National State of Oceans and Coasts 2018:

Blue Economy Growth

RO KOREA

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National State of Oceans and Coasts 2018:
Blue Economy Growth of RO Korea

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EXECUTIVE SUMMARY

1. Background

The ministers of the East Asian Seas (EAS) Region adopted the Da Nang Compact during the EAS Congress 2015 held in Da Nang, Viet Nam in November 2015. One of its targets is the development of a Regional State of Oceans and Coasts (SOC) report. The Republic of Korea prepared this National State of Oceans and Coasts (SOC) report as its contribution to the regional report.

The regional and national SOC reports aim to contribute to the assessment of development in blue economy, and monitoring of progress on the implementation of the Sustainable Development Strategy for the Seas of East Asia (SDS-SEA), UN Sustainable Development Goals (SDGs), other international agreements subscribed to by RO Korea, and related national laws and policies on oceans and coasts.

The definition of blue economy is given in the **Changwon Declaration 2012**,[1] which was adopted by the ministers of the East Asian Seas (EAS) Region as a way to respond to the challenges of the changing environment and climate as well as fostering economic development through activities that reduce negative impacts on ocean health and communities.

The National SOC Report provides information on the status of seas and coasts of RO Korea, including the ocean economy, the existing and potential uses of coastal and marine resources, and the corresponding benefits and impacts. Responding to the issues and pressures affecting both the ocean economy and ocean health, RO Korea adopted policies, laws, and institutional reforms as well as invested in research and development for innovative technologies, and more sustainable ocean industries.

[1] *"We understand the Blue Economy to be a practical ocean-based economic model using green infrastructure and technologies, innovative financing mechanisms, and proactive institutional arrangements for meeting the twin goals of protecting our oceans and coasts and enhancing its potential contribution to sustainable development, including improving human well-being, and reducing environmental risks and ecological scarcities."* (Changwon Declaration 2012)

2. The Seas and People of RO Korea

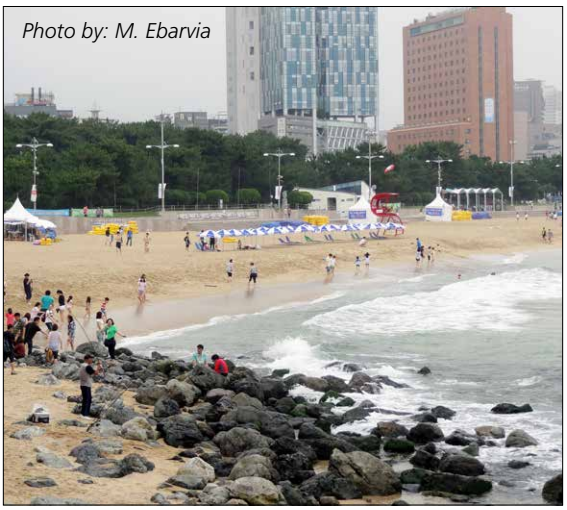


Photo by: M. Ebarvia

The Korean Peninsula is located at the rim of the Northwestern Pacific Ocean, and is surrounded by the sea on three sides: the East Sea, Yellow Sea, and the southern sea of Korea. The territorial sea area is 86,891 square kilometers (km^2), accounting for 17% of the EEZ and 87% of the national land area. Korea's seawaters are significantly influenced by the Tsushima Warm Current, a tributary of the Kuroshio Current from the south, and by the Liman Cold Current from the north, and thus both warm- and cold-water species appear altogether.

The coastline of Korea is 13,509 km long. The proportion of land-side artificial shoreline increased from 26.2% in 2000 to 49.4% in 2010. The rapid industrialization, pollution, and development of coastal-dependent industries, such as shipbuilding, ports and shipping, marine tourism, fisheries, and fish ports, and the development of marine renewable energy, such as tidal power generation, have impacts on the natural coasts and habitats.

Demography. The population has increased from 38,124,000 in 1980 to 51,246,000 in 2016. However, the population growth rate has continuously decreased – from 1.56% in 1980 to 0.45% in 2016. The population density is 471 people per km^2, which is among the highest in the world. The coastal population was 13,983,000 in 2016, which was 27.2% of the total population. There are 5,681,000 households in the coastal areas, accounting for 27.4% of the total households nationwide (20,724,000).

Economy. Korea's economic growth was achieved through a series of the *National Economic Development Plans* that were based on the strategy of importing raw materials and exporting finished goods, with steel, automobiles, ships, textiles, and most recently, computer chips having figured most importantly. In 2017, the gross domestic product or GDP (in constant, 2010 prices) was US$1.35 trillion.[2]

Human development.[3] The human development index (HDI) of RO Korea for 2017 is 0.903—which put the country in the very high human development category—positioning it at 22 out of 189 countries and territories. In 2017, life expectancy is 82.4 years, while expected years of schooling and mean years of schooling are 16.5 years and 12.1 years, respectively. Korea's GNI per capita increased by about 209.5 percent between 1990 and 2017. The gross national income (GNI) per capita in 2017 is US$35,945.

[2] World Bank. World Development Indicators. Accessed from: https://data.worldbank.org/country/korea-rep
[3] UNDP. 2017. http://www.oceanhealthindex.org/region-scores/scores/south-korea

Access to water and sanitation. Currently, access to improved water sources and sanitation facilities are almost universal in South Korea. 98.2% of the population has access to *safely managed* water supply as of 2017, while 99.9% of the population has access to *safely managed* sanitation facilities.[4]

Wastewater management. Between 1998 and 2008, investments of more than US$800 million were financed by the private sector to construct 100 wastewater treatment plants. It is estimated that 58 percent of wastewater treatment plants were privately-owned and managed by the end of 2012, and 42 percent by government utilities. The current task is to maintain the systems, reduce inefficiencies in the form of excess capacity, and promote green growth in the sector. This includes a plan to reduce electricity consumption in the sector by at least 50 percent. The Government also wants to consolidate utilities according to river basins by 2030 to achieve economies of scale and reduce the need for financial support from the government budget.

Table 1: Basic Geographic and Socioeconomic Indicators.

Indicator	
Land area[1]	97,480 square kilometers or km^2
Sea area (territorial waters up to 12 nautical miles)[2]	86,891 km^2
Coastline[2]	13,509 km
Population[1]	51,361,911 (as of 2017)
Coastal population[2]	13,983,000 = 27.2% of the total population (as of 2016)
Ocean economy (Gross value added or GVA, in constant prices)[3]	US$ 43.53 billion or 3.3% of GDP (as of 2013) US$ 36.95 billion or 2.9% of GDP in 2014
Employment in ocean economy[3]	656,303 (as of 2013)
Estimated value of coastal and marine ecosystem services[3]	US$ 42.4 billion – 44.5 billion (as of 2013)
Percentage of coastline with ICM[2]	100%
Marine protected area (percentage of territorial waters)[2]	1.6%
Ocean health index (OHI)[4]	74 (RO Korea ranks #41 among 221 countries and territories)
Gross domestic product (GDP, in constant 2010 US$ prices)[2]	US$ 1.35 trillion (as of 2017)
Human development index (HDI)[5]	0.903—very high human development category (as of 2017)
Gross national income (GNI) per capita (at 2011 PPP prices)[6]	US$ 35,945 (as of 2017)
Access to safely managed water supply[1]	98% (as of 2017)
Access to safely managed sanitation[1]	98.5% (as of 2017)

Source:
[1] World Bank. World Development Indicators. Accessed from: https://data.worldbank.org/country/korea-rep.
[2] SOC Report 2017 (draft)
[3] Chang, Jeong-In. 2017. "Measuring Ocean Economy in Korea" Presentation made at the 3rd Symposium on Oceans in National Income Accounts, OECD, Paris, 22 Nov 2017.
[4] KMI, 2018.
[5] http://www.oceanhealthindex.org/region-scores/scores/south-korea
[6] UNDP. 2018. Human Development Indices and Indicators: 2018 Statistical Update. Accessed from: http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/KOR.pdf

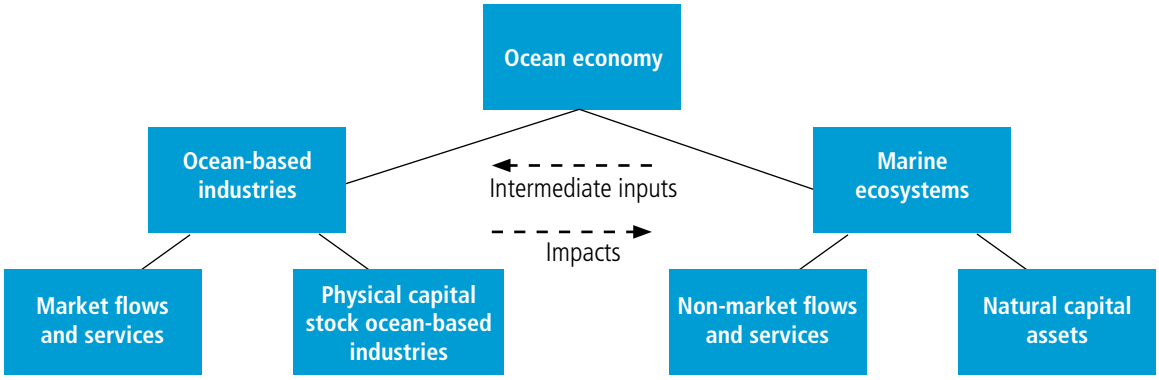
[4] World Bank. World Development Indicators. Accessed from: https://data.worldbank.org/country/korea-rep

3. Harnessing the oceans: Benefits and impacts

Oceans provide an extensive range of natural assets and resources – natural capital from which humans derive a wide variety of ecosystem services that make life possible and upon which human activities rely.

The entire ocean economy is measured as the sum of: (a) the economic activities with dependence on the ocean and coastal and marine resources, and (b) natural assets, goods and services of marine ecosystems upon which these industries depend on, and people rely on for food, income, livelihood, recreation, shoreline protection, etc. (**Figure 1**).

Figure 1: Ocean Economy.



Source: OECD (2016), The Ocean Economy in 2030, http://dx.doi.org/10.1787/9789264251724-en.

3.1 Ocean industry[5]

The ocean industry in 1990 was estimated at KRW 11,217 billion, which was 2.7 percent of GDP (KRW 416,965 billion). In 2007, it increased to KRW 79,181 billion, which shared 3.3 percent of GDP (KRW 2,396,329 billion). The ocean industry increased at an annual rate of 12.2 percent from 1990 to 2007, which was higher than 10.8 percent of the whole industry.

As of 2014, the gross output of Korea's ocean and fisheries industries was estimated to be KRW 147.0 trillion (US$139.6 billion), with the value added at KRW 38.9 trillion (US$37 billion), and accounting for 2.9% of the Korean economy or GDP (**Table 2**).

The contribution of each ocean industry to total ocean economy is shown in **Figure 2**. The fisheries industry (fisheries production processing, and distribution) took up 17.3% of the ocean

[5] Korea Maritime Institute (KMI). Korea's Ocean Economy 2018.

industries as a whole, in terms of value added. The share of shipping and ports industries is 11.8% and 5.1%, respectively. The vessel and offshore plant construction and repair industry has the biggest contribution to the ocean industry at 31%, followed by the marine and fisheries services with 27% share.

Employees or workers in the ocean industries numbered around 596,000. Marine and fisheries services employed the highest number of workers, followed by the vessel and offshore plant construction and repair, the shipping industry, and fisheries distribution industry.

The value added of Korea's ocean industry dived from KRW 42.1 trillion (US$43.53 billion) in 2013 to KRW 38.9 trillion (US$37 billion) in 2014. This is directly attributed to a fall in the value added of the ship-building industry due to the global economic slump and resulting drop in in the amount of ship-building orders received (KMI 2018). The ship-building, ports and shipping industries are relatively more sensitive to changes in global economic conditions.

According to the *Special Classification of Korea's Ocean and Fisheries Industries*, the fisheries production industry is composed of fishing, aquaculture, services incidental to fishing and aquaculture, and salt production. Fisheries processing consists of aquatic animal processing and storage, seaweed processing and storage, salt processing, and other fisheries processing. Fisheries distribution involves fisheries brokerage, wholesale and retail, and fisheries transportation and storage.

The shipping industry is classified into passenger transportation; freight transportation (ocean-going, and coastal water); and other shipping services (e.g., tug business; brokerage and agency; ship lease; ship management; and suppliers of lubricant and articles for ships). The port industry is classified into: (a) port transportation and support services offering logistics services (port loading and unloading; port storage and warehouse; freight inspection); and (b) other port-related business (e.g., freight packing; ports and terminal operation; supply of articles for ships; port security; etc.). Vessel and offshore plant construction and repair is a knowledge-based key industry involving the design and building of cargo ships, fishing boats, and offshore plants that are used by the shipping industry, marine resource development, fisheries, marine leisure and tourism, and the military industry.

Marine resources development consists of: (a) collecting aggregates, such as sand and gravel, and exploring for offshore oil and natural gas; (b) deep seawater utilization for mineral water, beverages, and cosmetics; (c) marine renewable energy – producing electricity using tidal current, tidal energy, wave power, offshore wind power, offshore solar energy, and ocean thermal energy conversion; and (d) marine bio-industry, which produces marine bio-food, medicines, and chemical products (cosmetics) using marine biotechnology based on marine bio-resources (fish and seaweeds). Marine construction industry includes constructing and maintaining ports, structures for coastline protection, and bridges; land reclamation; installing offshore plants; and establishing submarine cables.

According to MOF's *Second Basic Plan for the Promotion of Marine Tourism, 2014*, the marine leisure and tourism industry consists of marina industry, cruise industry, beach visitors and sea bathing tourism, recreational fishing, etc.

The marine and fisheries services industry is composed of: (a) marine waste processing, cleanup, and recovery; (b) marine and fisheries equipment wholesale and retail; (c) marine and fisheries human resource (HR) employment and supply services; (d) marine and fisheries education services; (e) marine and fisheries science and technology services; (f) marine and fisheries finance, insurance, accounting, law and management consulting; (g) fish and seafood restaurants; and (h) marine and fisheries associations, organizations and public institutions.

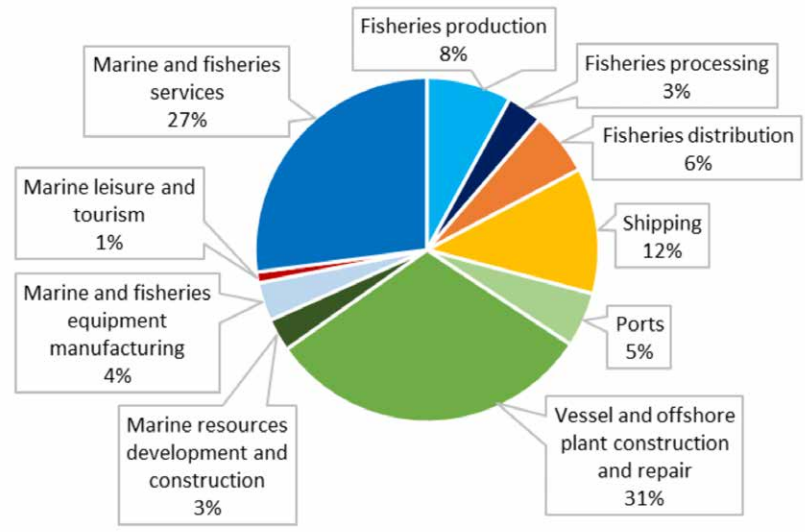
Photo by: M. Ebarvia

Table 2: Output, Value Added, and Employment of the Ocean Industries in 2014.

Ocean industries	Output		Value Added		Employment
	KRW, trillions	US$, millions	KRW, trillions	US$, millions	Number of persons
Fisheries production	7.6	7,211.2	3.1	2,946.5	44,990
Fisheries processing	9.4	8,966.1	1.3	1,248.8	40,655
Fisheries distribution	4.7	4,454.5	2.3	2,195.4	65,827
Shipping	30.5	28,963.5	4.6	4,348.4	70,279
Ports	5.0	4,724.5	2.0	1,883.9	27,494
Vessel and offshore plant construction and repair	64.2	60,987.4	12.0	11,438.6	131,418
Marine resources development and construction	2.6	2,458.0	1.2	1,153.4	13,739
Marine and fisheries equipment manufacturing	5.4	5,131.9	1.4	1,368.9	18,701
Marine leisure and tourism	1.2	1,161.4	0.4	386.9	10,985
Marine and fisheries services	16.4	15,551.1	10.5	9,975.0	172,071
TOTAL	**147.0**	**139,613.7**	**38.9**	**36,945.7**	**596,160**
Whole industry (GDP)	**3,658.0**	**3,473,026.6**	**1,354.9**	**1,286,387.0**	**23,567,991**
% of ocean industry to whole industry (GDP)	**4.0%**		**2.9%**		**2.5%**

Note: US$1 = KRW1,053.26 in 2014
Source: KMI (2018); 2014 Input-Output Tables of Bank of Korea

Figure 2: Share of Each Ocean Industry, 2014



Source: Korea Maritime Institute (KMI). Korea's Ocean Economy 2018.

3.2 Coastal and Marine Ecosystems

The oceans also provide goods and services that are not usually quantified in monetary terms, and excluded in the national income accounts. The ecosystem services include direct values, such as fisheries and tourism (included in the ocean economy accounts) as well as indirect values, such as shoreline protection, climate regulation, waste assimilation (regulating and supporting services). In 2013, the economic value of marine ecosystem in Korea was estimated at **US$42.4-44.5 billion** (Chang, 2017). The coastal waters have a value of US$23,422.9 million, with beaches and national parks contributing US$17,205.8 million (**Table 3**). Tidal flats have a value of US$16,629 million. The estuaries (excluding tidal flats) have a value ranging from US$2,380.0 million to US$4,463.8 million.

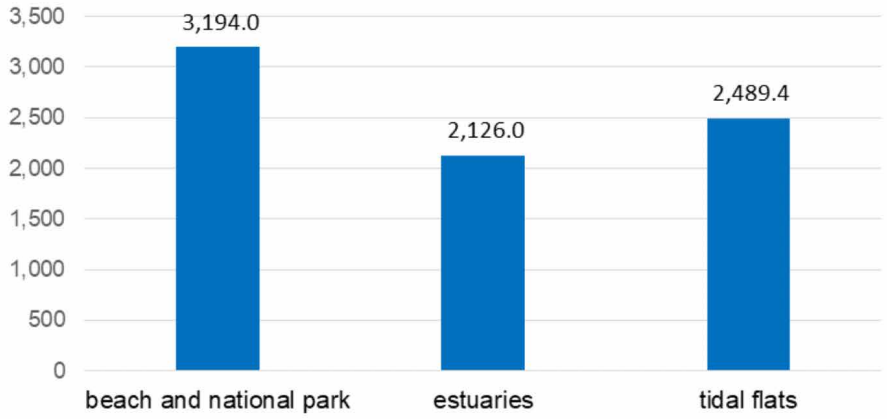
Table 3: Valuation of Coastal and Marine Resources.

Marine ecosystems	Ecosystem services and coastal resources	Annual economic value (US$)
Coastal waters	Food production	5,710.3
	Aggregates (sand, etc.)	250.0
	Natural gas	256.8
	Beaches	16,614.6
	National parks	591.2
Tidal flats		16,629.9
Estuaries (excluding tidal flats)		2,380.0 – 4,463.8
TOTAL		**42,432.8 – 44,516.6**

Source: Chang and Yoo (2015); Chang (2017)

Note: 1,000 KRW = 1 USD

Figure 3: Area of Coastal and Marine Ecosystems.



4. Transitioning to Blue Economy

The blue economy, as discussed during the East Asian Seas (EAS) Congress 2012, refers to a sustainable ocean-based economic model; one that employs environmentally-sound and innovative infrastructure, technologies, and practices, including institutional and financing arrangements, for meeting the goals of: (a) sustainable and inclusive development; (b) protecting our coasts and oceans, and reducing environmental risks and ecological scarcities; (c) addressing water, energy, and food security; (d) protecting the health, livelihoods, and welfare of the people in the coastal zone; and (e) fostering ecosystem-based climate change mitigation and adaptation measures.

The State is promoting blue economy and there are many initiatives in different ocean economic sectors. RO Korea is transforming its ocean economy using innovative technologies and sustainable solutions. **Table 4** shows the ocean economic activities, and new trends and developments towards blue economy. The innovative ocean industries include: marine ranching; offshore aquaculture; coastal and marine ecotourism; green port (Busan); ocean renewable energy; marine biotechnology; desalination; deep seawater utilization. However, these industries must be environment- and climate-friendly to ensure sustainable blue economy development. Initiatives to improve and protect ocean health and support blue economy include coastal zone management plans and programs; wastewater, solid waste and marine debris management; water resource management; and designation of marine protected areas; Wetlands Conservation Sites; and Fisheries Resources Protection.

Source: K.S. Lee 2017; Korea Institute of Ocean Science and Technology (KIOST)

Table 4: Developments in Blue Economy.

Ocean Economy	Blue Economy Initiatives
Fisheries and aquaculture • Domestic fisheries production has continuously decreased since 1980s. It stabilized at an annual average of 3 million tonnes for the past ten years. • **Pressures:** Depleting fisheries resources, Foreign illegal fishing, High labor cost in fishing	**Sustainable fisheries** • **Marine ranching** as a new system for fisheries production: involves installing artificial reefs and placing rubble and rocks on the seabed to form a foundation for ecosystems to develop; release of fish seeds to build up marine resources; improvement of habitats to maximize the value of fishing grounds; and establishment of systematic water management and valid user system to improve production. • **Community-based fisheries** resulted in increase of fisheries production, improvement of selling system and making brands of the fishing products, continuous increase of average fishermen's income. The fishing village cooperatives (*Ochonkye*) were established for the management of commonly-held fishing grounds and co-op facilities, and collective sale of produce. • Enactment for **offshore aquaculture**; National Plan for Aquaculture Development • **Policies on IUU fishing: Total allowable catch (TAC) program** as an output control, which regulates annual total amount of catch per species; **fishing permit and license; Vessel buy-back program** to reduce fishing vessels and address overfishing
Coastal and marine tourism • **Pressures:** seasonality; low priority of government; dual leading agencies	**Sustainable tourism** • **Ecotourism:** Suncheon Bay Eco-Park • **MPAs and ecotourism:** Cheongsando Island • Recreational sea fishing
Ports and shipping • RO Korea's economic system is based on importing raw materials and exporting finished goods, and about 99% of the cargo has been imported and exported by marine transportation. • **Pressures:** port development; sand mining; shipping accidents; oil spills; ballast water	**Sustainable ports** • **Green port:** Busan - 92 units of Diesel-RTGC converted to e-RTGC (energy and expenses reduced by 90%, GHG reduced by 74%) - 150 units of Diesel-Y/T being replaced by LNG-Y/T by 2020 (reducing greenhouse gas (GHG) emissions by 38%) - 23,568 indoor lighting devices changed to LED (reduced GHG by 1,203 tons) and commitment to change 100% of indoor lighting system to LED by 2020 - In 2014, Environment Ship Index (ESI) was introduced, providing 15% reduction in entry/departure charges to eco-friendly vessels (In 2014, 423 eco-friendly vessels called, and KRW 603 million (approximately US$ 600,000) in reduced entry/departure charges was achieved.) • **Waterfront program** • **National Oil Spill Response Plan** • **Enabling environmental policies and laws:** Framework Act on Low Carbon Green Growth; Harbor Act; Marine Environment Management Act; Sustainable Transportation Logistics Development Act; Clean Air Conservation Act

Table 4: Developments in Blue Economy. (cont.)

Ocean Economy	Blue Economy Initiatives
Energy	**Marine renewable energy** • Technology Development Project for Commercialization of Offshore Energy established by the Ministry of Ocean and Fisheries (tidal power energy, tidal current energy, wave power energy, and ocean thermal energy conversion) and Ministry of Trade, Industry and Energy (offshore wind energy). • The 254-megawatt (MW) **Sihwa Lake Tidal Power Plant** is the largest in the world. It also enhanced the economy by forming waterfront and tourist attraction. The annual power production of 552 GW has reduced CO2 emissions by 315,000 tonnes annually, and has oil import substitution effects of 862,000 barrels a year, which improves the energy self-sufficiency of the country. • **Offshore wind energy**: ten sites, including the Saemangeum Estuary, for the offshore wind energy development are under the stage of planning • Incentives: Feed-in-tariff (FiT) supports the tidal barrage power; Renewable Energy Certificate (REC) with variable weights; Renewable Energy Portfolio Standard
Water	• **Desalination** • **Deep seawater utilization** • **Rainwater harvesting**
Manufacturing of chemicals and pharmaceuticals	**Marine biotechnology – for food, chemicals, and medicines** • In 2013, MOF established the National Marine Biodiversity Institute of Korea (MABIK). • The domestic marine biotechnology market is expected to grow more than 14% annually from $70 million in 2012 to $360 million in 2020, which will share 5% of the world marine biotechnology market.
Pressures: pollution from land- and sea-based sources, marine debris	**Pollution reduction** • Complete prohibition of ocean dumping • Coastal Total Pollutant Control System • Special Area Management Plan (SAMP) • Sewerage systems and wastewater treatment facilities • Coastal Enhancement Program to address coastal erosion and sedimentation • Solid waste management: Implementation of waste separation and collection system • National Marine Debris Management Plan • National Oil Spill Response Plan
Pressures: Fisheries habitats, such as wetland and coastal waters, have been greatly lost due to coastal development.	**Habitat restoration and management** • ICM and coastal zone management (CZM) plans and programs • Designation of marine protected areas; Wetlands Conservation Sites; Fisheries Resources Protection Areas • MPAs and ecotourism • Yellow Sea Strategic Action Plan

5. Ocean Health Underpinning the Blue Economy

5.1 Coastal and Marine Ecosystems

The key habitats can be categorized into seven types: rocky intertidal zones, soft bottom intertidal zones, subtidal zones, deep seabeds, pelagic zones, Wangdolcho underwater rocky zones, and the waters around Dokdo Island. The major ecosystems that were assessed and valued are beaches and national parks; estuaries; and tidal flats (**Table 3**).

Korea Institute of Ocean Science and Technology (KIOST) completed an inventory of marine organisms in Korea with a total list of 9,798 species, by performing bibliographic studies and consultations with experts on individual species groups. Detailed information regarding individual species, such as scientific names, synonyms, distribution, ecological characteristics, and biography, were posted on the Korea Marine Biodiversity Information System (KOMBIS) (http://kombis.kordi.re.kr).

5.2 Marine Water Quality

Korea's water quality standard is divided into five classes based on items of causes of eutrophication (dissolved inorganic nitrogen (DIN), dissolved inorganic (DIP), the first reaction item (chlorophyll (Chl-a), transparency (SD)), and the secondary response item (low-level dissolved oxygen saturation (DO)). Over the past five years, the quality of the waters throughout the country has remained at the Class 2 except for the Masan Bay and the Sihwa Lake.

Table 5: Marine Water Quality.

Parameters	Rating
DO	Good
Nitrates	Good
Phosphates	Good
Heavy metals	Good
TSS	Good

5.3 Ocean Health Index

The Ocean Health Index (OHI)[6] for RO Korea in 2017 is **74**, which is above the global score of 70. RO Korea ranks #41 among 221 countries and territories. (Lower scores indicate that more needs to be done to protect ocean health.)

6. Governance Structure to Support Blue Economy and Protect Ocean Health

Since the early 1960s, Korea has used and developed the coastal space and resources densely in order to achieve rapid economic development, with its large population in its small peninsular territory. However, its coastal development has been carried out through sectoral management, such as fisheries management, marine environment management, port management, and coastal resources management. The sector-based coastal management system has resulted in serious environmental and socioeconomic issues, such as depletion of fisheries, reduction of habitats due to sand mining and reclamation of coastal waters including wetlands, pollution of coastal waters, increased marine debris, reduction of natural coastlines, and limitation of public access to coastal waters.

RO Korea is among the few countries with an ocean policy to address these issues and promote innovations and sustainable development in coastal and marine areas of the country.

The governance structure includes laws (acts), plans, institutional arrangements, and programs for sustainable development, preventing over-exploitation of coastal resources and space, reducing pollution from both land- and sea-based sources, and promoting innovations and new technologies. Korea's ocean economy has been promoted since the government established the **Ministry of Maritime Affairs and Fisheries** (MOMAF) in 1996, and enacted the *Basic Act on Ocean and Fisheries Development* in 2002 for the sustainable development of ocean resources and the ocean industry. The *First* (2002-2010) and *Second* (2011-2020) *Basic Plan for Ocean and Fisheries Development* have been established based on the *Basic Act on Ocean and Fisheries Development* (Korea's Ocean Act), which mandates the establishment of management infrastructure for land-based and sea-based activities.

6.1 Policy Support for Blue Economy

In 2014, the **Ministry of Ocean and Fisheries** (MOF) established the *Comprehensive Measures to Promote New Ocean and Fisheries Industry* with the aim of increasing the added value of the

[6] The **Ocean Health Index** (OHI) is a decision-making tool and framework for conserving the human-ocean ecosystem. OHI scientifically measures key elements from all dimensions of the ocean's health — biological, physical, economic and social — to inform policy decisions toward the sustainable use of the ocean. OHI measures progress on 10 human goals: food provision, artisanal fishing opportunities, natural products, carbon storage, coastal protection, livelihoods and economies, tourism and recreation, sense of place, clean waters and biodiversity. (http://www.oceanhealthindex.org/)

new ocean and fisheries industry to up to 7% of GDP by 2017, expanding the new ocean industry to KRW40 trillion by 2017, and creating 25,000 new jobs by 2017.

In 2016, the government established the *Strategy to Promote Ocean and Fisheries Industrialization R&D*, aiming at (a) creating a market of KRW3.4 trillion and employment of 36,000, and establishing four globally competitive companies by 2020; and (b) creating a market of KRW14.0 trillion and employment of 123,000, and establishing ten globally competitive companies by 2025.

In 2017, MOF established the *Strategy to Promote Business Start-up and Investment in Ocean and Fisheries*, which aims at: (a) promoting technology-based entrepreneurship; (b) strengthening enterprise investment attractiveness; (c) expanding network with capital market; (d) forming financial infrastructure; and (e) promoting investments and establishing investment ecosystem.

Since the Blue Economy is also based on innovative science and technology, the Korean government has given priority to the development of marine science and technology with corresponding policies, financing and other incentives. In 2011, the Ministry of Land, Transport and Maritime Affairs (MLTM) established the *2020 Roadmap for Ocean-science Technologies Development*. In 2013, the Ministry of Ocean and Fisheries (MOF), which is the leading department on ocean and fisheries management including ocean-science, revised the 2020 Roadmap for Ocean-science Technologies Development to include the fisheries resources management.

In 2014, MOF established the *Medium- and Long-term Plan for Ocean and Fisheries R&D* (2014-2020), which aims at: (a) developing the world's leading technologies from 7 in 2013 to 20 in 2020; (b) creating jobs in the ocean and fisheries sector from 6,000 in 2013 to 78,000 in 2020; and (c) increasing the private sector R&D participation rate from 18% in 2013 to 40% in 2020.

The new ocean industries, such as ocean (offshore) energy development, offshore aquaculture, coastal tourism, marine biotechnology, deep seawater utilization, desalination, and green port, have just begun to develop in Korea. **Tables 4 and 6** provide examples of these innovative initiatives.

In addition, the Korean government is pursuing various programs for the sustainable development of coastal resources and space, such as marine spatial planning (MSP), coastal zone management (CZM), marine ecosystems and fishery resources management, water quality improvement and pollution reduction, and water resource management in line with the Korea Ocean Act, UN SDGs, SDS-SEA, and other international commitments and national enactments.

6.2 Integrated Coastal Management

The coastal area is 32,369 km^2, which is 32.3% of the nationwide area. The *Coastal Zone Management (CZM) Act* passed the National Assembly in 1999, of which programs are the *National CZM Plan*, the *Local CZM Plans*, and the *Coastal Zone Enhancement Plans*. The National CZM Plan

and the Coastal Zone Enhancement Plans are developed by the central government while the Local CZM Plans are crafted by the local governments. 100% of the coastline is covered by the CZM Act.

In 2000, MOMAF established the *Guidelines for Establishment of Local CZM Plans*. In 2009, MOMAF revised the CZM Act, and introduced the zoning system in the coastal water zone to enhance the management of the coastline. The zoning system in the coastal water zone divided the coastal water zone into four areas considering the present status of use and development, the natural and environmental characteristics of the areas, the future direction for using the areas.[7] The four areas are: (a) usable area; (b) special area; (c) conservation area; and (d) management area. Each area can be divided into many sub-areas.[8] However, the CZM Act does not identify and regulate any prohibited, limited, allowable activities in the zoning areas.

6.3 Marine Environmental Management and Pollution Reduction


Photo by: M. Ebarvia

Korea government has established the First (1996-2000), Second (2001-2005), Third (2006-2010), and Fourth (2011-2020) Comprehensive Marine Environment Management Plan based on the Marine Environment Management Act (MEMA). The Fourth Plan (2011-2020) has included the establishment of the Comprehensive Management System for Reducing Land-based Sources of Pollution with a budget of $9 billion.

In 2004, MOMAF and Ministry of Environment (ME) established the *National Program of Action* (NPA), which includes four strategies in the Global Program of Action for the Protection of the Marine Environment from Land-based Activities (GPA):

a) Strengthening the pre-cautionary management including the Coastal Total Pollution Load System;
b) Strengthening the monitoring and knowledge infrastructure for scientific decision-making;
c) Strengthening the adaptive and sustainable management based on the priority;
d) Strengthening the participation and cooperation of local stakeholders.

The Korean government invested a large portion of the budget for marine environment management to reduce land-based sources – around 82% of the total budget ($10.9 billion) of the *Fourth Plan* (2011-2020). Most of the budget for reducing land-based pollution was invested in the installation of the sewerage system and wastewater treatment plants.

[7] CZM Act, Article 15.
[8] CZM Act, Article 19.

A seriously polluted area should be designated as a **Special Management Area**, and a corresponding *Special Management Area Plan* (SAMP) should be put in place. MOMAF monitored, surveyed and forecasted the carrying capacity of the Special Management Area, and the total land-based and sea-based pollutants flowing into the area. Through long discussion with major stakeholders including local governments, MOMAF established the SAMPs for the waters of Siwha-Incheon (2001), Masan (2004), Gwangyang (2005), Ulsan (2008), and Busan (2009). For the effective implementation of the plans, a Special Area Management Committee, consisting of local stakeholders, has been established for each site.

Moreover, MOMAF revised the *Marine Pollution Prevention Act* to designate valuable fishery resource areas as **Environment Conservation Areas**. MOMAF designated the Bay of Wando-Doam (2005), Gamak (2006), Deugryung (2007) and Hampyung (2009) as Environment Conservation Areas.

Cleaning up of Masan Bay

The coastal land of the Masan Bay had been densely developed by industrial complexes, a large port, and a sizeable urban population since the economic development in the 1960s. A large quantity wastewater had been generated and flowed into the bay. However, Masan Bay is the most closed sea in Korea, with limited circulation of water. Therefore, the water quality of the bay had deteriorated. Red tide (harmful algal bloom) frequently occurred in the bay. Consequently, in 1975, the Gapo Beach was closed, and in 1979, catching fish and shellfish was prohibited. In 1982, the bay was designated as the Special Red-tide Management Area.

In 1995, MOMAF conducted a study for introducing a precautionary approach, the Coastal Total Pollutant Load Control System, which could be applied in Masan Bay. The Special Committee for Masan Bay was established consisting of major stakeholders, such as the general public, the central and local governments, industry, and academia. In 2008, the government established the Basic Plan for Masan Bay Special Management to apply the Coastal Total Pollutant Load Control System. The chemical oxygen demand (COD) improved from 2.7 mg/l in 2009 to 1.4mg/l in 2014.

However, the government has set a goal to improve COD only – from Level 3 to Level 2 by 2020 – and did not include nutrient loads, such as nitrogen (N) and phosphorus (P), which are known to be among the causes of red tide in Korea. Moreover, the SAMP for the Masan Bay does not address the nonpoint sources, which are generated from the upstream areas. Therefore, a special law is needed to expand the geographical area of the watershed management plan so as to include nonpoint sources.

6.4 Coastal and marine ecosystem protection and conservation

Various acts have been enacted to establish policies and plans for conservation and protection of coastal and marine ecosystems. These include: the Conservation and Management of Marine Ecosystem Act, the Wetlands Conservation Act, the National Land Planning and Utilization Act for protection of the Fisheries Resources, and the Coastal Zone Management Act.

In Korea, marine protected areas (MPAs) are classified into sub-areas, such as areas for protecting marine organisms, for protecting marine ecosystems, and for protecting marine landscape. At present, a total of 12 areas with 254.322 km2 have been designated as areas for protecting marine ecosystems, and one area with 91.237 km2 for protecting marine landscape.

Moreover, a total of 14 sites with the size of 235.81 km2 of tidal wetlands have been designated as the Wetlands Conservation Sites based on the Wetlands Conservation Act.

6.5 Fisheries Management

A total of 30 areas with 3,161 km2 have been designated as Fisheries Resources Protection Areas, wherein the water areas and land areas are 2,760 km2 and 401 km2, respectively.

Marine ranching, offshore aquaculture and community-based fisheries are some of the initiatives introduced by the government to ensure sustainable fisheries development, food security, and habitat protection, and support livelihood of fishing communities.

6.6 Water Resource Management

RO Korea has been addressing its water challenges while meeting its economic development goals. The following are some of the best examples of how the country is achieving water security:

a) building an extensive dam system to control flooding and store flood waters for use in dry seasons and in dry regions;
b) restoring 929 km of the national river system (Four Major Rivers);
c) desalination to supplement drinking water needs in Busan, and industrial water to Gwangyan mill;
d) smart water management technologies to minimize loss and optimize performance across the entire water cycle;
e) rainwater harvesting: As of 2011, 59 cities throughout Korea have become "rain cities" including the capital, Seoul, and the major cities of Incheon, Kwangju, Busan, Daejeon and Daegu.[9]

[9] ???

7. Outlook for Blue Economy

With the enabling policies, institutional arrangements, and financing support in place, Korea is transforming its ocean economy to more sustainable blue economy. With increasing risks from environmental and climate change, and shifting stakeholder demands, the government has been introducing policy reforms and investing in R&D and innovative technologies to achieve economic growth, develop new ocean industries, create jobs, improve and protect ocean health, and ensure climate resiliency. The government also deems it crucial to involve the scientists, businesses, and other stakeholders in planning and decision-making. **Table 6** shows the status of Korea's ocean economy and ocean health, the pressures and challenges, and the response measures, such as supporting policies and blue economy initiatives.

Table 6: Summary: State of Ocean Economy and Ocean Health.

Indicator	Status/Trend	Major issues and challenges	Response	
			Key policies/laws; Action Plans	Examples of best practices or blue economy initiatives
State of ocean economy				
Ocean economy	Increasing	• Development-oriented legal system • Lower priority of ocean policy • High labor cost of ocean industry	• Korea's Ocean Act • Basic Plan for Marine and Fisheries Development • Increasing R&D for ocean industry	• Ocean economy accounting and valuation of coastal and marine ecosystems • Sustainable fisheries • Ecotourism and MPAs • Green port • Ocean energy • Marine biotechnology • Deep seawater
Fisheries and aquaculture	Fisheries: Decreasing	• Depleting fisheries resources • Overfishing • Foreign illegal fishing • High labor cost	• Fisheries Act • Fishery Resources Management Act • Fishery Resources Protection Act	• Sustainable fisheries: marine ranching; community-based fisheries; Fishery Resources Protection Areas; Total Allowable Catch (TAC) program
	Aquaculture: Increasing	• limited space • marine pollution: eutrophication, red tides • excessive use of feeds • biological contamination • introduced alien species • diseases and antibiotics • climate change	• National Plan for Aquaculture Development • Pollution reduction; wastewater management • Regulations for nearshore aquaculture	• Offshore aquaculture • Breeding and culturing of high-valued species • Seaweed farming has been industrialized

Table 6: Summary: State of Ocean Economy and Ocean Health. (cont.)

Indicator	Status/Trend	Major issues and challenges	Response	
			Key policies/laws; Action Plans	Examples of best practices or blue economy initiatives
State of ocean economy				
Marine and coastal tourism	Increasing	• Seasonality of beach tourism	• Basic Plan for Promoting Coastal Tourism • Marina Act • Korean South-Sea Tourism-Belt Development Project	• Ecotourism in Suncheon Bay, Jeju Island, Cheongsando Island • Ecotourism programs of local governments • Recreational fishing
Ports and shipping	Increasing	• Port development, reclamation • Sand mining • Oil spills • Invasive species	• Shipping Act • Harbor Act • International Ship Registration Act • MARPOL, Ballast Water Convention, Stockholm Convention, other IMO Conventions • Basic Harbor Plan	• Green port (Busan) • Waterfront program • Introduced Environment Ship Index (ESI) to give incentive to eco-friendly vessels by reducing their entry/departure charges
Ship-building	Medium and large shipyards: No change; Small shipyards: Decreasing	• oversupply of the world shipyards • recession of the world economy	• R&D in shipbuilding industry for eco-friendly ships	
Marine biotechnology	Increasing	• Proportion of marine biotechnology R&D budget to total biotechnology R&D budget is small	• Marine Life Resources Act 2012 • Marine Biotechnology Development Basic Plan (Blue-Bio 2016) • Measures for Revitalizing Marine Bio R&D (2010-2014) • Established the National Marine Biodiversity Institute of Korea (MABIK) • Next-generation Marine Biotechnology Upbringing Strategy	• Support for the deployment and industrialization of R&D results, and marine biotechnology companies • Promotion of marine bio industry performance • Formation of marine bio-area network

Table 6: Summary: State of Ocean Economy and Ocean Health. (cont.)

Indicator	Status/Trend	Major issues and challenges	Response	
			Key policies/laws; Action Plans	Examples of best practices or blue economy initiatives
State of ocean economy				
Ocean energy	Increasing	• Impact on fisheries	• Sixth National Electricity Supply & Demand Basic Plan • Second National Energy Basic Plan • Mid- and Long-term Offshore Energy Development Plan (2015-2025) • Technology Development Project for Commercialization of Offshore Energy established by MOF and MOTIE • Fourth New Renewable Basic Plan • Renewable Energy Portfolio Standard	• 255MW at the Siwha Tidal Power Plant (2011) • 14.5MW at the Uldolmok Tidal Current Power Plant (2017) • Jeju Pilot Wave Energy Plant • 40MW at the Jangjook Tidal Current Power (2019) • 100MW at the Incheon Tidal Power Plant (2020) • offshore wind energy in the Jeju Island • variable Renewable Energy Certificate (REC) weights
Employment in ocean economy	Increasing		• Comprehensive Measures to Promote New Marine Fisheries Industry • Strategy to Promote Industrialization of Marine Fisheries R&D • Strategy to Promote Business Start-up and Investment in Marine Fisheries	
Research, Development and Deployment (RD&D) in ocean economy	Increasing		• Roadmap for Ocean-science Technologies Development • Medium- and Long-term Plan for Ocean and Fisheries R&D (2014-2020)	• Offshore aquaculture • Ocean energy • Marine biotechnology • Deep seawater utilization
Mainstreaming of natural capital accounting	No change	• Access to data • Funding support		• Ocean economy accounting and valuation of coastal and marine ecosystems
State of ocean health				
Fish stocks	Decreasing	Reduction of habitat	• Fishery Resources Management Act	• Marine ranch program
Catch per unit	Decreasing	Overfishing; IUU fishing	• Fisheries Act	• TAC program • Vessel buy-back program

Table 6: Summary: State of Ocean Economy and Ocean Health. (cont.)

Indicator	Status/Trend	Major issues and challenges	Response	
			Key policies/laws; Action Plans	Examples of best practices or blue economy initiatives
State of ocean health				
Beach	Decreasing	• Coastal development • Public access • Pollution	• Beach Use and Mgmt Act • CZM Act; CZM plans	• Coastal use zoning • Beach tourism • Coastal clean up
Mudflats; tidal flats; tidal marshes	Decreasing	• Coastal development • Reclamation • Loss of habitats • Pollution • Climate change	• Wetland Conservation Act • Basic Plan for Wetlands Conservation	• Designation of Wetlands Conservation Sites • Recognition of blue carbon – carbon sequestration value of tidal marshes
Rare, threatened and endangered species	---	• Coastal development • Loss of habitat • Pollution • Climate change	• Marine Ecosystem Conservation and Management Act • Yellow Sea Strategic Action Plan	• Designation of specific marine species for protection • Designation of Marine Protected Areas and Wetlands Conservation Sites
Marine water quality	Improved (compared to the 1970s-1980s) No change (recent years)	• Pollution from land- and sea-based sources • Pollution from nonpoint sources • Red tides • Eutrophication	• Marine Environment Management Act • Marine Environment Conservation Plan • Designation of Special Area Management; Special Area Management Plan • Complete prohibition of ocean dumping • Marine Debris Management Plan • National Oil Spill Response Plan	• Sewerage systems and wastewater treatment facilities • Solid waste management systems • Rehabilitation of four major rivers • Ongoing clean-up of Masan Bay
Marine protected areas (% of territorial waters)	Increasing	• Opposition of residents on designation of MPAs	• Marine Ecosystem Conservation and Management Act • Designation of MPAs	• Ecotourism in MPAs
Pressures, risks and threats				
Population growth in coastal areas	Increasing	• Dense coastal development	• Coastal Zone Management Act • CZM Plans	
IUU fishing	No change	• Foreign encroachment • Depletion of coastal resources	• Fisheries Act • Fishery Resources Management Act • Fishery Resources Protection Act • Increasing capability of Korea Coast Guard (KCG) to address IUU fishing	• TAC program • Vessel buy-back program

Table 6: Summary: State of Ocean Economy and Ocean Health. (cont.)

