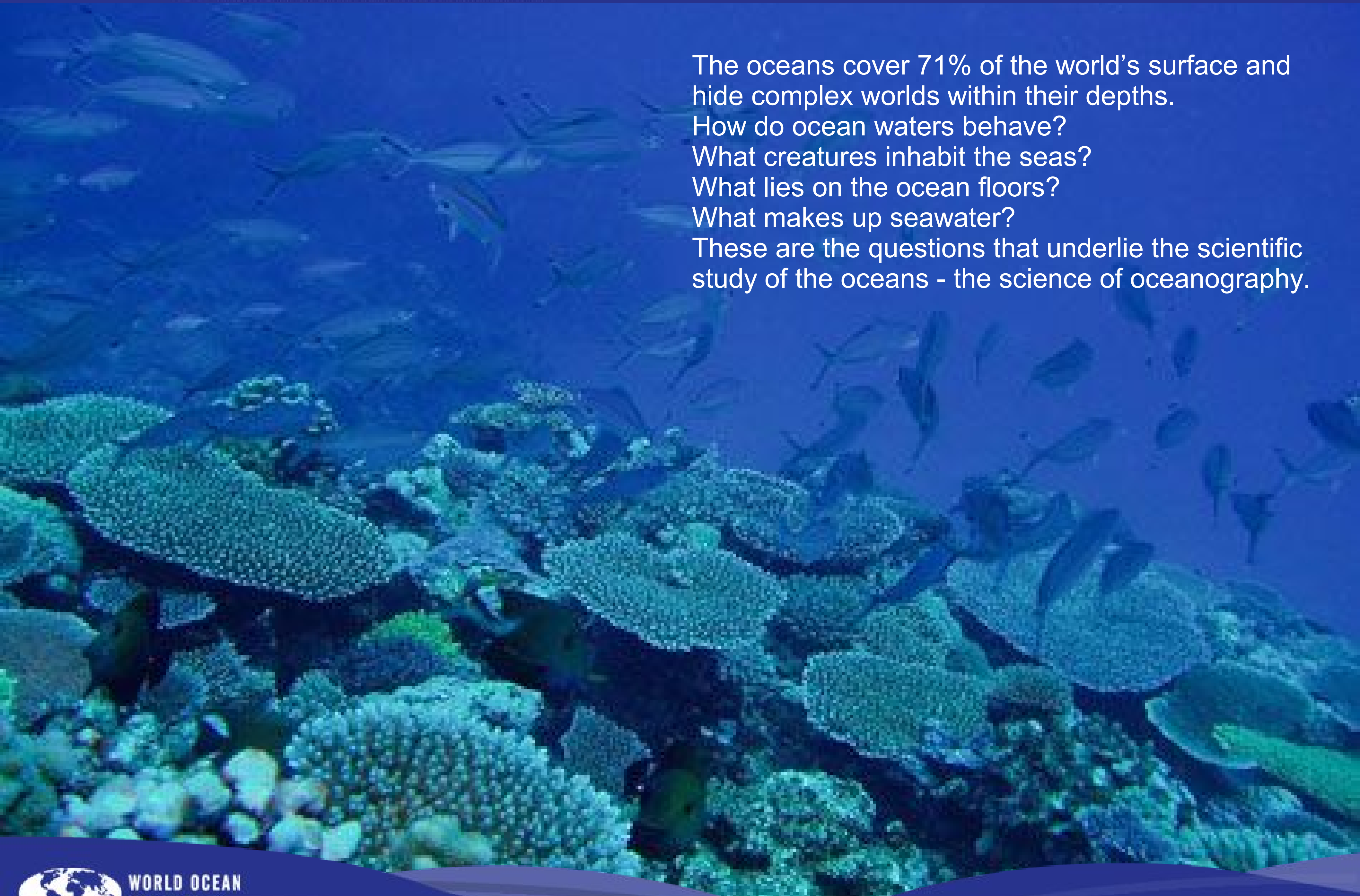
MILES DOWN!

OCEANOGRAPHY THROUGH HISTORY

The history of oceanography is an international story of invention, individual adventure, and exploration that remains little-known. This exhibition presents an historical overview, using timelines, text, photographs, and profiles of oceanographic expeditions and individual scientists from around the world.

WORLD OCEAN
Observatory



The oceans cover 71% of the world’s surface and hide complex worlds within their depths.
How do ocean waters behave?
What creatures inhabit the seas?
What lies on the ocean floors?
What makes up seawater?
These are the questions that underlie the scientific study of the oceans - the science of oceanography.

Scientists began to organize the study of the oceans as complex, interrelated systems in the late1800s.

Physics
explores the physical properties of the oceans, currents and waves

Biology
studies the organisms that live in the oceans

Oceanography
the scientific study of the oceans as complex, interrelated systems

History
who were the first?

Geology
explores the earth's history, composition, structure, processes and forces that shape the earth

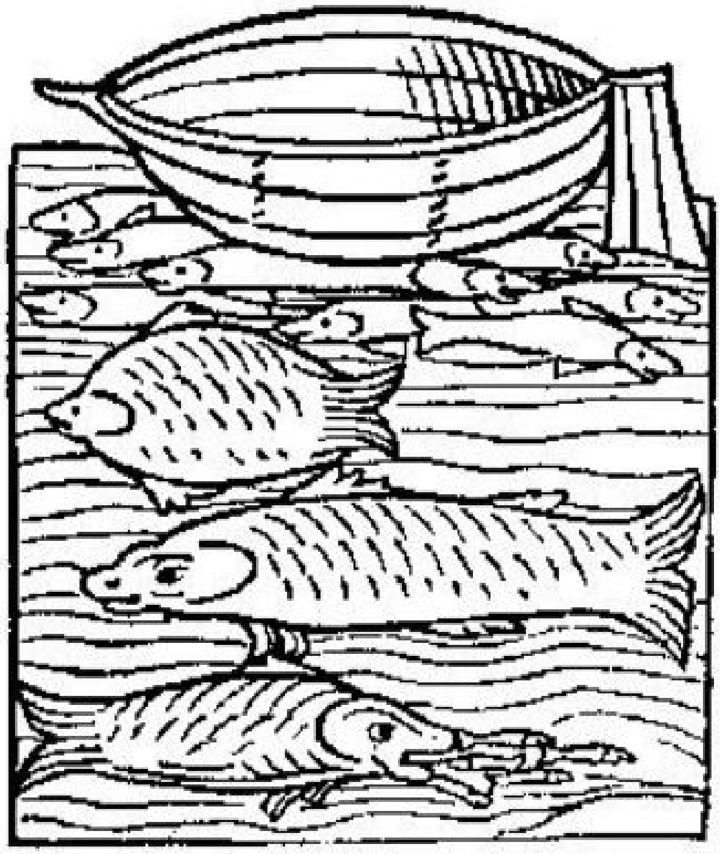
Chemistry
the properties, composition and structure of substances in the oceans and the changes they undergo when they combine or react

Technology
an oceanographer's tool box

Oceanography's practical origins

Thousands of years before formal oceanography, people observed the world's oceans, and knew practical things about waves, currents, fish, whales, and other sea creatures.

Their knowledge of coastal waters enabled them to build boats, go fishing, and navigate to trade with or settle other lands.



By the 15th century, people began to study the oceans more formally, driven by the search for wealth and by human curiosity. Fishermen and whalers, merchants and traders, navigators and colonizers, philosophers and scientists all faced the need to survive in an extreme environment.

Some sailed across huge, threatening oceans looking for isolated new lands. They defined the outlines of land and sea in the process. Others looked for what lives beneath the surface.

Seeking New Lands

Over thousands of years, sea traders laid down the outlines of geography: where the oceans and lands of the world intersect.

Navigators and explorers sought new lands to trade with, conquer, colonize, or settle. Many of these lands were isolated by huge oceans.

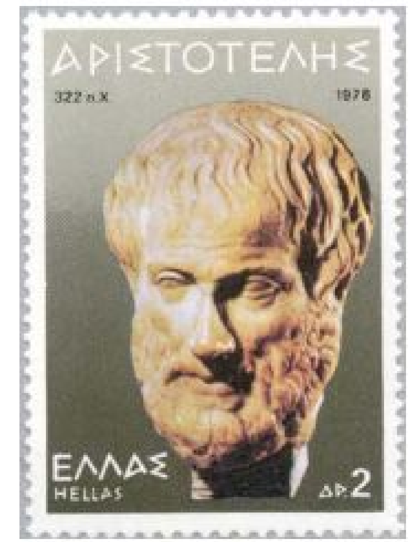
Merchants and traders wanted good routes to cross the seas – the quickest routes that held the least peril of losing ships, lives, and cargoes. Wealth through trade meant understanding the ocean: How do we get where we want to go? How do wind and water interact? Where did currents speed up voyages, or slow them down?

Before 1700, we knew the basic outlines of land and sea the world over.

Ancient Theories of the Oceans

In ancient times, Greek and Roman philosophers - the early scientists - studied the oceans as part of their inquiries into the physical world. This learning provides some of the foundations for modern ocean science.

Aristotle (384-322 BC) described a cycle of rainfall and evaporation and his ideas about the sea's origins.



The Greeks calculated the shape and circumference of earth and speculated about what lives deeper beneath the ocean's surface.

The Roman naturalist Pliny (1st century AD) had ideas about tides and salinity and listed the known marine species.

In Europe, little substantial marine science was done between Pliny's time and the Renaissance, four-teen hundred years later. But the Arab world preserved much of the early knowledge.

During the so-called Dark Ages, Arab geographers such as Muhammad al-Idrisi (1100-1165) continued to work on defining the world. Al-Idrisi's spherical world map (1154) was used by Renaissance-era ocean explorers. Note that south is at top.

Myths to Explain the Ocean's Mysteries

Throughout time, people have created mythologies to explain the mysteries of ocean behavior. These myths combine imagination, poetry, and spiritual beliefs.

Today, in many parts of the world, people continue to honor the oceans as places where spirit resides.

Ancient Beliefs Persist Today

Mazu was a 10th-century Chinese Taoist, Lin Moniang, who used her spiritual powers to aid fishermen and sailors. After her death she became known as the Goddess of the Sea, or Heavenly Mother (Tianhou).

A thousand years later, people maintain a vital Mazu culture through ceremonies at her home temple in Meizhou Bay, Fujian, on China's southeast coast, and throughout China, Taiwan, and other parts of Asia.

Ocean mythology can be seen in age-old customs. Seafarers continue old practices such as ceremonially naming boats while offering a libation to the sea; painting eyes on the bows so the boat can see where it is going; and buying (or placating) the wind by placing a coin under the mast of a sailboat.

Notable Discoveries

Starting in the 18th century, scientists began to build upon the practical ocean knowledge gathered by earlier seafarers and natural philosophers. They:

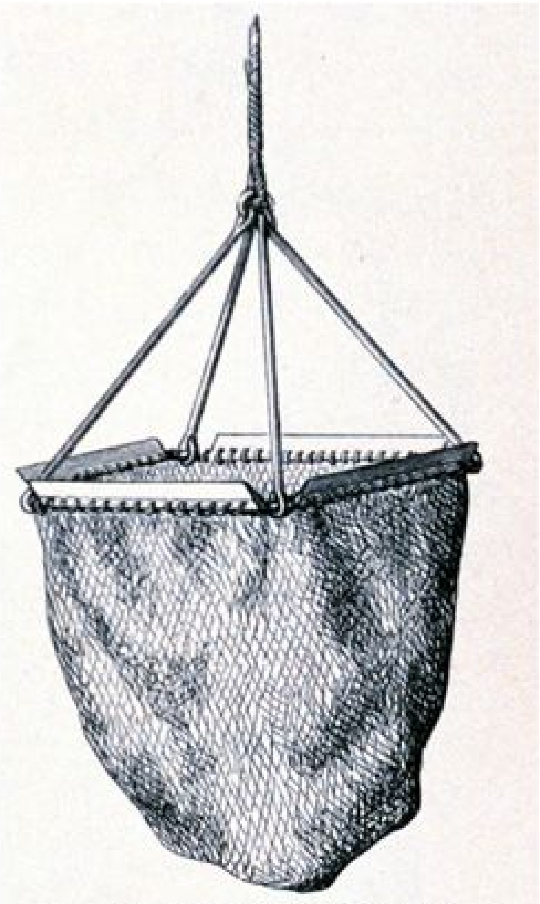


FIG. 44.—Otho Frederick Müller's Dredge. A.D. 1750.

- studied seawater's chemistry and salinity
- continued to take soundings to determine ocean depth, and to collect and study marine species
- charted currents and winds, whale and fish populations.

SIFTING DEPOSIT.

Each study led to even more questions about the seas, and how all these elements – winds, waves, currents, depth, and species – fit together.

Individual scientists pursued marine studies at an even greater pace during the 19th century. Notable discoveries hinted at the complexity of ocean systems. This era culminated in the 1870s voyage of HMS *Challenger*, which marks the beginning of modern scientific oceanography. The expedition's team used many scientific disciplines to achieve a fuller view of the oceans.

PLATE XXIII.—THE "CHALLENGER" AT ST. PAUL'S ROCKS.

Timeline 235 BC - 1876

235 BC – 415 AD
The ancient Greeks and Romans list species of marine animals, calculate the circumference of the earth, and theorize about the hydrological cycle and salinity; sailors routinely take soundings of depth

500-1000 AD

In Europe's Dark Ages, the theories of the ancients are forgotten after the fall of Greek and Roman civilizations, but the knowledge is preserved in the Arab countries. Sailors' practical knowledge continues to grow, as does scientific learning about the sea in the Middle East, China, and India

1711-1725
Luigi Marsigli (Italy) publishes *Histoire Physique de la Mer*, the first book devoted to marine science. It was based upon his 1680s studies of the Bosphorus, where he discovered that currents between the Black Sea and Mediterranean are caused by different water densities.

700-1200 AD
Viking sailors sample bottom sediments and take depth soundings, measuring by fathoms (1.83 meters or 6 feet), the distance between a man's outstretched arms (a measure still used today)

15th -18th centuries
The long voyages of Europe's Golden Age of Exploration produce maps to serve commerce and science and determine that all the oceans are connected

15th century
The French first use the term "océanographie," but the word vanishes again until the 1870s

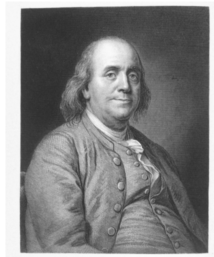
1520 and 1580
First circumnavigations of the world's oceans

1700s
Vitus Bering and others undertake Russian voyages of exploration to Northwest America and the Arctic

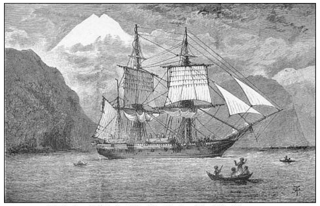
1736
Carolus Linnaeus (Sweden) develops a classification system for plants and animals, advancing scientific collection

1768-1779
The explorer James Cook (Britain) and naturalists gather data during expeditions to the Pacific and South Seas; measure winds, currents, temperatures; locate and map New Zealand, Australia, the Great Barrier Reef, and the Hawaiian Islands. Cook's voyages are sometimes called the first scientific oceanographic expeditions

1769
Benjamin Franklin (America) collects data to indicate the presence of the Atlantic Gulf Stream, in order to speed up postal services; also demonstrates relationships between weather and sea, a foundation for further studies



1818
Sir John Ross (Britain) hauls up marine specimens from more than a mile (2.2km) deep in the Arctic

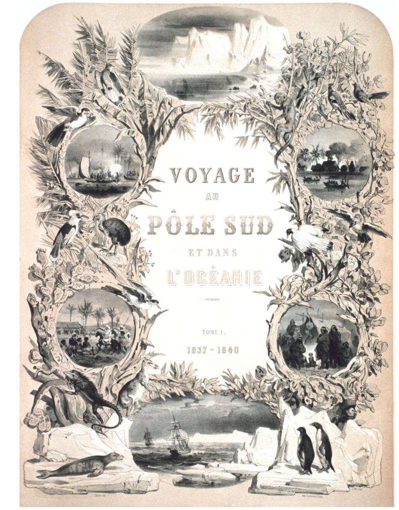


H.M.S. *Beagle* in Straits of Magellan. Mt. Sarmiento in the distance.

1831-1836
Charles Darwin (Britain) sails as unpaid naturalist / geologist on the voyage of HMS *Beagle*; develops theory on formation of coral reefs. His collections and observations lead to his theory of evolution, encouraging the search for living fossils and "missing evolutionary links" in the sea

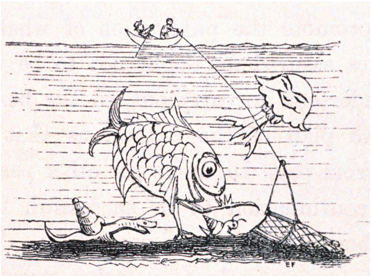
1832
James Rennell (Britain) publishes *An Investigation of the Currents of the Atlantic Ocean*

1839-1843
Sir James Ross' (Britain) expedition to south polar seas locates magnetic south pole and dredges life from deep sea



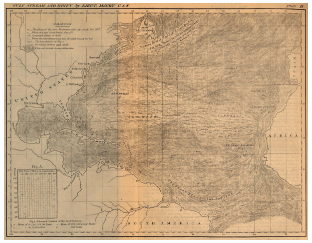
1839-1842
Wilkes Expedition (America), the U.S. Exploring Expedition, performs extensive studies in the Pacific Ocean, making great advances in hydrographic charts

1843
Edward Forbes (Britain) states that there is no life in the deep sea below 300 fathoms (1800 feet or 548 m); debate on this "azoic zone" continues until about 1860



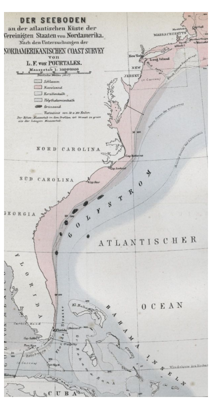
MILES DOWN!

OCEANOGRAPHY THROUGH HISTORY

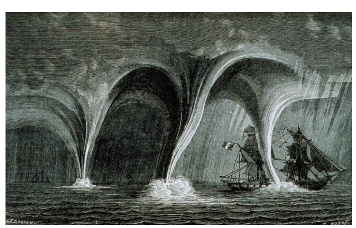


1841-1861
Matthew F. Maury (America) compiles vessels' wind and current data for improving navigation charts; creates whale chart based on ships' logbooks

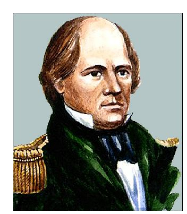
1849
US Coast Survey discovers presence of the continental shelf and slope



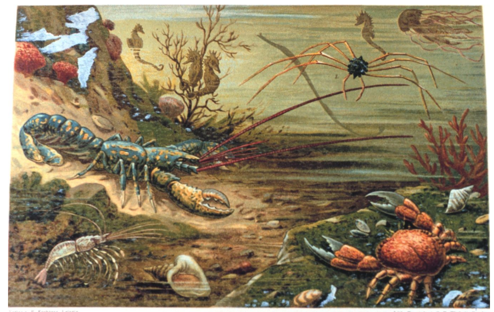
1853
The International Marine Conference in Brussels is the first international scientific meeting devoted to the oceans



1855
M. F. Maury publishes *The Physical Geography of the Sea*



1860s
Growing interest in deep sea studies; scientists find organisms living at 1200 m (3,940 feet or 656 fathoms)


Meerkrebse.

