Research on the direction of the policy to foster the marine bio industry through analysis of domestic and global trends

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◆ 국외훈련 개요

1. 훈련 국가 : 미국

2. 훈련 기관 : 콜로라도 주립대 (University of Colorado Denver)

3. 훈련 분야 : 경영학 석사

4. 훈련 기간 : 2018. 8 ~ 2020. 5

◆ 훈련기관 개요

1. 훈련기관 명칭 : 콜로라도 주립대학교
(University of Colorado Denver)

2. 훈련기관 주소 : 1201 Larimer street, Denver, CO, 80204

3. 훈련기관 홈페이지 : www.ucdenver.edu

4. 훈련기관 소개 및 연혁

□ 학교 개요

University of Colorado Denver (CU Denver)는 미국 콜로라도 주에 위치한 공립 연구 기관으로, 콜로라도주 대학 시스템(3개 캠퍼스, 볼더, 덴버, 콜로라도 스프링스)의 일부이다.

콜로라도 주립대학은 콜로라도에서 가장 큰 연구 기관으로 매년 3억 7500만 달러 이상의 연구비를 지원하고 있으며, 다른 주립 대학들보다 대학원 학과과정에 더 비중을 두고 있는 대학이다. 콜로라도 덴버 주립대는 덴버시 다운타운에 위치한 오로라 캠퍼스와 약 16키로미터 떨어진 Anschutz Medical 캠퍼스로 구성되어 있다. 콜로라도 덴버 주립대학과 콜로라도 메디컬 센터가 2004년 통합하면서 대학은 2개의 캠퍼스를 보유하게 되었다. 현재 2개의 대학 캠퍼스에는 1만8천명 이상의 학생들이 재학 중이다. 또한 대학은 CU Online을 통해 온라인 수업 및 학위를 활발히 제공한다.

University of Colorado Denver는 100개 이상의 학생 단체, 명예 단체, 전문 단체 등을 보유하고 있으며, 대학 및 지역 사회 내에서 회원들을 위해 사회, 봉사 및 구직 기회를 제공한다. 이와 더불어 CU Denver는 농구, 배구, 축구 등 각종 구기종목을 포함한 스포츠 및 레크리에이션 활동을 제공한다. 최근에는 학생들을 위한 최신 시설의 체육관을 개관한 바 있다.

□ 경영학 석사 프로그램: Masters of Science in Management and Organization

콜로라도 주립대학교 비즈니스 스쿨은 다양한 종류의 석사과정을 운영하고 있다. 일반 MBA 과정 뿐 아니라, 온라인 과정 및 1년 단기과정, 세부전공 별로 Masters of Science 학위과정 등을 운영하고 있다. 이러한 다양한 석사 프로그램은 일반 민간기업, 금융기관, 공공 및 비영리 기관 및 단체에서 일하고 싶은 학생들을 위한 전문 교육과정을 제공한다. 지금까지 한국 정부에서 파견 나온 공무원은 수강한 바 없을 뿐 아니라, 한국인 수강생 자체가 없다고 볼 수 있다. 2년 코스이며, 학과과정은 쿼터제가 아닌 학기제로 운영되며, 2년간 총 4학기에 걸쳐 수업을 받게 된다. 대부분의 수업은 미국학생들이 대부분이며, 비즈니스 스쿨의 특성상 직장인이 수업에 참여하는 경우가 많아 저녁시간 수업이 대부분이며 온라인 강좌를 제공하는 경우도 있다. 과목에 따라 다소의 차이는 있겠지만, 보통 한 강의에 약 10~20명 정도가 수강을 한다. 교과과정을 이수하기 위해서는 읽기, 쓰기, 발표 등에 대한 종합적인 이해가 필요하며, 과정의 특성상 에세이 작성 및 제출이 주를 이룬다. 학기 중 치러지는 시험도 자신의 의견을 작성하여 제출하는 에세이 형식이 많다.

□ 교과과정

석사 학위를 받기 위해서는 30학점 이상을 취득해야 하며, 모든

학점은 Letter Grade로 표시되며, 만점은 4.0이다. 학위취득을 위해서는 평균 GPA가 B학점 이상인 3.0이 되어야한다. 30학점을 이수하기 위해서는 필수과목 4과목과 선택과목 7과목, 총 11과목을 수강해야 한다. Management and Organization 전공 중에서 세부전공(Managing Human Resources, Business Strategy, Managing for sustainability, Global Management, Leadership 등)을 선택할 수도 있으며, 세부전공을 정한 경우 선택과목의 수강에 다소 제한이 발생한다.

