

# The Four Dimensional Connotation Definition of Scientific Understanding of the Ocean and Human Practical Achievements

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## Abstract

By analyzing the sustainable development process of strengthening marine environmental protection and global reporting and assessment of marine environmental conditions since the Human Environment Conference, this paper summarizes the scientific connotation of “scientific understanding of the ocean” reflected in the United Nations Global Marine Environmental Assessment Report, proposes the etymological definition and specific coverage, representative global and regional practical experience of scientific understanding of the ocean, and further analyzes and defines the human activities and cognitive evolution process of “scientific understanding of the ocean”. It marks the leap in human cognition in four dimensions: observation and evaluation, intervention and regulation, disciplinary knowledge system, and supporting guarantee system. It condenses the connotation definitions and human practical achievements of each dimension, and puts forward countermeasures and suggestions to strengthen marine environmental protection and sustainable development.

## Keywords

Scientific Understanding of the Ocean, Assessment of Marine Environmental States, Sustainable Development, Marine Environmental Protection

## 1. Introduction

The United Nations held a conference on the human environment in Stockholm, the capital of Sweden, in 1972. In its recommendations on the prevention and control of marine pollution, it acknowledged the shortcomings of existing systems and emphasized the need for a more comprehensive approach to protect the

marine environment and avoid various forms of degradation. The provisions of the 1982 United Nations Convention on the Law of the Sea [1], particularly Part XII, attempted for the first time to establish a general framework for a legal system that establishes the obligations, responsibilities, and rights of all countries in marine environmental protection matters on a global scale. The United Nations held the World Summit on Sustainable Development in Johannesburg, the capital of South Africa, in 2002. Based on the consideration that environmental, social, and economic sustainable development should not ignore the coverage of 70% of the Earth's oceans, the following recommendations were made: there should be a regular process to globally report and assess the states of the marine environment, including socio-economic aspects [2]. This suggestion has been adopted by the United Nations [3].

Although Part XIII of the United Nations Convention on the Law of the Sea proposes that countries should cooperate in marine scientific research based on the fundamental understanding of science as the marine environment, the 2017 and 2020 United Nations First and Second Marine Environmental Assessment Reports specifically set up chapters on scientific understanding of the ocean [4]-[6], and the UNESCO Intergovernmental Oceanographic Commission Global Marine Science Report identified and classified eight disciplinary classifications for global marine scientific research [7], so far there has been no clear definition of the connotation of "scientific understanding of the ocean". On the basis of summarizing previous related work, the author has proposed a etymological definition and specific coverage of scientific understanding of the ocean. Representative global and regional practical experiences have been analyzed through corresponding examples, and the human cognitive leap process in four dimensions of observation and evaluation, intervention and regulation, disciplinary knowledge system, and supporting guarantee system has been identified. The connotation definitions and human practical achievements of each dimension, as well as the interdependence and correlation between them have been condensed, in order to provide scientific basis support for the construction of a scientific, systematic, applicable, and effective sustainable development system for a community with a shared future for mankind and the ocean.

## **2. The Scientific Connotation of Global Marine Environmental States Assessment**

Since 2002, the United Nations has successively organized and launched relevant assessment work, including pre assessment of assessments, establishment of all AD HOC working groups and expert pool, and recommending and conducting routine global assessments of the states of the marine environment, such as the first and second phases.

### **2.1. The First World Ocean Assessment**

The first global assessment of the state of the marine environment organized by

the United Nations adopted a comprehensive evaluation method, which evaluates the main ecosystem services of the marine environment, and conducts sub evaluations of related food security and safety, other human activities and their impacts on the marine environment, marine biodiversity and habitat status, and then comprehensively evaluates the impact of humans on the marine environment and the comprehensive value of the ocean to humans [8]. From the overall framework and main chapter settings of the assessment report (Figure 1), it can be seen that its scientific connotation related to “scientific understanding of the ocean” is specifically reflected in:

1) Elaborated on the key factors, interrelationships, and evolutionary status of the marine environment and its ecosystem services, as well as the corresponding impacts of human activities, and related scientific evidence.

2) In order to achieve a scientific, comprehensive, and effective evaluation of the trends and consequences of impact, the gaps in scientific cognition and research, socio-economic development, and capacity building were analyzed, and improvement suggestions were proposed.