Indicator	Status/Trend	Major issues and challenges	Response	
			Key policies/laws; Action Plans	Examples of best practices or blue economy initiatives
Pressures, risks and threats				
Coastal erosion and sedimentation	Increasing	• Coastal development • Sand mining	• CZM Act • Coastal Enhancement Program	
Untreated wastewater discharges	Decreasing	• Coastal development • Nonpoint sources • Inflow through rivers during rainfall	• Water Quality Management Act • Marine Environment Management Act • Marine Environment Conservation Plan • Coastal Total Pollutant Control	• Designation of Special Area Management; Special Area Management Plan • Sewerage systems and wastewater treatment facilities • Increased access and coverage of sanitation and wastewater management systems
Solid waste generation	Increasing	• Coastal development • Inflow through river during rainfall • Shortage of recycling facilities and sanitary landfill	• Wastes Control Act • Marine Environment Management Act • National Marine Debris Management Plan	• Implementation of waste separation and collection system
Plastic waste generation and marine debris	Increasing	• Inflow through river during rainfall • Increasing volume of unrecyclable waste • Microplastics in oceans	• Wastes Control Act • Marine Environment Management Act • National Marine Debris Management Plan	• Implementation of waste separation and collection system • Coastal clean up • Increasing awareness of public and NGOs on impacts to the marine environment
Oil spills	---	• Management of container ships, coastal tankers	• Marine Environment Management Act • National Oil Spill Response Plan	• Improving oil spill contingency and response capacity
Greenhouse gas emissions	---		• Clean Air Conservation Act • Framework Act on Low Carbon Green Growth	• Green port (reduction of GHG emissions in Busan Port) • Development of ocean energy and coastal/ offshore wind power
Natural hazards (storms, storm surge; flooding); **Climate change** (sea level rise; ocean acidification)	Increasing	• The overall sea surface temperature around the Korean Peninsula has risen by 0.93°C. The rate of increase is higher than global average. • Korea's sea level rise (2.5mm/yr) is above the world average (1.8mm/yr).	• Coastal Zone Enhancement Plan • Wetland Conservation Act • Basic Plan for Wetlands Conservation	• Bioeconomic modeling (to access impact of ocean acidification on fisheries) • Designation of Wetland Conservation Sites • Climate resilient infrastructure

1 Introduction

1.1 Background

The ministers of the East Asian Seas (EAS) Region adopted the Da Nang Compact during the EAS Congress 2015 held in Da Nang, Viet Nam in November 2015. One of its targets is the development of a Regional State of Oceans and Coasts (SOC) report. China prepared this National SOC report as its contribution to the regional report. The theme of the first national State of Oceans and Coasts (NSOC) report is blue economy. The definition of blue economy is given in the Changwon Declaration 2012[1], which was adopted by the ministers of the East Asian Seas (EAS) Region as a way to respond to the challenges of the changing environment and climate as well as fostering economic development through activities that harness the natural capital of the oceans but at the same time reduce negative impacts on ocean health and communities. This is in line with the Agenda 2030 and the Sustainable Development Goals (SDGs), especially SDG 14 – Life Below Water.

1.2 Rationale

One of the most important but little noticed change over the past decades is how our perspective on the world's oceans has changed. Oceans were first considered vast and limitless. Following centuries of exploration, oceans became areas for shipping, deep sea fishing, nuclear testing, dumping of wastes, and exploitation for food, minerals, oil and gas, and other resources. Given the current challenges, studies on the state of the marine environment have become more significant. There is now increasing recognition that oceans are finite, with fragile ecosystems and biodiversity under pressure from human activities, and climate and environmental changes. Yet, the benefits derived from the oceans have not been fully quantified as well as the environmental and societal impacts and costs of over-exploitation, pollution, and years of neglect. It has therefore become critical to understand that human activities, whether on land or on sea, have impacts, and each of our uses of oceans involves real or potential tradeoffs with other uses. This means we need a much better and more detailed understanding of the economic values of oceans and coastal and marine resources, and the state of ocean health underpinning the sustainable development of oceans and coasts.

[1] We understand the Blue Economy to be a practical ocean-based economic model using green infrastructure and technologies, innovative financing mechanisms, and proactive institutional arrangements for meeting the twin goals of protecting our oceans and coasts and enhancing its potential contribution to sustainable development, including improving human well-being, and reducing environmental risks and ecological scarcities. (Changwon Declaration 2012)

Within this context, the term "blue economy" has entered into the vocabulary of economic development in all parts of the world. But the meaning of "blue economy" is still evolving, with some emphasizing the possibilities of new ocean-based industries, such as renewable energy or bio-pharmaceuticals, and others emphasizing the need to transform the traditional ocean economy and the emerging ocean industries into a more sustainable and inclusive blue economy, conserving the oceanic natural capital and providing opportunities across society. The blue economy, as discussed during the East Asian Seas (EAS) Congress 2012, refers to a sustainable ocean-based economic model; one that employs environmentally-sound and innovative infrastructure, technologies, and practices, including institutional and financing arrangements, for meeting the goals of: (a) sustainable and inclusive development; (b) protecting our coasts and oceans, and reducing environmental risks and ecological scarcities; (c) addressing water, energy, and food security; (d) protecting the health, livelihoods, and welfare of the people in the coastal zone; and (e) fostering ecosystem-based climate change mitigation and adaptation measures.

All of the socioeconomic developments are taking place in a changing climate that is altering the physical properties of oceans that may dramatically shift the foundations of ocean and coastal economies. Though changes such as sea-level rise and ocean acidification are becoming known, uncertainty still remains about the extent and timing with which these ocean changes will affect resources, coastal areas, and well-being.

The drivers of blue economy are many and varied, but have their origins in or growing familiarity with the ocean environment; new technologies that make it feasible and economically viable to tap ocean resources; longer-term growth and demographic trends fuelling; the search for food security and for alternative sources of minerals and energy; seaborne trade and rapid coastal and urbanization, among others (Economist Intelligence Unit, 2015).

These blue economy drivers are equally applicable to Korea. Since the early 1960s, Korea has used and developed the coastal space and resources densely in order to achieve rapid economic development, with its large population in its small peninsular territory. However, its coastal development has been carried out through sectoral management, such as fisheries management, marine environment management, port management, and coastal resources management. Similar to other countries, sectoral coastal management has brought serious coastal issues. Also, until recently, Korea's traditional maritime industries such as shipping, port, shipbuilding and fisheries industry have shown high growth rates. However, these traditional marine industries have reached a maturity stage and are showing some limitations in growth due to intense international competition and global economic downturn.

Therefore, there is a need to develop new industries that can prevent resource abuse, over-development, and pollution while ensuring sustainable development and creating employment

opportunities. The new marine industries, such as marine energy, marine minerals, marine biotechnology and marine tourism are expected to generate a lot of employment and create added value as technologies are developed. Therefore, the Korean government has started to establish and implement national plans to develop the blue economy along with investment for R&D. This report describes the blue economy policy, and the status of industrial development that the Korean government is pursuing with policy priority.

1.3 Objectives and framework of the SOC Report

RO Korea's National SOC Report provides information on the status of seas and coasts of RO Korea, including the national ocean economy; quantity and quality of resources in the coastal areas; and the existing and potential uses of such resources. The report also aims to contribute to the blue economy assessment and monitoring progress on the implementation of the Sustainable Development Strategy for the Seas of East Asia (SDS-SEA), the UN Sustainable Development Goals (SDGs), other international agreements subscribed to by RO Korea, and related national laws and policies on oceans and coasts.

The SOC report provides the description and assessment of the following:

1. *Socioeconomic conditions:* population, economy, social developments
2. *Ocean economy*: gross value added of the ocean economy and contribution to national economy; valuation of ecosystem services; key ocean economic activities (contribution to income and employment, pressures and issues, response in terms of policies and best practices)
3. *Developments in blue economy:* innovative and sustainable ocean economic activities; emerging industries; opportunities for investments and partnerships for blue economy development.
4. *State of ocean health underpinning the blue economy:* natural conditions (oceanography and physical features of the seas and coasts); marine water quality; ecosystems and biodiversity; pressures (risks and threats from human activities, natural hazards, and climate change; and impacts on the environment and communities).
5. *Governance structure supporting blue economy development:*
   a. *Institutional arrangements:*
      - Description of key policies, laws, and international agreements adopted that would address the pressures and threats to ocean health and ocean economy, and support blue economy development.
      - Supporting mechanisms (capacity development; research and development; financing, stakeholder participation; partnerships, etc.) for the implementation of these policies, laws, and international agreements.

b. *Sustainable development strategy and actions:* ocean and coastal management, fisheries management, ecosystem and biodiversity conservation, marine protected areas, pollution reduction, natural hazard management and climate change response to achieve the SDG 14 targets, SDS-SEA targets, other international commitments, and national targets to ensure ocean health and sustainable blue economy.

c. *Driving forces for blue economy*

6. *Conclusion and recommendations*

Jeju Island. *(Photo by KOREA.NET - Official page of the Republic of Korea, licensed under CC BY-SA 2.0)*

PART 1

THE SEAS AND PEOPLE

2 The Seas, People and Economy of RO Korea

2.1 The Seas and Coasts of RO Korea

The Korean Peninsula is located at the rim of the Northwestern Pacific Ocean, and is surrounded by the sea on three sides: the East Sea, Yellow Sea, and the southern sea of Korea, with total area of 443,838 km^2 (**Figure 2.1**). The territorial sea area is 86,891 km^2, accounting for 17% of the EEZ, and 87% of the national land area. Korea's seawaters are significantly influenced by the Tsushima Warm Current, a tributary of the Kuroshio Current from the south, and by the Liman Cold Current from the north, and thus both warm- and cold-water species appear altogether.

The East Sea, Yellow Sea, and southern sea of Korea have different geographical features. The East Sea area is 120,447 km^2, the average depth is 1,497 m and the maximum depth is 2,985 m. The east coast is mainly rocky coastline, and the coastline is monotonous. The Yellow Sea area is 191,449 km^2, the average depth is 51 m and the maximum depth is 124 m. The west coast is composed of large tidal flats along the shoreline. The area of the southern sea of Korea is 131,942 km^2, the average depth is 71 m and the maximum depth is 198 m. The southern sea of Korea contains many islands and marshes, with unique biodiversity and rich coastal resources along the *rias* (heavily dented) coasts. There are over 3,000 islands in Korea, mostly on the south coast.

Figure 2.1: Map of RO Korea.[2]

The coastline of Korea is 13,509 km long. The proportion of land-side artificial shoreline increased from 26.2% in 2000 to 49.4% in 2010. The area of the tidal flat was 2,489 km^2, about 2.4 percent lower than 2,550 km^2 in 2003. The development of coastal dependent industries, such as shipbuilding, marine tourism, harbors, fishing ports, and new energy generation, are increasing the degradation of natural coasts and habitats.

Korea's water quality standards are divided into three grades. Class 1 has a chemical oxygen demand (COD) of less than 1mg / l, Class 2 is

[2] https://www.cia.gov/library/publications/the-world-factbook/attachments/maps/KS-map.gif

1-2mg/l, and Class 3 is 2-4mg/l. Over the past five years, the quality of the waters throughout the country has remained at the Class 2, except for the Masan Bay and the Sihwa Lake, with the intensive management including the expansion of wastewater treatment facilities and the dredging of the contaminated waters. As of December 2010, there are 525 coastal and marine protection areas covering 10,006.9 km^2, which is equivalent to 10% of the national land area (100,033 km^2), and 11.5% of the territorial sea area (86,891 km^2).

Since the early 1960s, Korea has used and densely developed the coastal space and resources in order to achieve rapid economic development, considering its large population in its small peninsular territory. However, its coastal development has been carried out through sectoral management, such as fisheries management, marine environment management, port management, and coastal resources management. Similar to other countries, sectoral coastal management has brought serious coastal issues, such as depletion of fisheries, reduction of habitats due to sand mining and reclamation of coastal waters including wetlands, pollution of coastal waters, increased marine debris, reduction of natural coastlines, and limitation of public access to coastal waters.

Table 2.1: Changes in the Korean Coast during 2000 and 2010.

	2000	2010	Changes
Territorial Sea Area	-	86,891 km^2	-
National Land Area	99,540 km^2	99,897 km^2	+ 357 km^2
Tidal Flat Area	2,550 km^2 (2003)	2,489 km^2 (2008)	- 61 km^2
Islands	3,170	3,358	+ 188
Inhabited/Uninhabited	491/2,679	482/2,876	
Coastline	11,542 km	13,509 km	+ 1,967 km
Land Side Natural Coastline	4,596km	3,806km	
Coastal Population	12,636,677	13,391,048 (2009)	+754,371
Coastal Population Density	398 km^2	417 km^2	
Coastal Local Governments	78	74	- 4
Corresponding Area	31,797 km^2	32,077 km^2	+ 280 km^2
Number of Industrial Complexes	174	304	+ 130
Corresponding Area	483.0 million m^2	991.2 million m^2	
Harbors/Fishing Ports	50/354	57/394	+ 7/40
Fisheries Population	1,842,000 ton	2,540,000 ton	+ 698,000 ton
Port Cargo Volume	833.5 million ton	1,076.5 million ton	+ 242.9 million ton
Coastal/Marine Protection Area	422	525	+ 103

Source: MOF. MLTM. The Second Integrated Coastal Zone Management Plan. 2011

2.2 Demographic Features

The population of Korea is mostly homogenous. The major ethnic group is Korean, with about 20,000 ethnic Chinese Koreans. Given this homogeneity, the language spoken is Korean. In terms of the general population, the ratio between females and males are fairly even. The overall age groups form a bell curve, which provides the information that majority of the country's population are working-age appropriate and the difference between the young and the old are even.

The population has increased from 38,124,000 in 1980 to 51,246,000 in 2016. However, the growth rate of population has continuously decreased from 1.56% in 1980 to 0.45% in 2016. The population will be reached at peak, 52,960,000 in 2031 and will be decreasing thereafter, reaching at 45,246,000 in 2060. In 2016, the youth population under the age of 15 accounted for 13.4% of the total population. The working age population between 15 and 64 was 7.4%, and the elderly population over 64 years accounted for 13.2%. The number of families has increased from 11,355,000 families in 1990 to 19,111,000 families in 2015. However, the average number of household members has decreased 3.77 persons in 1990 to 2.53 persons in 2016.

The coastal population was 13,983,000 in 2015, which was 27.2% of the total population. The number of households (5,681,000) of the coastal areas was 27.4% of the nationwide households (20,724,000). The coastal area is 32,369 km^2, which is 32.3% of the nationwide area. The density of the coastal population was 432, which is slightly smaller than that of the nationwide density. The number of the coastal municipalities is 74, which is 32.3% of the nationwide municipalities.

Table 2.2: Coastal Population and Households (2015).

	Population (1000)	Households (1000)	Population Per Household	Areas (km^2)	Population Density (person/km^2)	Municipality Numbers
Nationwide (A)	51,328	20,724	2.48	100,266	512	229
Coastal (B)	13,983	5,681	2.46	32,369	432	74
B/A (%)	27.2	27.4	99.4	32.3	84.4	32.3

Source: Source: Statistics Korea. Korea Statistical Yearbook. 2016.

The number of fishery households has continuously decreased from 74,000 households in 2007 to 55,000 households in 2015. Also the population of fishery households has continuously decreased from 202,000 persons in 2007 to 128,000 persons in 2015. This phenomenon is similar to that of rural areas, as a result of the migration of young people from rural to urban areas. The employment numbers per fishery household keeps 1.6 persons. The average income of fishery household has continuously increased from 30,668,000 KRW in 2007 to 43,895,000 KRW in 2015. The fishery-related income among total income has continuously increased from 11,975,000 KRW in 2007 to 23,086,000 KRW in 2015, and so the fisheries dependent rate has increased from 39.0% in 2007 to 52.6% in 2015.

Table 2.3: Major Index of Fishery Households.

	Fishery Household Numbers (1000 families)	Fishery Household Population (1000)	Fishery Employment (1000)	Employment Per Family (persons)	Families Income (1000 KRW)	Fisheries Income (1000 KRW)	Fisheries Dependent Rate (%)
2007	74	202	123	1.7	30,668	11,975	39.0
2008	71	192	119	1.7	31,176	13,801	44.3
2009	69	184	116	1.7	33,945	16,220	47.8
2010	66	171	107	1.6	35,696	16,607	46.5
2011	63	159	104	1.6	38,623	20,432	52.9
2012	61	153	100	1.6	37,381	19,539	52.3
2013	60	147	98	1.6	38,586	18,538	48.0
2014	59	141	96	1.6	41,015	20,987	51.2
2015	55	128	90	1.6	43,895	23,086	52.6
2015/ 2014							
Rate (%)	-6.8	-9.2	-6.3	0.0	7.0	10.0	-

Source: Source: Statistics Korea. Korea Statistical Yearbook. 2016.

Photo by DonQuixote (Panoramio - Wikimedia Commons)

Both the number of fishermen and their households have continuously decreased since the 1970s. The number of fishermen was 800,896 in 1960, increased to 912,612 in 1970, and has decreased to 141,000 in 2014. And the old fishermen, who are older than 60 years old, accounted for only 6.2% of the total fishermen in 1970. However, old fishermen took up 44.6 % in 2012. This is because young fishermen have left the fisheries industry and the fisheries villages to other industry in cities.

Table 2.4: Trend of Fishermen in Korea.

No. of Fishermen				
Year	**Households**	**Total**	**Less than age 60**	**Older than age 60 (Ratio)**
1960	189,165	800,896	-	-
1970	194,601	912,612	855,977	56,977 (6.2%)
1980	134,109	725,314	675,693	49,621 (6.8%)
1985	126,800	602,237	547,299	54,938 (9.0%)
1990	121,525	496,089	442,349	53,740 (10.8%)
1995	104,480	347,210	288,430	58,780 (16.9%)
2000	81,571	251,349	199,188	52,161 (26.2%)
2005	79,942	221,132	158,635	62,497 (28.3%)
2010	65,775	171,191	112,509	58,682 (34.3%)
2012	61,493	153,106	92,069	61,037 (39.9%)
2014	58,791	141,000	78,000	63,000 (44.6%)

Source: Ministry of Ocean and Fisheries. Statistics on Ocean and Fisheries. Each year.

Koreans share one language, with approximately seventy million people around the globe speaking Korean. Korea has one of the highest literacy rates in the world due to the phonetic nature of the written language, which was invented in the mid-fifteenth century to give one language to Koreans.

Korea supports religious freedom. Confucianism, Buddhism and Christianity are the main formal religions. Many Koreans believe in the ancestral spirit and observe Confucian rituals. Confucianism is a political and social philosophy that pervades Korean culture.

2.3 Economic Development

South Korea is a small mountainous country. The population density stands at 471 people per square kilometer, which is among the highest of any country in the world. Although Korea is a mountainous and resource-poor country, its hardworking disciplined people have enabled themselves to enjoy the extraordinary economic boom that increased GNP per capita from US$82 in 1962 to over US$8,000 in 1999 (Cho and Olsen 2003).

Korea's economic growth is a miracle which has created something from nothing. The long periods under the Japanese colonialism (1910-1945) and the Korea war (1950-1952) completely devastated the economy already dealing with scarce natural resources and dense population on

little arable land. Korea's economic growth was initiated by a series of the National Economic Development Plans that were based on the strategy of importing raw materials and exporting finished goods, among which steel, automobiles, shipbuilding, textiles, and most recently, computer chips have been figured importantly.

The First National Economic Development Plan was started from 1962 to 1966, the second from 1967 to 1971, the third from 1972 to 1976, and thereafter the fourth, fifth, sixth and seventh through 1996. Through all the seven National Economic Development Plans from 1962 to 1996, Korean economy developed very rapidly and surprisingly. The annual economic growth rate was 8.7% in the 1960s, 7.6% in the 1970s, 9.1% in the 1980s and 7.1% in the 1990s. Accordingly, GNP per capita had increased from US$87 in 1962 to US$249 in 1970, US$1,598 in 1980 and US$5,886 in 1990. Korean exports also had increased from US$1 billion in 1970 to $10 billion in 1977. This took place in only 7 years whereas West Germany and Japan took eleven years and sixteen years, respectively (Cho 2016).

However, the economic growth showed very low rate entering 2000s. In 2005, the annual GDP growth rate was only 3.92%, and went down further to 2.7% in 2016 (**Table 2.5**). The Korean economy has gone through the stage of rapid growth, and then the economy slowed down due to the Asian financial crisis in 1997, and the global financial crisis in 2007- 2008.

Table 2.5: Trend of Economic Growth Rate.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Growth Rate (%)	3.9	5.2	5.5	2.8	0.7	6.5	3.7	2.3	2.9	3.3	2.6	2.7

Source: Statistics Korea. Korea Statistical Yearbook. 2016.

East View from N-Seoul Tower. *(Photo by InSapphoWeTrust, licensed under CC BY-SA 2.0)*

Table 2.6: Trend of GDP, GNI, and GNI per Capita (in current prices).

	GDP		GNI		Per Capita GNI	
	Billion KRW	Billion $	Billion KRW	Billion $	10 thousand KRW	$
1970	2,795	8.2	2,843	8.3	9	257
1980	39,471	65	39,083	64	103	1,686
1990	197,712	279	197,415	279	461	6,505
2000	635,185	562	630,614	558	1,342	11,865
2004	876,033	765	874,239	764	1,820	15,898
2005	919,797	898	912,609	891	1,896	18,508
2006	966,055	1,011	962,447	1,007	1,990	20,823
2007	1,043,258	1,123	1,040,092	1,119	2,140	23,033
2008	1,104,492	1,002	1,104,414	1,002	2,256	20,463
2009	1,151,708	902	1,148,982	900	2,336	18,303
2010	1,265,308	1,094	1,266,580	1,095	2,563	22,170
2011	1,332,681	1,203	1,340,530	1,210	2,693	24,302
2012	1,377,457	1,222	1,391,596	1,235	2,783	24,696
2013	1,429,445	1,305	1,439,644	1,315	2,867	26,179
2014	1,486,079	1,411	1,490,764	1,415	2,957	28,071
2015	1,558,592	1,378	1,565,816	1,384	3,094	27,340

Source: Statistics Korea. Korea Statistical Yearbook. 2016.

Using 2010 constant US$ prices, the gross domestic product (GDP) was US$1.27 trillion in 2015, and US$1.35 trillion in 2017. The gross national income (GNI) shows the same trend as the GDP: US$1.27 trillion in 2015, and US$1.35 in 2017. The GDP per capita (in constant 2010 prices) was US$26,152 in 2017 while the GNI per capita (in constant 2010 prices) was US$26,153 in 2017.

Because Korea lacks resources, it is very important to import raw materials through imports, process them, and export them. Therefore, the ratio of import and export to GDP is very high, of which rate was 59.2% in 2000 and increased 89.7% in 2001. It has decreased thereafter, but it still keeps about 70% now. The export and import were $172.2 billion and $160 billion in 2000 and have increased until 2014. However, due to the world economic recession, the export and import decreased in 2015 and 2016. The export and import were 495.4 billion and $406.0 billion in 2016.

Table 2.7. Trend of export and import (Billion $).

	Total	Export (A)	Import (B)	(A) – (B)	GDP	Total/GDP
2000	332.7	901.5	160.4	11.7	562	59.2%
2005	545.6	284.4	261.2	23.1	898	60.7%
2010	891.6	466.3	425.2	41.1	1,094	81.5%
2011	1,079.6	555.2	524.4	30.8	1,203	89.7%
2012	1,067.4	547.8	519.5	28.2	1,222	87.3%
2013	1,075.2	559.6	515.5	44.0	1,305	82.4%
2014	1,091.8	572.6	525.5	47.1	1,411	77.4%
2015	963.2	526.7	436.5	90.2	1,378	69.9%
2016	901.5	495.4	406.0	89.4	-	-

Source: Statistics Korea. Korea Statistical Yearbook. 2016.

2.4 Social Development

2.4.1 Human Development[3]

The human development index (HDI) is a summary measure for assessing long-term progress in three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living. A long and healthy life is measured by life expectancy. Knowledge level is measured by (a) mean years of education among the adult population; and (b) access to learning and knowledge by expected years of schooling for children of school-entry age. Standard of living is measured by Gross National Income (GNI) per capita expressed in constant 2011 international dollars converted using purchasing power parity (PPP) conversion rates.

Korea's HDI value for 2017 is 0.903— which put the country in the very high human development category—positioning it at 22 out of 189 countries and territories. Between 1990 and 2017, Korea (Republic of)'s HDI value increased from 0.728 to 0.903, an increase of 24.0 percent. Table 8 reviews Korea's progress in each of the HDI indicators. Between 1990 and 2017, Korea's life expectancy at birth increased by 10.7 years, mean years of schooling increased by 3.2 years and expected years of schooling increased by 2.9 years. In 2017, life expectancy is 82.4 years, while expected years of schooling and mean years of schooling are 16.5 years and 12.1 years, respectively. Korea's GNI per capita increased by about 209.5 percent between 1990 and 2017. The GNI per capita in 2017 is US$35,945 (PPP$).

[3] This section is from United Nations Development Programme (UNDP). 2018. Human Development Indices and Indicators: 2018 Statistical Update. Accessed from http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/KOR.pdf

Table 2.8: Human Development Index of RO Korea.

	Life Expectancy at Birth	Expected Years of Schooling	Mean Years of Schooling	GNI Per Capita (2011 PPP$)	HDI Value
1990	71.7	13.6	8.9	11,614	0.728
1995	73.9	14.5	10.0	16,482	0.778
2000	76.0	15.6	10.6	20,601	0.817
2005	78.4	16.3	11.4	25,315	0.855
2010	80.5	16.8	11.8	30,387	0.884
2015	81.9	16.5	12.1	34,276	0.898
2016	82.2	16.5	12.1	35,122	0.900
2017	82.4	16.5	12.1	35,945	0.903

Source: UNDP. 2018. (http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/KOR.pdf)

2.4.2 Literacy and Education

Photo from: Asia News

The *Basic Education Law* in 1949 and then the national strategic plan with a focus on education reforms in 1962 created compulsory education for children from elementary and middle school. By 1970, the literacy had gone up from 22% in 1945 to 87.6%. This progress did not stop, and now Korea has a literacy rate of 97.9%, breaking this percentage down further, 99.2% of males and 96.6% of females are literate. Its success in literacy and education is supported by their value-of-education cultural background.

The ratio of the budget of the Ministry of Education (MOE) is about 16% (16.4% in 2016). The number of students per class and per teacher in elementary school, middle high school, and high school has continuously decreased. The number of students per class and per teacher in elementary school is 22.4 and 14.6 in 2016, respectively. The number of students per class and per teacher in middle high school is 27.4 and 13.3 in 2016, respectively. The number of students per class and per teacher in high school is 29.3 and 12.9 in 2016, respectively. The number of students per staff in university has also decreased continuously, and it was 31.9 in 2016.

Table 2.9: Number of Students per Class and per Teacher.

	Budget of MOE	Elementary		Middle School		High School		University
	Per Total Budget	Per Class	Per Teacher	Per Class	Per Teacher	Per Class	Per Teacher	Per Staff
2009	18.0	27.8	19.8	34.4	18.4	34.2	15.7	36.4
2010	19.6	26.6	18.7	33.8	18.2	33.7	15.5	36.2
2011	17.1	25.5	17.3	33.0	17.3	33.1	14.8	35.5
2012	17.6	24.3	16.3	32.4	16.7	32.5	14.4	33.9
2013	16.6	23.2	15.3	31.7	16.0	31.9	14.2	33.6
2014	16.4	22.8	14.9	30.5	15.2	30.9	13.7	33.1
2015	15.9	22.6	14.9	28.9	14.3	30.0	13.2	32.3
2016	16.4	22.4	14.6	27.4	13.3	29.3	12.9	31.9

Source: Statistics Korea. Korea Statistical Yearbook. 2016.

The university entrance rate of the general high schools has continuously decreased from 84.9% in 2009 to 78.0% in 2016, and that of the vocational high school has decreased from 73.5% to 46.8% in 2013. The employment rate of the colleges and university is 69.5% and 64.4% in 2015, respectively.

The research and development (R&D) expenditure was KRW 63 trillion in 2014, an increase of 4.4 trillion (7.5%) over the previous year. The R&D expenditure as a percentage of GDP was 4.29% in 2014, up 0.14% from the previous year (4.15%). In 2014, R & D expenditure by financial resources is KRW 15 trillion for public including government funds, and the ratio of public to public is 24 to 76.

2.4.3 Gender

Equality of the sexes is constitutional. Daily life is, however, dominated by male guidance within a primary patriarchal society. Social organization is influenced by gender and age. Women dominate Shamanism as priestesses, but have limited roles within Christian and Buddhist religions. Women are expected to be submissive in public situations and at informal gatherings. Women are considered more independent than their male counterparts.

2.4.4 Access to Safe Water and Improved Sanitation[4]

Up until the 1970s, the water quality in South Korea was subpar due to the lack of a managed sewerage system and overall poor water management services. However, in 1965, the Korean

[4] Source: http: worldbank.org/water/korea-model-development-water-and-sanitation-sector

government decided to implement the *20-Year National Water Resource Plan*. The idea behind this plan was that adequate and safely managed water services were necessary for the health and wellbeing of the people. During this period, the Korean government started to integrate the water and sanitation sector into the overall economic development strategy of the country.

In the late 1980s, accelerated urbanization took its toll, and surface and underground water bodies became polluted. Majority of the rivers fell below the quality *index of 3 (indicating pollution)*. Pollution-induced morbidity became so widespread that the national government decided to change the water quality standards. Since the early 1990s, one of key reforms was the requirement for utilities to publish tap water quality report annually under the *Water Supply and Waterworks Installation Act*. This report must include the source of water, pollution information, drinking water quality standard test results, and contact details of the person in charge.

Currently, access to improved water sources and sanitation facilities are almost universal in South Korea. 98% of the population has access to safely managed water supply as of 2015, while 98.5% of the population has access to safely managed sanitation facilities.[5]

In wastewater, the country gave a large role to the private sector. Between 1998 and 2008, investments amounting to more than US$800 million were financed by the private sector for the construction of 100 wastewater treatment plants. This trend continued and it is estimated that 58 percent of wastewater treatment plants were privately owned and managed by the end of 2012. Now the task is to maintain the systems, reduce inefficiencies in the form of excess capacity, and promote green growth in the sector. This includes a plan to reduce electricity consumption in the sector by at least 50 percent. The Government also wants to consolidate utilities according to river basins by 2030 to achieve economies of scale and reduce the need for financial support from the government budget.

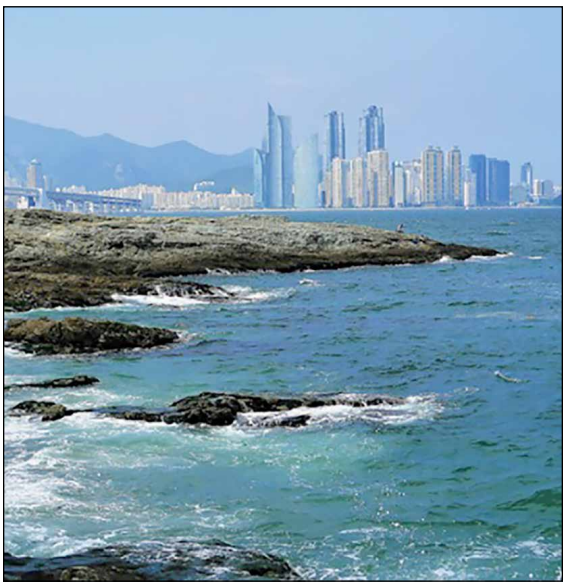
[5] Source: https://data.worldbank.org/country/korea-rep

PART 2

HARNESSING THE OCEANS

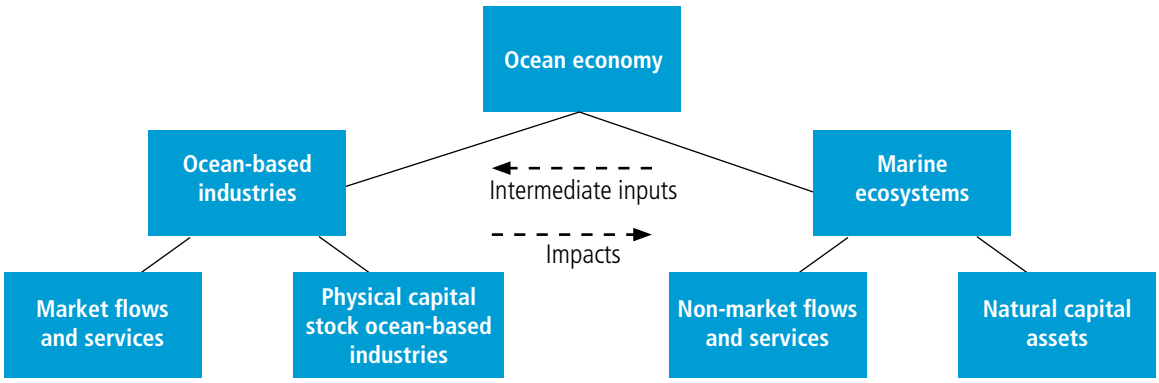
3 Ocean Economy

Oceans provide an extensive range of natural assets and resources – natural capital from which humans derive a wide variety of ecosystem services that make life possible and upon which human activities rely.



The entire ocean economy is measured as the sum of: (a) the economic activities with dependence on the ocean and coastal and marine resources, and (b) natural assets, goods and services of marine ecosystems upon which these industries depend on, and people rely on for food, income, livelihood, recreation, shoreline protection, etc. (**Figure 3.1**)

Figure 1: Ocean Economy



Source: OECD (2016), The Ocean Economy in 2030, http://dx.doi.org/10.1787/9789264251724-en.

The ocean economic activities can be measured using the System of National Accounts (SNA), and include:

- *ocean-based* activities, such as fisheries, marine tourism, shipping, oil and gas, ocean energy, etc.;
- *ocean-related* activities: (a) those that use products from the ocean (e.g., seafood processing, marine biotechnology, salt); (b) produce products and services for the ocean-

based activities (e.g., ports, ship-building, communication, maritime insurance); (c) marine education, and research and development; and (d) government agencies with direct maritime responsibilities (e.g., navy, coast guard, marine environmental protection, etc.).

The ocean also provides services that are not usually quantified and captured in the national income accounts, such as *regulating* services (e.g., carbon storage, shoreline protection, waste assimilation, nutrient cycling), *supporting* services (e.g., habitat, nursery), and *cultural* services (e.g., spiritual; aesthetic; bequeath).

3.1 Ocean Economic Activities: Contribution to GDP and Employment

There is not any standardized methodology and scope for estimating the ocean economy in RO Korea. The direct and indirect value of ocean industry in 1998 was estimated at KRW 31,763 billion, sharing 7.0 percent of GDP, in the *First Basic Plan for Marine and Fisheries Development (Oceans Korea 21)*. The shipping industry was KRW 8,278 billion, the largest industry among the ocean industry. The fisheries industry, the second largest industry, was KRW 8,147 billion. The shipbuilding industry was the third, KRW 6,265 billion. Despite the overall development of the marine industry, the marine tourism industry, marine energy industry, seabed resource industry and marine biotechnology industry were merely starters. The direct effects of the ocean industry as well as trigger effects are shown in **Table 3.1**.

Table 3.1: Value Added of the Ocean Industry (unit: KRW billion).

	Direct Effect	Trigger Effect	Total
Shipping Industry	5,435	2,843	8,278
Port Industry	1,366	1,450	2,786
Fisheries Industry	5,505	2,642	8,147
Shipbuilding Industry	3,478	2,787	6,265
Ocean Tourism	918	582	1,500
Ocean Mining, Etc.	2,930	1,857	4,787
Total	**19,602**	**12,161**	**31,763**

Source: MOMAF et al. The First Basic Plan for Marine and Fisheries Development (Oceans Korea 21). May 2000.

As of 2014, the gross output of Korea's ocean and fisheries industries was estimated to be KRW 147.0 trillion (US$139.6 billion), with the value added at KRW 38.9 trillion (US$37 billion), and accounting for 2.9% of the Korean economy or GDP (**Table 3.3**). The value added of Korea's ocean industry dived from KRW 42.1 trillion (US$43.53 billion) in 2013 due to the decrease in the value added of the ship-building industry as a result of the global economic slump and drop in in the amount of ship-building orders received (KMI 2018).

Table 3.2: Trend of Korean Ocean Industry (unit: KRW bi, %).

		Fisheries Industry	Shipbuilding Industry	Shipping Industry	Port Industry	Ocean Industry (A)	Whole Industry (B)	A/B
1990	Amount	4,522	2,742	2,676	1,276	11,217	416,965	2.7
	Ratio	(40.3)	(24.4)	(23.9)	(11.4)	(100.0)		
1995	Amount	6,283	6,806	7,023	2,212	2,212	841,519	2.7
	Ratio	(28.1)	(30.5)	(31.5)	(9.9)	(100.0)		
2000	Amount	8,010	12,711	13,345	2,836	36,901	1,392,918	2.6
	Ratio	(21.7)	(34.4)	(36.2)	(7.7)	(100.0)		
2005	Amount	9,715	23,223	19,984	3,790	56,712	2,068,808	2.7
	Ratio	(17.1)	(40.9)	(35.2)	(6.7)	(100.0)		
2007	Amount	10,879	36,504	26,190	5,609	79,181	2,396,329	3.3
	Ratio	(13.7)	(46.1)	(33.1)	(7.1)	(100.0)		
		5.3	**16.4**	**14.4**	**9.1**	**12.2**	**10.8**	

Source: Choi et al. A Strategy for Creating a New Ocean-based National Wealth towards Realizing Ocean-GNP Era. Korea Maritime Institute. 2010.

The contribution of each ocean industry to total ocean economy is shown in **Figure 3.2**. The fisheries industry (fisheries production processing, and distribution) took up 17.3% of the ocean industries as a whole, in terms of value added. The share of shipping and ports industries is 11.8% and 5.1%, respectively. The vessel and offshore plant construction and repair industry has the biggest contribution to the ocean industry at 31%, followed by the marine and fisheries services with 27% share.

Employees or workers in the ocean industries numbered around 596,000. Marine and fisheries services employed the highest number of workers, followed by the vessel and offshore plant construction and repair, the shipping industry, and fisheries distribution industry.

According to the *Special Classification of Korea's Ocean and Fisheries Industries*, the fisheries production industry is composed of fishing, aquaculture, services incidental to fishing and aquaculture, and salt production. Fisheries processing consists of aquatic animal processing and storage, seaweed processing and storage, salt processing, and other fisheries processing. Fisheries distribution involves fisheries brokerage, wholesale and retail, and fisheries transportation and storage.

The shipping industry is classified into passenger transportation; freight transportation (ocean-going, and coastal water); and other shipping services (e.g., tug business; brokerage and agency; ship lease; ship management; and suppliers of lubricant and articles for ships). The port industry is classified into: (a) port transportation and support services offering logistics services (port loading

and unloading; port storage and warehouse; freight inspection); and (b) other port-related business (e.g., freight packing; ports and terminal operation; supply of articles for ships; port security; etc.).

Vessel and offshore plant construction and repair is a knowledge-based key industry involving the design and building of cargo ships, fishing boats, and offshore plants that are used by the shipping industry, marine resource development, fisheries, marine leisure and tourism, and the military industry.

Marine resources development consists of: (a) collecting aggregates, such as sand and gravel, and exploring for offshore oil and natural gas; (b) deep seawater utilization for mineral water, beverages, and cosmetics; (c) marine renewable energy – producing electricity using tidal current, tidal energy, wave power, offshore wind power, offshore solar energy, and ocean thermal energy conversion; and (d) marine bio-industry, which produces marine bio-food, medicines, and chemical products (cosmetics) using marine biotechnology based on marine bio-resources (fish and seaweeds). Marine construction industry includes constructing and maintaining ports, structures for coastline protection, and bridges; land reclamation; installing offshore plants; and establishing submarine cables.

According to MOF's *Second Basic Plan for the Promotion of Marine Tourism, 2014,* the marine leisure and tourism industry consists of marina industry, cruise industry, beach visitors and sea bathing tourism, recreational fishing, etc.

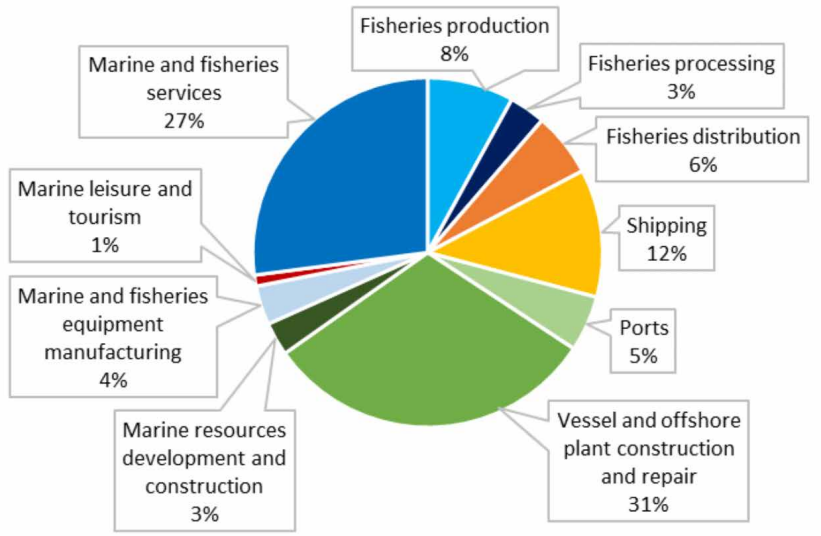
The marine and fisheries services industry is composed of: (a) marine waste processing, cleanup, and recovery; (b) marine and fisheries equipment wholesale and retail; (c) marine and fisheries human resource (HR) employment and supply services; (d) marine and fisheries education services; (e) marine and fisheries science and technology services; (f) marine and fisheries finance, insurance, accounting, law and management consulting; (g) fish and seafood restaurants; and (h) marine and fisheries associations, organizations and public institutions.

Table 3.3: Output, Value Added, and Employment of the Ocean Industries in 2014.

Ocean industries	Output		Value Added		Employment
	KRW, trillions	US$, millions	KRW, trillions	US$, millions	Number of persons
Fisheries production	7.6	7,211.2	3.1	2,946.5	44,990
Fisheries processing	9.4	8,966.1	1.3	1,248.8	40,655
Fisheries distribution	4.7	4,454.5	2.3	2,195.4	65,827
Shipping	30.5	28,963.5	4.6	4,348.4	70,279
Ports	5.0	4,724.5	2.0	1,883.9	27,494
Vessel and offshore plant construction and repair	64.2	60,987.4	12.0	11,438.6	131,418
Marine resources development and construction	2.6	2,458.0	1.2	1,153.4	13,739
Marine and fisheries equipment manufacturing	5.4	5,131.9	1.4	1,368.9	18,701
Marine leisure and tourism	1.2	1,161.4	0.4	386.9	10,985
Marine and fisheries services	16.4	15,551.1	10.5	9,975.0	172,071
TOTAL	**147.0**	**139,613.7**	**38.9**	**36,945.7**	**596,160**
Whole industry (GDP)	**3,658.0**	**3,473,026.6**	**1,354.9**	**1,286,387.0**	**23,567,991**
% of ocean industry to whole industry (GDP)	**4.0%**		**2.9%**		**2.5%**

Note: US$1 = KRW1,053.26 in 2014
Source: KMI (2018); 2014 Input-Output Tables of Bank of Korea

Figure 3.2: Share of Each Ocean Industry, 2014.



Source: Korea Maritime Institute (KMI). Korea's Ocean Economy 2018.

3.2 Valuation of Coastal and Marine Ecosystem Services

The various coastal and marine ecosystems are shown in **Table 3.4**. Korea's coastal and marine ecosystem services are valued at around US$40.46 billion to 42.54 billion (**Table 3.5**).

Table 3.4: Coastal and Marine Ecosystems in RO Korea.

Marine Ecosystem		km²	Marine Ecosystem Services	Valuation Methods
Coastal Waters	Beach National Park	(358 site) (4 site), 3,194 km²	Recreation, Cultural Services, Conservation Value	Non-market (Contingent Valuation Method, CVM)
	Other Coastal Waters		Food Production Raw Materials (Aggregate, Natural Gas)	Market Price
Estuaries		2,126 km²	Food Production Waste Treatment Refugia Recreation Inderect-use Value, Non-use Value	Market Price Replacement Cost Non-market (CVM) Non-market (Travel Cost Method, CVM) Non-market (CVM)
Tidal Flats		2,489.4 km²	Food Production Waste Treatment Refugia Recreation Disturbance Regulation Non-use Value (Conservation Value)	Market Price Non-market

Source: Chang & Yoo (2015)

Table 3.5: Valuation of Coastal and Marine Ecosystem Services in 2012 (in Million US$).

Marine Ecosystem Services		Annual Economic Value
Coastal Waters	Food Production	5,710.3
	Aggregate (sand, etc.)	250.0
	Natural Gas	256.8
	Beaches	16,614.6
	National Parks	591.2
Tidal Flats		**16,629.9**
Estuaries (excluding tidal flats)		**2,380.0 ~ 4,463.8**
Total		**40,460.1 ~ 42,543.9**

Source: Chang & Yoo (2015)

1,000 KRW = 1 USD

4 Fisheries and Food Security from Coastal and Marine Resources


Photo by: M. Ebarvia


Photo by: M. Ebarvia

4.1 Fishery resources

Over the last half a century, fisheries habitats such as wetland and coastal waters have been greatly lost due to the coastal development, although the fishing authority and fisheries industry have strongly opposed the development. As a result, the domestic fisheries product has been continuously decreased since 1980s. In 1960, the fisheries production amounted to 357 thousand tonnes and increased sharply to 3.6 million tonnes in 1986, which was the peak. However, it started to decrease from the mid-1980s and maintains about 3 million tonnes presently.

Table 4.1: Trend of Fisheries Products in Korea.

	1960	1970	1986	1990	1995	2000	2005	2010	2012	2014
Production (1,000Ton)	357	935	3,659	3,198	3,348	2,514	2,714	3,111	3,183	3,305
- Catching (1,000Ton)	357	816	2,712	2,425	2,325	1,861	1,673	1,756	1,694	1,758
- Farming (1,000Ton)	-	119	947	773	996	653	1,041	1,355	1,489	1,547

Source: Ministry of Ocean and Fisheries. Statistics on Ocean and Fisheries. Each year.

As per capita income increases, the demand for seafood as a healthy food has increased from 42.2 kg per person in 2001 to 53.8 kg per person in 2013 in Korea (MOF 2014). As the personal demand for seafood increases, the consumption of total seafood increases. However, the total domestic production of seafood is short of the total consumption, and the shortage is supplemented by imported seafood.

