Sea

The Korean Peninsula is surrounded by water on three sides, and is connected to China to the north. As South Korea is located at the gateway to the continent, it has a long history of active trading through the ocean. Korean navigation techniques involving tidal currents, ocean currents, and wind are also much more advanced than what is widely known. In terms of topography and climate, Korean seas have more complicated structures than those of any other country. Not only do they have various physical, chemical, and geological factors—such as seasonal ocean currents, tides, and complex topographical features—they have a range of marine lives with unique characteristics.

The eastern coastline of Korea is relatively simple, while the south and west coasts are complex with diverse coastal landforms. There are a total of 3,418 islands located around the Korean coastal areas, mainly concentrated in the South Sea and the Yellow Sea.

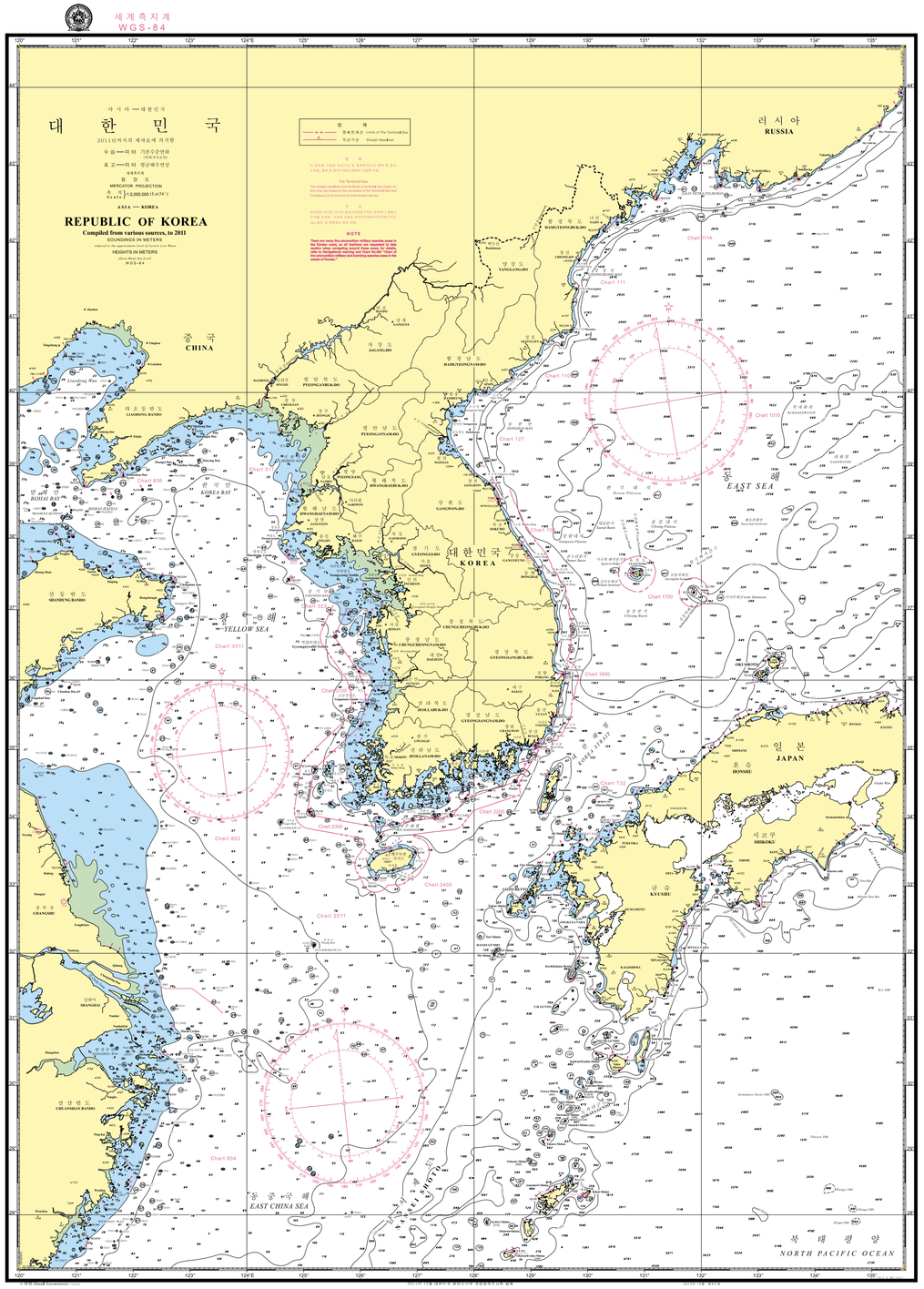
The Yellow Sea, which extends into the East China Sea, is characterized by shallow water less than 80 m deep and gently sloping submarine topography. It is named after its yellowish color, which arises from sediment-rich river water from the Yangtze and the Yellow River of the Chinese mainland. It has a low average salinity (30 – 33‰) that can be attributed to the influence of freshwater from the many rivers flowing from the Korean Peninsula and China. Sea surface salinity is further reduced during the rainy season of the summer due to an increase of freshwater from the land. During the warmer conditions of spring to summer, thermocline and halocline develop at a depth of 20 – 30 m, leading to stratification with high temperatures at the surface and low temperatures at the bottom. In winter, the cooling of the surface water causes vigorous vertical mixing, thus making stratification disappear. The Yellow Sea has a well-developed tidal current that arises from strong tidal activities.

The southern coast is mainly composed of the Korea Strait, which separates Korea and Japan. It is characterized by shallow water with an average depth of less than 100 m, and is a narrow waterway through which the Tsushima Current passes. Throughout the seasons, it is greatly affected by the fluctuation of the Kuroshio Current, which carries subtropical seawater characterized by high temperatures and high salinity. During the summer, seawater with low salinity from the East China Sea is distributed in the upper layer, while high-salinity seawater from the Kuroshio Current (known as Kuroshio Intermediate Water) spreads in the lower layer. Only Kuroshio Intermediate Water remains during the winter, due to the absence of low-salinity seawater from the East China Sea.

The east coast has a relatively simple coastline with deep water that reaches depths of 2,000 – 3,000 m. It has well-developed narrow beaches, but the steep slopes of coastal and seabed topography prevent the development of tidal flats and continental shelves. The submarine topography of the east coast is divided into three major basins. The Japanese Basin, which is over 3,000 m deep, is located to the north. In the south, the Yamato Uplift stands in the center, with the Ulleung Basin to the west and the Yamato Basin to the east. The Tsushima Current – which flows into the East Sea through the Korean Strait – spreads along the surface of the East Sea, while the East Sea Proper Water can be seen in the deep sea layer. With a salinity of 34.0 – 34.1% and a temperature of 0 – 1°C, the East Sea Proper Water displays characteristics that are only witnessed in the East Sea. The Tsushima Current (flowing from the south) and the Lehman Cold Current (flowing from the north) also meet at the East Sea.

Ocean

Ocean Map at a Scale of 1:2,000,000



Korea Hydrographic and Oceanographic Agency (2011)

History and Exploration of Oceans and Seas

History of the Korean Seas and Coastline

1787 French ocean explorer La Perouse surveyed Korean coastal waters.

1797 Broughton of England surveyed the east coast and the Port of Busan.

1816 Maxwell and Hall of England measured water temperature in the Yellow Sea and surveyed the west coast.

1845 Belcher of England surveyed the seas of Jejudo and Geomundo.

1906 The Korean Empire surveyed tides for port construction in areas such as Busan and Incheon.

1949 The Department of Hydrography (now the Korea Hydrographic and Oceanographic Agency) was founded in the Operation Agency of Navy Headquarters.

1973 The Ocean Development Institute was established (now the Korean Institute of Ocean Science and Technology).

1977 Tamhae, a marine resource research vehicle, was developed.

1984 The Korea Shipping Technology Institute was established (now the Korea Maritime Institute).

1986 Haeyang 250, an aquanautics survey submarine, was developed.

1987 The Korean Ocean Research & Development Institute (KOPRI) opened the Korean Polar Research Center.

1988 The King Sejong Station was constructed on King George Island in Antarctica.

1992 Onnuri, an ocean research vessel, started operations.

1993 An autonomous underwater vehicle that can survey at a depth of 200 m was developed.

1994 Ocean science technology development projects were launched.

1996
- The 1st phase (1996 – 2010) of surveying for basic maps of the sea was launched.
- The Ministry of Maritime Affairs and Fisheries was formed.

2000 The Korea South Pacific Ocean Research Center was created.

2002 The Dasan Arctic Station was constructed in Ny-Alesund, Spitsbergen.

2003 The Ieodo Ocean Research Station was constructed.

2004 Ocean science and technology development plans were devised.

2005
- HEMIRE, a remotely operated vehicle for deep sea floor exploration, was developed.
- The Korea Institute of Marine Science & Technology was established.

2008 The 2nd phase (2008 –) of surveying for basic maps of the sea was launched.

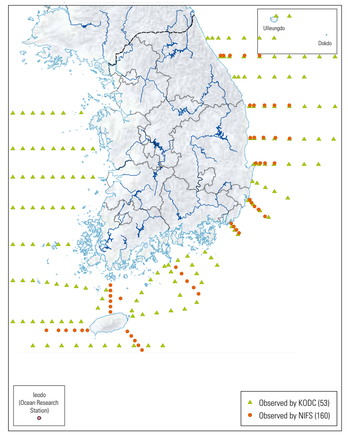
2009
- Araon, an ice breaking research vessel, started operations.
- Minero, a deep sea mineral resource collector, was developed.
- The Gageocho Ocean Research Station was constructed.

2010
- Isimi, an automatic underwater vehicle, was developed.
- Chollian, a geostationary oceanic and meteorological satellite, was launched.

2012
- The Korean Ocean Research and Development Institute (KORDI) was extended and reorganized into the Korea Institute of Ocean Science and Technology.
- The Korea National Maritime Museum opened.