필수과목은 아래와 같다.

- BUSN 6520 : Leading Individuals and Teams
- MGMT 6320 : Leading Organizational Change
- MGMT 6360 : Designing Effective Organizations
- MGMT 6380 : Managing People for Competitive Advantage

훈련결과보고서 요약

성명	강미숙	직급	서기관
훈련국	미국	훈련기간	2018.8.~ 2020.5
훈련기관	University of Colorado Denver	보고서 매수	114매 (영문)
훈련과제	선진사례 분석을 통한 해양바이오산업 육성방안 연구		
보고서 제목	국내외 동향 분석을 통한 해양바이오 산업 육성 정책방향 연구		
내용요약	Ⅰ. 연구의 배경 및 목적 □ 전 세계적으로 해양바이오산업의 중요성, 필요성에 대한 공감대가 확산됨에 따라, 주요국들이 산업 선점을 위해 다양한 정책적 노력을 추진하고 있으며, ○ 우리나라도 이러한 글로벌 트렌드에 대응하기 위해 2004년부터 R&D 지원을 확대하는 등 산업 육성을 위한 노력을 하고 있음 ○ 그럼에도 불구하고, 산업화 연계, 산업 생태계 조성 등에서 다소 미진한 모습을 보이면서 뚜렷한 성과가 없는 상황		

- 해양바이오 산업 전반에 대한 동향을 파악할 수 있는 자료도 전무한 상황이며, 전문인력 양성도 미흡

☞ 우리 경제의 활력을 되살리고, 양질의 일자리 창출 및 고부가가치 창출이 가능한 미래형 신산업 발굴을 위해 현재 해양바이오산업 정책의 문제점을 진단하고, 주요국 정책을 바탕으로 개선방향을 제시할 필요

□ 본 연구는 이러한 연구 목적을 달성하기 위하여 해양바이오의 개념과 분류방법 등을 살펴보고,,

○ 미국, EU, 일본 등 주요국이 해양바이오 산업을 어떤 방식으로 육성하고 있는지를 분석

○ 또한, 우리나라가 추진하였거나, 추진하고 있는 정책이 갖고 있는 문제점 및 한계점을 분석

- 아울러, 그간의 성과에 대해서도 확인함으로써 우리나라의 강점도 함께 분석

Ⅱ. 해양바이오 산업 개요

□ 바이오산업의 등장

○ 유전자조작기술의 개발 및 발전을 통해 1970년대를 전후로 바이오기술이 자리를 잡았으며, 점차 산업적으로 발전하면서 1990년대부터 바이오산업이라는 용어 사용

	○ 바이오산업은 최종재를 기준으로 산업을 분류하는 다른 산업들과는 달리 바이오 기술의 적용여부가 중요 - 따라서, 단일산업임에도 불구하고, 약, 식품, 화학, 환경, 에너지, 장비 등 세부산업으로 구분될 수 있음 □ 해양바이오의 개념 ○ 해양바이오란, 해양생물체 내에서 일어나는 현상, 구조 및 기능을 이해하고, 그로부터 얻어진 지식을 활용하여 제품을 생산하거나 서비스를 제공하는 것을 의미 - 또한, 해양바이오 기술은 해양바이오 자원을 기반으로 인류의 복지 증진에 기여하기 위한 기술 - GIA에 따르면, 해양바이오 기술은 해양생물체에 적용하는 과학기술로서, 지식, 재화, 서비스의 생산을 위해 생물 또는 비생물을 변환하는 기술 □ 해양바이오산업의 개념 ○ 바이오 및 해양바이오 기술의 정의에 기초하여 정의할 때, 해양바이오산업이란, 해양바이오 자원과 해양바이오 기술을 활용하여 인류에게 편익을 가져다 줄 수 있는 상품과 서비스를 생산, 제공하는 산업 - 자원, 식품, 의약, 화학, 에너지, 환경, 기기장비, 연구개발 및 서비스를 모두 포함 ○ 해양바이오산업은 해양바이오 자원 의존형 산업과 해