1872
First marine biological station founded at Naples by Anton Dohrn (Italy), followed by a laboratory at Villefranche sur Mer (France) in 1882

ANTON DOHRN
(1840 - 1909)

1872-1876
HMS *Challenger* expedition (Britain) under naturalists Sir Wyville Thomson (Scotland) and John Murray (Canada) performs oceans research worldwide; fifty volumes of results are published beginning in 1880, ushering in new era of science

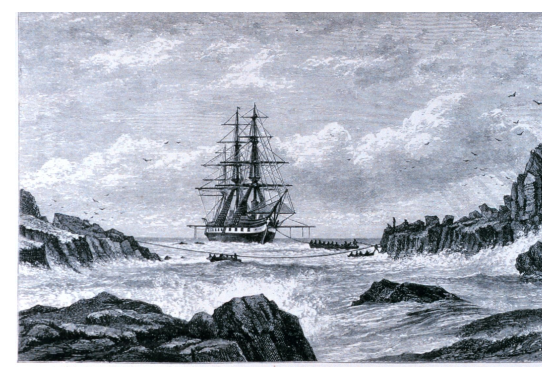
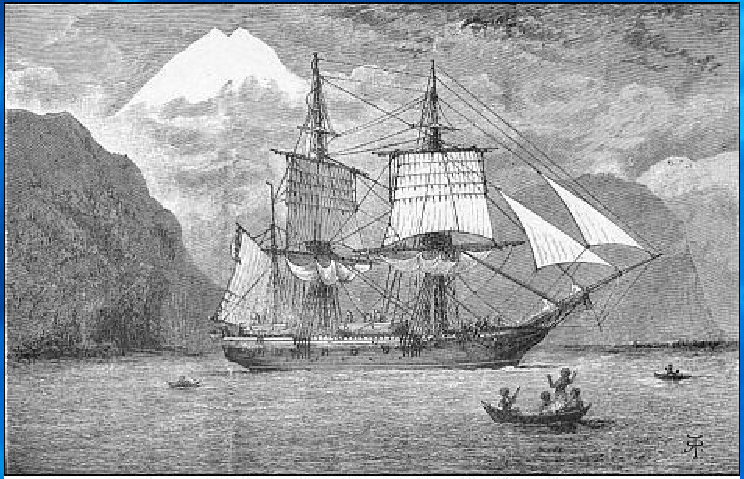


PLATE XXIII.—THE "CHALLENGER" AT ST. PAUL'S ROCKS.

WORLD OCEAN Observatory

Charles Darwin 1831-1859

Early marine biologists had the thrill of discovering a huge variety of life forms in the oceans. They looked into how species can thrive in environments so different from those on land.



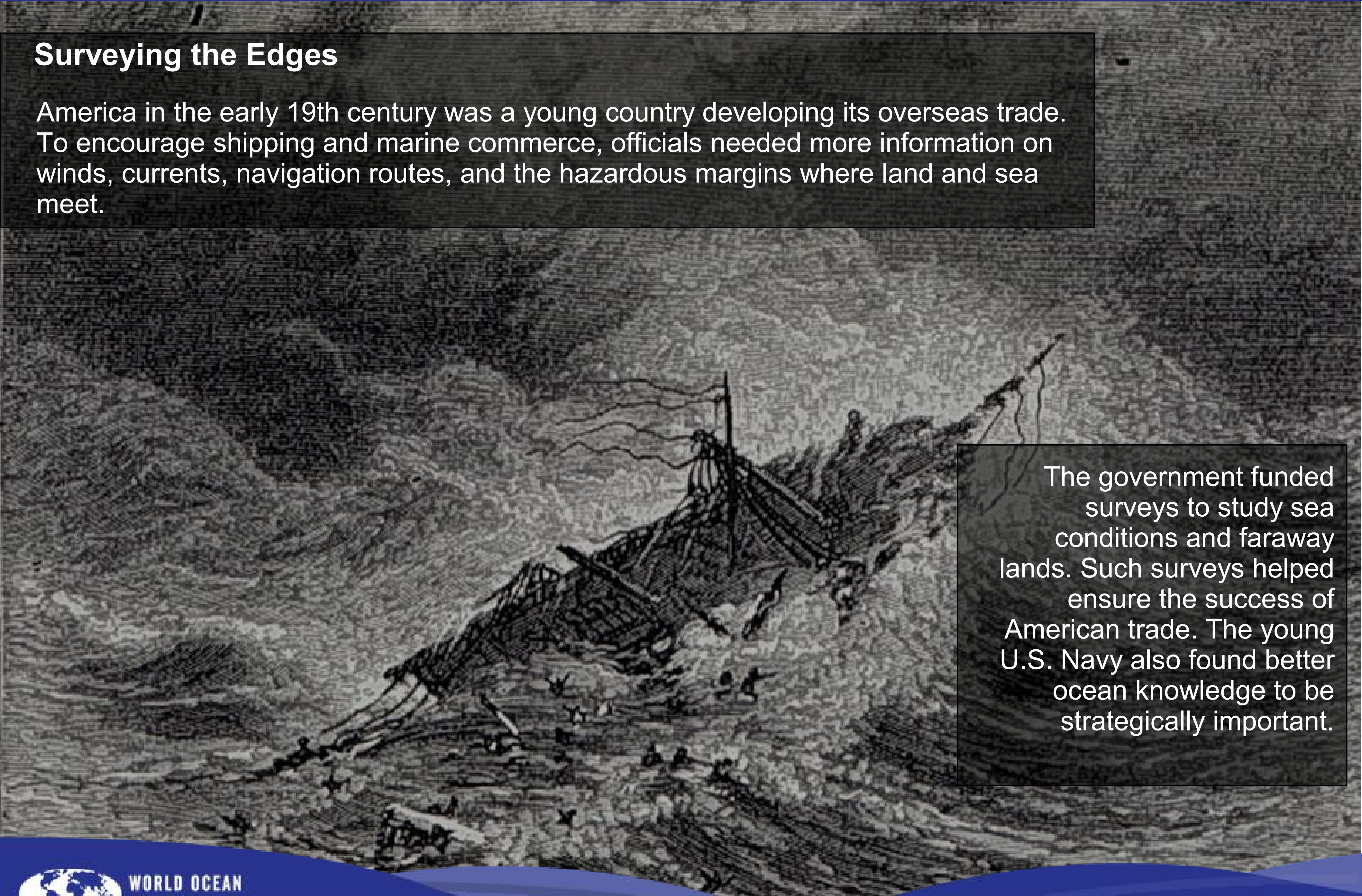
H.M.S. *Beagle* in Straits of Magellan. Mt. Sarmiento in the distance.

Charles Darwin sailed as naturalist and geologist on the voyages of HMS *Beagle* between 1831 and 1836. He systematically collected fossils, plants, and animals, resulting in tons of material for him and other scientists to study back home.

His marine observations led him to propose a theory on how coral reefs form. Digesting this material, over the next several decades, resulted in his theory of evolution (eventually published as *On the Origin of Species by Natural Selection* in 1859).

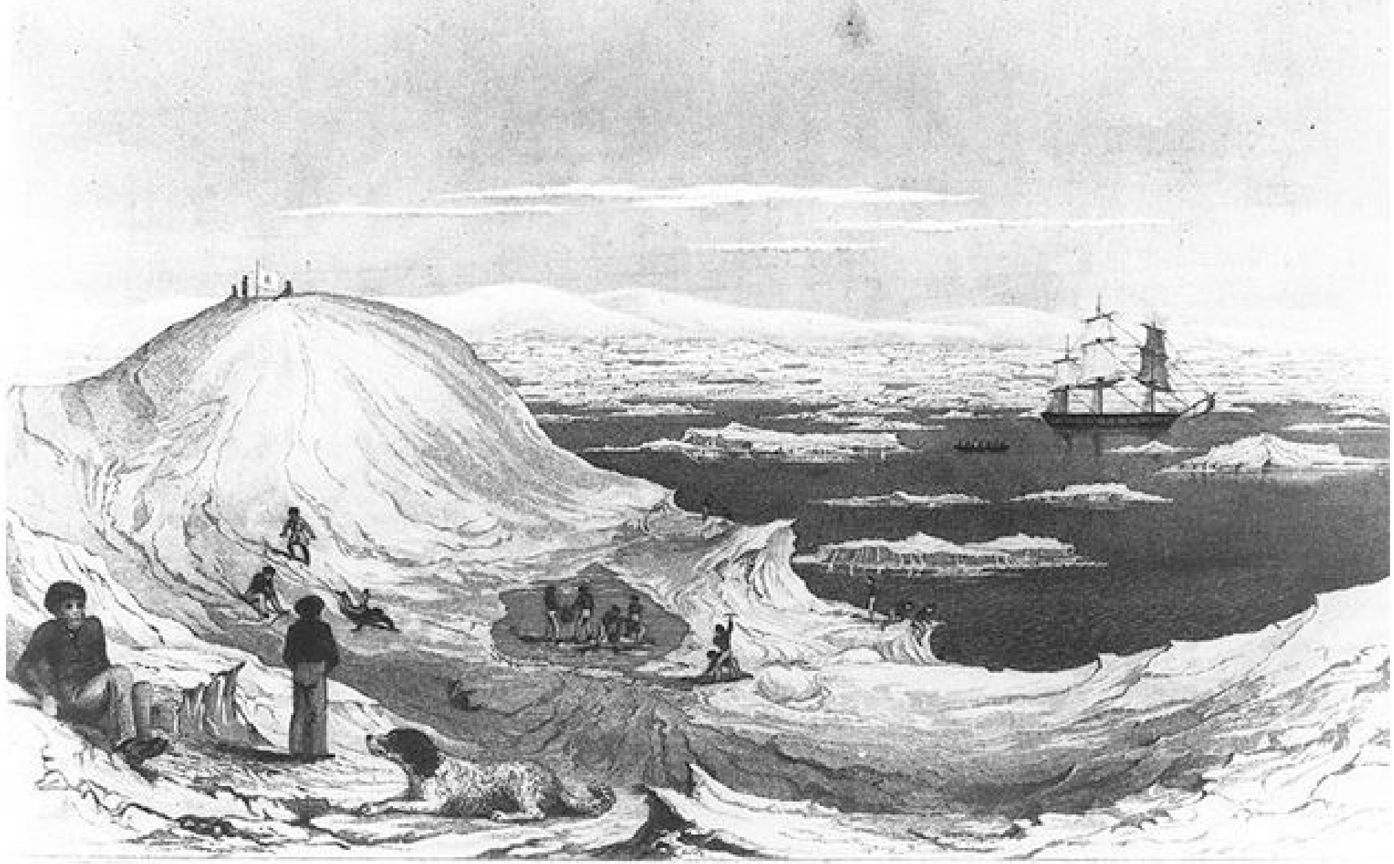
Surveying the Edges

America in the early 19th century was a young country developing its overseas trade. To encourage shipping and marine commerce, officials needed more information on winds, currents, navigation routes, and the hazardous margins where land and sea meet.



The government funded surveys to study sea conditions and faraway lands. Such surveys helped ensure the success of American trade. The young U.S. Navy also found better ocean knowledge to be strategically important.

In 1838, the U.S. Exploring Expedition went to sea on its assigned task: to survey and explore all around the world. Its goals included improving America's commercial interests in maritime trade, sealing, and whaling. The expedition also hoped to show that the American nation was mature enough to undertake an enormous scientific endeavor.

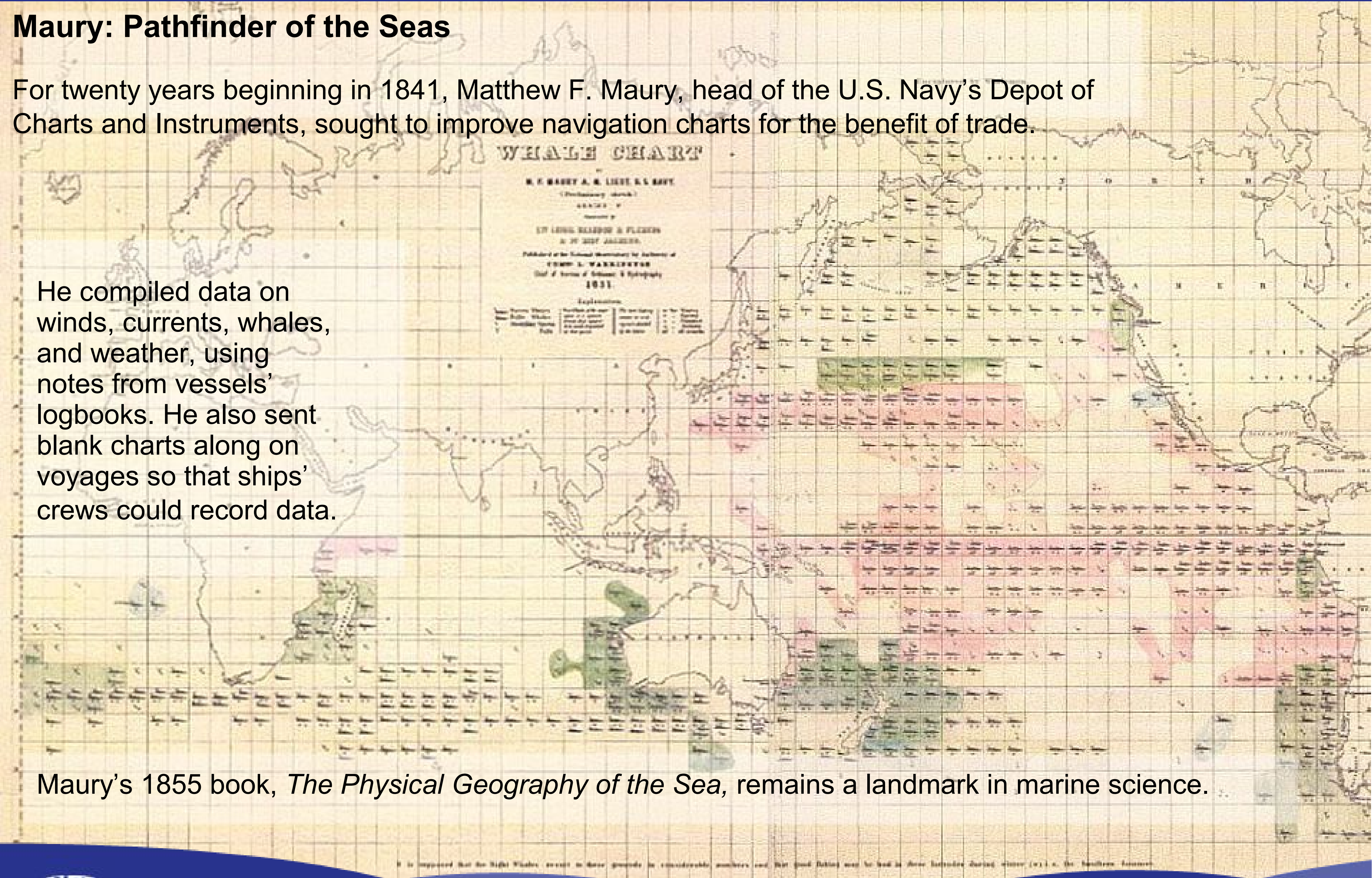


"View of the Antarctic Continent" with USS Vincennes nearby, 1840

The Wilkes Expedition achieved many significant results. Its ships explored the Pacific Ocean and South Seas, determined the existence of Antarctica, and advanced hydrographic charting.

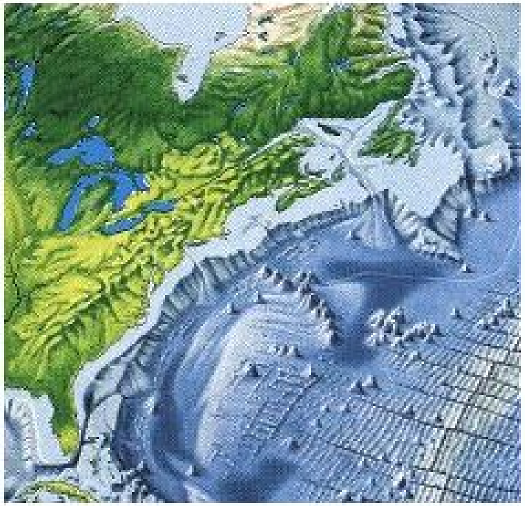
Maury: Pathfinder of the Seas

For twenty years beginning in 1841, Matthew F. Maury, head of the U.S. Navy's Depot of Charts and Instruments, sought to improve navigation charts for the benefit of trade.



He compiled data on winds, currents, whales, and weather, using notes from vessels' logbooks. He also sent blank charts along on voyages so that ships' crews could record data.

Maury's 1855 book, *The Physical Geography of the Sea,* remains a landmark in marine science.



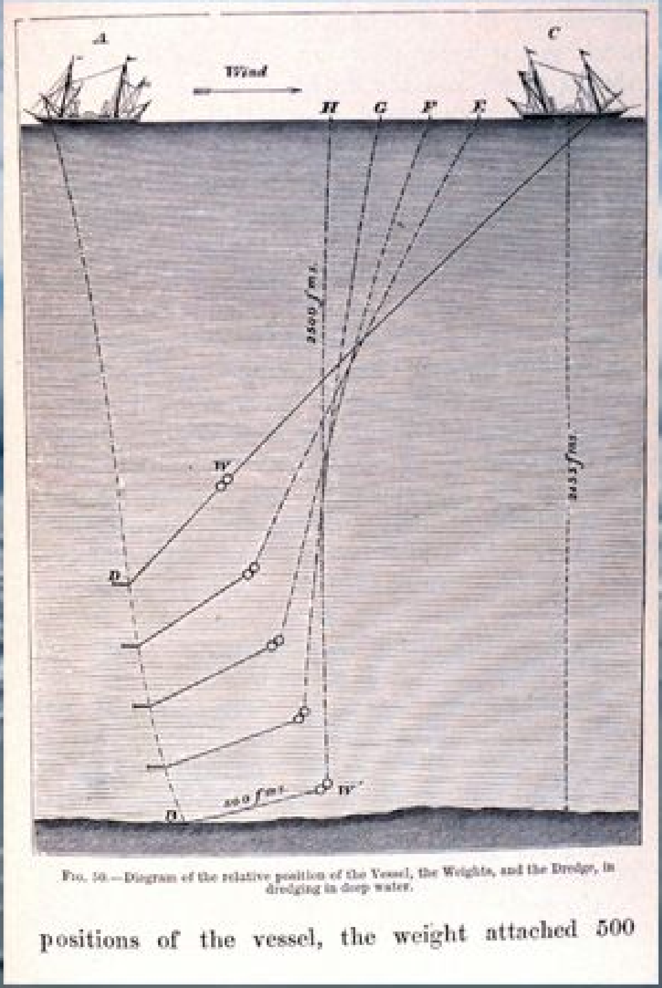
The U.S. Coast Survey

For hundreds of years, people surveyed waterways so that vessels could navigate them smoothly.

In 1849 Coast Survey soundings revealed the continental slope and shelf – the shallow areas near continents that are formed by sediments washing down from rivers. This stunning finding influenced the course of marine geology, biology, and hydrography.

Life in the Deep Sea?

In the early 1800s, many European naturalists held the theory that the deep sea was dense, dark, cold and lifeless. Therefore it was not worth exploring. In any case, technical limitations prevented looking too far below the ocean's surface.



A British naturalist, Edward Forbes, proposed his theory of the azoic (lifeless) zone in the 1840s, that is, no biological life could exist in the deep sea below the 300-fathom line. But was the deep sea really lifeless?

20,000 Leagues Under the Sea

Visionary French writer Jules Verne wrote a hugely popular book, *Twenty Thousand Leagues Under the Sea,* in 1869.

His fiction anticipates real scientific advances. Verne described technical innovations such as the deep-sea submarine and food made from sea life. But his explorers see no life in the deep ocean.

Real-life scientists, by this time, were seeing evidence of marine species thriving deep beneath the surface.