In the 1980s, the export of fisheries products far exceeded the import of fisheries products. However, in March 1994, the Korean government submitted a plan for the liberalization of fisheries import to the *General Agreement on Tariffs and Trade* (GATT), which took effect after 1998. As a result, the import of fisheries products has sharply increased and exceeded the export since the early 2000s. In 2014, the import of fisheries products (5,231,332 tonnes) far exceeded the export (701,570 tonnes) and even overtook the total domestic products (3,304,900 tonnes). Also there has been trade deficit since the early 2000s. As the government keeps the policy to expand Free Trade Agreement (FTA) with foreign countries and the diversification of trade, it is expected that the import of fisheries products will increase continuously in the future.

Table 4.2: Trend of Export and Import of Fisheries Products.

Year	Export		Import	
	MT	Amount ($1,000)	MT	Amount ($1,000)
1970	-	82,324	-	-
1980	-	759,524	-	37,284
1985	431,531	890,815	90,546	83,229
1990	454,512	1,513,094	285,934	368,095
1995	437,197	1,721,748	416,149	842,808
2000	533,824	1,504,470	749,191	1,410,598
2005	411,878	1,193,117	1,256,142	2,383,574
2010	793,045	1,798,162	4,715,726	3,458,400
2014	701,570	2,067,265	5,231,332	4,505,880

Source: Korea Maritime Institute. Statistics on Fisheries and Marine Environment. Each year.

Fisheries trade is increasing. However, only a few products have been traded, and those with a small number of countries. In terms of fishery exports, 60.4% of the total exports sent from Korea are delivered to just three countries, with three products comprising 49.3% of the total export. Similarly, imports from just three countries account for 64.5% of the total imports made by Korea, with three products comprising 34.5% of the total import (**Table 4.3**) (MOF and KIOST, 2014).

Table 4.3: Key fishery products and trading countries (based on 2010-2012 data)

	Export	Import
Countries	Top three (60.4%):	Top three (64.5%):
	Japan (25.0%), China (18.9%), Thailand (16.5%)	China (31.9%), Russia (23.0%), Vietnam (9.6%)
Fishery Product	Top three (49.3%):	Top three (34.5%):
	Tuna (32.1%), Squid (8.9%), Mackerel (6.0%)	Alask Pollack (20.0%), Mackerel Pike (3.8%), Squid (3.8%)

Source: MOF & KIOST. State of the Seas of Republic of Korea - Executive Summary -. December 2014.

Fishery products are food items, and therefore safety is crucial. The safety of fishery products is secured by strict hygiene control at each stage of their handling, including production (capture), processing, distribution, and consumption. During fisheries production and procession, safety inspections are conducted on fishery products to control the amount of hazardous scientific methods. In the distribution stage, the exposure of products to hazardous substances and unhygienic handling of products are minimized. The sales phase of the distribution process provides consumers with the correct product information, allowing them to consume sensibly (MOF and KIOST, 2014).

The most basic measure to ensure that fishery products are safe is the safety inspection. The fishery products targeted for this inspection are mostly those from inshore or coastal waters, particularly those that have not undergone the processes of production, storage, and transaction The actual water, fishing grounds, and materials used for production can also be inspected. Inspections typically seek to determine levels of heavy metals, antibiotics, food poisoning bacteria (*Vibrio parahaemolyticus*), shellfish poisons, and blowfish poisons. To increase and critical control point (HACCP), and seafood traceability systems are all enforced, in addition to the fishery product safety inspections (MOF and KIOST, 2014).

4.2 Fisheries: Catching Business

The capture fisheries or catching business was very poor in the 1950s. However, it began to grow with the government support since the 1960s. In 1996, the Korean government established the Fisheries Administration, which established and implemented the Fisheries Promotion Plan under the series of National Economic Development Plans. Under the Fisheries Promotion Plan, the Korean government and the fishing industry expanded the catching business "from Coastal Waters to Nearshore Waters, from Nearshore Waters to Distant Waters." The Korean government financially supported the fisheries industry by purchasing fishing vessels. Also the Korean government streamlined fisheries institutions and developed fisheries technologies for the fishing industry. Also the Korean government and the fishing industry developed foreign fishing grounds.

With government's strong support, the catching business increased continuously from 7,572 vessels (119,515 GT) in 1965 to 79,365 vessels (954,977 GT) in 1990, which was at its peak. With the increase of the fishing vessels, the production of catching business increased continuously from 357 thousand tonnes in 1960 to 816 thousand tonnes in 1970, and reached at its peak, to 2.7 million tonnes in 1986.

However, the catching business began to shrink since the mid-1980s because of habitat reduction, water pollution in the coastal water, illegal fishing by Chinese fishermen, reduction of fishing grounds in the nearshore waters due to Korea-Japan and Korea-China Fisheries Agreement, and the reduction of foreign fishing grounds due to UNCLOS. Also, sharply increasing costs for labor and energy contributed to the decline of the catching business. The catching business decreased from 79,365 vessels (954,977 GT) in 1990, to 74,669 vessels (598,365 GT) in 2010, and to 67,191 vessels (584,236 GT) in 2014. ***Also the production of the catching business decreased from 2.3 million tonnes in 1990s to 1.8 million tonnes in 2014*** (**Table 4.4**). As the fishing capacity was oversupplied compared with the fisheries resources, the Korean government started the vessel buy-back program in 1993 and has continued thereafter.

Table 4.4: Trend of fishing vessels in Korea

	1965	1970	1975	1980	1985	1990	1995	2000	2010	2014
No. of Motor Vessels	7,572	14,085	19,697	51,113	71,836	79,365	71,041	89,294	74,669	67,191
Gross Tonnage of Fishing Vessels	67,191	268,182	581,122	740,266	836,633	954,977	951,213	917,963	598,365	584,236
Production (1,000 Tonnes)	552	816	1,783	1,830	2,262	2,391	2,323	1,841	1,725	1,758

Source: Korea Maritime Institute. Statistics on Fisheries and Marine Environment. Each year.

Based on the Fisheries Act, the government has issued fishing permits to the fishermen who want to fishing in sea waters. The actual number of permits issued to fishermen was 38,575 in 1970 and increased to 101,011 which reached the peak in 2000 and thereafter has continuously decreased in proportion to the depletion of fishery resources.

Table 4.5: Trend of Number of Fishing Permits.

Year	1970	1980	1990	1995	2000	2005	2010	2014
Offshore Water	6,187	7,309	7,837	7,742	5,874	4,359	3,276	3,205
Coastal Water	32,388	27,947	47,087	62,072	86,129	80,518	58,091	52,836
Fixed Fishing Ground	-	-	-	2,285	8,406	7,876	6,540	6,106
Total	**38,57**	**35,256**	**54,924**	**72,099**	**100,409**	**92,753**	**67,907**	**62,147**

Source: Ministry of Ocean and Fisheries. Statistics on Ocean and Fisheries. Each year.

In proportion to the number of fishing permits, the total number of fishing vessels has increased. The fishing vessels were 7,572 vessels (119,515 GT) in 1965 and increased to 79,365 vessels (954,977 GT) in 1990, which was the peak. However, the catching business began to shrink since the 1990s because of habitat reduction and water pollution in coastal waters, reduction of fishing grounds in nearshore waters due to Korea/Japan and Korea/Chinese Fisheries Agreement, and reduction of the foreign fishing grounds due to UNCLOS. The fishing vessels have continuously decreased since 1995.

Table 4.6: Trend of Fishing Vessels in Korea.

	1965	1970	1980	1985	1990	1995	2000	2010	2014
No. of Motor Vessels	7,572	14,085	51,113	71,836	79,365	71,041	89,294	74,669	67,191
Tonnes of Fishing Vessels	119,515	268,182	740,266	836,633	954,977	951,213	917,963	598,365	584,236

Source: Ministry of Ocean and Fisheries. Statistics on Ocean and Fisheries. Each year.

In the meantime, the fishing vessels have been aging continuously. In 1970, the fishing vessels of less than ten years old were 46,809 vessels, and its ratio to the total vessels was 68.5 percent, and then increased to 66,618 vessels in 1985, which was the peak. However, since then, the fishing vessels of less than ten years old has continuously decreased. In 2012, there were 27,884 such vessels and its ratio to the total vessels were 37.2 percent. On the contrary, the fishing vessels older than 20 years have continuously increased from 1,278 vessels in 1980 to 12,704 vessels in 2012. Also its ratio to the total vessels has increased from 1.7 percent in 1970 to 16.9 percent in 2012. This means that the fisheries industry has not invested in the catching business due to financial difficulty, poor management, shift to aquaculture, and overall change in economic structure of the country.

Table 4.7: Trend of Fishing Vessels by Age (%).

Year	Less Than 10	Between 10-20	More Than 20	Total
1970	46,809 (68.5)	16,298 (23.8)	5,248 (7.7)	68,355 (100)
1980	63,014 (81.2)	13,282 (17.1)	1,278 (1.7)	77,574 (100)
1985	66,618 (73.2)	21,628 (23.8)	2,714 (3.0)	90,970 (100)
1990	51,235 (51.4)	42,518 (42.7)	5,895 (5.9)	99,658 (100)
1995	48,873 (63.6)	21,870 (28.5)	6,058 (7.9)	76,801 (100)
2000	64,638 (67.4)	21,753 (22.7)	9,499 (9.9)	95,890 (100)
2005	53,456 (58.9)	27,831 (30.7)	9,448 (10.4)	90,735 (100)
2010	32,838 (42.6)	33,542 (43.6)	10,591 (13.8)	76,974 (100)
2012	27,884 (37.2)	34,443 (45.9)	12,704 (16.9)	75,031 (100)

Source: Korea Maritime Institute. Statistics on Fisheries and Marine Environment. Each year.

4.3 Aquaculture: Fish Farming Business

Recognizing the limitations of the catching business mentioned above, the Korean government placed a high priority on nearshore aquaculture in the 1990s under the policy named "from Catching Business to Farm Business." The geographical conditions of the western and southern coastal waters of Korea are appropriate for aquaculture. The Korean government revised the Fisheries Act for establishing the National Plan for Aquaculture Development and supported the aquaculture industry financially and administratively.

Under the strong government support, the aquaculture industry has grown continuously since the 1990s. The number of aquaculture licenses increased from 3,445 in 1970, to 6,218 in 1980, to 8,513 in 1990s, and 9,907 in 2014. Also, permitted area for aquaculture increased from 35,495 ha in 1970 to 144,547 ha in 2014 (**Table 4.8**).

Table 4.8: Trend of Aquaculture Licenses in Korea.

	1960	1970	1980	1990	1995	2000	2005	2010	2014
Numbers	-	3,445	6,218	8,513	8,040	8,462	9,110	9,815	9,907
Area (ha)	-	35,495	78,573	113,026	108,537	121,973	124,668	141,015	144,547

Source: Ministry of Ocean and Fisheries. Statistics on Ocean and Fisheries. Each year.

The production of the aquaculture increased from 119 thousand tonnes in 1970 to 996 thousand tonnes in 1995, and decreased to 653 tonnes in 2000. However, it again increased to 1,041 thousand tonnes in 2005 and has increased continuously thereafter. Also the share of aquaculture to the total fisheries product has increased sharply from 12.8 percent in 1970 to 46.8 percent in 2014.

Table 4.9: Trend of Aquaculture Production by Marine Species Group.

Species Group	Production (1,000 tonnes)									
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Finfish	72.4	64.5	81.4	91.1	97.7	99.0	109.5	80.1	72.4	76.3
Shellfish	291.1	304.9	326.3	391.1	478.6	343.7	326.5	355.7	389.2	370.1
Invertebrate	10.7	11.6	12.2	12.2	16.5	17.3	18.6	17.5	23.7	20.2
Seaweed	452.1	536.7	621.2	764.9	793.0	921.0	858.7	901.7	992.3	1,022.3
Total	**826.3**	**917.7**	**917.7**	**1,259.3**	**1,385.8**	**1,381.0**	**1,313.3**	**1,355.0**	**1,477.6**	**1,488.9**

Source: MOF & KIOST. State of the Seas of Republic of Korea - Executive Summary -. December 2014.

Fish farming focuses on high-value fish species. Olive flounder and Korean rockfish account for over 80% of the total fish farmed, followed by red sea bream (3.8%), sea bass (2.0%), and black bream (1.5%). Research is being conducted with regard to farming tuna and groupers. In terms of farming methods, farming with a land-based system accounts for 52.6% of aquaculture production in Korea, while farming using a floating cage accounts for 46.7%, and embankment farming accounts for less than 1%. Over 99% of farmed flounders, which account for more than half of all fish farmed, are produced by land-based farming. Fish species account for approximate 5% of the total aquaculture production (MOF and KIOST, 2014).

Shellfish farming accounts for approximately 80% of the total animal aquaculture production, with the key farmed species being oysters, mussels, shortneck clams, ablones, arkshells, cockles, scallops, venus clams, and pen shells. Oysters and mussels account for approximately 77% and 17% of the total production, respectively. With regard to the culture method, hanging culture is used for oysters and mussels, and bottom culture is used for shortneck clams, arkshells, and cockles. Abalones are a unique shellfish species that are cultured in a method called "release-recapture" on operating coastal seaweed beds. Shellfish cultured on the bottom are particularly sensitive to environmental changes. The most common of these species are arkshells and cockles. The production of these species is vulnerable to changes in environmental variables that are most caused by anthropogenic activities in the vicinity of farms. Shortneck clam production is also unstable for similar reasons (MOF and KIOST, 2014).

The aquacultured invertebrates include tunicates, sea cucumbers, and shrimps. Of these, the most commonly cultured species, sea squirts, have perished in large numbers since the late 1900s, with the major cause supposedly being marine environmental changes. Shrimp culture once prospered on the western coasts of the country, with two penaeid prawn species, Chinese white prawns and Japanese Tiger prawns, cultured in embankment farms. However, production has substantially declined due to disease. Recently, whiteleg shrimps have been cultured in closed circulation system, with a production of approximately 2,000-3,000 tonnes annually (MOF and KIOST, 2014).

Seaweed farming has been successfully industrialized. In 2012, production reached 1,022,326 tonnes and accounted for 68.7% of all marine aquaculture production. Moreover, because farming technology in this area is highly advanced, this value will increase. Key species include laver, sea mustard, kelp, hiziki, green laver, gulfweed, seaweed fulvescens, green sea fingers, seersucker kelp, sea string, and various others. Seaweed farming is highly coast specific. Production on the southwest coasts accounts for 90% or more of total production. Seaweed itself does not cause environmental pollution and can actually purify its environment. Therefore, seaweed farming plays a positive role in preserving the ocean environment (MOF and KIOST, 2014).

Generally, aquaculture is limited by the space available for farming, feed, biological contamination (genetic variation, recessive traits, and introduced species), diseases and antibiotics (immunity and residue), eutrophication of fishing grounds, red tides, and climate change. Of these, the most limiting factor in Korea is the space available for farming, followed by marine pollution. The problem of available space has gradually lessened due to advancements in farming management techniques, but ocean pollution is expected to gradually intensify (MOF and KIOST, 2014).

4.4 Major Fisheries Management Programs

4.4.1 Vessel Buy-back Program

As the fishing capacity overtook the fisheries resources, the government introduced the vessel reduction program in 1994. The government purchased a total of 18,955 vessels for KRW 1,558 billion from 1993 to 2014 under the Vessel Buy-back Program, most of which were nearshore fishing vessels. Even though nominal fishing effort has stabilized due to limited entry, actual fishing effort has increased as the result of increasing horsepower and the improvement of fishing instruments. Based on the data from the vessel buy-back program in Korea, the number of vessels has decreased since 2000, but horsepower per vessel has steeply increased (Ryu, Nam, and Gates 2006).

Table 4.10: Trend of Vessel Buy-back Program.

Year	Total		Offshore Fishing Vessels		Nearshore Fishing Vessels	
	No. of Vessels	KRW millions	No. of Vessels	KRW millions	No. of Vessels	KRW millions
Total until 2002	2,400	746,445	1.308	572,982	1,092	173,463
2003	60	19,011	-	-	60	19,011
2004	698	17,384	-	-	698	17,384
2005	841	33,300	-	-	841	33,300
2006	1,598	50,278	-	-	1,598	50,278
2007	2,922	129,417	-	-	2,922	129,417
2008	5,512	323,610	-	-	5,512	323,610
2009	1,811	82,118	-	-	1,811	82,118
2010	1,267	65,686	-	-	1,267	65,686
2011	759	34,752	-	-	759	34,752
2012	368	16,676	-	-	368	16,676
2013	402	19,914	-	-	402	19,914
2014	380	20,197	-	-	380	20,197
Total	**18,955**	**1,558,788**	**1.308**	**572,982**	**17,647**	**985,806**

Source: Ministry of Ocean and Fisheries. Statistics on Ocean and Fisheries. Each year.

4.4.2 Total Allowable Catch (TAC) Program

In 1998, the Korean government introduced a total allowable catch (TAC) program as an output control measures, which regulates annual total amount of catch per species. The TAC was a groundbreaking program to Korean fishing communities, which have been familiar with the input control measures, such as fishing permit, fishing license, and reported fishing, for over half a century. Therefore, the Korean government established a strategy for extending the TAC step by step.

As a preliminary test, the first step was applied to the mackerel large purse seine fishery for 45 days, from September 16 to October 30, 1998. The second step was applied to 4 species (mackerel, jack mackerel, sardine, red snow crab) and 2 types of fisheries (the large purse seine fishery and the off-shore trap fishery) from 1999 to 2001. The third step was applied to 3 species (purplish Washington clam, fun mussel clam, Jeju-Island top shell) in 2001. In addition, king crab and blue crab (off-shore gill net fishery) was added in 2002 (Ryu, Nam, and Gates 2006). The Korean government will extend the TAC program to more species and fisheries with higher priority.

4.4.3 Marine Ranch Project

The marine ranching project has a series of aims, including installing artificial reefs and placing rubble and rocks on the seabed to form a foundation for ecosystems to develop. It also involves the release of fish seeds to build up marine resources, the improvement of habitats to maximize the value of fishing grounds, and establishment of systematic water management and valid user system to improve production. Ultimately, the aim is to create a new system of fishery production.

The marine ranching project includes the establishment of model marine ranches and coastal water ranches. The model marine ranches were created in five coastal water locations throughout Korea with a project budget of KRW 158.9 billion for the period from 1998 to 2013. The coastal water ranches were designed to improve income from fisheries, and revitalize the economy of fishing communities by securing stable fishery productivity and systemizing the use and management of marine resources, taking into account the characteristics of each local area. With the aim of completing 50 coastal water ranches, this project has a budget of KRW 250 billion from 2006 to 2020. By the end of 2013, 12 ranches had been completed.

The artificial reefs include various underwater structures installed for the purpose of fishery resource protection and enhancement and the improvement of fishery efficiency. They provide habitat where marine life can feed, breed, and shelter. In 1998, when the marine ranching project started, the focus of the fishery resource enhancement project moved from artificial reef fisheries to sea ranches. But this project is still a crucial part of the fishery resource enhancement program. Since 2004, a post-management plan for artificial reefs was established, and nationwide surveys of artificial reef fisheries was undertaken to identify the functionality of the marine life in these habitats and obtain

more detailed information about artificial reef fisheries. For areas with degraded functionality, the facilities were reinforced to sustain their function as fishing grounds, and abandoned nets and materials deposited on the artificial reefs were removed, allowing the reefs to recover their function. All of the data collected were entered into a database (DB) that was made available to policymakers and fishermen for the effective management of the fishery resources (MOF and FIRA, 2013).

Marine ranching

Activities:
- Installation of artificial reefs
- Release of fish seeds and aquatic species
- Marine afforestation and habitat restoration
- Removal of abandoned nets and materials
- Monitoring
- Database system made available to policymakers and fisherfolks

Source: Cho (2017)

4.5 Community-based Fisheries Management

Over half a century, most of fisheries management programs have been led by the government. However, such government-led fisheries management has shown some negative aspects, such as fishermen's increasing reliance on the government, weakening of ownership, overfishing of resources, and confusion in fishing industry (Lee and Midani 2014). Despite of the resource management efforts based on the control of production methods and inputs in the past, the fishery resources (particularly, economically-important species, such as yellow croaker, other croaker species, and hairtail) in coastal and offshore water have been continually depleted. The catch per unit effort (CPUE) has continually decreased since the mid-1970s, and total catches have gradually decreased in inshore and offshore since the mid-1980s due to overfishing (Ryu, Nam, and Gates 2006).

The government-led fisheries management was effective when fisheries resources were abundant and the number of fishing permits and licenses were few during the 1960s, 1970s, and 1980s. Since the 1990s, however, the fisheries resources began to be depleted and the number of fishing permits and licenses were recognized to be too many compared to the fisheries resources. In addition to the depletion of fisheries resources, the fishing grounds were reduced due to the Korea-Japan Fisheries Agreement in 2001 and the Korea-China Fisheries Agreement in 2003 and the UNCLOS in 1994. With the depletion of fisheries resources and increasing number of fishing permits and licenses, the conflicts among fishermen fishing in neighboring fishing grounds and the conflicts among fishermen fishing different categories of fishes began to rise. Moreover, the government could not solve the conflicts, which became more serious as time passes. The depletion of fisheries resources, too many fishing permits and licenses, and the conflicts among fishermen have resulted in illegal fishing and overfishing, and the vicious circle has reiterated.

4.5.1 Alternatives

The traditional government-led fisheries management could not solve the above-mentioned fisheries issues. Therefore, the Korean government had to find an alternative measure, and initiated the community-based fisheries management system, which is being implemented in Japan and Southeast Asia (CCSDKE 2010).

The community-based management system is based on the concept of people who are empowered with responsibility to manage their resources (Kay and Alder 1999). Community-based management is people-focused and community-focused management (Pomeroy, Parks, and Watson 2004). The community themselves design and implement the regulations with responsibilities and authorities devolved from the government. Therefore, the active participation of the community is important in the community-based management. Community participation usually begins with a bottom-up approach involving major stakeholder groups. The process is initiated through a government commitment to devolve some power to the community, and the community's recognition of the need to manage local areas. If the commitment is made and stakeholders are aware of the need to manage, then community-based management begins to evolve in the community. Subsequent actions and developments by the government and the community determine the progress towards full empowerment (Kay and Alder 1999).

In 2012, there were about 2,000 fishing villages in Korea, of which the average number of fishermen were 50 to 100, and total fishermen were about 140,000. Most of the fishing villages were collectively operating their own village fishing grounds. The average depth of the village fishing ground is five meters, and the primary products are seaweed and shellfish (Cheong 2004). Usually, the village fishing grounds are located near the fishing village and the fishing village should get licenses for operating the village fishing grounds from the government.

The fishermen in the fishing village are united as members of a fishing community (Ochonkye in Korean) for operating the village fishing ground. The Ochonkye, understood here to be the fishing village cooperative or fishing village association, was founded in 1962 after the central and regional fisheries cooperatives were established. The main role of the fishing village cooperative is managing commonly held fishing grounds and co-op facilities (Cheong 2004).

The system which the fishing village cooperatives operate their village fishing grounds collectively is very similar to the community-based fisheries management. They make their own rules for operating fishing village grounds. And they collectively produce and sell the fisheries products and distribute the benefits equally. Thanks to the system managed by the fishing village, the fishermen could understand the community-based fisheries management programs well in Korea.

4.5.2 Concept

The community-based fisheries management in Korea is also a co-management arrangement, wherein all the stakeholders, such as governments, fishery communities, and fishery experts work in partnership, and participate on a voluntary basis for the sustainable development of fishery resources.

The Korean government recommends and encourages fishery communities to implement a community-based fisheries management by giving them financial and administrative support. Experts advise and support the fishery communities in designing and implementing their community-based fisheries management.

4.5.3 Roles of Stakeholders

4.5.3.1 Government

As explained above, the government-led fisheries management for over half a century resulted in fisheries issues, such as fishermen's reliance on the government, weakening of ownership, conflicts among fishermen, depletion of fisheries resources, and illegal and overfishing. Therefore, in 2001, the Korean government introduced a new self-management system in which fishermen voluntarily make decisions on management and use of resources while receiving support from government regarding fishery resource management and to administer a sustainable fishing through ownership awareness and independence of fishermen (Lee and Midani 2014).

The Korean government establishes and implements a masterplan for the community-based fisheries management and a plan for supporting fishing communities, revises relevant laws on community-based fisheries management, and establishes and operates the committee for evaluating fishing communities. Local governments also carry out various functions for the successful implementation of the community-based fisheries management, including financial supports to the fishing communities that receive good evaluation.

4.5.3.2 Fishing Communities

In community-based fisheries management, the fishing community is responsible for its own fishing management and adjusts fishing activities. If disputes occur between communities, industries or regions in promotion of community-based management fisheries, a self-control conference is held to voluntarily resolve the programs through consultations and discussions (Lee and Midani 2014). The community-based fisheries management also involves voluntarily restricting fishing efforts to restore fishery resources, improving the environment of the fishing

grounds, improving the distribution system of fisheries products to increase fishermen's income, and resolving conflicts between fishing communities.

For implementing the above projects, the fishing community makes self-regulation, establishes a self-governance committee, and establishes a project plan with support from governments and fisheries experts. The government evaluates the whole process of the above projects and grants financial and administrative support to the fishing communities that get good evaluation.

4.5.3.3 Experts

Fisheries experts in semi-government organizations and fisheries associations help the fishing communities to join in the community-based fisheries management. For example, a public fishing village guidance serviceman is appointed for each participating community from the Fisheries Office to provide technical guidance and advice to self-managing communities. Also, private consultants with diverse experience in fishing industries provide one-on-one customized education to communities that either show poor progress or newly participate in community-based fisheries management, including substantiality by suggesting problems and alternative for communities (Lee and Midani 2014). Experts from the fisheries association help the fishing communities resolve conflicts on fisheries resource development. Moreover, the fisheries associations carry out education and training, outreach, evaluation, and workshops which are useful to the fishing communities.

4.5.4 Effects

Looking back from its introduction in 2001 to present, Korea's community-based fisheries management can be considered successful. The Ministry of Oceans and Fisheries (MOF) evaluates the community-based fisheries management as following (MOF 2014).

The coastal fisheries resources in Korea had continuously decreased from 9.5 million tonnes in the early 1980s to about 7.5 million tonnes in the early 2000s. However, it has started to restore after the introduction of the community-based fisheries management, and has reached about 8.5 million tonnes in 2010. With the decrease of fisheries resources, the fishing products also had continuously decreased from the early 1980s to the early 2000s, but it started to increase since the introduction of community-based fisheries management, although it shows some fluctuation.

With the increase of the fishing products and improvement of selling system and making brands of the fishing products, the average fishermen's income has continuously increased: 8.3 percent in

2007, 5.4 percent in 2009, 4.3 percent in 2011, and 3.2 percent in 2012. As the fishermen's income increases with the increase of fisheries production and the restoration of fisheries resources, many fishing communities have started to join in the community-based fisheries management, of which number has increased from 63 communities with 5,107 fishermen in 2001 to 1,039 communities with 67,687 fishermen in 2013.

4.5.5 Limitation and Future Direction

Korea's community-based fisheries management is a government centralized and incentive-based management, which has resulted in following limitations (Cho, 2016).

First, although the objective of community-based fisheries management is to induce the fisheries communities themselves to make decision on fisheries management, it was the Korean government who plans and implements the programs on the top-town basis. Therefore, the fishing communities expect continuous support from the government (Kim 2013), which would result in fishermen's reliance on the government.

Second, while the fishing communities get the benefits generated by the community-based fisheries management, the government pays most of the costs involved in the management. This would likewise lead to continuing fishing communities' reliance on the government. This is contrary to the objectives of the community-based fisheries management.

Third, the financial incentive has some positive effects to trigger fishing communities' competitive spirits for good assessment. However, it would cause disharmony between the winners and losers (CCSDKE 2010). If a community was not selected as a model community and was not supported by the government financially or administratively, then fishers in the community doubted the success of the project and the participation of the member fishermen became very passive (Lee, Gates, and Lee 2006). Also many fishing communities are carrying out the community-based fisheries management only to get the financial incentives and do not implement the community-based fisheries management after receiving the incentives (Lee 2012).

Therefore, the government should devolve more authority and functions to fishing communities to design and implement their self-regulated fisheries management, which can be implemented without government support. Also in the long run, the fishermen themselves should pay the cost of the community-based fisheries management to be financially independent from the government.

5 Shipping and Ports

5.1 Shipping[7]

Photo from: www.maritime-executive.com

Korea's economic system is based on importing raw materials and exporting finished goods, and about 99% of the cargo has been imported and exported by marine transportation. Therefore, over the past half a century, the Korean government has implemented very strong shipping polices to expand the national shipping fleet. As a result, in January 2014, the national fleet reached 85.2 million dwt (1,623 vessels), and Korea ranked 5th among international shipping nations.

The shipping industry has grown very large with the strong shipping policy, however, the recent changing shipping environment has limited the role of the government. The Korean government has joined the Organization of Economic Cooperation and Development (OECD) and the World Trade Organization (WTO), which require the shipping policy to be established in accordance with the international standards for fair competition. That means that the traditional one-sided supporting policies were no longer justified in Korea. The Korean government has drastically pursued deregulation for enhancing the comparative advantage in the international shipping industry, but it is facing cutthroat competition.

5.1.1 Large Shipping Industry

Korea has put a great strategic importance on their national shipping industry. There are two main reasons. First, foreign trade is a crucial element in Korea's economic growth strategy. Nearly 99 percent of the foreign trade in terms of volume is transported by sea. The second reason is attributable to the political situation between the two Koreas being hostile to each other. For these two reasons, the objectives of Korean shipping policy used to be aimed at the expansion of national fleet with a view to meeting rapid trade growth and preparing for the emergency situation that might happen politically (Ghang, 1998).

Over the last half century, the ocean-going shipping fleet has expanded from 430,000 GT in 1967 to 43,486,000 GT (1,126 vessels) in 2014 (**Table 5.1**). As of January 2014, the national fleet has

[7] This section is adapted, in parts, from (Cho, 2016).

ranked Korea the 5th in the world, following Greece, Japan, China, and Germany. In 1997, the total freight earnings reached $10 billion, and increased to $28.8 billion in 2011.

Table 5.1: Trend of National Ocean-going Fleet.

	1967	1970	1980	1990	2000	2010	2014
Number of Vessels	-	221	530	432	426	937	1,126
1,000GT	430	837	5,033	9,044	11,857	28,093	43,486

Source: MOMAF. Ocean and Fisheries Statistics. Each year.

As a result of the Designated Cargo System[8], which aimed to transport import/export cargo by Korean national fleet, the volume of cargo transported by Korean national fleet increased from 2.9 million tonnes in 1967 to 5.0 million tonnes in 1970, and to 130 million tonnes in 2013 (**Table 5.2**). Likewise, the ratio of cargo volume transported by the Korean national fleet to the total import/export cargo increased from 25.1% in 1967 to 45.3% in 1980. However, the ratio of cargo volume transported by Korean national fleet to the total import/export cargo has continuously decreased from 40.3% in 1990 to 11.7% in 2013, although the cargo volume itself has increased slightly. Since the elimination of the Designated Cargo System in 1993, the ratio of cargo transported by the foreign flag vessels has continuously increased, reaching about 90% in 2013. This shows that the transport market of the import/export cargo of Korea is completely open to the international shipping industry.

Whereas the ratio of cargo volume transported by the national fleet to the total cargo has continuously decreased, the cargo volume of cross trade transported by the national fleet has continuously increased from 0.7 million tonnes in 1967 to 11.4 million tonnes in 1980, and to 181.6 million tonnes in 2000. Since the 1990s, the national fleet has transported more cargo of cross trade than the import/export cargo of Korea. This means that it is more important for Korean shipping industry to enhance the international competitiveness rather than depending on subsidiary shipping policies.

Table 5.2: Trend of Cargo Volume Transported by Korean National Fleet (1,000RT).

	1967	1970	1980	1990	2000	2010	2013
Import/ Export Cargo	11,523	22,284	94,035	219,781	569,599	966,193	1,118,004
Transport by National Fleet	2,895	5,003	42,658	87,977	101,333	145,653	130,036
Ratio (%)	25.1	22.5	45.3	40.0	17.8	15.0	11.7
Cross Trade Cargo	770	5,398	11,437	31,558	181.640	na	na

Source: MOMAF. Ocean and Fisheries Statistics. Each year.

[8] The Designated Cargo System is also called the Waiver System or the Cargo Reservation System.

In 1967, the national shipping fleet was 430 thousand GT and the ratio of Korean fleet to the world shipping was less than 1 percent. However, the national fleet reached 40 million GT with tonnage share of 3.6% in 2014. Also the ratio of the import/export cargo volume to the world cargo volume increased from about 2% in 1960s to more than 10% in 2010s.

Table 5.3: Trend of Status of Korean National Fleet and Cargo Volume to the World Shipping Fleet and Cargo Volume.

	1967	1970	1980	1990	2000	2010	2013
National Shipping Fleet (A)	0.4	0.8	5	9	11	28	40
World Shipping Fleet (B)	-	227	419	426	538	957	1,122
Ratio (A/B, %)	-	(0.4)	(1.2)	(2.1)	(2.0)	(2.9)	(3.6)
Imp/Exp Cargo Volume (C)	11	22	94	219	569	966	1,123
World Cargo Volume (D)	-	-	3,679	4,126	6,273	8,444	9,505
Ratio (C/D, %)	-	-	(2.6)	(5.3)	(9.0)	(11.4)	(11.8)

Source: MOMAF. Ocean and Fisheries Statistics. Each year.

5.1.2 Small Government

Although the competition in the international shipping has been getting cutthroat fierce and the business environment has been growing worse, the role of the Korean government to protect the national shipping industry has been increasingly limited. This is because of the deregulation movement under the national economic policy aimed at enhancing efficiency and abiding by international standards, which the Korean government should accept as its economy has joined the global economic system.

Entering the 1980s, the Korean government shifted its basic economic policy from a government-led economy, which had been initiated by the government during the First 5-Year Economic Development Plan in 1962, to a market-oriented economy, which aimed to enhance international competitiveness through fair competition and deregulation. In 1981, the Korean government enacted the Monopoly Regulation and Fair Trade Act to promote fair and free competition. In 1989, the Korean government announced deregulation on eight service sectors, including the shipping industry. Also, with the launching of WTO in 1994 and by joining the OECD in 1996, the Korean government shifted the economic policy from protecting national industries from foreign businesses to conforming to international standards. This has greatly affected shipping policy.

In 1998, the Korean government abolished the Cargo Reservation System,[9] which was first introduced in the 1950s to protect Korean shipping industry in the liner sector. In 1967, the Korean government enacted the Shipping Promotion Act to apply the Cargo Reservation System to bulk cargoes. This Act marked the beginning of comprehensive government intervention in the shipping industry through the introduction of various regulations as well as assistance. The Act was replaced by the Shipping Fostering Act of 1984, which stipulated that a person who intends to transport such cargoes as prescribed in the Presidential Decree should utilize Korean flag vessels (Ghang 1998). Major energy sources, such as crude oil, iron ore, coal, LNG, etc., should also be transported by Korean flag according to the Cargo Reservation System, which was a main frame of Korean shipping policy (MOMAF 1997). However, in 1999, the Korean government abolished the Shipping Fostering Act of 1984 and the Cargo Reservation System upon joining the WTO and OECD. Since abolishing the Cargo Reservation System in 1999, the rate of import/export cargo volume transported by foreign flag to the total import/export cargo volume has continuously increased, and that of Korean flag has continuously decreased.

Until the end of the 1980s, the Korean government prevented foreign companies from entering the stevedoring business, harbor-related businesses, and shipping-related businesses such as the classification, forwarding, shipbroking, ship financing, etc. However, entering the 1990s, the Korean government deregulated all the above business activities and opened related markets to foreign companies and foreign terminal operators began operating in Korea (CCSDKE 2010).

Also in 1999, the Korean government revised the Shipping Act to abolish the Freight Report System and introduce the Freight Announcement System to prevent the government's intervention in the liner shipping sector. Also, the Freight Announcement System aims to improve the function of the liner market and thereby to establish the market order of liner freight (MOMAF 2002).

5.1.3 Supporting Mechanisms and Infrastructure for Shipping Industry

5.1.3.1 Research and Development

The ocean-going shipping industry is very competitive internationally and requires high-level professional expertise and experience based on research and development (R&D). The R&D for the shipping industry can be implemented by the public sector funded by financial investment, the private sector, and the shipping business itself.

In 1984, the Korean government established Korea Maritime Institute (KMI) for research and development on shipping and port policy. Since its establishment, KMI has recommended so many policy alternatives for the shipping industry. However, the research area on the shipping market forecast has been weak, which is very important to the shipping industry. KMI needs to research shipping market trends and forecasts that can be provided to the shipping industry

[9] The Cargo Reservation System was widely known as the waiver system, and was officially called as the Designated Cargo System.

for effective investment and management. Korea is no longer a low-cost country, but a high-cost country. Therefore, KMI needs to research innovative strategies to enhance international competitiveness for the Korean shipping industry.

5.1.3.2 Tonnage Tax and Ship Registry

Just as in other traditional shipping countries, there had been high potential for flagging-out in Korea due to high-cost seafarers and various tax burdens (MOMAF 2002). Therefore, the Korean government introduced a new ship registry system and a tonnage tax system to improve international competitiveness and thereby prevent flagging-out.

In 1997, the Korean government enacted the International Ship Registration Act to introduce the International Ship Registration System, which targets vessels of more than 500 GT and with less than 20 years bearing a Korean flag and bare boat charters with hire purchase (BBCHP). A considerable amount of tax can be deducted for registered vessels. Further, foreign seafarers are permitted to get onboard the registered vessels. Also, in 2002, the Korean government introduced the Jeju Special Shipping Registration System to reduce taxes, such as acquisition tax, property tax, and local taxes. Thanks to the above favors, vessels registered under the International Ship Registration System increased from 403 vessels in 2003 to 1,118 vessels in 2014. Furthermore, vessels registered in the Jeju Special Zone for Ship Registration increased from 386 vessels in 2003 to 1,100 vessels in 2014. The ship registration system should be revised in keeping with those of other major traditional shipping countries.

Taxes on the shipping business were very high and complicated, which weakened the international competitiveness of the Korean shipping industry. Consequently, in 2005, a new tonnage tax system was introduced for reducing corporate tax. Corporate tax for the shipping business is now calculated based on the net tonnage of vessels and days operated, not on business profits. The new corporate tax would be lower than the previous corporate tax, and shipping businesses can calculate the expected corporate tax regardless of the scale of business profits (MOMAF 2006). However, shipping businesses should pay the same amount of corporate tax even in the shipping recession (CCSDKE 2010). Thus, the tonnage tax system should be carefully operated in favor of shipping businesses.

Table 5.4: Trend of Vessels Registered to the International Ship Registration System and the Jeju Special Zone for Ship Registration.

Number of Vessels								
	2003	2005	2007	2010	2011	2012	2013	2014
International Registration	403	526	685	876	936	992	1,074	1,118
Jeju registration	386	509	668	852	915	961	1,051	1,100
Total	**467**	**474**	**1,348**	**1,728**	**1,851**	**1,953**	**2,125**	**2,218**

Source: MOF (2016)

5.1.3.3 Ship Financing

Until recently, Korean shipowners have purchased most of their ships through bank loans, which has required very high interest. The financial resources for shipping have always been limited, and are typically available only when the shipping market is booming. Therefore, usually, Korean shipowners have purchased ships during shipping booms with high interest rates and high purchasing prices. Contrary to during shipping booms, bank loans for shipping are practically unavailable during shipping recessions. Therefore, shipowners cannot help but sell their ships at low prices during the shipping recessions. In conclusion, the undeveloped financing system for shipping has always lowered the comparative competitiveness of the shipping industry in Korea.

Especially, during the Asian financial crisis of the late 1990s, the International Monetary Fund (IMF) demanded that the shipping industry lower its debt rate to less than 200%. Therefore, the shipping industry had to sell 125 ships, totaling 3.3 million GT. However, the shipping industry had very lack of the liquidity funds to expand the fleet. Therefore, in 2002, the Korean government enacted the Ship Investment Company Act to introduce a mutual fund, the Ship Investment Company System, which is very similar to KG Fund of Germany, KS Fund of Norway, and Maritime Finance Initiative (MFI) of Singapore (CCSDKE 2010). Owing to the Ship Investment Company System, Ship Investment Companies can supply new ships to shipowners to expand their managing fleet during shipping booms, and the shipowers can sell their fleets to the Ship Investment Companies who then charter out ships to the owners (MOMAF 2006). During its introduction between 2004 and 2012, the Korean government issued a total of 129 authorizations for Ship Investment Companies, which raised a total of $84.7 billion, and purchased a total of 185 ships.

At present, the Ship Investment Company System is in its early stages, so the scale of financing is very small compared with the Korean shipping fleet. The government and the shipping industry should develop the Ship Investment Company System to be able to provide financial resources to

the shipping industry during periods of lower prices than those of other major shipping nations. Also, the financing system should attract many large investors by ensuring stable investment returns.

Table 5.5: Status of Authorization of the Ship Investment Company ($1 billion).

	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
No. of Companies	17	17	15	13	11	21	18	12	5	129
Fund Amount	9.5	11.1	6.3	10.5	12.9	7.5	9.5	6.7	10.1	84.7

5.1.4 Way Forward

Over 50 years, the Korean shipping industry has developed greatly, from nothing to a total of 1,077 ocean-going vessels amounting to 40 million GT and more than $30 billion of freight earning. This is due to a strong shipping policy, increasing import/export cargo volumes, and low operating cost. However, recent shipping environment prevents Korean shipping industry from further enjoying the above conditions.

The shipping industry is very important to the Korean economy, which is based on import of raw material and export of finished goods. About 99% of import/export cargo is transported by sea. Therefore, over the half a century the Korean government has implemented a shipping policy that is very favorable to Korean shipowners. However, with the launching of the WTO in 1994 and joining the OECD in 1996 the shipping policy, which used to be favorable to Korean shipowners, has been no longer effective in the view of the international standards of practice. Also, Korean shipping industry cannot enjoy the increasing import/export cargo volume by abolishing the Cargo Reservation System in 1998. Furthermore, Korea is no longer a low-cost country, rather a high-cost country. As the wage of Korean seafarers has almost reached the level of the traditional shipping countries, the shipowners have continuously pressured the government and unions to allow seafarers from developing countries to get onboard Korean flag vessels.

Therefore, the shipping policy should be focused on consolidating the infrastructure such as research and development (R&D), education and training, ship registry and tonnage tax system, ship financing system. In addition, the shipping-related industry, such as marine insurance, classification, ship management, shipbroking, shipping legal services, should be developed to build marine clusters, which will eventually support the shipping industry in Korea. Finally, the shipping industry itself should try and invest in developing innovativeness and international competitiveness, admitting that Korea is a high-cost country, which should follow the international standards in shipping policies.

5.2 Ports

Korea's economic system is based on importing raw materials and exporting finished goods, and about 99% of Korea's cargo has been transported through Korean ports. Hence, port development was essential to transport import/ export cargo efficiently. In the 1960s to the 1980s, the Korean economy developed rapidly, and there had always been a lack of port capacity to handle the increasing import/export cargo volume. As a result, the Korean government had to supply port capacity to meet the increasing cargo volume by making financial investment the top priority. Moreover, all of the Korean ports were developed, owned, and managed by the Korean government.

5.2.1 Port Development and Management

Korea's economic growth was initiated by a series of National Economic Development Plans. The First National Economic Development Plan was run between 1962 and 1966, the second from 1967 to 1971, the third from 1972 to 1976, and thereafter the fourth, fifth, sixth and seventh through 1996. Through all of the seven National Economic Development Plans from 1962 to 1996, the Korean economy developed very rapidly and surprisingly. The annual economic growth rate was 8.7% in the 1960s, 7.6% in the 1970s, 9.1% in the 1980s and 7.1% in the 1990s. Thereby GNP per capita increased from $87 in 1962 to $249 in 1970, $1,598 in 1980, $5,886 in 1990, and to over $8,000 in 1999.

As the Korean economy grew, the import/export cargo volume increased, due to the export-driven economic system of Korea, and most of the import/export cargo was transported by ocean-going vessels through Korean ports. The import/export cargo volume increased from 11.5 million tonnes in 1967 to 28.4 million tonnes in 1971, to 105.3 million tonnes in 1981, to 262.9 million tonnes in 1991, and to 41.1 million tonnes in 1996, respectively. The annual increasing rate of import/ export cargo volume was 25.3% from 1967 through 1971, 13.9% from 1971 through 1981, 9.5% from 1981 through 1991, and 9.0% from 1991 through 1996, respectively. The coastal cargo volume also increased very rapidly from 1967 through the 1990s.

Table 5.6: Trend of Cargo Volume Transported by Vessels (1,000RT).

	1967	1971	1981	1991	1996	Annual increasing rate (%)			
						'67-'71	'71-'81	'81-'91	'91-'96
Total Cargo Volume	16,145	40,036	127,527	339,096	582,068	25.4	12.2	10.2	9.4
Imp/Exp Cargo	11,523	28,449	105,321	262,972	441,120	25.3	13.9	9.5	9.0
Coastal Cargo	4,622	11,587	22,206	76,124	140,948	25.8	6.7	13.1	10.8

Source: MOMAF. Ocean and Fisheries Statistics. Each year.

However, the port capacity did not meet the increasing cargo volume, which resulted in heavy vessel-congestion in the ports. For example, in 1990, a total of 3,381 vessels and 12,185 vessels arrived at Incheon Port and Busan Port, among which a total of 1,627 vessels and 953 vessels had to wait at average 96 hours and 58 hours at Incheon Port and Busan Port, respectively. Therefore, it was urgent for the Korean government to develop ports to handle the increasing cargo volume with limited resources. In 1967, the Korean government enacted the Harbor Act to develop ports under the national port development plans. Also in 1976, the Korean Port and Maritime Authority (KMPA) was established to develop ports as a national top priority, and it was exclusively in charge of port development and shipping management policies.

Ports development was conducted under the series of the National Economic Development Plans from 1962 through the 1990s. In the 1st plan (1962-1966), 713 meters of berths and 1,201 meters of lighter wharfs were developed. However, in the subsequent plans, the Korean government developed port capacities greatly in response to the increasing cargo volume. In those days from the 1960s to the 1990s, the Korean government planned to supply port capacity through ports development rather than to manage the ports economically. And all the Korean ports were developed, owned, and managed by the Korean government until the early 2000s.