	양바이오 지원형 산업으로 구분 - (자원의존형) 해양바이오 자원, 해양바이오 식품, 해양바이오 의약, 해양바이오 화학, 해양바이오 에너지, 해양바이오 환경 등 - (지원형) 해양바이오 기기 및 장비, 해양바이오 연구개발 및 서비스업 ○ 해양바이오 산업은 가치사슬 측면에서 일반 바이오 산업과 유사한 측면이 많음 - 가장 큰 차이점은 기초연구를 위한 자원 및 원료확보 단계에서 접근성에 제약이 크다는 점 - 그러나 이러한 제약성은 해양바이오 산업의 발전 잠재력으로 이어짐: 지구상 생명종의 약 80%가 해양에 서식하고 있으며, 그 중 1% 미만만 산업적으로 이용 Ⅲ. 국내외 해양바이오 산업 현황 □ 글로벌 해양바이오 산업 현황 ○ 해양바이오에 대한 관심 증가는 글로벌 해양바이오 산업의 확장으로 연결 - 특히, 향후 5년간의 연평균 성장률(5.2% 예상)은 지난 10여년간의 성장세(2.9%)에 비해 1.8배에 해당할 것이라는 전망도 존재(GIA)

- 여전히 미국, EU의 시장 점유율이 높지만, 아시아태평양 지역의 성장세가 높은 상황(연평균 약 5.5% 성장)

○ 산업분야별로는 의약품, 기능성 식품 및 화장품 등 소비재 분야가 성장을 주도할 것으로 예상

□ 우리나라 산업 현황

○ 우리나라 해양바이오기업 실태조사(2018)에 따르면,

- 대부분의 기업이 수도권에 분포(약 43%)하고 있으며, 매출 규모가 10억 미만 기업이 가장 큰 비중을 차지(34.7%)

- 또한, 매출 중 해양바이오 관련 매출이 전체 매출의 50% 이상인 기업도 12.5%에 불과

○ 기술 선진국에 비하면 아직 기술수준은 50~60% 수준에 머물고 있지만, 해양바이오 의약, 해양바이오 에너지 분야 등에서는 산업화 성공사례도 나타나고 있음

- (의약) 씨놀과 홍합유래 생체 접착제

- (에너지) 미세조류를 이용한 해양바이오 디젤

Ⅳ. 해외 주요국의 해양바이오 산업 육성정책 현황

□ 미국

○ 해양연구의 종주국이자 관련 연구 분야의 리더

	- 미국의 해양바이오산업 육성 정책의 특징은 연방정부 차원의 해양바이오 육성정책이 별도로 있는 것이 아니라, 바이오산업 전체 내에서 해양바이오에 대한 지원도 추진 - 바이오 전 분야에 걸쳐 현안문제 해결을 위한 맞춤형 투자가 이루어지고 있으며, 공공과 민간의 다양한 협업체계 모색 - 최근 해양바이오와 관련하여 이슈가 되고 있는 것은 1) 일반 바이오산업에 비해서 잠재성은 높으나 발전 속도가 더딘 이유 및 이를 해결하기 위한 정책적 노력, 2) 지속적인 성장을 위한 독립연구기관 필요성에 대한 논쟁 등 - 1) 산업 발전 속도 증가를 위해 가장 중요한 것은 IP 전략 수립, 자원 확보 및 관리, 세계질서에 대한 적응 등 - 2) 항공우주분야 발전을 위해 NASA가 존재하듯이 해양바이오에 대한 집중연구와 관리를 위한 별도 기구 필요 □ EU ○ 미국과 달리 해양바이오 분야에 특화된 전략인 "해양바이오: 유럽의 새로운 비전과 전략" 수립 - 회원국 간의 협력을 바탕으로 한 공동협력 프로그램 조성 및 운영

- 비회원국인 노르웨이는 풍부한 해양생물다양성을 바탕으로 관련 산업을 잘 육성하고 있는 국가 중 하나

□ 일본

○ 일본은 해양바이오식품 분야의 전통적 강국이며, JAMSTEC(해양과학기술센터), MBI(해양생명공학연구소) 등 정부 연구기관을 중심으로 관련 연구 추진