Korea Institute of Ocean Science & Technology (2015)

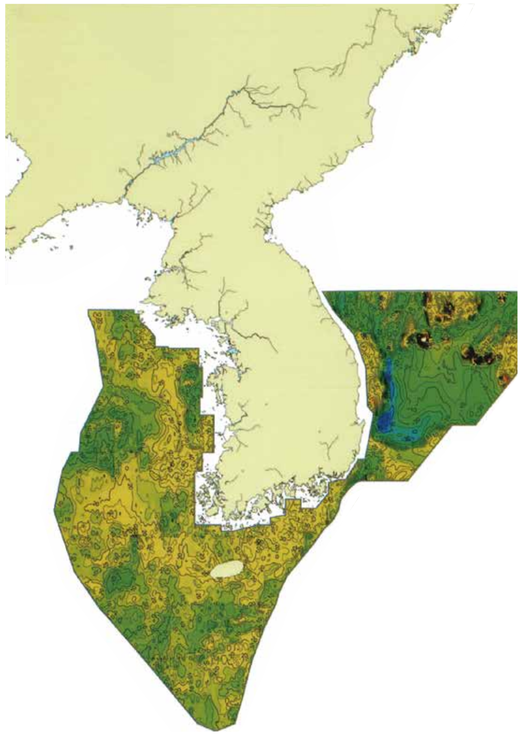
Paths of Ocean Exploration



Korea Hydrographic and Oceanographic Agency (2014)

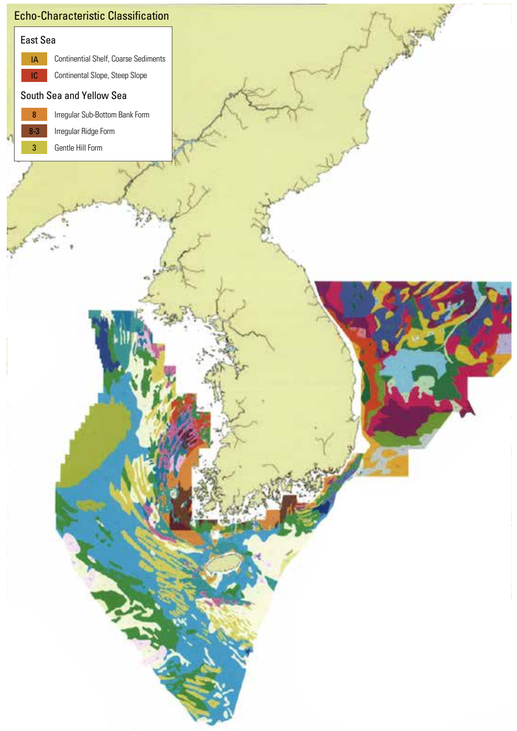
Results of Marine Surveys

Gravity Anomaly Map (National Marine Base Map, 2014)



Korea Hydrographic and Oceanographic Agency (2014)

Shallow Stratum and Topography (National Marine Base Map, 2014)

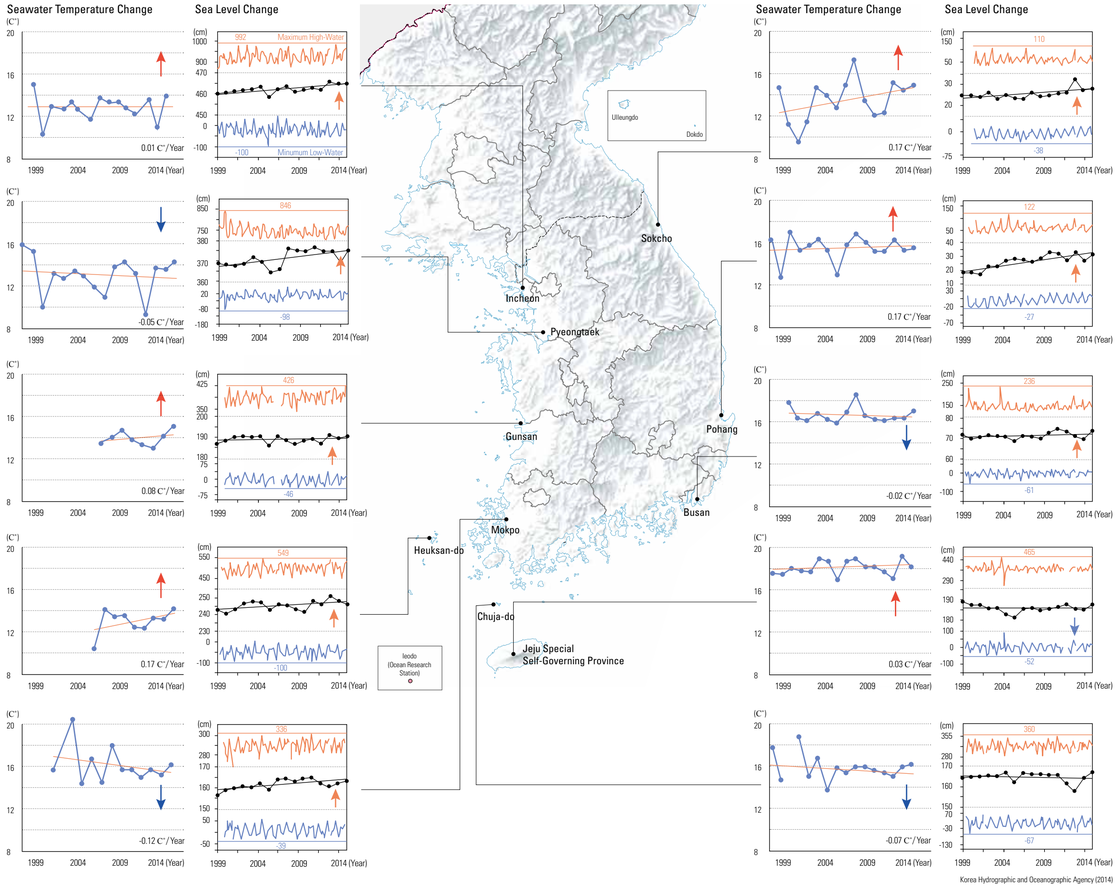


Korea Hydrographic and Oceanographic Agency (2014)

Modern marine surveying in Korea began in the 1700s, mainly carried out by foreign ocean explorers. Surveying by domestic explorers began in the mid-1900s with the founding of the Department of Hydrography in the Operation Agency of Navy Headquarters (currently the Korea Hydrographic and Oceanographic Agency: KHOA). The Ocean Development Institute, affiliated with the Korea Institute of Science and Technology (currently the Korea Institute of Ocean Science and Technology: KIOST), was established in 1973 and introduced active ocean exploration and research. Today, extensive exploration and research continues to be carried out along the coastal region of the Korean Peninsula, as well as in other regions such as the Arctic and Antarctic.

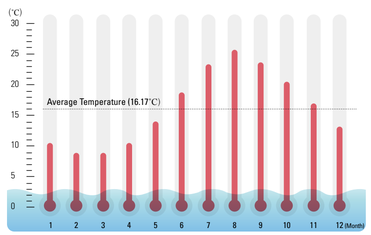
Marine surveying can be defined as the collection of oceanic data through various observation techniques to help develop an understanding of ocean characteristics and phenomena. It includes marine physical surveys, marine geological surveys, marine chemical surveys, and remote sensing data. Marine surveys in Korea are usually carried out by national institutes and laboratories such as KHOA, KIOST, and the National Institute of Fishery Science (NIFS). They are either carried out regularly or specifically for particular purposes.

Seawater Temperature and Sea Level Change (1999 – 2014)



Korea Hydrographic and Oceanographic Agency (2014)

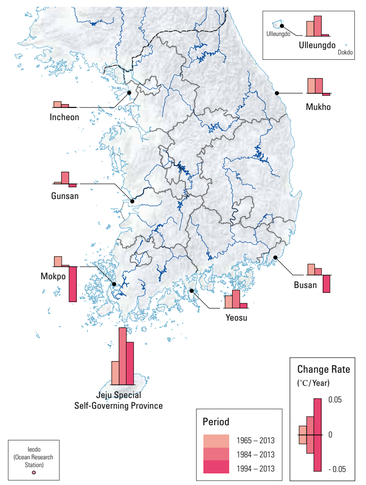
Sea Surface Temperature by Month



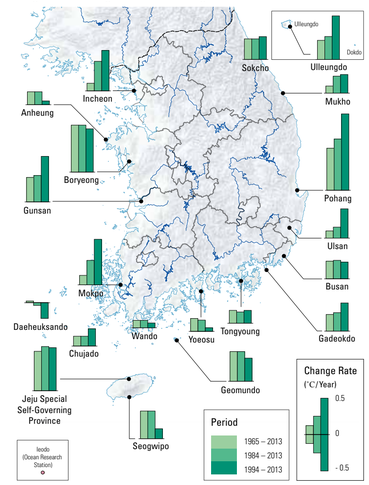
Korea Hydrographic and Oceanographic Agency (2014)

Physical surveys observe the physical properties of the ocean such as water temperature, salinity, waves, and ocean currents, while geological surveys focus on various seabed geological properties including sub-bottom profiles and bottom topography. Biological surveys collect and sort marine organisms and conduct chlorophyll analyses in order to estimate marine biota and productivity. Chemical surveys are carried out to investigate the influence of pollutants on the ocean, humans, and marine ecosystems by analyzing heavy metals, organic matter, and seawater itself. Remote sensing mainly provides data on physical, biological, geological, and chemical phenomena at the ocean surface by analyzing satellite images and aerial photographs.

Long-Term Change Rate of Sea Surface Temperature by Period



Long-Term Change Rate of Average Sea Level by Period



Korea Hydrographic and Oceanographic Agency (2014)

Physical Properties of the Ocean

Ocean Currents (Spring)

Ministry of Oceans and Fisheries, Korea Hydrographic and Oceanographic Agency (2006)

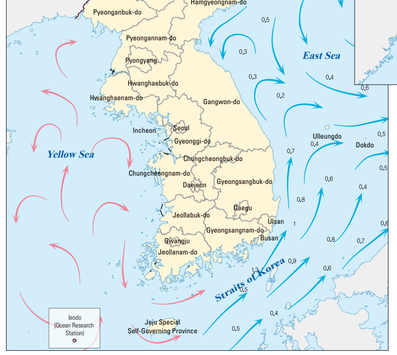
Ocean Currents (Summer)

Ministry of Oceans and Fisheries, Korea Hydrographic and Oceanographic Agency (2006)

Ocean Currents around the Korean Peninsula

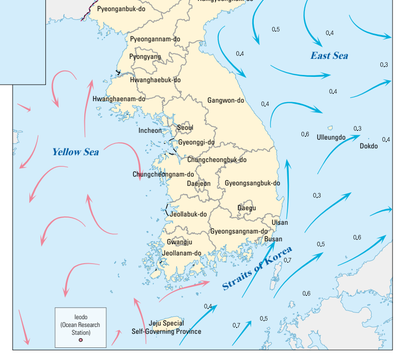
Korea Hydrographic and Oceanographic Agency (2016)

Ocean Currents (Fall)



Ministry of Oceans and Fisheries, Korea Hydrographic and Oceanographic Agency (2006)

Ocean Currents (Winter)



Ministry of Oceans and Fisheries, Korea Hydrographic and Oceanographic Agency (2006)

The Korean Peninsula is influenced by the Yellow Sea Warm Current, East Korean Warm Current, and Tsushima Warm Current, which are all branches of the Kuroshio Current. The Kuroshio Current is a western boundary current that is the second largest warm current after the Gulf Stream. It starts off at the eastern part of Taiwan in the western Pacific Ocean and flows to the north of Japan. It has high water temperatures of 20 – 30˚C and high salinity of 34 – 34.8‰.