Table 5.7: Trend of Port Development by Period of Economic Development Plan.

	Berth (m)	Lighters Wharf (m)	Cargo Capacities (1,000ton)	Berthing Capacities (vessels)
1st plan (1962-1966)	713	1,201	5,630	4
2nd plan (1967-1971)	5,083	2,295	4,131	14
3rd plan (1972-1976)	6,151	3,007	15,219	48
4th plan (1977-1981)	10,188	2,624	53,423	70
5th plan (1982-1986)	10,722	1,524	63,253	64
6th plan (1987-1991)	17,395	5,279	73,677	133
7th plan (1992-1996)	15,759	1,553	46,892	99

Source: CCSDKE 2010.

5.2.2 Hub Ports

Korea is geographically located in the center of Northeast Asia, where a large portion of international cargo volume has been rapidly produced, coinciding with the economic development of the region. Also, Korea is located in the middle of major shipping routes, such as North America - Asia and Europe - Asia. Since the mid-1990s the Korean government has developed Busan New Port and Gwangyang Port as hub ports with national top priority, taking advantage of being located at the center of the Northeast Asia.

5.2.2.1 Potential for Hub Ports

Korea's economic system is based on importing raw materials and exporting finished goods, among which steel, automobiles, shipbuilding, textiles, and most recently, computer chips have figured importantly. Foreign dependency, the ratio of trade amount to GDP, is very high, more than 70%.[10] Therefore, there is potential for increasing cargo volume as the Korean economy increases. Actually, the amount of import/export container cargo increased at a rate of 11.6% from 1981 to 1996, from 824,000 TEU in 1981 to 4,257,000 TEU in 1996. Also, the Korean government expected that container cargo would increase at a high rate when establishing the development of Busan New Port and Gwangyang Port in the mid-1990s.

About 99% of Korea's import and export cargo is transported through Korean ports. Therefore, ports development was essential to transport import and export cargo efficiently, in order to increase the international competitiveness of the import and export industries, and to foster the logistics industry related to ports in Korea.

Korea is located in the center of Northeast Asia, surrounded by East Russia, Japan, China, and Taiwan that generate a large volume of container cargoes. Busan port is located on main shipping routes to and from North America, Southeast Asia, and Europe. Therefore, there was a potential to attract a large volume of transshipment cargo from neighboring nations. Actually, the transshipment cargo had increased rapidly at a rate of 138.9% in the 1990s, from 70,000 TEU in 1991 to 472,000 TEU in 1996.

[10] The foreign dependency of 2014 was 75.7%.

Table 5.8: Trend of Container Cargo Volume until the Mid-1990s in Korea.

	1981	1986	1991	1996	Annual increasing rate (%)		
					'81-'91	'86-'96	'81-'96
Total Cargo Volume	824	1,645	2,761	5,370	12.9	12.6	13.3
Imp/Exp Cargo	824	1,559	2,567	4,257	12.0	10.6	11.6
Transshipment Cargo	0	43	70	472	205.1	27.1	138.9
Coastal cargo	0	0	54	169	197.3	233.3	123.1

Source: MOMAF 1997.

Before Busan New Port was developed as a hub port in Korea, most of the import/export container cargo was transported through Busan North Port. However, Busan North Port was geographically very limited and there was not enough space for container handling terminals. Therefore, 13 off-dock-container yards (ODCY) were operated for container handling before loading and after unloading. Also, all the container trucks should pass Busan city, resulting in traffic congestion, air pollution, and noise all the time. Therefore, it was necessary for the Korean government to develop new container ports, where increasing container cargo can be handled efficiently. The areas of Busan New Port and Gwangyang Port had potential for hub ports, where large spaces for container yards could be created by reclamation and transportation system to and from Seoul and Gyeonggi Province could be newly developed. In addition, the width of entrance and the depth of channel of the hub ports could be developed enough for the calling of the largest containership.

5.2.2.2 Development of Hub Ports

Since the 1990s the Korean government has established and carried out many national plans to develop Busan New Port and Gwangyang Port as hub ports in Korea, recognizing the potential of Busan Port and Gwangyang Port for hub ports.

In 1996, the Korean government enacted the New Harbor Construction Promotion Act to prepare for rapidly increasing demand for harbors and further to contribute to the development of the national economy with the efficient promotion of new harbor construction projects. In 1996, relevant ministers reported to President Kim Dae-Jung that 24 berths (4.6 million TEU annually) at Busan New Port and 24 berths (5.28 million TEU annually) at Gwangyang Port would be developed from 1995 to 2011. Based on the act, the Korean government designated Busan New Port and Gwangyang Port as new port construction projects in 1997.

In 2000, the "Ocean Korea 21," which was the *First National Basic Plan for Ocean and Fisheries Development* (2000-2010), included the plan for developing Busan New Port and Gwangyang Port as hub ports for the Northeast Asian region.

The Harbor Act regulates that a basic harbor plan should be established in every ten years for the purposes of promoting the development of harbors and operating harbors efficiently. Based on the act, the Korean government established the Second Basic Harbor Plan (2002-2011) in 2001, which addressed to develop Busan New Port and Gwangyang Port as hub ports. The import/export container cargo was forecasted to increase at a rate of 8.48% until 2011 and thereafter 6.15%. The transshipment container cargo was forecasted to increase at a rate of 19.73% until 2011 and thereafter 5.28%. Considering the sharp increase of import/export and transshipment container cargo, the Second Basic Harbor Plan (2002-2011) included to newly develop 33 berths at Busan New Port and 29 berths at Gwangyang, respectively.

Table 5.9: Forecast of Container Cargo Volume (Thousand TEU).

	1998	2000	2006	2011	2020	Annual increasing rate (%)	
						2011-2020	2011-2020
Total Cargo Volume	6,677	9,116	19,266	29,668	50,325	12.09	6.05
Imp/Exp Cargo	5,158	6,388	10,574	14,864	25,431	8.48	6.15
Transshipment Cargo	1,214	2,454	8,005	13,176	20,928	19.73	5.28
Coastal Cargo	306	274	687	1,628	3,966	13.72	10.40

Source: MOMAF 2002.

The new administration of President Roh Moo-Hyun embarked on a national initiative to create a new engine for economic growth which takes advantage of emerging Northeast Asian economic zone. In 2002, the Korean government designated Busan Port and Gwangyang Port as Customs-Free Zone (CFZ) to develop the ports as international logistics center. In August 2003, the Korean government established the "Port Logistics Policy in Northeast Asia," of which major tasks are as following:

i) Development of Busan New Port and Gwangyang Port to be accelerated[11] and a total of 63 berths to be newly developed by 2011, including 30 berths at Busan New Port with the cargo handling capacity of 8.04 million TEU and 33 berths at Gwanyang with the annual cargo handling capacity of 9.33 million TEU;

ii) A total of 7.66 million square meters of hinterland at Busan New Port and Gwangyang Port to be developed by 2013, among which 726 thousand square meters and 1.57 million square meters of hinterland at Busan Port and Gwanyang Port to be developed by 2008, respectively;

[11] The contents of development of Busan New Port and Gwangyang Port in the Second Basic Harbor Plan (2002-2011) and the "Port Logistics Policy in Northeast Asia" are almost the same, and as mentioned above both ports have been already developed since the mid-1990s.

iii) Various policy alternatives to be established and implemented to attract transshipment cargo to Korean ports.

Busan New Port is located 35km west from Busan city, and all the berths, container yards, loading/unloading facilities and equipment, transportation system, and other the port-related facilities have been newly developed. As described above, in 2003 the Korean government planned to develop 30 berths with the cargo handling capacity of 8.04 million TEU at Busan New Port until 2011 in the "Port Logistics Policy in Northeast Asia," considering the sharp increase of import/export container cargo and transshipment cargo. In 2011, the Korean government established the Third Basic Harbor Plan (2011-2020), which decided to develop a total of 45 berths at Busan New Port. However, during the development of Busan New Port, the container cargo volume was not increasing rapidly as expected. Therefore, the Korean government planned to develop new berths and terminals to keep up with the demand of the container cargo volume. At the end of 2013, a total of 21 berths with cargo handling capacity of 9.2 million TEU have been developed, which is fewer than the 30 berths that were aimed under in the Port Logistics Policy in Northeast Asia in 2003. A total of 4.65 million square meters of hinterland was planned to be developed at Busan New Port by 2013 in the Port Logistics Policy in Northeast Asia of 2003. During the development of hinterland, the original plan was changed to develop 9.4 million square meters of hinterland; developing 2.7 million square meters by 2012, 1.5 million square meters from 2013 to 2014, and 5.2 million square meters thereafter. At present, the hinterland of Busan New Port has been developed as scheduled.

One designated rail and two hinterland roads, which connect to expressways, have been developed by financial investment in 2011. Also, the development of another hinterland road will be completed by private investment in 2017. All the three hinterland roads start from the Busan New Port, run through non-residential areas, and connect to the Seoul-Busan Expressway and the Namhae Expressway.

Gwangyang Port is located in the southern part of the Korean peninsula, about 80 miles west from Busan New Port. In 2003 the Korean government planned to develop 33 berths at Gwanyang with the annual cargo handling capacity of 9.33 TEU considering the sharp increase of container cargo volume. However, during the development of Gwangyang Port, container cargo volume handled at the port did not increase sharply as expected. Therefore, the Korean government decided to develop a total of 21 berths from the original 33 berths at Gwangyang Port in the "Third Basic Harbor Plan (2011-2020)." The Korean government has planned to develop new berths and terminals to keep up with the demand of container cargo volume. At the end of 2013, a total of 14 berths with cargo handling capacity of 4.2 million TEU have been developed, which is far fewer than the 33 berths that are scheduled to develop in the Port Logistics Policy in Northeast Asia in 2003.

A total of 3.88 million square meters of hinterland was planned to be developed at Gwangyang Port by 2013 in the "Port Logistics Policy in Northeast Asia of 2003." During the development of hinterland, a total of 8.8 square meters of free trade zone have been designated, which includes 3.88 square meters of hinterland. A total of 388 million square meters of hinterland at Gwangyang Port has been developed at the end of 2012 **(YGPA 2015)**. Also the hinterland roads, which connect to three expressways, have been developed and it takes only three hours from Gwangyang Port to Seoul area. And the designated industrial rail has been developed, which enables to transport containers more efficiently.

5.2.2.3 Management of Hub Ports

Before the introduction of port privatization in Korea, the Korean government managed all the Korean ports nationally without competition between ports and within ports. However, since 2004, the Korean government has introduced port privatization in major ports to manage ports efficiently by the private sector. Busan Port Authority (BPA), Incheon Port Authority (IPA), Ulsan Port Authority (UPA), and Yeosu Gwangyang Port Authority (YGPA) were established in 2004, 2005, 2007, and 2011, respectively. Busan Port and Gwanyang Port handle import/export container cargoes of the same destination, such as North America, Europe, and other long distance. Also the two ports handle the transshipment container cargo to and from the same destination. As a result, an inter-port competition takes place between Busan Port and Gwanyang Port.

BPA and YGPA have offered concession contracts to private terminal operators to operate container terminals, which results in an intra-port competition within the same port. When the demand for terminals outstripped the supply at the beginning of the development of the Busan and Gwangyang hub port, the competition was not so severe. However, as the development of terminals completes, the intra-port competition is so severe that the terminal price of Busan Port and Gwangyang Port has cut to the lowest level among major ports in the world. The terminal charges of Busan Port and Gwangyang Port in 2011 were $5,184 and $4,032 per TEU for import/export container cargo, respectively. The handling charges of transshipment cargo at Busan Port and Gwangyang Port were $8,064 and $5,184 which were also at the very low level following Tianjin, Qingdao, and Shanghai.

Table 5.10: Terminal Price of Major Ports of 2011 ($/TEU).

	Busan	Gwangyang	Shanghai	Tianjin	Qingdao	Tokyo	Kaoshiung	Singapore	HK	Rotterdam	NY
Imp/Exp Cargo	5,184	4,032	12,096	9,792	9,792	19,584	11,405	12,096	23,040	24,192	25,344
T/S Cargo	8,064	5,184	6,451	2,880	2,880	14,746	13,248	23,040	13,824	17,856	18,432

Source: www.mof.go.kr
Note: $1 equals KRW1,152.

Before the development of Busan New Port and Gwangyang Port, most of import/export container cargo were transported through Busan North Port, passing Busan city by trucks, which caused traffic jam, air pollution, and noise. As Busan New Port develops, however, the container cargo has continuously moved from Busan North Port to Busan New Port. In 2006, a total of 12,038 thousand TEU (98.0%) and 237 thousand TEU (2.0%) of container cargo were handled at Busan North Port and Busan New Port, respectively. However, in 2014, a total of 6,717 thousand TEU (36.0%) and 11,966 thousand TEU (64.0%) were handled at Busan North Port and Busan New Port, respectively.

Table 5.11: Trend of container cargo handled at Busan New Port and Busan North Port (1000TEU).

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total	12,038	13,261	13.452	11,980	14,194	16,175	17,046	17,686	18,683
Busan North Port	11,801	12,682	11,873	9,289	8,709	8,425	7,603	6,722	6,717
Ratio (%)	(98.0)	(95.6)	(88.3)	(77.5)	(61.4)	(52.1)	(44.6)	(38.0)	(36.0)
Busan North Port	237	579	1,579	2,690	5,485	7,749	9,442	10.963	11,966
Ratio (%)	(2.0)	(4.4)	(11.7)	(22.5)	(38.6)	(47.9)	(55.4)	(62.0)	(64.0)

Source: http://www.busanpa.com (assessed in May 30, 2015).

Busan New Port was designed and developed to transport container cargoes by dedicated railways and roads which are in the suburb of Busan city, so there are no traffic jams, air pollution, and noise. Also the hinterland roads of Gwangyang Port connect to three expressways, which enable to transport containers very efficiently.

The shippers and consignee can choose inland container depot (ICD) or port terminals for custom clearance of their cargo. There is enough space for container terminals in Busan New Port and Gwangyang Port for custom clearance. Also there are enough ICDs nationally. Korea Custom Service (KCS) provides very fast and efficient custom clearance service in both the ICDs and port terminals. Also Busan New Port and Gwangyang Port were designed and developed to handle container cargo with the state-of-the-art facilities and equipment. BPA and YGPA have continuously developed the terminal automation system with support from the Korean government. As a result, ship congestion has reduced in the ports and traffic congestion has lowered in the hinterland roads, and the productivity of Busan Port and Gwangyang Port has increased more than that of Singapore and Rotterdam (Kim et al., 2009).

Terminal charges for T/S cargo at Busan Port and Gwangyang Port are the lowest level among major ports in the world. Also, BPA and YGPA have introduced various programs for attracting

T/S cargo such as providing various favorable volume incentives, reducing port charges, and improving cargo movement in the container terminals. As a result, T/S cargo of Busan Port has continuously increased from 634 thousand TEU in 1998 to 9.4 million TEU in 2014. Also, the ratio of T/S cargo to total cargo has increased from 11.9% in 1998 to 50.5% in 2014. T/S cargo of Gwangyang Port has continuously increased from 14 thousand TEU in 1998 to 518 thousand TEU in 2014. The terminal charge for T/S cargo of Gwangyang Port is much lower than that of Busan Port. However, T/S cargo volume of Gwangyang Port is much lower level than that of Busan Port.

Table 5.12: Trend of transshipment cargo handled at Busan Port (1000 TEU).

Year	1998	2000	2002	2004	2006	2008	2010	2012	2014
Total	5,312	6,383	9,453	11,492	12,039	13,453	14,194	17,046	18,683
T/S Cargo	634	1,232	3,887	4,792	5,208	5,808	6,276	8,148	9,429
Ratio (%)	(11.9)	(19.3)	(41.1)	(41.7)	(43.3)	(43.2)	(44.2)	(47.8)	(50.5)

Source: Korea Maritime Institute, Shipping Statistics Handbook 2014.

Table 5.13. Trend of container cargo handled at Gwangyang Port (1000TEU).

Year	1998	2000	2002	2004	2006	2008	2010	2012	2014
Total	455	678	1,126	1,349	1,770	1,822	2,088	2,154	2,336
T/S Cargo	14	32	314	360	448	322	314	322	518
Ratio (%)	(3.1)	(4.7)	(27.9)	(26.7)	(25.3)	(17.7)	(15.0)	(14.9)	(22.2)

Source: Korea Maritime Institute, Shipping Statistics Handbook 2014.

5.2.3 Port Privatization

5.2.3.1 Evolution of Port Privatization

The Korean government had limited financial resources for port development in the 1960s, 1970s, and thereafter. Therefore, the Korean government requested loan from IBRD for port development. In 1977, IBRD accepted the request from the Korean government with a recommendation to manage ports terminals by designated stevedoring companies. Based on the IBRD recommendation, the Korean government introduced the Terminal Operating Companies (TOC) System in 1977, by which designated stevedoring companies could handle the cargo at designated berths and terminals. However, the TOC system was not successful because the government leased designated stevedoring companies for a short period of

time, usually one year **(MOMAF 1997)**. The leasing-out terminals were very limited to the "Development Berths" which were developed by the loan from IBRD and the rental fee was fixed by regulation. Therefore, the TOC System was difficult in improving efficiency by private stevedoring companies.

In 1997, the Korean government introduced the TOC System again to response the increasing cargo volume efficiently, which designated stevedoring companies can use for a longer period of usually 30 years. The TOC system was introduced to shift from the state-own and state-management to the state-own and private-management for port efficiency. The TOC system was first introduced at Busan and Incheon Ports in January 1997, Ulsan, Yeosu and Gunsan Ports in May 1997, and Masan, Pohang, and Gwangyang Ports in June 1997, and nationally thereafter. Now stevedoring companies under the TOC system employ longshoremen as their own permanent employees. Furthermore, berths and terminals, which handle large volumes of specialized cargo, such as automobiles, oil and gas, coal, and ore, started to be constructed by the private investors, who employ longshoremen as their permanent staff.

After the introduction of TOC in the 1990s, there had been many voices for introduction of PA, especially from the academia and local governments. Although the Korean government agreed the feasibilities of PA for port efficiency, it had been very reluctant to introduce PA. This was because the Korean government had been used to developing, owning, and managing ports by themselves for a long time. However, voices calling for the introduction of PA were so strong that in 2003 the Korean government enacted the Port Authority Act and started to establish PAs of the large ports; Busan Port Authority (BPA) in 2004, Incheon Port Authority (IPA) in 2005, Ulsan Port Authority (BPA) in 2007, and Yeosu Gwangyang Port Authority (YGPA) in 2011, respectively.

5.2.3.2 Port Authorities Under the Government

In the early 2000s there were serious debates on the autonomous management of PAs in various discussions including the public hearings in the National Assembly before the establishment of PAs. Generally, the departments of the central government such as the Ministry of Finance and the Ministry of Maritime Affairs and Fisheries (MOMAF) wished to involve much in the management of PAs as the owner of the land and facilities of ports. Also the central government was not sure of the successful management of PAs with full autonomy, which was firstly introduced in Korea after the ports had been managed by the central government for a long time. However, local governments and most academia claimed a full devolution from the central government for efficient management of ports in a rapidly changing environment of ports. After a long negotiation, the Port Authority Act passed the National Assembly in 2003, by which the central government can control the management of PAs through various tools. However, the act states

that the central government should guarantee the autonomous management of PAs for ensuring the responsible management system.[12]

First, PAs should be established by investment in kind of the central government or local governments.[13] However, at present all the PAs (BPA, IPA, UPA, and YGPA) have been established by investment in kind of the central government only and the local governments have not participated in the capital investment.

Second, although the Governing Body of PA is consisted of various members including those appointed by recommendation of local governments, all the members are appointed by the minister of the Ministry of Oceans and Fisheries (MOF).[14] Also the head of PA is appointed by the minister of MOF through consultation with local governments.[15]

Third, businesses that PA can perform are also regulated by the act.[16] The central government has limited the function of PA as a landlord which leases out port facilities to private business.

Fourth, when PA plans to develop port construction projects, it should get approval of the execution plan from MOF.[17]

Fifth, major income of PAs is the rental fee of the port facilities. PA should report the rate of the rental fee to the minister of MOF, who can order change or adjustment of the rate of the rental fee.[18] Therefore, the central government (MOF) actually controls the rate of the rental fee by this regulation.

12 Port Authority Act, Article 3.
13 Port Authority Act, Article 6.
14 Port Authority Act, Article 11.
15 Port Authority Act, Article 16.
16 Port Authority Act, Article 8.
17 Port Authority Act, Article 22.
18 Port Authority Act, Article 30.

6 Other Ocean Economic Activities


Photo from: CNN/Shin Kim

6.1 Fish Ports

The Fishing Villages and *Fishery Harbors Act* defines the "fishery harbor" as any harbor with natural or artificial fishery facilities which serves as a major base for the fisheries industry and is designated and publicly announced under the Article 17 of this Act, and the types of fishery harbors shall be as follows:

i) State-owned fishery harbor: A nationwide fishery harbor or fishery harbor required for the development of fishing grounds (referring to fishing grounds falling under subparagraph 1 of Article 2 of the Fishing Ground Management Act; hereinafter the same shall apply) and evacuation of fishing vessels, as it is located on an insular area or remote area;

ii) Local fishery harbor: A local fishery harbor which serves as a main bas for assistance for the coastal fishery;

iii) Fishery harbor located in a fishing village: A small-scale fishery harbor, which serves as the main base for the livelihoods of people in a fishing village;

iv) Village joint-use fishery harbor: A small-scale fishery harbor or port use jointly by fishermen, which is not classified as a fishery harbor in a fishing village.

The government plans to invest a total of KRW10,312 billion for the development of fishery harbors such as the state-owned fishery harbors (KRW8,104 billion) and local fishery harbors (KRW2,207 billion). By 2014, the government has invested KRW 4,900 billion won: KRW3,477 billion for the state-owned fishery harbors and KRW1,423 billion for local fishery harbors.

As of 2014, 109 state-owned fishery harbors have been completed and 8 harbors are under construction. And 184 local fishery harbors have been completed and 100 harbors are under construction. In Korea, statistics on the unloading of fisheries resources from these fishery harbors are not collected.

6.2 Ship-building

Korea is one of the world's largest shipbuilders, producing 30% of the world's new ships every year until 2009. In 2012, it constructed ships capable of loading 31.4 million gross tonnes (GT), accounting for 33% of the global total. Hazardous substances generated during shipbuilding include oils and paints discharged into the ocean, and dust and particles emitted into the atmosphere. However, the amount of hazardous substances emitted during shipbuilding is not great. Moreover, because most shipyards have strict controls on the emission of hazardous substances, their impact on the marine environmental is limited.

There have been a total of 9 medium/large size shipyards in Korea, operating since 2000s. However, the small size shipyards have been continuously decreasing since 2007, which reached at peak, 66 shipyards.

Table 6.1: Trend of Shipyard Numbers

Year	2004	2006	2007	2008	2010	2012	2013	2014	2015
Medium/Large	9	9	9	9	9	9	9	10	9
Small	57	53	57	49	46	43	40	38	38
Total	**66**	**62**	**66**	**58**	**55**	**52**	**49**	**48**	**47**

Source: Korea Offshore & Shipbuilding Association (http://www.koshipa.or.kr)

The total ship orders reached at peak, 49.9 million tonnes in 2007, thereafter shows decreasing trend due to the oversupply of the world shipyards and the recession of the world economy. The domestic and export ship orders share 7.3% and 92.7% in 2015, respectively.

Photo from: Samsung Heavy Industries via Bloomberg

Table 6.2: Trend of Ship Orders.

	Total		Domestic		Export	
	No.	1,000GT	No.	1,000GT	No.	1,000GT
1998	175	9,998	-	-	175	9,998
2000	313	19,380	2	16	311	19,363
2002	230	12,773	-	-	230	12,773
2004	441	25,735	-	-	441	25,735
2006	498	33,656	-	-	498	33,656
2007	707	49,990	3	23	704	49,968
2008	467	33,775	14	613	453	33,162
2009	49	3,725	2	29	47	3,696
2010	320	18,904	14	580	306	18,324
2011	266	21,047	30	1,481	236	19,596
2012	214	12,660	38	1,298	176	11,302
2013	407	27,513	30	1,716	377	25,797
2014	293	21,146	25	826	268	20,320
2015	248	22,102	27	1,616	221	20,486

Source: Korea Offshore & Shipbuilding Association (http://www.koshipa.or.kr)

According to the Clarkson (2016.3), the shipbuilding capacity of Korea will decreased from 17.7 million compensated gross tonnage (CGT) in 2012, to 14.9 million CGT in 2015, to and 13.0 million CGT in 2021. This decline is similar to the decline in global shipbuilding capacity in China, Japan and Europe.

Table 6.3: Trend of Shipyard Numbers.

	Korea	China	Japan	Europe	Etc.	Total
2012	17.7	25.6	10.7	4.3	5.4	63.0
2013	16.0	22.4	9.1	3.4	4.9	55.8
2014	14.9	19.2	8.9	3.3	4.7	50.9
2015	14.9	18.9	8.7	3.2	4.3	50.0
2016	14.6	18.2	8.6	3.1	3.8	48.3
2017	14.2	16.2	8.4	3.0	3.4	45.2
2018	13.6	15.4	8.1	3.0	3.3	43.4
2019	13.2	14.4	7.7	3.0	3.2	41.5
2020	13.2	13.4	7.7	3.0	3.1	40.4
2021	13.0	13.4	7.7	2.9	3.0	39.9

Source: Clarkson 2016.3 and Korea Offshore & Shipbuilding Association (http://www.koshipa.or.kr)

Although the ship orders have decreased since 2007, the workers employed in the shipyard (both in shipbuilding and offshore plant) have continuously increased from 86,682 in 2001 to 143,581 in 2007, to 153,769 in 2010, and to 203,282 in 2015. In addition to the shipbuilding industry, the shipbuilding equipment companies also employ a large number of people. They have decreased from 67,420 in 2010 to 58,263 in 2015. The R & D cost of the shipbuilding industry is about 1% of sales. The sales and research and development expenses for 2015 were KRW 26,603.6 billion won and 282.5 billion won, respectively.

In 2016, there is a total of shipbuilding & offshore plant related 14 colleges, 19 universities, and 17 graduate schools in Korea. The number of R & D personnel in the shipbuilding industry increased from 1,541 in 2008 to 2,262 in 2014, but fell to 2,181 in 2015.

In 2015, the export of the shipbuilding and offshore plant amounted to $40,107 million, contributing to exports for the third time following semiconductors ($62,916 million) and automobiles ($45,794 million).

6.3 Marine Services

The marine-related industry (e.g., marine insurance; shipping classification and registry; ship management) is a high value-added industry, which is dominated by traditional shipping nations,

especially European countries. Since the marine-related industry is a knowledge-intensive industry, which demands highly educated shipping experts and institutions, there are technical and institutional barriers for newly emerging shipping nations to enter, including Korea. The marine-related industry is at the initial stage in Korea. Until recently, the marine-related services have been provided by traditional shipping countries in Europe. This is because the history of shipping in Korea is very short compared with other traditional shipping nations, and the shipping policy has focused on the expansion of the national shipping fleet, not on the marine-related industry.

The marine-related industry supports the shipping industry, which also supports the marine -related industry. Korea has a potential to develop the marine-related industry. However, it is not an easy job to educate and train high-level shipping and its related business experts, acquire professional shipping and shipping-related knowledge, and establish relevant international institutions. Therefore, it is necessary to establish a long-term strategy, which can develop the marine-related business that has a comparative advantage. Korean shipping industry has already reached a total of 40 million GT, and ranked 5th in the world. The marine-related industry is closely related with the above shipping fleet. There are two marine merchant universities in Korea where many ship officers and engineers have been well trained. Many of them have accumulated excellent shipping experiences gained from boarding ocean-going vessels of advanced foreign shipping companies since the 1960s. The government and the shipping industry need to send these human resources to foreign universities and foreign marine-related companies through international cooperation, also invite foreign experts to Korean companies as regular staffs to share the skills and experiences.

6.3.1 Marine insurance

Before the Korean government joined the OECD in 1996, it had been compulsory for Korean shipowners to buy the Hull and Machinery Insurance from insurance companies in Korea. However, as Korea became a member of OECD, the government deregulated and opened the domestic insurance market to foreign insurers, and Korean shipowners were made free to buy the Hull and Machinery Insurance from any available insurers around the world. In fact, many shipowners started to buy the Hull and Machinery Insurance from foreign insurers and continue to do so. The competition in the hull insurance market has become so fierce that the domestic insurance companies are now forced to offer lower premium and better services than those of foreign insurers to attract Korean shipowners. In 2000, in the midst of this transitional period, the Korea Shipownerin Mutual Protection & Indemnity Association (Korea P&I Club) was established to provide Korean shipowners with the third party liability. However, since Korean shipowners were already no longer required to buy the third party liability from Korean companies, Korea P&I Club attracted few Korean shipowners. To this day, a large number of the shipping companies, especially large shipping companies, have not entered Korea P&I Club. Additionally, it is to Korea P&I Club's disadvantage that it has not been able to join IGA clubs and is, therefore, unable to provide letters of undertaking guaranteed by the IGA clubs. It is important that all related parties, namely Korea P&I Club, the shipping industry, and the Korean government, work together to enable Korea P&I Club to buy reinsurance from the IGA clubs.

6.3.2 Classification

Korean Register of Shipping (KR) was established in 1960 when there was a small shipping fleet in Korea. In 1978, the Korean government delegated the governmental inspection and certification of Korean flag vessels to KR. After that, the fleet of KR has increased continuously with the increase of Korean shipping fleet. In 2014, KR carried out Korean governmental inspection and certification of 1,670 vessels and class inspection of 2,920 vessels. Also in 2014, KR carried out inspection and certification of 1,257 foreign flag vessels. In addition to vessels survey, KR is doing business in the areas of ISM, ISO, ISPS, CE Mark, KOLAS, 3rd party inspection, condition survey for navy and coast guard vessels, renewable energy inspection, and provision of training course. In 1975, KR joined IACS as an associate member, and in 1988, joined as a regular member. As of 2013, the KR fleet reached 60 million GT.

While the increase of the world shipping fleet has been sluggish recently, the competition among classification societies has become severe. As new classification societies with very low level of requirements have proliferated, they themselves have become the object of inspections of the various *Memoranda of Control* by the PSC (Silo et al. 2013). Professional high-level training and education for the surveyor are required and investment for research and development (R&D) is also important for enhancing the comparative advantage in the competitive Classification Societies.

6.3.3 Ship management

Two marine merchant universities (KMOU and MMU) have trained excellent ship officers and engineers, who started to get onboard the vessels of foreign shipping companies since the 1960s. Therefore, the crew manning business started in the 1960s. However, a full-fledged ship management has started recently with the enactment of the Ship Management Industry Development Act in 2012. Thus, the ship management is in the beginning stage like other shipping-related businesses in Korea.

In 2001, a total of 183 ship management companies managed 1,574 vessels. In May 2015, the number of ship management companies was reduced to 131. However, the number of vessels increased to 1,967, among which domestic and foreign flag vessels are 823 and 1,144, respectively. The ship management companies also manage a total of 8,168 crews, among which domestic and foreign crews are 5,084 and 3,084, respectively. Most of the ship management companies have been established by the shipping companies to manage their own vessels. And the ship management companies are small in business scale, managing 11.2 vessels on average. A very few companies are managing more than 50 vessels (Kim, Jung, and Yeo, 2012).

Although there is a high potential for development of ship management business in Korea, a long-term strategy needs to be established in such competitive and knowledge-intensive

industry. Korea has an international competitive advantage in training excellent ship officers and engineers. The ship management needs to be developed based on the technical human resources.

6.3.4 Ship brokerage

Compared with the shipping fleet of 40 million GT and the large size of shipbuilding industry of Korea, the Ship brokerage business is very weak. In 2012, there were a total of 1,800 companies, but reduced to 980 and 887 in 2014 and 2015, respectively. Most of the shipbroking companies are small in business scale. The total sales of the Ship brokerage business are about $2 billion, most of which come from forwarding business (Lim et al., 2009).

The shipping and shipbuilding business are active in East Asia and will further increase as the economic development continues. A long-term strategy should be established for ship brokerage industry, especially training experts. As mentioned above, KMI needs to research the shipping market trends and forecast until the private businesses strengthen their capabilities.

6.4 Marine Education

Photo from: KIMFT via Wikipedia

There are two maritime universities and two marine high schools in Korea focusing on maritime affairs education. Moreover, there are six fisheries universities and 8 fisheries high schools. The Korea Institute of Maritime and Fisheries Technologies (KIMFT) is the training institute for maritime and fisheries seafarers. There are twenty universities, which have a department of oceanographic and ocean science, ocean engineering, marine biology, marine environment, and maritime safety.

6.5 Seafarers

The number of Korean seafarers is steadily declining. There were 36,976 seafarers in 2015, peaking at 39,002 in 2008. In 2015, a total of 33,975 are employed in the national flag ships, among which 9,308 and 7,847 are employed in ocean going ships and coastal ships, respectively. Around 1,492 and 15,328 are employed in the deep-sea fishing vessels and the near-sea fishing vessels, respectively. Korean seafarers employed in foreign vessels have also continuously decreased from 4,212 in 2008 to 3,001 in 2015. However, their earnings have continuously increased to $ 849.8 million in 2015.

Table 6.4: Status of employed seafarers

	2006	2008	2010	2012	2014	2015
Total	38,821	39,002	38,758	38,906	37,125	36,976
National Flag	34,667	34,790	34,970	35,355	34,016	33,975
- Ocean Going	7,445	8,673	9,077	9,308	9,378	9,308
- Coastal	7,801	7,845	8,062	8,262	7,850	7,847
- Deep-sea Fishing	2,339	1,897	1,892	1,981	1,572	1,492
- Near-sea Fishing	17,082	16,375	15,939	15,797	15,216	15,328
Foreign flag	4,154	4,212	3,562	3,551	3,109	3,001
Foreign exchange						
Earnings ($1000)	400,532	577,865	633,340	718,851	828,938	840,876

Source: Ministry of Ocean and Fisheries (MOF). Statistical Yearbook of Ocean & Fisheries 2016.

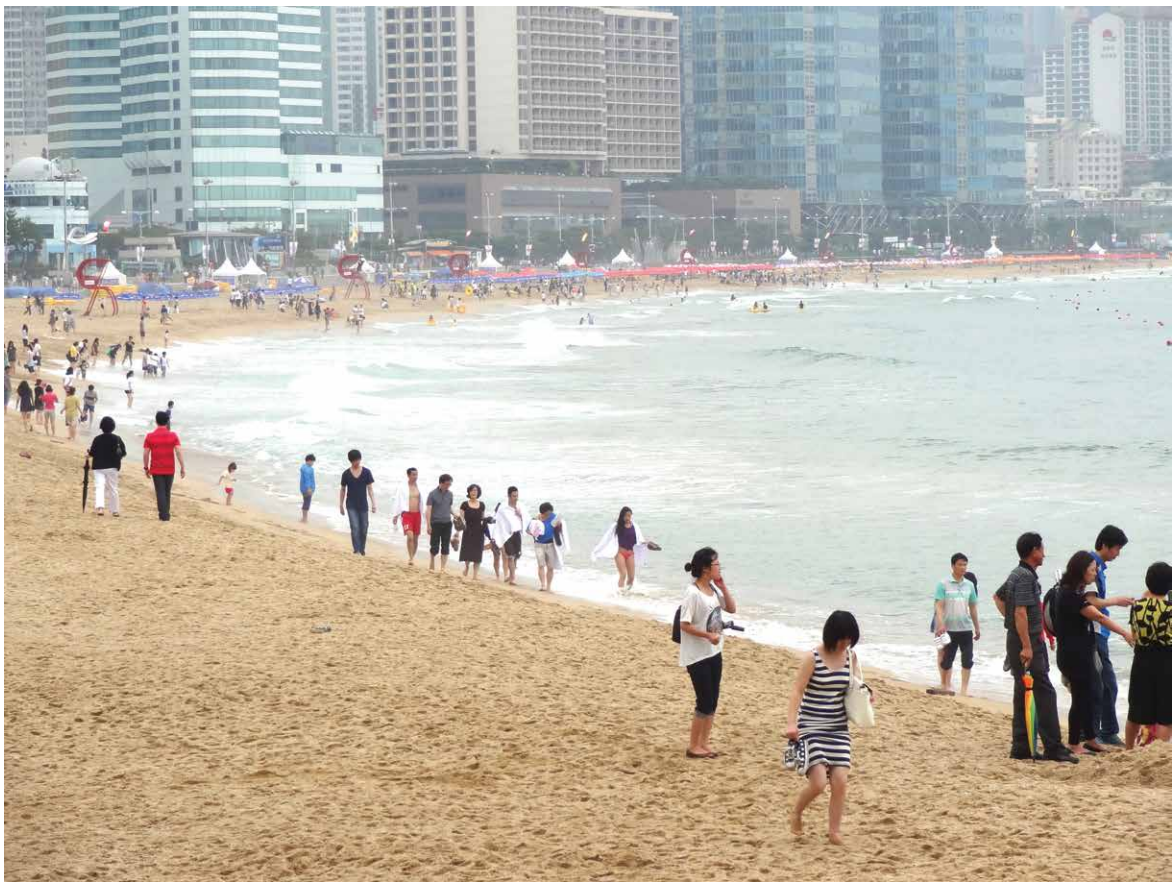


Photo by M. Ebarvia

Photo by M. Ebarvia

PART 3

DEVELOPMENTS IN BLUE ECONOMY

7 National Plan for Blue Economy

Korea's ocean economy has been promoted since the government established the Ministry of Maritime Affairs and Fisheries (MOMAF) in 1996, enacted the *Basic Act on Ocean and Fisheries Development* in 2002 for the sustainable development of ocean resources and the ocean industry development, and adopted the *Basic Plan for Ocean and Fisheries Development* (OK 21) in 2004. The blue economy strategy is being pursued by national planning and technology development.

Until recently, Korea's traditional maritime industries, such as shipping, port, shipbuilding, and fisheries industry, have shown high growth rates. However, these traditional marine industries have reached a maturity stage and are showing some limitations in growth due to intense international competition and global economic downturn. On the other hand, new marine industries, such as marine energy, marine minerals, marine biotechnology and marine tourism, are expected to generate employment and create added value. However, there was no government policy at that time, no industrial environment had been created for the growth of the emerging marine industries, and no system had been developed to create synergies between public and private sectors.

Therefore, in 2014, the Ministry of Ocean and Fisheries (MOF) established the *Comprehensive Measures to Promote New Ocean and Fisheries Industry* with the following aims: (a) increasing the added value of the marine fisheries and new industries up to 7% of GDP by 2017; (b) expanding the new ocean and fisheries industry to KRW40 trillion by 2017; and (c) creating 25,000 new jobs by 2017. To achieve this goal, the MOF will pursue the following policies:

i) To facilitate the creation of new industries through the development of promising technologies and new market exploration;
ii) To establish the foundation for fostering new industry through establishment of industrial clusters, improvement of legal system, and establishment of public-private cooperation system;
iii) To strengthen competitiveness of new industry through training of professional manpower, strengthening R&D capacity, and supporting overseas expansion.

Through this plan, the MOF will focus on the following 10 key strategic industries:

i) Utilization and development of ocean resources: (1) Offshore plant service, (2) marine biotechnology, (3) deep seawater; (4) ocean energy;

ii) Marine environment preservation and enhancement of marine safety: (5) Vessel ballast water, (6) Next-generation ship navigation system (e-Navigation); (7) Green ports;
iii) Future industrialization and innovation of traditional industries: (8) Ship management, (9) Advanced aquaculture, (10) Seafood.

The R&D budget of the maritime and fisheries sector has been steadily increasing every year, reaching KRW572.3 billion in 2016. As a result, research papers and patent applications have been steadily increasing. However, due to the government-led R&D system in the past, the market-oriented R&D promotion based on industrial demand has been limited. In addition, the R&D management system, which does not reflect the characteristics of the industrial field, failed to produce innovative results. The support system that can link the results of R&D to industrialization was insufficient.

For this reason, in 2016, the government established the *Strategy to Promote Industrialization of Ocean and Fisheries R&D*, aiming at:

i) Creating a market of KRW3.4 trillion, creating 36,000 jobs, and establishing four globally competitive companies by 2020;
ii) Creating a market of KRW14.0 trillion, creating 123,000 jobs, and establishing ten globally competitive companies by 2025.

To achieve this goal, the government selected 15 key tasks under the three major strategies;

i) **Innovation in the R&D system**: (1) Strengthening market-oriented R&D, (2) Improving the planning system that reflects industry demand, (3) Establishing a pro-enterprise management system, (4) Enhancing enhancement of post-support and performance utilization;
ii) **Strengthening R&D in the seven key industries**: (1) Early commercialization of marine energy, (2) Nurturing maritime industries utilizing opportunities for strengthening international regulations, (3) Cutting-edge industrialization of aquaculture and food technology, (4) Securing deepwater resources through overcoming extreme environments., (5) Pioneering the world market for marine biotechnology, (6) Practical use of advanced equipment for underwater construction, and (7) Creation of new industries through integrated fusion innovation;
iii) **Promotion of industrialization and reinforcement of infrastructure**: (1) Strengthening the legal and institutional basis, (2) Revitalizing technology finance and funds, (3) Nurturing and nurturing industrial manpower, (4) Strengthening industrialization promotion systems and support organizations.

As mentioned above, the government established the *Comprehensive Measures to Promote Ocean and Fisheries New Industry* in 2014 and the *Strategy to Promote Industrialization of Ocean*

and Fisheries R&D in 2016. However, until now, the investment of the marine fisheries sector has not been achieved as expected due to the following reasons:

i) The bottom of the marine fisheries industry is weak enough to attract investment;
ii) The business capacity of marine fisheries is weak;
iii) There is not enough support system to promote start-up and investment.

Consequently, in 2017, MOF established the *Strategy to Promote Business Start-up and Investment in Marine Fisheries*, aiming at:

i) **Promoting technology-based entrepreneurship**: (1) Establishment of one-stop support system for marine fisheries business, (2) Strengthening support for commercialization of promising items, (3) Support for preliminary start-ups for their proliferation, (4) Customized start-up support for each cycle;
ii) **Strengthening enterprise investment attractiveness**: (1) Support for technology development and creation of investment, (2) Strengthening professional education at each stage and establishing a consulting program, (3) Support for overseas advancement and market opening;
iii) **Expansion of network with capital market**: (1) Strengthening links with the investment review team, (2) Improvement of IR of marine fisheries, (3) Establishing a marine fisheries investor network;
iv) **Expansion of financial infrastructure**: (1) Establishment of technical, financial and technology trading support system, (2) Establishment of marine fisheries welfare funds and theme funds, (3) Promotion of investment and finance in marine fisheries;
v) **Establishment of investment and investment ecosystem**: (1) Establishing a credibility base for start-up and investment promotion, (2) Support for marine fisheries business establishment and investment base, (3) Establishment of foundation and investment platforms and statistics.

8 Blue Economy Initiatives

8.1 Ocean Energy Development

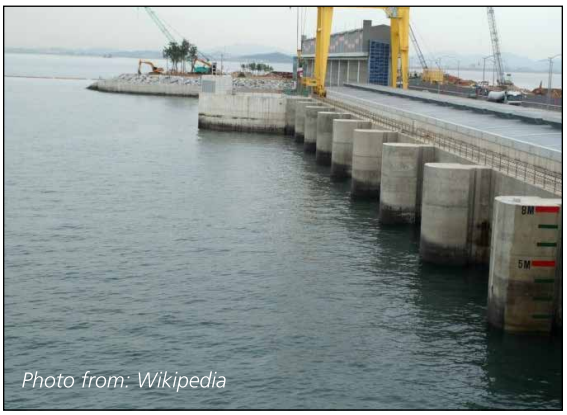


Photo from: Wikipedia

Kang et al. estimated that the total offshore ocean energy resources in Korea are 18,000 MW: the tidal power energy of 6,500 MW, the wave power energy of 65,000 MW, the tidal current energy of 1,000 MW, and the ocean thermal energy conversion of 4,000 MW. The west coast is suitable for development of the tidal power energy of 6,500 MW: 500 MW of the Garolim Bay, 1,500 MW of the Incheon Bay, 800 MW of the Gangwha Bay, and 2,300 MW of the Haejoo Bay. The south western coast is suitable for the tidal current power of 1,000 MW: 50 MW of the Strait of Uldolmok, 150 MW of the Strait of Jangjook, and 250 MW of the Strait of Maenggol, respectively. The wave power resources in the coastal waters are 6500 MW, but if it the deep sea is included, the resources increase to 50 GW (Kang et al., 2012). Although there are rich resources for the offshore energy in Korea, the goal for developing the offshore energy in the national plans for renewable energy is very low compared with other renewable energy.

8.1.1 National Ocean Energy Development Program

Korea's ocean energy development has been carried out based on the *Technology Development Project for Commercialization of Offshore Energy* established by the Ministry of Ocean and Fisheries (MOF), and Ministry of Trade, Industry and Energy (MOTIE).

MOF is in charge of the ocean energy development of the tidal power energy, the tidal current energy, the wave power energy and the ocean thermal energy conversion based on the Enforcement Regulation of MOF and Affiliated Agency Organization. MOTIE is in charge of the offshore development of the offshore wind energy based on the Enforcement Regulation of MOTIE and Affiliated Agency Organization.

Korean government invested KRW156.2 billion for offshore energy development from 2000 to 2014; KRW49.0 billion for the tidal current, KRW48.2 billion for the wave power, KRW8.9 billion for the tidal power, KRW20.5 for the ocean thermal energy conversion, and KRW29.6 for the

complex generation. The average level of Korea's ocean energy technology is 80.2 percent of the technology of the advanced countries (Kang et al., 2012).

8.1.2 Tidal Power Energy

The tidal power energy has been commercialized since 2011 by construction and operation of the Siwha Tidal Power Plant. However, the plans for construction of other tidal power plants at the Garolim Bay and the Incheon Bay have been suspended, facing the strong opposition from the residents and fishermen worrying about the potential environmental damage. And the development of the turbines is in the state of standstill.

