involved in the particular ship, although the English term Research Vessel is also used in various spaceships.

Modern versions of research vessels are subdivided into:

.1 Hydrographic research vessels

.2 Oceanographic research vessels

.3 Fishing research vessels

.4 Naval research vessels

.5 Polar research vessels

2.4 Hydrographic research vessels

A hydrographic craft is a vessel designed to conduct hydrographic research. Hydrogeography is meant to measure and describe the physical properties of an aquatic environment. Nautical charts are produced from this information to ensure safe navigation from military and non-military transport. Hydrographic vessels also conduct seismic surveys on the seabed and the underlying geology. In addition to the production of diagrams, this information is useful for detecting geological features that may carry petroleum or natural gas. These boats usually mount equipment on a sliding structure, for example, air cannons, used to create a high pressure shock wave to sound the layers beneath the bottom, or placed in the Carina, for example, a depth gradient. In practice, hydrographic vessels are often equipped to perform multiple roles. Some work as oceanographic research vessels. Naval hydrographic vessels often do naval research, for example, underwater detection.

2.4.1 The Hellenic Navy's Hydrographic vessels

The Hellenic army navy employs hydrographic research vessels of four types. The largest type "Υ/Γ-ΩΚ ΝΑΥΤΙΛΟΣ Α-478" is 63 meters in length and smallest is just 14 meters in length and has the name of "Υ/Γ-ΩΚ ΑΚΑΤΟΣ 14 Α-14". The largest type can withhold 6 officers, 36 petty officers and sailors.

Υ/Γ-ΩΚ ΝΑΥΤΙΛΟΣ Α-478

Υ/Γ-ΩΚ ΑΚΑΤΟΣ 14 Α-14

2.4.2a The National Oceanic and Atmospheric Administration and the use of Multibeam sonar

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

The National Oceanic and Atmospheric Administration (NOAA) provides detailed information of the use of hydrographic vessels in research.

One of the common practices of the hydrographic research vessels is using sonar to scan the surrounding environment. Sonar, is helpful for exploring and mapping the ocean because sound waves travel farther in the water than do radar and light waves. NOAA scientists primarily use sonar to develop nautical charts, locate underwater hazards to navigation, search for and map objects on the sea floor such as shipwrecks, and map the sea floor itself.

2.4.2b Multibeam sonar

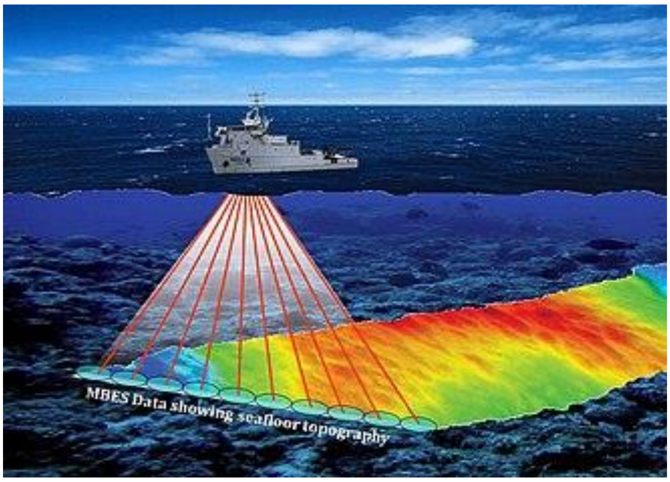
Multibeam sonar measures the depth of the sea floor by analyzing the time it takes for sound waves to travel from a boat to the sea floor and back. It provides amazing detail of the sea floor, especially in rocky and rough terrain, where it gives a complete picture of the bottom. Multibeam sonar is very useful in areas such as the Northeast U.S. and Alaska, where the sea floor is complex and often strewn with thousands of rocks. However, in relatively shallow, flat areas, like those found along the mid-Atlantic coast, the multibeam may not be very efficient. So, NOAA surveyors use another tool called side scan sonar. This kind of sonar creates an image of the sea floor, but does not determine depths. If surveyors find a wreck or obstruction using side scan sonar, they will determine the least depth with multibeam sonar.

The other essential ingredients to charting are accurate positioning and tides or water levels. Until the 1970s, hydrographers determined positions of water depths by using a sextant. Today's modern Global Positioning System provides accuracy and efficiencies never dreamed of only a few years ago. Information gained by measuring and predicting the rise and fall of tides, and accurate positioning, is critical to mariners as they guide large ships in and out of our ports. In many cases, ships are less than three feet off the bottom and within inches of clearance below a highway bridge. Today's technology gives pilots and mariners the knowledge to maneuver along coastlines and into ports and harbors.

Once hydrographic data has been collected using sonar, data processing begins as it is put into context, or referenced to the location at which it was collected. The raw soundings are adjusted to a standard or absolute water level (datum) using predictions (and subsequent final observed tides) from tidal observations collected at water-level stations. Horizontal positions (latitude and longitude) are recorded using Differential Global Positioning System equipment and need no further adjustment. Information about the coastline is compared extensively to recent coastal survey maps to identify new features and modifications. Eventually, the sounding data are re-processed to produce the final soundings.

2.4.3 Hydrographic research and nautical Charts

As the American nation's nautical chart maker, the Office of Coast Survey uses hydrographic data to update NOAA's suite of over a thousand nautical charts. The numbers on a nautical chart are depth measurements, acquired from hydrographic surveys. Nevertheless hydrographic survey is not only used for the exploration and digital illustration of the surrounding water volumes, they have a significant role in response to natural disaster. Following hurricanes or other types of coastal disasters, navigation response teams, part of the Office of Coast Survey, conduct hydrographic surveys of the ocean floor, looking for changes in depth or debris from storms below the surface of the water that could pose great danger to vessel traffic above.



Last but not least in addition to generating the data needed to update nautical charts, hydrographic surveys support a variety of activities such as port and harbor maintenance (dredging), coastal engineering (beach erosion and replenishment studies), coastal zone management, and offshore resource development. Detailed depth information and seafloor characterization is also useful in determining fisheries habitat and understanding marine geological processes.

2.5 Oceanographic research vessels

Oceanographic research vessels carry out research on the physical, chemical and biological characteristics of water, the atmosphere and climate, and to these ends carry equipment for collecting water samples from a range of depths, including the deep seas, as well as equipment for the hydrographic sounding of the seabed, along with numerous other environmental sensors. These vessels often also carry scientific divers and unmanned underwater vehicles.

2.5.1 Oceanographic research in Greece

Oceanographic research in Greece dates back to the late 1930s, but until the mid 1980s it mostly involved activities in the coastal environment. The Institute of Oceanography was established in 1985 as one of the three institutes of the Hellenic Centre for Marine Research (HCMR). During the 1990s the Institute of Oceanography (I.O.) expanded rapidly, both in terms of activities and personnel as a result of its increased involvement in multidisciplinary projects from the European Commission as well as more applied national projects. The Institute, now in a very competitive position in European marine research and plays a leading role in the eastern Mediterranean.

The oceans and seas play a critical role in global and regional climate. Ocean and sea currents transport heat which drives atmospheric circulation and, in conjunction with marine biogeochemical processes, influence atmospheric CO2 concentrations. The oceans and regional seas also cover the major geodynamic features which reveal the inner workings of the Earth and present the seismogenic, volcanic and climate-related hazards to the human population. Within the frame of the above concept, the Institute of Oceanography aims at the systematic and multidisciplinary study, understanding and monitoring of the physical, chemical, biological and geological processes which regulate all aspects of the marine environment and the ecosystems functioning, the ocean-atmosphere and ocean-solid earth interplay and the solid earth dynamics.

2.5.2 The Hellenic Institute of Oceanography (IO) and its mission

The overall scientific mission of the Institute of Oceanography (IO) is :

The mulltidisciplinary study and the long term monitoring of the physical, chemical, biological and geological processes that govern the structure, functioning and evolution of pelagic and benthic ecosystems.
The interaction of the hydrosphere with their physical boundaries, the atmosphere, the coastal zone, the seabed and the related geodynamic processes and hazards.
The operational long-term monitoring and forecasting of the marine environment.
The study of the dynamics of water masses, the climatic variations, the biogeochemical cycles, the food webs, the biodiversity and their interaction.

It explores the marine and underwater energy resources and geo-hazards, the anthropogenic impact on the marine environment and implements integrated coastal zone management actions.

It is active in the fields of operational oceanography, marine renewable energy and underwater geoarchaeology.

Organizes and manages integrated marine observatories and develops marine technology.

2.5.3 The I.O. Fleet

The fleet of the Institute of Oceanography comprises of underwater vehicles and research vessels. The first research vessel of this kind deployed in Greece is R/V AEGAEO. R/V AEGAEO was built in 1985 at the Chalkis shipyard and started her scientific operations in the Eastern Mediterranean. In 1987 the scientific expeditions extended to the western Mediterranean Sea.

R/V AEGAEO (in the port of PIRAEUS)

From June 1996 to Feb 1997 the R/V AEGAEO was converted and enlarged by 10,5 m. R/V AEGAEO, 62 meter in length, was refitted in 1997 and now comprises a completely modernised floating laboratory, equipped with all the latest technology necessary for HCMR's valuable research work which ranges from the geophysical exploration of the sea floor to environmental monitoring. R/V AEGAEO is the mother ship for submersible THETIS and ROV Super Achilles. The laboratories and the equipment were changed for the better and R/V AEGAEO became a modern floating laboratory able to carry out all kind of scientific and technical operation. R/V AEGAEO has undertaken the detection and recovery of 2 ambulance helicopters, in the sea area of Sounio and Ikaria Island, one mirage 2000 in central Aegean Sea and a Chinook, helicopter south of the Athos peninsula. The scientific equipment listed in R/V AEGAEO consists of two Multibeam sonars (SEABEAM 2120 & 1180), one side scan Sonar, system for seismic analysis type Air-gun (5-40 inch 3) and a sparker system (3-9 KJ).

Another notable Greek research vessel is R/V PHILIA which was built at Piraeus in 1985 , commissioned in 1986, operates from her home port of Irakleion, not only in Cretan waters, but also throughout the Aegean and Ionian. The R/V PHILIA's greatest asset is her flexibility, she is large enough to operate offshore but because of her shallow draft she can also operate close inshore. She has covered many thousands of miles carrying out research and in 1997 was refitted with a bulbous bow and a second engine as part of the Greek Government's commitment to marine science research. This particular ship is equipped with Echo sounder Simrad EK 500 split beam 38 and 120 kHz. Echo sounder Simrad EK 400 single beam 120 kHz, Echo sounder Biosonics dual beam 120 kHz V-Fin. RoxAnn and Side Scan Sonars, one SCANMAR net recorder. Underwater remote operated vehicles (ROV): Benthos Mini Rover (300 m), DSSI Max Rover Mk 11 (2000 m). Various underwater cameras Osprey and underwater sledges. 3 Seabird CTD. 7 Aanderaa RC7 meters. Various water and plankton samplers. Sediment traps, various benthic samplers (grabs, box and multi-corers) and benthic draggers. Pelagic, benthic trawls and otter and beam trawls.

R/V PHILIA

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2.5.4 R/P FL.I.P

Oceanographic research is conducted by many types of ships and other crafts but one of the most impressive is the Research Platform FL.I.P.(stands for FLoating Instrument Platform), named as such because it is unpowered and requires to be towed to position

FL.I.P. Ship getting into position

R/P FLIP is an open ocean research platform owned by the U.S. Office of Naval Research (ONR) .The platform is 108 meters long and is designed to partially flood and pitch backward 90°, resulting in only the front 17 meters of the platform pointing up out of the water, with bulkheads becoming decks. When flipped, most of the ballast for the platform is provided by water at depths below the influence of surface waves .At the end of a mission, compressed air is pumped into the ballast tanks in the flooded section and the platform, which has no propulsion, returns to its horizontal position so it can be towed to a new location.

The research vessel has enjoyed tremendous success since it was put into operation in the year 1962, carrying out analyses pertaining to the global oceanology and the maritime ecosystem. It is used to research about wave length, density and temperature of the water, acoustics of the water and other relevant meteorological data that could prove helpful to study marine flora and fauna. Another unique aspect of the Flip Ship is that only one such research ship has been designed and therefore the importance of the Flip Ship increases by a considerable amount. Which is why, in order to keep abreast of the many modern developments in technology, the Flip Ship underwent a renovation in the year 1995 and has able to predict many important points and changes that happen to the ocean and the marine life on a constant basis. The research instruments are designed sideways in such a way that when the ship turns from the horizontal to the vertical position, the instruments are switched into a usable position automatically.

2.6 Fisheries research vessels

A fishing vessel requires platforms that are capable of towing different types of fishing nets, collecting plankton or water samples from a range of depths, and carrying audio-finding fish-finding equipment. Fishing research vessels are often designed and built on the same lines as a large fishing vessel, there is a space reserved for workshops and storage of equipment, as opposed to the storage of catches. Fishery research includes areas of fisheries science, fishing technology, fisheries management and relevant socio-economics. The scope covers fisheries in salt, brackish and freshwater systems, and all aspects of associated ecology, environmental aspects of fisheries, and economics.

2.7 Naval research vessels

Naval research vessels investigate issues related to the navy, such as the detection of submarines and mines, and testing new sonar systems and possibly weapons.

2.8 Polar research vessels

Polar research vessels are built around an icebreaker, allowing them to participate in ice navigation and operate in polar waters. These vessels usually have double roles, particularly in Antarctica, where they also operate as polar replenishment and supply vessels on the Antarctic research bases.