The Yellow Sea Warm Current, which branches north off the Kuroshio Current, passes through the China Liaodong Peninsula via Heuksando and Baengnyeongdo of Korea, and reaches Bohai Bay of China when it becomes stronger in the summer. It grows weaker and changes into coastal water during autumn, heads south, and finally flows east along the Jeju Strait.

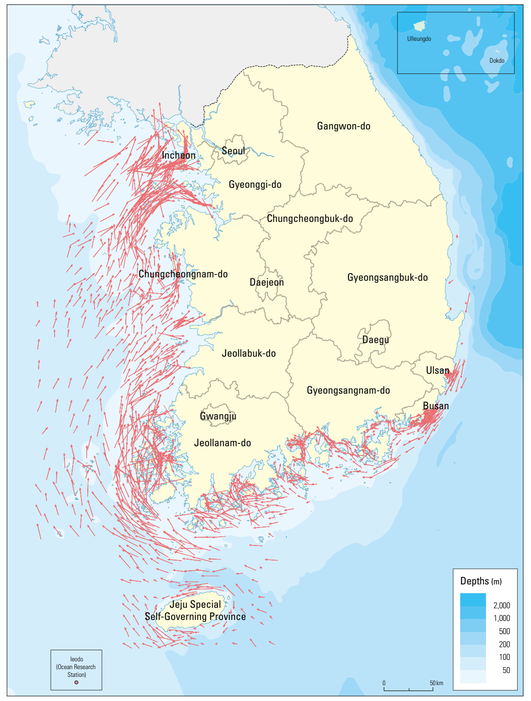
The Tsushima Current branches off the Kuroshio Current in the East China Sea and flows north along the East Sea. Characterized by high water temperature and high density, it lacks the original black color of the Kuroshio Current and is instead tinged cobalt-blue. It serves as the main factor of the snow that falls in the Yeongdong area of Korea.

The East Korean Warm Current branches off the Tsushima Warm Current at the east end of the Korea Strait and flows north along the southeast coast of the Korean Peninsula. It mixes with the North Korea Cold Current at the northern latitudes of 36 – 38˚ and changes direction toward the open sea to the southeast. The boundary between the two currents changes continuously and forms a large eddy in the East Sea. Afterwards, the current changes direction to flow northeast and finally rejoins the Tsushima Warm Current.

The Liman Cold Current begins in the vicinity of the Russian Tatar Strait and flows south along the Eurasian continent to the East Sea. While there are several theories on its formation, it is most commonly considered that the Tsushima Current cools as it flows north through the East Sea and mixes with the freshwater of the Amur River as it flows south. The Liman Cold Current, which gets its name from the Russian term that refers to the mouth of a great river, has a low temperature and low salinity and is inhabited by an abundance of cold sea fish species.

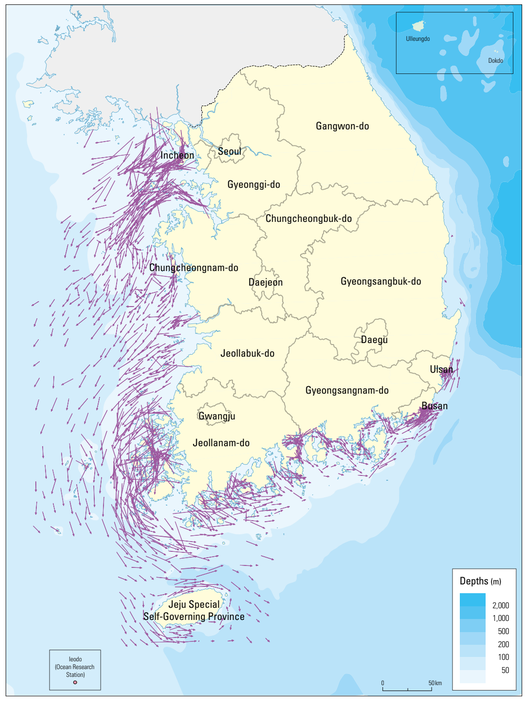
The North Korea Cold Current is an extension of the Liman Cold Current that flows southwest along the east coast of North Korea. During the summer, it reaches up to the Wonsan area of North Korea. The current is strengthened during the winter and affects as far south as Gangwon-do of South Korea.

Tidal Currents (High Tide)



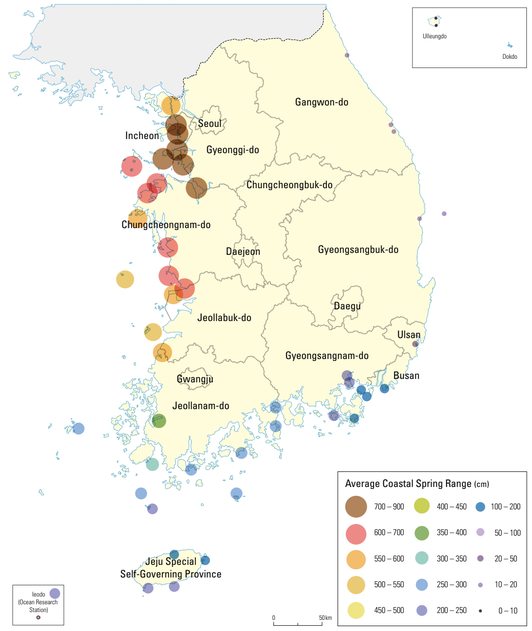
Ministry of Oceans and Fisheries, Korea Hydrographic and Oceanographic Agency (2006)

Tidal Currents (Low Tide)



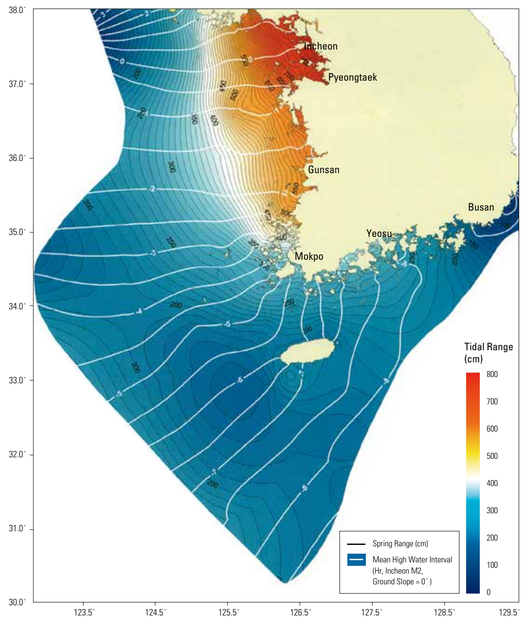
Ministry of Oceans and Fisheries, Korea Hydrographic and Oceanographic Agency (2006)

Average Coastal Spring Range



Ministry of Oceans and Fisheries, Korea Hydrographic and Oceanographic Agency (2006)

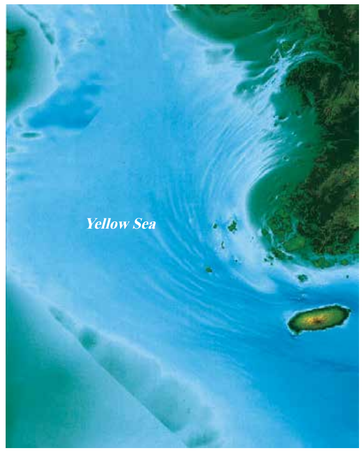
Co-Tidal Chart and Co-Range Line at Spring Range



Ministry of Oceans and Fisheries, Korea Hydrographic and Oceanographic Agency (2006)