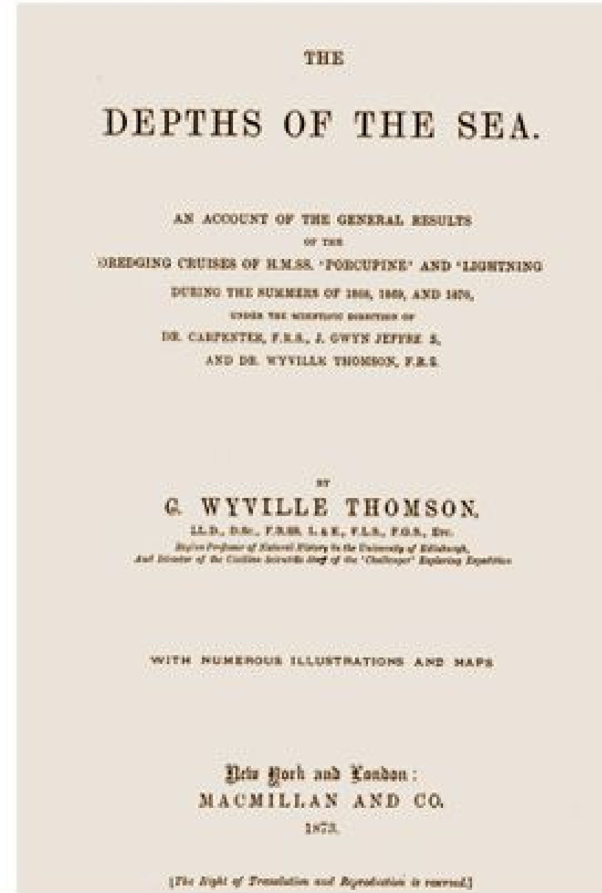
The Beginnings of Deep-Sea Exploration

After British naturalist Charles Darwin published his theory of evolution in 1859, the investigation of marine life turned to the deep sea, soon regarded as the "cradle of life." Scientists searched there for living fossils, or missing evolutionary links. They also studied the sea floor and its life to prepare to lay communications cables between continents.

We now know that the deep sea is the largest habitat on earth. Life has been found at depths that 19th century scientists could only dream of sampling. But even after more than150 years of exploration, there is still much we don't know about fish and other creatures that live in the abyssal sea.

The Royal Society

Britain's Royal Society was founded in 1660 to represent the interests of science. Its interest in any scientific endeavor guaranteed prestige, and was often accompanied by government funding. Scientists made great advances once the Royal Society began to support investigation of the deep sea. Other European countries such as the Scandinavian nations, Germany, and France, also set up scientific societies. The Europeans' pursuit of ocean science for knowledge's sake contrasted with the practical approach of the Americans at that time.



THE

DEPTHS OF THE SEA.

AN ACCOUNT OF THE GENERAL RESULTS
OF THE
DREDGING CRUISES OF H.M.SS. 'PORCUPINE' AND 'LIGHTNING
DURING THE SUMMERS OF 1868, 1869, AND 1870,
UNDER THE SCIENTIFIC DIRECTION OF
DR. CARPENTER, F.R.S., J. GWYN JEFFREYS,
AND DR. WYVILLE THOMSON, F.R.S.

BY
G. WYVILLE THOMSON,

WITH NUMEROUS ILLUSTRATIONS AND MAPS

New York and London:
MACMILLAN AND CO.
1873.

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The Royal Society decided that it was important to collect enough data to confirm British scientists' deep-sea hypotheses. This led to the landmark oceanographic voyage of HMS *Challenger* and the era of modern oceanography.

The Voyage of *HMS Challenger,* 1872-1876

Oceanography's emergence as a distinct science is marked by the worldwide voyage of the HMS *Challenger* between 1872 and 1876. A converted British warship, *Challenger* was equipped with the latest scientific gear to study the deep ocean.

In December 1872, the *Challenger* expedition set out from England with a simple but enormous mission: To sail the globe and survey all aspects of the deep sea. Four years later, the ship had visited all the world's oceans except the Arctic Ocean, and had traveled almost 69,000 nautical miles (127,000 km).

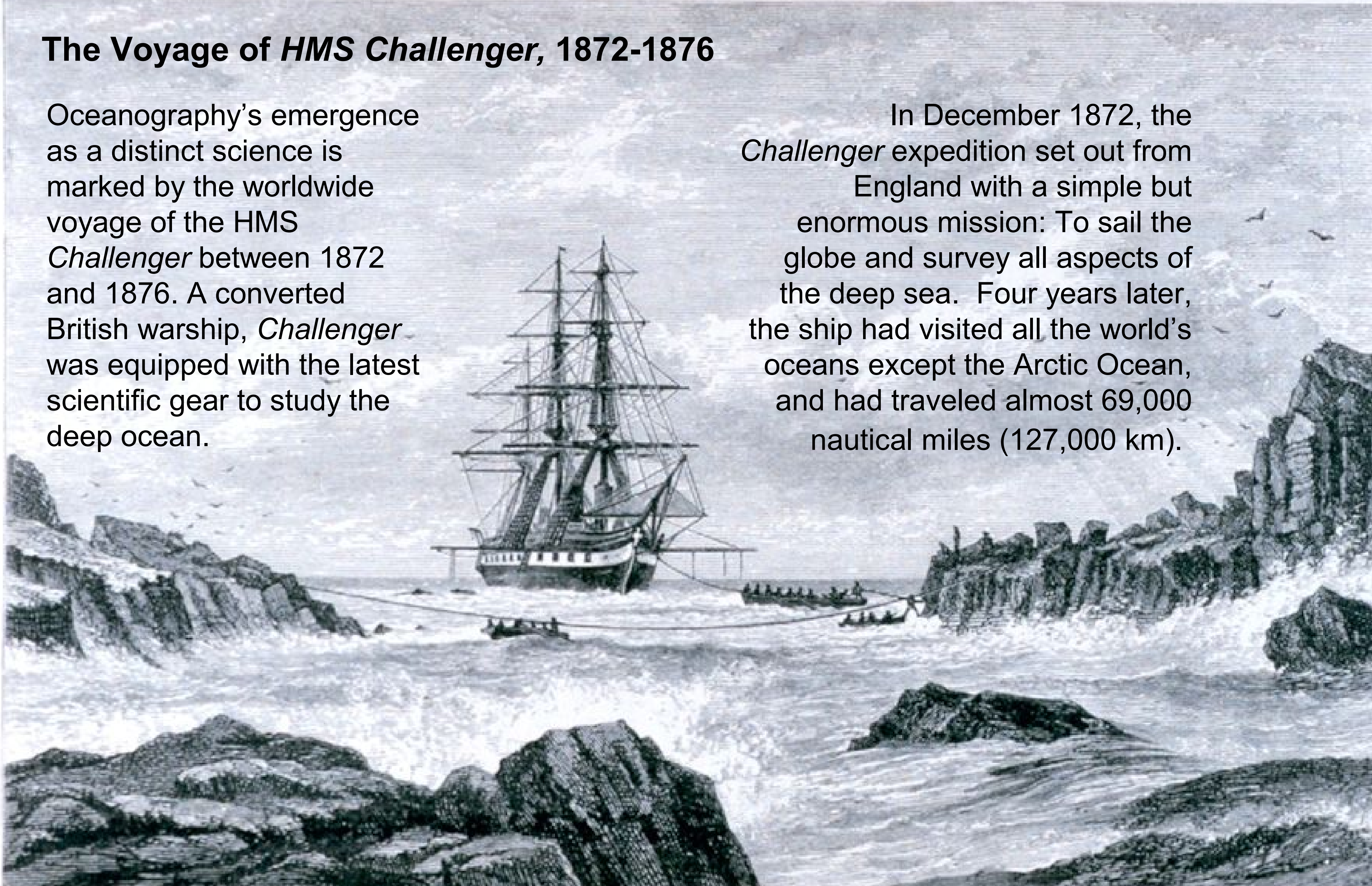
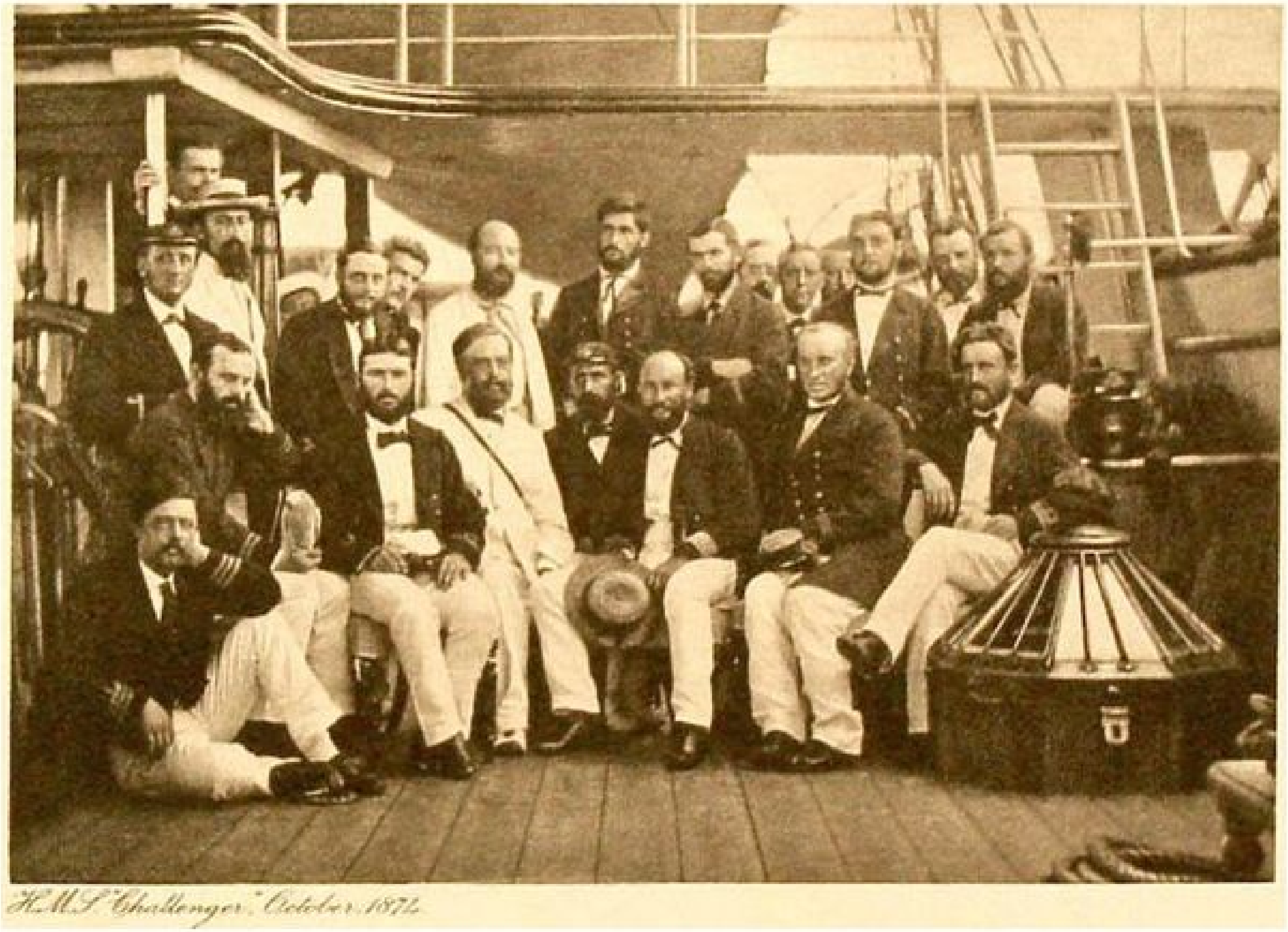


PLATE XXIII.—THE "CHALLENGER" AT ST. PAUL'S ROCKS.

The Men of HMS *Challenger*

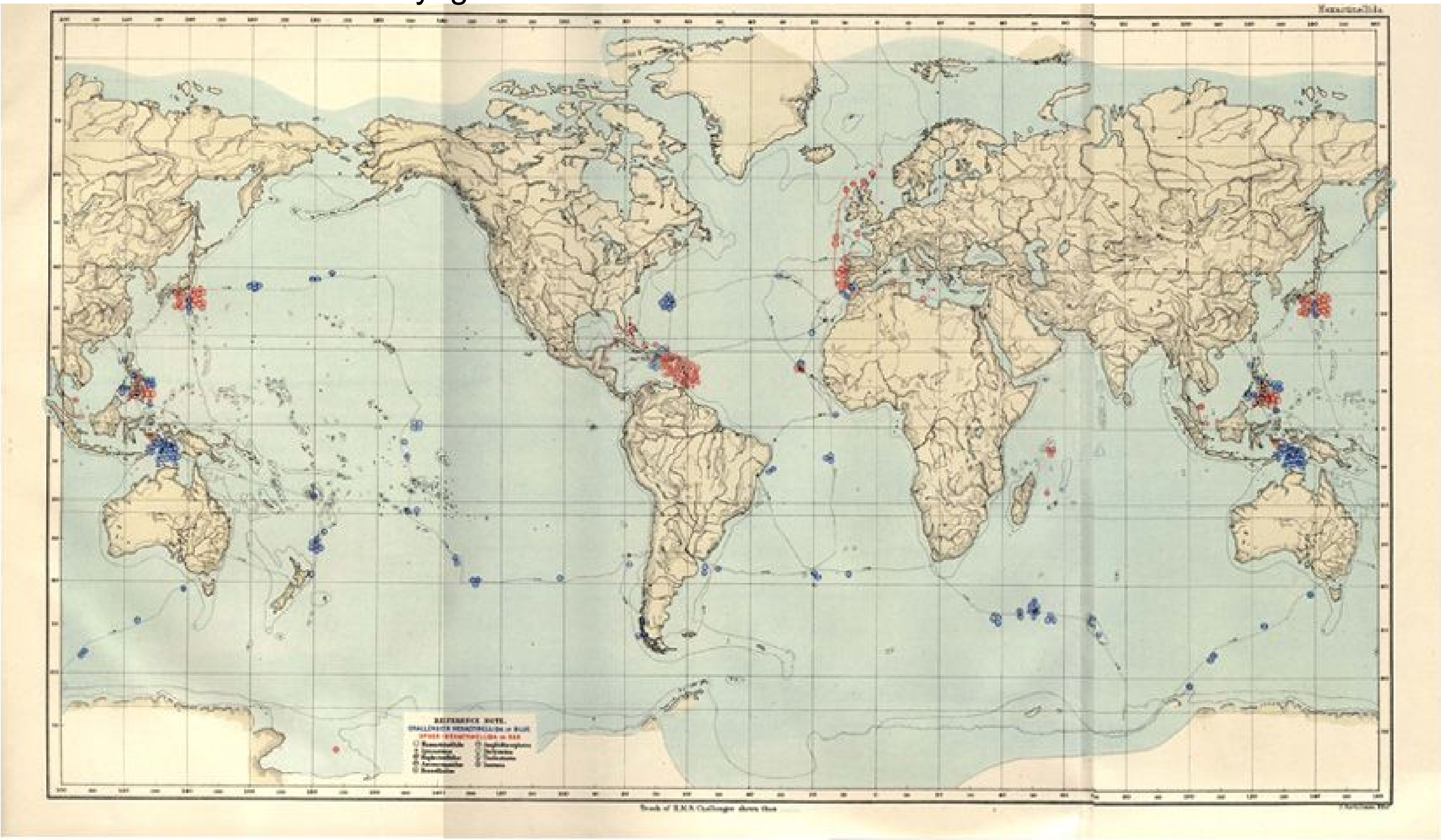
The Royal Society chose naturalist Sir Charles Wyville Thomson of Scotland to head the expedition, assisted by John Murray of Canada. Aboard the *Challenger* were five scientists and an artist, making up the civilian scientific staff, as well as a naval crew of experienced officers and men to run the vessel.

Many of the crew members assisted with the scientific work, supplying the considerable manpower needed to haul back dredges and nets assisted by a steam winch, and sorting the finds.



The Route

Challenger's expedition was not a straightforward long-distance voyage, but a voyage between "stations" in various parts of the ocean. At each station, the crew performed scientific work. There were 362 scientific stations made on the voyage.



The Methods

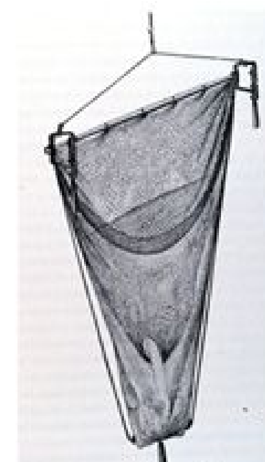
Challenger's scientists and crew used several methods for studying the ocean. They measured water temperature at the surface and at depth using submersible thermometers.

Fig. 17.—The Dredging and Sounding Arrangements on board the 'Challenger.'

They dredged up samples of marine animals, plants, and sediments from the bottom. With trawls and nets, they collected fish and other animals. They took soundings, with weighted devices, to gauge the ocean's depth.

Reading Thermometers.

Using these methods, the *Challenger* expedition found undersea mountain chains, collected more than 4,700 previously unknown sea animals and plants from various depths, and sounded the deep Marianas Trench, at 8,185 meters (almost 5.1 miles deep). While the work emphasized biology, scientists also examined the chemistry and density of seawater, and analyzed sediments dredged up from the sea floor.



