Korea’s Marine Spatial Management based on Ocean data for a sustainable future
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Ⅰ Challenges to Ocean, How to Respond?

Ⅱ Marine Data for MSP

Ⅲ Future plans: Digital twin & Simulator
I. Challenges to Ocean, How to Respond?

1. Marine Spatial Planning for Sustainability

Marine space faces various problems due to increased demand for use for multiple activities, climate change, rising sea levels, and changes in the marine ecosystem.

To respond to this, the UN Sustainable Development Goal 14 (UN SDG 14) seeks to ensure sustainability below water by 2020 (Skovgaard, 2021).

Marine Spatial Planning can be one way of achieving the UN SDG 14. The objective of MSP is to promote the sustainable growth of maritime economies, the sustainable development of marine areas, and the sustainable use of marine resources” (European Commission, 2014).

Korea’s Ministry of Oceans and Fisheries adopted marine spatial planning as a policy tool to manage its water sustainably.

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1. Challenges to Ocean, How to Respond?

2. Progress in the establishment of the MSP policy system in Korea

- MOF, MSP T/F formation
- Preparation of integrated basic plan for marine & fisheries information system
- Pilot Project – MSP of Gyeonggi Bay
- Reflecting MSP in Core government tasks
- Roadmap for establishment of MSP in all areas
- Preparation for enactment of the 「Act on Marine Spatial Planning and Management」
- Enactment of the Act on Marine Spatial Planning and Management
- Enforcement of the Act
- Establishment of the Marine Spatial Policy Department of the MOF
- Enactment of enforcement decree, enforcement rules, and a number of administrative rules of MSP
- Establishment and announcement of the 1st marine space basic plan
- Establishment of Marine Spatial Management Plan – Busan
- Establishment of Marine Spatial Management Plan – Gyeonggi, Incheon, Gyeongnam, Jeju
- Establishment of Marine Spatial Management Plan – Chungnam, Gangwon, Ulsan, Jeonnam, Jeonbuk, Geonbuk
- Establishment of the 1st marine space management plan for all sea areas completed
I. Challenges to Ocean, **How to Respond?**

2. Act on Marine Spatial Planning and Management (2018)

1. **Main Contents of the Act on MSP**

After the enactment of Act on Marine Spatial Planning and Management (2019), the establishment of Marine Spatial Management Plans (MSMP) for the entire sea area is completed (2022)

**MSMP’s designation of 9 marine use zones**
Fishery activity protection zones, Aggregate and mineral resource development zones; Energy development zones, Marine tourism zones, Environment and ecosystem management zones, Research and education conservation zones, Port and navigation zones, Military action zones, Safety management zones

**Establishment of Integrated Marine Spatial Information System**
>> Data platform

**Marine Spatial Suitability Assessment**
Evaluate whether new plans to use marine space are sustainable and appropriate for the characteristics of the target maritime area (about 300 cases per year)
I. Challenges to Ocean, How to Respond?

2. Act on Marine Spatial Planning and Management (2018)

② Ocean Data for MSP

Korea’s MSP system is an evolution of the Integrated Coastal Zone Management system. The difference is that the level of spatial analysis based on the marine data platform has improved.

<table>
<thead>
<tr>
<th>Before 2018</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COAST MANAGEMENT ACT</strong></td>
<td><strong>ACT ON MARINE SPATIAL PLANNING AND MANAGEMENT</strong></td>
</tr>
<tr>
<td>Coastal area(in 12NM water, 500m from coastline Land)</td>
<td>Territorial water, including EEZ, CS</td>
</tr>
<tr>
<td>Plans for Coastal Management Areas</td>
<td>Marine Spatial Management Plan</td>
</tr>
<tr>
<td>heads of City, County, District (Lower-level local government)</td>
<td>The Minister of Oceans and Fisheries and Metropolitan city Mayors, Province Governors</td>
</tr>
<tr>
<td>Planner collected data by individually verifying its location and production organization</td>
<td>Information collection, integration(API, EAI, sFTP, search, and use through integrated marine spatial information system(Platform))</td>
</tr>
<tr>
<td>Limited information (difficulty using spatial information, Non-spatialized data, past information not updated) Simple overlay Reflect already designated areas(port, farm, MPA..) Setting Priority to overlapped marine zones</td>
<td>Improved analysis techniques, data periodically updated from production organizations through database. Identify the actual space usage status(e.g., ship movement information) and reflect it in zoning. Designate a management zone when overlapped uses by conflict analysis.</td>
</tr>
</tbody>
</table>
Ⅱ. Marine Data for MSP