- 다른 국가와의 차이점은 중앙정부 뿐 아니라 지방정부 차원의 지원정책도 활발히 이루어지고 있다는 점

□ 중국

○ 해양생명공학 863 프로그램 이후, 신약개발에 초점을 두고 해양바이오 산업 육성중

- 특히, 동부 연안의 성(산동성, 광동성, 절강성)을 중심으로 해양바이오 산업에 대한 투자 증대, 해양바이오 클러스터 조성 등을 통해 시너지 효과 기대

□ 싱가포르

○ MSRDP(국가해양과학연구 프로그램)을 통해 해양과학 연구에 대한 투자 확대 중

- MSRDP는 (1) 해양생태계 및 생물다양성 증대, (2) 해양환경에 대한 모니터링 강화, (3) 해안생태연구 등에 관심을 갖고 지원중

	- 뿐만 아니라, 해양과학기술 플랫폼 개발, 인력양성 프로그램 개발 등 관련 산업 생태계 조성을 위해 노력 □ 우리나라 ○ (기술수준) 최고 기술 보유국 대비 60% 수준이며, 기술격차는 5.9년인 것으로 조사 - 건강기능식품군의 경우 67.2% 수준에 도달하여 다른 분야에 비해서는 기술격차가 많이 축소 - 반면, 의료기기는 여전히 50% 수준에 머무르고 있음 ○ (투자규모) 2003년까지는 연 20억원 미만이었으나, 2004년부터 투자를 대폭 확대(연평균 23% 증가) - 식품・화장품 등 신소재(37%)에 가장 많은 투자를 하고 있으며, 자원 확보 및 활용기반(24%), 에너지(24%), 생명현상 활용연구(15%) 순으로 투자 - 투자 확대에도 불구하고, 국가 전체 바이오 분야 대비 해양바이오에 대한 투자비중은 여전히 미미한 수준 ○ (지원정책) - (현황) 국립해양생물자원관 설립, 해양수산생명자원 관련 법령 통합 시행 등을 통해 관리기반 마련 및 유용한 해양생명자원 확보를 위하 인프라 확충(자원조사선 점차 확대)

	- (문제점) 전문인력 및 전문 컨설팅 부족, 전략적 자원 관리 미흡, 취약한 산업 생태계로 인한 사업화 성공 사례 부재 등 Ⅵ. 해양바이오 산업 정책 방향 □ 자원확보 강화 및 활용도 제고 ○ 해양바이오 산업의 지속적인 발전과 성장을 위한 가장 기본적인 단계가 유용자원의 확보와 관리인 만큼 그 간의 지원 정책 개선 및 미비점 보완 등의 노력 필요 - 자원확보를 위한 기초조사 확대, 수집된 자원 활용도 제고를 위한 다양한 정책(해양바이오 뱅크 활성화, 해양수산생명자원 지도 제작 및 배포 등) 마련 - 또한, 자원확보를 위한 국제적 협력방안 모색도 필요 □ R&D 지원체계 개선 ○ 연구개발의 성격을 고려하여 관리방식 차별화 - 임상실험 등이 필요한 과제의 경우, 관련부처와의 협업 필수 - 기반구축연구의 경우, 대량배양기술 확보 등 표준화 연구에 집중 투자 - 산업화가 용이한 기술은 시제품 제작부터 표준화, 사업화 등 가치사슬의 후반부에 집중 투자

	○ R&D 성과제고를 위해 기관 특성에 맞는 과제 선정 및 추진 - 기초연구를 위해서는 대학 및 출연연구기관이 전담하고, - 산업화 가능성이 높은 응용기술 연구의 경우에는 과제 기획 등 추진 단계 전반에 기업의 참여 유도 □ 산업생태계 조성 지원 ○ 네트워크 구축을 위해 협회나 학회 구성 및 운영 - 동일산업에 종사하는 기업간 유대 강화, 의견수렴을 통한 정책건의, 정보공유를 통한 산업 발전 등의 효과 기대 - 포럼 및 컨퍼런스의 정기적 개최를 통해 기술 및 정책 동향 파악 및 분석, 기업에 제공 등도 추진 ○ 해양바이오산업처럼 기술력이 필요한 산업은 고급인력을 유치하는 것이 산업 발전을 위한 핵심 요인 - 학교에서 습득한 이론적 지식을 활용할 수 있는 협동 프로그램 구성 및 운영, 실습기회를 제공하기 위해 정부 지원 R&D 프로젝트 참여 가능성 제고 등 ○ 투자기반 조성을 위해 모태펀드 등을 활용하는 방안 검토 - 해양바이오와 같은 신산업의 경우, 대규모의 장기적 투자가 필요한 만큼 민간투자가 절대적으로 필요하나, 초기에는 투자의 마중물 역할을 할 기관투자자 필요