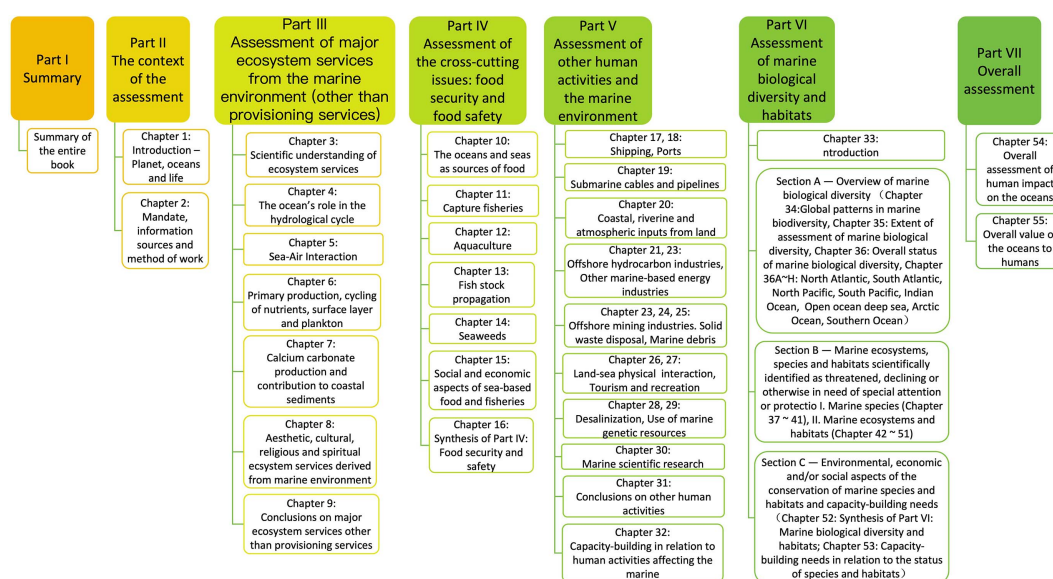


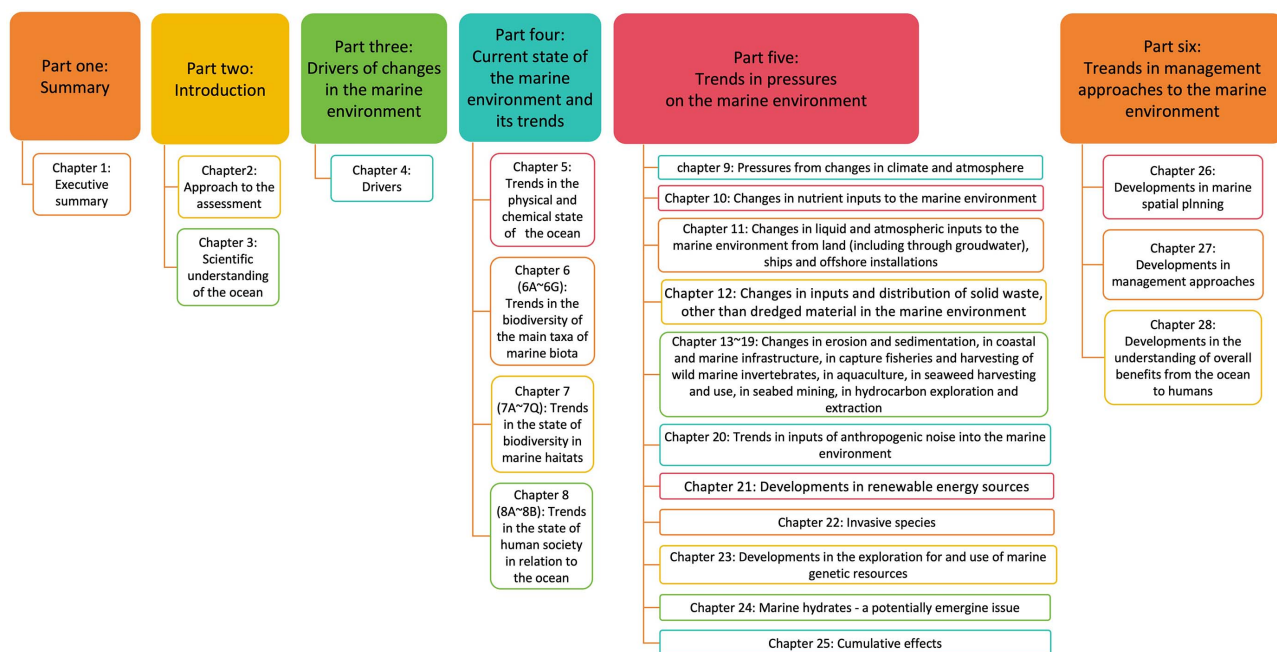
Figure 1. Overall framework and main chapter settings of the First World Ocean Assessment Report.