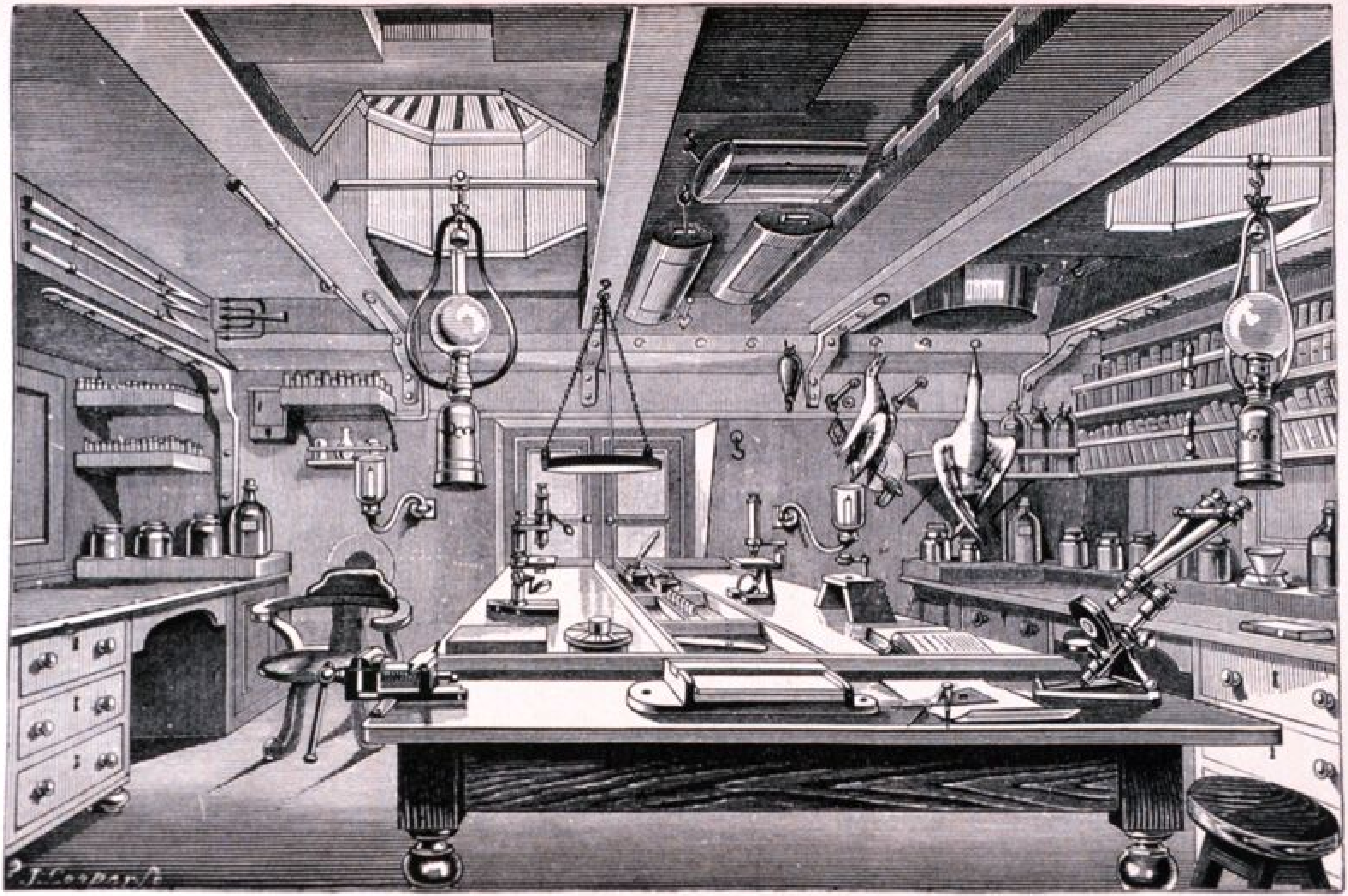
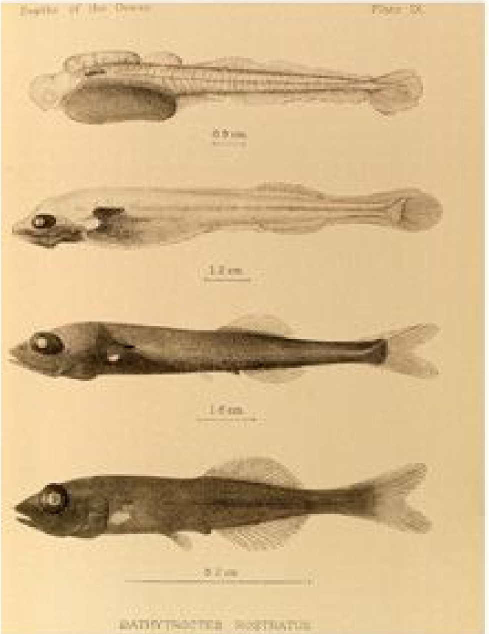


FIG. 1.—The Natural History Work-room.

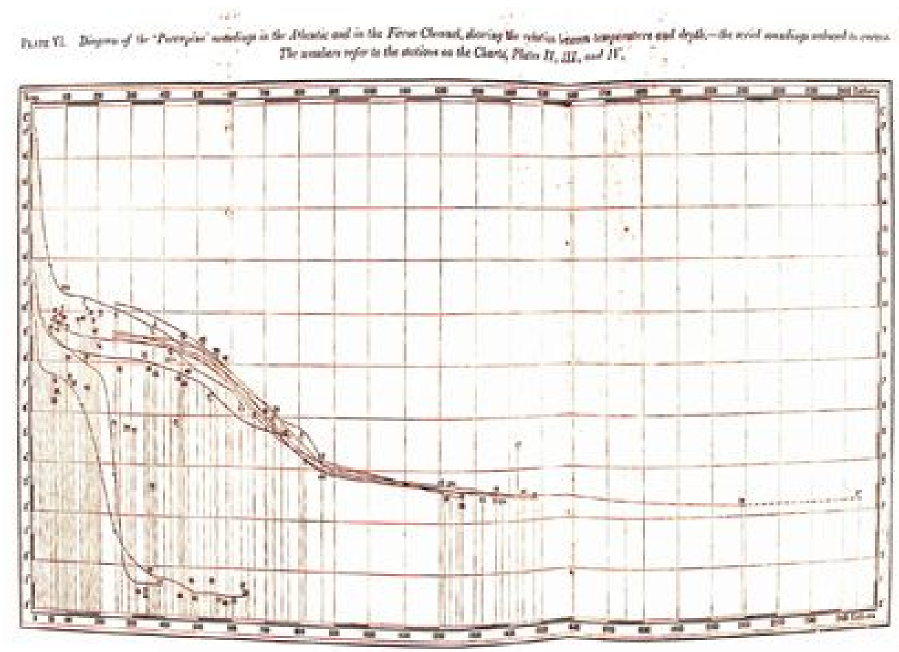
Scientists' workroom aboard HMS *Challenger*.

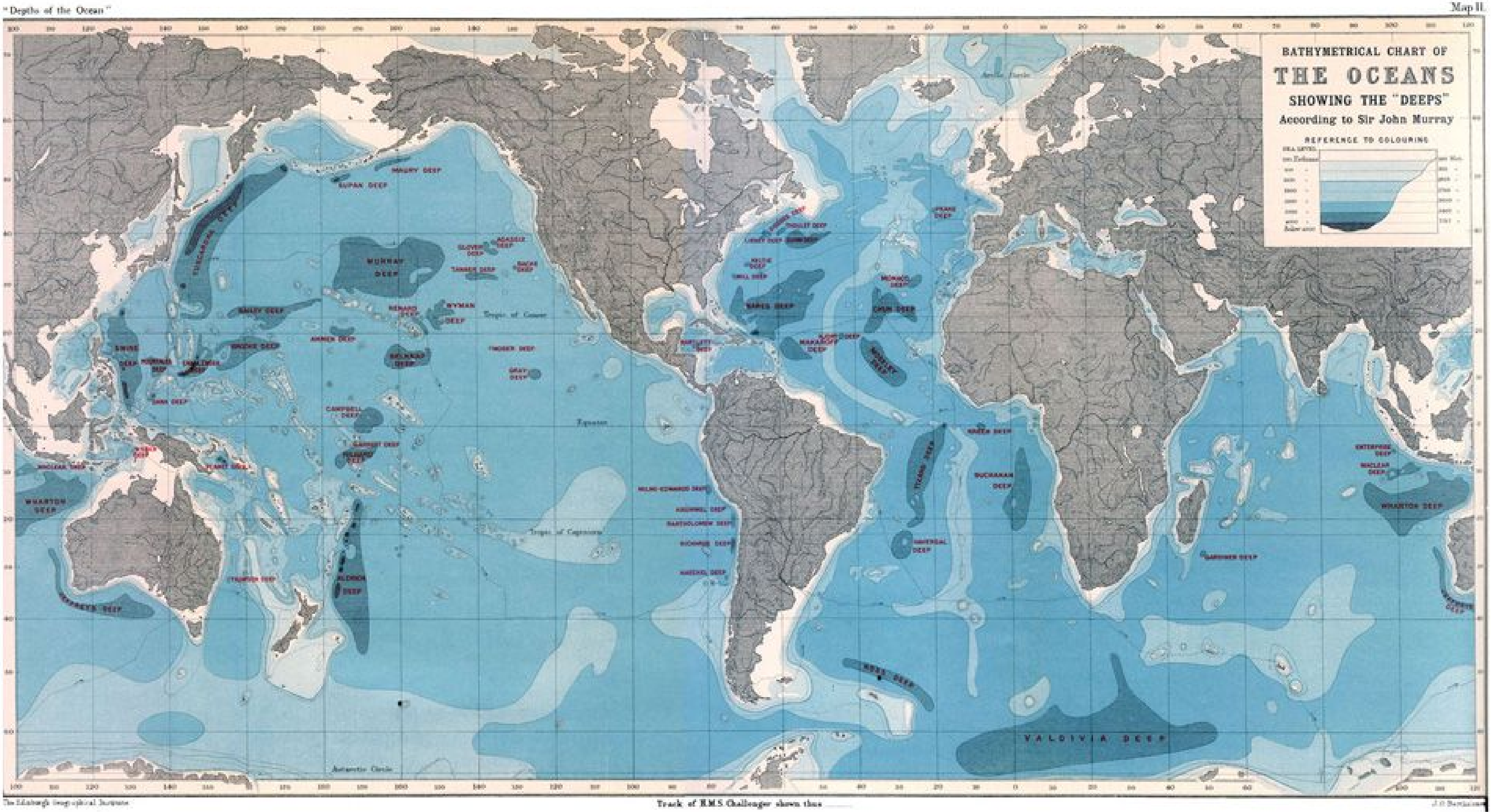


Challenger's Results

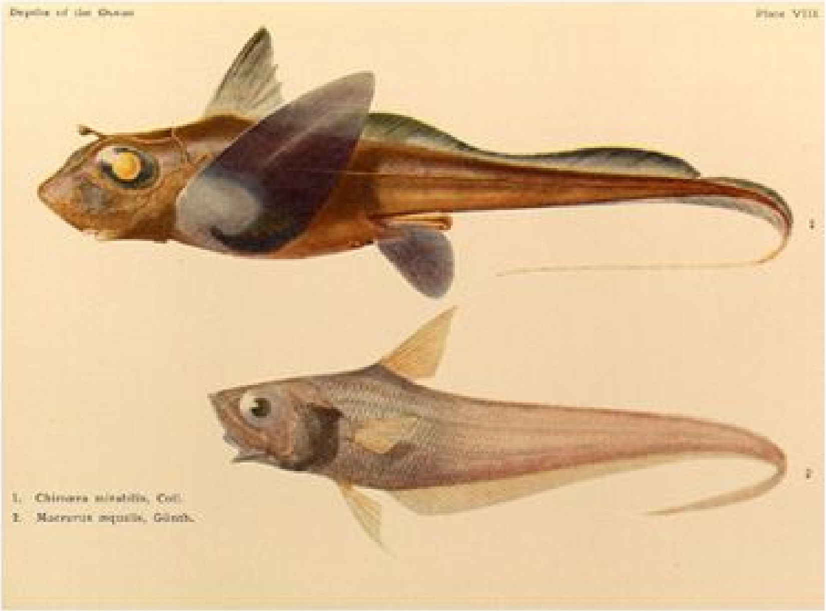
Once back in England, it took scientists almost twenty years to sort and examine the specimens and materials collected during *Challenger*'s cruise. Seventy-six specialists studied portions of the collections. Thirteen thousand different kinds of plants and animals, more than 1,400 water samples, and hundreds of sea-floor deposits were analyzed.

Eventually, fifty volumes of findings were published, first under the supervision of Sir Wyville Thomson and later under Dr. (Sir) John Murray. The *Challenger* reports (published between 1880 and 1895) remain a landmark of marine science, recording in detail all knowledge of the deep sea at that time.

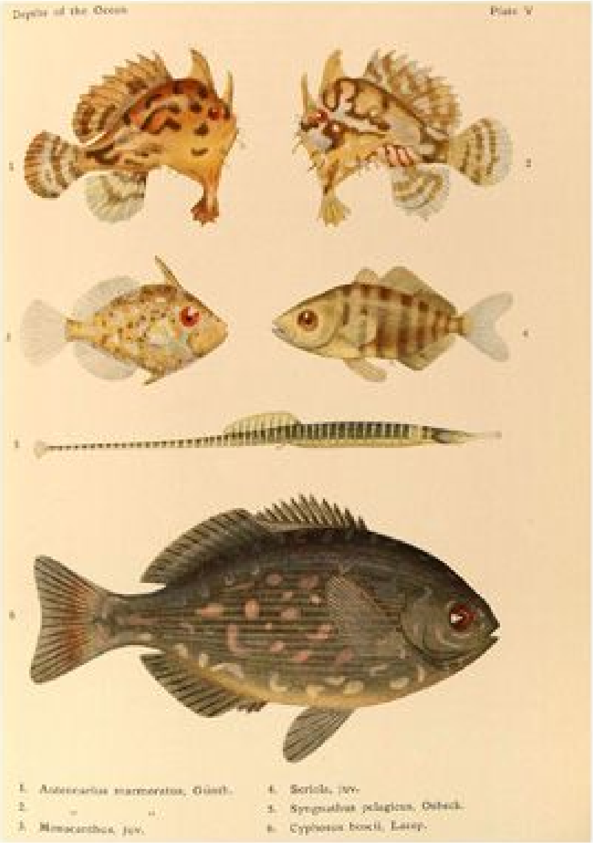


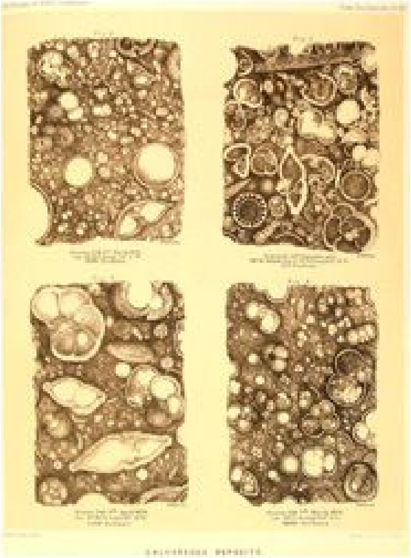


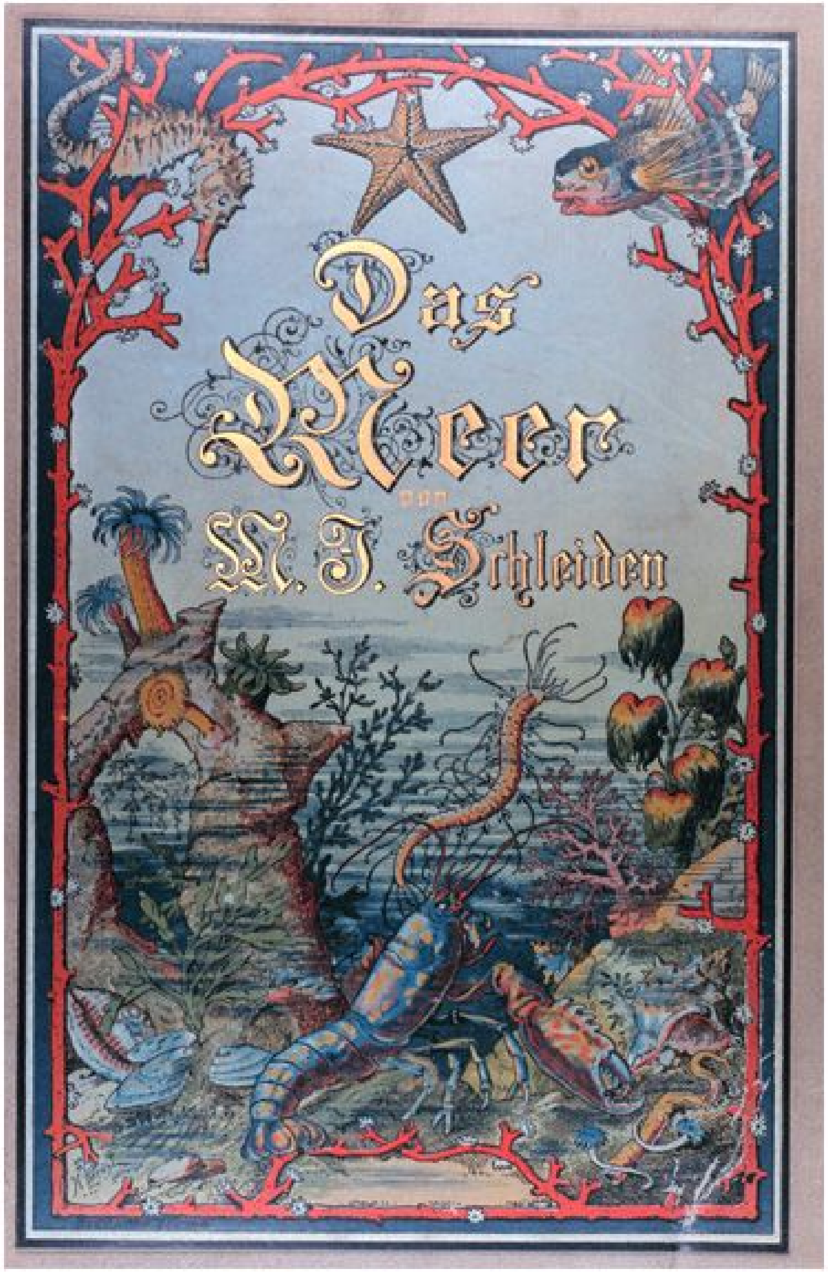
"Depths of the Ocean"
Map II.
BATHYMETRICAL CHART OF
THE OCEANS
SHOWING THE "DEEPS"
According to Sir John Murray
REFERENCE TO COLOURING
MURRAY DEEP
VALDIVIA DEEP
WHARTON DEEP
Tropic of Cancer
Equator
Tropic of Capricorn
Antarctic Circle
Track of H.M.S. Challenger shown thus



The many exciting scientific discoveries made aboard *Challenger* greatly advanced marine science. Among the most significant outcomes, scientists found that there was no depth limit to life on the sea floor and also found an amazing abundance of marine organisms at various depths.





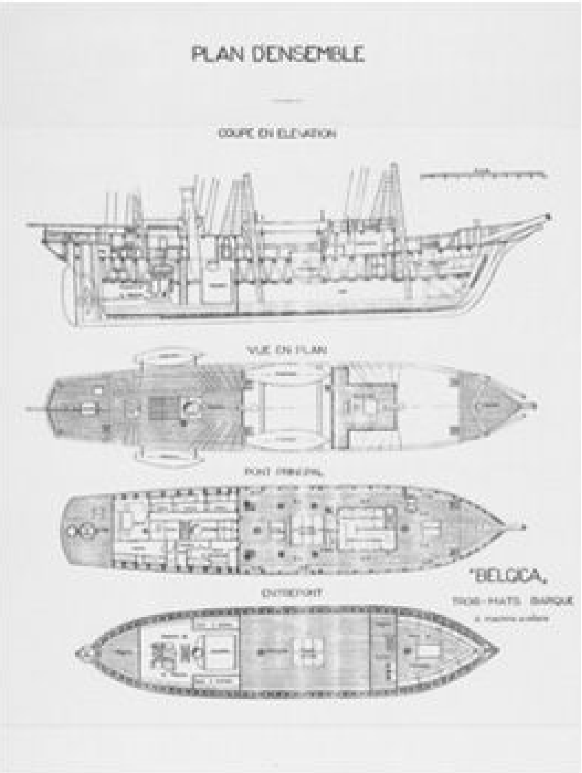


National Expeditions:
The Foundations of Oceanography, 1880 - 1940

Other nations, inspired by the *Challenger* expedition, sent out oceanographic missions in the 1880s through the 1930s. Many made exciting discoveries and advanced the technology needed to study the sea. Altogether, they began to tie information together into the emerging picture of oceans as complex, dynamic systems.

EXPÉDITION ANTARCTIQUE BELGE

Champs de glace et voies d'eau à la date du 5 mars 1898.



The Costs of Oceanography

Oceanographers and marine scientists need specialized vessels and tools to perform their studies. It's a costly science. Ships are critical as the foundation for work at sea, as are support boats (and, today, remote underwater vehicles) for exploring below the surface. Vessels need trained crews to run them. Up-to-date research equipment and shipboard laboratories for analyzing data are essential.

The scientists themselves require specialized training and good salaries. There are large costs to fuel and provision a long voyage.