I. Background and purpose of the study

1. Background

Around the world, consensus on the importance and necessity of marine biotechnology is spreading, and based on this, major countries are providing full support to the related companies. The marine bio industry, which started in the application field of biotechnology, has been increasing in anticipation of the growth potential of the marine bio industry as the industry based on marine life is gradually expanding.

In line with this global trend, Korea is also providing various support to foster the marine bio industry. Starting with the Marine Bio 21 project established in 2004, the Basic Plan for Fostering Marine Biotechnology (2008) and Strategy for Fostering Next-Generation Marine Biotechnology (2014) have been established, and research and development projects for major technology development are also being steadily under way. Due to the nature of the industry, most of the policies are related to technology development. It occupies more than 10% of the total R & D budget of the Ministry of Oceans and Fisheries, which is the main ministry for the development of the marine bio industry, and related technology has been established as a major R & D project of the Ministry of Oceans and Fisheries since the early 2000s.

Despite this continuous support, however, there have been very few successful cases which has led to industrialization. As of 2016, of the 160 companies in the marine bio industry, 78 were successfully commercialized, and the number of products was confirmed to be about 70. Considering the amount of support for R & D in the marine biotechnology sector, the success rate of such commercialization is very low. The process of industrialization of offshore biotechnology takes several stages, and it is necessary to check whether the country's R & D policies are being promoted toward promoting industrialization.

In addition, I think it can not be overlooked that much of the policy for the development of the marine bio industry was focused on R & D support. For example, there is no data available to periodically grasp the trends in the overall domestic marine bio industry. In other words, it is difficult to understand the overall situation of the industry that is essential before establishing the policy, and the size of the domestic and foreign marine bio industry currently being announced by each research institute differs in the scope of the industry, which means that there is a limitation to understand the overall market trend. In other words, there is a lack of continuity of estimating the scale of the domestic marine bio industry and grasping recent trends, and thus relying on foreign prospects. The lack of trend data means that there is a limit to reviewing the effectiveness of the policies. For the continuous and balanced development of the marine bio industry, not only technological development but also the creation of an industrial ecosystem should be considered. In order to prepare an effective policy, it is absolutely necessary to establish a system for investigating the status of industrial activities with credibility and provide regular information based on this. Through this, it is necessary to collect basic information on all activities related to marine biotechnology, and to establish rational policies and promote effective enforcement based on accurate diagnosis of the marine bio industry based on regular surveys. It is necessary to face these problems and come up with a solution.

The reason for trying to identify the limitations of the policies and to come up with a solution is that, as mentioned above, the expectation for the bio-industry is constantly increasing, making it one of the industries with high growth potential. In order to revitalize our economy, create high-quality jobs, it is necessary to discover and foster new industries that can create high added value, and the marine bio industry is likely to become such a new industry. Even though the past support policy has been somewhat ineffective, it can be considered that it has contributed sufficiently to establish the infrastructure for growth, such as fostering related experts and preparing research infrastructure. In order to secure faster growth, it is necessary to find better policy alternatives.

2. Purpose of study

The most important purpose of this study is to find policy alternatives and implications for effective support of the marine bio industry. In order to achieve this goal, this study will take a closer look at the concept of marine bio and the approach of each country. As mentioned before, I believe that there has been support for the marine bio industry in Korea, so I will be able to grasp the problems of our approach and support policy by looking at other countries' approaches. In addition, through the recent trend analysis on the industrialization stage of the domestic marine bio, I will analyze the problems of Korea's policy and suggest directions and action plans.

Ⅱ. Overview of the industry

1. Emergence

Interest and support for the bio industry has increased since decades ago. Looking at the process, the bio industry started on the basis of biology at the academic level, but afterwards it became a technological level with the development of genetic engineering technology in the 1970s, and used the term bio industry as a new industry group since the 90s.