Danish fisheries research vessel

German Naval research vessel

French Polar research vessel

3. Reefer Ships

A **reefer ship** is a refrigerated cargo ship , typically used to transport perishable commodities which require temperature-controlled transportation, such as fruit, meat, fish, vegetables, dairy products and other foods.

3.1 History of ship refrigeration

By 1869, reefers were shipping beef carcasses frozen in a salt-ice mixture from Indianola, Texas, to New Orleans, Louisiana, to be served in hospitals, hotels and restaurants. By 1874 they were shipping frozen beef from America to London, which developed into an annual tonnage of around 10,000 short tons (8,900 long tons; 9,100 t). The insulated cargo space was cooled by ice, which was loaded on departure. The success of this method was limited by insulation, loading techniques, ice block size, distance and climate.

The first attempt to ship refrigerated meat was made when the Northam sailed from Australia to the UK in 1876. The refrigeration machinery broke down en route and the cargo was lost. In 1877, the steamers Frigorifique and Paraguay carried frozen mutton from Argentina to France, proving the concept of refrigerated ships, if not the economics. In 1879 Strathleven, equipped with compression refrigeration, sailed successfully from Sydney to the UK with 40 tons of frozen beef and mutton as a small part of her cargo.

Dunedin

The clipper sailing ship Dunedin, owned by the New Zealand and Australian Land Company (NZALC), was refitted in 1881 with a Bell-Coleman compression refrigeration machine. This steam-powered freezer unit worked by compressing air, then releasing it into the hold of the ship. The expanding air absorbed heat as it expanded, cooling the cargo in the hold. Using three tons of coal a day, this steam powered machine could chill the hold to 40 °F (22 °C) below the surrounding air temperature, freezing the cargo in the temperate climate of southern New Zealand, and then maintaining it below freezing (32 °F, 0 °C) through the tropics. Dunedin's most visible sign of being an unusual ship was the funnel for the refrigeration plant placed between her fore and main masts (sometimes leading her to be mistaken for a steamship which had been common since the 1840s). In February 1882, Dunedin sailed from Port Chalmers New Zealand with 4,331 mutton, 598 lamb and 22 pig carcasses, 246 kegs of butter, and hare, pheasant, turkey, chicken and 2,226 sheep tongues and arrived in London after sailing 98 days with its cargo still frozen. After meeting all costs, the NZALC company made a £4,700 profit from the voyage.

Soon after Dunedin's successful voyage, an extensive frozen meat trade from New Zealand and Australia to the UK was developed with over 16 different refrigerated and passenger refrigerated ships built or refitted by 1900 in Scotland and Northern England shipyards for this trade. Within 5 years, 172 shipments of frozen meat were sent from New Zealand to the United Kingdom. Refrigerated shipping also led to a broader meat and dairy boom in Australia, New Zealand and Argentina. Frozen meat and dairy exports continued to form the backbone of New Zealand's. As of 2012, New Zealand has no refrigerated cargo ships

The Nelson brothers, butchers in County Meath, Ireland, started shipping extensive live beef shipments to Liverpool, England. They successfully expanded their beef business until their imports from Ireland were insufficient to supply their rapidly growing business and Nelson decided to investigate the possibility of importing meat from Argentina. The first refrigerated ship they bought was Spindrift which they renamed in 1890 SS Highland Scot. A vessel of 3,060 gross tons bought by James Nelson and Sons in 1889 and fitted with a somewhat primitive refrigerating plant operating on the cold air system became one of the pioneer vessels in the trade of refrigerated meat and other perishable commodities. They hauled beef carcasses from Argentina to Britain. Their regularly scheduled shipments and ships developed into the Nelson Line that was formed in 1880 for the meat trade from Argentina to UK. Refrigeration made it possible to import meat from the United States, New Zealand, Argentina and Australia.

All of their ships had a "Highland" first name. The Nelson Line began passenger service in 1910 between London, England and Buenos Aires and in 1913 came under control of the Royal Mail Steam Packet Company. In 1932 Royal Mail Group collapsed, Royal Mail Lines Ltd was founded, and Nelson Line merged into the new company.

3.1.1The United Fruit Company

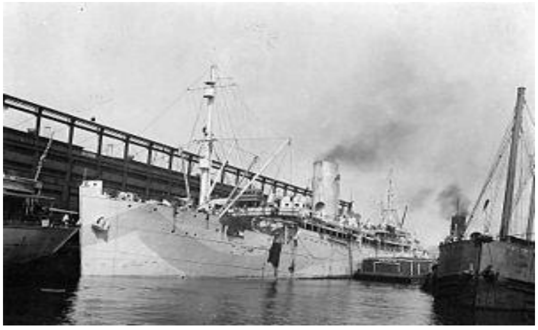
The United Fruit Company was an American corporation that traded in tropical fruit (primarily bananas), grown on Latin American plantations, and sold in the United States and Europe. The company was formed in 1899, from the merger of Minor C. Keith's banana-trading concerns with Andrew W. Preston's Boston Fruit Company. It flourished in the early and mid-20th century, and it came to control vast territories and transportation networks in Central America, the Caribbean coast of Colombia, Ecuador, and the West Indies. Though it competed with the Standard Fruit Company (later Dole Food Company) for dominance in the international banana trade, it maintained a virtual monopoly in certain regions, some of which came to be called banana republics, such as Costa Rica, Honduras, and Guatemala.


United Fruit Company in Jamaica

The United Fruit Company has used some type of reefers, often combined with cruise ship passenger accommodations, since about 1889. Because of their cargo was mostly bananas, they were nicknamed the "Banana Fleet". Since bananas are relatively light and the normal shipping route was to Central America and then back to various U.S. ports, these ships were often built as combination cargo ships and what are now called cruise ships to pay for more of their operating expenses. After about 1910, they called these combination cruise and cargo ships the "Great White Fleet". To avoid US shipping regulations and taxes they are registered in about six other countries, with very few now maintaining US registry. European associates with their own ships were often employed to ship fruit to Europe. United Brands was taken over by Chiquita Brands International in the 1980s and owns the largest fleet of banana boats in the world, but none of them now sails under the US flag. SS Pastoresand SS Calamares were built in Ireland in 1912 and 1913 for the United Fruit Company as a combination cruise ship and refrigerated cargo ship.

The United Fruit Company's fleet of about 85 ships was one of the largest civilian fleets in the world. These ships normally carried up to 95 cruise ship passengers and a crew to ports in Central America and then would return to the United States with passengers and a cargo of refrigerated bananas and miscellaneous cargo. They were part of United Fruit's "Great White Fleet"—to minimize heat build-up the ships were all painted white.

USS Pastores



USS Calamares

The renamed USS Pastores and USS Calamares were taken over by the United States Navy in World War I and used to take troops and refrigerated supplies to and from Europe. After hostilities ceased they were returned to United Fruit Company in 1919. They were requisitioned again on 2 June 1941 from United Fruit for use in World War II. After hostilities ceased they were then returned again to United Fruit Company in 1946.

During the last fifty years the refrigerated ship has changed conditions of life for millions of people, especially those who live in crowded industrial countries such as the British Isles, in primarily agricultural and farming countries overseas such as Australia, New Zealand, South Africa and the Argentine, and in many tropical countries. Thanks to the steam and motor ship, to the research scientist and the engineer, our transport of perishable foodstuffs, particularly meat and fruit, has made immense strides in recent years.
For ages the ship has been the great instrument that civilized peoples have used to counter possible famine. Lack of scientific knowledge, however, and the slowness and uncertainty of sail prevented the efficient transport of food that tainted quickly. Non-perishable food bulked large in the cargoes of the ancient merchant fleets. Grain ships from Egypt brought wheat to Ostia, the port of Rome. To this day dried or cured fish is consumed in large quantities by Latin peoples, and Newfoundland schooners still trade across the Atlantic and down the American seaboard to the West Indies and Latin America; but the science of carrying fresh meat and fruit across the sea made little progress from ancient times to the ‘seventies of the last century, when the clippers raced home from China with tea.

Pickling in brine was the chief method of preserving food on land and at sea. Those who made long voyages gave up hope of dainty meals as soon as the coast dropped below the horizon. Live chickens, and often a cow, were carried to alleviate the hardships of ocean travel, and on special voyages animals and seeds were taken by sailing ships to newly discovered lands to propagate the herds and crops that now flourish. It was not possible in those days to transport thousands of tons of meat and fruit in prime condition from one side of the world to the other.

The problem of preserving food, however, did much to help the development of shipping. Spices were needed to preserve meat and to disguise the taste of food that was no longer fresh. The spices carried to Europe by the early merchant adventurers fetched high prices. When South America, Australia and New Zealand began to develop as cattle- and sheep-raising countries, meat was at first merely a by-product. There was too much of it to be consumed locally. In contrast to the hides and wool of the animals, meat could not be preserved during the voyage through the tropics to the meat-eating countries. Similarly many fruits rotted in orchards overseas because they could not be brought to market in industrial countries. These countries were limited to the consumption of local fruits and of oranges or similar fruits that could survive a short sea voyage. Thus, except when there was a glut, fruit was a luxury beyond the means of poor people, and the possibility of being able to eat fresh fruit all the year round seemed fantastic and against the laws of Nature. People would have laughed at the idea of buying for a penny an apple that had been brought 12,000 miles to market.

If it were not for the work of the food ships the inhabitants of Great Britain would starve. Grain and beverages such as tea, coffee and cocoa do not require refrigeration or the newer methods of gas-storage, but every year the importance of the refrigerated ship increases. More than half the beef and mutton eaten in Great Britain is imported, as well as 90 percent of the butter and 75 percent of the apples. Bananas and citrus fruits imported from distant countries would never reach Great Britain but for the refrigerated vessel. The ship is the main link in the system of scientific storage that begins at the overseas port and ends in British shops.

Food preservation with natural ice has been known for centuries. Ice was imported into Great Britain in large quantities during Queen Victoria's reign and up to 1914, when war compelled the British to rely upon refrigeration plants. Natural ice was tried as a food preservative in sailing ships, but it was not successful because the ice thawed too quickly. The rapid growth of the population and the continued scarcity of meat became a serious problem in the middle of the last century. Salted beef and pork and canned beef and mutton were imported and cattle were shipped alive from America. It was impossible to ship live cattle from the Antipodes because the distance was so great and consequently the freight charges were high.

3.2 Vital Temperatures

Frozen meat requires to be kept at 12° to 15° Fahrenheit, chilled meat at 29°, with no more than a ½° degree variation on either side of the nominated temperature. Fruit requires various temperatures, pears being carried at about 29°, apples at 32° to 33°, oranges at 35° to 45° and bananas at 54°. Fruit is generally carried in chambers fitted with forced air circulation, and frozen and chilled meats in chambers cooled by pipe grids on the walls and overhead. A refrigerated ship generally carries engineers who have nothing to do with the operation of the vessel, but who are concerned solely with the condition of the perishable cargo of food. Should a vessel meet with a mishap, one of the first things the underwriters ascertain is whether her refrigerating plant is working. If the storage plant is not functioning, the cargo, worth thousands of pounds, will be ruined. The temperature of a hospital patient on the danger list is not more carefully charted than the temperature of the refrigerated cargo of a ship.

Time is vital, particularly with fruit, and modern fruit carriers are much faster than general cargo ships. Liners on the Australian route carry meat cargoes. So rapidly does meat decompose in the tropics that, were it economically possible to transport unrefrigerated fresh meat from Australia to Great Britain by air, the meat would decompose on the flight through the torrid zone. Refrigeration is the only possible method. The weight of the plant at the time of writing rules out the possibility of air transport. The transport of fruit presents more difficulties than the transport of meat. Even to-day there are many luscious tropical fruits which cannot be shipped for any distance. There are limitations to the plan of plucking unripened fruit and shipping it so that it reaches market before it has time to rot. Only within recent years has the orange been obtainable all the year round, and the banana was a curiosity in Great Britain until the beginning of this century.

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Fleets of specially designed ships are devoted solely to the shipment of bananas. Hundreds of millions of bands (bunches) of bananas are shipped annually in specially built vessels from tropical America, the West Indies and the Canary Islands to the United Kingdom, the United States, and the Continent. The French have vessels to bring the fruit from their colonies in the West Indies and Africa, and the Germans have built ships for bringing bananas from German-owned plantations in the Cameroons.

Bananas are cut, when they are green and hard, in hands of about a hundred bananas attached to the stalk. The whole operation of cutting and marketing the banana is carefully timed. Some companies have their own plantations in the tropics, their own fleet of refrigerated ships and their own marketing organization. The plantation manager is informed beforehand when a vessel is due, and arranges for the fruit to be cut and ready directly the ship arrives. Then the bananas are placed in the insulated and ventilated holds and are inspected at intervals during the voyage

Vessels built for the banana trade are equipped with refrigerating machinery and fans for circulating large volumes of air over brine-cooling batteries. Instead of deep holds the vessels have ’tween decked holds. Fresh air is admitted according to requirements, and as the ship approaches a discharge port where the temperature is low the air is' heated before the bananas are unloaded so that they do not suffer damage by frost.The carriage of fruit presents special problems to the shipowner, for it is impossible to mix citrous and non-citrous fruit cargoes, because the one will spoil the other.

Modern fruit ships are among the fastest cargo ships afloat The Caribbean Sea is one of the centres of the banana trade, the converging point of the routes of the fleets owned by the United Fruit Company and others. It is. one of the king-pins of the fruit trade, and this in turn is one of the most vital outlets of world shipping at the present time.