8.1.2.1 The Siwha Tidal Power Plant

Siwha tidal power plant. Photo by KIOST; K.S. Lee

The Lake Siwha was an estuary with vast wetlands and the associated watersheds of 494 km^2 receiving nutrients from six small rivers that flow into the Yellow Sea. The Lake Siwha is in the western part of Gyeonggi Province and surrounded by the metropolitan city of Seoul being only 35 km to the east, the metropolitan city of Incheon in the north, the city of Anyang in the east, and the cities of Suwon and Hwaseong in the south. About three fourths of the total population of Korea is living in this area. It means that the Siwha estuary always presented itself a prime opportunity for being developed for any purposes.

The Siwha Lake Reclamation Project built a 12.7 km dyke in the mouth of the estuary to keep 180 million tonnes of freshwater in the estuary (lake) for agriculture, to create land by reclamation of 110 km^2 of wetlands and estuaries for rice production, industrial complexes, and a new city that could alleviate the economic concentration and dissipate the population of the Seoul metropolitan area. The construction of the dyke was started in 1987 and completed in 1994. The general public accepted the reclamation of wetlands and estuaries for creating land for economic development including agriculture from the 1960s to the 1980s. Also, there had not been any failure, that is, environmental disaster caused by large-scale reclamation until the Siwha Lake Reclamation Project. Therefore, the Siwha Lake Reclamation Project was planned and carried out without strong opposition from the whole Korean society and with the weak opposition of a few scientists and experts.

Two large industrial complexes and a new city (Ahansan City) were built before completing the dyke, from which about 127,000 tonnes of industrial wastes and about 49,000 tonnes of sewage flowed into the lake. Also many farms were built in the watershed, from which about 9,000 tonnes of BOD flowed into the lake. Those land-based sources of pollution heavily degraded the

lake before the completion of the dyke, and water could not be used for agriculture. Therefore, in 1991, the government officially declared the abandonment of keeping freshwater in the lake and allowed seawater to infiltrate (Nam, Choi, and Chang, 2001).

To keep the seawater in the lake, the government regularly opened the gates of the dyke to flush out the polluted water from the lake and to take seawater in from the outer coastal waters. However, the quantity of intake of seawater was only 16 million tonnes a day, which was only 8.9% of the storage capacity of the lake, so the waters in the upper part of the lake could not properly circulate. Also, the two gates were built 10 meters higher than the bottom of the seabed, and the waters below the gates could not circulate well. The Lake Siwha Reclamation Project has completely failed and resulted in an environmental disaster. The public and NGOs recognized the value of wetlands and estuaries from the failure of the Lake Siwha Reclamation, and thereafter began to oppose any large-scale reclamation of wetlands and estuaries in Korea.

In this situation of keeping seawater instead of freshwater in the lake, a project for building a tidal power generator in the dike was established to produce electricity, and also flush out the polluted water of the lake and take the clean sea water into the lake. The average of over 7 meters of the tidal gap was good for building a tidal power generator. The bigger the capacity of the generator is, the better it is for exchanging the polluted lake water with the clean waters. The Lake Siwha Tidal Power was constructed in 2003 to 2011, with an investment of KRW355.1 billion.

The Siwha Tidal Power Plant is generating electricity two times a day, using the water fall at high tide. The installed capacity with 10 water-turbine-generators of 25400 KW is 254 MW. The total annual power production is 552GW. The water-turbine-generator has three wings, with a diameter of 7.5 meters, rpm of 64.29. A total of 482.13 cubic meters of water per second is used. The maximum, regular, and minimum waterfall is 7.50 meters, 5.82 meters, and 1.00 meters, respectively. There are a total of 8 sluice gates with 15.3 meters of width and 12 meters of height. The total circulation of the seawater is 147 million m^3 a day, which means that about half of the total waters of the Lake Siwha is circulated. The Siwha Tidal Power Plant has produced electricity since 2011: 0.5 billion KW until December 2012, 1.0 billion KW until December 2013, and 1.5 billion KW until January 2015 (K-Water, 2016).

The K-Water estimates the effects of the Siwha Tidal Power Plant as followings:

i) The water quality of the Lake Siwha has been improved to COD 2.0 ppm, which is similar to the level of the coastal waters outside of the Lake;
ii) The annual power production of 552 GW is enough to supply a city of 500,000 inhabitants;
iii) The annual power production of 552 GW has reduced CO_2 emissions of 315,000 tonnes annually;
iv) The annual power production of 552 GW has oil import substitution effects of 862,000 barrels a year, which improves the energy self-sufficiency;

v) The Siwha Tidal Power Plant has enhanced opportunities for marine-based tourism and leisure activities with expected visitors of 1.5 million people yearly.

8.1.2.2 The Garolim Bay Tidal Power

The Garolim Bay Tidal Power was planned to construct a dike of 2,053 meters in the mouth of the Garolim Bay at the western coast of Korea. A total of 96.03 km^2 of land was scheduled to be created with the construction of the dike. The relevant government department planned to invest KRW1,022.5 billion to make the dike and the tidal power. However, in October 2014, the Ministry of Environment (ME) returned back the Environment Impact Assessment, and the fishermen and NGOs strongly opposed the plan. At present, the plan is at a standstill and cannot be implemented.

8.1.3 Tidal Current Power Energy

The Uldolmok Tidal Current Power Test Plant was constructed as a pilot MOF R&D Project, with an investment of KRW13.0 billion. The total power capacity is one MW with two sets of 500 kW each. The Uldolmok Tidal Current Power Test Plant is a R&D facility which was constructed for practical use. The Uldolmok Strait is considered as a suitable site for current power plants, of which maximum current is 11 knots and the width is 294 meters. Because of strong current, the construction took 4 years from April 2005 to March 2009. The structure of the Plant including the superstructure is 16 meters of length, 36 meters of width and 48 meters of height, with 1000 tonnes of weight.

The Uldolmok Tidal Current Power Test Plant was scheduled to produce 90,000 kW from 2013. However, the economic feasibility was too poor to operate continuously. And the superstructure of the Plant adversely impacts the surrounding scenery. In September 2012, a typhoon damaged the Plant, and caused it to stop operating.

The Uldolmok Tidal Current Power Test Plant has succeeded in proof for development of scientific technologies. However, it has not entered the stage of the semi-commercialization because it has not operated for over one year and failed to produce the targeted one-GWh. And the lower weighted value of the Renewable Energy Certificate (REC) for the tidal current power makes the economic feasibility very low, thus preventing the private businesses to enter the tidal current power industry. Moreover, the cost for installing the supporting structure in the seawater is 2.5 times higher than that on the land, resulting in poor economic feasibility of the tidal current power industry.

8.1.4 Wave Power Energy

The East Sea and the coast of the Jeju Island Sea are appropriate sites for the wave power energy. The potential resources of the coast of the Jeju Island are estimated to be 1,950MW, of which

5%, if developed, is able to supply the electricity to 35,000 families. At present, R&D for the wave power energy is undergoing for both the near-shore and the deep sea.

The Jeju Wave Power Plant was constructed as a pilot project from August 2003 to June 2015 with an investment of KRW25.5 billion. It was built at one km from the shoreline of the west coast of the Jeju Island. The average depth is 16 m. The concrete caisson has length of 37 m, width of 35.2 m, and height of 29.5 m, and weighs 12,000 tonnes. The total power capacity is 500 kW, with two sets of 250 kW. In 2014, a detailed design of an electric-type wave turbine and electric control device and mooring facilities for the deep sea wave power were completed.

8.1.5 Offshore Wind Energy

As the land space for wind energy is limited and opposition of the residents has become strong, the demand for the offshore wind energy is increasing in Korea. Also, as the Renewable Energy Portfolio Standard (RPS) started to assign the large-scale producers of over 500MW to mandatorily supply 2% until 2012 and 10% of renewable energy until 2020, large-scale sites for the offshore wind energy have become to be developed. Therefore, about ten sites including the Saemangeum Estuary for the offshore wind energy development are under the stage of planning, all of which sites are in the southwestern coast of Korea. As a representative project, MOTIE announced that a site for the offshore wind energy producing 2.5 GW will be developed in the south western coast, with the goal to produce over 7.3 GW until 2030. KEPCO E&C is scheduled to develop a site for the offshore wind energy in the Jeju Island coast, where 102 MW will be produced until 2013. The Jeollanam-do Province will develop a 5GW-scale site for the offshore wind energy on the basis of strong wind of 7-8 meters per second (Kang et al., 2012).

8.1.6 Prospect of Ocean Energy Development

The *Sixth National Electricity Supply and Demand Basic Plan*, established in August 2013, aimed to produce the offshore energy of 2,480 GWh in 2025, which is 3.2% of new renewable energy of 77,364 GWh. The offshore energy would be 255 MW at the Siwha Tidal Power Plant from 2011, 14.5MW at the Uldolmok Tidal Current Power Plant from 2017, 40 MW at the Jangjook Tidal Current Power from 2019, and 100 MW at the Incheon Tidal Power Plant from 2020.

The *Second National Energy Basic Plan*, established in January 2014, decreased the share of the offshore energy to 2.4% among the new renewable energy in 2020, 1.6% and 1.3% in 2025 and 2035, respectively. Originally, the Garolim Tidal Power Plant of 520 MW and the Ganwha Tidal Power Plant was scheduled to construct until 2020. However, it has suspended due to strong opposition from residents, claiming the environmental damages.

Table 8.1: Targets for Renewable Energy Supply by Sources (% of Total Renewable Energy).

Year	Sunlight	Solar Heat	Wind	Geothermal	Waste	Bio	Water	Offshore	Total
2020	11.1	1.4	11.3	2.5	47.3	17.6	6.3	2.4	100
2025	13.3	3.9	12.5	4.6	40.2	19.6	4.3	1.6	100
2035	14.1	7.9	18.2	8.5	29.2	17.9	2.9	1.3	100

Source: The Second National Energy Basic Plan.

The *Fourth National Renewable Basic Plan*, developed in 2014, aims to produce the offshore energy to be 1.6 percent of the total renewable energy by 2025. The plan will introduce a variable REC weight value to attract investment of the private business. For example, in case of the offshore wind energy, 2.5 will be given in 1-5 years, 2.0 in 6-15 years, and 1.0 after 16 years.

In July 2015, MOF and MOTIE established the *Mid- and Long-term Offshore (Ocean) Energy Development Plan (2015-2025)*. The goals of the Plan are:

i. To produce offshore (ocean) energy, and make it 1.6 percent of the total renewable energy by 2025 (according to the *Second National Energy Basic Plan* and the *Fourth New Renewable Basic Plan*);
ii. To increase technologies of the offshore energy from 79% in 2012 to 95% of the technology-advanced countries by 2025;
iii. To foster five small and competitive offshore energy businesses by 2025.

- **Wave Energy**:
  i. To develop a tidal power system optimized in the coastal waters of Korea through test operation (2015-2016) of the Jeju Pilot Wave Energy Plant;
  ii. To accelerate a floating-type wave energy generating system (2015-2016, 300 kW), which is using the deep sea wave energy;
  iii. To develop a small-size wave energy generating system to supply electricity to small islands;
  iv. To expedite commercialization through establishment of a real ocean test bed, which is connected with the Jeju Pilot Wave Energy Plant (2016-2021), and through construction of a private-oriented test bed;
  v. To establish a wave energy generating test bed of 5MW using the Jeju Pilot Wave Energy Plant and to expand it to a real ocean combined generating test bed of 20 MW.

- **Tidal Current Power**:
  i. To develop and operate an active control-type generating system for early commercialization by participation of the private sector until 2018, and to expedite commercialization through transfer of the technologies;

ii. To establish a real ocean test bed through expansion of the Uldolmok Tidal Current Power Plant (2017-2022) and to expedite the commercialization;
iii. To establish five sites of real ocean test beds (4 sites of 1 MW and 1 site of 0.5 MW).

- **Ocean Thermal Energy Conversion (OTEC)**:
  i. To manufacture a 1MW level OTEC facility of commercialization module (2016-2017) and to test at a real ocean test bed (2017-2018);
  ii. To develop a system for seawater heating and cooling system of 1,000RT and then 2,000RT (2015-),
  iii. To install and operate at the sea of Kiribati and to acquire the track record.

- **Compound Offshore Energy**:
  i. To develop compound offshore energy technologies, which connect the offshore wind energy and wave energy until 2025;
  ii. To develop an integrated control system of the floating-type offshore wind energy and wave power until 2016 and to test at a real ocean test bed and to standardize the design until 2018.

8.1.7 Supporting Policies: Renewable Energy Certificate

In 2010, Korean government introduced the *Renewable Energy Portfolio Standard* (RPS), which requires the electricity generation businesses to supply certain portion of renewable energy. The object of the RPS is to promote competition among the electricity generators, lower costs through R&D, and enhance the competitiveness of the renewable energy industry. However, the RPS system did not provide enough incentive for the private businesses to invest in the ocean energy development, such as the tidal current energy and the wave energy. The cost for the offshore energy is higher compared to present technologies, although the potential opportunity is high (Kim et al., 2015).

Consequently, the Korean government introduced the *Renewable Energy Certificate* (REC), which certifies businesses that produce electricity using the renewable energy facilities. Since September 2014, the REC weighted value of 2.0 has been assigned to the tidal power and current power. However, this REC value for the ocean energy was low compared with other renewable energy. Thus, there was a demand for the REC for the ocean energy to be assigned a higher value to attract the private business into the ocean energy industry.

In response, the *Fourth New Renewable Basic Plan* introduced a variable REC weighted value to attract private investment. In accordance to this plan, the *Mid- and Long-term Offshore Energy Development Plan* also introduced a variable REC weighted value as an incentive to attract businesses to the offshore energy development.

Table 8.2: REC weighted value of new and renewable energy by sources

	REC	Sources of Energy and Criteria		
		Installation Type	Detailed Criteria	
Solar Energy	1.2	Installation on the general land	Less 100kW	
	1.0		Over 100kW	
	0.7		Over 3,000kW	
	1.5	Using the existing facilities, such as buildings	Less 3,000kW	
	1.0		Over 3,000kW	
	1.5	Installation floating on the water surface		
Other New and Renewable Energy	0.25	IGCC		
	0.5	Waste, gas of reclamation site		
	1.0	Water power, wind power on land, bio-energy, RDF energy by fire, gas generation of waste, tidal current power (with breakwater)		
	1.5	Biomass fired generation of wood, offshore wind energy (Less 5km of connected distance)		
	2.0	Fuel cell, tidal current		
	2.0	Offshore wind energy (Over 5km of connected distance), geothermal heat, tidal current power (without breakwater)		Fixed type
	1.0-2.5			Variable type
	5.5	ESS facilities (connected with wind power)		Year 2015
	5.0			Year 2016
	4.5			Year 2017

Source: MOTIE notification No. 2014-164 dated on September 12, 2014

8.1.8 Way Forward

a. Increase the investment for technology development.

There are very rich resources of ocean energy in the Korean waters. However, due to very strong current, high tidal gab, and frequent typhoons, innovative technologies are needed. Therefore, technologies for the offshore energy have been developed by the national research institutes and universities with support from the government. Since the early 2000, the government has invested in the areas, where the likelihood of success to develop the technologies and potential effects are large. However, the trend of the investment has been at a standstill: KRW26.2 billion in 2011, KRW19.8 billion in 2012, KRW26.8 billion in 2013, KRW24.9 billion in 2014, and KRW17.1 billion in 2015, respectively. The more stable environment for R&D should be established including expansion of investment. Moreover, a differentiated strategy should be established, considering the technologies maturity.

b. Establish ocean test bed for the technologies.

A real ocean test bed considering strong current and frequent typhoons has not been established in the coastal water of Korea, which prevents performance verification, and expansion of the technologies.

c. Commercialize the developed technologies.

Because the offshore energy needs a large amount of investment, it is imperative to attract the private sector. The system for development of technologies by the government and subsequent commercialization of the developed technologies by the private sector should be established.

d. Put in place enabling conditions (Marine Spatial Plans; flexible REC; etc.).

It is not easy to attract the private businesses in the ocean energy industry. The Korean seawaters have been already used and developed densely by various stakeholders, including fishermen, who are opposing the ocean energy development in their business area. Also, there are concerns about the environmental impacts. Therefore, it is necessary to establish a Marine Spatial Planning (MSP) program to coordinate the use and development among various stakeholders, and conduct environmental damage assessment. Relevant laws as well as institutional incentives, such as flexible REC value, should be crafted to attract investment into the offshore energy industry.

8.2 Offshore Aquaculture

The capture fisheries business had developed fast with strong government support and economic development from the 1960s to 1980s. As a result, the fisheries catch of Korea ranked twelfth in the world and the export of fisheries products ranked top among the primary industries in Korea. However, beginning early in the 1990s, the capture fisheries business started to decrease due to a loss of habitat caused by coastal development, deteriorating water quality, illegal fishing, and overfishing. Also, there was a loss of fishing grounds due to the *Korea-Japan* and *Korea-China Fisheries Agreement* in 2001 and 2003, respectively. Moreover, offshore foreign fishing grounds were reduced sharply due to the coastal states' declaration of EEZs based on the UNCLOS.

Hence, the Korean government adopted the farming business or aquaculture. As government policy shifted from capture business to farming business, the nearshore aquaculture industry started to receive strong support from the government. The government's plan was that the share of aquaculture to total products would increase from 27% in 2000 to 45% by 2030. Considering that nearshore aquaculture has some limitations, such as environmental pollution, losses caused by frequent red-tide and strong typhoons, and loss of price competitiveness against imported fisheries products, the Korean government introduced offshore aquaculture.

8.2.1 Nearshore Aquaculture


Photo from: cuaquaculture.ppginteractive.com

Recognizing the limitations of the capture fisheries business mentioned above, the Korean government placed a high priority on nearshore aquaculture in the 1990s under the policy "from Catching Business to Farm Business." The geographical conditions of the western and southern coastal waters of Korea are appropriate for aquaculture.

Korean government revised the *Fisheries Act* to establish the *National Plan for Aquaculture Development* and supported the aquaculture industry financially and administratively. Under the strong government support, the aquaculture industry has grown continuously since the 1990s. The production of aquaculture increased from 351 thousand tonnes in 1970 to 1.6 million tonnes in 2014 (**Table 8.3**). At present, the production of the aquaculture shares about 50% of the total fisheries production in Korea.

As the nearshore aquaculture develops densely in the limited space of coastal waters, it affects the marine environment adversely. Much quantity of uneaten feed have deposited on the seabed and degraded the water quality. Since most of the feed for the nearshore aquaculture are raw fish-based moist pellet, the aquaculture environment is affected adversely, impacting fishery resources, and causing fish disease (MOMAF 2002). The general public's concern on the antibiotics and feed causes the price of farmed fish to decline. The increasing production costs, such as labor and energy, are making it hard for nearshore aquaculture to continue operating. Consequently, the policy for nearshore aquaculture was changed to restrict new permit.

Table 8.3: Aquaculture Business in Korea.

	1970	1980	1990	1995	2000	2005	2010	2012	2014
Production(1,000 ton)	351	541	773	996	653	1,041	1,355	1,816	1,547
Value (KW billion)	37	108	420	648	684	1,348	1,816	1,759	1,932

Source: Korea Maritime Institute. Statistics on Fisheries and Marine Environment. Each year.

8.2.2 Technology Cooperation for Development of Offshore Aquaculture

In the United States, the demand for seafood continues to grow as increasing number of Americans seeks healthier diets. During the 1980s and 1990s, the value of U.S. aquaculture rose by about 400 percent to almost $1 billion. There is a great potential for marine aquaculture to become an even more important source of seafood for the U.S. market and a way to help reduce the nation's seafood trade deficit of $7 billion a year (USCOP 2004).

In the past, however, the marine aquaculture was constrained by its complex technology, diversity of species, multiple user conflicts, environmental and ecological concerns, and a fragmented institutional and regulatory system. Such constraints prevented traditional coastal aquaculture from expanding to reach its potential, and blocked the application of new and innovative approaches to developing sustainable marine aquaculture in the nearshore.

National management of marine aquaculture activities should minimize potential environmental impacts. These impacts include the spread of disease among fish populations, genetic contamination and competition between farmed and native stocks, and effects from aquaculture operations on water quality, wetlands, and other natural habitats. Fish waste, dead fish, uneaten food, and antibiotics may contaminate the water around aquaculture facilities and harm surrounding ecosystems (USCOP 2004).

As competition for space in nearshore areas intensifies, the marine aquaculture industry is increasingly looking toward opportunities in federal offshore waters. The expansion of aquaculture activities into the outer Continental Shelf provides potential benefits, as well as additional concerns. Locating marine aquaculture activities farther offshore may reduce the visibility of these activities from land, be less intrusive to fisheries and recreational activities, and have fewer environmental impacts than activities located in nearshore areas (USCOP 2004).

By shifting offshore aquaculture out of more delicate coastal zones into areas with greater capacity of assimilation of nutrients, the environmental consequences of aquaculture are greatly reduced. This also makes the technology useful as a tool for coastal management. Moving aquaculture away from the coast provides a mechanism to improve inshore water condition but still permit economic development.

Four international workshops have been held since 1996, and a competitive grant has funded nearly $8 million of projects dealing with pilot scale testing of the offshore concept and the species that might be used in offshore production. Pilot projects exist in Hawaii, Puerto Rico, and New Hampshire. Thus far, the research has shown very little impact on the environment, the scale of production is significantly greater than most other commercial, land-based systems, the health and growth of the fish are much improved, and the systems are capable of withstanding most hurricanes and other storm conditions.

NOAA has started to transfer the offshore aquaculture technology to Korea through MOMAF/ NOAA Partnership since 2001 and Korea's hatchery technologies contributed to the success of the offshore aquaculture in Korea. The offshore aquaculture technology was tested in the coastal waters of Seogwipo, Jeju Island, in the southern part of Korean Peninsula. However, due to the uncertainty and risk of the business, companies adopted a "wait and see" approach before making any investments.

A Korean-American businessman and two Korean businessmen looked at the concept of the offshore aquaculture and decided to invest in this new business. At the end of 2004, those businessmen jointly established a company, NOAH Offshore Farm Co. Ltd. for the offshore aquaculture business. In 2005, NOAH installed three cages for offshore aquaculture, put 700 thousand striped rock bream fry into the cages from June to July 2004, and began to harvest them from April 2005.

In July 2005, NOAH put 550,000 thousand of 5-gram striped rock bream fry into No.1 cage and the survival rate was 90.9%. At the same time, NOAH put 75,000 thousand of 10-gram striped rock bream fry into No.2 cage and the survival rate showed 66.7%. In August 2005, 80,000 thousand of 124-gram striped rock bream fry were put into No.3 cage and the survival rate was 81.3%. These results were different from the original expectation, leading NOAH and scientists to study the factors.

The total cost of production of striped rock bream fry was $984,030, of which: fry (seed), 26%; aquafeed, 22.9%; labor, 22.8%; depreciation for cage, nursery, nets, warehouse, scuba gear, vehicles, 10.5%; other items, such as electricity, fuel, insurance, 16.8%. The total production in 2006 was 115 tonnes. The total sales and profits in 2006 were $1,495,614, and $511,583, respectively.

Table 8.4: Production Parameters.

Cage No.	Species	Beginning Stage			Final Stage			Survival
		Date	Pieces (thousand)	Average Size (g)	Date	Pieces (thousand)	Average Size (g)	Rate (%)
1	Rock Bream	July 7	550	5	November 21	500	93	90.9
2	Rock Bream	July 7	75	10	November 21	50	150	66.7
3	Rock Bream	July 8	80	124	November 21	65	327.5	81.3

Sources: Kim DH, Douglas L. Korea-U.S. Joint Project for Offshore Aquaculture-a Trip Report to MOMAF and NOAA. 2006.

8.2.3 Institutional Support for Replication

As the NOAH business went well in the offshore waters of Jeju Island in 2004 through 2006, demand for permits for the offshore aquaculture started to rise in other provinces. As demand for permits increases, owners of the nearshore aquaculture worried about their business and strongly opposed to institutionalize the offshore aquaculture business such as the enactment of the permits. Therefore, the government decided to issue only one permit for 'Experimental Research Business' per Province. With this decision, in addition to the permit in Jeju Island, the government issued a permit to Gyeongsangnam-do Province in 2006, Jeollanam-do Province in 2007, and Gangwon-do Province in 2008. The target species for those 'Experimental Research

Business' were red sea-bream, grouper, mackerel, and tuna, which did not overlap with those of the nearshore aquaculture.

In 2007, the National Fisheries Research and Development Institute (NFRDI) evaluated that the equipment and fishes of offshore aquaculture were safe from typhoons and strong currents and the growth rate of species of the offshore aquaculture was 20 percent higher and survival rate was two times higher than those of the nearshore aquaculture, respectively. Since assorted feed instead of raw fish-based moist pellet are used in offshore aquaculture, fishes are more likely to be evaluated as eco-friendly food and the marine environment are less affected (Hong, 2009).

As the 'Experimental Research Business' went well in 2010 through 2013, the government revised the Fisheries Act to institutionalize the offshore aquaculture. The *Fisheries Act* defines that "farming business" includes both nearshore aquaculture and offshore business. 'Offshore waters' mean sea waters that are not surrounded by land, i.e., are open to sea, and where waters flow well and so the pollutants are not deposited. The enforcement decree of the act regulates that the depth of the 'offshore waters' should be more than 35 meters.

The act regulates that the minister of Ministry of Ocean and Fisheries (MOF) issues permit for the offshore aquaculture while chief of local governments (cities and counties) issues permit for the nearshore aquaculture. Until now the minister of MOF has issued a total of nine permits to private venture businesses. In preparation to the rapid increase in demand for permits, the act regulates the order of priority for permits and mandates to establish a committee to coordinate conflicts and issues concerning the offshore aquaculture.

8.2.4 Issues

As described above, the fishermen and the private businessmen had believed until 2009 that the facilities and equipment would be safe from any typhoon and strong currents. However, in 2009, facilities and equipment of the offshore aquacultures were much damaged by the typhoon 'Bolaven' and fishes were lost.

There was another shock to the offshore aquaculture caused by the big tsunami in Japan in 2011. Korea's offshore aquaculture imported tuna fry from Japan. However, since 2011 the tuna fry could not be imported from Japan, which meant that the offshore aquaculture could not produce the high value species.

Due to the above two incidents, the demand for permits for the offshore aquaculture stopped increasing, and even one private business has returned his license to the government. Thus, the government has tried hard to grow the offshore aquaculture by providing much favorable financial support and even freed the offshore aquaculture to produce the same species that the nearshore aquaculture cultivated. Before the above incidents, the offshore aquaculture was expected to

compete with the nearshore aquaculture, which was already facing management difficulties (Cha, Lee, and Kim, 2009). At present, the only exception is jacopever. Recently, the government has succeeded in developing artificial incubation of tuna, which could stabilize the tuna fry supply to the offshore aquaculture.

8.2.5 Way Forward

The offshore aquaculture has been introduced in Korea to address the limitations of the nearshore aquaculture, such as low productivity, degraded water quality, fish diseases, and loss caused by frequent red-tide and typhoons. The offshore aquaculture is in the beginning stage towards full-fledged business, having passed through experimental research business.

While there are many potential benefits to the offshore aquaculture, there are also barriers blocking the expansion of aquaculture into offshore waters. Compared to the nearshore aquaculture, the offshore aquaculture needs large scale investment. Therefore, big private businesses should be invited to invest and given financial support. Private businesses can also insure business risk to insurance companies.

Compared to the nearshore aquaculture, the offshore aquaculture also needs advanced science-based information. Thus, the government should invest in developing technologies on facilities and equipment, which can be safe from strong currents and typhoons. The present facilities and equipment were not safe from the typhoon 'Bolaven,' which stopped the fishermen from participating in the offshore aquaculture business. Also, the government should strongly support the development of technologies on artificial incubation of high-value species to supply fry stably to the offshore aquaculture.

At present, the *Fisheries Act* regulates definition, permit, and order of priority for issuing the permit of offshore aquaculture. However, limited regulations in the Fisheries Act cannot solve barriers blocking the expansion of the offshore aquaculture. Therefore, the 'Offshore Aquaculture Act' should be enacted for the industrialization of offshore aquaculture (Hong, 2009) and for solving permit for public water use, offshore user conflicts, and environmental monitoring.

8.3 Coastal Tourism

Generally, tourism, including the coastal tourism, is recognized not only to boost a local economy and create many jobs, but also can be developed in environment-friendly ways. The coastal tourism shares a large portion in the ocean industry in many countries including Korea. Coastal tourism is expected to grow continuously as the national economy develops and personal income and leisure time increase.

8.3.1 Emerging Coastal Tourism and Contribution to Ocean Economy

The ocean economy was estimated to be KRW31,763 billion in 1998, which was 7.0% of GDP (MOMAF 2000). The marine tourism sector was KRW1,500 billion, which is only 4.7% of the ocean industry (MOMAF et al. 2000). The portion of the marine tourism, is very small compared with those of U.S. and China because it might be underestimated. In 2009, Lim et al. estimated the ocean industry at KRW20,931 billion in 2005, which is only 2.5% of GDP. However, marine tourism (KRW2,289 billion) was 10.9% of the ocean industry (Lim et al., 2009). In 2006, MOMAF and Arthur D Little estimated the ocean industry at KRW60 trillion in 2005, of which 35% was marine tourism (MOMAF and Arthur D Little, 2006).

Although the coastal tourism shares a smaller portion in the ocean industry in Korea compared with U.S. and China, most authors claimed that it will grow fast in the future and the growth prospects are enormous (Hwang and Ma, 1999; Hwang and Kim, 1999; Jung, 1999; KMI, 2000; Kim, 2006; MOMAF and Arthur D Little, 2006; Choi 2008). The long-term trend of marine tourism is believed to be growing more rapidly than that of inland tourism. According to a poll conducted by the Korea Tourism Research Institute (KTRI), the ratio of coastal areas selected for preferred summer holiday destination increased from 45.5% in 1996 to 75.2% in 1997 (Hwang and Kim, 1999). In 2000, Korea Maritime Institute (KMI) estimated that the share of marine tourism to the total tourism will increase from 26% in 2000 to 40.8% in 2020 (MOMAF, 2000). Most of the authors claimed that the demand for marine tourism will grow due to increasing income and leisure time and limited resources for the land-based tourism.

8.3.2 Second Basic Plan for Promotion of Coastal Tourism (2014-2023)

The government has adopted the *Second Basic Plan for Promotion of Coastal Tourism* (2014-2023). This is an action plan for the coastal tourism under the *Basic Plan for Marine and Fishery Development* based on the *Basic Act on Ocean and Fisheries Development* (BAOFD).

The government has set two policy goals to achieve the vision of **Realization of Northeast Asian Marine Tourism Hub**. One is to reach a total of 500 million marine travel dates by 2023, and the other is to create 35,000 new jobs in marine tourism by 2023. To achieve these goals, the plan contains 17 detailed projects under five strategic divisions and a total of KRW3.3 trillion will be invested to carry out the projects.

Table 8.5: Detailed Projects under Five Strategic Divisions.

Five Strategic Divisions	Detailed Projects
• **Marine tourism with rest and recovery**	1. Promotion of four seasons of beach use 2. Attracting marine healing tourism 3. Creation and maintenance of marine recreation space 4. Marine waterfront space of old port
• **Marine tourism with experience and learning**	5. Activation of ecotourism 6. Expansion of marine leisure sports 7. Marina industrial advancement
• **Marine tourism with culture and art**	8. Identification and industrialization of marine cultural resources 9. Expansion of marine cultural facilities 10. Brand development of marine culture city
• **Marine tourism with life stories**	11. Use of fishing village as tourism resources 12. Development of the coast with theme 13. Activation of island sightseeing
• **Marine tourism from all over the world**	14. Realization of Northeast Asia Cruise Hub 15. Establishment of international marina network 16. Development of Yeosu Expo Complex as an international marine tourism hub 17. Participation and attraction of international conventions and events

Source: MOF. Second Basic Plan for Promotion of Coastal Tourism (2014-2023).

Korean government will enact the *Marine Leisure Activity Promotion Law* and adopt implementation plans by sector to effectively carry out the 17 detailed projects (**Table 8.5**). In addition, the Marine Tourism Promotion Council will be established to foster a cooperation system with related ministries and strengthen linkage and integration with relevant marine-related businesses.

8.3.3 Major Issues

Although the coastal tourism shares a large portion in the ocean industry, the following issues prevent its development.

8.3.3.1 Ambiguous Definition

Tourism is ambiguous in terms of its definition, scope and operation. On the one hand, it denotes an enormous and fragmented global industry providing a wide range of services and products to tourists as well as non-tourists. On the other hand, tourism also means travel for pleasure. Because tourism is hard to separate from other categories of leisure activities (e.g., play, sport, adventure, outdoor, and other recreation), substantial differences remain among researchers as to how to determine when individuals are behaving as tourists (Miller, 1993).

The definition of the coastal tourism is also ambiguous and too wide. Hall argued that the concept of the coastal tourism embraces the full range of tourism, leisure, and recreation-oriented activities that take place in coastal zones and offshore coastal waters (Hall, 2001). The ratio of coastal tourism to the ocean industry in the three documents cited in Section 8.3.1 (MOMAF et al., 2000; Lim et al., 2009; MOMAF and Arthur D Little, 2006) are very different even though they were analyzed in a very short period from 2000 to 2009, because the coastal tourism was defined differently in each paper.

Conceptually and operationally, the ambiguity of coastal tourism makes it difficult to establish the coastal tourism statistics and policies. The stakeholders of the policies are also ambiguous. The lack of statistics on coastal tourism affect policy-making. As a result, the Marine Leisure Division of MOF was established in 2013.

8.3.3.2 Seasonality

Sea swimming is a dominant activity among sea-based recreations in Korea. However, since Korea is located in temperate zone, sea swimming is possible only for three weeks a year during July and August. This makes Korean marine tourism market subject to strong seasonality with very low efficiency of resource utilization throughout a year (Hwang and Kim, 1999).

The seasonality is the most difficult problem to solve in the coastal tourism in Korea. Choi argued that a small-scale development in fishing villages cannot accommodate the rapidly increasing demand of the coastal tourism, so the "Hub & Spoke" system, by which a large-scale development area is connected with many small-scale development areas, should be developed (Choi, 2008). Based on the opinions of those scholars, local governments, which struggle to boost the local economy and raise tax, tend to establish large-scale development plans in coastal areas. However, such large-scale development in coastal areas raises many issues, such as environmental impacts, conflicts among stakeholders, feasibilities of investment, etc. Other sustainable tourism and recreational activities, besides swimming, should be promoted.

8.3.3.3 Dual Leading Departments

There are dual leading departments, namely the Ministry of Culture, Sports, and Tourism (MCST) and the Ministry of Ocean and Fisheries (MOF), for the coastal tourism management in Korea. The *Government Organization Act* (GOA) nominates MCST as a leading department for tourism management stating that the minister of MCST shall administer duties concerning culture, arts, video, advertisement, publishing, publications, sports, tourism, the publicity of state affairs and government announcements. Of course, tourism includes the coastal tourism. The *Tourism Promotion Act* mandates the minister of MCST to establish the *Master Plan for Development of Tourism,* and the mayors and provincial governors should establish the *Plan for Zonal Tourism Development* based on this *Master Plan*.

In the meantime, the *Basic Act on Ocean and Fisheries Development* (BAOFD) also nominates MOF as a leading department for marine tourism stating that in order to support and foster sports and leisure activities in the sea, the minister of MOF shall formulate and implement a plan to promote sports and leisure activities in the sea. Also Articles 6 and 28 of the BAOFD mandates the minister of MOF to include marine tourism development programs in the *Basic Plan for Marine and Fishery Development,* and establish action plans for marine tourism.

Generally, MCST and local governments have lower understanding on the environment-sensitiveness of coastal zones, and tend to establish plans for large-scale developments in coastal areas. However, MOF emphasizes the principle of sustainable development. Therefore, there are frequent conflicts among related governments in developing coastal areas.

8.3.3.4 Low Priority

Virtually all coastal and ocean issues affect coastal tourism and recreation either directly or indirectly. Clean water, healthy coastal habitats, and a safe, secure, and enjoyable environment are clearly fundamental to successful coastal tourism. Similarly, bountiful living marine resources (fish, shellfish, wetlands, coral reefs, etc.) are of critical importance to most recreational experiences. Security from risks associated with natural coastal hazards, such as storms, hurricanes, tsunamis, etc. is a requisite for coastal tourism to be sustainable over the long term (Cicin-Sain et al., 1998).

As described earlier, Korea's coastal areas have already been densely used and developed by so many stakeholders. Therefore, many relevant individual policies and programs have been put in place and implemented long before the introduction of coastal tourism policy. Although many existing policies, such as port development and management, coastal shipping management, fisheries management, marine environment management, marine parks management, wetland management, marine protected area management, etc., are closely related with coastal tourism, they have not made coastal tourism as a top priority. Considering that coastal tourism shares a large portion of the ocean economy, and is expected to grow continuously, it still has not received more attention from the government.

8.3.4 Good Practices

8.3.4.1 Suncheon Bay Eco Park

Suncheon Bay is located at the center of the southern coast of the Korean peninsula. It has 5.4 km^2 of reed field, 22.6 km^2 of mudflat, and 75 km^2 of coastal water areas. Until the 1990s, various demands for coastal development had created pressure on Suncheon Bay. However, from the late 1990s, residents, non-governmental organizations (NGOs), and Suncheon city

have struggled together to keep Suncheon Bay from development and succeeded in the following:

- In July 2000, the Korean South-Sea Tourism-Belt Development Project was started;
- In December 2003, MOMAF designated the Suncheon Bay as the Wetlands Conservation Sites;
- In November 2004, Suncheon Bay Eco Park was opened to the public;
- In 2004, Suncheon Bay joined the "International Network for Preserving Hooded Crane;"
- In January 2006, Suncheon Bay joined the "RAMSAR Convention Sites", the first in Korea.

Approximately 158 species of birds have been observed making their home in Suncheon Bay. These include 15 species of hooded crane that have been declared a natural treasure of Korea. Six endangered species, 13 protected species, 12 species listed in the Red Data Book of the International Union for Conservation of Nature (IUCN), 15 species listed in the Convention on International Trade in Endangered Species (CITES) Annex, and 15 species listed in the RAMSAR Convention. Suncheon Bay provides habitats for many other birds and species (Suncheon Bay website on September 2015).

With the successful conservation of Suncheon Bay, tourists began to increase very sharply. Since the opening of the Suncheon Bay Eco Park in November 2004 till 2006, the entrance fee was free. In 2007, as tourists began to increase, the Suncheon city began to impose KRW2,000 for the entrance fee. In 2013, the number of tourists reached its peak, at 2.3 million people.

In 2014, Suncheon city increased the entrance fee to KRW5,000 to have less tourists and mitigate impacts on the coastal environment. Suncheon city analyzed that the increase of the entrance fee did not contribute to the reduction of the tourists, but rather, the aftermath of the recession of the Korean economy and the Sewol Ferry accident. Therefore, in 2015, Suncheon city has increased the entrance to KRW7,000, yet the tourists has continuously increased.

8.3.4.2 Cheongsando Island

The Cheongsando Island is located in the most southern part of the Korean peninsula, 9.2km south from a large island, Wando Island. The total area is 41.5 km^2 and the population is about 2,559 in 2012. In 1981, the island and the surrounding coastal waters were designated to be included in the Dadohae Marine National Park. In 1993, major scenes of a famous Korean movie "Seopyunje" were shot in the island. The major industry was agriculture and fisheries before 2007, which was typical in most islands in Korea. However, since Cheongsando Island was selected as a "Slow City" firstly in Asian countries, the situation changed quite differently. The tourists has increased from 146,209 in 2008 to 217,537 in 2009, to 478,906 in 2011, and decreased to

301,692 in 2012 due to the recession of the Korean economy. As a result, tourism has become the largest industry. In 2012, the number of tourism businesses, most of which are restaurants and lodging houses, has increased to 163, followed by wholesale and retail businesses. The tourism business has employed 450 workers, which is the largest number followed by those hired in wholesale and retail businesses. According to a survey, about 60 percent of the tourists knew that Cheongsando Island was selected as a "Slow City." In 2013, the surrounding waters of the Cheongsando Island were designated as a marine protected area (MPA).

8.3.5 Way Forward

The coastal tourism has inherent characteristics, effects on the local economy and the potential threats to the environment. Cicin-Sain & Knecht argued that while there is a general recognition that coastal tourism and recreation are important in coastal zones, their impact is systematically undervalued both economically and as the most important driver of coastal development in many U.S. coastal states (Cicin-Sain & Knecht, 2000). Therefore, coastal tourism policy should be carefully established and implemented considering the economy and the fragile environment.

The coastal tourism shares a large portion in the ocean industry and is growing fast with the increase of income and leisure time. Therefore, the coastal tourism will grow continuously if the relevant governments establish the coastal tourism policy successfully. However, there are major issues on the coastal tourism such as its ambiguous definition, dual leading departments, seasonality, and the low priority of the coastal tourism, all of which are not easy to solve. The coastal tourism policy should be planned and managed considering the long-range effects on the economy and threats to the fragile coastal environment. Enactment of a coastal tourism law, coordination among relevant government departments, keeping the principle of the sustainable coastal tourism, and integration of the coastal tourism in the existing coastal policies and programs are challenges to the major issues.

8.3.5.1 Relevant Law

A specific coastal tourism law should be enacted to define coastal tourism, implement tourism programs efficiently, and set a relationship between the coastal tourism programs and other coastal programs.

8.3.5.2 Coordination

Various government departments, laws, and plans have related tourism development aspects in Korea, and even more complex are those related with the coastal tourism development (Choi, 2008). More than 40 laws pertain to related coastal tourism development (Kim, 2006). Therefore, coordination among relevant departments as well as local governments is critical for a desirable and sustainable coastal tourism development. In particular, coordination between the two leading departments, MCST and MOF, is very important. As described

above, the role of MCST is to promote the tourism industry and the role of MOF is to both promote coastal tourism and conserve coastal resources. This could result in possible conflicts between the leading departments in pursuing the appropriate coastal tourism development. Generally, the coastal development for the coastal tourism is related with the land use plan, for which coordination with the Ministry of Land, Infrastructure and Transportation (MLIT) and the Ministry of Environment (ME) is compulsory.

Choi argued that the coordination among the government departments is not easy, so it is necessary to strengthen tourism administration and enhance the implementation of the tourism policies (Choi, 2008). It may be the same in the U.S. because Cicin-Sain & Knecht argued that while a variety of federal efforts are focused on different programs of importance to the coastal tourism, these have not been successfully coordinated. To remedy this situation, consideration could be given to the creation of an interagency initiative devoted to coastal tourism among major federal agencies with programs in this area (Cicin-Sain & Knecht, 1998). It is important to keep the principle of the sustainable coastal tourism and to prevent imprudent coastal development no matter what kind of coordination is made among the relevant departments and stakeholders.

8.3.5.3 Integration

It may be important to develop new large projects for the promotion of the coastal tourism. However, Korean coastal spaces and resources have already been densely used by various stakeholders and many relevant policies and programs have been also established and implemented. Therefore, it is very difficult to develop new tourism projects, especially large projects in coastal areas.

As previously mentioned, most of the existing coastal policies and programs would affect coastal tourism. However, coastal tourism has been excluded from the management system and in most coastal policies and programs. Therefore, coastal tourism should be integrated in the management tools of the existing coastal policies and programs. The Suncheon Bay Eco Park and Cheongsando Island are good examples of how the existing coastal policies and programs are successfully implemented, conserving the coastal resources with the coastal tourism.

8.3.5.4 Sustainable Coastal Tourism

The seasonality of the coastal tourism needs to be solved, but not only by a large scale development, which adversely impacts the environmentally-sensitive coastal areas, and may not guarantee economic benefits. Actually, it is difficult to find any successful cases of the large-scale development for the coastal tourism developed by many local governments. On the other hand, sustainable coastal tourism with small-scale development can be a possible alternative

to overcome the seasonality, and generate economic benefit in terms of jobs and earnings. There are many successful cases of the sustainable small-scale coastal tourism. Cicin-Sain et al. (1998) argued that sustainable development of coastal tourism is dependent on:

i) Good coastal management practices (particularly regarding proper siting of tourism infrastructure and the provision of public access);
ii) Clean water and air, and healthy coastal ecosystems;
iii) Maintaining a safe and secure recreational environment though the management of coastal hazards (such as erosion, storms, and floods), and the provision of adequate levels of safety for boaters, swimmers, and other water users;
iv) Beach restoration efforts that maintain the recreational and amenity values of beaches; and,
v) Sound policies for wildlife and habitat protection.

8.3.5.5 Recreational Fishing

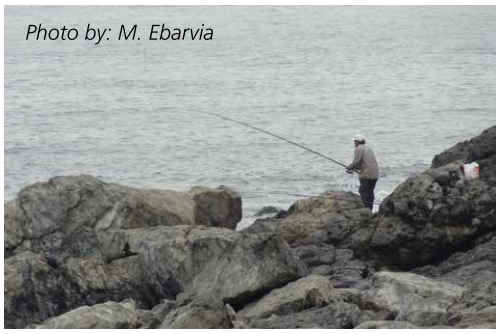


Photo by: M. Ebarvia

Recreational sea fishing is rapidly gaining popularity. According to the monthly magazine, "Sunday Recreational Fishing," there are about 500 thousand people enjoying recreational fishing, and over 200 recreational sea fishing clubs nationwide. Currently, a popular fishing type is fishing from the seaside rocks or piers within ports. But more people are taking part in a new and more active type, which is fishing from rented boats mostly owned by fishermen. In this case, the *Fishing Management and Promotion Act* was legislated in 2012, in order to protect the safety of recreational anglers, and to increase incomes of fishermen. According to MOMAF, the total income from renting of fishing boats was estimated about KRW12 billion in 1997, generated from about 2,800 registered recreational fishing boats and 477 thousand users (Hwang and Kim, 1999).

In 2015, about 4,000 recreational fishing boats are registered and over 2 million users are enjoying the recreational sea fishing. The recreational fishing boats and users have increased very sharply in three years since the formal introduction of the program. The recreational sea fishing shows that the demand for the coastal tourism can be created regardless of the scale of the development. Hwang and Kim argued that emphasis should be placed on diversifying marine tourism activities other than sea swimming to reduce seasonality in marine tourism. Possible policy options for this purpose would include supporting the development of infrastructure, such as waterfronts and connecting roads to accommodate the sea-associated tourism activities in coastal communities. Moreover, the culture, life styles, and major products of traditional fishing villages could be converted into a good tourism attraction (Hwang and Kim, 1999).