Submarine Topography

Submarine Topography of the Yellow Sea

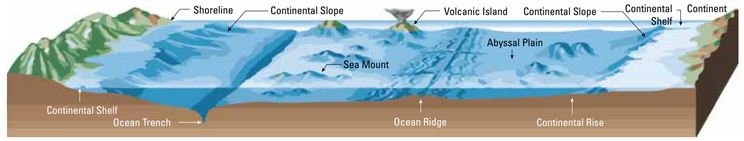


Submarine Topography of the South Sea

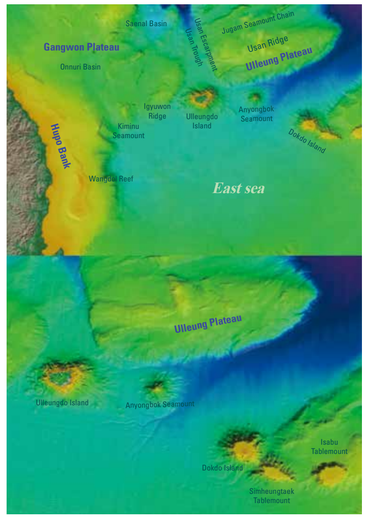
Submarine Topography of the East Sea

Sub-Bottom Topography around Ieodo Ocean Research Station

Diagram of Submarine Topography



Major Submarine Features and Names in the East Sea



Major Korean-Named Ocean Places around the Korean Peninsula

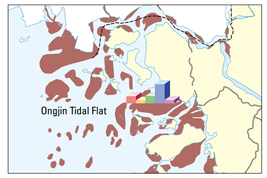
Sea	Ocean Place Name	Location (WGS-84)	
		Latitude	Longitude
Yellow Sea	Galmaegi Reef	37° 47.0′ 16″ N	124° 22.0′ 54″ E
	Byongpeung Escarpment	37° 20.0′ 59″ N	124° 33.0′ 25″ E
	Saeteok Bank	37° 39.0′ 28″ N	124° 28.0′ 17″ E
	Ongjin Basin	37° 21.7′ 00″ N	124° 36.6′ 00″ E
	Jeolla Sand Ridge Province	36° 18.0′ 00″ N	124° 42.0′ 00″ E
		34° 36.0′ 00″ N	124° 42.0′ 00″ E
		36° 18.0′ 00″ N	124° 42.0′ 00″ E
		34° 36.0′ 00″ N	124° 54.0′ 00″ E
		36° 18.0′ 00″ N	125° 54.0′ 00″ E
		35° 30.0′ 00″ N	125° 54.0′ 00″ E
South Sea	Jeju Valley	33° 38.0′ 00″ N	126° 57.0′ 00″ E
	Parang Reef	32° 08.0′ 45″ N	125° 13.0′ 25″ E
East Sea	Gangneung Canyon	37° 48.2′ 00″ N	129° 13.7′ 00″ E
	Donghae Canyon	37° 40.5′ 00″ N	129° 22.1′ 00″ E
	Ulsan Submarine Canyon	35° 28.0′ 40″ N	129° 59.0′ 21″ E
	Wangdol Reef	36° 43.0′ 09″ N	129° 43.0′ 55″ E
	Hupo Bank	36° 40.0′ 00″ N	129° 45.0′ 00″ E
	Onnuri Basin	37° 45.0′ 00″ N	129° 51.0′ 00″ E
	Gangwon Plateau	37° 45.0′ 00″ N	130° 10.0′ 00″ E
	Saenal Basin	38° 16.0′ 00″ N	130° 25.0′ 00″ E
	Igyuwon Ridge	37° 33.0′ 00″ N	130° 27.0′ 00″ E
	Usan Trough	37° 39.0′ 00″ N	130° 51.0′ 00″ E
	Usan Ridge	37° 51.0′ 53″ N	130° 56.0′ 44″ E
	Usan Escarpment	37° 41.0′ 00″ N	131° 00.0′ 00″ E
	Jugam Seamount Chain	38° 10.0′ 00″ N	131° 11.0′ 00″ E
	Anyongbok Seamount	37° 30.0′ 30″ N	131° 21.0′ 30″ E
	Ulleung Plateau	38° 12.0′ 00″ N	131° 26.0′ 00″ E

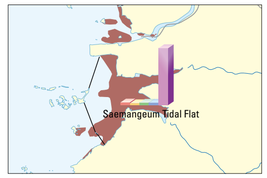
Korea Institute of Ocean Science & Technology, Korea Hydrographic and Oceanographic Agency (2015)

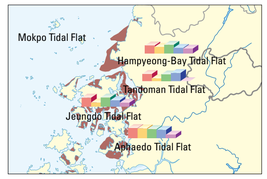
Marine geographical names are largely divided into sea surface names and undersea feature names. They are adopted as official names by the announcement of the Minister of Oceans and Fisheries. Sea surface names include the titles of topographic features above the sea surface, such as oceans, straits, bays, inlets, and waterways. Undersea feature names refer to sub-bottom topographic features, such as reefs, banks, submarine canyons, basins, sea mounts, ridges, and trenches. The “Standardization of Undersea Feature Names” from the International Hydrographic Organization-Intergovernmental Oceanographic Commission (IHO-IOC) classifies undersea features into 52 types, but the “Ocean Place Name Standardization Manual” of Korea categorizes them into 42 types.

The main undersea features in Korea are the Gageo Reef and Ongjin Basin in the Yellow Sea, the Jeju Sea Valley in the South Sea, and the Gangwon Plateau, Usan Trough, and Ulleung Plateau in the East Sea. There are also some Korean-named undersea features in overseas areas, such as the Boreumdal Guyot, Changpogo Seamount, and Kkotsin Knoll. These features enhance the nation’s position in the marine field and serve as indicators of the development of marine survey technology in Korea.

Tidal Flats

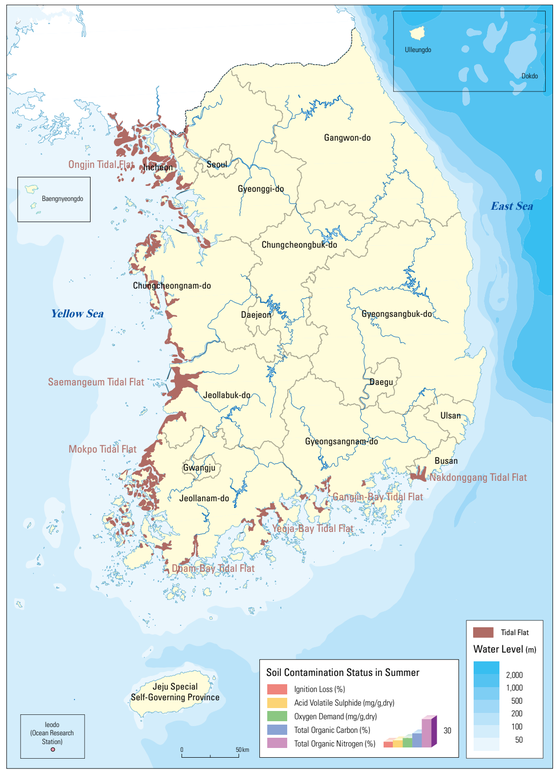




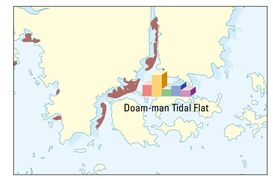


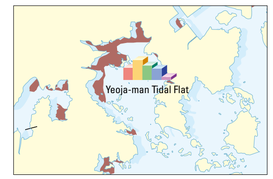
Gyeonggi-man Tidal Flat

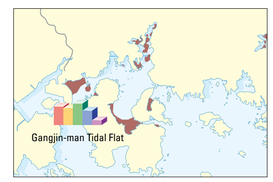
Coastal Tidal Flats



Ministry of Oceans and Fisheries (2007)







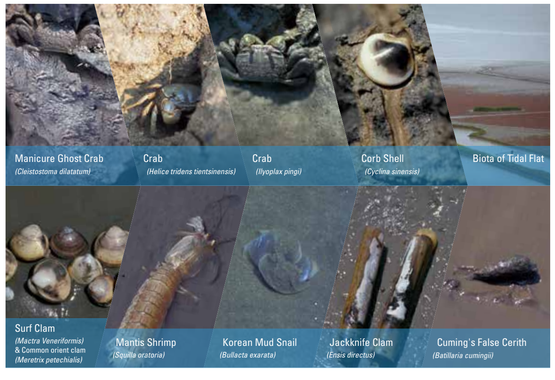
Nakdonggang Tidal Flat

Taean Tidal Flat

Gomso-man Tidal Flat

Suncheon-man Tidal Flat

Yeoja-man Tidal Flat



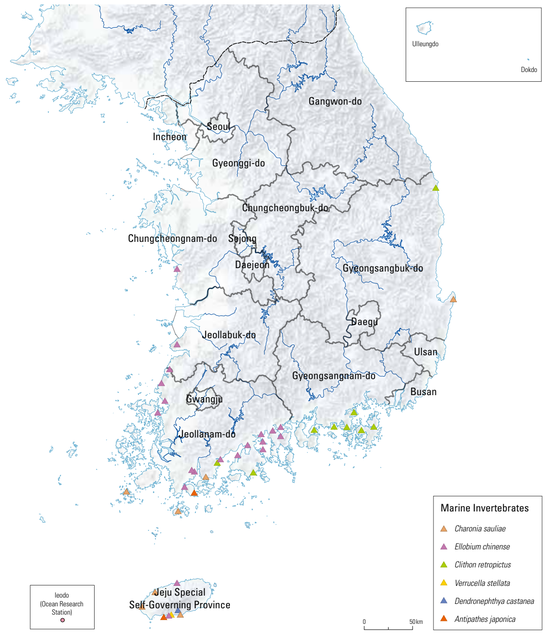
Tidal flats are classified into mud flats, sand flats, or mixed flats, depending on surface sedimentary facies. They can also be categorized according to geomorphological features as follows: open, which are strongly affected by tidal currents and waves; estuarine, located along the coast with large rivers flowing into them; and bay, which are rarely affected by waves due to their narrow mouths.

The Gyeonggi-man tidal flat and the Taean tidal flat are mixed flats, where certain areas are composed largely of mud and sand. The Suncheon-man and Yeoja-man tidal flats include vast coastal wetlands and a variety of vegetation, and the Nakdonggang tidal flat has a near-shore sand ridge due to the active inflow of sediment from the Nakdonggang River.

Estuaries are ecological transition zones where freshwater and seawater meet. Although they are home to the highest productivity on the planet, their ecosystem is increasingly impaired due to various development ventures. In response, Korea has been carrying out surveys of the current ecosystem status of national estuaries with high biological diversity and superior ecological functions. These surveys have been effective in the designation of the estuaries as Ecosystem Conservation Areas or Wetland Protection Areas. From 2004 to 2014, the Ministry of Environment completed a detailed investigation for 28 main estuaries (such as the Hangang estuary and Tamjingang) through the 1st Intensive Survey on Estuarine Ecosystems. Currently, the National Wetland Center of Korea is in the process of conducting detailed and basic investigations for the other estuaries as well.