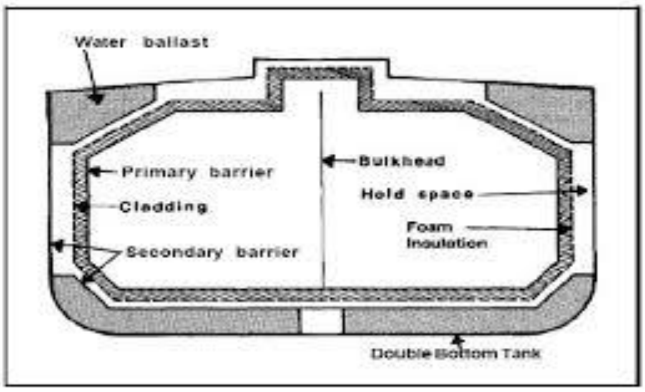
Until recently few fruits could claim to have fleets of ships devoted exclusively to their transportation, and in this respect the banana was predominant. Its importance is still undeniable, but its predominance is now shared by citrous fruit and by deciduous fruit. The civilized world, with the possible exception of America, does not normally employ the banana as a breakfast food, but uses it lavishly for dessert purposes. People do, however, demand grape-fruit for breakfast, and clamour for oranges and the fresh fruits of the tropical and subtropical regions of the earth. Thanks to refrigeration, these fruits are brought in first-class condition to our tables, whatever the season and whatever the meal. It is the fruit ship which makes this possible.

The concept of refrigerated cargo was first used to ship bananas but it has developed to ship other perishable foodstuffs too. It has to be noted that in some countries such refrigerated carriers form a very integral part of the nation’s economy. One of the most famous refrigerator ships is the Baltic Start. As the name suggests, the ship is a part of the Baltic region of Europe. A reefer ship would be of immense help to Middle-Eastern countries where the infrastructure for foodstuffs like fruits is limited from local sources.The power or electricity to ensure continuous stability of the cold conditions in such ships is aided with the help of electricity supply attached to the main power supply of the ship. Additionally, compressors for refrigeration systems are also fitted to maintain the coolness of such refrigerated containers.

Reefer Vessel transporting bananas

Another major aspect involved with such ships is the fact that water coolers are used to keep the temperature steady in case the cargo is stored in the interior of the ship. The presence of the cool air acts a regulator to the temperature in case the cargo is stored and kept in the deck-side of the ships.A reefer ship is a utility ship with a difference. These refrigerated carriers are well-known in the shipping industry. Through refrigerated shipping, the problem of distributing foodstuffs to the needy and required is solved. Refrigerated cargo ensures that necessary food is given to the required – even if the process is slow and delayed.

The cargo holds of a reefer ship are most unlike those found on their predecessors, the general cargo ship. Each cargo carrying space is lined by layers of insulation material that effectively reduces its volumetric cargo capacity. The insulation is necessary by the very nature of its trade. Furthermore, the hold (usually the floor), is double skinned to allow for even circulation of the cooling air. Usually this affected by wooden gratings with precisely measured air passage openings that allow the cold air to percolate upwards through the cargo. The cargo may be carried loose (in bins), in individual boxes or in pallets. A typical reefer ship has today about 7000m² reefer hold for pallet cargo, or equivalent to about 600.000 ft³.In addition a ship of the existing types can carry about 100 - 300 loaded forty feet containers.



Most reefer ships operate at higher cruising speeds, usually 18 - 23 knots, primarily reducing carriage times of perishable fresh fruit and of course allowing operational flexibility and to decrease turnaround times. Reefer vessels are able to carry any frozen or cooled cargo including fruits, vegetables, fish and meat. The temperature range is -30 to +12 ºC depending on the type of cargo. The most sensitive cargo prevalent is that of fresh Bananas.

3.3 Total number of Reefer ships

The total number of reefer ships world-wide today is about 1000 (reefers above 100.000 ft³).

3.4 Specialized Equipment on Reefers

Reefer ships require the following for effective carriage:

i) A cargo cooling system. This entails the incorporation of a cargo cooling plant. Usually a bank of compressors are used which cool refrigerant gas (freon is most in use). This cold freon in turn cools the secondary refrigerant which is usually brine. The brine is circulated to all cargo spaces and through cooling (evaporating coils) fitted under powerful fans. The subsequent air flow cools the cargo. The system is comparable to the modern day air-flow home refrigerators marketed these days.
ii) As is obvious, defrosting needs to be affected when freezing temperatures are maintained – as often as 2-3 times a day on occasion. Hence powerful heating apparatus needs to be fitted.
iii) Effective control systems to meet precision temperature requirements.
iv) Higher capacity generators to meet the power needs.
v) Special monitoring equipment (computerised or manual) for safe monitoring of equipment and cargo.

vi) Effective ventilation control systems. High level of humidity needs to be maintained. A reefer vessel can ill afford weight loss from cargo due to low humidity level.
vii) Extra hold bilge-pumping requirements. After loading, due to rapid forced drop in temperatures, condensation leads to large water accumulation and needs to be controlled.
viii) Modern reefer vessels also incorporate Inert gas generators and systems –thus cooling and atmosphere control are both applied to the cargo.

3.5 New Developments in Refrigerated transport.

This section will mostly discuss one of the latest developments in reefer transportation. Reefer carriage traditionally entailed keeping the goods in suspended animation – so to say, by bringing down the temperature of the cargo. Research and experimentation showed that by limiting availability of oxygen to fresh fruit further inhibited the natural ripening process. Imagine that you are exposed to very low temperatures. Your breathing slows down, your heart rate reduces and you will in time end up in a state similar to hibernation. What would happen if someone at the same time also chose to choke your air supply – you would turn unconscious much earlier. Mind you, the temperature cannot be too cold or your body will freeze and stop to function. Neither can you be denied all oxygen as that would lead to asphyxiation.

A similar condition is generated on board vessels for the live fruit forcing them to go into a state similar to hibernation. The oxygen denial is applied by using inert gas generators that are now increasingly found on reefer vessels. Inert atmospheres now are no longer the domain of oil tankers. Application of this technology manifests in what is called Controlled Atmosphere (CA)

3.6 Transportation in the reefer world.

Even the simpler temperature control carriage requirements are being modified because of technology. Gone are the days when a degree on either side of carriage requirement was acceptable. If bananas need to be carried at 13.3°C, then that is the temperature that must be maintained. It is apt to point out that with the greater control that technology affords us, the fruit can be kept on the mother plant for a longer period – thus enhancing its size, weight and marketability. The catch lies in the fact that the longer one delays harvesting the produce, the closer it reaches maturity. It is then more likely to ripen if the precise storing conditions are not met and in turn lead to turning of other cargoes.

The carriage temperatures defined are also undergoing changes. For example, studies have revealed that bananas may be carried at 12.8°C or 13.3°C or 13.5°C depending on the soil the plant rooted in, the thickness of the skin, etc.

3.7 Controlled Atmosphere (CA) in Transportation

Controlled atmosphere technology works by reducing produce respiration, slowing ethylene production, inhibiting pathogen reproduction, and killing insects. The greatest impact on insects is achieved by maintaining low Oxygen concentrations for an extended period of time which leads to O^2 deprivation in insect body tissues. At exposure concentrations of 0.5 percent O^2 for 96 hours, 100 percent mortality has been observed for nearly all insects tested.

The old concept of measuring shelf life of fresh produce in weeks or months is now obsolete. With CA carriage, shelf life is now measured in BTUs (thermal units indicate metabolic life). The ripening of fruit can be successfully manipulated by utilising CA technology during transit, thus extending the cargo's shelf life. Atmospheric components such as O^2 and CO^2 are manipulated to create an environment that restricts the respiration process of fresh produce and helps to impede fungal growth.

Controlled atmospheres are essentially those which deviate from the normal air composition of 21% oxygen, 78% nitrogen and 300ppm of carbon dioxide. Other gases are also present but normally in too small a concentration to have a prime effect on stored produce.
The most common inerting gas used is Nitrogen. Special generator units are employed to extract the atmospheric Nitrogen (reducing O^2 content). The resulting air mixture is then pumped into the cargo holds, purging the existing mass of air. The atmosphere in the hold is controlled to preset levels (depending on fruit) and CA carriage requirements complied with. The principle technologies employed for transportable CA systems have included Membrane type N^2 Generators, PSA (pressure swing adsorption) type Generators or stored gas (Air transport usually).

3.8 Training of the Crew-Safety & Environmental

Reefer vessel crew need to be explained the necessary techniques that involve carriage of a perishable, edible commodity. Further, reefer trade involves cargo that will not undergo further
processing but is loaded consumer ready. The basic requirement is cleanliness. Reefer ships will accumulate fungal growths over a passage. This needs specialised equipment and material to remove.

The reefer equipment and its associated controls need careful understanding and training. Reefer crew is also made aware of the associated dangers with handling of chemicals and gases that are used in the reefer plant.

3.9 Types of reefers

Reefer ships may be categorised into three types:

3.9.1 Side-Door Vessels

Side-door vessels have water-tight ports on the ship's hull, which open into a cargo hold. Elevators or ramps leading from the quay serve as loading and discharging access for the forklifts or conveyors. Inside these access ports or side doors, pallet lifts or another series of conveyors bring the cargo to the respective decks. This special design makes the vessels particularly well suited for inclement weather operations as the tops of the cargo holds are always closed against rain and sun.

3.9.2 *Conventional Vessels*

Conventional vessels have a traditional cargo operation with top opening hatches and cranes/derricks. On such ships, when facing wet weather, the hatches need to be closed to prevent heavy rain from flooding the holds. Both above ship types are well suited for the handling of palletized and loose cargo.

3.9.3 Refrigerated Container Ships

Refrigerated container ships are specifically designed to carry containerised unit loads where each container has its individual refrigerated unit. These containers are nearly always twenty-foot equivalent units (often called TEU) that are the size of "standard" cargo containers that are loaded and unloaded at container terminals and aboard container ships. These ships differ from conventional container ships in their design, power generation, and electrical distribution equipment. They need provisions made for powering each container's cooling system. Because of their ease of loading and unloading cargo many container ships are now being built or redesigned to carry refrigerated containers.

A major use of refrigerated cargo hold type ships was for the transportation of bananas and frozen meat, but most of these ships have been partly replaced by refrigerated containers that have a refrigeration system attached to the rear end of the container. While on a ship these containers are plugged into an electrical outlet (typically 440 VAC) that ties into the ship's power generation. Refrigerated container ships are not limited by the number of refrigeration containers they can carry, unlike other container ships which may be limited in their number of refrigeration outlets or have insufficient generator capacity. Each reefer container unit is typically designed with a stand-alone electrical circuit and has its own breaker switch that allows it to be connected and disconnected as required. In principle each individual unit could be repaired while the ship was still underway.

Refrigerated cargo is a key part of the income for some shipping companies. On multi-purpose ships, refrigerated containers are mostly carried above deck, as they have to be checked for proper operation. Also, a major part of the refrigeration system (such as a compressor) may fail, which would have to be replaced or unplugged quickly in the event of a fire. Modern container vessels stow the reefer containers in cellguides with adjacent inspection walkways that enable reefer containers to be carried in the holds as well as on the deck. Modern refrigerated container vessels are designed to incorporate a water-cooling system for containers stowed under deck. This does not replace the refrigeration system but facilitates cooling down of the external machinery. Containers stowed on the exposed upper deck are air-cooled, while those under deck are water-cooled. The water cooling design allows capacity loads of refrigerated containers under deck as it enables the dissipation of the high amount of heat they generate. This system draws fresh water from the ship's water supply, which in turn transfers the heat through heat exchangers to the abundantly available sea water.

There are also refrigeration systems that have two compressors for very precise and low-temperature operations, such as transporting a container of blood to a war zone. Cargoes of shrimp, asparagus, caviar and blood are considered among the most expensive refrigerated items. Bananas, fruit and meat have historically been the main cargo of refrigerated ships.

4. Fishing Vessels

A fishing vessel is a boat or ship used to catch fish in the sea, or on a lake or river. Many different kinds of vessels are used in commercial, artisanal and recreational fishing.

The total number of fishing vessels in the world in 2016 was estimated to be about 4.6 million, unchanged from 2014. The fleet in Asia was the largest, consisting of 3.5 million vessels, accounting for 75 percent of the global fleet. In Africa and North America the estimated number of vessels declined from 2014 by just over 30 000 and by nearly 5 000, respectively. For Asia, Latin America and the Caribbean and Oceania the numbers all increased, largely as a result of improvements in estimation procedures.

It is difficult to estimate the number of recreational fishing boats. They range in size from small dinghies to large charter cruisers, and unlike commercial fishing vessels, are often not dedicated just to fishing.Prior to the 1950s there was little standardisation of fishing boats. Designs could vary between ports and boatyards. Traditionally boats were built of wood, but wood is not often used now because it has higher maintenance costs and lower durability. Fibreglass is used increasingly in smaller fishing vessels up to 25 metres (100 tons), while steel is usually used on vessels above 25 metres.

4.1 Fishing vessels and SOLAS

International treaties such as the International Convention for the Safety of Life at Sea (SOLAS) have been in force for any decades for commercial shipping, including cargo and passenger ships. SOLAS includes a number of regulations which are applicable to all ships, such as its SOLAS chapter V, on safety of navigation. However, many other SOLAS regulations provide an exemption for fishing vessels.