8.4 Marine Biotechnology Industry[19]

8.4.1 Supporting Policies and Programs

The Ministry of Oceans and Fisheries (MOF) has strengthened the policy for the marine biotechnology industry by establishing the department responsible for marine biotechnology, enacting relevant laws, and establishing national plans since 2004. In 2012, the government enacted the *Marine Life Resources Act* for the purpose of ensuring marine bio and fisheries bio-resources and systematic management and operation. In 2015, MOF established the Marine and Fisheries Bio-resources Division under the Marine Environment Policy Bureau to oversee marine biotechnology policies such as securing and managing marine life resources, technology development, and industrialization.

In 2004, MOF established the *Marine Bio-21 (2004-2013)* to invest KRW159.1 billion, and establish three research centers for marine and extreme bio-molecular, genome, marine bioprocess, marine natural products new-drug. Since this project was first attempted at the national level, the plan focused on technology development and resource acquisition rather than industrialization.

In 2008, the government established the *Marine Biotechnology Development Basic Plan* (Blue-Bio 2016), aiming at becoming to be one of the world's seven major powers of marine biotechnology. The project focused on four system areas and four R&D areas. The four system areas are: a) early securing of future source technology, b) expansion of high value-added industry, c) expansion of infrastructure and advancement of system, and d) strengthening of international cooperation. The four R&D sectors are: a) marine bio-technology, b) marine bio-production technology, c) marine new material development technology, and d) marine eco-environment preservation technology.

In 2009, MOF established the *Measures for Revitalizing Marine Bio-R&D (2010-2014),* and invested KRW915.5 billion with the aim of creating a marine bio market of KRW 6.7 trillion by 2016. In this plan, promoting industrialization, strengthening support system for marine biotechnology companies, developing commercialization technology, and spreading and expanding industrial performance were suggested as the tasks to be promoted.

In 2014, the government established the *Next-generation Marine Biotechnology Upbringing Strategy*, which proposed five strategies and four key R&D fields to enhance economic value creation and secure source technology to be implemented by 2023. In addition, in 2016, the government established additional measures to foster and industrialize marine biotechnology and emphasized industrialization support than previous plans. These measures aim to: support industrialization of R&D achievement, foster marine biotechnology companies, spread marine bio-industry performance, and form a marine bio-area network.

[19] This section is adapted, in parts, from (Jang et al., 2016).

In 2013, MOF established the National Marine Biodiversity Institute of Korea (MABIK), with the following major tasks:

i) Collection, conservation, management, investigation and research of marine bi-resources;
ii) Exhibition and training of marine bioresources;
iii) Operation of responsible agencies for marine bioresources;
iv) Policy development and institutional research on marine bioresources;
v) Collection, registration, conservation, utilization and evaluation of information on marine bioresources;
vi) Information exchange and cooperation on marine biodiversity;
vii) Establishment and operation of integrated information system for marine bioresources.

The domestic marine biotechnology market is expected to grow more than 14% annually from $70 million in 2012 to $360 million in 2020, which will share 5% of the $7.2-billion world marine biotechnology market. Currently, the domestic marine biotechnology market is highly concentrated in the food sector, but it is estimated that the future development of the pharmaceutical and chemical fields will be as strong as the food sector. Of the 73 companies with a high degree of full-time occupation in the marine biotechnology field, 39 companies belong to the food sector, followed by chemical (12) and medicine (10) companies.

Table 8.6: Status of Marine Biotechnology Businesses.

Industry Classification	Number of Companies	Ratio (%)
Marine Bio Resources	4	5.5
Marine Bio Food	39	53.4
Marine Biopharmaceutical	10	13.7
Marine Biochemistry	12	16.4
Marine Bioenergy	1	1.4
Marine Bio Environment	4	5.5
Marine Biotechnology Equipment	1	1.4
Marine bio R&D and Services	2	2.7
Total	**73**	**100.0**

Source: Jang et al. Domestic marine bio-industrial trend and policy direction (in Korean), Korea Maritime Institute KMI Analysis of Issues No.1. 2016.

Development of marine biotechnology is considered to be important in the nation's overall technology development strategy. As a result, the **Marine Biological Resource Conservation and Marine Biotechnology Utilization Technology** is selected among the 100 most important science and technology of the *Second Science and Technology Basic Plan (2007-2016)*, and is being strategically promoted. From 2004 to 2013, the government invested a total of KRW159.1 billion in marine biotechnology research and development (R&D) through the Securing Marine Life Resources and Foundation Infrastructure Construction Project and the Marine Biotechnology Basic and Industrialization Technology Development Project. The most invested areas in the above two projects are the Overseas Marine Life Resource Development and Utilization Infrastructure Construction Project and the Marine Extreme Bio Molecular Genome Research.

As a result of these projects, the number of research papers increased from 15 in 2004 to 175 in 2013, 1,412 papers. Except for some periods, domestic patent applications have continued to increase in the application area. Although the industrialization stage is weak, commercialization of marine biotechnology has started gradually based on the papers and patents (**Table 8.7**).

Table 8.7: Major R&D achievements in marine biotechnology and status of industrialization

Year	Paper		Patent				Industrialization	
	SCI	Non-SCI	Domestic		Overseas		Commercialization	Technology Transfer
			Application	Registration	Application	Registration		
2004	15	10	9	-	6	-	-	-
2005	40	17	41	1	12	-	-	2
2006	108	40	67	9	12	-	10	2
2007	106	15	48	52	34	4	5	4
2008	154	24	56	32	17	1	7	1
2009	128	20	33	15	28	10	7	-
2010	137	32	28	15	14	6	3	1
2011	150	39	79	16	17	17	9	5
2012	170	22	79	35	28	11	8	5
2013	175	10	55	33	40	13	7	4
Total	**1,183**	**229**	**495**	**208**	**208**	**62**	**56**	**24**

Source: Jang et al. Domestic marine bio-industrial trend and policy direction (in Korean), Korea Maritime Institute KMI Analysis of Issues No.1. 2016.

8.4.2 Issues and Way Forward

Over the past decade, the government has invested KRW160 billion in marine biotechnology R&D, resulting in 1,183 SCI research papers, 773 patent applications and registration, and 24 technologies transfers. Nevertheless, despite the R&D achievements of the past decade, the technological gap is still large compared to other leading nations. Korea's overall level of marine biotechnologies is 41.4% of the country with the highest technology as of 2013.

From 2012 to 2104, the marine biotechnology R&D budget of MOF has reached an annual average of KRW75.5 billion, which is only 2.6% of the national total biotechnology R&D budget. Lack of R&D budget is estimated to be the main reason for the technological gap compared to the top technology holders. Also, Korea lacks infrastructure, personnel and research environment for technology development. There is also not enough support system linking industry-academia-research and promoting marine bio-industrialization.

For Korea's marine bio-industrialization, it is required to strengthen policies, such as securing technologies, establishing infrastructure, and creating an industrial environment for marine biotechnology.

In order to secure technological competitiveness, it is necessary to select and concentrate strategies in the areas of marine biopharmaceuticals, chemicals, food, etc. based on the potential of development such as market growth and current capacity. In order to expand the infrastructure, it is necessary to maximize utilization through expansion and efficiency of R&D investment, continuous acquisition of marine life resources and integrated management. In order to create an industrial environment, it is necessary to investigate the state of industry and infrastructure and to establish a cooperation system between enterprises.

8.5 Deep Seawater Utilization

The deep seawater in the East Sea is 1.69 million km^2, about 95% of the total seawater of the East Sea. The total area of East Sea is 1.3 million km^2, and the average depth is 1,543m. Scientists estimate that the potential annual production of the deep seawater of the East Sea is 3.97 trillion tonnes. At present, the annual amount of intake of the deep seawater in the East Sea is 3.40 million tonnes, which is only 0.000001% of the potential 3.97 trillion tonnes. The amount of deep seawater in the East Sea is considered unlimited.

The deep seawater is a recyclable and renewable resource and will not be depleted, making it a useful resource for the future in the event of a lack of water resources. As a result of analyzing the characteristics of the deep seawater in the East Sea, the temperature was lower than that of the deep water of the same depth in the foreign countries and the mineral content was similar to

that of foreign deep water. Considering the topography and surrounding conditions, most areas of the East Sea have economic feasibility for deep seawater development. Therefore, in 2007, the government enacted the *Development and Management of Deep Seawater Act* to preserve, manage, develop or use the deep seawater in an environmentally friendly manner for the future generations and the public interests, thereby contributing to the healthy life of nationals and development of related industries. Based on the act, the government established the *First Master Plan on Deep Seawater* (2008-2013) in 2007, and the *Second Master Plan on Deep Seawater* (2014-2018) in 2014.

To ensure stable and efficient use of the deep seawater resources, the Korean government controls the ocean deep seawater intake area on the principle of designating "one for each city and county." By 2013, the government has authorized a total of nine deep ocean water intakes in the East Sea. The deep seawater for beverages accounted for about 80% of the deep seawater market from 2008 to 2012. There are 69 types of deep seawater products, such as salt, confectionery, alcohol, cosmetics and tofu, accounting for the remaining 20%. Although the total sales of the deep seawater for beverages are increasing each year, the market is not activated due to excessive initial facility costs and lack of social awareness of the deep seawater. The deficit of the deep seawater industry is continuously increasing due to the initial over-investment of the facility.

Table 8.8: Trend of Production and Sales of Deep Seawater for Beverages.

	Production (Bottles)	Sales (Bottles)	Sales Amount (KRW Thousand)	Ratio Among Total Deep-sea Water Production
2008	11,062,664	7,665,183	4,452,051	5,666,892 (79%)
2009	13,449,322	11,029,839	6,118,444	8,125,142 (75%)
2010	15,220,602	14,803,834	7,119,436	8,532,056 (83%)
2011	20,997,330	21,809,925	10,238,559	11,827,714 (87%)
2012	20,534,294	20,039,221	9,000,032	10,647,147 (85%)
Total	**81,264,212**	**75,348,002**	**36,928,522**	**44,808,190 (82%)**

Source: MOF. Second Master Plan on Deep Sea Water (2014-2018). 2014.

The government plans to establish an industrial cluster as one of the strategies to make up for the sluggishness of the deep seawater industry. Currently, more than a dozen marine deep seawater companies are preparing to move to the Gangwon Goseong County, one of the candidate areas of the deep seawater industrial cluster (Yoon et al, 2014). The deep seawater industrial cluster will include research institutes, manufacturing industries, agricultural and industrial complexes, fisheries resource development centers, spas and leisure facilities, and public relations centers.

The government plans to invest a total of KRW30.7 billion in the *Second Master Plan on Deep Seawater* (2014-2018) for R&D and concentrate on developing drinking water, food, industrial use technology in agriculture and fisheries industry, heating and cooling, and development of research center. As of June 2013, there are 411 patent applications related to the deep seawater industry.

8.6 Green Port

Busan Port, Incheon Port, Gwangyang Port, and Ulsan Port are the major ports in Korea. **Table 8.9** shows the number of vessels that entered these ports in 2015. Busan Port Authority (BPA), Incheon Port Authority (IPA), Yeosu Gwangyang Port Authority (YGPA), and Ulsan Port Authority (UPA) have established and implemented Green Port Programs to reduce air pollution, including CO_2, from vessels, improve water quality, and enhance public access to port. This section focuses on the green port program of Busan Port.

Busan Port Authority (BPA) has been working very hard to establish and implement Green Port Program of Busan Port. In February 2010, BPA established a Task Force Team, which has exclusively focused on new ideas and policies for Green Growth of Busan Port.

Table 8.9: Number and Gross Tonnage of Vessels Entering Korean Ports in 2015.

Ports	Number of Vessels	GT (in millions)
Busan Port	49,047	627.9
Incheon Port	18,766	189.0
Gwangyang Port	24,177	351.5
Ulsan Port	25,705	216.0

8.6.1 Air Pollution Management

The Ministry of Environment has established the national standards of air quality and water quality in the country, and the local governments enforce the relevant laws to achieve the national environment standards. Busan City meets the air quality standards for SO_2, PM_{10}, CO, NO_2 and O_3 because there are not many manufacturing factories and heavy and chemical industry in the city.

Busan City has addressed emissions from automobiles, which are the major pollution source. From 2006 to 2014, Busan City invested USD140 million for the conversion of diesel-using engine to CNG-using-engine of large vehicles, attachment of diesel particle filters and diesel oxidation catalysts in diesel-using vehicles, and in scrapping of old vehicles. (Seoul City has invested about USD 200 million

annually for reduction of emissions from vehicles.) The Ministry of Environment covered half of the costs and Busan City covered the other half.

8.6.2 e-RTGC at the Busan North Port

There are a total of 186 Rubber Tired Gantry Crane (RTGC) units at Busan North Port (Container Berths). RTGCs are owned and operated by the terminal operators, not by BPA. RTGCs use fuel oil, which produce air pollution and noise. BPA decided to convert oil-using RTGCs to electricity-driven RTGCs (e-RTGC). The total cost of converting from oil to electricity per unit is about USD400 thousand, half of that (USD200 thousand) is for converting the engine system of the RGTCs and the other half is for the construction of the electricity supply system.

The terminal operators and BPA agreed to share the total cost equally: the cost for converting the engine systems of the RGTCs is covered by the terminal operators while the cost for the construction of the electricity supply system is covered by BPA.

A total of 94 units were converted to e-RTGC until 2010 and 78 units have been converted to e-RTGC after 2010. BPA estimated that converting 94 units of RTGC to e-RTGC reduce CO_2 emissions by 28,000 tonnes, and save USD16 million in operating cost, annually. (The reduction of 28,000 tonnes of CO_2 were calculated taking into account the CO_2 emission caused in the production of the electricity for e-RTGC. BPA estimated operating cost of RTGC is USD18,000 per month assuming an oil price of USD 1.2 per litre; however, the operating cost of e-RTGC is estimated to be USD2,000 per month.)

BPA also estimated that e-RGTC reduces noise levels from 85 dB to 65 dB, and the breakdown rate of an e-RGTC is about half of a RTGC. Following BPA's e-RGTC plan, Incheon Port Authority, the 2nd largest port in Korea, is scheduled to also convert their RTGC to e- RTGC.

8.6.3 A Rail Mounted Gantry Cranes

The Busan New Port was planned and developed to be environment friendly and cost-effective. A total of 267 Transfer Cranes were planned to be equipped at the Busan New Port if a total of 30 berths are developed by 2015. From the beginning of the Busan New Port Planning, BPA decided to install Rail Mounted Gantry Cranes, which is operated by electricity, not by fuel oil.

BPA estimated that 267 units of RMGC could reduce CO_2 emissions by 80,000 tonnes and save USD80 million annually. Moreover, the productivity of the Busan New Port Terminal is estimated to be 20% to 30% higher than traditional port terminals, like the Busan North Port.

8.6.4 Gate Automation and Container Handling Automation

8.6.4.1 Gate Automation

The Busan North Port is very limited geographically and there are not enough yards for container handling. Therefore, 13 off-dock-container yards (ODCY) were operated for container handling before loading and after unloading. Previously, when container trucks arrived at Busan North Port from an ODCY, there was usually heavy traffic at the gate, because of container information limitation, resulting in air pollution and time-losses due to the long lines of container trucks into the Busan Downtown.

Thus, BPA invented a Gate Automation System using Radio Frequency Identification (RFID) for container trucks to pass the gate to designated berths without delay. At present, there are no long lines of container trucks at the gates waiting information to designated berths.

8.6.4.2 Container Handling Automation

BPA and terminal operators have introduced Tandem Container Cranes which can load and unload four 20-feet containers at the same time. BPA also introduced a Yard Tractor Pooling System at container berths for more effective loading and unloading.

8.6.5 Light Emitting Diode (LED) Lighting System

BPA has decided to change all of the old lighting systems of the Port of Busan to Light Emitting Diode (LED) systems. The total number to be changed is 22,723 (inside buildings: 22,450; outside buildings: 273). BPA estimated that the old lighting system consumes one unit of energy to produce 10% of lighting and 90% of heat; however, LED system consumes one unit of energy to produce 30% of heat and 70% of lighting. BPA estimated that the energy savings from using LEDs are 60% compared to the old lighting system. The life-span of an LED system is much longer than the old lighting system, about ten times longer. However, the price of one unit of LED is around USD50 to 80, while that of the old lighting system is around USD0.3. Nonetheless, BPA estimated that changing the old lighting system to LED will reduce CO_2 emissions by 2,000 tonnes and save electricity worth USD370,000 annually.

8.6.6 Coastal Transportation

8.6.6.1 Shuttle voyage between the Busan New Port and the Busan North Port

After the Busan New Port started handling container cargoes in 1996, demand for transhipment of containers between the Busan New Port and the Busan North Port has continuously increased. The distance between the Busan New Port and the Busan North Port is 25 km. The

cost of transhipping containers by truck is about USD 80 per TEU and the cost of transporting the containers by shuttle ship is higher than that. However, the container trucks must run through the downtown of Busan City, which creates traffic jams, air pollution, and noise. BPA estimates that the social cost of truck transport, due to pollution, road damages, traffic jam and road accidents, is USD9.5 million per year.

In 2007, BPA started to support one private business, Pusher Tug and Hold Barge for shuttle between the Busan New Port and the Busan North Port. The cash incentive to the private business is USD200,000 as basic cost and USD41 per TEU. At present, the share of truck and coastal shuttle transportation of containers between the two ports is about 70% and 30%, respectively.

8.6.6.2 Shuttle Voyage Between Incheon and Busan Ports

The final destination of most containers unloaded at the Port of Busan is the Seoul Metropolitan City and surrounding cities, and most of the containers were transported between these two regions by trucks, which create traffic jams and air pollution. Road transportation of containers consumes much oil compared to coastal transportation, and damages roads. Therefore, there were numerous calls to activate the coastal transportation.

Previously, there was coastal transportation of containers between the Port of Busan and the Port of Incheon, and between the Port of Busan and the Port of Kwangyang, in the 1990s and early 2000s. Coastal transportation between the Port of Busan and the Port of Incheon started in 1996 and transported 80,223 TEU. It peaked in 1999 with 132,000 TEU. However, cargo volumes decreased after 1999 and it stopped in 2006. Coastal transportation between the Port of Busan and the Port of Kwangyang started in 1998 and continued until 2004, peaking in 2001 with 43,000 TEU.

The Cargo owners preferred road transport rather than coastal shipping because the transportation time was shorter. Coastal transportation between the Port of Busan and the Port of Incheon takes 47 hours, while road transportation and rail transportation between Seoul and Busan take 13 hours and 19 hours, respectively. Transportation by coastal shipping lost its competitiveness compared to ocean-going shipping and road transportation.

In response to these issues, the Korean Government has decided to support private business (coastal shipping) for coastal transportation, such as through: i) exemption of port charges, ii) subsidy of fuel oil, and iii) a USD20 cash incentive per TEU, with USD10 coming from BPA and USD10 from IPA. The coastal shipping industry claims that carrying one TEU makes a loss of USD100. About 40% of the total loss is covered by the incentive under the government plan. In 2009, coastal transportation for containers between the Port of Busan and the Port of Incheon resumed under the support scheme described above.

Port of Busan. *(Photo by Busan Metropolitan City)*

PART 4

STATE OF OCEAN HEALTH UNDERPINNING THE BLUE ECONOMY

9 Coastal and Marine Ecosystems and Biodiversity

9.1 Key Habitats and Biodiversity[20]

The key habitats can be categorized into seven types: rocky intertidal zones, soft bottom intertidal zones, subtidal zones, pelagic zones, Wangdolcho underwater rocky zones, the waters around Dokdo Island, and deep seabeds.

9.1.1 Marine Biodiversity[21]

Korea Institute of Ocean Science and Technology (KIOST) completed an inventory of marine organisms in Korea (Park et al., 2007), listing a total of 9,798 species, by performing bibliographic studies and consultations with experts on individual species groups. Detailed information regarding individual species, such as scientific names, synonyms, distribution, ecological characteristics, and biography, were posted on the Korea Marine Biodiversity Information System (KOMBIS) (http://kombis.kordi.re.kr).

Common minke whale found in Korean East Sea.
Source: theculturetrip.com/asia/south-korea

By classifying the 9,798 marine species in the bibliography into groups, scientists identified 2,578 species of phytoplankton, 201 species of zooplankton (including protozoan), 46 species of halophyte, 988 species of algae (including green, brown, and red algae), 5,008 species of invertebrates, and 977 species of fish (Park et al., 2007).

The many species of invertebrates (excluding the zooplankton) included 1,842 species of mollusks, 1,573 species of arthropods, 405 species of annelids, 310 species of cnidarians, 264 species of sponges, 192 species of rotifers, 172 species of echinoderms, 138 species of bryozoans, and 93 species of tunicates.

[20] This section is adapted, in part, from (MOF & KIOST, 2014).
[21] This section is adapted, in part, from (MOF & KIOST, 2014).

There were also 35 species of marine mammals, and minor groups consisting of cone species of ctenophore, two species of hemichordates, and 20 species of arrow worms. If more extensive research is undertaken in the future, the scale of marine biodiversity is likely to be far greater than is reported at present.

9.1.2 Deep Seabeds

A basic survey of marine ecosystems in the East Sea, Yellow Sea, and the southern sea of Korea has been conducted since 2006, and has identified the number of animal species according to their seabed habitat. In seabed habitats consisting of sandy or muddy materials, a total of 1,525 species of large benthic invertebrates have been recorded over the last eight years. Arthropods and mollusks account for 457 and 914 species, respectively. 376 annelids, 93 echinoderms, and 142 other animal species have also been recorded.

The general survey of coastal marshes, which has been conducted in 2008 to 2013, has recorded a total of 717 species of invertebrates, 240 arthropods, 213 annelids, 185 mollusks, 30 echinoderms, and 49 other animal species.

9.1.3 Rocky Intertidal Zones

The inhabitants of rocky intertidal zones include species of algae, such as *Grateloupia chiangii, Lomentaria catenanta*, and *Chondracanthus tenella*. The zones located in the South Sea are dominated by species of Mollusca, such as *Septifer virgatus, Nodilittorina exigua, Littorina brevicula, Crassostra gigas, Nerita japonica*, and *Thais clavigera*, and species of Crustacea, such as *Chthamalus challenger, Balanus albicostanus, Pollicipes mitella*, and *Tetraclita japonica*.

In the rocky intertidal zones around Geomun Island, investigations have recorded a total of 433 species of invertebrates, including the legally protected species *Euplexaura crassa, Plumarella spinosa, Antipates japonica, Chronica sauliae, and Sesarma intermedium*. There are also several records of *Dedronephthya spinulosa, Anthoplexaura dimorpha, Spirastella insignis*, and *Certonardoa semiregularis*, all of which originated from tropical or subtropical regions and are known to have dispersed throughout the south coast of Korea.

Of all the taxonomic groups, the family Gobiidae, known to consist of 59 species in 27 genera, has been the most successful in these Korean rocky intertidal zones (Kim et al, 2005). A total of 107 species of algae have been sampled in the hard (rocky) intertidal zones located in the southern waters of the East Sea, of which the green algae account for 11 species (10.3%), the brown algae with 30 species (28.0%), and the red algae with 66 species (61.7%).

The common species recorded throughout the year are *Ulva pertusa* in the Chlorophyta; *Dilophus okamurae* in the Phaeophyta; and *Corallina pilulifera, Pachmeniopsis lanceolata, Chondrus*

ocellatus, Champia japonica, Champia parvula, Chondria crassicaulis, Polusiphonia morowii, and *Symphyocladia latiuscula* in the Rhodophuta.

A total of 38,832 invertebrate species in 79 genera (971 individual/square meters) have been recorded in the same zone. The dominant species are *Chthamalus challengeri*, which belongs to the Arthropoda Cirripedia; *Septifer virgatus*, which belongs to the Mollusca Bivalvia; and *Nodilittorina exigua, Cellana grata*, and *Cellana toreuma*, which belongs the Mollusca Gastropoda. The subtidal areas are predominantly inhabited by *Balanus trigonus, Pachycheles stevensii, Eunice sp., Pagurus proximus*, and *Lithophaga curta*.

9.1.4 Soft-bottom Intertidal Zone

The Korean soft-bottom intertidal zone, i.e., mudflats, are reported to be predominantly inhabited by salt-tolerant plants, such as *Suaeda japonica* and *Zoysia sinica*, as well as more than 135 species of invertebrates, including an unidentified polychaete, *Hemigrapsus penicillatus, Macreophhalmus japonicas, Ophiopeltis sinicola, Protankyra bidentata*, and some species of the Mollusca, such as *Bullacta exarata, Batilaria multiformis, Niotha livescens*, and *Ruditapes philippinarum*. Relatively extensive Polychaeta surveys have been conducted on the mudflats, and a total of 181 species in 144 genera, 38 families, and 14 orders have been found in 59 sites on both the western and southern coasts of the country and their surrounding waters, most of which (86 species) belong to the Phylodicida (Paek et al., 2005).

In the representative mudflat of Hampyeong Bay, 77 species of benthic diatoms have been reported (Lee and Jung, 2011). At Anmyeon Island, which is a sandy intertidal zone, the 10 most dominant species account for 92.6% of all the reported inhabitants. *Urothoe convexa*, which belong to the Amphipoda, are the most dominant, accounting for more than 50% of total inhabitants, followed by *Kellia japonica* in the Bivalvia and *Haustorioides koreanus* and *Mandibulophoxus mai* in the Amphipoda (Jung et al., 2013).

The most dominant fish species are mainly in the Gobiida. A total of four species are found in Korea: *Boleophthalmus pectinirostris, Scartelaos gigas, Periophthalmus modestus*, and *P. maguspinnatus*.

9.1.5 Subtidal Macrobenthic Zone

With regard to subtidal macrobenthic communities, many reports have confirmed the following species to be the most dominant: species of the Polychaeta including *Lumbrineris longifolia, Prionospio pinnata, Cirrophorus furcatus*, and *Magelona japonica,* and species of the Mollusca including *Theora fragilis. Capitellid polychaetes* are also densely populated throughout the entire western and southern coasts of the country. In terms of biomass, *P. bidentata* dominates most of the western and the southern seas of Korea, and *Echinocardium cordatum* and *Schizasgter lacunosus* dominate the Yellow Sea and the southern sea of Korea, respectively (MLTM, 2011a).

The tidal areas located on the southern coast of the country, which include Geomun Island, are predominantly inhabited by *Ampharete arctica, Lumbrineris japonica, Tamballagamia fauvelli*, other species of the Polychaeta (MLTM 2011b).

The distribution of meiobenthic communities has not been confirmed at the species level because most species that have been sampled are new. The benthic copepods consist of a variety species that belong to the families Miraciidae, Ameiridae, and Ectinosomatidae, of which the common genera are *Amphiascoides, Haloschizopera*, and *Pseudameira*.

The distribution of nematodes has also not been confirmed at the species level, but the genera that predominantly inhabit the south coast are *Sabatieria* and *Dorylaimopsis* in the family *Comesomatidae, Dichromadora* and *Spilophorella* in the family Chromadoridae, *Parodontophora* and *Spilphorella* in the family Axonolaimidae, and *Viscosia* in the family Oncholaimidae (MLTM 2011a).

9.1.6 Pelagic Zone

A recent survey of bacteria communities that inhabit the pelagic zones found that most of the bacteria recorded on the south coast belong to the classes Alphaproteobacteria, Gammaproteobacteria, Flavobacteriacease, and Actinobacteria (MLTM 2011a). The diatom species *Skeletonema cf. marinoi* has been reported to be the most dominant phytoplankton inhabiting Korean waters regardless of the season. The western coast of the country is dominated by diatom species, such as *Thalassionema nitzschioides, Paralia sulcata*, and *Merosira arctica*. The south coast is seasonally dominated by the diatom species *Eucampia zodiacus, Chaetoceros curvisetus, C. debilis, Diatoma elongatum, Thanlassiosira subtilis*, and *T. Allene. Skeltonema cf. marinoi, Guinardia striata*, and *Gonyaulax polygramma* in the phylum Dinoflagellata are often present in spring or summer. Zooplankton species are only seen during specific seasons (MLTM 2011a). The south coast in spring is largely dominated by Noctiluca, which can comprise over 95% of all species. Among the Copepods, *Paracaslanus parvus s.l.* and *Acartia omorii* have been found to dominate Korean inner bays and coastal areas throughout the year. In fall, warm water oceanic species, including *Euchaeta concinna, E. indica*, and *Eucalanus mucronatus,* are present, increasing the biodiversity. Nectonic fishes that swim swiftly on the surface of the sea are also present and include mackerels, horse mackerels, tunas, Indo-Pacific sailfish, and sharks. Species in the class Chondrichthyes (sharks and skates) are rapidly decreasing in number around South Korea due to the high demand for skates. Therefore, greater efforts to preserve them, including a management season, are needed.

9.1.7 Wangdolcho Underwater Rocky Zones

The Wangdolcho underwater rocky zones contain different species according to the specific habitat. Depths above 10 m are dominated by brown algae, such as *Undaria pinnatifida* and *Ecklonia cava*, whereas *Balanus trigonus, Halichondria sp.*, and similar species are present in locations with fewer algae. The proportion of infraclass Cirripedia found in shallow waters has

decreased, and *Rhizopsammia minuta mulsuensis* and *Halichondria sp.* have become dominant. *Halocynthia roretzi* is present in precipitous areas, and *Melithaea flabellifera* and *Sloanderia secunda* are present in shaded locations and valley-shaped rocky bottoms that strengthen the tidal currents. The Wangdolcho zones are also inhabited by microbenthic and mobile southern species, such as *Rhynchocinetes uritai* and *Ophioplocus japonicas*, and a few nocturnal species, such as *Anthocidaris crassispina*, have also been observed.

Depths below 20 m are dominated by *Strongycentrotus nudus* and *Aphelasterias japonica*, although on the east coast, relatively dense populations of adhesive organisms, such as *Cliona celata* and species of the family Plumulariidae are found.

A total of 41 macrobenthic species are present, with key commercial species, including *Halocynthia roretzi, Mytilus coruscus, Anthocidaris crassipina*, and *Strongycentroutus nudes*, being up to 30% larger in the Wangdolcho zone than in coastal areas.

9.1.8 Waters Around Dokdo Island

The marine life around Dokdo Island consists of 223 algal species including *Eisenia bicyclis, Ecklonia cava*, and *Undaria pinnatifida* (26 species of green algae, 65 species of brown algae, and 132 species of red algae). Its marine invertebrates are reported to consist of 144 species of the Mollusca (including *Batillus cornutus* and *Nordotis madaka*), 89 species of the Arthropda (including *Tetraclita japonica* and those in the genus *Pagurus*), 45 species of the Cnidara, 79 species of the Annelida, 14 species of the Echinodermata, and 386 other species. A total of 109 fish species have been reported to inhabit this area, including *Semicossyphus reticulatus* and *Oplegnathus fasciatus*. Because Dokdo Island is located within waters where cold and warm currents mix, this has an abundance of migratory fishes and is extremely valuable as a repository of marine resources due to its high level of biodiversity (Myung, 2009).

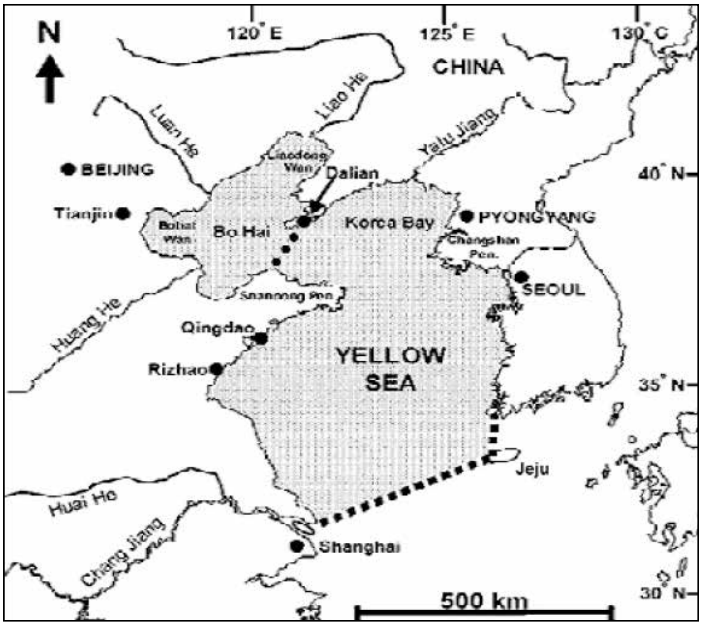
9.2 Yellow Sea Large Marine Ecosystem[22]

9.2.1 Geographical Status of YSLME

The Yellow Sea is the semi-enclosed body of water bounded by the Chinese mainland to the west, the Korean Peninsula to the east, and a line running from the north bank of the mouth of the Yangtze River (Chang Jiang) to the south side of Jeju Island. It covers an area of about 400,000 km^2 and measures about 1,000 km (length) by 700 km (maximum width). The floor of the Yellow Sea is a geologically unique, post-glacially submerged, and shallow portion of the continental shelf. The seafloor has an average depth of 44 m, a maximum depth of about 100 m, and slopes gently from

[22] This section is adapted, in part, from (UNDP/GEF 2007).

Figure 9.1: Boundaries of the Yellow Sea LME.



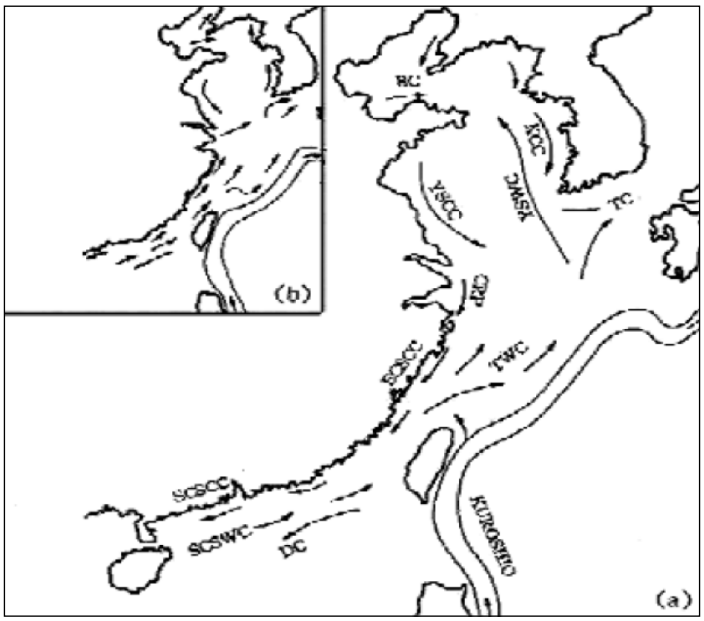
the Chinese continent and more rapidly from the Korean Peninsula to a north-south trending seafloor valley with its axis close to the Korean Peninsula. This axis represents the path of the meandering Yellow River (Hwang He) when it flowed across the exposed shelf during lowered sea level, and emptied sediments into the Okinawa Trough. The Sea annually receives more than 1.6 billion tonnes of sediments, mostly from the Yellow River (Hwang He) and Yangtze River, which have formed large deltas. The Yellow Sea is connected to the Bo Hai Sea in the north and the East China Sea in the south, thus forming a continuous circulation system. Major rivers discharging directly into the Yellow Sea include the Han, Yangtze, Datung, Yalu, Guang, and Sheyang.

The hydrographic properties and circulation of the Yellow Sea are created predominantly by winter cooling and summer heating, freshwater discharge from rivers and, arguably, the inflow of warm saline waters in a branch of the Kuroshio. Wind-forcing and freshwater runoff are also influenced by the cold and dry northerly winter monsoon and the warm humid southerly summer monsoon.

The major water masses of the Yellow Sea are the Yellow Sea Cold Water, the Yellow Sea Warm Current Water and Yangtze River mixed water. Yellow Sea Cold Water is formed during winter cooling and occupies the lower layer of the basin. This water mass survives throughout the summer. The Yellow Sea Warm Current is relatively saline and flows northwestward between Sokotra Rock and Jeju Island, into Jeju Strait and the eastern Yellow Sea. The predominant direction of outflow from the Yangtze is to the south consistent with geostrophy, but in the summer, Yangtze River mixed water extends northeastward toward Jeju Island, and lowers the salinity of the waters to the west of Jeju Island. Current speeds in the eastern part of the Yellow Sea are usually less than 0.2 knots except for areas near to Huksando and Jeju Island where stronger currents are observed.

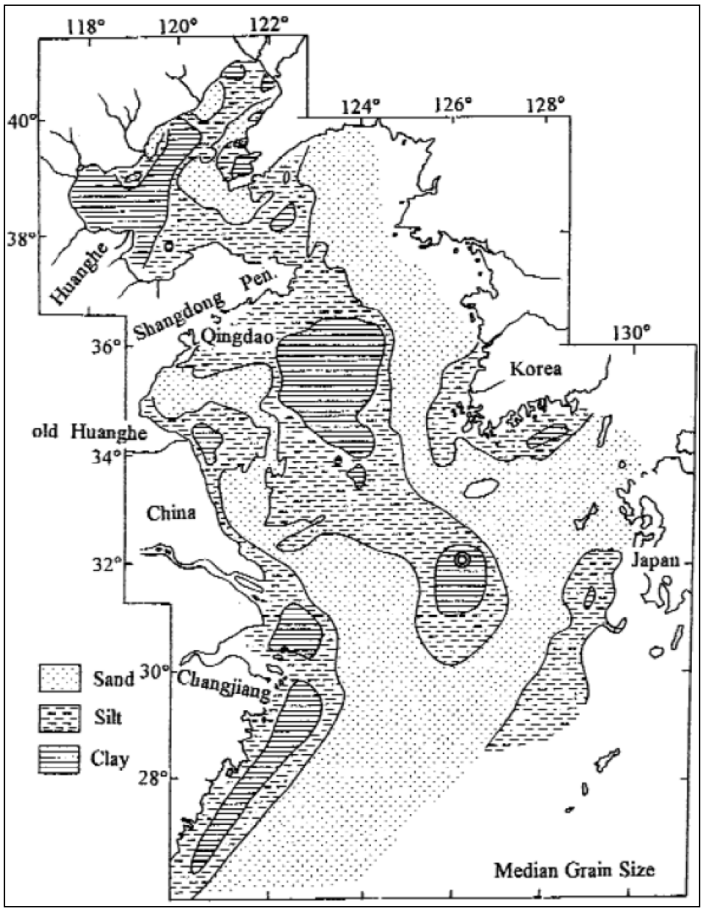
In summer, the circulation of the Yellow Sea comprises southward flowing Chinese coastal water, northward flowing Yellow Sea Warm Current influenced by the Kuroshio to the east, and the northeastward movement of water from the East China Sea with a central cyclonic gyre. In winter, the central cyclonic gyre is not as pronounced, but apart from the southward coastal flow along the Korean Peninsula, the overall circulation of the Yellow Sea remains essentially cyclonic. This circulation pattern is reflected in the water velocities across a zonal transect at 360N.

Figure 9.2: Yellow Sea Circulation in (a) Winter; and (b) Summer



The sediments of the Yellow Sea are mostly terrigenous, carried by rivers and winds from the surrounding lands. The annual input of fine-grained detritus to the Bohai Sea was, until recently, approximately 1 billion tonnes per year. Over 90% of this sediment load has been delivered historically by the Yellow River, but this has already been reduced and is predicted to fall to about 300 million tonnes by 2019 as a result of engineering works on the Yellow River. Excluding the Changjiang (Yangtze River), about 50 million tonnes of sediments are discharged by rivers directly to the Yellow Sea proper, including a considerable amount of coarse-grained material from rivers draining the Korean Peninsula. However, these inputs are probably dwarfed by the portion of the ca. 500 million tonnes per year of alluvial sediment that is discharged by the Changjiang that enters the Yellow Sea. Terrigenous sediment is distributed by tidal currents, longshore currents, waves and the Yellow Sea Warm Current. Fine sediment is deposited where current and wave actions are lowest. As a result, fine-grained surficial sediments are found in the central region of the Yellow Sea, on the Chinese coast, and on the southwest and southern coasts of Korea. Sandy sedimentary facies exist in the eastern central and northern coastal areas of the Korean Peninsula.

Figure 9.3: Surficial Bottom Sediment Grain-Size Distribution in the Yellow and Bohai Seas



9.2.2 Environment Problems

9.2.2.1 Pollution

The causes of pollution are associated with release from specific industries, transport sources, agricultural activities, mariculture and municipal sources, especially sewage and solid wastes. They also include the construction of engineering works, such as dams, on watercourses, particularly major rivers. Among these causes, the most frequent are releases from industrial, agricultural and municipal sources that contribute to eutrophication, faecal contamination and marine litter. Much the same situation applies at the level of secondary causes where the issues associated with inadequate controls on agricultural and municipal waste management practice are again highlighted. Among tertiary causes, there exists greater emphasis on the lack of controls in variety of human and industrial activities, limited investment in the infrastructure for waste management and control infrastructure, and rapid economic and social development, especially in China. Among quaternary causes, there occurs increased emphasis on the lack, or poor implementation, of controls in the field of waste management and inadequate

balance in policies relating to economic expansion and environmental protection. This latter cause becomes dominant in the list of root causes although there are instances in which it is noted that improvements can be expected with respect to some problems (particularly those relating to maritime transport and the implementation of the Stockholm Convention). Under root causes there are also references to the limited influence of the environmental constituency in government, and inadequacies of contemporary policy priorities.

9.2.2.2 Ecosystem Problems

In the case of the causal chain for ecosystemic problems, the first and second levels of cause lie predominantly in the scientific domain where the causes of a particular change in condition generating concern has an immediate and secondary cause in the realm of the natural sciences. It is only at the tertiary cause level that anthropogenic activities become identifiable, and these include overfishing and climatic change putatively associated with an increased concentration of carbon dioxide in the atmosphere. Among quarternary causes are global climatic change and rapid coastal zone development combined with an inappropriate legislative or regulatory balance between economic development and environmental protection. As might be expected, the root causes most commonly cited are limited progress in mitigating the releases of carbon dioxide to the atmosphere and, specifically, the limited expectations and achievements of the 1997 Kyoto Protocol. Other root causes include weak enforcement of controls on fishing activities and legislative and administrative weaknesses in facilitating adequate protection of the coastal zone in the context of the pace of economic development in the region.

9.2.2.3 Fisheries Problems

The causal chains for the fisheries problems include subordinate socio-economic and scientific causal chains. In the case of the decline in the landings of commercially important species, the immediate causes are identified as overexploitation of target fish species and climatic change, respectively. The overexploitation of target species is attributed to both overcapacity in the fishing sector (e.g., too many fishing vessels chasing a reduced stock of target fishing), and deficiencies in fish stock management. These latter two secondary causes then follow separate causal chains into tertiary causes, one socio-economic and other scientific.

The first tertiary cause relates to the lack of alternative livelihoods and the unchecked demand for seafood. The quaternary causes in this chain are deficiencies in the management and control (regulation) of fisheries, with the root causes being the lack of a comprehensive and effective system of fish stock management, and the lack of compliance assurance infrastructure. The other (scientific) causal chain assigns a tertiary cause, which is the weakness in the scientific knowledge of ecosystem processes resulting in limits on the degree to which comprehensive stock management can be developed. The quaternary causes are

essentially weaknesses in support for education and research. The root causes in this chain becomes poor management (in the policy sector and among government agencies) of the limits to sustainable natural resource exploitation.

In relation to unsustainable maricultural practices, the primary causes are similarly split into socio-economic and scientific causal chains. The socio-economic primary causes include over-intensive maricultural development, the over-exploitation of natural habitats, the consequences of the release of material (nutrients, bacteria, viral and faecal matter, and food residues) having adverse effects on the environment and human health concerns. It might appear that the environmental and human health consequences of excessive maricultural developments are effects rather than causes. However, it must be remembered that the stated problems is unsustainable mariculture and, accordingly, these actual or potential effects become the reason, or causes, of the unsustainability. The scientific causes, primarily the variability of environmental conditions, again follow into secondary and tertiary causes of limited scientific knowledge and limited application of science to the regulation of maricultural development.

The root causes in all causal chains for unsustainable mariculture appear as a lack of comprehensive and coherent legislative framework for coastal zone and maritime resource development, a lack of coordinate among sectors, and deficiencies in the application of sound science to sustainable coastal development.

9.2.2.4 Biodiversity Problems

The biodiversity causal chains differ slightly from those for the other sectors. Several of the immediate causes of problems are identical or similar to the problems in other components, such as overexploitation of fisheries and loos of habitat. Climate change also appears as a contributory cause of the decline of vulnerable species that are also important components of Yellow Sea biodiversity. In this latter case, and also where climatic change appears as a secondary cause, reference is made to the causal chains for the pollution component of the project. Other secondary causes include rapid economic development, increased demand for seafood, engineering works on watercourses and inappropriate fishing practices. It is, however, at the level of tertiary causes that a reduced number of causes become evident. The entry "inadequate balance between for protection of the environment and biodiversity' occurs frequently as does "inadequate controls on fishing and natural resource exploitation practices", which includes reference to "traditional exploitation practices". Other entries include "poor compliance with regulations" and "pressure for hinterland development, power production, irrigation and water supplies". These are further narrowed at the level of quaternary causes primarily into deficiencies in comprehensive development planning and deficiencies in fisheries management. The biodiversity causal chain results in several forms of the root causes, but all contain a similar message, namely that development is

proceeding in the absence of comprehensive and coherent legislation to ensure concomitant environmental and biodiversity protection, and that there also exists poor enforcement of existing legislation and inadequate provision of public information.

9.2.3 Way Forward: Interventions for YSLME

Improving Legislation and Bilateral Agreements

The most important interventions to incorporate into the *Yellow Sea Strategic Action Plan* (SAP) are improvements to legislation and associated regulations in the People's Republic of China and the Republic of Korea. Such improvements should be aimed at enhancing the protection of marine and coastal biodiversity and the marine environment of the Yellow Sea, its resources and amenities. Specifically, efforts need to be directed to improving both the comprehensiveness and coherence of legislation so that existing gaps and loopholes are closed. Moreover, to the extent possible, the legislative, administrative and regulatory frameworks in the People's Republic of China and Korea should be harmonized to provide a "level playing field" for human activities within, and on the borders of, the Yellow Sea. To this end, a comprehensive and critical review of the existing legislative provisions in the two countries should be undertaken as a means of examining opportunities for improving the protection of the Yellow Sea environment and its biodiversity and promoting the comparability of controls on human activities in the two countries.