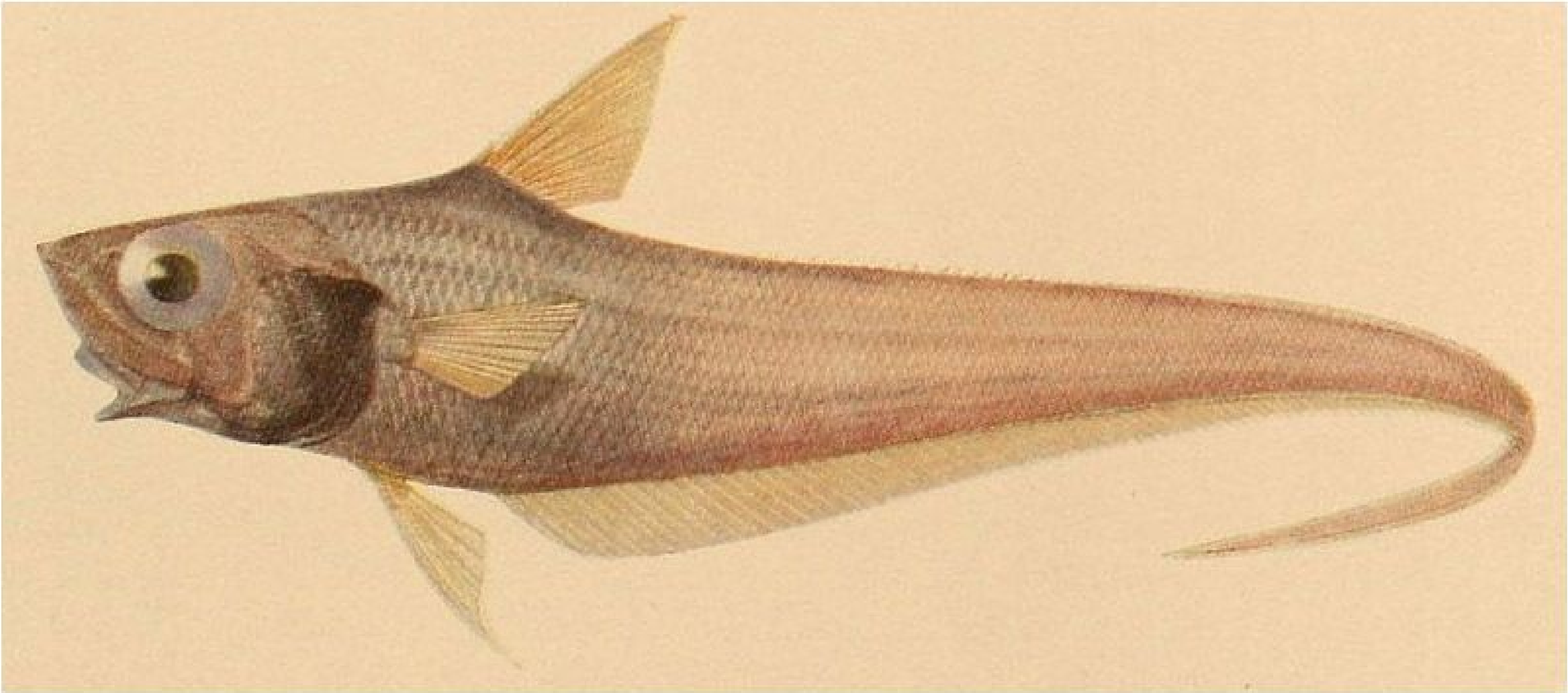
Since scientists don't spend all their time at sea, they also need laboratories and offices on shore. There they conduct data analysis and plan the next voyages.

The Russian Expeditions aboard *Vitiaz* and *Yermak*

Russia has an eminent history of oceanographic study dating back earlier than the 18th century. But for a long time Russian science was shrouded by secrecy and political competition, so it is not as well known as science in other nations.

In the 1890s the Russian icebreaker *Yermak* opened up new areas of the Arctic for study. By the end of the 20th century, Russian scientists had a comprehensive view of Arctic ecosystems that could be brought together with the western scientists' work to understand this critical area of the world ocean.

Scandinavian Scientists



Fishing was a lifeline to the Scandinavian countries of Norway, Sweden, Denmark and Finland, so ocean research there tended to support the fisheries.

Scandinavian scientists advanced physical oceanography when they found that plankton (microscopic marine life) is a biological “marker” for water masses, just as temperature and salinity are physical and chemical markers. Water masses influence currents, so these plankton studies added to a dynamic picture of the sea in motion.

Fisheries research

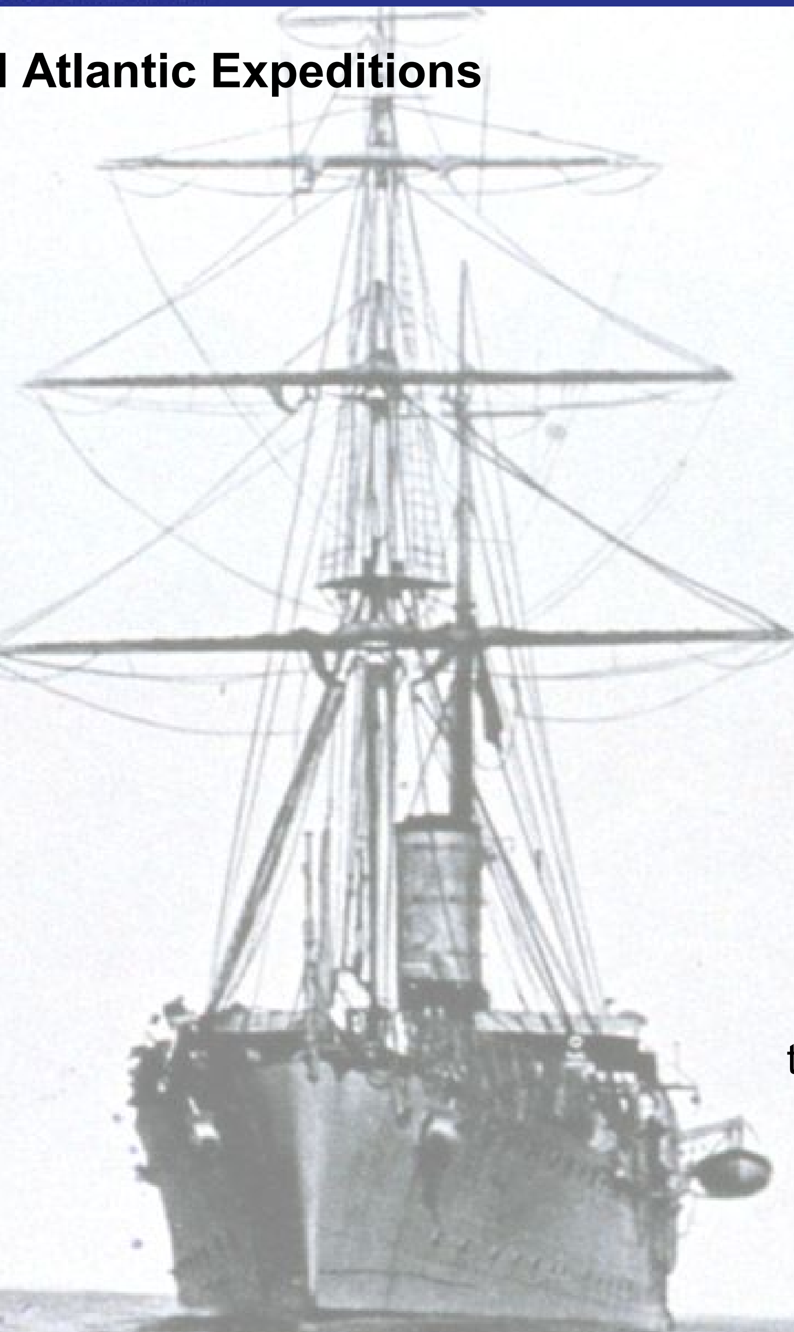
Late in the 19th century, European fishing regions saw smaller catches. Some suspected a human impact, in addition to natural shifts in fish populations. As human populations grew, so did the demand for fish. So fishermen used more efficient boats and nets to bring in huge catches. But over time, the catches declined. Marine scientists took up the question of why fish abundance changes.

In 1902, several European countries joined together to promote fisheries research, in order to ensure future fish stocks. The organization ICES (International Council on the Exploration of the Sea) began by coordinating simultaneous hydrographical studies.

Eventually this work linked currents and water masses, fish life cycles and migration, and the availability of plankton as food for larval fish: all essential to understanding fisheries.

The German Antarctic and Atlantic Expeditions

The German Antarctic Expedition of 1911-1912 achieved the first basic studies of the Antarctic Ocean.



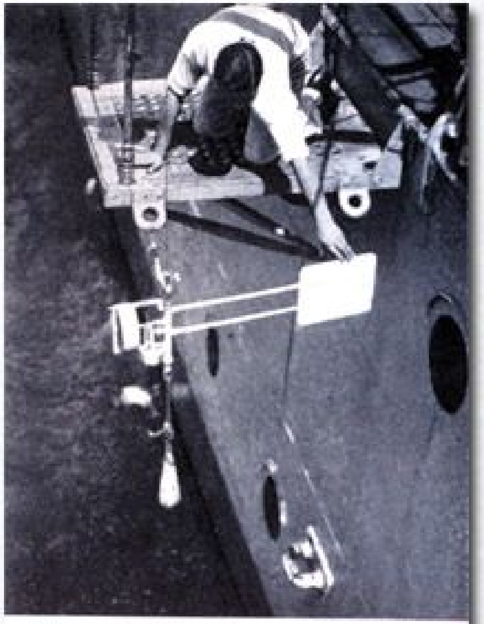


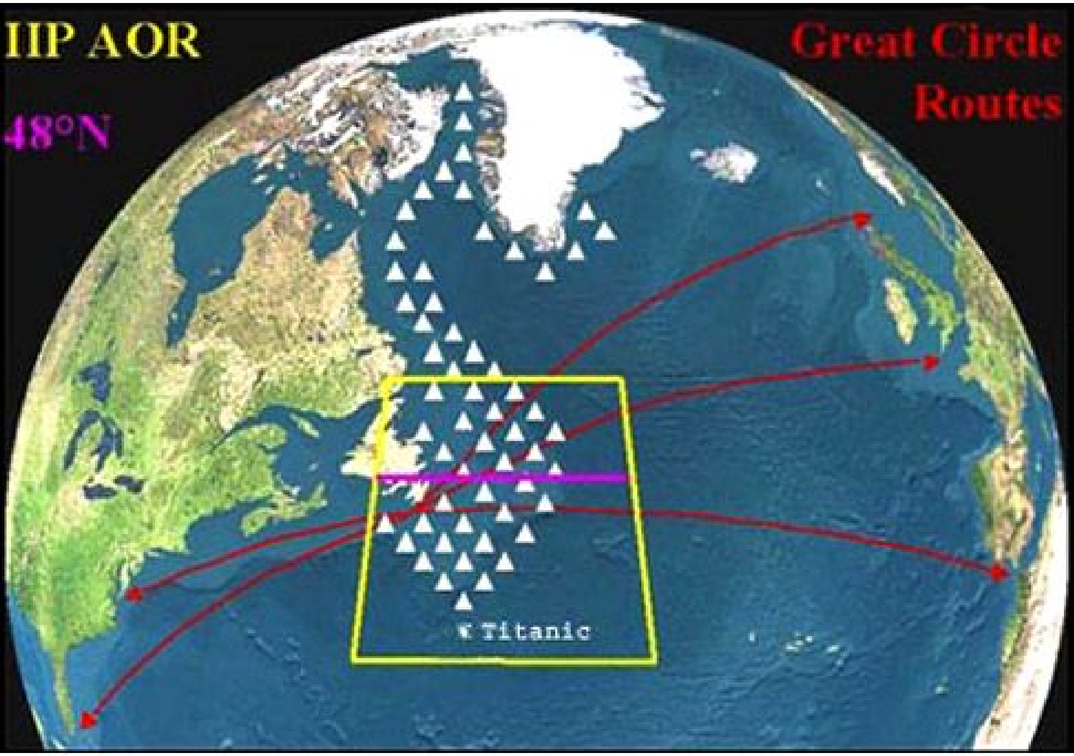
Abb. 334. Der Merz-Ekmansche Strommesser für Einzelmessungen.

In the mid-1920s, scientists with the German Atlantic Expedition aboard the *Meteor* set out to extract gold from seawater, in order to pay war debts. The scientists found only a small percentage of the gold they expected but they did take seawater samples for chemical analysis and charted temperature and salinity.

They also mapped a continuous ridge along the mid-Atlantic sea floor by using the relatively new sonic depth finder, based on the echo sounder device. This technology was developed before and during World War One, as a way of detecting icebergs and military submarines.

The International Ice Patrol, Currents, and Echo Sounders

Once again, commercial and military needs both played a role in the next major developments of ocean technology. The fearful shipping hazards posed by icebergs on the busy North Atlantic seaways were dramatized by the sinking of the passenger steamer *Titanic* in 1912.



The International Ice Patrol (a 16-nation effort begun in 1914) first tracked icebergs by observing them from patrol vessels and reporting them to other shipping. Later, the Patrol drew upon marine science by using Helland-Hansen’s dynamic technique: predicting ocean currents so that vessels could avoid the worst iceberg areas.

Canadian Reginald Fessenden had developed an Iceberg Detector and Echo Depth Sounder – an underwater sound-oscillation device that sends sound towards a solid object and measures the time it takes for the echo to return. This was altered into a submarine detector and used by British warships and French submarines against the German U-Boat force during World War One. Germany also developed an echo-sounding device for undersea warfare, later used for marine science.

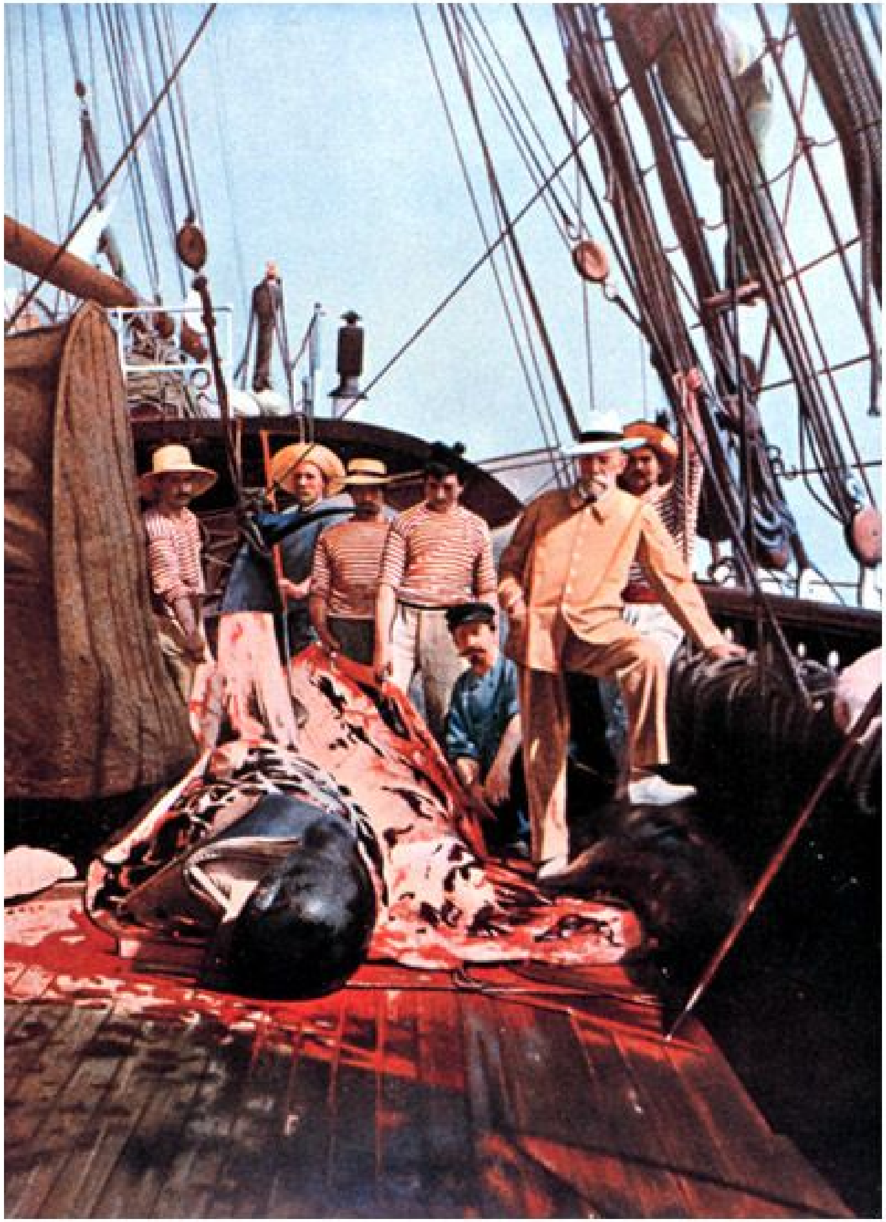
Today's Ice Patrol technology includes airplanes, radar and loran, as well as underwater sound equipment.

The Great War and Oceanography

The outbreak of war among European nations interrupted ocean research. Submarine warfare required a quick response. Developing military uses for the new echo sounder required data on sea floor profiles and sediments, temperature and salinity. Scientists redirected their work towards physical oceanography, rather than marine biology, during these years.

Dutch geologists take core samples around Indonesia

In a trip to the Indonesian seas in 1929-1930, scientists aboard the Dutch vessel *Willibrord Snellius* pioneered a new technique. Using an explosive bottom sampler called the Piggot gun, they brought up a 6-foot core of marine sediment for analysis. This core-sampling technique and its later refinements opened up huge advances in marine geology.



Visionary Scientists

Many visionary scientists pursued ocean research in the late 19th and 20th centuries, often working cooperatively with scientists from other nations. They developed new techniques and research questions. Many worked within large institutions and governments because of the high costs of ocean science. The need to train new scientists led to the founding of many great oceanographic institutions.

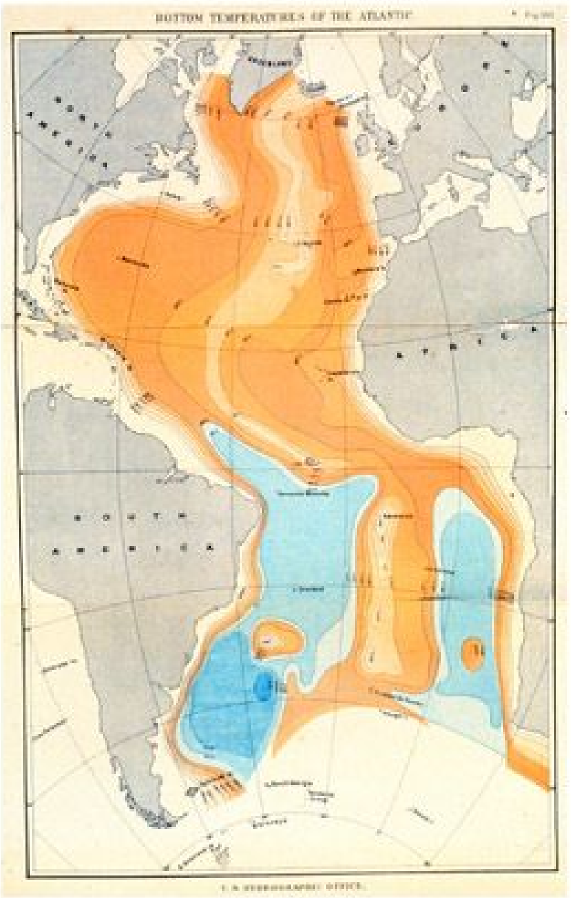
Ocean scientists also dealt with political concerns. Whether a result of institutional or international politics, issues of money and power have frequently steered the course of investigations carried out at sea.

Spencer Fullerton Baird (1823-1887)

An energetic American zoologist, Baird served for many influential years (1850-1887) at the Smithsonian Institution, establishing the National Museum and later becoming Secretary. Concurrently, he was appointed head of the new U.S. Fish Commission in 1871. The Marine Biological Laboratory he established at Woods Hole, Massachusetts has evolved into a major oceanographic institution, and under his direction the research vessel *Albatross* performed studies of fisheries and coastal ecology. Baird's scientific work had a very broad range, from birds and reptiles to marine biology, and he published over 1,000 articles and books.