Unlike other merchant ships, which load cargo in a port and then carry it to unload at another port, fishing vessels set out to sea unladen, catch fish and sail back to port with their catch of fish. Some larger trawlers and factory ships freeze, process and tin fish, out at sea. IMO has been working to address fishing vessel safety for many decades. In collaboration with the Food and Agriculture Organization of the United Nations (FAO) and the International Labour Organization (ILO).In 1977, IMO adopted the Torremolinos International Convention for the Safety of Fishing Vessels, which was later modified by the 1993 Torremolinos Protocol. As both of these treaties had failed to come into force, IMO later adopted the 2012 Cape Town Agreement, to bring into effect the provisions of the earlier treaties.

The Cape Town Agreement includes mandatory international requirements for stability, construction and associated seaworthiness of fishing vessels of 24 metres in length and over, as well as requirements for life-saving appliances, communications equipment and fire protection. It should be noted that IMO's MARPOL regulations for the prevention of pollution from ships do apply to fishing vessels, inclduing regualtions for the prevention of pollution by garbage from ships, which prohibit the discharge of garbage and operational waste, including fishing gear, into the sea.

4.1.1 The Cape Town Agreement

The 2012 Cape Town Agreement is an internationally-binding instrument. The Agreement includes mandatory international requirements for stability and associated seaworthiness, machinery and electrical installations, life-saving appliances, communications equipment and fire protection, as well as fishing vessel construction. The 2012 Cape Town Agreement is aimed at facilitating better control of fishing vessel safety by flag, port and coastal States. It is also expected to contribute to the fight against IUU fishing.

4.2 History of Fishing Vessels

Early fishing vessels included rafts, dugout canoes, and boats constructed from a frame covered with hide or tree bark, along the lines of a coracle. The oldest boats found by archaeological excavation are dugout canoes dating back to the Neolithic Period around 7,000-9,000 years ago.

These canoes were often cut from coniferous tree logs, using simple stone tools. These early vessels had limited capability, they could float and move on water, but were not suitable for use any great distance from the shoreline. They were used mainly for fishing and hunting.

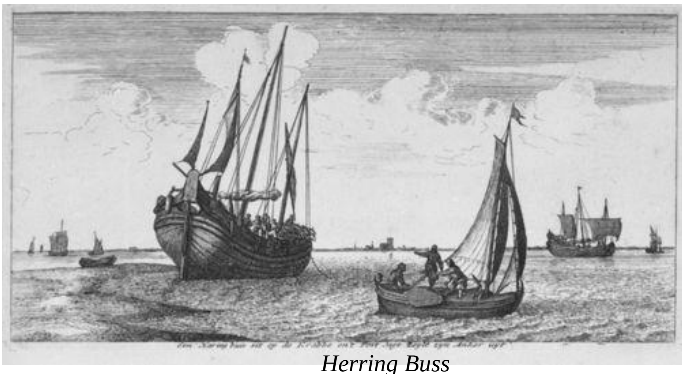
The development of fishing boats took place in parallel with the development of boats built for trade and war. Early navigators began to use animal skins or woven fabrics for sails. Affixed to a pole set upright in the boat, these sails gave early boats more range, allowing voyages of exploration.

Replica of Egyptian narrow boat

Around 4000 B.C., Egyptians were building long narrow boats powered by many oarsmen. Over the next 1,000 years, they made a series of remarkable advances in boat design. They developed cotton-made sails to help their boats go faster with less work. Then they built boats large enough to cross the oceans. These boats had sails and oarsmen, and were used for travel and trade. By 3000 BC, the Egyptians knew how to assemble planks of wood into a ship hull. They used woven straps to lash planks together, and reeds or grass stuffed between the planks to seal the seams.

At about the same time, the Scandinavians were also building innovative boats. People living near Kongens Lyngby in Denmark, came up with the idea of segregated hull compartments, which allowed the size of boats to gradually be increased. A crew of some two dozen paddled the wooden Hjortspring boat across the Baltic Sea long before the rise of the Roman Empire. Scandinavians continued to develop better ships, incorporating iron and other metal into the design and developing oars for propulsion.

In the 15th century, the Dutch developed a type of seagoing herring drifter that became a blueprint for European fishing boats. This was the Herring Buss, used by Dutch herring fishermen until the early 19th centuries.

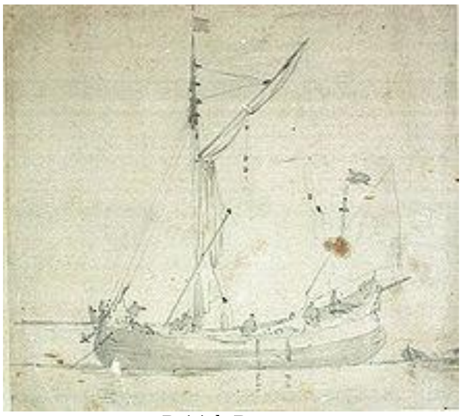


Herring Buss

During the 17th century, the British developed the dogger, an early type of sailing trawler or longliner, which commonly operated in the North Sea. Doggers were slow but sturdy, capable of fishing in the rough conditions of the North Sea. Sometime after the early 18th century , dories appeared in New England. A dory is a small, shallow-draft boat, about 5 to 7 metres or 16 to 23 feet long. It is usually a lightweight boat with high sides, a flat bottom and sharp bows. They are easy to build because of their simple lines. For centuries, dories have been used as traditional fishing boats, both in coastal waters and in the open sea The Banks dories appeared in the 1830s. They were designed to be carried on mother ships and used for fishing cod at the Grand Banks.

4.3 Modern fishing trawler

The British dogger was an early type of sailing trawler from the 17th century, but the modern fishing trawler was developed in the 19th century, at the English fishing port of Brixham.



British Dogger

By the early 19th century, the fishermen at Brixham needed to expand their fishing area further than ever before due to the ongoing depletion of stocks that was occurring in the overfished waters of South Devon. The Brixham trawler that evolved there was of a sleek build and had a tall gaff rig, which gave the vessel sufficient speed to make long distance trips out to the fishing grounds in the ocean. They were also sufficiently robust to be able to tow large trawls in deep water. The great trawling fleet that built up at Brixham, earned the village the title of 'Mother of Deep-Sea Fisheries'.

This revolutionary design made large scale trawling in the ocean possible for the first time, resulting in a massive migration of fishermen from the ports in the South of England, to villages further north, such as Scarborough, Hull, Grimsby, Harwich and Yarmouth, that were points of access to the large fishing grounds in the Atlantic Ocean.

The small village of Grimsby grew to become the largest fishing port in the world by the mid 19th century. With the tremendous expansion in the fishing industry, the Grimsby Dock Company was formed in 1846. The dock covered 25 acres (10 ha) and was formally opened by Queen Victoria in 1854 as the first modern fishing port.

The facilities incorporated many innovations of the time - the dock gates and cranes were operated by hydraulic power, and the 300-foot (91 m) Grimsby Dock Tower was built to provide a head of water with sufficient pressure by William Armstrong.

The elegant Brixham trawler spread across the world, influencing fishing fleets everywhere. Their distinctive sails inspired the song Red Sails in the Sunset, written aboard a Brixham sailing trawler called the Torbay Lass. By the end of the 19th century, there were over 3,000 fishing trawlers in commission in Britain, with almost 1,000 at Grimsby. These trawlers were sold to fishermen around Europe, including from the Netherlands and Scandinavia. Twelve trawlers went on to form the nucleus of the German fishing fleet.

4.4 Steam Powered Boats

The earliest steam powered fishing boats first appeared in the 1870s and used the trawl system of fishing as well as lines and drift nets. These were large boats, usually 80–90 feet (24–27 m) in length with a beam of around 20 feet (6.1 m). They weighed 40-50 tons and travelled at 9–11 knots

The earliest purpose built fishing vessels were designed and made by David Allan in Leith in March 1875, when he converted a drifter to steam power. In 1877, he built the first screw propelled steam trawler in the world. This vessel was Pioneer LH854. She was of wooden construction with two masts and carried a gaff rigged main and mizen using booms, and a single foresail. Pioneer is mentioned in The Shetland Times of 4 May 1877. In 1878 he completed Forward and Onward, steam-powered trawlers for sale. Allan built a total of ten boats at Leith between 1877 and 1881. Twenty-one boats were completed at Granton, his last vessel being Degrave in 1886. Most of these were sold to foreign owners in France, Belgium, Spain and the West Indies.

The first steam boats were made of wood, but steel hulls were soon introduced and were divided into watertight compartments. They were well designed for the crew with a large building that contained the wheelhouse and the deckhouse. The boats built in the 20th century only had a mizzen sail, which was used to help steady the boat when its nets were out. The main function of the mast was now as a crane for lifting the catch ashore. It also had a steam capstan on the foredecknear the mast for hauling nets. The boats had narrow, high funnels so that the steam and thick coal smoke was released high above the deck and away from the fishermen. These funnels were nicknamed woodbines because they looked like the popular brand of cigarette. These boats had a crew of twelve made up of a skipper, driver, fireman (to look after the boiler) and nine deck hands.

Steam trawlers were introduced at Grimsby and Hull in the 1880s. In 1890 it was estimated that there were 20,000 men on the North Sea. The steam drifter was not used in the herring fishery until 1897. The last sailing fishing trawler was built in 1925 in Grimsby.

Trawler designs adapted as the way they were powered changed from sail to coal-fired steam by World War I to diesel and turbines by the end of World War II.

The first purpose built stern trawler was Fairtry built in 1953 at Aberdeen. The ship was much larger than any other trawlers then in operation and inaugurated the era of the 'super trawler'. As the ship pulled its nets over the stern, it could lift out a much greater haul of up to 60 tons. Lord Nelson followed in 1961, installed with vertical plate freezers that had been researched and built at the Torry Research Station. These ships served as a basis for the expansion of 'super trawlers' around the world in the following decades.

In recent decades, commercial fishing vessels have been increasingly equipped with electronic aids, such as radio navigation aids and fish finders. During the Cold War, some countries fitted fishing trawlers with additional electronic gear so they could be used as spy ships to monitor the activities of other countries.

The 200-mile fishing limit has changed fishing patterns and, in recent times, fishing boats are becoming more specialised and standardised. In the United States and Canada more use is made of large factory trawlers, while the huge blue water fleets operated by Japan and the Soviet-bloc countries have contracted. In western Europe, fishing vessel design is focused on compact boats with high catching power.

Commercial fishing is a high risk industry, and countries are introducing regulations governing the construction and operation of fishing vessels. The International Maritime Organization, convened in 1959 by the United Nations, is responsible for devising measures aimed at the prevention of accidents, including standards for ship design, construction, equipment, operation and manning.Commercial fishing vessels can be classified by architecture, the type of fish they catch, the fishing method used, or geographical origin. The following classification follows the FAO, who classify commercial fishing vessels by the gear they use.

4.5 Trawlers

A trawler is a fishing vessel designed to use trawl nets in order to catch large volumes of fish.

4.5.1 Outrigger trawlers

Outrigger trawlers use outriggers to tow the trawl. These are commonly used to catch shrimp. One or two otter trawls can be towed from each side. Beam trawlers, employed in the North sea for catching flatfish, are another form of outrigger trawler. Medium-sized and high powered vessels, these tow a beam trawl on each side at speeds up to 8 knots.

4.5.2 Beam trawlers

These trawlers use sturdy outrigger booms for towing a beam trawl, one warp on each side. Double-rig beam trawlers can tow a separate trawl on each side of the trawler. Beam trawling is used in the flatfish and shrimp fisheries in the North Sea. They are medium-sized and high powered vessels, towing gear at speeds up to 8 knots. To avoid the boat capsizing if the trawl snags on the sea floor, winch brakes can be installed, along with safety release systems in the boom stays. The engine power of bottom trawlers is also restricted to 2000 HP (1472 KW) for further safety.

4.5.3 Otter trawlers

Otter trawlers deploy one or more parallel trawls kept apart horizontally using otter boards. These trawls can be towed in midwater or along the bottom.

4.5.4 Pair trawlers

These are trawlers which operate together towing a single trawl. They keep the trawl open horizontally by keeping their distance when towing. Otter boards are not used. Pair trawlers operate both midwater and bottom trawls.

4.5.5 Side trawlers

Side trawlers have the trawl set over the side with the trawl warps passing through blocks which hang from two gallows, one forward and one aft. Until the late sixties, side trawlers were the most familiar vessel in the North Atlantic deep sea fisheries. They evolved over a longer period than other trawler types, but are now being replaced by stern trawlers.

4.5.6 Stern trawlers

They have trawls which are deployed and retrieved from the stern. Larger stern trawlers often have a ramp, though pelagic and small stern trawlers are often designed without a ramp. Stern trawlers are designed to operate in most weather conditions. They can work alone when midwater or bottom trawling, or two can work together as pair trawlers.

4.5.7 Freezer trawlers

The majority of trawlers operating on high sea waters are freezer trawlers. They have facilities for preserving fish by freezing, allowing them to stay at sea for extended periods of time. They are medium to large size trawlers, with the same general arrangement as stern or side trawlers.

4.5.8 Wet fish trawlers

Wet fish trawlers are trawlers where the fish is kept in the hold in a fresh/wet condition. They must operate in areas not far distant from their landing place, and the fishing time of such vessels is limited.

Freezer Trawler

Otter Trawler

4.6 Whalers

A whaler or whaling ship is a specialized ship, designed, or adapted, for whaling: the catching or processing of whales. The former includes the whale catcher – a steam or diesel-driven vessel with a harpoon gun mounted at its bow. The latter includes such vessels as the sail or steam-driven whaleship of the 16th to early 20th centuries and the floating factory or factory ship of the modern era. There have also been vessels which combined the two activities, such as the bottlenose whalers of the late 19th and early 20th century, and catcher/factory ships of the modern era. Most whale catchers are employed in the Antarctica Whaling Expeditions, the name given to the annual voyage of whale fleets to the far southern waters. Most of these ships are owned by Russia and Japan.