## 2.2. The Second World Ocean Assessment

The second world ocean assessment organized by the United Nations focuses on analyzing the changes in the state of the marine environment and its related assessments since the first assessment, and further highlights the role of using the DPSIR (Drivers Pressure States Impact Response) comprehensive assessment method to provide scientific decision support for the United Nations and its member states to scientifically understand the ocean and formulate ecological protection measures. From the main chapter settings of the second global assessment of the state of the marine environment report (Figure 2) and its layout in the DPSIR comprehensive assessment system (Table 1), it can be seen that its scientific

connotation related to “scientific understanding of the ocean” is specifically reflected in:

- 1) More prominent empirical observations, causal relationships, environmental conditions, and trend analysis of the causes, processes, and consequences of the impact of human survival and development on the marine environment;
- 2) Conducted an assessment of the needs, goals, and contributions of sustainable development, as well as the status and countermeasures of human positive response actions in scientific understanding of the ocean and strengthening ecological management;
- 3) Analyzed the progress and gaps in scientific cognition, socio-economic development, and capacity building, and proposed improvement suggestions.



**Figure 2.** Overall framework and main chapter settings of the Second World Ocean Assessment Report.

**Table 1.** Layout of main chapters in the DPSIR comprehensive assessment system of the second global marine environment assessment report.

Types in DPSIR system	Main chapters of the marine environment assessment report					
Driver D	Chapter 4: Changes Driven by Marine Environment, Including Population, Food, Resource Utilization, Sustainable Development Goals, Energy, Transportation, Leisure and Entertainment, Cultural Needs and Aspirations, Contributions					
Pressure P & Impact I (I)	Chapter 9: Pressure changes from climate and atmosphere	Chapters 10 - 12: Changes in input of various substances	Chapter 13: Changes in erosion and sedimentation	Chapter 14: Changes in Coastal and Marine Infrastructure	Chapters 15 - 18: Changes in Fisheries and Products	Chapters 19: Changes in underwater mining, oil and gas exploration, and extraction

## Continued

Pressure P & Impact I (II)	Chapter 21: Renewable Energy and Marine Hydrates	Chapter 24: Marine hydrates—a potentially emerging issue	Chapter 22: Invasive species including ballast water	Chapter 23: Development and utilization of marine genetic resources	Chapter 21: Trend of artificial noise input	Chapter 25: Cumulative impact
States S	Chapter 5: Trends in Physical and Chemical States: Surface and Deep Temperature, sea level, sea ice, salinity, ocean circulation, Chemistry includes acidification and dissolved oxygen			Chapters 6 and 7: The development trend of marine biodiversity	Chapter 8: The relationship between human society and the ocean	
Response R	Chapter 3: Scientific understanding of the ocean includes research	Chapter 26: Ocean Space Management and Development	Chapter 27: Development Management Methods	Chapter 28: Developments in the understanding of overall benefits from the ocean to humans		

### 3. Scientific Understanding of the Definition and Scope of the Ocean

#### 3.1. Etymological Definition and Coverage, Global and Regional Practical Experience

The author believes that from the etymological definition, “scientific understanding of the ocean” generally refers to the cognitive ability of human beings to the ocean, the related objective world that is interrelated with the survival and development of human beings, and the internal laws therein, as well as the relevant activities carried out, and the knowledge and discipline system constructed. Furthermore, from the perspective of the process of marine environmental protection and sustainable development related to the prevention and control of marine pollution and the avoidance of various forms of degradation since the United Nations Conference on the Human Environment in 1972, the above cognitive abilities, related activities, knowledge, and scientific research system specifically cover but are not limited to the following content and practical experience:

1) According to the United Nations Convention on the Law of the Sea, “science” is regarded as the fundamental understanding of the marine environment, and “marine scientific research” is an important matter that countries should cooperate on. Countries have the obligation to protect and preserve the marine environment, and should actively participate in regional and global programs to assess the nature and scope of marine pollution or degradation, and strive to observe, measure, estimate, and analyze the risks or impacts of marine environmental degradation using recognized scientific methods. It is necessary to provide appropriate assistance to developing countries in preparing environmental assessments.

2) The United Nations has promoted the regular process of global reporting and assessment of the state of the marine environment, including socio-economic

aspects, from the perspective of environmental, social, and economic sustainable development. It has established a DPSIR comprehensive assessment system that links the state of the marine environment with human socio-economic development. This system specifically reflects the relationship between human activities driving, putting pressure on the marine environment, causing changes in the state of the marine environment, forming various forms of adverse effects, and human taking active response actions to avoid and mitigate adverse effects and achieve sustainable development, as well as the assessment of the actual situation, including the assessment and gap analysis of knowledge and capacity building related to scientific understanding of the ocean, socio-economic development, and other aspects, and policy recommendations.