Alexander Agassiz (1835-1910)

A naturalist, Alexander Agassiz began oceanographic studies in 1877 and led American oceanographic work aboard the *Blake* in the Atlantic. Agassiz was also an industrialist. Some of his profits later supported Harvard's Museum of Comparative Zoology, which had been founded by his father Louis Agassiz.



The elder Agassiz was a renowned geologist and zoologist whose teaching method - direct studies from nature – greatly influenced the development of science in America.

Reginald Fessenden

Widely known today for making the first radio broadcast in 1906, Canadian Reginald Fessenden invented over a hundred patentable devices. While employed at the Submarine Signal Company of Boston, Fessenden designed an underwater sound oscillator (left). It was successfully tested in 1914, and became the basis for the echo sounder, the Iceberg Detector, and the sonic depth profiler - devices that re-shaped our knowledge of the underwater environment and sea floor.

Victor Hensen

Hensen was a German physiologist who coined the term plankton for the simplest forms of marine life, those minute animals and plants that drift through the water and provide essential food for larger organisms. He led a significant study of Atlantic plankton in 1899.

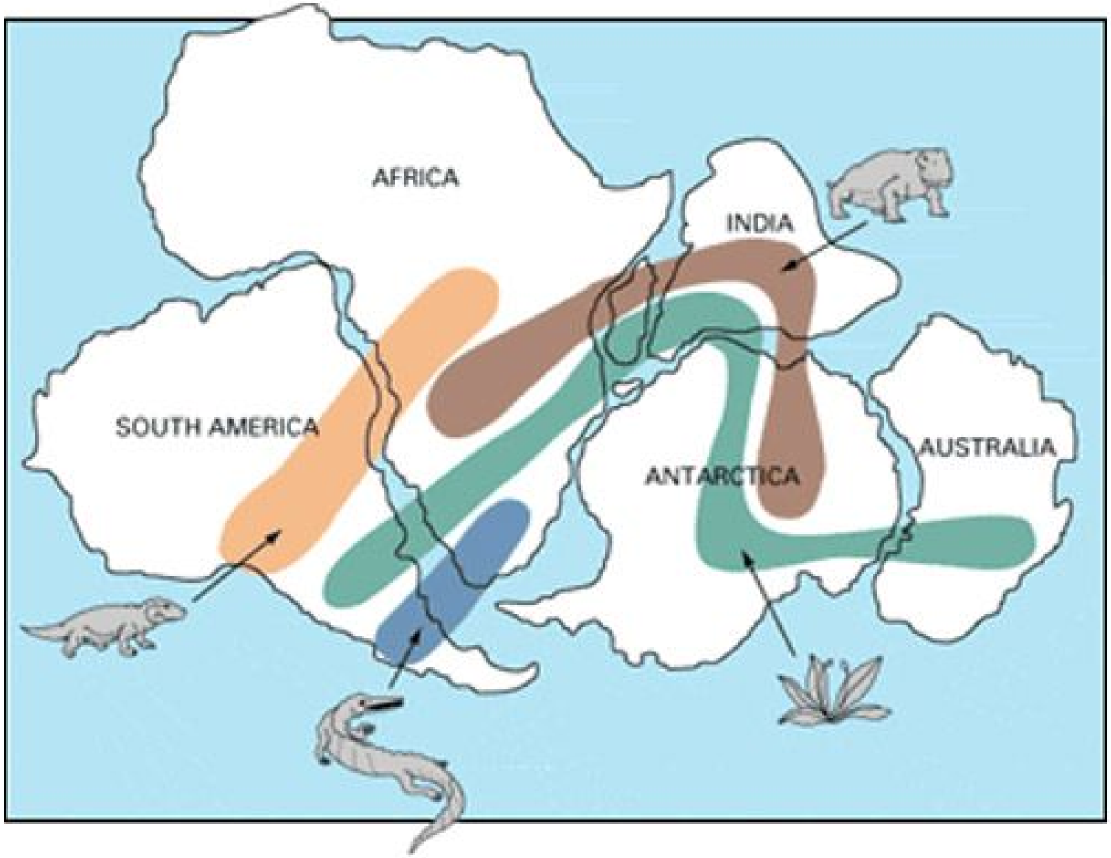
Henry Bigelow

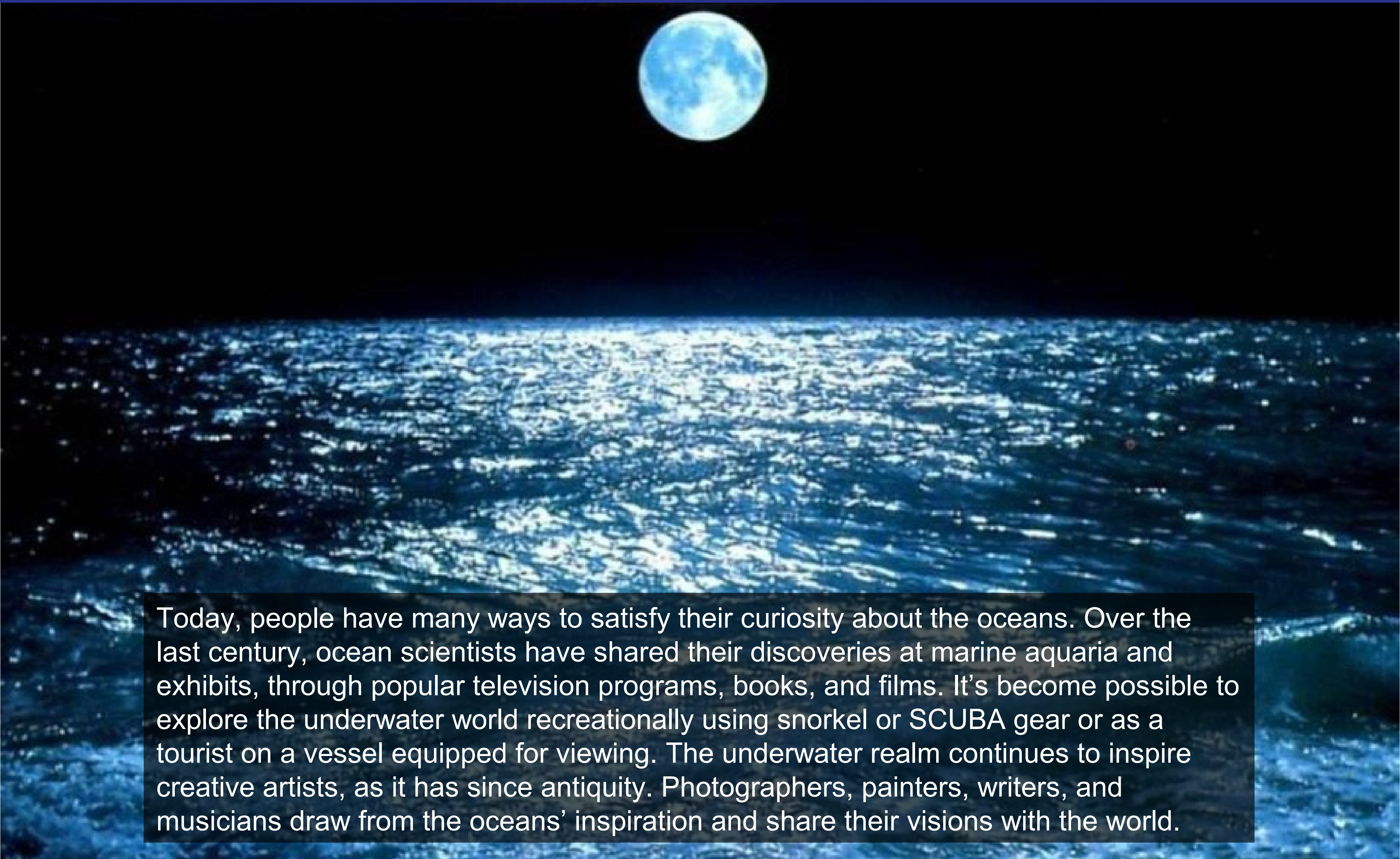
Bigelow (above), a student of the legendary Alexander Agassiz, was inspired by the ICES method to perform long-term studies of a single body of water: the biologically rich Gulf of Maine. Over several decades, Bigelow ran studies on fish, plankton, and hydrography, resulting in a fuller understanding of the gulf.

Alfred Wegener

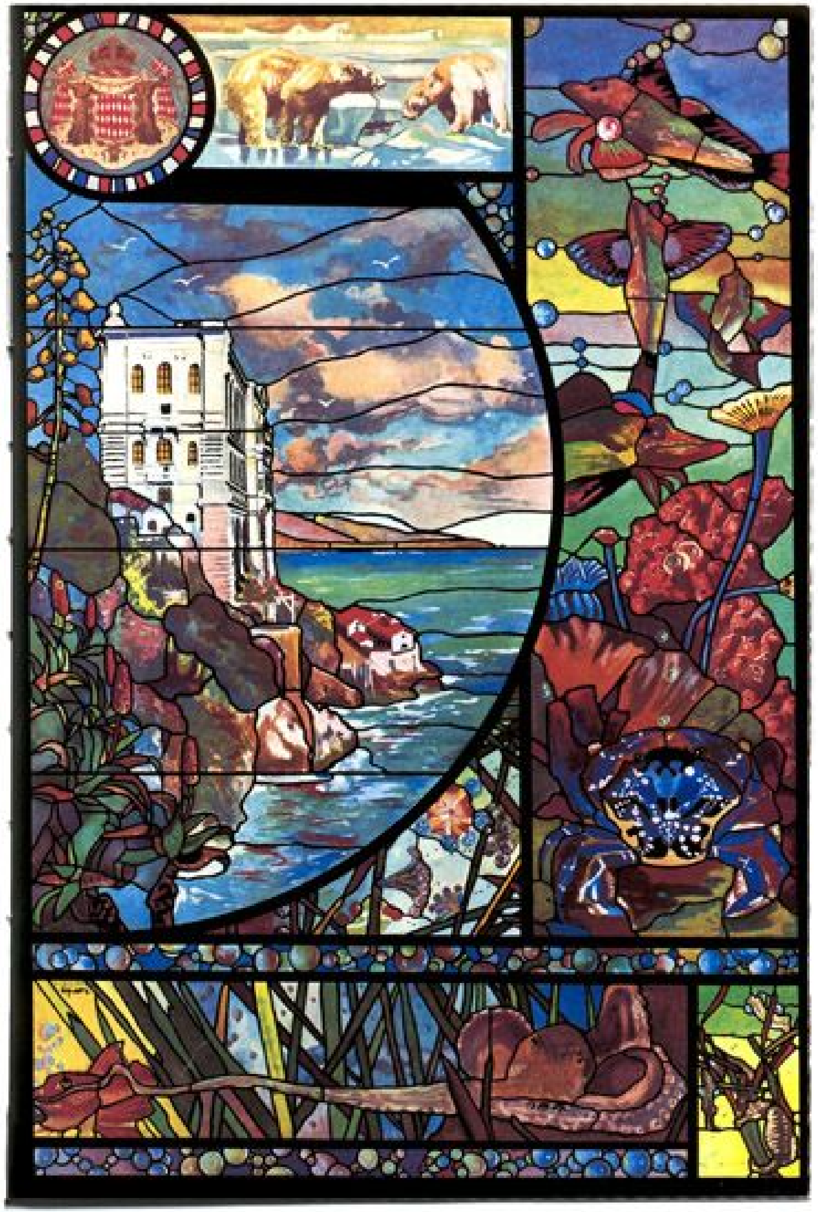
In 1912, German geophysicist Alfred Wegener proposed an idea that contradicted much of what scientists believed about the world: that the continents are not fixed in location, but have moved over millennia to their present locations. Wegener based his idea on much older scientific speculations, adding evidence from paleontology that Brazil and western Africa must have been connected at one time.

A heated debate continued for decades. In the 1960s new techniques and new evidence from sea-floor spreading and paleomagnetism emerged to support the concept of continental drift and expand it to plate tectonic theory.





Today, people have many ways to satisfy their curiosity about the oceans. Over the last century, ocean scientists have shared their discoveries at marine aquaria and exhibits, through popular television programs, books, and films. It’s become possible to explore the underwater world recreationally using snorkel or SCUBA gear or as a tourist on a vessel equipped for viewing. The underwater realm continues to inspire creative artists, as it has since antiquity. Photographers, painters, writers, and musicians draw from the oceans’ inspiration and share their visions with the world.



Aquaria and Oceanographic Museums

Growing interest in the sea led to the world's first public aquarium, opening in London in 1853. Once better techniques for keeping fish alive were developed in the 1870s, aquaria spread across Europe - and eventually around the world.

At the turn of the 20th century, the "Scientist Prince" Albert I of Monaco set up a pioneering Oceanographic Museum (with its own aquarium) and also founded an Oceanographic Institute in Paris; both still flourish. Today, marine institutes in Africa, Asia, the Middle East, Australia and New Zealand, Europe and Russia, South America and the Caribbean, and North America provide specialized training and offer public programs to share the results of their work.

Expositions and Fairs

A prime attraction at the 1933 Century of Progress Exposition in Chicago was Otis Barton's invention, the bathysphere. In this apparatus – essentially a steel sphere tied by cable to a ship on the surface – naturalist Dr. William Beebe and engineer Barton dove many times, reaching a record depth of 3,028 feet (923 meters) off Bermuda in 1934. Beebe recounted their trips into the deep ocean in many articles and books, exciting public imagination with the richness of marine life.

Diving In! Access to the Depths

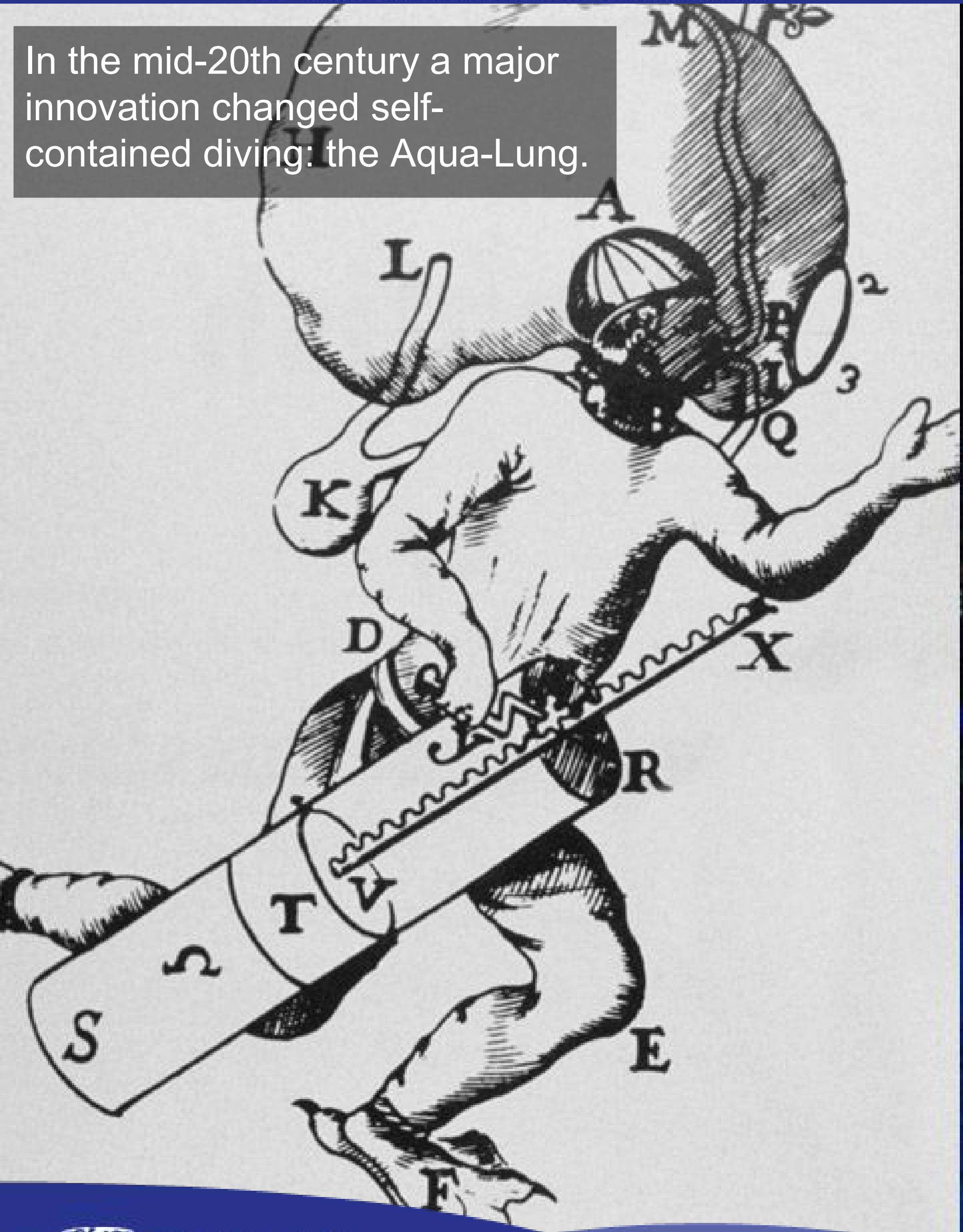
Since ancient times people have explored underwater by holding their breath.

We extended underwater time and range by capturing surface air in diving bells or going underwater in self-contained vessels.

In the 19th century, the diving helmet and suit became practical, and a form of SCUBA (self-contained underwater breathing apparatus) was invented.

Scuba opened the underwater realm to recreation as well as science and warfare.

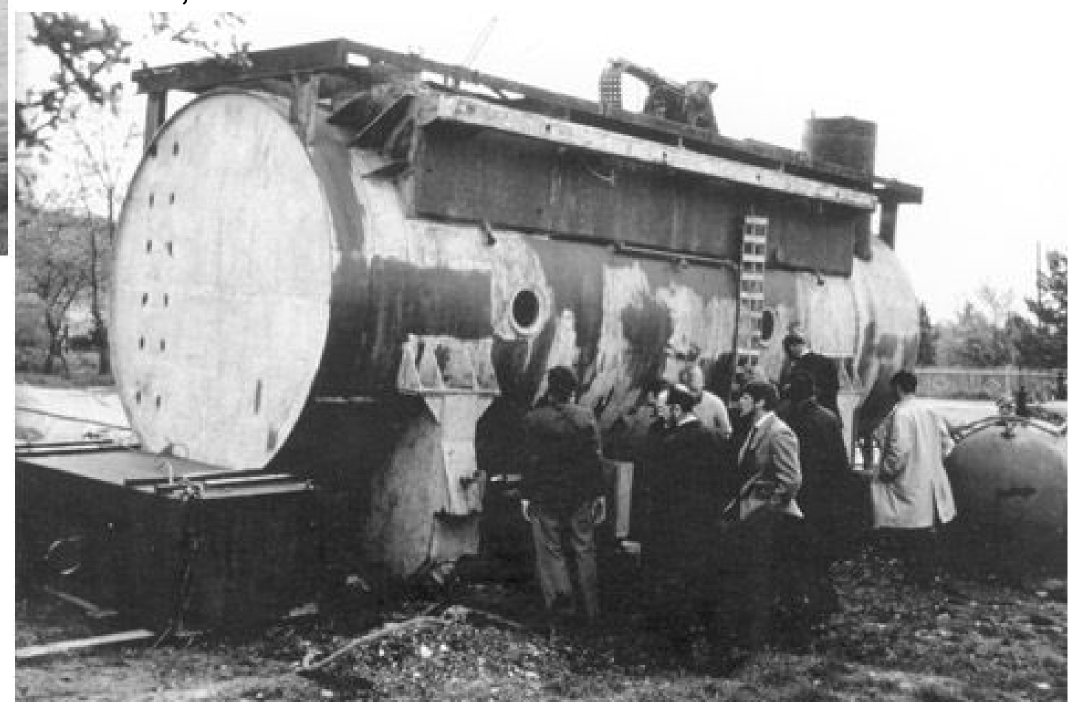
In the mid-20th century a major innovation changed self-contained diving: the Aqua-Lung.