Whale catcher, also called whale killer or whaler, large, fast steamship or motor vessel from which whales are harpooned and killed and marked for pickup by a parent vessel called a factory ship. Whale catchers are the descendants of the early whaleboats that were carried aboard a whaler and sent out to stalk and kill the whale. Early whaleboats were oar-driven and manned by a small crew. Modern whale catchers range in length from 60 feet (18 metres) to the 200-ft ships that are used in the Antarctic.Whales are located with the aid of aircraft and are killed with harpoons. After the whale has been harpooned, its carcass is filled with air to keep it afloat, marked for identification, and set adrift. The catcher then radios the location of the catch to the factory ship and goes on to another kill; a tugboatfetches the whale to the factory ship.

Whaleships had two or more whaleboats, open rowing boats used in the capture of whales. Whaleboats brought the captured whales to the whaleships to be flensed or cut up. Here the blubber was rendered into oil using two or three try-pots set in a brick furnace called the tryworks.At first, whale catchers either brought the whales they killed to a whaling station, or factory ship anchored in a sheltered bay or inlet. With the later development of the slipway at the ship's stern, whale catchers were able to transfer their catch to factory ships operating in the open sea.

4.6.1 In Wartime

The crews of whaling vessels fought small skirmishes for the control of the Spitsbergen whale fishery between 1613 and 1638.

In the late 18th and early 19th century, the owners of whalers frequently armed their vessels with cannons to enable the vessels to protect themselves against pirates, and in wartime, privateers. Weapons were also carried on vessels visiting Pacific islands for food, water, and wood in order to defend themselves from the sometimes hostile natives. At the outbreak of the French Revolutionary Wars in 1793, British privateers captured several French whalers, among them Necker and Deux Amis, and Anne. Dutch privateers captured Port de Paix and Penn. At the time, many French whalers transferred to the American flag,[citation needed] the United States being neutral in the Anglo-French war.

Some whaleships also carried letters of marque that authorized them to take enemy vessels should the opportunity arise. In July 1793 the British armed whaleship Liverpool, of 20 guns, captured the French whaleship Chardon. However, Chardon's crew succeeded in retaking their vessel.

4.6.2 Modern era

Since the 1982 moratorium on commercial whaling, few countries still operate whalers, with Norway, Iceland, and Japan among those still operating them. Of those, the Nisshin Maru of Japan's Institute of Cetacean Research (ICR) is the only whaling factory ship in operation.

As compared to whaling before and during the 19th century, which was executed with handheld harpoons thrown from oar-powered whaleboats(depicted most famously in Herman Melville's Moby Dick), whaling since the 1900s is quite different. Whale oil, which fossil-fuel based alternatives has supplanted, is no longer the primary commercial product of whaling. Whaling is now done for whale meat for the relatively small culinary market. (Norwegian whalers account for about 20% of whales caught and Japanese whalers for about 60%.) Harpoon cannons, fired from harpoon ships with displacement in the hundreds of tons, are now universally used for commercial whaling operations. These motorized ships are able to keep up with the sleeker and fast-swimming rorquals such as the fin whale, that would have been impossible for the muscle-powered rowboats to chase, and allow whaling to be done more safely for the crews.

The use of grenade-tipped harpoons has greatly improved the effectiveness of whaling, allowing whales to be killed often instantaneously as compared to the previous method in which whales bled to death, which took a long time and left the whale to thrash around in its death throes. These harpoons inject air into the carcass to keep the heavier rorqual whales hunted today from sinking. However, the harpoon-cannon is still criticized for its cruelty as not all whales are killed instantly; death can take from minutes to an hour.

Japan is currently the only country that engages in whaling in the Antarctic, which is now under the protection of the International Whaling Commission as the Southern Ocean Whale Sanctuary. The area formerly saw large scale commercial whaling operations by numerous countries before the moratorium. The three Japanese harpoon ships of the ICR serve a factory ship that processes the catch on board and preserves it on site in refrigerators, allowing the long endurance whaling missions. These whaling operations, which are claimed by Japan to be for research purposes, sell the meat from these operations on the market, allowed under the current moratorium to defer research costs. They are highly controversial, and are challenged by anti-whaling parties as being merely a disguise for commercial whaling.
The Sea Shepherd Conservation Society has clashed with the Japanese whalers in the Antarctic in confrontations that have led to international media attention and diplomatic incidents.

Whaler ship bow

4.7 Seiners

4.7.1 Purse seines

Purse seines are used in the open ocean to target dense schools of single-species pelagic (midwater) fish like tuna and mackerel. A vertical net ‘curtain’ is used to surround the school of fish, the bottom of which is then drawn together to enclose the fish, rather like tightening the cords of a drawstring purse. MSC certified fisheries using purse seines must ensure that they leave enough fish in the ocean to reproduce. This can be achieved by targeting schools of adult fish and using a mesh size large enough to allow smaller fish to swim free. Purse seines can also be used to catch fish congregating around fish aggregating devices (FADs). This fishing method can result in higher levels of bycatch, making it harder for these fisheries to achieve MSC certification.

4.7.2 Indian seines

Indian seines were made from wild grasses or fiber from spruce roots. The bottom line of the net's webbing had stones to weight the net, and cedar sticks served to float the top line. The movement of the cedar sticks caused by agitated fish helped keep the salmon from escaping. Seines were fished on smooth bottoms where salmon congregated. Haul seines also caught other fish, and new settlers in the region picked up the technique.

4.7.3 American seiners

American seiners have their bridge and accommodation placed forward with the working deck aft. American seiners are most common on both coasts of North America and in other areas of Oceania. The net is stowed at the stern and is set over the stern. The power block is usually attached to a boom from a mast located behind the superstructure. American seiners use Triplerollers. A purse line winch is located amidships near the hauling station, near the side where the rings are taken on board.

4.7.4 European seiners

European seiners have their bridge and accommodation located more to the after part of the vessel with the working deck amidships. European seiners are most common in waters fished by European nations. The net is stowed in a net bin at the stern, and is set over the stern from this position. The pursing winch is normally positioned at the forward part of the working deck.

4.7.5 Drum seiners

Drum seiners have the same layout as American seiners except a drum is mounted on the stern and used instead of the power block. They are mainly used in Canada and USA.

4.7.6 Tuna seiners

Tuna purse seiners are large purse seiners, normally over 45 metres, equipped to handle large and heavy purse seines for tuna. They have the same general arrangement as the American seiner, with the bridge and accommodation placed forward. A crows nest or tuna tower is positioned at the top of the mast, outfitted with the control and manoeuvre devices. A very heavy boom which carries the power block is fitted at the mast. They often carry a helicopter to search for tuna schools. On the deck are three drum purse seine winches and a power block, with other specific winches to handle the heavy boom and net. They are usually equipped with a skiff.

4.7.7 Seine netters

The basic types of seine netters are the anchor seiners and Scottish seiner in northern Europe and the Asian seiners in Asia.

4.7.8 Anchor seiners

Anchor seiners have the wheelhouse and accommodation aft and the working deck amidships, thus resembling side trawlers. The seine net is stored and shot from the stern, and they may carry a power block. Anchor seiners have the coiler and winch mounted transversally amidships.

4.7.9 Scottish seiners

They are basically configured the same as anchor seiners. The only difference is that, whereas the anchor seiner has the coiler and winch mounted transversally amidships, the Scottish seiner has them mounted transversally in the forward part of the vessel.

4.7.10 Asian seiners

In Asia, the seine netter usually has the wheelhouse forward and the working deck aft, in the manner of a stern trawler. However, in regions where the fishing effort is a labour-intensive, low-technology approach, they are often undecked and may be powered by outboards motors, or even by sail.

Seiner

4.8 Longline Fisheries

As the name suggests, longline fisheries trail a long line, or main line, behind a boat.

Baited hooks are attached to the nets at intervals to attract the target species. Longlines can be set for pelagic (midwater) or demersal (bottom) fishing, depending on the target species. Without careful management, longline fisheries can have unintended interactions with non-target fish, seabirds, and other marine life. Because of this, to become MSC certified, they are often required to make improvements to their monitoring programs, and to mitigate interactions with non-target species.MSC certified longline operations, such as those fishing for Patagonian toothfish in the Southern Ocean, have employed measures such as weighted long lines that sink more quickly, and tori-lines that scare away seabirds. Some have even made changes to fishing times to avoid interaction with endangered, threatened and protected (ETP) species.

4.8.1 Pelagic Longlines

Drifting pelagic longline is used worldwide to catch widely distributed pelagic and semi-pelagic fish. This gear is very effective in catching tunas, billfish and sharks, among others (Doumenge, 1998; Matsuda, 1998). It consists of a main line or "mother" line, suspended in the water by secondary lines called float lines, which carry the floats. The branch lines hang from the main line and carry hooks on the ends. The characteristics of the materials, dimensions, types of floats and hooks, as well as the configuration of the lines are quite variable, depending mainly on the origin of the fleets, the fishermen and the target species. Drifting longline is used by a large number of countries throughout the Atlantic Ocean and Mediterranean Sea, on vessels up to approximately 60 meters in length, to catch mainly tunas and swordfish and, to a lesser extent, sharks and other pelagic fish. The expansion of this fishery occurred in the late 1950s, when the oriental fleets, especially the Japanese fleet, started to operate in the Atlantic and Pacific Oceans (Pintos Paiva, 1961a; Suda, 1971; Honma, 1973). Since then, longline has continued to evolve and integrate new technologies and today this fishing gear is used by modern and efficient fleets, with large fishing power.

4.8.2 Fishing with longline

Normally, deep longline fishing uses a considerable number of hooks, which is why the fishing operation lasts more than 20 hours and requires a larger number of crew members than surface longline. The vessel characteristics, the number of crew members and mechanization has permitted reaching speeds of up to 12 knots during the setting, and in some cases exceeding 3,000 hooks in each set. The haul back is carried out on the starboard side of the vessel and the operation requires numerous crew members, since the processing on board of the catch and equipment repairs require considerable manpower. Choo (1976) described the fishing operation of the Korean flag fishing vessel Taechang 2, which operated in the Atlantic in 1975. Although this vessel´s fishing operation was mechanized, the retrieval of the branch lines was done manually. Thus, the duration of the setting and haul was approximately a full day, setting between 1,500 and 2,900 hooks.

4.8.3 Settings

The setting is performed at a speed between 10 and 12 knots. The times when this work is done vary depending on the fishing areas, the target species, and weather and oceanographic conditions. The number of hooks ranges between approximately 2,000 and 3,500 and the number between floats goes from 4 to 18. A minimum of five crew members should work on the set. One member of the crew deploys the branch lines in the area where they are baited, while another puts the bait on the hook. This work is done on the stern of the vessel and a conveyor belt is usually used, where the baiting takes place. This conveyor belt transports the baited branch line to the set area. A third crew member casts the hooks and positions the snap on the main line. In many cases, a hook casting machine is used. A fourth member of the crew deploys the floats and one or two more prepare and bring the floats and baited hooks close to the set area (López et al. 1979). A variety of baits are used, often in the same section, alternating between squid, mackerel and other small pelagic fishes.

4.8.4 Description of Deep Longline Vessel

In general, the deep longline vessels that operate in the Atlantic are 40 to 60 meters in length, while some can be as long as 100 meters with 300-500 GRT. They are not very high and most of the work areas are sheltered so that the crew can work safely when the sea conditions are rough and the crew is on the bow part of the vessel. The crew on board is comprised of some 20-25 persons. In the case of the Japanese fleet, more than 70% of the crew is comprised of foreigners, mostly from Indonesia and the Philippines. In other fleets, such as those of Chinese Taipei and Korea, the percentage of foreign crew members is lower.

4.9 Influence of the environment on the fishing operations

As in the case of any fishery, various environmental factors affect the longline fishing operations and the catch yields and may even determine the possibility of carrying out these operations. These factors are considered by the vessel master in deciding how and where best to carry out the fishing operations, striving to maximize the catch yields, while maintaining the safety of the crew and the vessel and seeking to avoid or minimize the loss of the fishing equipment. In regard to the yield of the fishing operations, some environmental factors directly affect the possibility of catching the target species and there are others factors that can affect the quantity and quality (and therefore the economic value) of the catch retained. The sea temperature partially determines the availability of the different species. The majority of the target species of the pelagic longline fisheries are characterized by having a wide range of tolerance to sea temperature, even when they have preferences and very dynamic behavior. Thus, in some cases, depending on the environmental conditions, different longline configurations are used to catch the same species.

Given that the target species are highly migratory and often show segregation by size classes, in many areas where the longline fisheries operate, their abundance and yields do not remain constant throughout the different seasons. As a result, the fleets respond to the spatial-temporal dynamics that are characteristic of each region, according to the target species of their fishing effort. In some cases, the target species undertake diel vertical migrations and therefore the probability of catching these species with longline at a given depth would vary depending on the time of day. Because of this, in some areas deep pelagic longline is not used during the day and surface longline is not used at night. Although it has been determined that the lunar phase affects the vertical behavior of some species, this effect does not apply in the same manner to all individuals.

The characteristics of the water masses, including sea surface temperature, the concentration of chlorophyll, the speed of the current, the altimetry, and the depth of the thermocline are used by the vessel masters to choose the fishing areas and decide how to configure and set the longline. For this, the vessel masters use information obtained by remote sensors and received on board the vessel from various communication and information systems, as well as data obtained from the vessel itself from thermometers, depth and temperature sensors, disposable bathythermographs, timer devices, and Doppler current meters, among others.