1. The Marine Data System Development

Establishment of a foundation for integrated maritime and fishery information (big data) and supporting services for marine spatial planning and management through analysis of maritime and fishery information (‘18~’22)

Key Tasks

- To Strengthen maritime and fishery information management
- To Establish a foundation for providing marine and fisheries information
- To Implement intelligent administration centered on participation and collaboration

- Integrate and manage data distributed and contained across various organizations
- Create standards to promote data linkage, open access, and use
- Expanding marine spatial information from territorial waters to the EEZ area
- Structured and unstructured Big Data collection and linked analysis
- Support comprehensive analysis function using fusion information
- Support for establishing marine management plans
- Establishment of a foundation for integrated management of maritime space
- Establishment of a marine spatial information management system

<table>
<thead>
<tr>
<th>1단계 (2018년~)</th>
<th>2단계 (2019년~)</th>
<th>3단계 (2020년~)</th>
<th>4단계 (2021년~)</th>
<th>5단계 (2022년)</th>
</tr>
</thead>
<tbody>
<tr>
<td>해양수산박테이터 공동활용 기본가이드</td>
<td>해양수산정보 통합DB구축 및 서비스기반 연속정보생산</td>
<td>해양공간통합관리업무지원 응용데이터생산</td>
<td>빅데이터분석모델 확산</td>
<td>해양수산공통기반 안전화</td>
</tr>
</tbody>
</table>
II. Marine Data for MSP

2. Marine Data System Concept
### 3. Dataset of the Marine Data System

<table>
<thead>
<tr>
<th>Field</th>
<th>Key Information</th>
<th>Amount</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ocean</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marine industry</td>
<td>Marina, trails, festivals, observatories, government offices, ticket offices,</td>
<td>241</td>
<td></td>
</tr>
<tr>
<td></td>
<td>museums, arboretum, showers, recreational fishing grounds, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marine environment</td>
<td>Marine ecology map, marine debris, marine environment theme map, marine protected</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>organisms, use of public water points, public water reclamation, beach</td>
<td></td>
<td>*283 types of core information and 487 types of general information to support integrated marine space</td>
</tr>
<tr>
<td></td>
<td>environment information, etc.</td>
<td></td>
<td>management*</td>
</tr>
<tr>
<td>Deep-sea fishery</td>
<td>deep-sea fishing information, deep-sea fishing operation status</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><strong>Fishery</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marine fisheries</td>
<td>Comprehensive information by fish species, marine product processing, fishing</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>performance report, production area commission information, fishery direct</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>payment system information, sea salt history information, marine product</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>history tracking management information, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fishing resources</td>
<td>Sea forest, coastal fishing resources, fishing industry, sea forest seaweed</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td></td>
<td>information, sea ranch, protected water, seagrass, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fishing &amp;</td>
<td>Fish farm, fishing village fishing port information, fishing ground</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>aquaculture</td>
<td>information, red tide news, fishing ground information map, sea fish condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>information, jellyfish alarm, national fishing port information, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Shipping &amp;</strong></td>
<td>passenger ship, ship information, passenger terminal, shipping business</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td><strong>transportation</strong></td>
<td>information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shipping logistics</td>
<td>Marina vessel information, marina arrival and departure information, port</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td></td>
<td>operation information, dry dock, secondary dock, trade port, coastal port,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>floating bridge, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Port operation</td>
<td>Rocks which covers and uncovers, exposed rock, whirlpool, anchorage, no signal,</td>
<td>161</td>
<td></td>
</tr>
<tr>
<td></td>
<td>lighthouse, signal station, Channel, pilot boarding and disembarkation area,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maritime safety</td>
<td>etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maritime safety</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Port</td>
<td>Port construction Port hinterland complex, new port area, marina port</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>facilities, port underground facility information, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common</td>
<td>total population, building information, country indicators, real estate</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>administrative</td>
<td>statistical information, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>770</td>
<td></td>
</tr>
</tbody>
</table>
**II. Marine Data for MSP**

4. Evaluation of marine spatial characteristics and setting of use zones using marine data

### Steps to prepare marine space management plan (draft)

<table>
<thead>
<tr>
<th>Research &amp; analysis</th>
<th>Evaluation</th>
<th>Marine use zoning</th>
<th>Management plan (draft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set up policy direction</td>
<td>Produce score map</td>
<td>Drawing Map</td>
<td></td>
</tr>
</tbody>
</table>