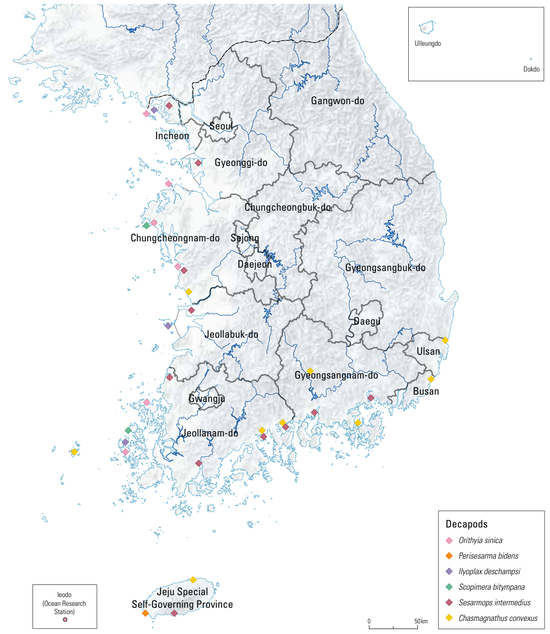
Major Marine Animals

Marine Invertebrates



National Marine Biodiversity Institute of Korea (2016)

Decapods



National Marine Biodiversity Institute of Korea (2016)

Major Marine Organisms


Ellobium chinense


Clithon retropictus


Sesarmops intermedius


Chasmagnathus convexus


Charonia sauliae


Verrucella stellata


Antipathes japonica


Dendronephthya castanea

Protected Marine Animals

Classification	Number of Species	Remarks
Mammals	16	Indo-Pacific Bottlenose Dolphin *(Tursiops aduncus)*, *Phoca largha* and so forth.
Invertebrates	31	*Clithon retropictus*, *Antipathes japonica* and so forth.
Seaweed/Seagrass	7	*Coccophora langsdorfii*, *Phyllospadix iwatensis* and so forth.
Amphibians	4	*Chelonia mydas*, *Caretta caretta* and so forth.
Fish	5	Spiny seahorse *(Hippocampus histrix)*, *Rhincodon typus* and so forth.
Birds	14	*Platalea minor*, *Uria aalge* and so forth.
Total	77	(as of 2016/09/28)

Ministry of Oceans and Fisheries (2016)

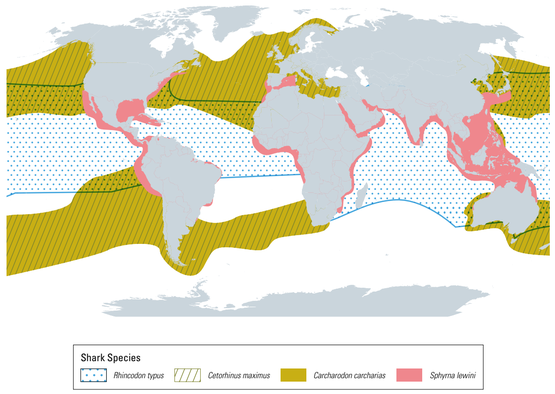
9,534 marine life species inhabit the oceans of South Korea. Invertebrates constitute the highest portion with a total of 4,989 species. 77 valuable species that are threatened or need to be protected have been designated as Endangered Marine Species.

Among the species of invertebrates, 20 have been designated as Endangered Marine Species, including 16 species of Actinozoa (*Plumarella spinosa, Plumarella adhaerens, Euplexaura crassa, Verrucella stellata, Plexauroides reticulata, Plexauroides complexa, Dendronephthya suensoni, Dendronephthya castanea, Dendronephthya mollis, Dendronephthya putteri, Dendronephthya alba, Dendrophyllia cribrosa, Dendrophyllia ijimai, Tubastraea coccinea, Antipathes japonica, Dichopsammia granulosa*), 2 species of mollusks (*Scelidotoma vadososinuata hoonsooi, Charonia sauliae*), and 2 species of enchinoderms (*Ophiacantha linea, Nacospatangus alta*). These species, which inhabit the subtidal zones or crawl on the ocean bottom, are extremely vulnerable to ocean development projects, trawling, marine pollution, and so on.

Among the Endangered Marine Species, 11 species of marine invertebrates (*Sesarmops intermedius, Chasmagnathus convexus, Pseudohelice subquadrata, Ocypode stimpsoni, Scopimera bitympana, Perisesarma bidens, Uca lactea, Periserrula leucophryna, Synandwakia multitentaculat dohelice subquadrata, Ellobium chinense, Clithon retropictus*) inhabit intertidal regions, such as tideland or brackish water zones. Excluding *Perisesarma bidens* and *Uca lactea*, 9 of these species bear high ecological value as endemic species to the coastal regions of Asia. However, their habitats are directly affected by human activity such as the reclamation of tideland, pollution, and coastal improvement, as they are located on the boundary between ocean and land. As such, they are in need of urgent protection.

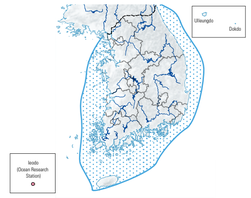
Crabs, which are a representative marine species of Korea, belong to phylum *Arthropoda*, class *Crustacea*, order *Decapoda*. They have a thick shell, a pair of claws, and four pairs of legs, and are the most evolved arthropods inhabiting the sea and freshwater. There are over 4,500 species of crabs across the globe and approximately 200 species inhabit Korea. Among these, about 60 species can be found in tidal flats, brackish water zones, or the foot of mountains by the seaside. The rest inhabit the subtidal zone and the deep sea. Upper and intermediate tidal flats (including brackish water and supratidal zones) are highly exposed to development processes by anthropocentric activities, and thus require management and conservation measures.

Sharks

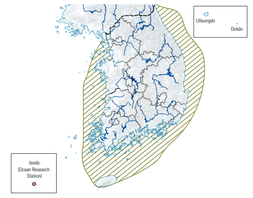


National Marine Biodiversity Institute of Korea (2016)

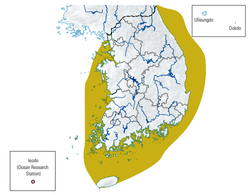
Whale Shark *(Rhincodon typus)*



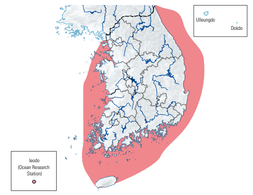
Basking Shark *(Cetorhinus maximus)*



Great White Shark *(Carcharodon carcharias)*

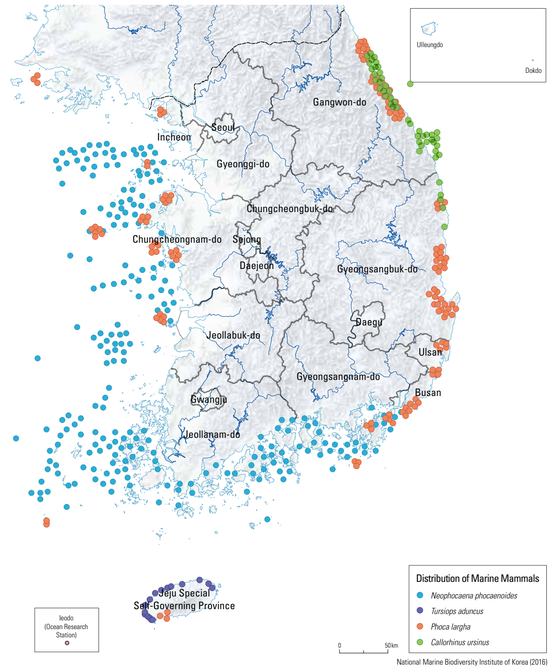


Scalloped Hammerhead *(Sphyrna lewini)*



National Marine Biodiversity Institute of Korea (2016)

Distribution of Marine Mammals



National Marine Biodiversity Institute of Korea (2016)


Indo-Pacific bottlenose dolphin *(Tursiops aduncus)*


Finless porpoise *(Neophocaena phocaenoides)*

Spotted seal *(Phoca largha)*


Northern fur seal *(Callorhinus ursinus)*

Sharks are among the most well-adapted fish species to the marine ecosystem, and can be found in ocean depths and surfaces, continental shelves of less than 200 m deep, and also lakes that are connected to the ocean. Some species can adapt to freshwater and inhabit the upstream of brackish water zones in river estuaries.

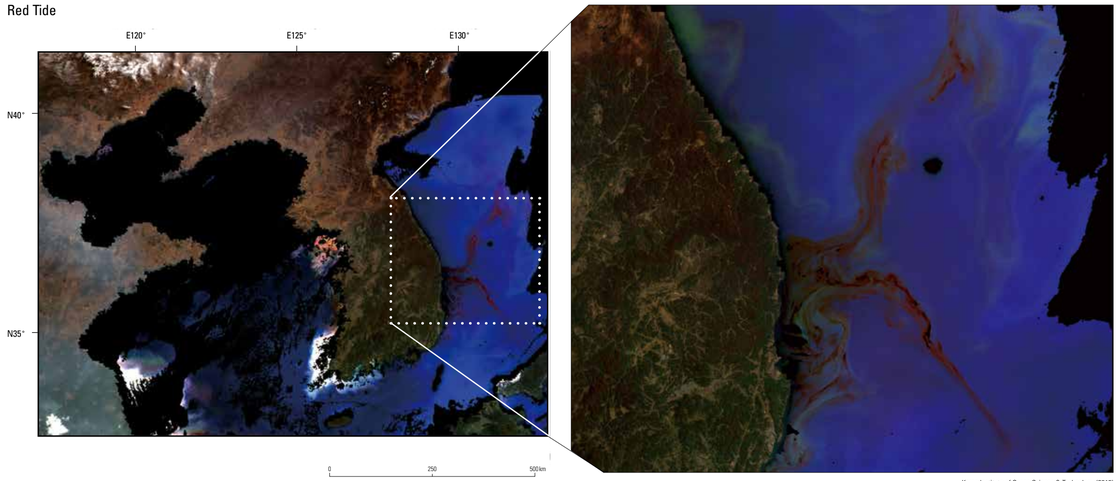
So far, approximately 400 species of sharks have been reported worldwide. Order *Carcharhiniformes* sharks are the most abundant with 7 families, 47 genera, and 208 species. 42 species of 19 families have been reported to inhabit the coasts of Korea, among which the family *Carcharhinidae* is most common with 10 species.

43 species of sharks found in domestic waters are listed on the International Union for Conservation of Nature (IUCN) Red List with 1 species under Endangered (EN), 11 as Vulnerable (VU), 10 as Near Threatened (NT), 9 as Least Concern (LC), and 12 as Data Deficient (DD). The whale shark (*Rhincodon typus*) and the scalloped hammerhead (*Sphyrna lewini*) have been designated as Endangered Marine Species.

Diverse marine mammals can be found all around the world, with 127 species recorded so far, including 89 cetaceans, 33 pinnipeds, 4 sirenians, 2 sea otters (*Enhydra lutris*), and 1 polar bear (*Ursus maritimus*). 30 species of cetaceans and 3 species of pinnipeds are found in Korea, and species such as the North Atlantic right whale (*Eubalaena glacialis*), gray whale (*Eschrictius robustus*), humpback whale (*Megaptera novaeangliae*), blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), sei whale (*Balaenoptera borealis*), Bryde's whale (*Balaenoptera edeni*), sperm whale (*Physeter microcephalus*), Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), spotted seal (*Phoca largha*), northern fur seal (*Callorhinus ursinus*), and Steller sea lion (*Eumetopias jubatus*) have been designated as Endangered Marine Species. Recently, the finless porpoise (*Neophocaena phocaenoides*), which is experiencing a drastic decrease in its numbers, has also been added to this list. The Indo-Pacific bottlenose dolphin, spotted seal, northern fur seal, and finless porpoise are still frequently observed in domestic waters.