The presence of temperature fronts, upwellings and geographic features such as seamounts and, in some cases, the continental slope itself, are variables that also affect the local abundance of various target species of the pelagic longline fisheries.

Another environmental factor that can affect pelagic longline fishing operations is the predation of the catch by some odontocete cetaceans and sharks. The damage that they cause by eating the fish that have been caught by the longline can result in highly substantial economic losses, since the damaged fish have a much lower market value and in some cases the damage is so substantial that the fish caught have no value at all. At times, different methods are used (acoustic deterrent devices and evasive maneuvers) to reduce this problem and to be able to continue the operation. However, in extreme situations, the economic evaluation of this predation made by the vessel masters causes them to change the fishing area.

At the operational level, the wind and the resulting waves can restrict the vessel master´s options with regard to the direction of setting and hauling of the longline. This affects the smaller vessels more, as they are more susceptible to the intensity of the wind and the waves during the haul back of the longline. The currents can cause difficulties, since in some cases they cause the gear to shift several miles during the inactive period, resulting in complications if working close to a jurisdictional limit (EEZ, MPA), or even causing tangling and/or breakage of the longline. At times, sections of the longline that have become detached move several miles away, resulting in delays of several hours in the fishing operation.

5. Cable Ships

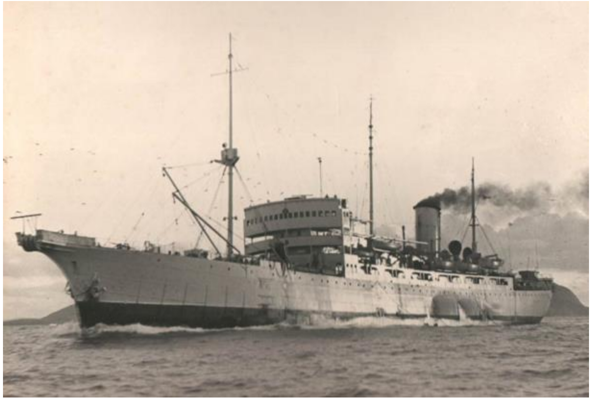
A cable layer or cable ship is a deep-sea vessel designed and used to lay underwater cables for telecommunications, electric power transmission, or other purposes Since, in today’s times, underwater cable connectivity has become more relevant and useful, the importance and relevance of a Cable Laying Ship has also increased manifold. Cable ships are distinguished by large cable sheaves for guiding cable over bow or stern or both. Bow sheaves, some very large, were characteristic of all cable ships in the past, but newer ships are tending toward having stern sheaves only.

The first transatlantic telegraph cable was laid by cable layers in 1857–58. It briefly enabled telecommunication between Europe and North America before misuse resulted in failure of the line. In 1866 the SS Great Eastern successfully laid two transatlantic cables, securing future communication between the continents.

5.1 Historical Cable Ships

5.1.1 The Monarch

The Monarch was the first ship to be permanently fitted out as a cable ship and operated on a full-time basis by a cable company The cable laying equipment of Monarch was a major step forward compared to the unspecialised ships that had previously been used for cable laying, with sheaves to run the cable out of the hold and a powerful dedicated brake to control the cable running out.



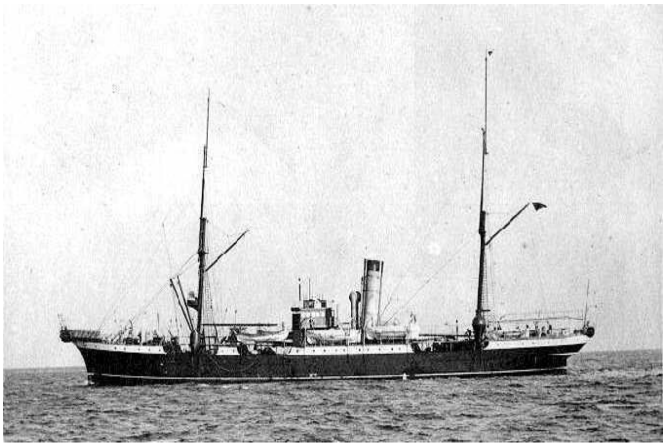
5.1.2 SS Great Eastern

SS Great Eastern was an iron sailing steamship. She was by far the largest ship ever built at the time of her 1858 launch, and had the capacity to carry 4,000 passengers from England to Australia without refuelling. Her length of 211 m was only surpassed in 1899 by the 215 m RMS Oceanic. The ship's five funnels were rare. These were later reduced to four.
Shortly after her ill-fated maiden voyage, during which she was damaged by an explosion , she plied for several years as a passenger liner between Britain and North America before being converted to a cable-laying ship and laying the first lasting transatlantic telegraph cable in 1866. The conversion work for Great Eastern's new role consisted in the removal of funnel no. 4 and some boilers as well as great parts of the passenger rooms and saloons to give way for open top tanks for taking up the coiled cable. She laid 4,200 kilometres (2,600 mi) of the 1865 transatlantic telegraph cable. From 1866 to 1878 the ship laid over 48,000 kilometres (30,000 mi) of submarine telegraph cable including from Brest, France to Saint Pierre and Miquelon in 1869, and from Aden to Bombay in 1869 and 1870
Finishing her life as a floating music hall , she was broken up on Merseyside in 1889.

SS Great Eastern

5.1.3a CS Mackay-Bennett

CS Mackay-Bennett was a cable repair ship registered in London, England. The ship is remembered for being the ship that recovered the majority of the bodies of the victims of the



Titanic sinking. One of the first ships built from steel, she had a relatively deep keel design to: accommodate as much cable as possible; keep the ship stable in the Atlantic Ocean swells; and yet a design which was also very hydrodynamic to keep her fuel efficient and fast in operation. The hull design included bilge keels to keep her stable, and she had two rudders, one fore and one aft, to maximize maneuverability

5.1.3b Recovery of bodies from wreck of RMS Titanic

In April 1912, whilst working on maintaining the France-to-Canada communications cable, the ship became famous as the first vessel contracted by the White Star Line to carry out the difficult task of recovering the bodies left floating in the North Atlantic, after the Titanic disaster.After a seven-day recovery operation, the CS Mackay-Bennett had recovered 306 of the 328 bodies found from among the 1,517 who perished aboard Titanic, she buried 116 at sea, of which only 56 were identified and she set sail for home with 190 bodies on board, almost twice as many as there were coffins available.

5.2 Modern cable ships

A Cable Laying Ship is created specifically to cater to the purpose of laying cable lines underwater. But at the same time since cable laying work does not take place round-the-clock and throughout the year, a Cable Laying Ship is also additionally used as research ships to monitor various happenings in the oceanic and sea waters. Because laying an underwater cable line is so different but practical in the contemporary world, the work and the purpose of a Cable Laying Ship becomes very helpful to the world. A Cable Laying Ship is built with every modern gadget required to make the process of laying the intricate lines of cable on the oceanic floor simpler. It is enabled with Dynamic Positioning and Dynamic Tracking systems which pinpoint the exact location of the ship in the mid-ocean and lay the underwater cable lines appropriately.

The torso of a Cable Laying Ship is huge because of the nature of the work it undertakes. Most of the cable laying ships have a tonnage of over 11000 tons and are capable of laying not just one line of underwater communicative cable lines but two-three lines in addition. And because it is so bulky in its torso, a cable laying ship cannot be used for operations in shoals or shallow waters where there is a chance of land merging with the waters because the shallowness of the water tends to curtail and hamper the movement of the cable laying ship. To ensure that cable is laid and retrieved properly, specially designed equipment must be used. Different equipment is used on cable-laying ships depending on what their job requires. In order to retrieve damaged or mislaid cable, a grapple system is used to gather cable from the ocean floor.

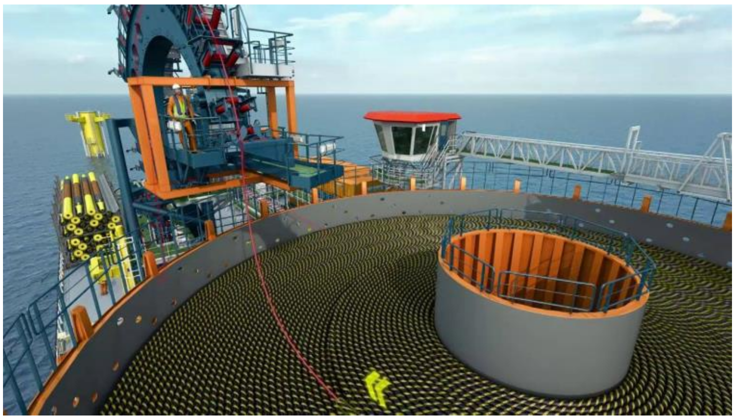
There are several types of grapples, each with certain advantages or disadvantages. These grapples are attached to the vessel via a grapple rope, originally a mix of steel and manila lines, but now made from synthetic materials. This ensures that the line is strong, yet can flex and strain under the weight of the grapple. The line is pulled up by reversing the Linear Cable Engine used to lay the cable.

The size specification of a Cable Laying Ship depends on the depth of the ocean floor where it is required to be positioning the cable lines. If the depth of the ocean bed or floor is more, then the size of the ship is bigger and huger, whereas if the depth of the ocean bed or floor is not much, then the Cable Laying Ship's size tends to be smaller. However, it has to be noted that whether smaller or huger, the size of a cable laying ship many times bigger than that of a normal ship because of the extensive nature of the ship's purpose.

5.3 Cable Ship equipment

Cable laying ships have all the facilities that any other type of ship has. Apart from that , the cable laying machine pulls the cables out of the holding chambers with the help of a deployment equipment.

The cable laying machine consists of a drum suspended from a crane which rolls the cable around it and lays it on the sea floor with the help of slots made in the ship's astern. The drum operation system can be pneumatic or hydraulic depending on the size and weight of the cables.



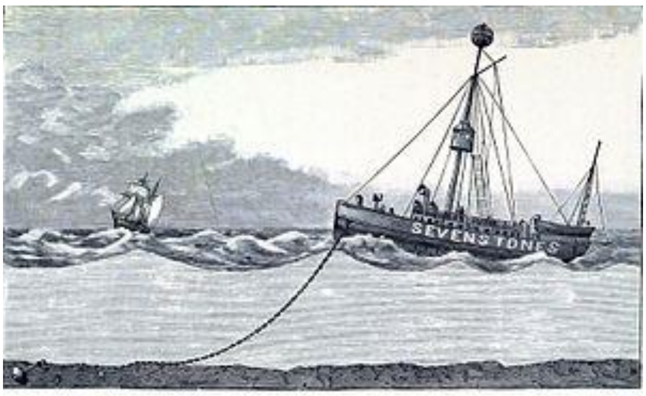
When the cables reach the ocean floor, they are buried in the sea bed with the help of a trenching system. This method is used for cable laying at greater depths. In case of shallow waters, directional drilling method is used.

6. Light Vessel

A light ship is a vessel that operates basically as a surrogate lighthouse tower to assist ships in navigation. Although lightships still exist contemporarily, their viability was huger in those times when marine construction and architecture wasn't as developed and advanced, as it is today. They are used in waters that are too deep or otherwise unsuitable for lighthouse construction. Although some records exist of fire beacons being placed on ships in Roman times, the first modern lightvessel in England, placed there in 1734.

6.1 History of Light Vessels

The earliest recorded operational date of the light vessel is said to be in 1734 in the Thames River in England**.** By the next century, the concept and the idea had moved further west and very soon, such vessels were started be operated by the United States of America. Contemporarily, the concept of a light ship is quite synonymous with the USA, as further technological advancements were made to the original light vessel concept in the country.

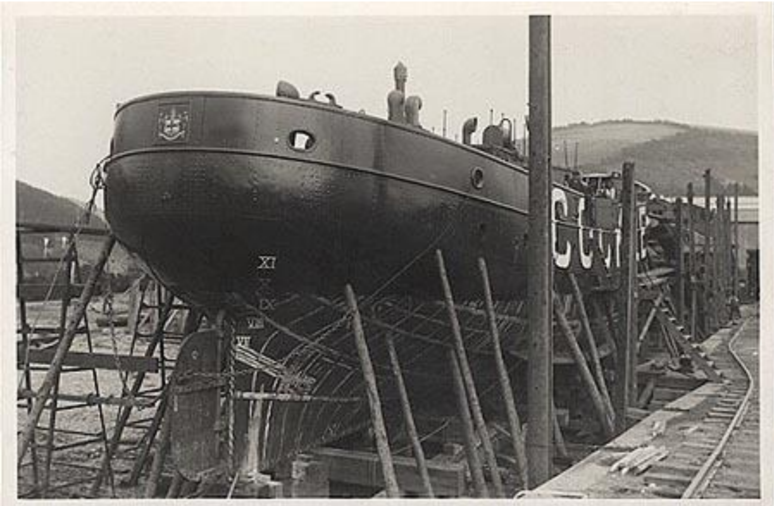


SEVENSTONES LIGHTSHIP, SHOWING MOORINGS.

The type has become largely obsolete; lighthouses replaced some stations as the construction techniques for lighthouses advanced, while large, automated buoys replaced others. Today not many of these mobile-yet-stationary lighthouses exist and even if some do, they are looked as a novelty yet important value addition to the maritime community across the world.