### Summary of evaluation procedures

<table>
<thead>
<tr>
<th>Set up evaluation items by marine use</th>
<th>Develop grid</th>
<th>Individual score map</th>
<th>Comprehensive score map (converted from individual score map)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score map for 9 different marine uses (a value between 0 and 1)</td>
<td>Score is assigned to the grid that contains individual evaluation item (a value between 0 and 1)</td>
<td>Default: 3-minute interval grid After adjustment: 1.5-minute interval grid</td>
<td></td>
</tr>
</tbody>
</table>

Formation and operation of Regional Council on marine space management
II. Marine Data for MSP

4. Evaluation of marine spatial characteristics and setting of use zones using marine data

**Marine use zone procedure (draft)**

**STEP 1**
Identify key marine activity areas for each marine use zone based on the results from evaluating marine spatial characteristics.

**STEP 2**
Review and reflect Article 3 and 4 of Act on Marine Spatial Planning Addenda(functional areas/statutory zones)

**STEP 3**
Determine marine use zones, considering designation criteria according to regulations (characteristics, use, status of marine space/statutory areas)

**STEP 4**
Identify conflicts between activities in marine space and adjust marine use zones (give priority)

**STEP 5**
Comprehensively consider the steps 1 to 4 results to decide the final draft marine use zone.

**Analysis of high-volume and continuous data**

Processing of high-volume and continuous data is to identify the distribution of spatial activities of ships using the target area. It collects static and dynamic data for ship movement, fishing activity areas, location-based fishing volume, and dense traffic areas. It develops them into spatial information with unit data, producing various heat maps for characteristic evaluation and analysis.
Ⅱ. Marine Data for MSP

5. Pre-Post Comparison  Fishery Activity Protection Zone

Plans for Coastal Management Areas reflects only areas for which rights have been established or permitted under other laws to determine use (e.g., aquaculture area, fishing port area, fisheries resource protection area, etc.)

Marine spatial planning decides on marine use zones by analyzing statutory data and accumulated status information (Fishing vessel track, Density of traffic volume, Conflict area against other activities, Fish Catch density, etc.).
### Future plans: Digital twin & Simulator

1. Limitations of the current system - Lack of key information to reduce uncertainty in decision-making considering future changes

- A system for analysis of marine spatial information and scenario-based predictive evaluation is required to support the frequent establishment and implementation of marine spatial management plans (designation and change of marine use zones) of cities/provinces.

- Marine spatial management plans currently under development do not consider various "what if" scenarios to determine marine use zones. (past status data and statutory areas are dominating to other information)

- Suitability is determined based on the report paper prepared by the developer (lack of alternative basis for determination during the review)

- The use of analytical information is still limited, utilizing the spatial density and distribution of activities such as fishing and tourism through VPASS data analysis.

* Though this is data on the past-current status, it can be used as the basis for various predictive evaluations using big data. Therefore, it is essential to build a system to utilize such data
Ⅲ. Future plans: Digital twin & Simulator

2. Marine Digital Twin?

- **Concept of Digital Twin**
  - Reproduce realistic cities or factories
  - Simulation in progress
  - Virtual space
  - Clear feedback
  - Real-time data collection
  - Real space

- **Benefits?**
  - Reducing Cost & Time for Policy Decision making
  - Testing for risk management

- **Digital Twin of the Ocean Project (DITTO)**
  - What is the most cost effective option to mitigate the coastal impact of sea level rise?
  - EU has built prototype for marine digital twin focusing on DITTO

- **DTO content**
### III. Future plans: Digital twin & Simulator


| Ultimate goal | Development of intelligent marine-space policy simulation technology based on the marine digital platform for maritime activity prediction and analysis of spatial changes and policies according to scenarios and development of plans to improve technology to support policies |
| Focal points of research | Present directions for development/use of analysis on requirements for digital twin-based policy simulator  
Development and pilot use of sectoral marine policy scenarios and evaluation indicators  
Development and validation of a digital twin-based policy simulator |

| Segment 1 | Analysis of needs for MSP simulator by police officers and related experts; Case studies |
| Segment 2 | Development of policy support toolkit and policy simulator validation and utilization technology |
| Segment 3 | Development of policy support scenario and its utilization technology |

<table>
<thead>
<tr>
<th></th>
<th>Segment 1</th>
<th>Segment 2</th>
<th>Segment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Analysis of needs for MSP simulator by police officers and related experts; Case studies</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Phase 1</th>
<th>Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st year</td>
<td>2nd year</td>
<td>3rd year</td>
</tr>
<tr>
<td>4th year</td>
<td>5th year</td>
<td></td>
</tr>
</tbody>
</table>

| Current direction | Establish agendas and development direction | Develop scenarios and analysis engine, etc. | Promote simulator development and pilot research |
| New | Setting the direction for development of policy support functions | Develop technology to support spatial plan changes (automation of GIS-based analysis for characteristic evaluation and use zone designation) | Develop analysis technology for spatial planning evaluation (develop a simulator to evaluate use suitability and demand for changes) |
| Implementation on integrated marine space management information system for immediate use | Implementation on digital twin system |
Ⅲ. Future plans: **Digital twin & Simulator**