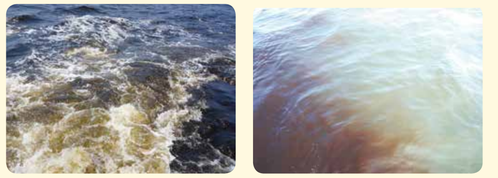
Marine Environments

Red Tide



Korea Institute of Ocean Science & Technology (2015)

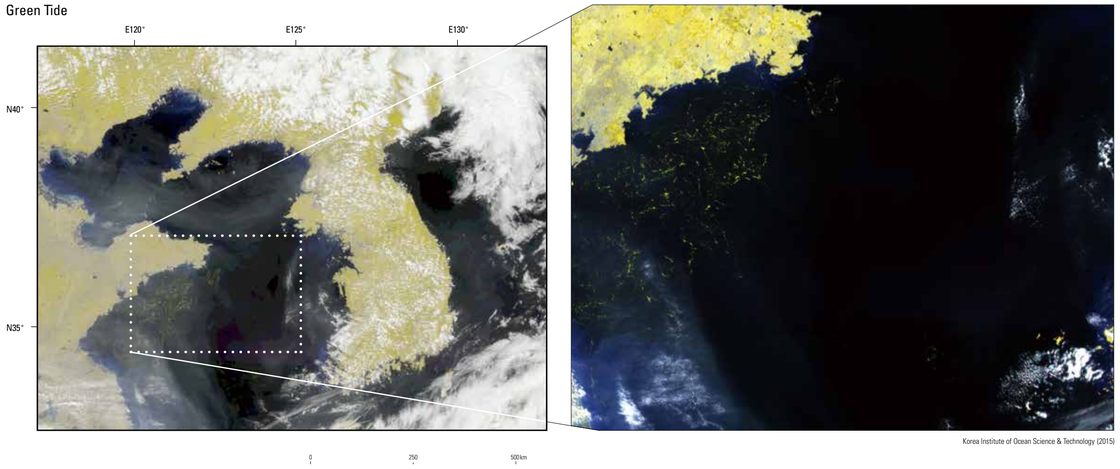
Occurrence of Red Tide



Red tide refers to when seawater is discolored red due to a mass bloom of phytoplankton – mainly cyanobacteria, diatoms, and dinoflagellates – in the ocean. Depending on the species of plankton, the color of the water can show tinges of yellowish brown, yellow, or grass green. Red tides cause great damage to marine ecosystems as they cause mass kills of coastal fish species all across the globe.

While diatoms were widely responsible for red tides along the Korean southern coast in the early 1990s, *Cochlodinium polykrikoides* (a species of dinoflagellates) has primarily been the cause since 1995. Red tides from *Cochlodinium polykrikoides* blooms occur in the clear waters between Narodo and Namhaedo and spread throughout the South Sea of Korea. In some years, they spread to the west coast and the East Sea as well.

Green Tide



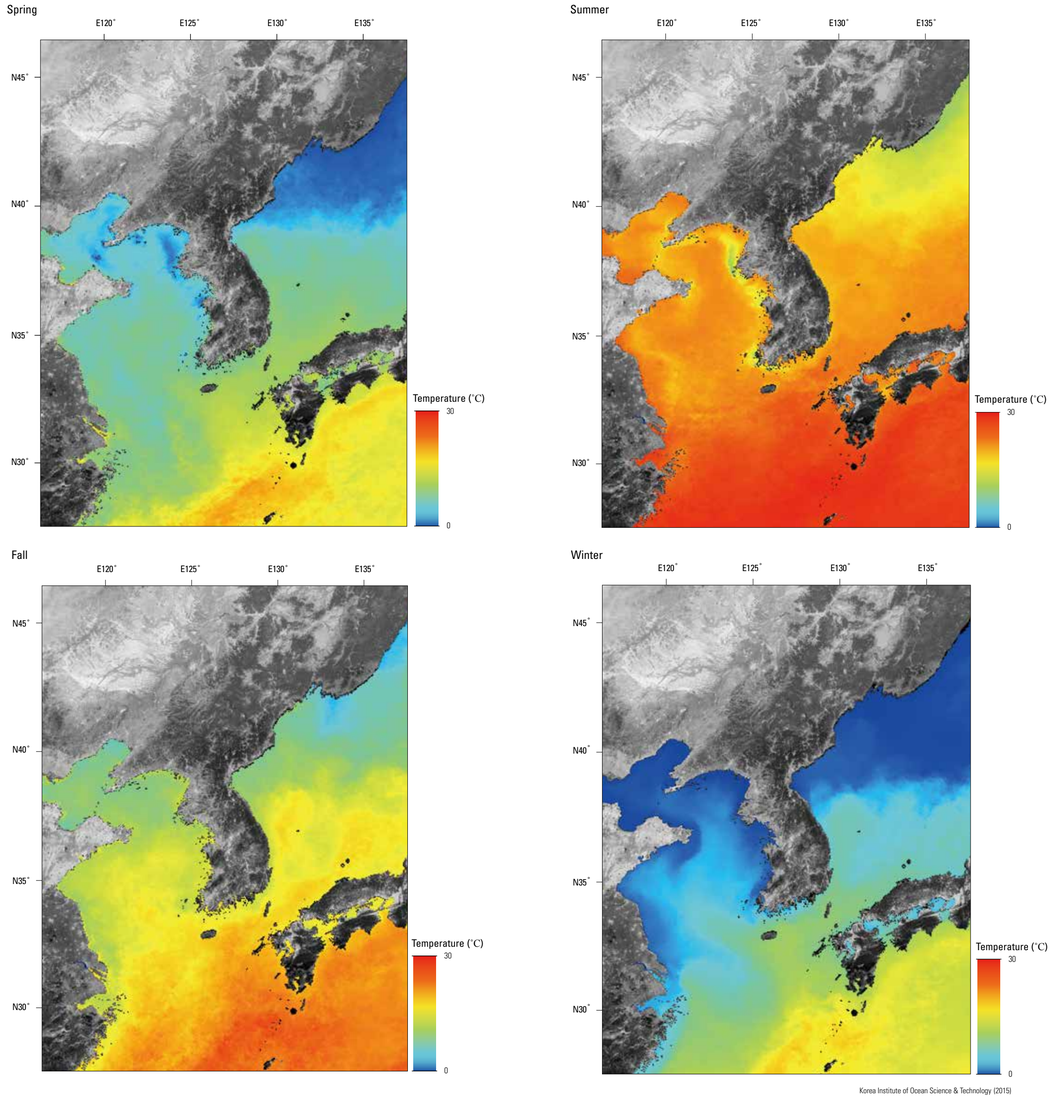
Korea Institute of Ocean Science & Technology (2015)

Occurrence of Green Tide

Green tide takes place when suspended algae proliferate in slow-flowing rivers or eutrophic lakes that contain high concentrations of carbon, nitrogen, and phosphorus, and consequently turn the water green. When green tide occurs, green algal blooms cover the water surface and shut out sunlight. Although the green algae discharge oxygen by photosynthesizing during daytime, they also consume oxygen in the evening. This creates anaerobic conditions in the water column that kill off aquatic organisms.

While green tides are found in oceans all across the world, they are generally small and constrained to coastal areas. Since 2000, green tides have been forming in the Yellow Sea and the East China Sea every year, usually appearing in coastal areas such as Qingdao and the Yangtze River estuary. Small patches of green algae have also been found in the open sea. In Korea, green algae mainly appear in rivers; those that form in the sea are not harmful to the Korean coast.

Sea Surface Temperature by Season



Korea Institute of Ocean Science & Technology (2015)

The greatest seasonal variation in the marine environment around Korea can be found in the temperature of seawater. Closely related to atmospheric temperature, seawater temperature has an average surface temperature of 5°C in the winter and 20°C in the summer. As seawater temperature has a specific heat that is much greater than that of the atmosphere, it has a smaller dynamic range.

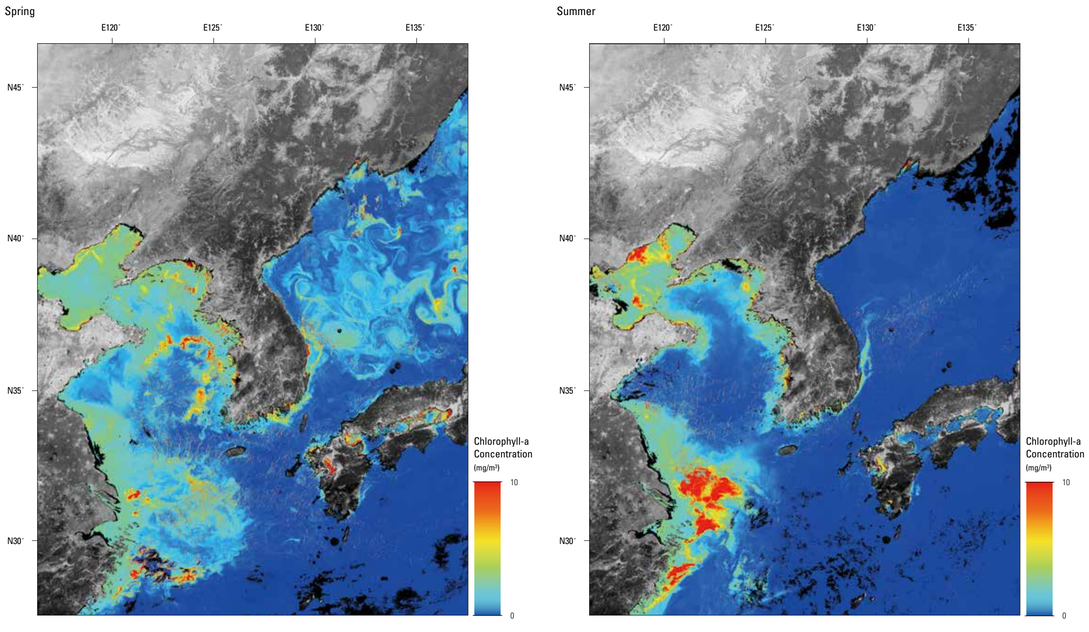
Chlorophyll is a photosynthetic pigment in phytoplankton that serves as an indicator of primary productivity of the ocean. For instance, high chlorophyll concentration indicates high primary productivity. Due to the large rivers of China and the Korean Peninsula, the Yellow Sea has an abundance of inorganic nutrients, which are the food source of phytoplankton. This causes the Yellow Sea to have higher chlorophyll concentrations than the East Sea or the South Sea. In particular, blooms—the mass breeding of phytoplankton—that occur in spring and autumn can sometimes lead to red tide. During the summer, the movement of deep seawater to the surface, or upwelling, occurs in the East Sea, causing high chlorophyll concentrations along some parts of the eastern coasts.