In 1943 Jacques-Yves Cousteau and engineer Emile Gagnan created a regulator that automatically supplied compressed air when a diver breathed in. Marketed commercially beginning in France in 1946, the Aqua-Lung was carried on the diver's back and used with an insulating suit. This combination freed divers to explore without being tethered to a vessel.

Vessel diving

Vessel diving continued to be an important means of studying the deep. Otis Barton went deeper and deeper in his bathysphere, reaching 4,200 feet (1280 meters) in 1948. In 1960 the bathyscaphe *Trieste* – a self-contained, self-propelled diving vessel designed by August Piccard – reached the deepest part of the ocean. In it, Jacques Piccard and Lt. Don Walsh descended 35,820 feet (10,918 meters, or more than 6-3/4 miles) at the Marianas Trench, southwest of Guam in the Pacific.



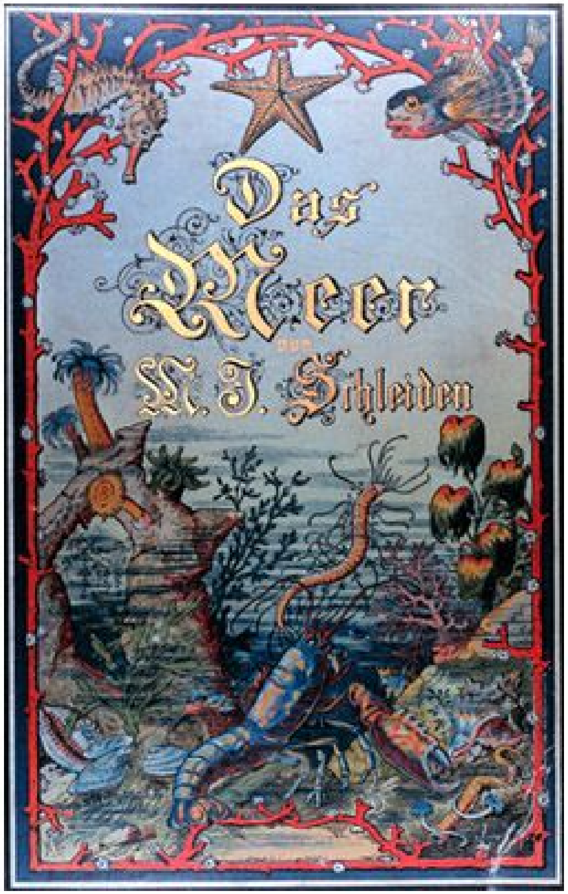
Deep ocean submersibles developed from the bathyscaphe to be more maneuverable. The first of these, *Alvin*, was built in 1964 and so far has made more than 4,200 dives. Alvin is well known for exploring newly discovered hydrothermal vents in the 1970s. It also took scientists down to survey the deep-ocean wreck site of RMS *Titanic* in 1986.

Jacques Cousteau (1910-1997)

The name Jacques-Yves Cousteau came to mean “oceans” to millions of people between the 1950s and the 1990s. The long-time director of the Oceanographic Museum in Monaco popularized ocean science. Over the course of 60 years in ocean work, Cousteau was a serious scientist, naval officer, undersea inventor, writer, and a global icon who opened the doors to the ocean and passionately defended the seas.

Film and Television

With scuba gear, photographers could go beneath the surface starting in the 1950s. Films and television broadcasts featuring underwater footage became hugely popular. Jacques Cousteau was a pioneer of underwater films and documentaries, beginning during World War Two.



The Written Word

While the 19th century French writer Jules Verne had a perennial hit in his fantastic book *Twenty Thousand Leagues Under the Sea*, the 20th century brought additional classics on the ocean. Scientist Rachel Carson published *The Sea Around Us* and *The Edge of the Sea* in the 1950s. This award-winning ocean biography combined science with lyrical writing to explain the formation, evolution, and life of the oceans. Bestsellers in 29 languages, these books brought world attention to the ocean.

Music

Musicians and composers have long taken inspiration from the sea. Traditional music includes sea-related work and folk songs from all cultures.

Popular and classical composers express the inspiration of the sea in more formal ways. Today's recording technology creates a different realm of "sea music." Incorporating underwater sounds like the song of the humpback whale has been popular for decades. There are now underwater music festivals that use the acoustics of the ocean and offer underwater broadcasts to audiences of snorkelers and SCUBA divers – a total musical immersion.

Art and Photography

Artists and sculptors have always depicted the sea, its mythological and natural inhabitants, in thousands of ways. Underwater exploration offered artists new subjects. Exotic marine animals like whales and dolphins, once known to only a few seafarers, became better known and therefore more popular in art.
Development of underwater cameras began in the 19th century, and made a huge advance with SCUBA gear after the Second World War.
While underwater is still the most challenging realm for photography, the resulting images have been enormously popular.

Late 20th Century Oceanography in the International Arena

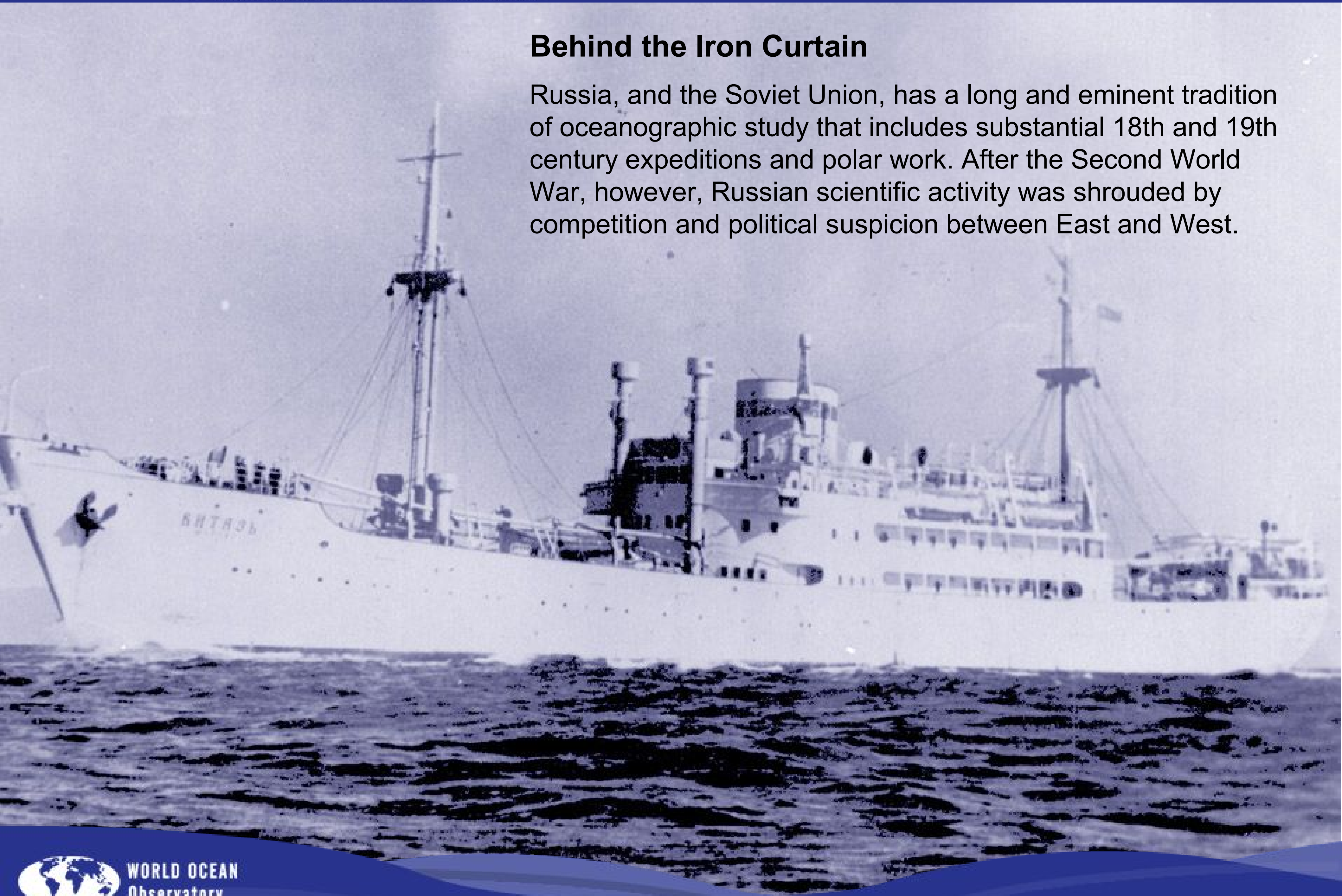
World events of the mid and late 20th century forced cooperation between navies and scientists, a collaboration now typical for oceanography.

World War Two required all the world's navies to know more about the sea. Physical oceanographers studied waves, weather, and surf conditions so that armed forces could plan amphibious landings, contributing to the knowledge of ocean climatology.

After the war, the intensifying Cold War between the USSR and the US moved to the deep sea. The United States responded to the threat of submarine warfare with the Soviet Union by funding major oceanographic and military research on the submarine environment. Soviet scientists competed with their own studies, although with fewer resources. Ocean science also focused on geology and geophysics as the idea of continental drift was examined. International efforts became important in this era.

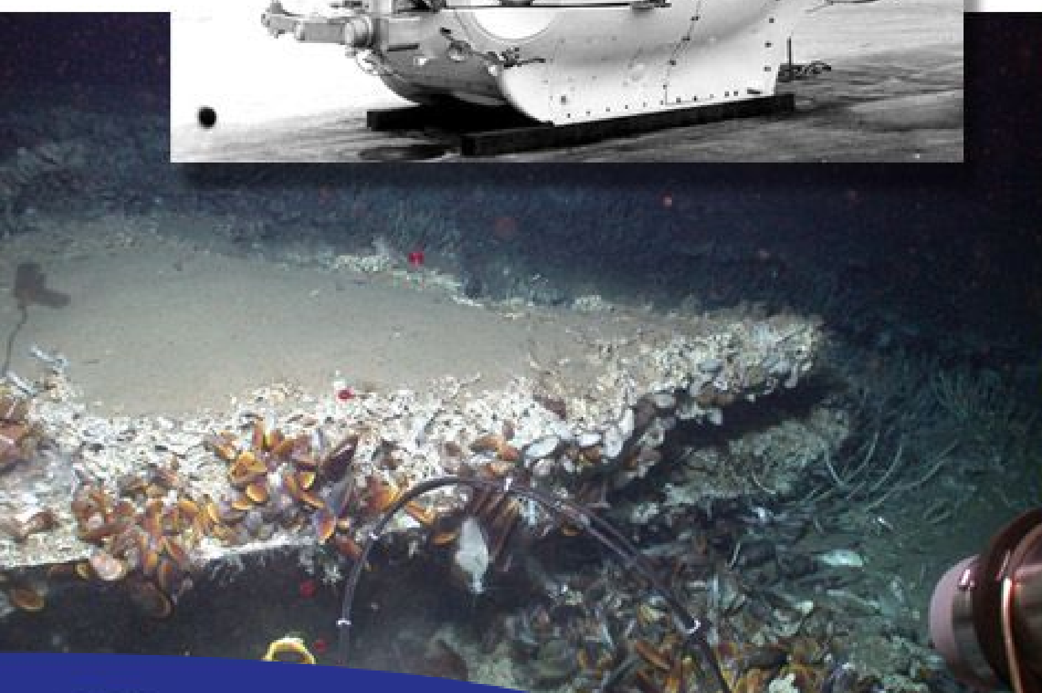
Behind the Iron Curtain

Russia, and the Soviet Union, has a long and eminent tradition of oceanographic study that includes substantial 18th and 19th century expeditions and polar work. After the Second World War, however, Russian scientific activity was shrouded by competition and political suspicion between East and West.

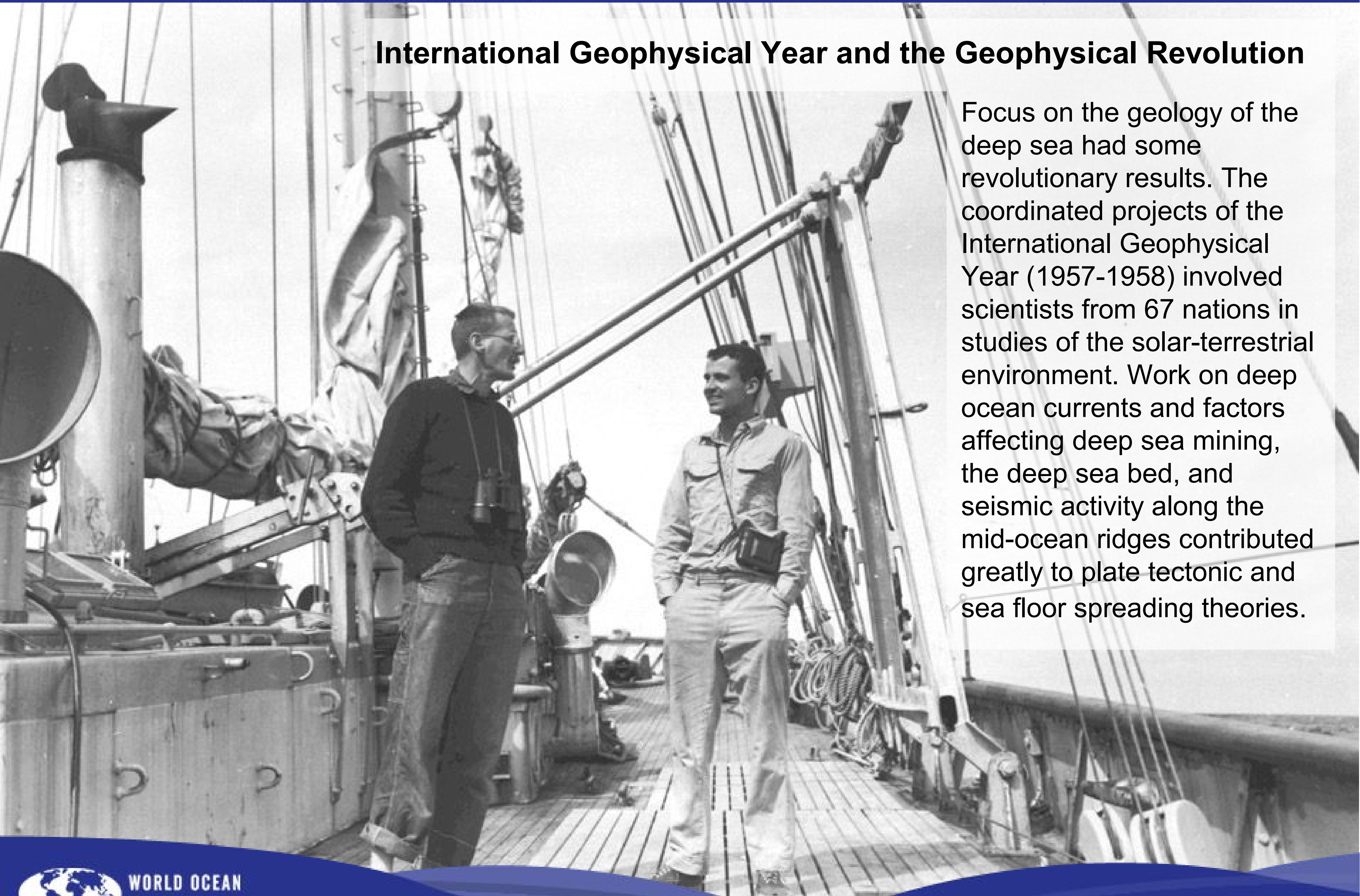


The United States Navy

The focus on antisubmarine warfare made navy funds available to hundreds of American scientists and institutions for widespread ocean surveys. Sonar, ocean acoustics, underwater weapons, and conventional and nuclear submarines that could run quietly all developed quickly. The Navy improved the bathyscaph, built a deep sea piloted submersible (*Alvin*) in 1964, and began to test undersea robots in the 1960s. These contributed to exciting new discoveries in geology, as well as to continuing Cold War submarine warfare.



International Geophysical Year and the Geophysical Revolution

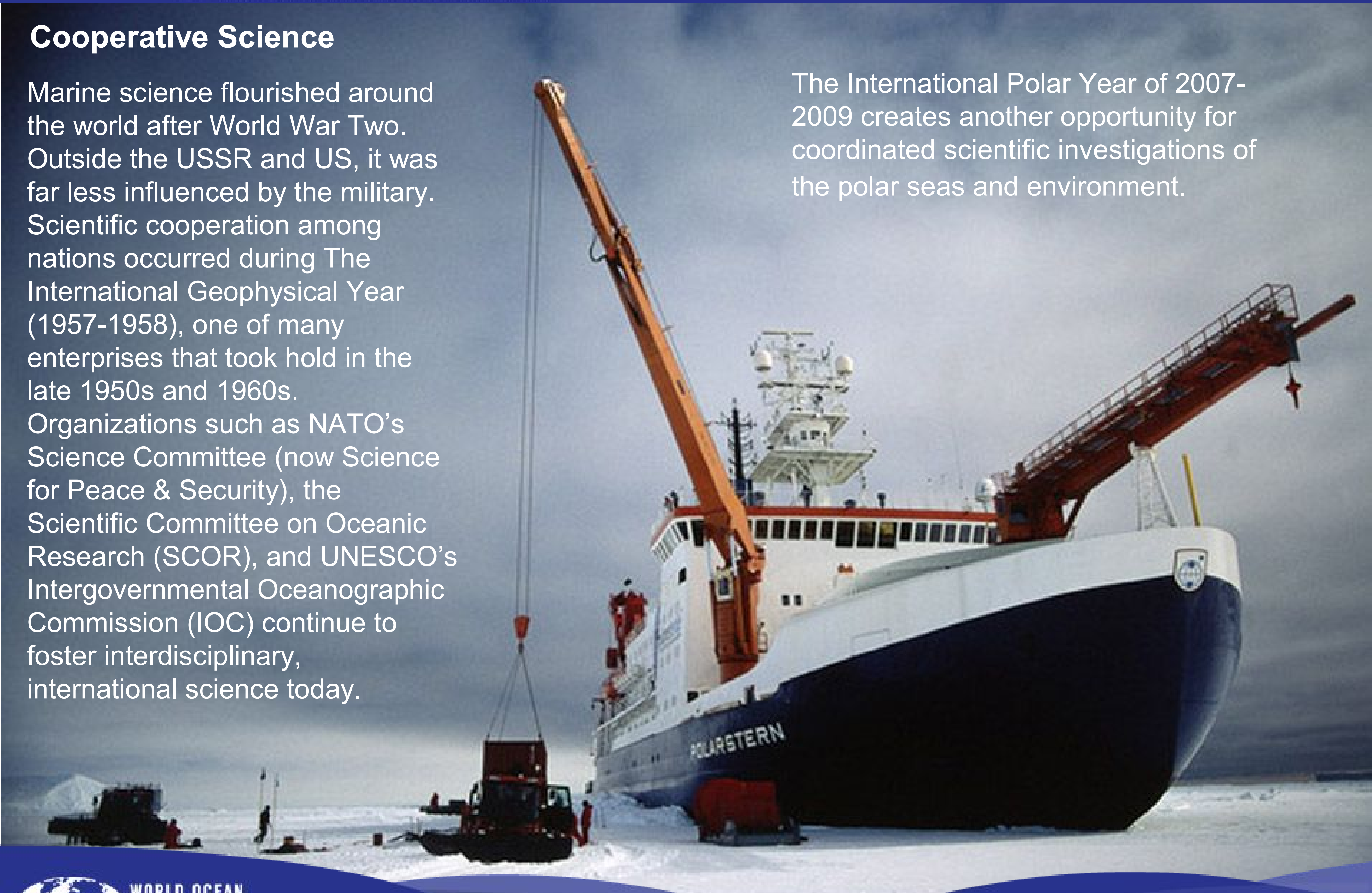


Focus on the geology of the deep sea had some revolutionary results. The coordinated projects of the International Geophysical Year (1957-1958) involved scientists from 67 nations in studies of the solar-terrestrial environment. Work on deep ocean currents and factors affecting deep sea mining, the deep sea bed, and seismic activity along the mid-ocean ridges contributed greatly to plate tectonic and sea floor spreading theories.