The bio industry is difficult to see as a single industry and can be divided into medicine, food, chemical, and environment. The bio-industry is usually divided into red, white, and green. Red refers to medicines (including diagnosis), white refers to chemicals, environment, energy, and greens refers to agriculture and food. In addition, infrastructure platform technology is often cited as a fourth area, which includes genetic analysis and diagnostic reagents. Accordingly, various ministries are pursuing bio-industry policies.

In general, the medicine sector is rated as having the best prospects. Recently, Korea is focusing on discovering new drug and biosimilars, and through this, we are making significant profits. Bioenergy is improving little bit late than globally expected, and low demand continues due to low oil prices, shale oil and gas, and renewable energy. In the bio-energy sector, the participation of large companies will be essential. On the other hand, the bio industry related to the food is characterized by being too subdivided so that it is not large.

Biotechnology is also divided into traditional old biotech and new biotech with advanced biotechnology. In general, the bio industry has been narrowly defined as an industry to which new bio technology is applied, but in recent years, the meaning of the bio industry has expanded to include the traditional old biotech industry.

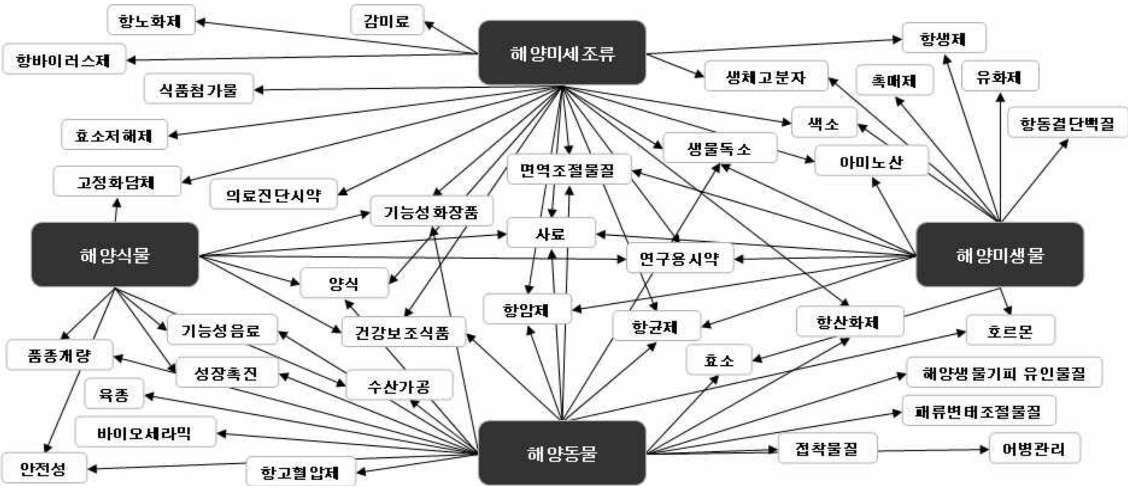
Among the bio-industries, the main reason for the increasing interest in the marine bio sector is that there has been less interest in marine resources so far than the resources in the land, so the possibility of pioneering resources remains. Due to the necessity of securing new materials because of the depletion of terrestrial materials, many countries or companies pay attention to the possibility of using marine life resources. Marine life resources account for 90% of the world's species, but utilization rate is less than 1%, so the demand and expectation of marine resources will continue to increase in the future.

2. Concept of "Marine Bio"

Marine bio means understanding the phenomenon in marine organisms, structure and function of the marine organisms, and using the knowledge obtained therefrom to produce products or provide services. Marine Organism refers to all of the marine microorganisms, marine microalgae, marine animals, and marine plants that are economically and socially valuable or have practical and potential uses.

In the case of the marine bio sector, the biotechnology and bio-industry are defined in a narrow way. Marine bio products should only be distinguished from products containing just aquatic products. For example, it is not a marine bio product to the stuff that contained grounded seaweed. In a strict sense, it can be called a marine bio only when marine biotechnology is applied.

Marine Biotechnology is a technology for contributing to the promotion of human welfare based on marine bio resources. GIA, a market research institute, defines marine bio technology as "a science and technology that applies to marine organisms and transforms biological or non-living organisms for the production of knowledge, goods, and services."