The absorption coefficient of dissolved organic matter (aCDOM) is obtained by analyzing the absorbance of colored dissolved organic matter (CDOM) in the sea. DOM breaks down into inorganic nutrients, which serve as food for phytoplankton. Consequently, red tide or greed tide can occur when DOM concentration is extremely high. DOM usually flows into the ocean through rivers on land, which explains why the Yellow Sea, the South Sea, and coastal areas of the China Sea have high DOM concentrations.

Suspended sediments have two sources: one is sediment runoff carried through rivers from the land to the ocean, and the other is suspended sediments pulled up from the ocean bottom due to waves or currents. As the greater portion of sediment is composed of sediment runoff, the coastal areas of the Yellow Sea, the South Sea, and China have an abundance of suspended sediments. The concentration of suspended sediments is mostly influenced by waves and wind and is generally highest during the winter.

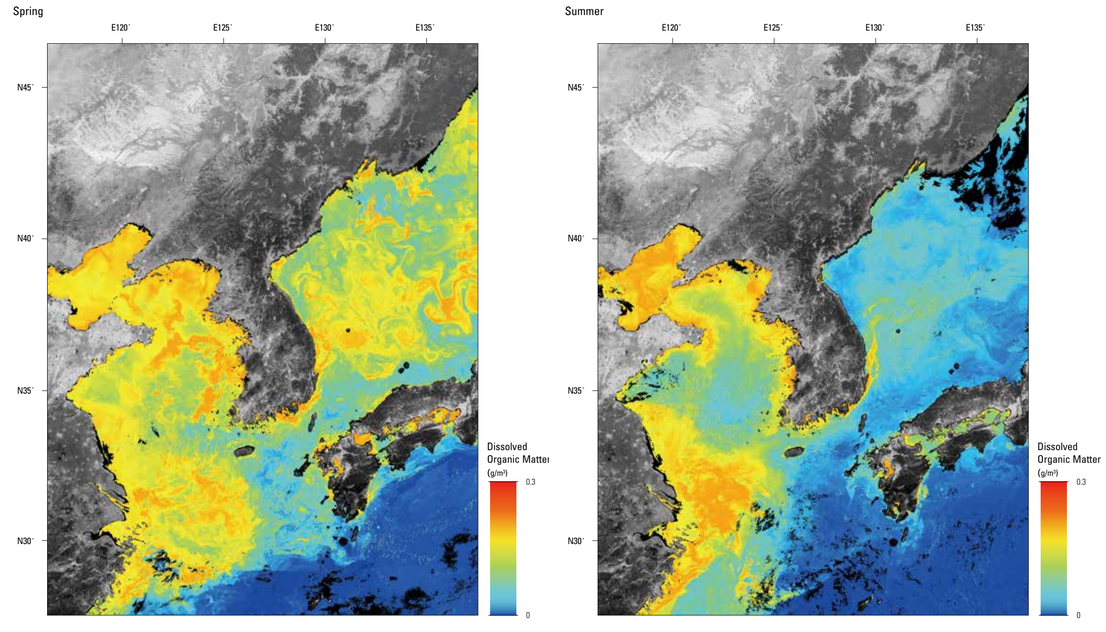
Visibility is an index for measuring how deep light can penetrate into the sea. It is an intuitive indicator of sea water turbidity and clearly displays seasonal variation. The East Sea and the South Sea are characterized by relatively clear water with about 10 m of visibility in the summer. While the Yellow Sea has comparatively high visibility offshore in the open water, visibility in coastal regions is less than 8 m due to river discharge and the resuspension of bottom sediments. During the winter months, stronger waves and wind lower visibility in all the seas surrounding the Korean Peninsula.

Chlorophyll-a Concentration by Season



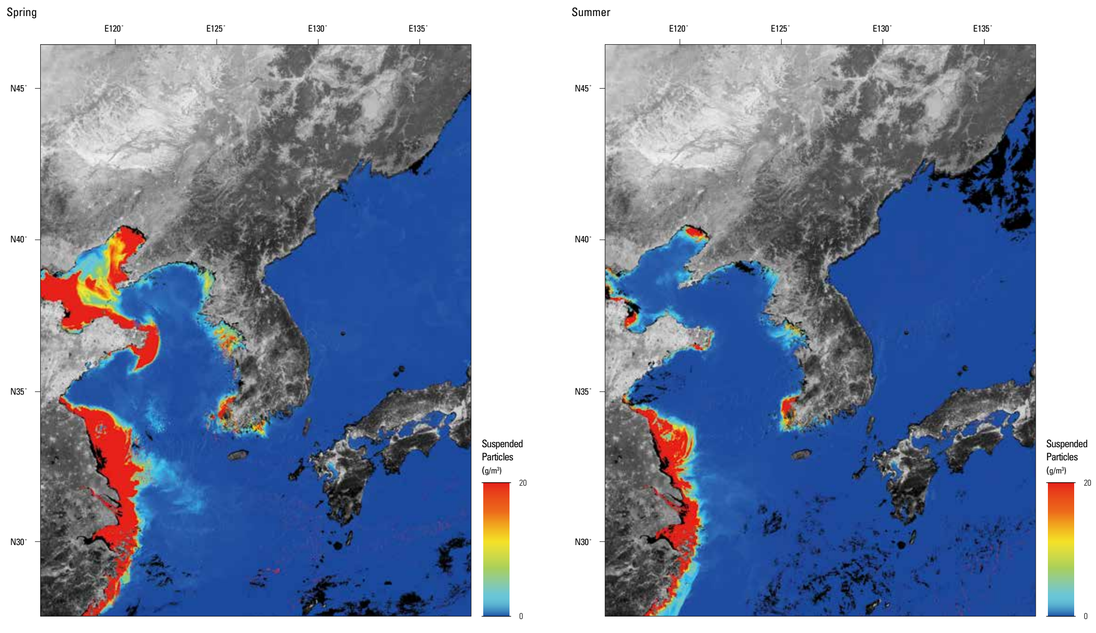
Korea Institute of Ocean Science & Technology (2015)

Dissolved Organic Matter by Season



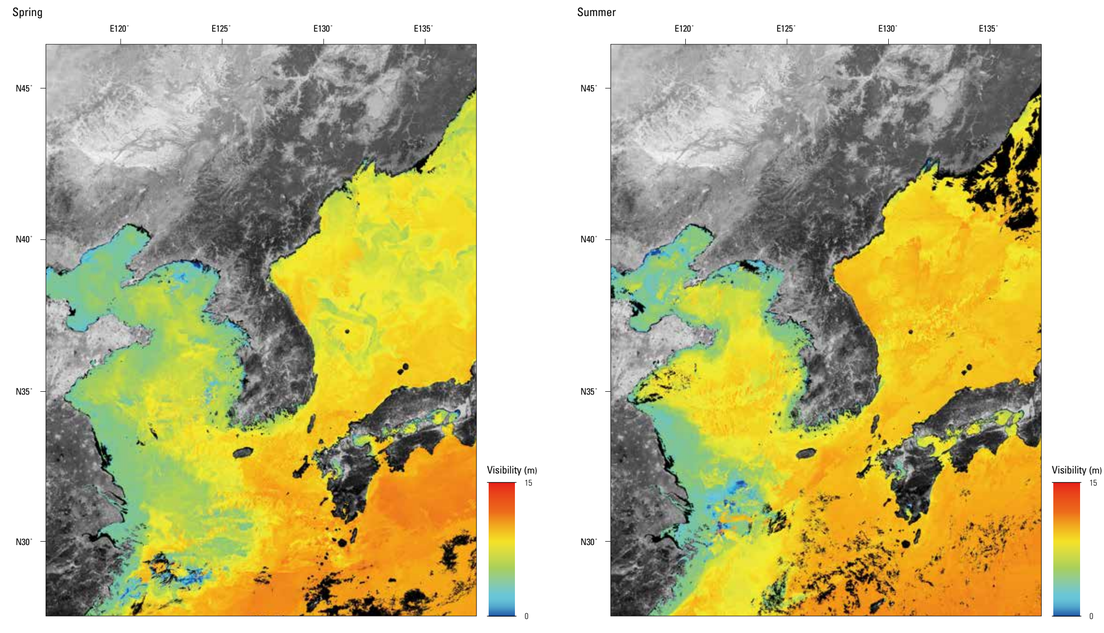
Korea Institute of Ocean Science & Technology (2015)

Concentration of Suspended Particles by Season



Korea Institute of Ocean Science & Technology (2015)

Visibility by Season



Korea Institute of Ocean Science & Technology (2015)

Uses of the Ocean

Regional International Sea Routes

Incheon Port International Passenger Terminal, Pyeongtaek Port International Passenger Terminal, Busan Port International Passenger Terminal, DBS Cruise Ferry Co., Ltd

Changes in Major Harbors

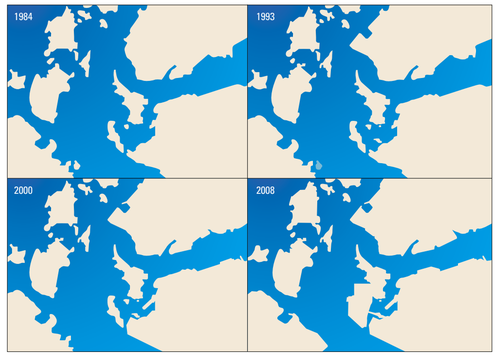
Incheon Harbor

Incheon Port Authority (2015)

Pyeongtaek Harbor

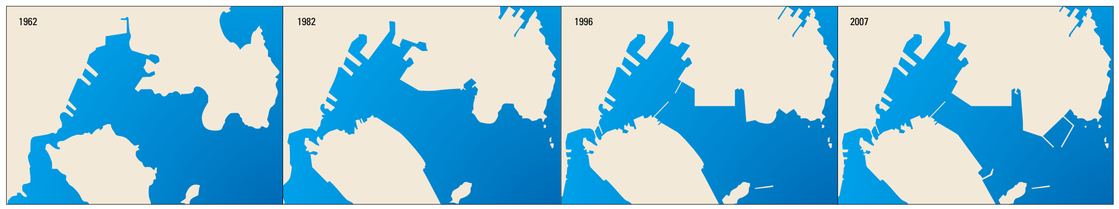
Pyeongtaek Port Authority (2015)

Mokpo Harbor



Mokpo Regional Oceans & Fisheries Administration (2015)

Busan Harbor



Busan Port Authority (2015)

Following the first stage of the Incheon Harbor development from 1973 to 1978, the second stage was held from 1981 to 1985, during which a grain terminal, silo facilities, and an 8th pier were constructed. Trade between Korea and China has since increased in accordance with China's rapid economic growth, along with the designation of the Free Economic Zone and the extension of the port logistics complex. Incheon Harbor also established ten international passenger sea routes between Korea and China and set a record of more than one million international passengers in the year of 2011. Furthermore, the harbor contributes to the maritime transport service by running twelve sea routes to coastal islands.