3) The Global Ocean Science Report of the Intergovernmental Oceanographic Commission of UNESCO identifies and categorizes eight disciplinary classifications of global ocean science research, including: marine ecosystem functions and processes, ocean and climate, ocean crust and marine geological hazards, blue growth, ocean health, human health and well-being, ocean technology and engineering, ocean observation and ocean data. It reports on the human, material, and financial resources of ocean science research in various countries, as well as the scientific contributions of published papers [9].

4) The United Nations' 2030 Agenda for Sustainable Development was officially launched on January 1, 2016 [10], calling on countries to take action and strive to achieve 17 sustainable development goals in the next 15 years, in which the Goal 14 is to protect and sustainably utilize the ocean and its resources to promote sustainable development. Relevant data indicates that ocean temperature, composition, ocean currents, and life drive the Earth system. Rainwater, drinking water, weather, climate, coastlines, food, and oxygen in the air are ultimately provided and regulated by the ocean. The ocean has always been an important channel for trade and transportation, and managing this important global resource is a major aspect of building a sustainable future. Protecting and managing ocean resources faces many serious challenges such as pollution, depletion of fisheries, and loss of coastal habitats.

5) During the implementation of the second global assessment of the state of the marine environment, the United Nations organized multiple regional seminars in different regions and held multi stakeholder dialogues and capacity building workshops at the United Nations headquarters. The latest progress and successful experiences were introduced at the national, regional, and global levels, including the construction of a marine resource management system, the establishment of marine protected areas, addressing challenges such as invasive alien species, plastic pollution, and climate change, conducting comprehensive regional pollution prevention and control, international exchange activities on marine themes, strengthening multi stakeholder exchanges and achievement linkage in scientific assessment and decision-making, and enhancing relevant capacity building.

### 3.2. Definition of Four Dimensional Connotation and Achievements in Human Practice

Based on the analysis of the above etymological definitions and their contents, the author further analyzes and defines the human activities and cognitive evolution process of “scientific understanding of the ocean”, and identifies the cognitive leap process of human beings from traditional marine scientific research to the “observation and evaluation” dimension of the marine environment, including observation, monitoring, investigation, simulation, prediction, and evaluation of the current status, evolution laws and trends of the marine environment, as well as various influencing factors. It is also identified a new dimension of cognitive leap process, i.e. the conscious “intervention and regulation” of human behavior to achieve sustainable development, utilization and protection of the ocean and marine resources, and the service functions provided to humans. It is also identified another new dimension of cognitive leap process of comprehensive cross integration of theoretical and technological methods, i.e. the synchronous formation and continuous improvement for “disciplines and knowledge systems” by humans in related natural, engineering, social, economic and management aspects. And it is further marked the awakening and action of human beings to establish, improve, and operate a “supporting guarantee system” to achieve the above goals, including policies, regulations, systems, cooperation, talent, equipment, infrastructure, data and model platforms, publicity and education, etc. It has opened up a new cognitive leap process in the dimensions of multi stakeholder and capacity building. The identifications of the leap of human cognition in the above four aspects demonstrate the connotation, definition, and practical achievements of human “scientific understanding of the ocean” from different dimensions. The four dimensions have interdependent relationships and independently reflect their respective development characteristics. The specific relationships are as follows:

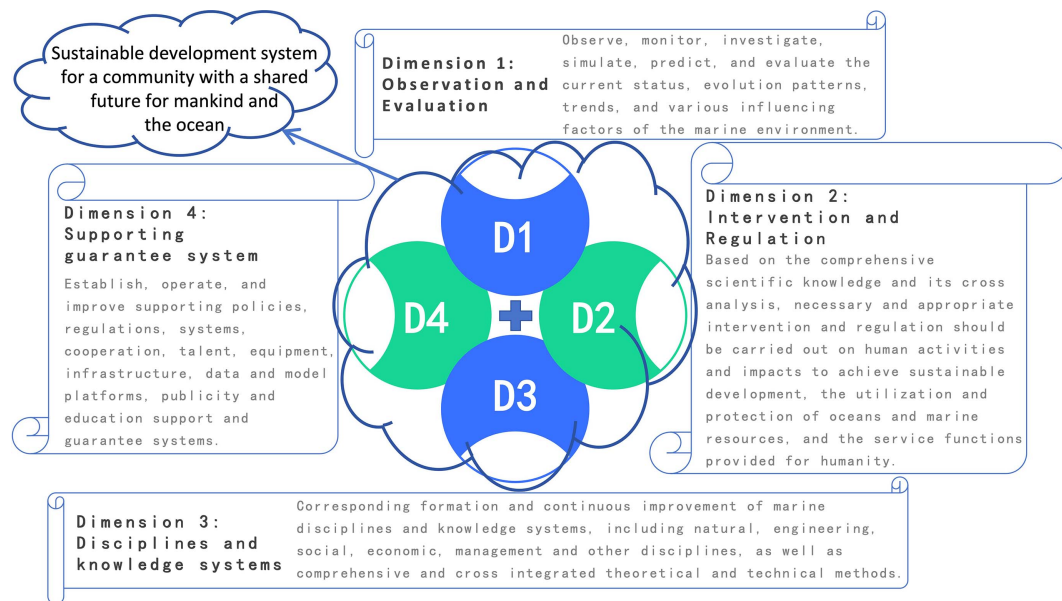
1) By observing and evaluating the marine environment in Dimension 1, we can grasp the current situation and evolution, and provide scientific decision-making basis for necessary intervention and regulation of human activities in Dimension 2.