<Figure 1. Main application fields of marine organisms>

According to the Basic Plan for Fostering Marine Biotechnology ('08 ~ '16), marine biotechnology is an technology which is understanding the phenomena, structures and functions occurring in marine organisms, and using the knowledge obtained from them to produce products or provide services to improve the welfare of people.

By definition at domestic and abroad, it can be said that marine bio technology refers to technology that produces products and services that can bring benefits to human beings based on marine bio resources.

3. Concept and characteristics of the marine bio industry

1) Concept of the marine bio industry

Based on this basic concept of marine bio, marine bio industry is that produces and provides products and services that can bring benefits to humans by utilizing marine bio resources and marine bio technologies. It can be said to include chemical, energy, environment, equipment, research and development and services. In other words, the marine bio industry is somewhat different from other industries in that the final product is based on the application of bio technology rather than the final products.

Nevertheless, it seems necessary to classify the marine bio-industry when considering the understanding of the marine bio-industry and the ease of establishing support policies. Considering the convenience of classification and similarity of support methods, it can be divided into marine bio resource-dependent industries and marine bio-supported industries. The marine bio-resource-dependent industry is an industry in which production activities are performed by utilizing the biological processes of marine bio-resources, such as the industries related to marine bio resources, marine bio food, marine bio medicine, marine bio chemistry, marine bio energy, marine bio environment.

On the other hand, the marine bio-supporting industry is an industry that provides inputs to the marine bio-resource-dependent industry, and includes marine bio device and equipment, marine bio research and development, and service industry.

<Table 1. Category of Marine Bio Industry>

Category	Definition
Marine Bio Resource	Industrial activities to discover, remove and cultivate or rear organisms for new functions by applying biotechnology to marine biological resources
Marine Bio Food	Fields related to various food and beverage products, health functional foods, animal feeds, etc., produced by applying biotechnology to marine biological resources.
Marine Bio Medicine	Medicines and basic medicinal substances used to diagnose, prevent, and treat various diseases of humans or animals by applying biotechnology with marine biological resources as raw materials

Marine Bio Chemistry	Chemical products such as perfume, cosmetics, household chemicals, toothpaste, soap, detergents, surfactants, fragrances, and brighteners using biotechnology based on marine biological resource
Marine Bio Energy	Alternative fuel materials produced through chemical and biological conversion processes from marine biomass such as biodiesel and bioethanol, and fuel materials produced as a result of biological processes by marine organisms
Marine Bio Environment	Activities of manufacturing, researching and developing for the purpose of environmental purification, environmental restoration, reduction and prevention of environmental pollution by using marine organisms or marine biotechnology Or activities for diagnosis and measurement of pollution and for construction of facilities by using the process which is mentioned above
Marine Bio Device & Equipment	Industrial activities to manufacture, import, research and develop device & equipment and process parts used for research, development, and industrial applications that include marine biomaterials or marine biotechnology.
Marine Bio R&D and Services	A service that performs clinical and non-clinical research and development under contract from a consignor using knowledge and technology of marine life pollution, and supports such execution, and a service type service that performs research and development necessary to develop products related to marine life pollution technology

Source: Ministry of Oceans and Fisheries(2016)

The classification system of the marine bio-industry is based on the bio-industry classification system, and is divided into areas where production is being performed in the marine sector or where there is a high possibility of industrialization. The linkages and differences between the bio-industry classification and the marine bio-industry classification are shown in the figure below.

Bio Industry Classification
Bio Medicine
Bio Chemistry-Energy
Bio Food
Bio Environment
Bio Medical Equipment
Bio Devices & Equipment
Bio Resources
Bio Services

Marine Bio Classfication	Difference between two
Marine Bio Resource	Enhancement of marine life resource relevance
Marine Bio Food	Enhancement of marine life resource relevance
Marine Bio Medicine	Excluding items that are not related to pharmaceuticals and marine life resources using life-related resources.
Marine Bio Chemistry	Enhancement of marine life resource relevance
Marine Bio Energy	Excludes bioenergy other than marine biomass fuels and marine bio plant fuels
Marine Bio Environment	Enhancement of marine life resource relevance
Marine Bio Devices & Equipment	Separated into medical devices and industrial devices
Marine Bio R&D and Services	Enhancement of marine life resource relevance