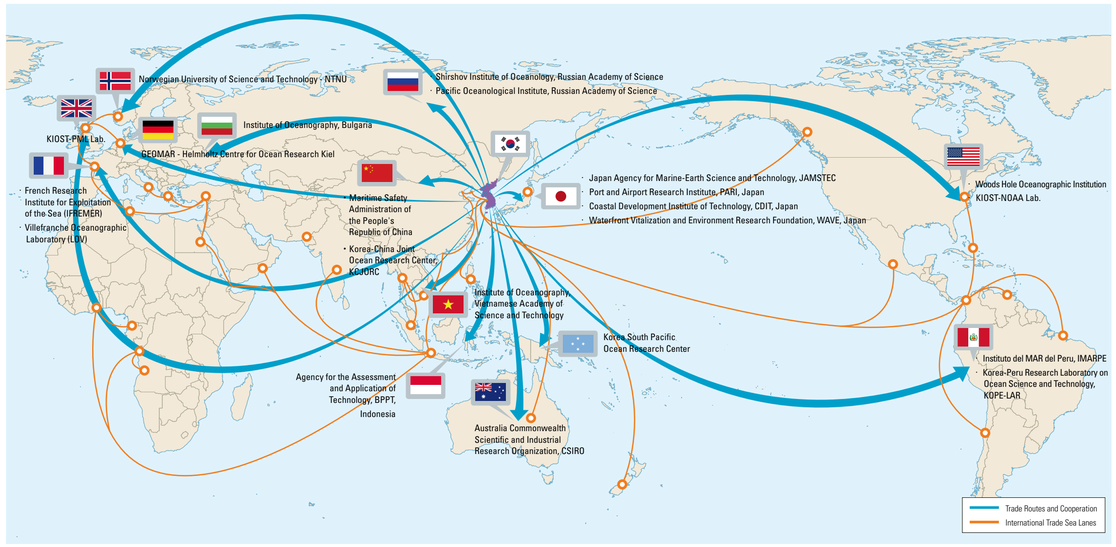
Pyeongtaek Harbor is a newly-constructed port that opened 110 to 120 years later than Busan and Incheon Harbor. It initially opened in 1986 but only served as a port for processing oil shipments. Since then, it transformed into a business specific harbor to replace the growing container traffic of Incheon Harbor, and finally began to fully take on the role of a commercial trade port in the late 1990s. Pyeongtaek Harbor holds a development history that is greatly different from those of other harbors. While the others were actively promoted by the leading role of the state (the central government) and received a variety of policy support from the beginning, Pyeongtaek was developed by the local government and was able to achieve short-term success as a fast-growing port due to external factors, such as the economic growth of China. Currently, it has 62 port facilities and performs the role of a general trade port that can handle passengers and a wide range of cargo. It has 35 general piers, 3 car terminals, and 8 passenger terminals.

Mokpo Harbor was used as a base for the mass exploitation of textiles and grains during the Japanese Colonial Period. Traces still remain of a Japanese enclave that was located in the region around the harbor. Following the restoration of Korean independence, Mokpo Harbor was divided into the North and South Ports according to their respective functions. The North Port was developed as a fishery product-only port, while the South Port served as a passenger-only and cargo-only port to Samhakdo. Today, the Mokpo Coast Passenger Terminal and Mokpo International Passenger Terminal have been constructed and are in the process of developing various international sea routes, including one to Shanghai.

Busan Harbor is the oldest harbor in Korea. As its facilities were insufficient to handle the rapid increase in container traffic that accompanied the sudden economic growth, cargo had to be processed at the normal port instead of the container port. The dilapidated conditions also led big shipping agents to avoid using the harbor. To respond to this, Busan Harbor began constructing a new port on Gadeokdo specifically for handling large-scale containers in October, 1997. The Busan International Passenger Terminal currently operates a ferry between Busan and Japan as well as a cruise line between Busan and Jejudo.

International Cooperation

Trade Routes and Cooperation



Korea Institute of Ocean Science & Technology, Korea Hydrographic and Oceanographic Agency (2015)

Major Korean-Named Submarine Topographies

Ocean	Ocean Place Name	Representative Location (WGS-84)	
		Latitude	Longitude
East Pacific Ocean	Boreumdal Guyot	16° 09.2′ N	126° 25.8′ W
	Yeon Guyot	16° 21.8′ N	133° 37.2′ W
	Haemirae Knoll	10° 39.9′ N	135° 48.1′ W
	Geupsuseon Knoll	16° 31.3′ N	132° 57.0′ W
	Jeonbok Knoll	17° 00.2′ N	135° 49.4′ W
	Olchaengi Knoll	16° 59.7′ N	135° 59.5′ W
	Pungdengi Knoll	16° 53.6′ N	125° 35.9′ W
	Garakji Knoll	17° 00.2′ N	125° 45.4′ W
	Bongsudae Knoll	16° 10.2′ N	126° 31.8′ W
	Maetdol Knoll	10° 28.2′ N	135° 36.6′ W
	Hangari Knoll	16° 07.0′ N	125° 59.0′ W
	Paeraengi Knoll	10° 51.7′ N	135° 36.6′ W
	Gamasot Knoll	10° 45.6′ N	135° 29.5′ W
West Pacific Ocean	Changpogo Seamount	15° 20.0′ N	158° 45.0′ E
	Cheonghaejin Seamount	15° 04.0′ N	158° 53.1′ E
	Arirang Guyot	11° 50.0′ N	157° 40.0′ E
	Onnuri Guyot	15° 05.0′ N	159° 15.0′ E
	Baekdu Guyot	15° 40.0′ N	160° 05.0′ E
Antarctic Ocean	Gungpa Hill	76° 28.8′ S	168° 20.8′ E
		76° 27.5′ S	168° 22.2′ E
		76° 26.3′ S	168° 21.0′ E
	Sssangdungi Hill	67° 16.1′ S	179° 03.1′ W
		67° 16.1′ S	179° 04.2′ W
	Dolgorae Hill	70° 37.3′ S	173° 06.0′ E
		70° 38.6′ S	173° 05.7′ E
	Kkotsin Knoll	61° 36.2′ S	172° 29.0′ W
	Maisan Hill	75° 49.1′ S	165° 41.9′ E
	Gokkal Hill	69° 32.4′ S	172° 32.3′ E
	Dalpaengi Knoll	69° 32.9′ S	176° 43.6′ W

Korea Hydrographic and Oceanographic Agency (2015)

Korean-Named Overseas Submarine Features

Boreumdal Guyot, Changpogo Seamount, and Kkotsin Knoll are just some of the many Korean-named undersea features that are located overseas. These newly found submarine features are mostly distributed in the Pacific and the Antarctic Oceans. The Korean names enhance Korea's position in the marine field and serve as indicators of the advancement of its marine surveying technology.

International cooperation in marine affairs plays a leading role in handling marine environmental issues around Korea, advancing marine environmental management, and enabling national empowerment. It also increases national influence within the global society through the reinforcement of activities in international organizations and regional communities. The figure above displays the some of the many overseas laboratories and institutes that hold partnerships with South Korea.

Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) was established as a project of the United Nations Development Programme (UNDP) to promote collaborations on marine environment initiatives around East Asia, including marine ecosystem preservation and sustainable use planning for coastal/marine resources. Eight member countries developed the program as an international organization in 2009 to further manage marine environment issues. Korea became a member in 1994 and is currently one of eleven countries (including China, Japan, Singapore, and Vietnam) that are working with the organization.

Since 1974, the United Nations Environment Programme (UNEP) developed a series of world regional sea programs. As one of the programs, the Coordinating Body on the Seas of East Asia (COBSEA) was established in 1994 for preserving and developing the East Asian coastal/marine environment. A total of ten countries, including Korea (which joined in 1994), Indonesia, Cambodia, Malaysia, and China, are currently developing and implementing management guidelines for marine environment preservation, and also estimating the status of the marine environment in the East Asian seas.

The Northwest Pacific Action Plan (NOWPAP), also one of UNEP's regional programs, was founded in 1994 by the governments of four countries near the Northwestern Pacific Ocean (Korea, China, Japan, and Russia). It was established with the aims to strengthen the countries' cooperation in preserving coastal/marine environments and in pursuing sustainable development in the Northwestern Pacific Ocean. NOWPAP has four local activity centers that are used for its annual intergovernmental conference, secretariat, joint projects, and expert meetings.

The Yellow Sea Large Marine Ecosystem (YSLME) project was established with the support of Korea, China, and the UNDP/Global Environment Facility (GEF). Its agenda pushes for the sustainable use of the Yellow Sea environment, which has been damaged by the overfishing of marine resources and reckless coastal development. The first stage of the project was carried out from 2005 to 2009 and the second stage, which began in June 2014, will continue on to May 2017. The purpose of the second stage is based on the national strategic plan to reduce pollution sources and preserve fisheries in the Yellow Sea.

The Korea-China Yellow Sea Marine Environment Joint Survey, which was carried out over a 12-year period from 1997 to 2008, is the sole Yellow Sea project that Korea and China surveyed together. The results of the survey are projected to be helpful in solving marine environment disputes between the two countries.