In this context, the two riparian states might wish to consider a bilateral agreement, either independently or under a regional umbrella organization, to cooperate in the enhancement of their legislative and regulatory provisions for the protection of the Yellow Sea. Such an agreement could constitute a basis of a Strategic Action Programme that would include reviews of legislation and an agreement to foster the harmonization of laws and regulations, first domestically and then bilaterally.

Compliance with Laws and Regulations

The second most important topic for inclusion in the SAP would be an agreement to improve the level of compliance with laws and regulations in all sectors of human activities having the potential to adversely affect the Yellow Sea. Currently, there exist deficiencies in the extent of compliance with laws and regulations. This is most evident in the marine fisheries sector. The creation of a comprehensive compliance assurance mechanism in both countries would clearly provide substantial benefits to the environment and the protection of biodiversity.

Implementation of International Conventions

The full implementation of the Ballast Water Convention, the Stockholm Convention, and the new provisions (Annex V) of the MARPOL Convention will provide increased protection of the Yellow Sea from the introduction of alien species, and through the management of persistent organic pollutants and mitigation of solid wastes derived from the marine transport sector. The SAP should

concentrate on complementary initiatives to these developments as a means of reducing stress on the Yellow Sea from other sources and activities.

Addressing the Agricultural Runoff

There are two issues in which interventions directed at lower levels in the causal chains would be both tractable, sensible and offer substantial benefits. The first intervention addresses agricultural runoff from both arable farming and animal husbandry. Fertilizers, animal sewage, pesticides and considerable quantities of nutrients from agricultural activities need to be addressed, and there would be considerable benefit in reducing such runoff. This can be done by imposing buffer zones between farms and adjacent waters, such as streams lakes and rivers, to absorb some of the contaminants. The inclusion of a programme to steadily introduce additional buffer zones between farms and freshwater bodies could be included in the SAP. Other mitigation measures, new facilities and technologies to reduce or treat agricultural wastes, and stormwater management have to be studied and considered for implementation.

Application of the Environmental Impact Assessment

The second intervention is more generic – the application of environment impact assessments (EIA) to future coastal zone developments as a means of ensuring that all potential interactions with, and effects on, exiting activities, resources and amenities are considered prior to the endorsement and approval of new developments. The scale of development for which EIA would be required could be determined by the two riparian states during the course of the SAP preparation process.

Commitment to Improving Solid Waste Management

The two countries should consider making a stronger commitment to improving solid waste management in all sectors of human activities, especially the construction and municipal sectors, as a means of reducing the entry of floating and submerged solid waste into the marine environment where it interferes with both recreational and fishing activities and can present hazards to navigation. Marine debris, especially plastic waste, affect fisheries and marine life.

Fish Stock Management

Harmonization of the scientific basis for the management of individual fish stocks would improve the consistency of fisheries management in both China and Korea. It would also provide a vehicle for harmonizing the marine natural resource management frameworks between the two countries.

The polyculture approach to mariculture, in which pelagic fish, mollusc and seaweeds are grown in sequence along the prevailing current direction in coastal areas, is worthy of wider application as a means of minimizing the adverse effects and maximizing the benefits of mariculture. The polyculture

concept would appear to warrant testing in coastal areas to determine the optimum density and mix of organisms that can be cultured in sequence as a function of water advection rates.

Habitat and Biodiversity Conservation

One of the outstanding scientific and management challenges is the protection of biodiversity through habitat preservation. It would appear that the World Wide Fund for Nature, together with its Korean scientific institute partners, has made a commendable attempt to define the areas, animals and plants worthy of primary protection. Future work in the biodiversity components of the project should consider building on this work by devising ways to protect these areas and resources. Such measures, once devised, might also be included among the interventions in the SAP for the Yellow Sea.

9.3 Rare, Threatened and Endangered Species[23]

In compliance with the *Act on Marine Ecosystem Conservation and Management* enacted in 2006, MOF is protecting and managing marine species in various ways, such as establishing marine protection areas (MPAs) and designating specific marine species for protection. The marine species protected by applicable laws include seven species of seaweeds/sea grass, 24 species of invertebrates, and 15 species of mammals (Kim et al., 2010). The National Marine Biodiversity Institute has additionally advised that seahorses, specifically two species of the genus *Hippocampus (Hippocampus kuda and Hippocampus histrix)* should be protected.

About 1,000 species of sea fishes have been reported in Korea, 612 of them from the waters of Jeju Island (Kim et al., 2005; Kim, 2009). In the East and Yellow Seas and the southern sea of Korea, eelgrass is reported to serve an important spawning (Daegan et al., 2002; Ryu et al., 2011) or nursery ground (Daegan et al., 2002; Kwak et al., 2006; Kim et al., 2009) for fishes. The seven species of eelgrass designated as marine species to be protected, are expected to make a substantial contribution to the protection of the coastal ecosystem, and provide a favored habitat for pipefishes (including sea horses) (Kim et al., 2009), and are therefore expected to assist in conserving these species.

There are species that need protection but have not yet been designated as marine species to be protected. The shuttles hoppfish (*Periophthalmus modestus*) and the blue spotted mudskipper (*Boleophthalmus pectinirostris*) are highly adapted to mudflats and need to be conserved because they are very sensitive to environmental changes. The keystone species, giant sharks and giant rays, require conservation because they breed late in their lifespan and have a low fecundity. Furthermore, species reported as endemic to the Korean seas, such as the four species in the Yellow Sea (*Acentrogobius pellidebilis, Repomucenus leucopoecilus, Sebastes koreanus and Ophisurus rotundus*), and the five species in the southern sea of Korea (*Hongeo koreana,*

[23] This section is adapted, in part, from (MOF & KIOST, 2014).

Dictyosoma tongyeongensis, Albula koreana, Eulophias koreanus, and *Pisodonophis sangjuensis*) need protection and continued monitoring to prevent local extinction.

9.4 Management of Key Habitats and Biodiversity

9.4.1 Marine Protected Areas

Korean government signed the *Biodiversity Convention* in October 1994, and established an *Implementation Plan of Marine Ecosystem Survey* (IPOMES) in 2001 for the purpose of surveying marine ecosystems and biodiversity. In 2006, Korean government enacted the *Conservation and Management of Marine Ecosystem Act* to protect marine ecosystems from man-made damage, and conserve or manage marine ecosystems in a comprehensive and systematic manner, such as conserving marine biological diversity, and promoting sustainable use of marine biological resources, thereby improving the quality of national life and protecting marine assets. Korea has been conducting general surveys of marine ecosystems and biodiversity every 10 years, and undertaking information management and building a biodiversity database.

The act defines the **Marine Protected Areas** (MPA) as highly worthy of conservation, as they are ecologically important due to diverse marine organisms or excellent marine assets, including marine landscape, which are determined by Ordinance of the Ministry of Oceans and Fisheries (MOF) under Article 25. (Refer to section **12.2.1 Marine Protected Areas** for more details.)

9.4.2 Wetlands Conservation Sites

In 1997, the Korean government ratified the *Ramsar Convention on Wetlands*, which was the hallmark policy for conservation of the wetlands. In 1999, the government enacted the *Wetlands Conservation Act* for the efficient conservation and management of the wetlands for biodiversity and improving international cooperation. Based on the act, the government established the *First Basic Plan for Wetlands Conservation* (2007-2011).

Following the first basic plan, the government established the *Second Basic Plan for Wetlands Conservation* (2013-2017). At present, a total of 14 sites with the size of 235.81 km^2 of tidal wetlands have been designated as the Wetlands Conservation Sites based on the Act.

9.4.3 Fishery Resources Protection Zone

Since 1975, Korean government began to designate the **Fisheries Resources Protection Area** based on the *National Land Planning and Utilization Act*. Article 40 of this act states that MOF may determine, either *ex officio* or upon request from the heads of related administrative agencies, any designation or alteration of Fishery Resources Protection Zones for public waters necessary to protect and foster fishery resources or the land adjacent thereto, by an urban or province

plan. The *Fishery Resources Management Act* Article 1 states that the purpose of this act is to contribute to the continuous development of fisheries and to the income growth of fishermen by establishing plans for the management of fishery resources and efficiently managing fishery resources through the prescription of matters necessary for the protection, recovery, formation, etc. of fishery resources. (Refer to section **12.2.2.Wetland Conservation Sites** for more details.)

9.4.4 Marine Bio-Resources Program

In 2013, MOF established the National Marine Biodiversity Institute of Korea (MABIK), which has the following major tasks:

i) Collection, conservation, management, investigation and research of marine bi-resources;
ii) Exhibition and training of marine bioresources;
iii) Operation of responsible agencies for marine bioresources;
iv) Policy development and institutional research on marine bioresources;
v) Collection, registration, conservation, utilization and evaluation of information on marine bioresources;
vi) Information exchange and cooperation on marine biodiversity;
vii) Establishment and operation of integrated information system for marine bioresources.

MOF will operate the *Marine BioResources Observatory Program* to promote development of exploration and exploration technologies for marine bio-resources, development of cultivation technologies for future biological resources, such as deep sea creature, compilation of information on marine bio-resources, development of gene classification technologies. The Marine BioResources Observatory Program will include exploring overseas biological resources and building forward bases.

MOF will strengthen the management system for the targeted marine bio-resources: to update the list of protected marine and harmful marine species and promote related research; establishment of emergency control system for harmful marine life; promotion of domestic implementation system for the *Ballast Water Convention*.

10 Risks and Threats to Blue Economy and Ocean Health

10.1 Human Activities and Environmental Damage[24]

Environmental disturbances caused by human activities directly affect the regulating and supporting services, and subsequently affect provisioning and cultural services. Since the 1970s, Korea has used the seas as a space for exploitation. The sea has been used as a location for marine logistics, development of mineral and fishery resources, disposal of inland waste, and construction of industrial complexes and residential areas following land reclamation. Further, Korea is developing ocean energy through its new renewable energy policy, which proposes a plan for the continuous development and commercial utilization of wind, tidal, wave force, and ocean thermal energy.

10.1.1 Marine Transportation

Hazardous substances emitted into the atmosphere during normal operation include carbon dioxide, sulfur oxides, and nitrogen oxides. Hazardous substances discharged into the ocean include oils, wastewater, antifouling paint residues, and alien and invasive species contained in the ballast water or stuck to the hull's surface. Regulations regarding the hazardous substances emitted from ships operating in oceans and coastal waters have been enforced since 1970, in compliance with international conventions and local laws.

Statistics on the release of ballast water containing alien and invasive species likely to disturb marine ecosystems are reported every year in Korea. According to an annual report of ballast water emissions issued by the Korea Ocean Research & Development Institute (KORDI, 2013), a total of 90 million tonnes of ballast water is discharged into local harbors, of which about 42 million tonnes are estimated to be discharged immediately from ships arriving from foreign harbors. Of these foreign harbors, 94% are Asian ports. The amount of ballast water loaded from local ports and released into foreign ports is estimated to be approximately 179 million tonnes, far greater than the inbound volume.

There have been 6,608 oil spills in the last 20 years in Korea, with an annual average of about 330 cases. An upward trend in the number of oil spills was seen until 2000, and a downward trend since 2001. There have been years with a large number of oil spills due to accidental releases from oil tankers. Substantial efforts to prevent maritime accidents have taken place in Korea, and

[23] This section is adapted, in part, from (MOF & KIOST, 2014).

consequently, the number of cases and the volume of spillage have gradually fallen (KMST, 2013). Considering the constantly increasing volume of marine transportation, it is unrealistic to expect a large reduction in the number of oil spills. Moreover, because the greatest impacts on the marine environment are due to the large-scale maritime accidents that occur sporadically and inadvertently, we cannot overlook the serious impact that maritime accident may have on the environment.

Korea has signed the *MARPOL Convention* and other IMO Conventions, and is an active participant in international efforts toward marine environment protection. Korea has prepared and is implementing specific plans for the following: a preventive management system for maritime accidents, preparedness for oil spills and HNS contamination, ensuring scientific responsiveness to marine pollution, establishing a ballast water management system, continued disposal of neglected ships, and establishing a red tide and pest control system. However, the collection and maintenance of quantitative data on the outcomes of these measures has been insufficient to date.

10.1.2 Harbor Activities

Development in Korean harbors has followed the same path as national development. To date, over 30 large trade harbors have been constructed nationwide, and these have played a significant role in making Korea a global economic power. Additionally, Korea, which is surrounded by water on three sides and has many islands, has developed and operated 29 harbors along the coast, connecting nearby islands with the mainland.

Korea's major harbor development plans are formulated by the government every 10 years, modified every 5 years, and implemented according to the *National Masterplan for Harbor Development*. When establishing this masterplan, the *Environment Impact Assessment Act* (EIAA) requires an assessment of the environmental impact of developing and operating the harbor. The *Pre-environmental Investigation System* that reviews national development projects from the perspective of environmental conservation was introduced in 1993. In 2012, the Environment Impact Assessment Act was revised, and the review process categorized project assessments as either *Strategic Environmental Impact Assessment* or *Small Scale Environmental Impact Assessment*. For harbors with an area over 10,00 m^2, a Strategic Environmental Impact Assessment should be conducted in compliance with the EIAA.

Harbor development affects water quality, hydraulics, ecosystems, air quality, and noise, adds construction waste, and has other landscape and sociocultural impacts. Harbor operations also affect water quality, ecosystems, air quality, waste production, landscape, and sociocultural conditions. Once constructed, harbors operate for several decades, and they could continue to have negative impacts on the marine environment around them. Therefore, for harbor construction and operation, a specific plan should be prepared to monitor the environment and prevent contamination and other impacts.

In conclusion, harbors are fundamentally important to Korea, whose economy largely depends on foreign trade. Accordingly, it is essential to develop and maintain harbors to ensure increased trade volumes or for other necessities that will enable Korea to maintain its competiveness. However, the development and operation of harbors may have negative impacts on the marine environment. Because it is difficult to recover marine ecosystems once they are damaged, preventive measures are crucial. Korea currently performs an environmental impact assessment when a harbor is developed, but the environmental impact of the harbor's operation is not routinely monitored. To ensure effective management of the environment around harbors, it is necessary to identify the size of the harbor based on an accurate prediction of demand, establish a harbor environmental management plan, takes measures to minimize the environmental damage in each phase of development and operation, and create an eco-friendly harbor space.

10.1.3 Land-based Sources of Marine Pollution

To protect the marine environment from land-based sources of pollution, the Korean government established an inter-department strategy, called the *Basic Plan for Marine Environment Conservation*, and began to systematically control contaminants originating from land at their source (MLTM et al., 2011). As a result, the capacity of sewage treatment facilities has steadily increased, and although the values of all indicators including biological oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS), total nitrogen (TN), and total phosphorous (TP) have risen, the efficiency of eliminating the contaminants has also improved. The area of the country where sewage treatment is available has also steadily grown, from 75.8% of the nation in 2002 to 90.9% in 2011. The wastewater treatment capacity has also improved, with tertiary treatment capacity from 1,929,000 tonnes a day in 2002 to 13,795,000 tonnes a day in 2011. Sewage production has not changed significantly since 2005 (Ministry of Environment, 2011).

The number of wastewater dischargers has increased from 39,012 facilities in 2004 to 48,266 in 2010. The amount of discharge has increased slowly since 2003, and the rate of wastewater discharge has been increasing since 2006 (National Institute of Environmental Research, 2012).

The government's improved legal system and the expansion of investment in pollution prevention have improved the sewage and industrial wastewater treatment capacity and reduced the use of fertilizers, resulting in gradual improvements in coastal pollution. Additionally, the government is operating a coastal contamination quota control system in some areas, including Masan Bay and the Shiwha Lake, where coastal pollution is severe.

In 2006, the government established a series of marine waste reduction program. As a result, the amount of dredged materials, sewage sludge, fish waste, and natural organic matter dumped at sea was reduced by 10% in 2011 compared with 2008 levels. Starting in 2016, dumping sewage sludge at sea will be banned (MLTM, 2012). Dumping solid waste at sea reduces the water quality

in the local area and exposes marine life to toxic substances, which may pass through the food chain and become a serious threat to human health.

10.1.4 Marine Debris

Korea's marine debris management policy was implemented following the *Basic Plan for Marine Debris Management*, which is established every five years based on the *Marine Environment Management Act*. According to a study used to establish the Second Basic Plan for Marine Debris Management (KOEM, 2013; Jang et al., 2014a), based on all available research materials, the annual flow of marine debris in Korean waters was estimated to have been 91,195 tonnes in 2012, of which 64% (58,370 tonnes) was generated from marine activities. The amount of natural debris, such as bushes and trees flowing into the sea due to floods or storms (classed as marine debris in Korea), is 85,612 tonnes a year. If this is included in the marine debris weight, the proportion of marine debris originating on land would rise to 67%. At the end of 2012, the total sum of marine debris in Korea amounted to 152,241 tonnes, of which 90.5% was founded to be submerged on the seabed.

Regular monitoring of the debris in coastal areas (25 mm or large) has revealed that the average amount of debris in Korean coastal area is 480.9 pieces, amounting to 86.5kg/0.48cubic meter per 100 m. Plastics, including Styrofoam, account for 66.7% of the total number of pieces, 42.8% of the total weight, and 62.3% of the total volume of debris (Hong et al., 2014). The amount of debris (25 mm or large) in the coastal areas is similar with that of European seas. About 35% of the debris originates from the fishing industry, and Styrofoam buoys used in aquaculture, which account for 12.8% of the debris, are designated as a priority for control (Hong et al., 2014). Styrofoam breaks apart particularly easily and is a very important component of marine debris smaller than 25 mm (Lee et al., 2013).

There has been little assessment of the environmental and socioeconomic impact of marine debris. Hong et al. (2013) reported that fishhooks and fishing lines used for leisure fishing can cause serious damage to sea birds and marine animals. Jang et al. (2014b) estimated that the debris produced by storms in the Nakdong River in July 2011 caused damage valued at KRW 29-37 billion to the tourism industry of Geoje Island, which is located at the mouth of the river. Park (1999) reported that from 1996 to 1998, engine damage, distress, delayed operation, and propeller damage caused by marine debris accounted for as much as 9% of total shipping accidents. According to the results of al long-term research and planning study to solve the problems of marine debris (MOF and KIMST, 2013), information on the flow and stock of marine debris, preparedness for the problems of microplastics, and information regarding damage to the marine environment, ecosystems, and economy are required.

Global efforts to reduce the damage caused by marine debris include reducing inflows to the sea, collecting existing debris, and mitigating the negative impact of debris (NOAA and UNEP, 2011).

Reducing inflows will prevent debris from flowing into the sea, which is a more efficient approach than collecting the existing debris at sea. In the *First Plan for Marine Debris Management* (MLTM et al., 2008), the Korean government assigned about 83% of the total marine debris management budget to debris collection, but cut the debris collection budget by approximately 72% in the Second Plan (MOF et al., 2013), while slightly increasing the preventive project budget.

The stages of the First Plan, based on a global perspective (MLTM et al., 2008) were as follows: First, a "**drainage management responsibility system**" (NOWPAP Special Monitoring and Coastal Environment Assessment Regional Activity Center (CERRAC), 2013) was introduced for the largest five rivers in Korea to reduce the inflow of land-based debris and to establish the "*Basic Plan for River Mouth Debris Management*" (MOE, 2008; MOE, 2013) to prevent debris from flowing into the sea.

Second, the government implemented an "Incentive Program, where the government pays for fishermen who collect derelict fishing gear (Cho, 2009). The "**floating barge for derelict fishing gear** (DFG)" program encourages fishermen to bring back the DFG voluntarily without any financial incentives. This program is actively promoted as a more efficient alternative to the existing debris collection system.

Third, the government implemented a **national beach debris monitoring program** since 2008 to raise public awareness and to encourage participation in the policy. In 20 coastal areas across the nation, surveys were conducted by civic organizations to identify the composition and density of beach debris every 2 months. This program demonstrates the synthesis of science and policy, becoming a model case of citizen science, with people participating in policy and science (Hong et al., 2014).

In the past, Korea's marine debris management has focused on collection and disposal, but the focus has now shifted toward the prevention and strengthening of management platforms. The Second Plan (MOF et al., 2013) aims to strengthen management at its source and to build a statistical surveying system to narrow the knowledge gap. The national policy regarding marine debris management is likely to be refined based on studies, which provide quantitative data about the inflow and distribution of marine debris, including microplastics, and surveys that identify the social, economic, and environmental impacts of marine debris. Additionally, further public education to raise awareness among people engaged in fisheries will help in reducing marine debris. Research in the field of social science needs to be conducted to determine why fishermen discard DFG at sea and how this behavior can be prevented.

10.1.5 Marine Sand Mining

Aggregates (sand and gravel) are one of three basic materials required for the construction of infrastructure for national economic development, including housing, roads, bridges, and harbors.

Due to a radical decrease in aggregate supply from rivers and mountains since 2006, marine sand has become the most important source of aggregates in Korea, accounting for 44% of the total annual supply (annual average collection is 26.3 million cubic meters since 2007). As a result of construction industry demand, investment in construction is expected to grow by an average of 2.1% annually during 2014 to 2018; thus the demand for fine aggregates (i.e., marine sand) is also expected to see steady growth (MOLIT, 2014a; MOLIT 2014b).

An analysis of the amounts of marine sand mining during 2002-2013 and the future supply plan (2014-2018) indicates that the majority of marine sand (71%) has been collected from the western coast of the country and will continue to be supplied from there (68%) in the future.

Marine sand mining involves the use of a hydraulic dredge pump, which uses considerable pressure to lift sand-water slurry from the seafloor onto the mining barge. Due to this method, sand mining activities have had adverse physical, biological, and economic impacts on the marine environment.

The **physical impacts** include (i) changes to seabed topology resulting from furrow or hollows; (ii) changes in water depth; (iii) changes in tidal currents and corrosion in nearby areas; (iv) settling and deposition of suspended sediment and changes in the geology; and (v) increased noise in nearby water.

The **biological impacts** include (i) disturbance and loss of seabed habitat; (ii) increased turbidity and contamination due to suspended sediment; (iii) delayed recovery of the marine ecosystem and changes in the ecological community; and (v) changes in the movements of fish.

The **economic impacts** include (i) decreased fish catch caused by changes to marine ecosystem, (ii) increased fishing cost due to the need to avoid the sand mining area; and (iii) reduced income from tourism and the depreciated asset value of the local community caused by coastal erosion in beach or residential areas. Additionally, concentrated and repeated mining in a particular water area may cause an accumulation and expansion of damage over the long term (Lee et al., 2010a, 2010b).

The assessment of the social, economic, and environmental impacts of marine sand mining in Korea shows that, in light of the number of marine species lost and the reduction in biomass, which are the indicators of environmental impact, the western coast is expected to experience the largest impact due to its large supply of sea sand, with the south coast being the next-most affected.

Looking at the regulatory system established to protect the marine environment from the impacts of marine sand mining, the *Marine Environment Management Act* stipulates that if the volume of mining is less than 200,000 m^3 in territorial waters or 400,000 m^3 in exclusive economic zones (EEZ),

an application should be made for a license titled "**Agreement on the Use of a Water Area**." If the volume is greater than 200,000 m^3, the applicant must pass an "**Environmental Impact Assessment on the Use of a Water Area**." The *Environmental Impact Assessment Act* maintains that if the area of aggregate mining is 250,000 m^2 or over or the volume of mining is 500,000 m^3 or over, the applicant should undertake an "**Environmental Impact Assessment**." Regulations have become stricter to protect the marine environment.

However, an Environmental Impact Assessment, which is stricter than the Agreement on the Use of a Water Area, and the Environmental Impact Assessment on the Use of a Water Area, can be bypassed if the applicant files an application with a volume smaller than set in the regulations. When preparing the Agreement on the Use of a Water Area or the Environmental Impact Assessment on the Use of a Water Area, there is no standard for assessment applicable to the project type; thus, a subjective assessment is likely to be made. The scope of the investigation is too short to investigate the long-term, repeated, and accumulated impacts. Furthermore, even the scale of mining is regulated by the Marine Environment Impact Assessment, and the objectivity of the assessment is dependent on the individual performing the assessment because the assessor may subjectively choose what and how to assess.

Therefore, implementing legal provisions requires the ability to assess the impact that sand mining has on the marine environment and on socioeconomic wellbeing. However, considering the large area and the long period over which marine environmental change occurs contrasted with the short term of the assessment and absence of continued monitoring and investigation before and after the assessment, it is highly unlikely that damage to the marine environment caused by sand mining can be evaluated in an objective and quantitative manner. Even if the environmental damage is assessed scientifically, an Environmental Economic Valuation of the affected marine environmental resource should be made before a cost-benefit analysis of the sand mining operation is undertaken. With such a step, we could ensure more efficient and sustainable management of marine resources from the viewpoint of the national economy (Kim, 2009). However, this economic valuation is currently excluded from the items assessed as it requires more data and time than is available. This matter requires urgent attention.

10.2 Natural Hazards and Climate Change

10.2.1 Effects of Climate Changes[25]

- **Meteorology**

Korean peninsula is dominated by seasonal winds: the southerly wind in summer and the northerly wind in winter. Using the Korea Meteorological Administration's observation data, collected at Jeju Island, it was found that the strength of the wind around the Korean Peninsula is becoming

[25] This section is adapted, in part, from (MOF & KIOST, 2014).

weaker (Park et al., 2012b). However, the trend in summer was not clear. During typhoons, momentum is exchanged between the atmosphere and the sea around the Korean Peninsula. It is difficult to confirm how typhoon incidence, frequency, and intensity will change over a long period of time, but the frequency of their appearance is observed to be decreasing (KORDI, 2011).

• Thermal exchange

Limited information is available regarding thermal exchange at sea surface. According to a study by Park et al. (1995), the effective annual thermal exchange from the sea into the atmosphere in the Ulleung basin area in the East Sea averages -40 Wm(-2). In the Yellow Sea, up to 100-400 Wm(-2) is emitted through the sea surface in the winter, and 50-200 Wm(-2) of heat flows from the atmosphere in the summer (Youn et al., 1998).

• Sea level rise

According to the results of an analysis of the tidal level and satellite observation data, the mean sea level increase around the Korean Peninsula is 1.3 to 2.0 times higher than the global average. About 27% of the total population of Korea and 84% of national industrial complexes are located in coastal areas. Therefore, Korea's socio-economic wellbeing is highly vulnerable to sea level rise.

The impact of a typhoon on coastal areas varies with intensity. The Korean aquaculture industry may need to be reformed, and technologically updated, depending on changes in water temperature.

• Sea surface temperature

According to NFRDI Serial Oceanographic Observation (NSO), from 1968 to 2006 the overall sea surface temperature around the Korean Peninsula has risen by 0.93 degree C (0.024 degree per yr). Compared with the global average (0.5 degree C per 100-year and the North Pacific average (0.46 degree per 100-year), the rate of increase is very high. NFRDI predicted that the overall average sea surface temperature around the Korean Peninsula will rise 4.02 degree C by 2100, whereas for the same date, the East Sea, Yellow Sea, and the southern sea of Korea will experience average temperature increases of 3.79, 4.41, and 3.86 degree C, respectively.

• Salinity

Salinity has dropped by 0.23 psu (-0.006 psu yr (-1)) in the overall surface waters surrounding the Korean Peninsula during the last 40 years; in the southern sea of Korea, it has dropped by 0.45 psu, and in the Yellow Sea and the East Sea, by 0.28 psu and 0.07 psu, respectively. By 2100, the overall average salinity is forecasted to drop by 0.63 psu.

• CO_2 concentration

The annual average concentration of CO_2 over the Korean Peninsula was 400.2 ppm in 2012, and the annual average rate of increase was 2.1 ppm yr (-1), which is similar to the reported global rate of increase (KMA, 2012). As the concentration of CO_2 in the air has risen, the CO_2 inflow to the East China Sea also has risen at a rate of 0.4-0.8 mole per m2 per year, which is a higher rate of increase than has been observed in other oceans at the same latitude (Park et al., 2008b).

• Nutrients

Analysis of the nutrients in North Pacific waters during the period between 1980 and 2010 has revealed no drastic changes in phosphate, but an increase in nitrogen levels. This has been reported to be the result of the deposition of nitrogen oxides from the atmosphere due to the rapid industrialization of Korea and China (Kim et al., 2011). In addition to the atmospheric deposition of nitrogen oxides, the level of nutrients carried by the warm Tsushima Current is about tenfold higher than atmosphere deposition, suggesting that the amount of nutrients contained in Korean waters may be affected by climate change (Kim et al., 2013)

• Dissolved oxygen

Jung (2008) analyzed dissolved oxygen data from 1968 to 2005 obtained from the NFRDI Serial Oceanographic Observation (NSO) data provided by NFRDI and found that the dissolved oxygen content had decreased in all layers of the sea. This may be caused by the increase water temperature, which results in a decrease in gas solubility. The saturation of dissolved oxygen, which does not display the gas solubility effect caused by water temperature, was also found to decrease.

• Primary productivity

Satellite data-based surveys over wide areas have revealed some details of the primary productivity of Korean waters. Yoo and Kim (2003) estimated primary productivity in the East Sea to be 240.9 gC per m2 per year from 1979 to 1986 based on the data from Nimbus 7's Coastal Zone Color Scanner Experiment (CZCS). Yamada et al. (2005) used SeaWiFS data, and estimated the annual average primary productivity in Russian coastal areas at 170 gC per m2 per year; in Japanese basin central waters at 161 gC per m2 per year; and in Korean southeast and southwest waters during the period between 1998 and 2003.

10.2.2 Economic Cost of Climate Change

The frequency and intensity of sea-induced natural hazards, such as sea-level rise due to climate change, typhoon, tsunami, and acidification of the ocean are intensifying. Korea's sea level rise 2.5 mm per year is well above the world average 1.8 mm per year. The lowland coast is

overflowing and coastal erosion is getting worse. From 1989 to 1998, the damage caused by marine disasters was KRW1.3 trillion. The amount of damage from 2000 to 2007 was KRW2.1 trillion, and increased by KRW 800 billion (MLTM, 2011).

NFRDI is conducting an economic feasibility study, using bioeconomic modeling and dynamic maximum economic yield (MEY) techniques, to determine the impact of ocean acidification on the entire fishing industry, particularly oysters and flatfishes (NFRDI, 2013). The result of this study will be Korea's first assessment of the socioeconomic effect caused by ocean acidification. If the primary productivity of the ocean changes, then changes will occur to the biogeochemical carbon cycle and food chains in affected areas. These changes may have many consequences, including local climate change, changes in the fish catch and species, and changes in the construction and amount of bio-resources (MOF & KIOST, 2014).

10.2.3 Responses

• Coastal Zone Enhancement Plan

The government is implementing a number of measures against marine disasters caused by climate change. *The Coastal Zone Enhancement Plan* is a prime example. MOF, in consultation with the local governments, identifies actions designed to enhance and restore the following specific coastal features and attributes: (i) prevention of the local coastal hazards, (ii) restoration of degraded habitats and ecosystem, and (iii) revitalization of waterfronts and provision of public access to the shore. The enhancement plan is to be reviewed and modified every ten years. Unlike the National CZM Plan and the Local CZM Plans, the *Coastal Zone Enhancement Plan* is implemented on the basis of individual project. Most of the costs for these initiatives are provided by the central government according to the priorities set by the Coastal Zone Management Committee. From 2001 to 2009, the government invested KRW 433.4 billion on 281 projects in the *First Coastal Zone Enhancement Plan*.

• Wetland conservation

The government is promoting wetland conservation policies to protect marine ecosystems, which also contribute to mitigating the damage caused by climate change, such as typhoons. In 1999, the government enacted the *Wetlands Conservation Act* for the efficient conservation and management of the wetlands for biodiversity. Based on the act, the government established the *First Basic Plan for Wetlands Conservation* (2007-2011) for the efficient conservation and management of wetlands, establishment of basic framework for national wetlands conservation policy, the designation and management of the **Wetlands Conservation Sites**, and establishment of the **National Wetlands Research Center**. Following the first basic plan, the government established the *Second Basic Plan for Wetlands Conservation* (2013-2017). At present, a total of 12 sites with the size of 218 km^2 of tidal wetlands have been designated as the *Wetlands Conservation Sites* based on the Act.

PART 5

GOVERNANCE STRUCTURE AND MECHANISMS SUPPORTING BLUE ECONOMY DEVELOPMENT

11 Institutional Aarrangements and Governance

11.1 Establishment of Ministry of Oceans and Fisheries and Ocean Policy Bureau

Hong and Chang (1997) noted that the ocean governance has evolved in three phases in Korea. An initial attempt to draw many fragmented marine programs together was the establishment of a Ministry of Maritime Affairs, which was replaced by the Maritime Administration (1955-1966) under the Ministry of Commerce and Industry. However, the Administration was abolished after the military coup of 1961, and subsequently, ocean governance was dispersed into several agencies, such as the Fisheries Administration in 1966, and the Maritime and Port Administration in 1976 (Hong & Chang 1997). This fragmented institutional arrangement continued for about half a century. In 1996, however, the Korean government integrated the fragmented government authorities into one single agency, the Ministry of Maritime Affairs and Fisheries (MOMAF).

MOMAF was officially established on August 8, 1996, in response to a Presidential declaration made on the very first Ocean Day, which was celebrated nationally on May 31, 1996. MOMAF integrated almost all marine administrations into one "superagency." The basic framework of the Ministry incorporated the Maritime and Port Administration (MPA), the Fisheries Administration (FA), Korea Coast Guard (KCG), the Hydrographic Affairs Office, and other marine-related agencies (Hong and Chang 1997).

Together with the creation of MOMAF, the Korean government revised the *Government Organization Act* (GOA) mandating MOMAF to be in charge of oceans policies as follows (Article 44): (1) the Minister of MOMAF is in charge of function of fisheries, shipping, ports, marine environment preservation, oceanographic research, marine resources development, marine science technology research and development (R&D) and maritime safety and judge; (2) KCG, which is in charge of function of police and oil response at sea, is under the Minister of MOMAF.

Based on the GOA, most of the ocean-related government agencies together with their authorities were integrated into MOMAF: MPA with shipping and port management, FA with fisheries management, KCG with maritime law enforcement, Maritime Safety Tribunal with maritime accident investigation and judgment, and National Oceanographic Research Institute (NORI) with oceanographic concerns. MOMAF also took over marine environment management from the Ministry of Environment (ME), and public water management and reclamation policy

from the Ministry of Construction and Transportation (MOCT). Therefore, most of ocean-related organizations were integrated into one single ministry, except shipbuilding, weather forecasting, and exploitation of offshore natural raw material. In 2008, MOMAF and MOCT were merged into the Ministry of Land, Transportation and Maritime Affairs. However, following a reorganization, the Ministry of Oceans and Fisheries (MOF) was re-established in 2013.

Integration of Ocean Policy

After the creation of MOMAF, the integration of ocean policies in Korea was pursued in two ways: first by MOMAF, and second by pan-ocean related agencies including MOMAF. However, the previous sectoral management based on the individual relevant laws continued as MOMAF took them over initially without integration. Faced with various issues, MOMAF created a new bureau, the Marine Policy Bureau, to establish and implement policies towards the sustainable development of marine environment and resources that had been neglected before the establishment of MOMAF. Under the Marine Policy Bureau, the Marine Policy Division, Marine Research and Development Division, Marine Environment Policy Division, Marine Environment Conservation Division, Coastal Planning and Management Division, and Legislation Team for Marine Environment were established. The representative policies being implemented by the bureau include: integrated coastal management, wetlands management, reclamation policy, special area management, marine debris management, marine sand management, and R&D for ocean science and technologies.

11.2 Policies and Laws for Sustainable Development

In 1987, the Korean government enacted the *Marine Development Basic Act* (MDBA) to coordinate the sectoral management of oceans policies, which were conducted by multi-governmental agencies. The MDBA was a response to an urgent need for a more visionary approach and direction necessary for marine development, and for rationally coordinating inter-ministerial conflicts by the Marine Development Committee (MDC), chaired by the Prime Minister (Hong and Chang 1997). However, the Korean government failed to achieve this goal because the major contents of MDBA were primarily to enhance R&D for oceans science and technologies rather than to establish a comprehensive oceans policy. Therefore, MOMAF repealed the MDBA and enacted the **Basic Act on Ocean and Fisheries Development** (Korea Oceans Act) in 2002 to establish a comprehensive oceans policy.

Over the last half a century the sectoral and development-oriented ocean management in Korea has resulted in serious issues, such as over-exploitation of marine living resources, excess development of coastal areas, destruction of coastal habitats, degradation of water quality, etc. Therefore, an integrated ocean policy has to address these externalities and impacts more effectively. The basic principle of integrated ocean policy in Korea is to internalize the externalities

through environment-friendly and sustainable development of ocean resources and space. This is well recognized in the **Basic Act on Ocean and Fisheries Development** (*Korea's Oceans Act*) as follows:

Article 2 (Basic ideology): *Recognizing that the sea is a rich repository of natural resources and a ground for living as well as a route of logistics, and as such it exerts considerable influences on the national economy and national living, the basic ideology of this Act is to cultivate the opulent and vivid seas to be bequeathed to the future generations, by creating the environment in which the marine industries are equipped with more knowledge, information and high value added, and by seeking after the environment-friendly and sustainable development or utilization of marine resources.*

Moreover, the principle of sustainable development of ocean resources and space is also well recognized in the *First Basic Plan for Marine and Fisheries Development* (Oceans Korea 21) as shown below:

i) **Creation of national ocean area, full of vitality**: To positively respond to the new ocean order through management of large marine areas and the expansion of marine economic areas and to build up a healthy and abundant ocean to hand over to the future generation;
ii) **Creation of high value-added marine industry**: To improve the international competitiveness or traditional marine industry such as shipping, port, fisheries through reshuffling into high-technologies and high-value producing industry;
iii) **Sustainable development of marine resources**: To realize a commercial business of marine minerals, biology, and energy resources and to build up a system for sustainable development of marine culture and tourism resources through multi-use of ocean space.

If a program or policy is established based on a relevant law, it can have priority, and appropriate budget can be secured easily. Therefore, there are huge demands for enactment for every program and policy these days. Thus, there are increasing demands for enactment in all the governmental departments for establishing their own programs and policies. However, a proposed bill have to pass various procedures, such as consultation among government departments and public hearings. If there are serious conflicts over the proposed bill between the relevant government departments and stakeholders, the prime minister or the national assembly tries to coordinate and address the conflicts through public hearings, workshops, seminars, and expert suggestions.

The *Korea Oceans Act* provides goals, principles, basic direction that all the individual ocean laws and policy should follow and mandates the Korean government to establish the integrated *Basic Plan for Marine and Fisheries Development*. The major contents of the Act are the following:

1) Establishment of oceans policy and implementation system
- To establish a Basic Plan for Marine and Fisheries Development every 10 years,
- To establish a Marine and Fisheries Development Committee;

2) Management and preservation of oceans
- To manage the marine environment and resources for preservation and sustainable development,
- To establish a plan for preservation of marine environment,
- To manage the ocean ecosystem for preservation and restoration,
- To establish a plan for maritime safety management;

3) Development and exploitation of ocean resources
- To establish a plan for management, preservation, development, and exploitation of ocean resources,
- To establish and implement a Marine Science and Technology Development Plan,
- To manage coastal and ocean spaces,
- To achieve international cooperation for oceans management;

4) Promoting ocean industries
- To establish and implement a Shipping and Port Industry Development Plan,
- To establish and implement a Ports and Fishing Ports Facilities Expansion Plan,
- To establish and implement a Fisheries Industries Promotion Plan,
- To support and finance fisheries-related institutes for fisheries R&D,
- To establish and implement a Comprehensive Fisheries Village Development Plan,
- To establish and implement a Marine Tourism Promotion Plan,
- To support small & medium-size businesses to develop ocean-related technologies;

5) Establishment of infrastructure for marine and fisheries development
- To establish the Research and Development Institutes for developing oceans policy,
- To establish and manage Education and Training Institutes for supplying ocean-experts,
- To establish and manage the National Marine and Fisheries Information Center for effective management of ocean information and data,
- To support ocean research and development programs, and training of ocean experts,
- To support general public's ocean constituencies.

Since the creation of MOMAF, many individual laws have been enacted under the goals, principles, basic direction of the Korea Oceans Act. **Table 11.1** shows the major ocean-related laws that have been enacted based on the Korea Oceans Act.

Table 11.1: Major ocean-related laws in Korea

The New Port Development Enhancement Act, 1996
The International Shipping Register Act, 1999
The Coastal Zone Management Act, 1999
The Special Act for Support for Fishermen and Fisheries Industry Development following Fisheries Agreement, 1999
The Water Leisure Safety Act, 1999
The Fisheries Ground Management Act, 2000
The Fisheries Product's Quality Management Act, 2001
The Agriculture and Fisheries Woman Promoting Act, 2001
The Shipping Investment Corporation Act, 2002,
The Raising-Fisheries Promoting Act, 2002
The Act Regarding Establishment and Management of Agri-Fisheries and Agri-Fisheries Village Special Response Committee, 2002
The Fishing Crewmen and Fishing Vessel's Disaster Compensation Insurance Act, 2003
The Act Regarding Improvement of Fisheries Cooperatives, 2003
The Port Authority Act, 2003
The Act Regarding Punishment of Hazard Activity to Vessel and Offshore Plant, 2003
The Special Act on Liquidation of Small Bottom Trawlers, 2004
The Special Act for Support to Agri-Fishermen following FTA, 2004
The Act Regarding Antarctic Activities and Environment Protection, 2004
The Act Regarding Agri-Fishermen's Life Quality Enhancement and Development Promotion of Agri-Fisheries Village Region, 2004
The Fisheries Village and Fisheries Port Act, 2005
The Act Regarding Sustainable Development of Dokdo, 2005
The Special Act for Support for Reorganization of Port Labors Supplying System, 2005
The Preservation and Management of Marine Ecosystem, 2006
The Marine Environment Management Act, 2007
The Act Regarding Development and Management of Deep Sea Water, 2007
The Vessel Ballast Water Management Act, 2007

Table 11.1: Major ocean-related laws in Korea (cont.)

The Act Regarding Preservation and Management Uninhabited Islands, 2007
The ISPS-Code Act, 2007
The Special Act for Promotion of Samangeum Project, 2007
The Act Regarding Exchange Between Cities and Agri-Fisheries Villages, 2007
The Fisheries Animal Disease Management Act, 2007
The Aquaculture-Fisheries Products Disaster Insurance Act, 2007
The Deep-Sea Fishing Industry Development Act, 2006
The Special Act Regarding Support for 2010 Yeosu Expo, 2008
The Special Act for Support to Damaged Residents by M/V Hebei Spirit and Restoration of Marine Environment, 2008
The Act Regarding Construction and Management of Marina Ports, 2009
The Fisheries Resources Management Act, 2009
The Agri-Fisheries Food Science and Technology Promotion Act, 2009

Sources: MLTM. The Second Marine and Fisheries Development Basic Plan (2011-2020). 2010. 10.

11.3 Research and Development (R&D)

11.3.1 Science-based Ocean Policy

The target of the *First Basic Plan for Ocean and Fisheries Development* – Ocean Korea 21-- was to increase the share of the ocean industry in the GDP: from 7.0 percent in 2000 to 11.3 percent in 2030. In 2010, the government established the *Second Basic Plan for Ocean and Fisheries Development (2011-2020)*, which aims to achieve KRW123 trillion of added value of the ocean industry, equivalent to 7.6 percent of GDP by 2020. The second plan also aims to increase the level of the ocean science and technologies to 90 percent of those of advanced countries by 2020.

Traditional ocean industry, such as shipbuilding, shipping, port, logistics, and fisheries industry, faces fierce competition internationally, thus the technologies should be developed and maintained at the top level at all times.

Other advanced countries have made a huge investment in blue economy and emerging industries, such as biotechnology, ocean energy development, etc., wherein the market potential is high. Korea is falling behind other countries, both in terms of technology level and investment volume.

Korea should participate more in international cooperation, especially in the areas of marine environment, maritime safety, maritime terrorism, and climate change, all of which provide challenges and opportunities to Korea. There has been a huge demand for the ocean science and technologies for the ocean industry and ocean management, and it will continue in the future as we recognize the value of the oceans.

11.3.2 Institutional Framework and Financing for R&D

The National Science and Technology Council (NSTC), which is chaired by the prime minister and consists of the ministers of relevant governmental departments and civilian experts, establishes and reviews the national science and technology policies, and allocates the budget for R&D to relevant governmental departments. In 2004, NSTC deliberated and passed the *Ocean-Science Technologies Development Plan* for the first time, which was prepared by MOMAF and ocean scientists. Based on this plan, a total of KRW3 trillion was allocated for 71 projects for the ocean science and technologies until 2013.

There are various financial resources for the development of ocean science and technologies. However, major resources are the budget from the central government. In 2005, the government established Korea Institute of Marine Science & Technology Promotion (KIMST) to select and evaluate ocean-science R&D projects, which are financed by the central government. Various organizations, such as government-run research institutes, universities, and private research institutes, conduct the ocean-science R&D projects, most of which are managed by KIMST. However, in 2013, about 80 percent of R&D fund has been allocated to government-run research institutes, such as Korea Institute of Ocean Science and Technology (KIOST), which are well equipped with the research infrastructure, such as researchers, equipment, facilities, and instruments. Only 16 percent of R&D fund has been allocated to the universities and 4 percent to the private firms. The institutional framework for the development of ocean science and technologies such as government organizations, policies and programs, funding for R&D, and research organizations are well established as described above. However, the level of ocean science and technologies of Korea is only about 57 percent of the advanced countries (MOF 2014).

11.3.3 Funding for R&D

Both public and private sectors provide R&D fund for ocean science in Korea. However, more than 90 percent of funding for R&D is provided by the public sector because most of the ocean-science technologies are for the public. Fund for ocean science R&D has increased by an annual rate of 19.1 percent from 2006 to 2013. However, the amount of fund for the ocean-science, KRW518 billon, is only 3 percent of the total national R&D fund, which accounts for a very small portion compared with that of U.S. (8.5%), Japan (8.1%), and China (7.1%) in 2009. The Ministry of Ocean and Fisheries (MOF) is in charge of securing the funding for the ocean-science in Korea. However, MOF competes for the limited financial resources with various governmental departments.