6.2 Construction

A crucial element of lightvessel design is the mounting of a light on a sufficiently tall mast. Initially, this consisted of oil lamps that could be run up the mast and lowered for servicing. Later vessels carried fixed lamps, which were serviced in place. Fresnel lenses were used as they became available, and many vessels housed these in small versions of the lanterns used on lighthouses. Some lightships had two masts, the second holding a reserve beacon in case the main light failed. Initially, the hulls were constructed of wood, with lines like those of any other small merchant ship. This proved to be unsatisfactory for a ship that was permanently anchored, and the shape of the hull evolved to reduce rolling and pounding. As iron and steel were used in other ships, so were they used in lightvessels, and the advent of steam and diesel power led to self-propelled and electrically lighted designs. Earlier vessels had to be towed to and from station.

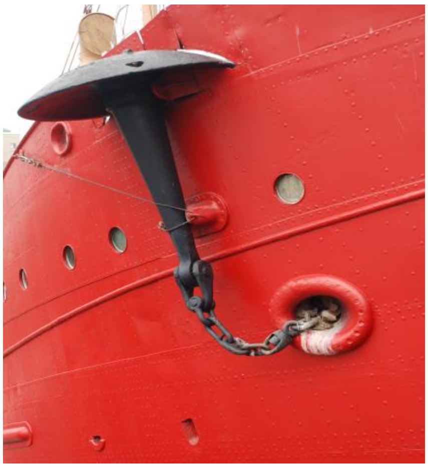


Lightship under construction

Much of the rest of the ship was taken up by storage and crew accommodations. The primary duty of the crew was, of course, to maintain the light, but they also kept record of passing ships, observed the weather, and on occasion performed rescues.In the early 20th century, some lightships were fitted with warning bells, either mounted on the structure or lowered into the water, the purpose of which was to warn of danger in poor visibility and to permit crude estimation of the lightship relative to the approaching vessel.

6.3 Mooring

Holding the vessel in position was an important aspect of lightvessel engineering. Early lightships used fluke anchors, which are still in use on many contemporary vessels. These were not very satisfactory, since a lightship has to remain stationary in very rough seas which other vessels can avoid, and these anchors are prone to dragging. Since the early 19th century, lightships have used mushroom anchors, named for their shape, which typically weigh 3-4 tons. The effectiveness of these anchors improved dramatically in the 1820s, when cast iron anchor chains were introduced.



Mushroom anchor on a lightship

7. Training Ship

A training ship is a ship used to train students as sailors. The term is especially used for ships employed by navies to train future officers. Essentially there are two types: those used for training at sea and old hulks used to house classrooms. The hands-on aspect provided by sail training has also been used as a platform for everything from semesters at sea for undergraduate oceanography and biology students, marine science and physical science for high school students, and character building for at-risk youths. Training ships vary in type and specifications. Some of the most notable trainings ships are :

7.1 Statsraad Lehmkuhl

Statsraad Lehmkuhl is a three-masted barque rigged sail training vessel. Her length-over-all is 98,00 m, her breadth is 12,60 m and a max. height of 48,00 m . It is based in Bergen, Norway and contracted out for various purposes, including serving as a school ship for the Royal Norwegian Navy

It was built in 1914 as a school training ship for the German merchant . After the First World War the ship was taken as a prize by the United Kingdom and in 1921 the ship was bought by Norway . In 2000, she was chartered by the German Navy. The three sister ships of Statsraad Lehmkuhl also survive

7.2 Stavros S Niarchos

Stavros S Niarchos is a British brig-rigged tall ship, 59.4 m long with a breadth of 9.9m , she normally sails with a crew of up to 67 people. The crew consists of 6 permanent crew, 13 volunteer crew and up to 48 voyage crew. She was primarily designed to provide young people with the opportunity to undertake voyages as character-building exercises, rather than pure sail-training.

In January 2006 Stavros S Niarchos rescued the two women crew from a vessel taking part in a race. The rescue was made in heavy weather.

7.3 Pamir

Launched on 29 July 1905. She had a steel hull and tonnage of 3,020 GRT (2,777 net). She had an overall length of 114.5 m (375 ft), a beam of about 14 m (46 ft) and a draught of 7.25 m (23.5 ft). Three masts stood 51.2 m (168 ft) above deck and the main yard was 28 m (92 ft) wide. She carried 3,800 m² (40,900 ft²) of sails and could reach a top speed of 16 knots (30 km/h). Her regular cruise speed was around 8-9 knots.

On 10 August 1957, she left Buenos Aires for Hamburg with a crew of 86, including 52 cadets. Unfortunately the morning of 21 September 1957 and in the middle of the Atlantic, 600 nautical miles (1,100 km) west-southwest of the Azores at position 35°57′N 40°20′W, Pamir capsized and only 4 crewmen and 2 cadets survived

8. Pleasure Crafts

A Pleasure Craft (or pleasure boat) is a boat used for personal, family, and sometimes sportsmanlike recreation. Such watercraft are divided into two main categories: motorboats and sailboats. There are also rowboats and canoes. They are used for holidays, for example on a river, lake, canal, waterway, in an archipelago or coastal area. Pleasure craft are normally kept at a marina. They may include accommodation for use while moored to the bank.

In Great Britain, many narrowboats were converted into pleasure craft from their previous use for cargo transport on canals, and today the same hull style is commonly used for new pleasure craft using the canal system.
There are two main categories:

8.1 Motorboats

A motorboat, speedboat, or powerboat is a boat which is powered by an engine. Some motorboats are fitted with inboard engines, others have an outboard motor installed on the rear, containing the internal combustion engine, the gearbox and the propeller in one portable unit.

An inboard-outboard contains a hybrid of an inboard and an outboard, where the internal combustion engine is installed inside the boat, and the gearbox and propeller are outside.

There are two configurations of an inboard, V-drive and direct drive. A direct drive has the powerplant mounted near the middle of the boat with the propeller shaft straight out the back, where a V-drive has the powerplant mounted in the back of the boat facing backwards having the shaft go towards the front of the boat then making a V towards the rear. The V-drive has become increasingly popular due to wakeboarding and wakesurfing.

8.1.1 Invention

Although the screw propeller had been added to an engine (steam engine) as early as the 18th century in Birmingham, England, by James Watt, boats powered by a petrol engine only came about in the later part of the 19th century with the invention of the internal combustion engine.

The earliest boat to be powered by a petrol engine was tested on the Neckar River by Gottlieb Daimler and Wilhelm Maybach in 1886, when they tested their new "longcase clock" engine. It had been constructed in the former greenhouse (converted into a workshop) in Daimler's back yard. The first public display took place on the Waldsee in Cannstatt, today a suburb of Stuttgart, at the end of that year. The engine of this boat had a single cylinder of 1 horse power. Daimler's second launch in 1887 had a second cylinder positioned at an angle of 15 degrees to the first one, and was known as the "V-type".

The first successful motor boat was designed by the Priestman Brothers in Hull, England, under the direction of William Dent Priestman. The company began trials of their first motorboat in 1888. The engine was powered with kerosene and used an innovative high-tension (high voltage) ignition system. The company was the first to begin large scale production of the motor boat, and by 1890, Priestman's boats were successfully being used for towing goods along canals. Another early pioneer was Mr. J. D. Roots, who in 1891 fitted a launch with an internal combustion engine and operated a ferry service between Richmond and Wandsworth along the River Thames during the seasons of 1891 and 1892.

The eminent inventor Frederick William Lanchester recognized the potential of the motorboat and over the following 15 years, in collaboration with his brother George, perfected the modern motorboat, or powerboat. Working in the garden of their home in Olton, Warwickshire, they designed and built a river flat-bottomed launch with an advanced high-revving engine that drove via a stern paddle wheel in 1893. In 1897, he produced a second engine similar in design to his previous one but running on benzene at 800 r.p.m. The engine drove a reversible propeller. An important part of his new engine was the revolutionary carburettor, for mixing the fuel and air correctly. His invention was known as a "wick carburetor", because fuel was drawn into a series of wicks, from where it was vaporized. He patented this invention in 1905.

The Daimler Company began production of motor boats in 1897 from its manufacturing base in Coventry. The engines had two cylinders and the explosive charge of petroleum and air was ignited by compression into a heated platinum tube. The engine gave about six horse-power. The petrol was fed by air pressure to a large surface carburettor and also an auxiliary tank which supplied the burners for heating the ignition tubes. Reversal of the propeller was effected by means of two bevel friction wheels which engaged with two larger bevel friction wheels, the intermediate shaft being temporarily disconnected for this purpose. It was not until 1901 that a safer apparatus for igniting the fuel with an electric spark was used in motor boats.

Motoboat has one engine or more that propel the vessel over the top of the water. Boat engines vary in shape, size and type. Engines are installed either inboard or outboard. Inboard engines are part of the boat construction, while outboatboard engines are secured to the transom and hangs off the back of the boat. Motorboat engines run on gasoline or diesel and fuel. Engines come in various types. Engines vary in fuel type such as: gasoline, diesel, gas turbine, rotary combustion or steam. Motorboats are commonly used for recreation, sport or racing. Boat racing is a sport where drivers and engineers compete for fastest boat. The American Powerboat Association (APBA) splits the sport into categories. The categories include: inboard, inboard endurance, professional outboard, stock outboard, unlimited outboard performance craft, drag, modified outboard and offshore. Engines and hulls categorize racing. The two types of hull shape are runabout and hydroplane. Runabout is a v-shape and hydroplane is flat and stepped. The type of hull used depends on the type of water the boat is in and how the boat is being used. Hulls can be made of wood, fiberglass or metal but most hulls today are fiberglass.

High performance speedboats can reach speeds of over 50 knots. Their high speed and performance can be attributed to their hull technology and powerful engine. With a more powerful and heavier engine, an appropriate hull shape is needed. High performance boats include yachts, HSIC (high speed interceptor craft) and racing powerboats.

A V-type hull helps a boat cut through the water. A deep V-hull helps keep the boat’s bow down at low speeds, improving visibility. V-hulls also improve a boat’s speed and maneuvering capabilities. They stabilize a boat in rough conditions

8.2 Sailboats

A sailboat or sailing boat is a boat propelled partly or entirely by sails smaller than a sailing ship. Distinctions in what constitutes a sailing boat and ship vary by region and maritime culture.

The following is a partial list of sailboat types and sailing classes, including

.1 Keelboats

.2 Dinghies

.3 Multihull

8.2.1a Keelboats

A keelboat is a riverine cargo-capable working boat, or a small- to mid-sized recreational sailing yacht. The boats in the first category have shallow structural keels, and are nearly flat-bottomed and often used leeboards if forced in open water, while modern recreational keelboats have prominent fixed fin keels, and considerable draft. The two terms may draw from cognate words with different final meaning.

8.2.1b Modern Keelboats

A keelboat is technically any sailboat with a keel—as opposed to a centerboard or daggerboard. In New Zealand the term keeler is frequently used as a generic alternative - meaning any sailboat with a keel, regardless of size.

ISAF (International Sailing Federation) usage differentiates keelboats (including the 12-meter class) from generally larger yachts, despite overlap in the sizes of boats in the two classes. The Olympic Games uses keelboat to describe keeled boats with up to a three-man crew, as opposed to larger-crewed boats such as the 12-metre class.

In some countries yachts can also be differentiated from keelboats with the addition of a toilet or "head" as the term "keelboat" is in some places understood to mean a sailboat with a keel that is designed purely for recreational/racing purposes, while the term "yacht" describes a sailboat designed for overnight transport.

8.2.2 Dinghy

A dinghy (or dingey) is a type of small boat, often carried or towed for use as a lifeboat or tender by a larger vessel. The term is a loanword from the Bengali ḍiṅgi, Urdu ḍīngī & Hindi ḍieṁgī. Utility dinghies are usually rowboats or have an outboard motor, but while some are rigged for sailing, they are not to be confused with sailing dinghies which are designed first and foremost for sailing. Dinghies' main use is transfers from larger boats, especially when the larger boat can't dock at a suitably-sized port or marina. Dinghies usually range in length from about 2 to 6 m (6 to 20 ft). Larger auxiliary vessels are generally called tenders, pinnaces or lifeboats. Folding and take-down multi-piece (nesting) dinghies are used where space is limited. Some newer dinghies have much greater buoyancy, giving them more carrying capacity than older boats of the same size.

i) Whaleboats are among the classic "pulling" (rowing) boats, with a sharp bow, fine stern lines and a canoe stern. Despite being somewhat more tippy, with less cargo capacity than prams, they row, motor and sail well because of their fine lines. Prior to the introduction of fibreglass as a construction material, dories were more popular because their ease of assembly and, thereby, lower cost.

ii) Whitehall rowboats were the water taxis of the late 1800s until the invention of the small gasoline outboard. Considered one of the most refined rowboats for harbour and lake use, Whitehall rowboats are a descendant of the captain's gig which was used for a similar purpose on a naval vessel.

iii)Dories are sharp-ended boats traditionally made of wood but now also produced in fibreglass or aluminium. They cut the water well, but their initial stability is low, making them feel tippy in flat water; a loaded dory becomes more stable as it is loaded. Dories are not generally used as service boats to yachts; they were used in large numbers in the cod fishing business, launched in numbers from the deck of a schooner hove to on the Grand Banks or other fishing ground. A dory can be landed or launched through surf where a Whitehall may founder. Dories are seldom called dinghies.

iv) Prams are usually short with transoms at both bow and stern. They are difficult to tip and carry a lot of cargo or passengers for their length but are slower to row because of their short length and extreme rocker, although a skeg and/or bilge runners can make a difference, and even without they will row better than an inflatable. Popular as tenders on sail boats with limited deck space.

v) Some inflatable boats have a rigid deck and transom which allows an engine to be used for propulsion. They row poorly and do not tow well because of their blunt bows and large wetted surface area, but they are exceptionally buoyant.

vi) Rigid safety dinghies are designed to row, motor, tow, and sail. In addition to their self-rescue lifeboat functionality, these boats serve as everyday tenders and as recreational boats. They are extremely buoyant and/or unsinkable and have great carrying capacity relative to length.