### Objectives

**Support optimal decision-making through scientific prediction and simulation before making decision on marine-space policies**

Prepare for uncertainties in marine spaces and reduce conflicts regarding use and development of marine spaces

#### Policy objectives

- **Analysis**
  - Identify risks and opportunities
- **Response**
  - Mitigation/recovery/emergency response
- **Decision-making**
  - Optimal decision-making for alternatives

- Data collection and analysis
- Modeling
- Influence Factor, elements
- Identify future conditions and events through simulation
- Determine definitions and identification methods
- Scenario development and its application in decision-making

- Develop mitigation technology
- Develop recovery technology
- Capacity building for emergency response
Ⅲ. Future plans: Digital twin & Simulator
### Future plans: Digital twin & Simulator

**Marine Spatial Policy Simulator Example**

**Simulator to analyze prospective needs and conflicts caused by vessel activities**

- **Demand for analysis of traffic characteristics and conflicts with other activities to be caused by vessel activities using big data**
  - Identify detailed navigation characteristics and determine navigation zones based on the latest information by ship type/season (periodical updates of GICOM data)
  - Analyze conflicts with other activities to be caused by vessel activities and coordinate scenario-based zones using navigation information
  - Identify prospective navigation areas through big data-based prediction of future traffic changes

- **Density analysis using wake data and quantitative evaluation of navigation characteristics**
  - Traffic characteristics of main/branch lines
  - Traffic density grade by vessel type
  - Various criteria/methods for density analysis

- **Analyze and coordinate conflicts based on scenarios**

- **Predict potential traffic changes using big data**

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**Gyeokpo Port ↔ Wido Port route**

**Nearby Yuldo Island and Byeokpa Port**

**Geumodo Island ↔ Dolsando Island route**

**Dumido Island, Tongyeong ↔ Yokjido Island route**
Ⅲ. Future plans: **Digital twin & Simulator**

**Marine Spatial Policy Simulator Example**

**Simulator to assess impact on physical environment from use and development (What if)**

For coastal environment/safety, it is critical to conduct predictive analysis of environmental impact from use and development due to sea level rise and climate change:

- Assess the impact on the physical environment according to the scenario depending on characteristics of sea area and development type in conjunction with a geosystem prediction model for quasi-real-time wave observation information and sea level rise.
- Provide standards for optimal model application by comparing related sediment movement, Suspended Solids Diffusion models.

### Configuration of coastal numerical modeling

**Composition and outline of predictive numerical model**

- Numerical models typically consist of Wave and Flow modules.
- Prediction from Flow module enables prediction of sediment movement (floating sand diffusion).

1. Set up the model grid
2. Bathymetric data
3. Physical factors
   - Fluid density
   - Floor friction coefficient
   - Sediment size/density
   - Sediment movement coefficient
4. Numerical factors
5. Boundary conditions
   - Water level
   - Harmonic constant
   - Fluid outflow, etc...

### Suspended Solids Diffusion and sediment prediction model system

**Short-term area model**

- Short-term prediction of floating sand/sediment from typhoon and storm, and prediction of terrain changes

**Mid-term area model**

- Prediction of seasonal and year-round floating sand diffusion and prediction of terrain changes

**Long-term coastline model**

- Long-term prediction of floating sand/sediment diffusion and prediction of coastline changes

**Coastal diffusion and sediment change prediction package**

- Software tools for analyzing coastal dynamics:
  - Xbeach model
  - Delft3D model
  - Unibest-CL+ model
III. Future plans: Digital twin & Simulator

Marine Spatial Policy Simulator Example

Marine space monitoring and management simulator (Detecting changes in coastline and fishfarm)

- It is difficult to check whether actual activities in marine spaces are under appropriate statutory plans, consultation, evaluation, and permission.
- Monitoring and managing whether marine activities occur under marine spatial policy is necessary.

- Monitor and analyze maritime activity state through quasi-real-time image data (satellite, aviation) analysis technology.
- Determine the appropriateness of marine space use and development under the initial plan and monitor illegal activities and changes in the surrounding environment resulting from marine space use and development.
THANK YOU

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