Principle 7: Grades 9-12

Principle 7: The ocean is largely unexplored.

Ocean Exploration Requires Technological Innovations

C.
The ocean covers 70% of the Earth, but less than 5% of it has been explored, due to extreme physical properties of the ocean that make exploration difficult, e.g., temperature, light, salinity, depth, vastness, and pressure. The ability to explore the ocean depends on the development and use of new technologies, all of which have strengths and limitations.

C.1.
Scientific models and simulations are used to describe, manipulate and experiment with ocean systems, in order to better understand these systems and their interactions, interconnections and interdependence.

C.3.
Scientific models are physical, mathematical, or logical representations of entities, processes and phenomena that make them comprehendible (e.g., computer rendering of ocean circulation patterns).

C.4.
Simulations are the implementation of these models over time to test, analyze and experiment with the representations of these real-world ocean systems.

C.5.
Scientific models are limited by the accuracy of their representation of the complexity of ocean systems, which in turn is limited by: our scientific knowledge of the systems; our ability to transform our knowledge into accurate mathematical equations; our ability to collect sufficient types and quantity of data over time and geographic locations; and the power of computers to use these data to recreate the systems and make calculations and simulations.

C.6.
Advances in technology, such as satellites, seafloor and sea surface observatories and digital media, have facilitated improvements in scientific models and simulations because they offer scientists extensive real-time data over time and space.

C.7.
Tools and technologies have been developed and deployed both in outer and inner space to collect a wide variety of data from ocean systems over time and geographic location.

C.8.
Submersibles allow scientists to observe and collect data below the ocean's surface. These include Human-Occupied Vehicles (HOVs), Remotely-Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs).

C.9.
HOVs allow scientists to go down to great depths to observe and collect samples. HOVs are compact and dependent on surface-support vessels.

C.10.
Groundbreaking research, such as the discovery of life at hydrothermal vents, has been done in HOVs. However, they are not capable of reaching the deepest regions in the ocean, are costly to operate, and lack the versatility and endurance of ROVs and AUVs.

C.11.
ROVs are underwater robots tethered (i.e., linked by a cable) to a ship and operated by a pilot on that ship. The cables carry electrical power, video and other data signals back and forth between the pilot and the vehicle.

C.12.
ROVs can be outfitted with additional sensors and equipment, such as sonars, magnetometers, robotic arms and water samplers, so scientists can collect data and specimens, and conduct experiments deep under the surface of the ocean.

C.13.
AUVs are undersea computer-controlled systems. There is no physical connection to their operator, who may be onshore or aboard a ship. They are self-guiding and self-powered, are safe from bad weather and can reach shallower water than boats and deeper water than human divers or ROVs.

C.14.
AUVs can be outfitted with oceanographic sensors to measure numerous physical and biological features of the ocean. The geographic coverage and length of deployment time to collect data by AUVs is not limited by a cable or human occupant.

C.15.
Scientists and natural resource managers use this data to understand the ocean and climate processes, as well as to monitor water quality and other activity around protected areas.

C.16.
Satellites collect and transmit large-scale, continuous data from sensors (e.g., satellite imagery), or transmitters on buoys placed in fixed locations in the ocean, or on AUVs and living organisms that move throughout the ocean.

C.17.
Scientists, and citizens alike, use satellite data from buoys in fixed locations to obtain information about local and regional places to understand daily, seasonal or annual patterns of change at these locations.

C.18.
AUVs, such as gliders, can be programmed to collect data from specific depths along pre-determined paths. Satellites receive the data from the AUVs to obtain information about the ocean surface and water column for a geographic region.

C.19.
Satellite data from living organisms (e.g., from transmitters attached to elephant seals, tuna and/or sea turtles) provide information such as where these organisms travel. Scientists use this data to understand the geographic range and distribution, habitats and migratory patterns of these organims.

C.20.
Satellites with cameras and radiometers provide extensive images of the ocean surface. For example, data from NOAA and NASA satellites are used to map sea surface temperatures and productivity.

C.21.
Ocean-observing systems (OOS) are newer approaches to studying the ocean. They provide scientists with extensive and continuous data about the Earth, ocean and atmosphere, so they can investigate the interactions and interconnections of ocean and climate processes, and the impacts from human activities.

C.22.
An OOS employs both remote and *in situ* sensing methods to gather data. Remote sensing includes satellite-, aircraft- and land-based sensors, power sources and transmitters. *In situ* sensing includes platforms (ships, buoys, gliders), sampling devices, power sources and transmitters. These devices and sensors collect a variety of data, such as salinity, sea surface temperature and cloud cover, which are transmitted to computers in labs onshore.

C.23.
Advancements in technology to conduct molecular analysis (e.g., DNA technology and isotope analysis) provide scientists with more detailed information on organisms in large-scale systems (e.g., population structures, food webs and migrations).