8.2.3a Multihull

A multihull is a ship or boat with more than one hull, whereas a vessel with a single hull is a monohull.

Multihull ships can be classified by the number of hulls, by their arrangement and by their shapes and sizes.

8.2.3b Multihull History

The first multihull vessels were Austronesian canoes. The builders hollowed out logs to make canoes and stabilized them by attaching outriggers to prevent them from capsizing. This led in due course to the proa, catamaran, and trimaran.

In Polynesian terminology the catamaran is a pair of Vaka held together by Aka, whereas the trimaran is a central Vaka, with Ama on each side, attached by Aka. Catamarans and trimarans share the same terminology.

Ama − The ama is the outrigger hull, attached to add stability.

Aka − The aka connects the vaka to the ama. In Hawaiian, this is called the iako (crossarm).

Vaka − The vaka is the main canoe-like hull.

8.3 Multihull Types

The vast majority of multihull sailboats are :

.1 Catamarans

.2 Trimarans are less common,

and .3 *Proas* are virtually unknown outside the South Pacific.

8.3.1a Catamaran

A catamaran is a multi-hulled watercraft featuring two parallel hulls of equal size. It is a geometry-stabilized craft, deriving its stability from its wide beam, rather than from a ballasted keel as with a monohull sailboat. Catamaran is from a Tamil word, kattumaram, which means "logs tied together".

Catamarans typically have less hull volume, higher displacement, and shallower draft (draught) than monohulls of comparable length. The two hulls combined also often have a smaller hydrodynamic resistance than comparable monohulls, requiring less propulsive power from either sails or motors. The catamaran's wider stance on the water can reduce both heeling and wave-induced motion, as compared with a monohull, and can give reduced wakes.

Catamarans range in size from small (sailing or rowing vessels) to large (naval ships and car ferries). The structure connecting a catamaran's two hulls ranges from a simple frame strung with webbing to support the crew to a bridging superstructure incorporating extensive cabin and/or cargo space.

8.3.1b History of catamarans

Catamarans from Oceania and Maritime Southeast Asia became the inspiration for modern catamarans. Catamaran-type vessels were an early technology of the Austronesian peoples. Early researchers like Heine-Geldern (1932) and Hornell (1943) once believed that catamarans evolved from outrigger canoes, but modern authors specializing in Austronesian cultures like Doran (1981) and Mahdi (1988) now believe it to be the opposite.

Two canoes bound together developed directly from minimal raft technologies of two logs tied together. Over time, the double-hulled canoe form developed into the asymmetric double canoe, where one hull is smaller than the other. Eventually the smaller hull became the prototype outrigger, giving way to the single outrigger canoe, then to the reversible single outrigger canoe. Finally, the single outrigger types developed into the double outrigger canoe (or trimarans).

A drawing of an early Catamaran

This would also explain why older Austronesian populations in Island Southeast Asia, Madagascar, and the Comoros tend to favor double outrigger canoes, as it keeps the boats stable when tacking. But they still have small regions where catamarans and single-outrigger canoes are still used. In contrast, more distant outlying descendant populations in Micronesia and Polynesia retained the double-hull and the single outrigger canoe types, but the technology for double outriggers never reached them (although it exists in western Melanesia). To deal with the problem of the instability of the boat when the outrigger faces leeward when tacking, they instead developed the shunting technique in sailing, in conjunction with reversible single-outriggers.

Despite their being the more "primitive form" of outrigger canoes, they were nonetheless effective, allowing seafaring Polynesians to voyage to distant Pacific islands.

Catamarans were seldom constructed in the West before the 19th century, but they were in wide use as early as the 5th century by the Tamil people of Tamil Nadu, South India.

The 17th-century English adventurer and privateer William Dampier encountered the Tamil people of southeastern India during his first circumnavigation of the globe. He was the first to write in English about the watercraft he observed in use there. In his 1697 account of his trip, A New Voyage Round the World.

The acquisition of the catamaran and outrigger canoe technology by the non-Austronesian peoples in Sri Lanka and southern India is due to the result of very early Austronesian contact with the region, including the Maldives and the Laccadive Islands, estimated to have occurred around 1000 to 600 BCE and onwards.

8.3.1c Sailing

The first documented example of double-hulled craft in Europe was designed by William Petty in 1662 to sail faster, in shallower waters, in lighter wind, and with fewer crew than other vessels of the time. However, the unusual design met with skepticism and was not a commercial success.

The design remained relatively unused in the West for almost 160 years until the early 19th-century, when the Englishman Mayflower F. Crisp built a two-hulled merchant ship in Rangoon, Burma. The ship was christened Original. Crisp described it as "a fast sailing fine sea boat; she traded during the monsoon between Rangoon and the Tenasserim Provinces for several years".

Later that century, the American Nathanael Herreshoff constructed a double-hulled sailing boat of his own design (US Pat. No. 189,459). The craft, Amaryllis, raced at her maiden regatta on June 22, 1876, and performed exceedingly well. Her debut demonstrated the distinct performance advantages afforded to catamarans over the standard monohulls. It was as a result of this event, the Centennial Regatta of the New York Yacht Club, that catamarans were barred from regular sailing classes, and this remained the case until the 1970s.

On June 6, 1882, three catamarans from the Southern Yacht Club of New Orleans raced a 15nm course on Lake Pontchartrain and the winning boat in the catamaran class, Nip and Tuck, beat the fastest sloop's time by over five minutes.

In 1936 Eric de Bisschop built a Polynesian "double canoe" in Hawaii and sailed it home to a hero's welcome in France. In 1939, he published his experiences in a book, Kaimiloa, which was translated into English in 1940.

Roland and Francis Prout experimented with catamarans in 1949 and converted their 1935 boat factory in Canvey Island, Essex (England), to catamaran production in 1954. Their Shearwater catamarans easily won races against monohulls. Yellow Bird, a 1956-built Shearwater, raced successfully by Francis Prout in the 1960s, is in the collection of the National Maritime Museum Cornwall. Prout Catamarans, Ltd. designed a mast aft rig with the mast aft of midships to support an enlarged jib—more than twice the size of the design's reduced mainsail; it was produced as the Snowgoosemodel. The claimed advantage of this sail plan was to diminish any tendency for the bows of the vessel to dig in.

In the mid-twentieth century, beachcats became a widespread category of sailing catamarans, owing to their ease of launching and mass production. In California, a maker of surfboards, Hobie Alter, produced the 250-pound (110 kg) Hobie 14 in 1967, and two years later the larger and even more successful Hobie 16. As of 2016, the Hobie 16 was still being produced with more than 100,000 having been manufactured.

8.3.2a Trimaran

A trimaran (or double-outrigger) is a multihull boat that comprises a main hull and two smaller outrigger hulls (or "floats") which are attached to the main hull with lateral beams. Most trimarans are sailing yachts designed for recreation or racing; others are ferries or warships.

8.3.2b History of Trimarans

The first double-outrigger boats were developed by the Austronesian people and are still widely used today by traditional fishermen in maritime Southeast Asia and Madagascar. It developed from the more ancient single-outrigger boats as a way to deal with the problem of the instability of the latter when tacking leeward. Double-outrigger boats, however, did not develop among Austronesians in Micronesia and Polynesia (although it exists in western Melanesia), where single-outrigger boats and catamarans are used instead.

Some of the current US terminology are derived from the Polynesian terminology on outriggers, despite trimarans not being native to the region. Sailing catamarans and trimarans gained popularity during the 1960s and 1970s.

Amateur development of the modern sailing trimaran started in 1945 with the efforts of Victor Tchetchet, a Ukrainian émigré to the US, who built two trimarans made of marine plywood, which were about 24 feet (7 metres) long. He is credited with coining the term, "trimaran." In the 1950s and 60s, Arthur Piverdesigned and built plywood kit trimarans, which were adopted by other homebuilders, but were heavy and not sea-kindly by modern standards. Some of these achieved ocean crossings, nonetheless. Other designers followed, including Jim Brown, Ed Horstman, John Marples, Jay Kantola, Chris White, Norman Cross, Derek Kelsall and Richard Newick, thus bringing the trimaran cruiser to new levels of performance and safety.

Following the homebuilt movement, production models became available. Some trimarans in the 19–36-foot lengths (5.8–11.0 m) are designed as "day-sailers" which can be transported on a road trailer. These include the original Farrier – Corsair folding trimarans, such as the F-27 Sport Cruiser – and original John Westell swing-wing folding trimaran (using the same folding system later adopted also on Quorning Dragonfly) and like trimarans.

The trimaran concept has also been used for both passenger ferries and warships. For example, in 2005 the 127-metre trimaran (417 ft) Benchijigua Express was delivered by Austal to Spanish ferry operator Fred Olsen, S.A. for service in the Canary Islands. Capable of carrying 1,280 passengers and 340 cars, or equivalents, at speeds up to 40 knots, this boat was the longest aluminum ship in the world at the time of delivery. A modern warship, the RV Triton was commissioned by British defence contractor QinetiQ in 2000. In October 2005, the United States Navy commissioned for evaluation the construction of a General Dynamics LCS trimaran designed and built by Austal. The DARPA is experimenting with the trimaran design.

8.3.2c Folding trimarans

Several manufacturers build trimarans in which the floats can be removed, repositioned, or folded near to the main hull. This allows them to be trailerable and/or to fit in a normal monohull space in a marina. At least six technologies are in use:

.1 Demountable fixed tubes: Some trimarans are built demountable to allow them to be trailered to a launch site and then assembled before launching. This takes longer than a folding system but is typically lighter and less costly, and can also be used for craft with too much beam for a folding system. For example, the small modern Weta Trimaran uses tubes to connect the floats to the main hull, which are lashed in from a canvas trampoline and further held in place by the sidestays. Similarly, the original Dragonfly Trimarans (Dragonfly 600) and the home built W22 trimaran use this design.

.2 Telescopic tubes: The French company Astusboats produces a range of trimarans that use telescopic tubes to connect the floats to the main hull.

.3 Hinge and latch: The W17 trimaran uses a strong hinge and latch system that allows the amas to fold over the main hull to reduce width for trailing. Suitable for craft under 18 ft only unless waterstays are added.

.4 Vertical folding: Farrier Marine use a vertical folding mechanism, first used on the Trailertri and subsequently on most of his designs. All Farrier designed boats are known as Fboats (F22, F24, F27 etc.). Whisper also uses a vertical folding mechanism as do Corsair Marine, who use the vertical folding mechanism designed by Ian Farrier. (When Farrier resigned from the company in 2000, the "F" (for Farrier) designation was replaced with a "C" (for Corsair) designation on their trimarans.) Trimax trimarans use a folding mechanism claimed to be a further development of the Farrier design.

.5 Horizontal articulation: Dragonfly Trimarans use a nearly horizontal articulation called SwingWing. The slight angle makes the floats fold into the narrower, lower part of the central hull and also increases stability when in the folded position. A similar horizontal articulation design is also used in the Sea on 96CRB. This kind of system was first used in Ocean Bird trimarans designed by John Westell and built by Honnor Marine Ltd of Totnes.

.6 Horizontal folding: Telstar trimarans uses a unique horizontal folding design along with a simple mast raising system to facilitate trailer sailing. It can be powered easily with the amas folded in or extended.

8.3.3a Proa

A proa refers to various types of multihull outrigger sailboats of the Austronesian peoples. The terms were used for native Austronesian ships in European records during the Colonial Era indiscriminately, and thus can confusingly refer to the double-ended single-outrigger boats of Oceania, the double-outrigger boats of Island Southeast Asia, and sometimes even ships with no outriggers or sails at all.

In its most common usage, the term "proa" refers to the Pacific proas which consist of two (usually) unequal length parallel hulls. It is sailed so that one hull is kept to windward, and the other to leeward. It is double-ended, since it needs to "shunt" to reverse direction when tacking. It is most famously used for the sakmanships of the Chamorro people of the Northern Marianas, which were known as the "flying proas" for their remarkable speed.

In Island Southeast Asia, the term "proa" may also sometimes be used, but the terms perahu, prau, prahu, paraw or prow are more common. These differ from the Pacific proas in that they are not double-ended and have a trimaran configuration with two outriggers. These are widely used in the native ships of Indonesia, Malaysia, and the Philippines, and continue to be used today as traditional fishing, cargo, and transport vessels.

Proas are traditionally rigged with the crab claw and tanja sails. The modern proa exists in a wide variety of forms, from the traditional archetype still common in areas described, to high-technology interpretations specifically designed for breaking speed-sailing records.

The term "proa" originates from Early Modern English "prow" or "praw". It probably entered the English language via Dutch prauw and Portuguese parão, with influence from Spanish proa, meaning "prow". It is likely ultimately derived from Malay perahu meaning "boat", from the Proto-Western-Malayo-Polynesian doublets *parahu and *padaw, both meaning "sailboat".

8.3.1Modern variations

In the Marshall Islands, where the craft were traditionally built, there has been a resurgence of interest in the proa. People hold annual kor-kor races in the lagoon at Majuro, along with events such as a children's riwut race. The kor-kors are built in traditional style out of traditional materials, though the sails are made with modern materials (often inexpensive polyethylene tarpaulins, commonly known as polytarp).

A loose group of individuals from all over the world has formed from those interested in the proa, including people with a historical perspective and those with a scientific and engineering perspective. Many such individuals are members of the Amateur Yacht Research Society.

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