11.3.4 Roadmap for R&D

In 2004, MOMAF established the *Roadmap for Ocean-science Technologies Development*, which passed the deliberation process of NSTC for the first time. Based on the roadmap, a total of KRW3 trillion was scheduled to be invested in 71 projects for the ocean-science technologies until 2013.

In 2011, the former Ministry of Land, Transport and Maritime Affairs (MLTM), which was in charge of the ocean-science policy, established the *2020 Roadmap for Ocean-science Technologies Development*. In 2013, the Ministry of Ocean and Fisheries (MOF) revised the 2020 Roadmap for Ocean-science Technologies Development to include the fisheries resource management. In 2014, MOF established the *Medium and Long-term Plan for Ocean and Fisheries R&D (2014-2020)*, aiming at:

i) Developing the world's leading technologies from 7 in 2013 to 20 in 2020;
ii) Creating jobs in the marine and fisheries sector from 6,000 in 2013 to 78,000 in 2020;
iii) Increasing the private sector R&D participation rate from 18% in 2013 to 40% in 2020.

Specifically, the plan emphasizes the development of the ocean economy: development of marine resources and marine energy, fostering of advanced marine equipment industry, upgrading of port and shipping logistics function, industrialization of marine fishery bio resources, future industrialization of traditional fishery industry, securing competitiveness of offshore plant, and leading eco-friendly ship market.

The government also addressed ocean-science policy in the F*irst and Second Basic Plans for Ocean and Fisheries Development*, which were established in 2000 and 2010, respectively.

12 Sustainable Development Programs for Blue Economy

The Korean government has established and promoted many programs for sustainable development of marine resources in accordance with Korea's *Oceans Act* and *Ocean Korea 21*. These are also in line with the UN Sustainable Development Goals (SDGs).

12.1 Marine Spatial Planning

The coastal resources and space have been used and developed densely in Korea since industrialization during the 1960s, resulting in inefficiency, social costs, and conflicts among multiple stakeholders. As an alternative solution, the Korean government introduced the coastal zone management (CZM) program in 1999. In 2009, MOF revised the *CZM Act* and introduced a coastal zoning system, which divides the coastal water zone into four areas; the usable area, the special area, the conservation area, and the management area. However, the *CZM Act* does not regulate any prohibited, limited, allowable activities in the zoning areas, which makes the implementation ineffective. Moreover, the CZM program is effective only within the territorial waters. There was no law or policy tool for coordination and resolution of conflicts among multiple stakeholders beyond territorial waters up to the EEZ.

Currently, the Korean government is introducing a marine spatial planning (MSP) program to make up for limitation of the CZM program in the territorial waters and to effectively manage the EEZ. The MSP program aims to:

1) Establish an information common use system
   - To establish an Information Strategic Planning (ISP) until 2016,
   - To start the integration of information and data from 2017;
2) Enact laws and create organizations
   - To conduct a basic research for enactment of MSP and feasibility of creating new organization in 2016,
   - To draft a MSP Act in 2017,
   - To enact a MSP Act and to expand relevant organization until 2018;
3) Strengthen spatial managing tools
   - To introduce a Marine Spatial Assessment System and a Marine Planning Assessment System until 2017,

- To enact the Marine Spatial Assessment System and the Marine Planning Assessment System from 2018 to 2020;

4) Support R&D for ocean spatial planning
- To carry out the basic research and secure budget in 2016,
- To carry out R&D from 2017 to 2023;

5) Carry out a pilot project
- To review and analyze the spatial characteristics of the pilot site (part of EEZ and part of territorial waters of the Gyeonggi-do Province) in 2016,
- Mapping of the spatial information of the pilot site in 2016,
- To establish a Marine Spatial Information System for the pilot site in 2016,
- To establish a draft MSP for the pilot site from 2016 to 2017
- To develop a roadmap to extend the pilot MSP to the whole ocean area from 2016 to 2017;

6) Enhance public relations and outreach
- To form a social consensus and to strengthen international cooperation in 2016,
- To announce MSP program and to implement public relation and outreach in 2017.

In 2017, the government established a marine spatial plan in the vicinity of Gyeonggi Bay. In 2018, the government introduced a marine spatial plan for the neighboring waters of Yeosu and Tongyeong, and plans to expand it nationwide.

12.2 Marine Ecosystem Management

12.2.1 Marine Protected Areas

In 2006, Korean government enacted the *Conservation and Management of Marine Ecosystem Act* to protect, conserve or manage marine ecosystems in a comprehensive and systematic manner, such as conserving marine biological diversity and promoting sustainable use of marine biological resources, thereby improving the quality of national life and protecting marine assets.

The act defines the Marine Protected Areas (MPAs) as highly worthy of conservation, as they are ecologically important due to diverse marine organisms or excellent marine assets, including marine landscape, which are determined by Ordinance of the Ministry of Oceans and Fisheries (MOF) under Article 25. Based on the act, the minister of MOF may designate areas as MPA, whose marine ecosystem or marine landscape requires special protection. MPAs are classified into following sub-areas based on the characteristics of marine ecosystems:

i) **Areas for protecting marine organisms** - Areas needed to protect marine organisms;
ii) **Areas for protecting marine ecosystems** - Areas with excellent marine ecosystems or diverse marine organisms, or areas with vulnerable ecosystems, which are unlikely to be restored, if damaged;

iii) **Areas for protecting marine landscape** – Areas with excellent marine landscape, where the topography, geological features and biota of the seaside or under the sea achieve harmony with marine ecosystems.

At present, 12 areas with 254.322 km^2 have been designated as *Areas for protecting marine ecosystems*, and one area with 91.237 km^2 has been designated as *Areas for protecting marine landscape*.

To designate MPA, the minister of MOF shall draft a topographic map determined by Presidential Decree in a written plan on designation which includes the following, listen to the opinions of the relevant local residents, interests persons and the heads of local governments, and then undergo consultations with the heads of the relevant central administrative agencies and deliberation by the Marine Fishery Development Committee:

i) Grounds and purposes of designation or alteration;
ii) Current status and characteristics of major marine ecosystems;
iii) Specific use area or current status of using land in designated areas and adjacent areas;
iv) Classification of marine protected areas and management plan;
v) Current status of fishing rights and mining rights and drawings;
vi) Current status of regulated areas under statutes.

Article 27 of the Conservation and Management of Marine Ecosystem Act prohibits following activities in the MPAs:

i) Capturing, collecting, transplanting or damaging marine organisms;
ii) Newly constructing or extending building or other structures;
iii) Changing the structure of public waters, or increasing or decreasing the water level or quantity of the sea water;
iv) Changing the quality of public waters or land;
v) Collecting the sea san, quarts sand, soil and stones;
vi) Throwing away specific substances harmful to the water quality.

The MPAs cover 4.3% of Korea's territorial waters (World Bank 2017).

12.2.2 Wetlands Conservation Sites

In 1997, the Korean government ratified the *Ramsar Convention on Wetlands*, which was the hallmark policy for conservation of the wetlands. In 1999, the government enacted the *Wetlands Conservation Act* for the efficient conservation and management of the wetlands for biodiversity and improving international cooperation. Based on the act, the government formulated the *First Basic Plan for Wetlands Conservation (2007-2011)*, of which major outcomes are the establishment of basic framework for national wetlands conservation policy, the designation and management of the Wetlands Conservation Sites, the host of the 10th Ramsar Assembly Meeting in 2008 at Changwon City in Korea, and the foundation of the National Wetlands Research Center (Kim et al., 2013).

Following the first basic plan, the government adopted the *Second Basic Plan for Wetlands Conservation (2013-2017)*. At present, a total of 14 sites with the size of 235.81 km^2 of tidal wetlands have been designated as the Wetlands Conservation Sites based on the Act. The designation of the Wetlands Conservation Sites is a very difficult undertaking because most of the fishermen living in these areas are strongly opposed to the designation (Cho, 2016). Article 13 of the *Wetlands Conservation Act* prohibits following activities in in the **Wetlands Conservation Sites:**

i) New construction and extension of a building or other structures;
ii) Act that brings about increase or decrease in the level or volume of waters in the wetlands;
iii) Gathering earth, sand, pebbles, stones, etc.;
iv) Extraction of minerals;
v) Artificial introduction and cultivation, capturing or gathering of animals and plants.

12.2.3 Fishery Resources Protection Zone

Since 1975, Korean government began to designate the **Fisheries Resources Protection Area** based on the *National Land Planning and Utilization Act*. Article 40 of this act states that the Minister of Oceans and Fisheries (MOF) may determine, either *ex officio* or upon request from the heads of related administrative agencies, any designation or alteration of Fishery Resources Protection Zones for public waters necessary to protect and foster fishery resources or the land adjacent thereto, by an urban or province plan. The *Fishery Resources Management Act* Article 1 states that the purpose of this act is to contribute to the continuous development of fisheries and to the income growth of fishermen by establishing plans for the management of fishery resources and efficiently managing fishery resources through the prescription of matters necessary for the protection, recovery, formation, etc. of fishery resources.

At present, a total of 30 areas with 3,161 km^2 have been designated as the Fisheries Resources Protection Areas, among which the water areas and land areas are 2,760 km^2 and 401 km^2, respectively. The coastal waters and the inland waters are 2,864 km^2 and 297 km^2, respectively.

The following activities in the Fisheries Resources Protection Areas can be performed with permission from the managing agencies that have jurisdiction over such zones:

i) Construction of buildings and other facilities for the protection, formation, etc. of fishery resources;
ii) Installation of buildings and other facilities necessary for residents' livelihood;
iii) Forestation, rearing forests, and forest road construction under the *Forest Resources Creation and Management Act*.

Moreover, the following activities can be decided for the protection and formation of fisheries resources in the Fisheries Resources Protection Areas:

i) Prohibition of capture or gathering;
ii) Fishing Prohibited Zones;
iii) Release of illegal catches;
iv) Prohibition of sale of illegal catches;
v) Restriction on capture and gathering by non-fishermen;
vi) Establishment of period for suspension of fishing.

12.3 Coastal Zone Management

Integrated coastal management (ICM) is a process for the management of the coast and all aspects of the coastal zone using an integrated approach to achieve sustainable development. In Korea, the ICM program is fostered through the *Coastal Zone Management Act* and subsequent Coastal Zone Management Plans. **100% of Korea's coastline is covered by the ICM programs and CZM plans**.

Similar to other countries, sectoral coastal management has brought serious coastal issues, such as depletion of fisheries, reduction of habitats due to sand mining and reclamation of coastal waters including wetlands, pollution of coastal waters, increased marine debris, reduction of natural coastlines, and limitation of public access to coastal waters. Therefore, in 1999 the Korean government introduced the *Coastal Zone Management (CZM) Act* to address the coastal issues through the integration of the sectoral coastal management plans and programs.

The *CZM Act* passed the National Assembly in 1999. The boundaries of the coastal water zone are defined to extend seaward to encompass territorial waters, i.e., within 12 nautical miles of mean high water specifically including all intertidal wetlands. The boundary of the coastal land zone includes 500 meters inland from mean high water or one km in the case of areas developed as fishing harbors, ports, and industrial complexes. The major programs of the CZM Act are the *National CZM Plan*, the *Local CZM Plans*, and the *Coastal Zone Enhancement Plans*. The National CZM Plan and the Coastal Zone Enhancement Plans are established by the central government.

The **First National CZM Plan** that was put to the public notice in 2000 contained six major components in the 10 coastal regions, such as future development and conservation priorities, the designation of conservation areas, pollution load management, the identification of scenic areas and sites, the identification of sites for coastal readjustments, and prevention and mitigation of natural disasters. However, the six components are not mandatory, but just the direction for future management. Therefore, this national planning scheme does not articulate specific policies, incentives, or mechanisms for achieving these broadly defined development policies.

Photo by M. Ebarvia

The national plan and local plans as well as the coastal readjustment plan must be approved by the Coastal Zone Management Committee chaired by the Vice-Minister of MOMAF and then passed on to the Environment Conservation Committee that is chaired by the Prime Minister. The **Second National CZM Plan** was established in 2011, with nearly same contents as the first plan.

Table 12.1: The Basic Policy Directions of the Coastal Regions in the National CZM Plan.

Zone	The Basic Policy Directions
Mid-part of West Sea - I	Management of Pollution Load
Mid-part of West Sea - II	Preservation of coastal scenic area, Enhancement of stewardship
Southern part of West Sea - I	Multipurpose Use of Coastal Resources
Southern part of West Sea - II	Development of Islands, Preservation of Wetlands
Western part of South Sea	Conservation of Fisheries Resources, Enhancement of Coastal Tourism
Mid-part of South Sea	Conservation of Fisheries Resources, Management of Pollution Load
Eastern part of South Sea	Ocean-friendly City Planning
Southern part of East Sea	Management of Pollution Load, Protection of Islands Ecosystem
Mid-part of East Sea	Preservation of Coastal Scenic Areas, Enhancement of Coastal Tourism
Jeju Island	Protection of Island Ecosystem, Enhancement of Coastal Tourism

Within the framework of the national plan, local governments may voluntarily develop Local CZM Plans, with three elements: (i) statements of policies, (ii) the procedure whereby the policies and guidelines of the national plan will be implemented, and (iii) policies and priorities of the application of coastal zone readjustment projects.

In 2000, MOMAF established the *Guideline for Establishment of Local CZM Plans*. According to the guidelines, the coastal zone of both the coastal land zone and coastal water zone should be divided into five areas: 1) coastal zone for strict conservation, 2) coastal zone for semi-strict conservation, 3) coastal zone for use, 4) coastal zone for development adjustment, and 5) coastal zone for development inducement. These five areas would be managed according to their functions and goals.

Nonetheless, the future management of those five areas of the coastal land zone still has to follow the existing national plans and programs, which are based on corresponding laws.

Similar to the coastal land zone, the coastal water zone was already used and managed in accordance with the various relevant Acts and practices for ports and harbors, fishing harbors, marina harbors, aquaculture, fishing ground, marine parks, protected and conservation areas, power-generating facilities, shipbuilding yard, military facilities, etc. Thus, the future management of those five areas of the coastal water zone has to be established incorporating the existing use and management system. Just like the coastal land zone, the direction and recommendations in the coastal water zone are not mandatory, and require agreement for the future development and use.

Hence, in 2009, MOMAF revised the *CZM Act*, and introduced the zoning system in the coastal water zone. The zoning system in the coastal water zone divides the coastal water zone into four areas considering the present status of use and development, the natural and environmental characteristics of the areas, and the future direction for using the areas.[26] The four areas are the 1) **usable area**, 2) **special area**, 3) **conservation area**, and 4) **management area**, and each area can be divided into many sub-areas. However, the *CZM Act* does not regulate any prohibited, limited, allowable activities in the zoning areas.[27] Compared with the previous CZM Act, the revised CZM Act provides the Local CZM Plans with mandate to manage according to the functions of the four areas and the sub-area in the coastal water zone.

[26] CZM Act article 15.
[27] CZM Act article 19.

12.4 Pollutin Reduction and Water Quality Management

12.4.1 National Plans for Reducing Land-based Sources of Pollution

12.4.1.1 Korea's Ocean Policy

Based on Korea's *Ocean Act*, the Korean government established the *First Basic Plan for Ocean and Fisheries Development* (Ocean Korea 21)[28], which included the policy for marine environment conservation with the following aims:

i) To improve the quality of coastal water up to class 2 by 2010 through reducing land-based sources and implementing Special Area Management Plans (SAMP) for pollution hot spots;
ii) To purify 104 polluted sites by 2010 through the establishment of pollution prevention system for land-based waste and implementation of continuous clean-up for polluted waters;
iii) To restore marine ecosystem aggravated by pollution and overfishing and to establish infrastructure for the sustainable use of marine living resources.

In 2010, the *Second Basic Plan for Ocean and Fisheries Development (2011-2020)* was adopted, and included the following objectives for marine environment conservation:

i) To establish an assessment system on ecosystem and socio-economic impact caused by marine pollution;
ii) To strengthen sites and source-specific management system based on coastal and ocean characteristics;
iii) To establish management of infrastructure for land-based and sea-based sources.

12.4.1.2 Comprehensive Marine Environment Management Plan

In 1977, the Korean government enacted the *Marine Pollution Prevention Act* (MPPA) incorporating *MARPOL Convention*, to regulate pollution from vessels. The Ministry of Environment (ME) was in charge of the MPPA, however, gave low priority to the marine environment management compared with other drinking water and terrestrial environment management. In 1996, MOMAF took over the implementation of MPPA and started to strengthen the marine environment management. In 2008, MOMAF totally revised the MPPA to include both ship-based and land-based sources, and renamed it the *Marine Environment Management Act* (MEMA).

[28] Korea's Oceans Act, Article 6.

The MEMA states that the government should establish the *Comprehensive Marine Environment Management Plan* (CMEMP) every five years. The First CMEMP was established for years 1996 to 2000, the Second CMEMP for 2001 to 2005, the Third CMEMP for 2006 to 2010, and the current Fourth CMEMP for 2011 to 2020.

According to the Korea's Ocean Policy for reducing land-based sources, the Second CMEMP (2001-2005) adopted the precautionary approach to reduce the land-based sources, which are more than 80% of the total sources of marine pollution. The Third CMEMP (2006-2010) adopted both the precautionary approach and the integrated management of coastal land and waters for reducing land-based sources. The Fourth CMEMP (2011-2020)[29] included the Establishment of Comprehensive Management System for Reducing Land-based Sources, with a budget of $9 billion.

12.4.1.3 National Program of Action

In 2004, MOMAF and ME established the *National Program of Action* (NPA), which followed the four strategies in the *Global Program of Action for the Protection of the Marine Environment from Land-based Activities* (GPA):

i) Strengthening the pre-cautionary management, including the *Coastal Total Pollution Load System*;
ii) Strengthening the monitoring and knowledge infrastructure for scientific decision-making;
iii) Strengthening the adaptive and sustainable management based on the priority;
iv) Strengthening the participation and cooperation of local stakeholders.

MOMAF and ME are in charge of marine and terrestrial environment management, respectively. In 2006, they established the Policy Coordination Committee to effectively manage the land-based sources through *Special Area Management Plans* (SAMPs) and coastal estuary management. Also, they could implement the NPA effectively because many laws and programs relevant to GPA have been already enacted and established (Lee 2007).

12.4.2 Budget Allocation

The Korean government invested a large portion of the budget for marine environment management to reduce pollution from land-based sources: 92.2% of the total budget ($5.4 billion) of the Second CMEMP (2001-2005); 85.3% of the total budget ($6.4 billion) of the Third CMEMP (2006-2010); and 82% of the total budget ($10.9 billion) in the Fourth CMEMP (2011-2020).

[29] In 2011, the MPPA was revised to establish the Comprehensive Marine Environment Management Plan for every ten years.

Previously, the government has put management priority on drinking water over the water for industry, and the water for agriculture over coastal waters (Nam and Kang 2003). Consequently, the sewage treatment in the coastal areas has been far lower than those in the inner land areas. However, since the adoption of CMEMPs, most of the budget for reducing land-based sources was invested for the installation of sewer pipes and building wastewater treatment plants. For example, 73% of the budget for reducing land-based sources ($5.5 billion) in the Third CMEMP (2006-2010) was invested for the sewerage and treatment system.

12.4.3 Special Area Management Plans and Environment Conservation Areas

The MPPA states that a seriously polluted area should be designated as a **Special Management Area**. Before the establishment of MOMAF, the Special Management Areas was under the authority of ME, which designated the coastal waters of Ulsan, Busan, Masan and Gwangyang as the Special Management Areas. The MPPA states that a *Special Area Management Plan* (SAMP) should be crafted once an area is designated as a Special Management Area. However, ME did not develop any SAMP because most of the pollutants in the area were land-based and it was hard to persuade stakeholders to reduce their pollution loading.

However, since taking over the MPPA from ME, MOMAF monitored, surveyed and forecasted the carrying capacity of the Special Management Area and the total land-based and sea-based pollutant flowing into the area. Through long discussion with major stakeholders including local governments, MOMAF developed the SAMPs for the waters of Siwha-Incheon (2001), Masan (2004), Gwangyang (2005), Ulsan (2008), and Busan (2009), totaling 1,127.61 km^2 of sea and 1,065.15 km^2 of land. For the effective implementation of the SAMPs, a Special Area Management Committee consisting of local stakeholders, has been established for each site.

MOMAF also revised the *Marine Pollution Prevention Act* to designate valuable areas as fishery resources conservation areas, which specifically called as *Environment Conservation Areas*. MOMAF designated the Bay of Wando-Doam (2005), Gamak (2006), Deugryung (2007) and Hampyung (2009) as the Environment Conservation Area, totaling 1,172.41 km^2 of sea and 1,718.40 km^2 of land, with the main objectives of controlling the land-based sources of pollution.

12.4.4 Coastal Total Pollutant Load Control System

Although MOMAF established the SAMPs for the waters of Siwha-Incheon, Masan, Gwangyang, Ulsan, and Busan, it was hard to reduce the land-based sources because the end-pipe discharge criteria were regulated based on the *Water Quality Management Act*. The water quality of the Special Management Areas, especially the Bay of Masan, was deteriorating.

The coastal land of the Bay of Masan had been densely developed by industrial complexes, a large port, and a sizeable urban population since the economic development of the 1960s, and a large

quantity of pollution load from land-based sources had flowed into the bay. However, the Bay of Masan was the most closed sea in Korea, and the circulation of the bay was very limited. Therefore, the water quality of the bay got worse. Consequently, in 1975, the Gapo Beach was closed, and in 1979, catching fish and shellfish was prohibited. Moreover, red tide frequently occurred in the bay, and in 1982, the bay was designated as the *Special Red-tide Management Area*. The water quality of the bay became the interest of politicians, government officials, fishermen, and scientists. The government expanded the installation of sewerage system, built wastewater treatment plants, and strengthened the end-pipe criteria in the bay. However, the post-discharge measures were not effective, and the water quality had not improved.

In 1995, MOMAF conducted a study for introducing a precautionary approach, and then developed the *Coastal Total Pollutant Load Control System*, which could be applied in the bay. The Special Committee for Masan Bay was established consisting of major stakeholders, such as the general public, the central and local governments, industry, and academia. In February 2008, the government established the *Basic Plan for Masan Bay Special Management* to apply the Coastal Total Pollutant Load Control System. Before the establishment of the basic plan, 32 official meetings were convened, 3 rounds of public hearing inviting all relevant local NGOs were conducted, and 14 times of official meetings were held to effectively manage the basic plan (Lee 2008). As a result of the Coastal Total Pollutant Load Control System, the water quality of the Bay of Masan has been greatly improved.

However, the government has set a goal to only improve the COD[30] level 3 to COD level 2 by 2020, which does not include nutrient loads, such as nitrogen (N) and phosphorus (P). The N and P are known to be one of the causes of the red-tide in Korea.

In order to reach the COD level 2 from the present level 3, the total pollution load has been allocated to the relevant local governments, which re-allocates their shares only to public facilities and infrastructures, such as wastewater treatment plants and sewer systems, and not to the private sector. This is because the local governments hesitate to limit their regional economic development by imposing the cost-burden to the private sector (Lee et al. 2009). Moreover, SAMP for the Masan Bay also does not address the nonpoint sources, which are generated from the upland by private businesses. Therefore, a special law is needed to expand the geographical area of the watershed management as well as include nonpoint sources.

12.5 Water resource management[31]

South Korea has been addressing its water challenges while meeting its economic development goals. The following are some of the best examples of how the country is achieving water security:

[30] COD: Chemical Oxygen Demand.
[31] From https://arad.co.il/blog/5-examples-of-how-south-korea-meets-its-water-challenges/

1. Building an extensive dam system to control flooding and store flood waters for use in dry seasons and in dry regions: When dams currently under construction are finished, it is expected that 50% of South Korea's total water supply will come from storage.[32] South Korea has even constructed the Peace dam on the Bukhan river to prevent the flooding that originates from its neighbor to the north.[33]

2. Restoring 929 km of the national river system: South Korea has spent $18 billion on the Four Major Rivers project to secure water resources against potential water scarcity, improve water quality and restore river ecosystems. The project has not only restored the rivers themselves but also the 14 tributaries that feed them and, in its final phase, will revitalize many small local streams as well.[34]

3. Desalination: Korean companies have become leaders in the global desalination market. Since January 2015, a $175 million desalination plant in the southern port city of Busan has been generating around 45,000 tonnes per day of freshwater – enough to meet the drinking water needs of 150,000 people. Another desalination plant started supplying 30,000 tonnes of industrial water per day to the Gwangyan mill – meeting 13% of the plant's water needs.[35] These plants were built by large Korean enterprises, such as Doosan Heavy Industries and POSCO (formerly Pohang Iron and Steel Company). (However, desalination is energy-intensive, and the environmental impact on the marine environment have to be addressed.)

4. Smart water management technologies: The state-run Korea Water Resources Corp. (K-Water) has developed and deployed a wide range of smart water management technologies, which leverage Korea's advanced ICT infrastructure to minimize loss and non-revenue water, and optimize performance across the entire water cycle. K-Water is now actively exporting these solutions to other countries.[36]

5. Rainwater harvesting: It all started with a pilot project in Star City in 2008, where Prof. Mooyoung Han, a renowned global proponent of rainwater harvesting, convinced a contractor to install a rainwater tank in the underground parking lot of a high-rise complex under construction. Prof. Han was soon able to prove that this one tank saved 40,000 m^3 of water a year. The Star City municipal government soon required that rainwater harvesting/stormwater management systems be incorporated into all new buildings. As of 2011, 59 cities throughout Korea have become "rain cities" including the capital, Seoul, and the major cities of Incheon, Kwangju, Busan, Daejeon and Daegu.[37]

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[32] Aquastat, *Republic of Korea*, 2011
[33] Brett Smith, *South Korea: Environmental Issues, Policies and Clean Technology*, July 9, 2015
[34] *South Korea's Four Rivers Restoration*, Water & Wastewater International, June 2011
[35] *Korean city turning seawater to drinking water*, December 2014; *POSCO E&C completes Korea's first commercial desalination plant*, November 2014
[36] *S. Korea showcases smart water management at world forum*, April 2015; *S. Korea, Chile agree to cooperate in smart water management*, July 2016;
[37] *A Shining Star in Rainwater Harvesting*, Water & Wastewater International, April 2011

Four River Restoration and Water Resource Management Efforts in Korea
Photos from Korea Environment Institute; Lee Jin Hee

PART 6

SUMMARY AND CONCLUSION

13 Summary and Conclusion

Korea is highly dependent on the oceans, both economically and socially. The coastal area is 32,369 km^2, which is 32.3% of the nationwide area. In 2015, the coastal population was 13,983,000, which was 27.2% of the total population. In 2000, there were 174 industrial complexes with corresponding area of 483.0 million m^2. In 2010, the number of industrial complex increased to 304, with corresponding area of 991.2 million m^2. Korea's economic system is based on importing raw materials and exporting finished goods, and about 99% of the cargo has been transported by sea.

As per capita income increased, the demand for seafood as a healthy food has also increased from 42.2 kg per person in 2001 to 53.8 kg per person in 2013 in Korea.

In the *Second Basic Plan for Ocean and Fisheries Development* (2011-2020), the direct and indirect value of the ocean industry was estimated to be around at KRW 54,375 billion in 2007, which was 5.6% of GDP. The share of the shipbuilding industry was 64.3% (KRW 34,964 billion) of the ocean industry, followed by the shipping industry (21.6%, KRW 11,759 billion) and the port industry (7.9%, KRW 4,274 billion). The ocean industry is expected to increase to KRW123,869 billion in 2020, which shares 7.6% of GDP. It was estimated the ocean economy contributes around 3.3% of the GDP in 2013 in value-added (Chang, 2017). A more recent study shows that the ocean economy of RO Korea decreased to US$36.95 billion in vaue added, or 2.9% of GDP in 2014 (KMI, 2018). Ship-building, shipping and ports are still the top ocean industries.

The traditional maritime industries, such as shipping, fisheries, ports, and shipbuilding, are suffering from intense international competition, and huge investment is required to survive. In addition, the industrialization and economic policies since the 1960s resulted in many issues on the coast, such as depletion of fisheries, reduction of habitats due to sand mining and reclamation of coastal waters including wetlands, pollution of coastal waters, increased marine debris, reduction of natural coastlines, and limitation of public access to coastal waters. In response, the government undertook reorganization of institutions and adoption/revision of relevant laws and policies.

The governance structure includes laws (act), plans, systems and programs for sustainable development, preventing over-exploitation of coastal resources and space, and reducing pollution from both land- and sea-based sources. Korea's ocean economy has been promoted since the government established the **Ministry of Maritime Affairs and Fisheries** (MOMAF) in 1996, enacted the **Basic Act on Ocean and Fisheries Development** in 2002 for the sustainable

development of ocean resources and the ocean industry development, and established the **Basic Plan for Ocean and Fisheries Development** (OK 21) in 2004. With these policies and institutional arrangements in place, Korea is transforming its ocean economy to more sustainable **blue economy**.

The State is promoting blue economy and there are many initiatives in different ocean economic sectors, in line with the Changwon Declaration 2012. In 2014, the Ministry of Ocean and Fisheries (MOF) established the **Comprehensive Measures to Promote New Ocean and Fisheries Industry** with the aim of increasing the value-added of the new marine industry up to 7% of GDP, expanding the new ocean industry to KRW40 trillion, and creating 25,000 new jobs by 2017.

In 2016, the government established the **Strategy to Promote Industrialization of Ocean and Fisheries R&D**, with the aim of: i) creating a market of KRW3.4 trillion, creating an employment of 36,000, and establishing four globally competitive companies by 2020, and ii) creating a market of KRW14.0 trillion, and employment of 123,000, and establishing ten globally competitive companies by 2025.

In 2017, MOF established the **Strategy to Promote Business Start-up and Investment in Ocean and Fisheries**, aiming at i) promoting technology-based entrepreneurship, ii) strengthening enterprise investment attractiveness, iii) expanding network with capital market, iv) forming financial infrastructure, and v) promoting investments and establishing investment ecosystem.

The new or emerging ocean industries, such as offshore energy development, offshore aquaculture, coastal tourism, marine biotechnology industry, deep sea water, desalination, and green port, has just begun to develop in Korea.

With Blue Economy, the Korean government has given priority to the development of innovative marine science and technology with corresponding policies, financing and other incentives. In 2004, MOMAF established the **Roadmap for Ocean-science Technologies Development**, which passed the deliberation process of NSTC for the first time. Based on the roadmap, a total of KRW3 trillion was scheduled to be invested in major 71 projects for the ocean-science technologies until 2013. In 2011, the Ministry of Land, Transport and Maritime Affairs (MLTM) established the **2020 Roadmap for Ocean-science Technologies Development**. In 2013, the Ministry of Ocean and Fisheries (MOF), which is the leading department on ocean and fisheries management including ocean-science, revised the *2020 Roadmap for Ocean-science Technologies Development* to include the fisheries resources management. In 2014, MOF established the **Medium and Long-term Plan for Ocean and Fisheries R&D (2014-2020)**, including fisheries as well as oceans, with the target of: (i) developing the world's leading technologies from 7 in 2013 to 20 in 2020, (ii) creating jobs in the marine and fisheries sector from 6,000 in 2013 to 78,000 in 2020, (iii) increasing the private sector R&D participation rate from 18% in 2013 to 40% in 2020.

The Korean government is also pursuing various programs for the sustainable development of coastal resources and space, such as marine spatial planning (MSP), coastal zone management (CZM), marine ecosystems and fishery resources management, and water quality and water resource management in line with the Korea Ocean Act, UN SDGs, SDS-SEA, and other international commitments and national enactments.

Table 13.1 show the status of Korea's ocean economy and ocean health, the pressures and challenges, and the response measures, such as policies and blue economy initiatives. The transformation from the traditional ocean economy to blue economy, by sector, is shown in **Table 13.2**.

Table 13.1: Summary: State of Ocean Economy and Ocean Health

Indicator	Status/Trend	Major issues and challenges	Response	
			Key policies/laws; Action Plans	Examples of best practices or blue economy initiatives
State of ocean economy				
Ocean economy	Increasing	• Development-oriented legal system • Lower priority of ocean policy • High labor cost of ocean industry	• Korea's Ocean Act • Basic Plan for Marine and Fisheries Development • Increasing R&D for ocean industry	• Ocean economy accounting and valuation of coastal and marine ecosystems • Sustainable fisheries • Ecotourism and MPAs • Green port • Ocean energy • Marine biotechnology • Deep seawater
Fisheries and Aquaculture	Fisheries: Decreasing	• Depleting fisheries resources • Overfishing • Foreign illegal fishing • High labor cost	• Fisheries Act • Fishery Resources Management Act • Fishery Resources Protection Act	• Sustainable fisheries: marine ranching; community-based fisheries; Fishery Resources Protection Areas; Total Allowable Catch (TAC) program
	Aquaculture: Increasing	• limited space • marine pollution: eutrophication, red tides • excessive use of feeds • biological contamination • introduced alien species • diseases and antibiotics • climate change	• National Plan for Aquaculture Development • Pollution reduction; wastewater management • Regulations for nearshore aquaculture	• Offshore aquaculture • Breeding and culturing of high-valued species • Seaweed farming has been industrialized
Marine and coastal tourism	Increasing	• Seasonality of beach tourism	• Basic Plan for Promoting Coastal Tourism • Marina Act • Korean South-Sea Tourism-Belt Development Project	• Ecotourism in Suncheon Bay, Jeju Island, Cheongsando Island • Ecotourism programs of local governments • Recreational fishing

Table 13.1: Summary: State of Ocean Economy and Ocean Health (cont.)

Indicator	Status/Trend	Major issues and challenges	Response	
			Key policies/laws; Action Plans	Examples of best practices or blue economy initiatives
State of ocean economy				
Ports and shipping	Increasing	• Port development, reclamation • Sand mining • Oil spills • Invasive species	• Shipping Act • Harbor Act • International Ship Registration Act • MARPOL, Ballast Water Convention, Stockholm Convention, other IMO Conventions • Basic Harbor Plan	• Green port (Busan) • Waterfront program • Introduced Environment Ship Index (ESI) to give incentive to eco-friendly vessels by reducing their entry/departure charges
Ship-building	Medium and large shipyards: No change; Small shipyards: Decreasing	• oversupply of the world shipyards • recession of the world economy	• R&D in shipbuilding industry for eco-friendly ships	
Marine biotechnology	Increasing	• Proportion of marine biotechnology R&D budget to total biotechnology R&D budget is small	• Marine Life Resources Act 2012 • Marine Biotechnology Development Basic Plan (Blue-Bio 2016) • Measures for Revitalizing Marine Bio R&D (2010-2014) • Established the National Marine Biodiversity Institute of Korea (MABIK) • Next-generation Marine Biotechnology Upbringing Strategy	• Support for the deployment and industrialization of R&D results, and marine biotechnology companies • Promotion of marine bio industry performance • Formation of marine bio-area network
Ocean energy	Increasing	• Impact on fisheries	• Sixth National Electricity Supply & Demand Basic Plan • Second National Energy Basic Plan • Mid- and Long-term Offshore Energy Development Plan (2015-2025) • Technology Development Project for Commercialization of Offshore Energy established by MOF and MOTIE • Fourth New Renewable Basic Plan • Renewable Energy Portfolio Standard	• 255MW at the Siwha Tidal Power Plant (2011) • 14.5MW at the Uldolmok Tidal Current Power Plant (2017) • Jeju Pilot Wave Energy Plant • 40MW at the Jangjook Tidal Current Power (2019) • 100MW at the Incheon Tidal Power Plant (2020) • offshore wind energy in the Jeju Island • variable Renewable Energy Certificate (REC) weights

Table 13.1: Summary: State of Ocean Economy and Ocean Health (cont.)

Indicator	Status/Trend	Major issues and challenges	Response	
			Key policies/laws; Action Plans	Examples of best practices or blue economy initiatives
State of ocean economy				
Employment in ocean economy	Increasing		• Comprehensive Measures to Promote New Marine Fisheries Industry • Strategy to Promote Industrialization of Marine Fisheries R&D • Strategy to Promote Business Start-up and Investment in Marine Fisheries	
Research, Development and Deployment (RD&D) in ocean economy	Increasing		• Roadmap for Ocean-science Technologies Development • Medium- and Long-term Plan for Ocean and Fisheries R&D (2014-2020)	• Offshore aquaculture • Ocean energy • Marine biotechnology • Deep seawater utilization
Mainstreaming of natural capital accounting	No change	• Access to data • Funding support		• Ocean economy accounting and valuation of coastal and marine ecosystems
State of ocean health				
Fish stocks	Decreasing	Reduction of habitat	• Fishery Resources Management Act	• Marine ranch program
Catch per unit	Decreasing	Overfishing; IUU fishing	• Fisheries Act	• TAC program • Vessel buy-back program
Beach	Decreasing	• Coastal development • Public access • Pollution	• Beach Use and Mgmt Act • CZM Act; CZM plans	• Coastal use zoning • Beach tourism • Coastal clean up
Mudflats; tidal flats; tidal marshes	Decreasing	• Coastal development • Reclamation • Loss of habitats • Pollution • Climate change	• Wetland Conservation Act • Basic Plan for Wetlands Conservation	• Designation of Wetlands Conservation Sites • Recognition of blue carbon – carbon sequestration value of tidal marshes
Rare, threatened and endangered species	---	• Coastal development • Loss of habitat • Pollution • Climate change	• Marine Ecosystem Conservation and Management Act • Yellow Sea Strategic Action Plan	• Designation of specific marine species for protection • Designation of Marine Protected Areas and Wetlands Conservation Sites

Table 13.1: Summary: State of Ocean Economy and Ocean Health (cont.)

Indicator	Status/Trend	Major issues and challenges	Response	
			Key policies/laws; Action Plans	Examples of best practices or blue economy initiatives
State of ocean health				
Marine water quality	Improved (compared to the 1970s-1980s) No change (recent years)	• Pollution from land- and sea-based sources • Pollution from nonpoint sources • Red tides • Eutrophication	• Marine Environment Management Act • Marine Environment Conservation Plan • Designation of Special Area Management; Special Area Management Plan • Complete prohibition of ocean dumping • Marine Debris Management Plan • National Oil Spill Response Plan	• Sewerage systems and wastewater treatment facilities • Solid waste management systems • Rehabilitation of four major rivers • Ongoing clean-up of Masan Bay
Marine protected areas (% of territorial waters)	Increasing	• Opposition of residents on designation of MPAs	• Marine Ecosystem Conservation and Management Act • Designation of MPAs	• Ecotourism in MPAs
Pressures, risks and threats				
Population growth in coastal areas	Increasing	• Dense coastal development	• Coastal Zone Management Act • CZM Plans	
IUU fishing	No change	• Foreign encroachment • Depletion of coastal resources	• Fisheries Act • Fishery Resources Management Act • Fishery Resources Protection Act • Increasing capability of Korea Coast Guard (KCG) to address IUU fishing	• TAC program • Vessel buy-back program
Coastal erosion and sedimentation	Increasing	• Coastal development • Sand mining	• CZM Act • Coastal Enhancement Program	
Untreated wastewater discharges	Decreasing	• Coastal development • Nonpoint sources • Inflow through rivers during rainfall	• Water Quality Management Act • Marine Environment Management Act • Marine Environment Conservation Plan • Coastal Total Pollutant Control	• Designation of Special Area Management; Special Area Management Plan • Sewerage systems and wastewater treatment facilities • Increased access and coverage of sanitation and wastewater management systems

Table 13.1: Summary: State of Ocean Economy and Ocean Health (cont.)

Indicator	Status/Trend	Major issues and challenges	Response	
			Key policies/laws; Action Plans	Examples of best practices or blue economy initiatives
Pressures, risks and threats				
Solid waste generation	Increasing	• Coastal development • Inflow through river during rainfall • Shortage of recycling facilities and sanitary landfill	• Wastes Control Act • Marine Environment Management Act • National Marine Debris Management Plan	• Implementation of waste separation and collection system
Plastic waste generation and marine debris	Increasing	• Inflow through river during rainfall • Increasing volume of unrecyclable waste • Microplastics in oceans	• Wastes Control Act • Marine Environment Management Act • National Marine Debris Management Plan	• Implementation of waste separation and collection system • Coastal clean up • Increasing awareness of public and NGOs on impacts to the marine environment
Oil spills	---	• Management of container ships, coastal tankers	• Marine Environment Management Act • National Oil Spill Response Plan	• Improving oil spill contingency and response capacity
Greenhouse gas emissions	---		• Clean Air Conservation Act • Framework Act on Low Carbon Green Growth	• Green port (reduction of GHG emissions in Busan Port) • Development of ocean energy and coastal/ offshore wind power
Natural hazards (storms, storm surge; flooding); **Climate change** (sea level rise; ocean acidification)	Increasing	• The overall sea surface temperature around the Korean Peninsula has risen by 0.93°C. The rate of increase is higher than global average. • Korea's sea level rise (2.5mm/yr) is above the world average (1.8mm/yr).	• Coastal Zone Enhancement Plan • Wetland Conservation Act • Basic Plan for Wetlands Conservation	• Bioeconomic modeling (to access impact of ocean acidification on fisheries) • Designation of Wetland Conservation Sites • Climate resilient infrastructure

Table 13.2: Developments in Blue Economy.

Ocean Economy	Blue Economy Initiatives
Fisheries and aquaculture • Domestic fisheries production has continuously decreased since 1980s. It stabilized at an annual average of 3 million tonnes for the past ten years. • **Pressures:** Depleting fisheries resources, Foreign illegal fishing, High labor cost in fishing	**Sustainable fisheries** • **Marine ranching** as a new system for fisheries production: involves installing artificial reefs and placing rubble and rocks on the seabed to form a foundation for ecosystems to develop; release of fish seeds to build up marine resources; improvement of habitats to maximize the value of fishing grounds; and establishment of systematic water management and valid user system to improve production. • **Community-based fisheries** resulted in increase of fisheries production, improvement of selling system and making brands of the fishing products, continuous increase of average fishermen's income. The fishing village cooperatives (*Ochonkye*) were established for the management of commonly-held fishing grounds and co-op facilities, and collective sale of produce. • Enactment for **offshore aquaculture**; National Plan for Aquaculture Development • **Policies on IUU fishing: Total allowable catch (TAC) program** as an output control, which regulates annual total amount of catch per species; **fishing permit and license; Vessel buy-back program** to reduce fishing vessels and address overfishing
Coastal and marine tourism • **Pressures:** seasonality; low priority of government; dual leading agencies	**Sustainable tourism** • **Ecotourism:** Suncheon Bay Eco-Park • **MPAs and ecotourism:** Cheongsando Island • Recreational sea fishing
Ports and shipping • RO Korea's economic system is based on importing raw materials and exporting finished goods, and about 99% of the cargo has been imported and exported by marine transportation. • **Pressures:** port development; sand mining; shipping accidents; oil spills; ballast water	**Sustainable ports** • **Green port:** Busan - 92 units of Diesel-RTGC converted to e-RTGC (energy and expenses reduced by 90%, GHG reduced by 74%) - 150 units of Diesel-Y/T being replaced by LNG-Y/T by 2020 (reducing greenhouse gas (GHG) emissions by 38%) - 23,568 indoor lighting devices changed to LED (reduced GHG by 1,203 tons) and commitment to change 100% of indoor lighting system to LED by 2020 - In 2014, Environment Ship Index (ESI) was introduced, providing 15% reduction in entry/departure charges to eco-friendly vessels (In 2014, 423 eco-friendly vessels called, and KRW 603 million (approximately US$ 600,000) in reduced entry/departure charges was achieved.) • **Waterfront program** • **National Oil Spill Response Plan** • **Enabling environmental policies and laws:** Framework Act on Low Carbon Green Growth; Harbor Act; Marine Environment Management Act; Sustainable Transportation Logistics Development Act; Clean Air Conservation Act

Table 13.2: Developments in Blue Economy. (cont.)

Ocean Economy	Blue Economy Initiatives
Energy	**Marine renewable energy** • Technology Development Project for Commercialization of Offshore Energy established by the Ministry of Ocean and Fisheries (tidal power energy, tidal current energy, wave power energy, and ocean thermal energy conversion) and Ministry of Trade, Industry and Energy (offshore wind energy). • The 254-megawatt (MW) **Sihwa Lake Tidal Power Plant** is the largest in the world. It also enhanced the economy by forming waterfront and tourist attraction. The annual power production of 552 GW has reduced CO2 emissions by 315,000 tonnes annually, and has oil import substitution effects of 862,000 barrels a year, which improves the energy self-sufficiency of the country. • **Offshore wind energy**: ten sites, including the Saemangeum Estuary, for the offshore wind energy development are under the stage of planning • Incentives: Feed-in-tariff (FiT) supports the tidal barrage power; Renewable Energy Certificate (REC) with variable weights; Renewable Energy Portfolio Standard
Water	• **Desalination** • **Deep seawater utilization** • **Rainwater harvesting**
Manufacturing of chemicals and pharmaceuticals	**Marine biotechnology – for food, chemicals, and medicines** • In 2013, MOF established the National Marine Biodiversity Institute of Korea (MABIK). • The domestic marine biotechnology market is expected to grow more than 14% annually from $70 million in 2012 to $360 million in 2020, which will share 5% of the world marine biotechnology market.
Pressures: pollution from land- and sea-based sources, marine debris	**Pollution reduction** • Complete prohibition of ocean dumping • Coastal Total Pollutant Control System • Special Area Management Plan (SAMP) • Sewerage systems and wastewater treatment facilities • Coastal Enhancement Program to address coastal erosion and sedimentation • Solid waste management: Implementation of waste separation and collection system • National Marine Debris Management Plan • National Oil Spill Response Plan
Pressures: Fisheries habitats, such as wetland and coastal waters, have been greatly lost due to coastal development.	**Habitat restoration and management** • ICM and coastal zone management (CZM) plans and programs • Designation of marine protected areas; Wetlands Conservation Sites; Fisheries Resources Protection Areas • MPAs and ecotourism • Yellow Sea Strategic Action Plan

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