2) Through Dimension 1 “Observation and Evaluation” and Dimension 2 “Intervention and Regulation”, the related “Discipline and Knowledge system” of Dimension 3 has been synchronously formed and continuously improved, further supporting the continuous development and improvement of Dimensions 1 and Dimensions 2.

3) Through the creation and development of Dimension 4 “Supporting Guarantee System”, provide supporting guarantees for the sustainable development of Dimension 1 “Observation and Evaluation”, Dimension 2 “Intervention and Regulation”, and Dimension 3 “Discipline and Knowledge System”.

4) Under the condition of sustainable and healthy development in all four dimensions, and with mutual support and organic integration, it can be achieved to

provide scientific decision-making support for the comprehensive construction of a scientific, systematic, applicable, and effective sustainable development system for a community with a shared future for mankind and the ocean (Figure 3).



**Figure 3.** Definition of the four dimensional connotation of “scientific understanding of the ocean” and achievements in human practice.

## 4. Conclusions

Since the 1972 Conference on the Human Environment in the past 50 years, compared to traditional marine scientific research, humans have made cognitive leaps and practical achievements in the four dimensions of “scientific understanding of the ocean” in the process of strengthening marine environmental protection and global reporting and assessment of marine environmental conditions for sustainable development, including:

Dimension 1: Observation and Evaluation: Observing, monitoring, investigating, simulating, predicting, and evaluating the current status, evolution patterns, trends, and various influencing factors of the marine environment.

Dimension 2: Intervention and Regulation: Based on the comprehensive scientific knowledge and cross analysis mentioned above, necessary and appropriate intervention and regulation should be carried out on human activities and impacts to achieve sustainable development, the utilization and protection of oceans and marine resources, and the service functions provided for humanity.

Dimension 3: Discipline Knowledge System: Corresponding formation and continuous improvement of marine disciplines and knowledge systems, including natural, engineering, social, economic, management and other disciplines, as well as comprehensive and cross integrated theoretical and technical methods.

Dimension 4: Supporting Guarantee System: Establish, operate, and improve supporting policies, regulations, systems, cooperation, talent, equipment, infrastructure,

data and model platforms, publicity and education, and other supporting guarantee systems.

Despite the above achievements, human beings are still in an earlier stage of exploration in various dimensions of scientific understanding of the ocean, including cognition, work tasks, environmental challenges, socio-economic development, and capacity building. The mutual support and organic integration between various dimensions still need to be optimized and developed. There is still a significant gap between the 17 Sustainable Development Goals of the United Nations' 2030 Agenda for Sustainable Development, including Goal 14, which aims to protect and sustainably use the ocean and its resources to promote sustainable development. As an emerging developing country, there is still a significant gap between China and developed countries in terms of scientific cognition and specific practices in the four dimensions mentioned above. To this end, taking China as an example, in its 14th Five Year Plan and subsequent periods, in the fields of marine environmental security, global change response, and ecological environment protection, we should further strengthen the research, development, and capacity building of observation and evaluation, intervention and regulation, disciplinary knowledge system, and supporting guarantee system. During the 14th Five Year Plan period, we should establish strategic goals for pollution prevention and control, energy conservation and emission reduction, and marine ecological protection and sustainable development in various industries such as national, regional, industry, and social levels, issue and implement special plans, improve and operate relevant institutional guarantee systems, funding guarantee plans, and scientific and technological support planning plans at the national and industry levels, establish responsibility supervision, monitoring, accountability, effect monitoring and evaluation systems for the implementation of special plans, and provide supporting scientific and technological support and guarantee support.

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### **Conflicts of Interest**

The author declares no conflicts of interest regarding the publication of this paper.

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