Cooperative Science

Marine science flourished around the world after World War Two. Outside the USSR and US, it was far less influenced by the military. Scientific cooperation among nations occurred during The International Geophysical Year (1957-1958), one of many enterprises that took hold in the late 1950s and 1960s. Organizations such as NATO's Science Committee (now Science for Peace & Security), the Scientific Committee on Oceanic Research (SCOR), and UNESCO's Intergovernmental Oceanographic Commission (IOC) continue to foster interdisciplinary, international science today.

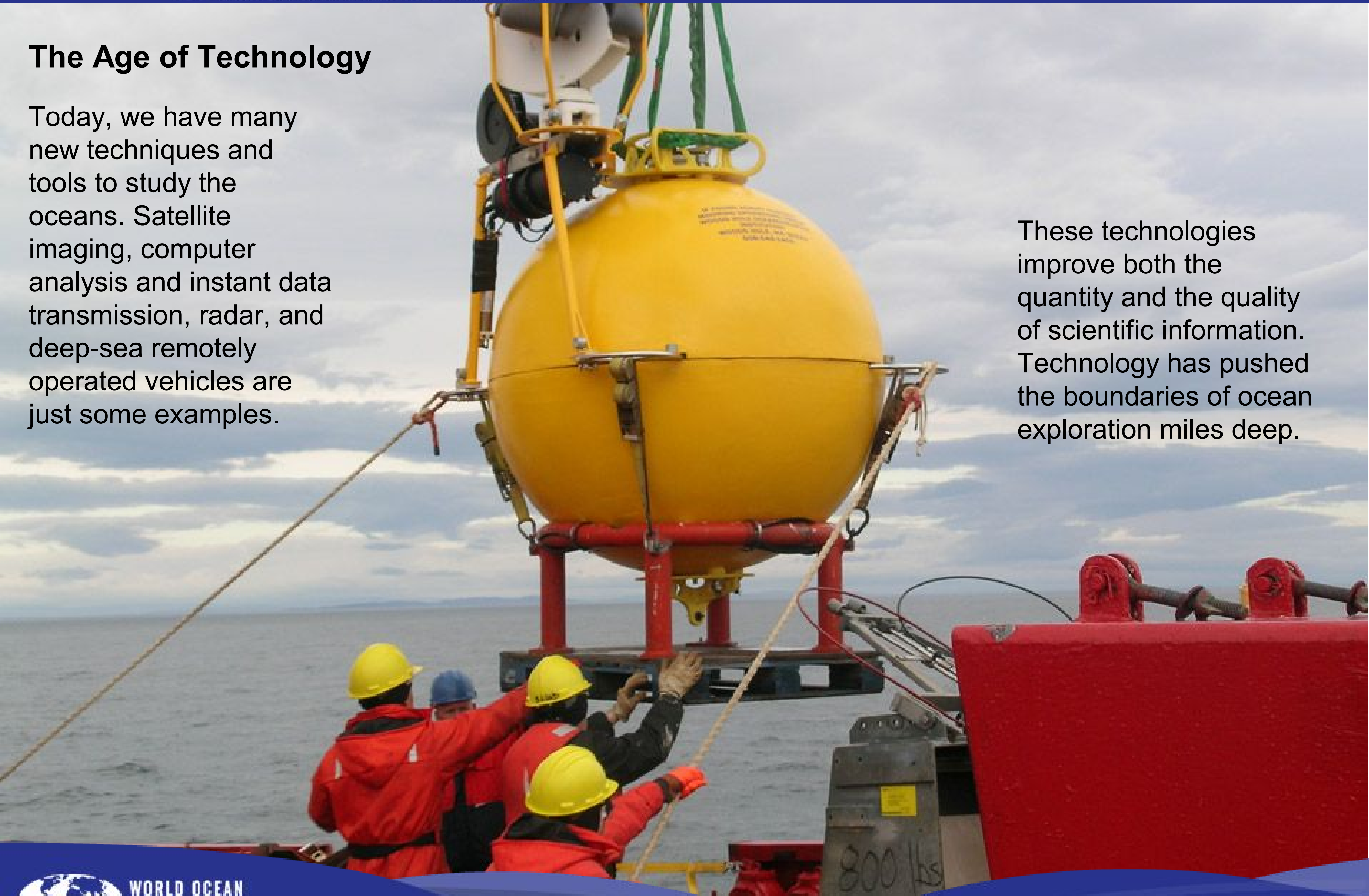
The International Polar Year of 2007-2009 creates another opportunity for coordinated scientific investigations of the polar seas and environment.



The Age of Technology

Today, we have many new techniques and tools to study the oceans. Satellite imaging, computer analysis and instant data transmission, radar, and deep-sea remotely operated vehicles are just some examples.

These technologies improve both the quantity and the quality of scientific information. Technology has pushed the boundaries of ocean exploration miles deep.



Recent Discoveries

Remotely operated vehicles (ROVs) make it possible to explore parts of the sea floor that would be too difficult to reach in a manned submersible.
Discoveries made by deep submersibles include volcanic activity and hydrothermal vents rich in mineral deposits, black smokers (undersea geysers that shoot out dark water), deep sea vents with organisms that thrive at high-temperatures, and other phenomena.

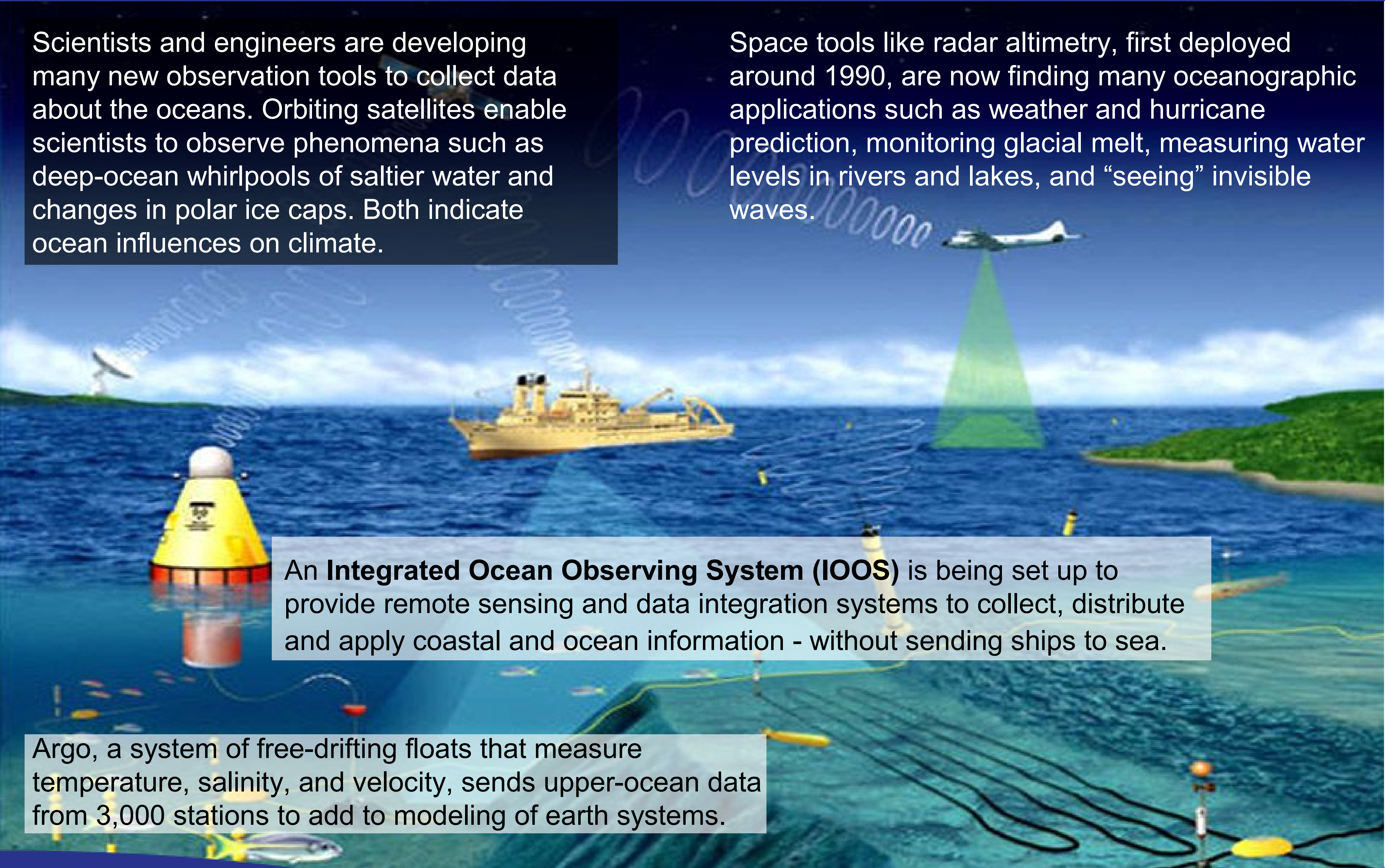
Underwater vehicles open up the possibility of deep-sea mining for minerals.

MILES DOWN!

OCEANOGRAPHY THROUGH HISTORY

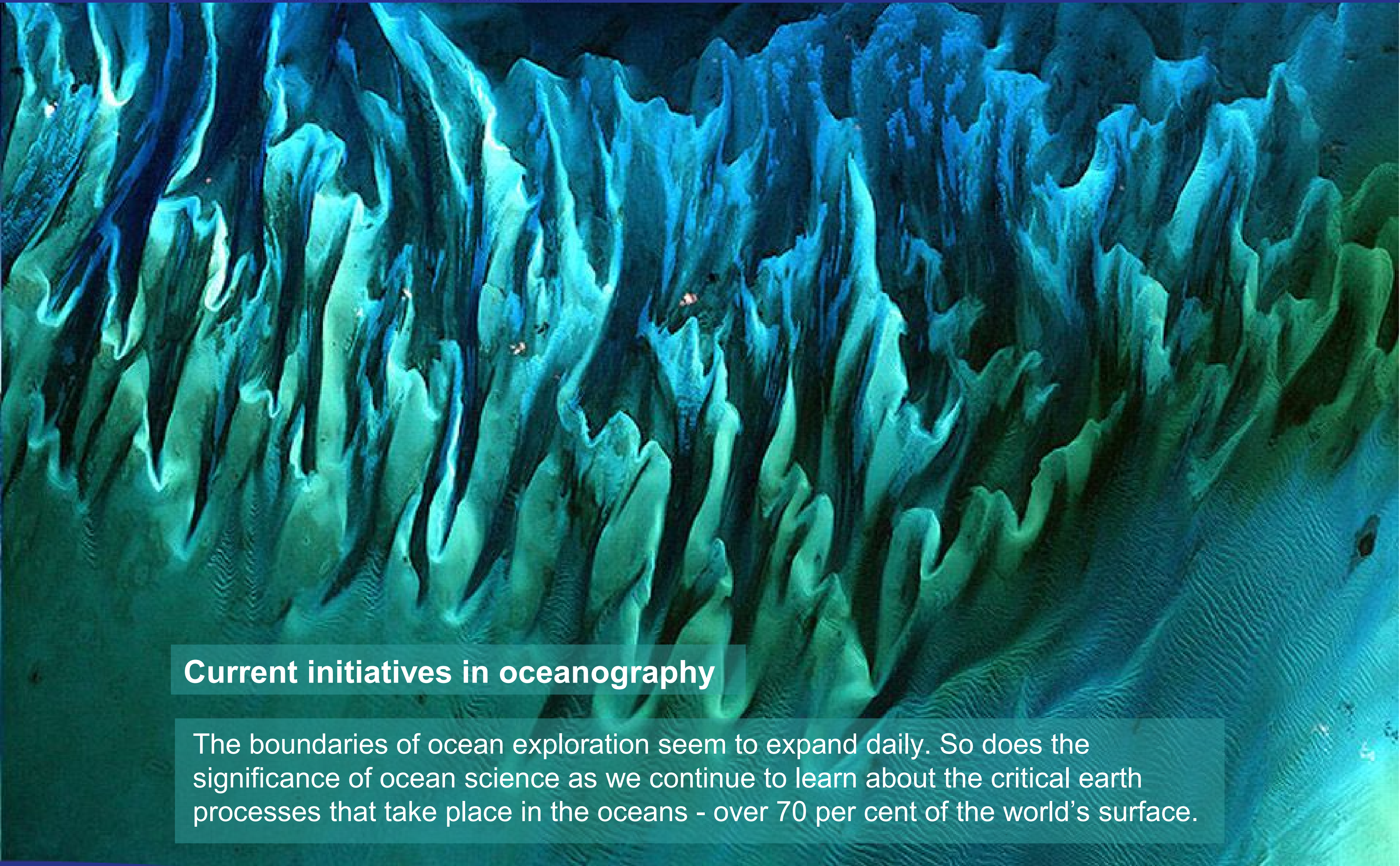
Scientists and engineers are developing many new observation tools to collect data about the oceans. Orbiting satellites enable scientists to observe phenomena such as deep-ocean whirlpools of saltier water and changes in polar ice caps. Both indicate ocean influences on climate.

Space tools like radar altimetry, first deployed around 1990, are now finding many oceanographic applications such as weather and hurricane prediction, monitoring glacial melt, measuring water levels in rivers and lakes, and “seeing” invisible waves.



An **Integrated Ocean Observing System (IOOS)** is being set up to provide remote sensing and data integration systems to collect, distribute and apply coastal and ocean information - without sending ships to sea.

Argo, a system of free-drifting floats that measure temperature, salinity, and velocity, sends upper-ocean data from 3,000 stations to add to modeling of earth systems.



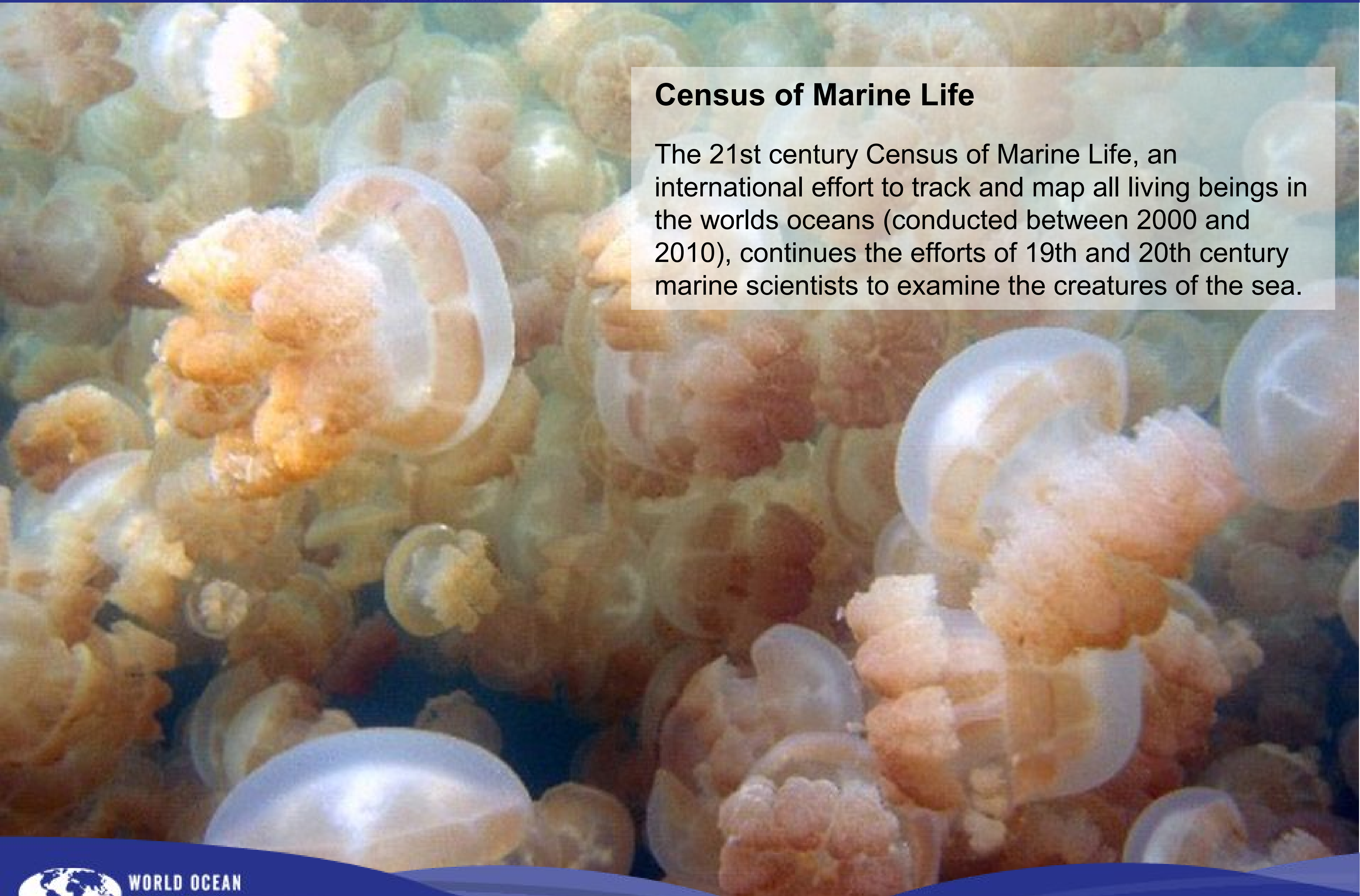
Current initiatives in oceanography

The boundaries of ocean exploration seem to expand daily. So does the significance of ocean science as we continue to learn about the critical earth processes that take place in the oceans - over 70 per cent of the world's surface.

The emergence of oceanography brought together many branches of science and applied them to the oceans.

Today, oceanography contributes to a holistic systems science that sees all earth's phenomena as interrelated.

The oceans are inseparable from the atmosphere and the land. The oceans' role in climate change, the Arctic and Antarctic regions, seafloor mapping, and the status of marine life are among current initiatives in oceanography.



Census of Marine Life

The 21st century Census of Marine Life, an international effort to track and map all living beings in the worlds oceans (conducted between 2000 and 2010), continues the efforts of 19th and 20th century marine scientists to examine the creatures of the sea.

Climate and Arctic Studies

Deep-ocean circulation patterns govern the planet’s climate. The traditional oceanographic studies of water temperature, depth, and salinity, which define water masses and drive their circulation, are as important as ever. Oceans data from the Arctic Ocean is especially critical to understanding changes in earth’s climate everywhere.

Ocean Frontiers

Medicine, climate, public health, and hydrology are among the many new frontiers of ocean information to be explored in the years to come. Deep sea mining, medicines using marine material, and food fish are among the commercial interests on the frontiers of the ocean. The more oceanography is done, the greater scientific basis exists for international projects in the shared oceans.