<Table 2. Linkage between Bio and Marine Bio>

2) Characteristics of the marine bio industry

I will look at the characteristics of the marine bio industry based on commonalities and differences with the general bio industry. First of all, the common point is that a variety of value chains coexist depending on the industry sector, and that they are related to horizontal and vertical industrial structures and infrastructures and institutions. The value chain of the bio industry basically goes through the steps of "basic research → candidate development → effectiveness evaluation → clinical experiment → approval → production / sale". Relevant actors in each stage of the value chain include suppliers of raw materials, consigned companies for research and clinical trials, consignment companies for production, and sales promotion companies. The entire process of the value chain involves government, venture financing, related licensing systems, and infrastructure (personnel training, etc.).

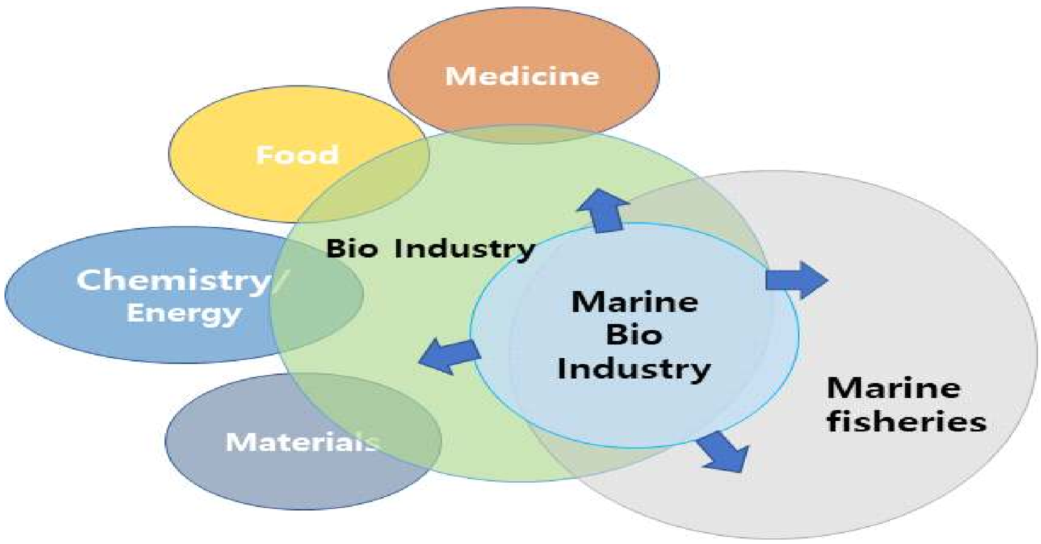
Value Chain	Basic Research	Candidate Development	Effective-ness	Clinical	Approval	Production/ Sales
Core	Raw material research / Information gathering	Raw material processing / Conversion / Information processing	Assess for effective-ness	Exper iment	License	생산 /마케팅
Related subjects	Univ/ Research Institute	Specialized Company			Gov.	Consu mer
Infra/ System	Governmental Support	Investors such as Venture Capital		Law/Regulation		-

<Table 3. Value Chain of Bio Industry>

The biggest difference between the marine bio industry and the general bio industry in this value chain is that access to resources is more limited than land in the stage of securing resources and raw materials for basic research.

However, this drawback leads to potential. About 80% of the world's living species inhabit the ocean, and less than 1% of them are used industrially, so it is evaluated that the potential of the marine bio industry is higher than that of general bio industry.

Regarding the development potential of the marine bio industry, the main characteristic is that marine bio technology can be applied to existing industries to expand the scope of the industry. In other words, the sub-industries of the marine bio industry are not only highly applicable to existing industries such as the food industry, pharmaceutical industry, cosmetics and chemical industry, environmental industry, and energy industry, but also existing industries that were not based on marine organisms or marine bio technology can be replaced with marine bio products depending on the technology level and marketability in the future. As the demand for marine biotechnology and new marine biomaterials in the fields of medicine, chemicals, energy, food, and environment will increase, the marine bio industry will also expand.



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<Figure 2. Industry related to the marine bio industry>

<Definition and classification of biotechnology by OECD>

1. Definition

The OECD defined biotechnology and related terms in 2002. At the time, the OECD defined biotechnology as the application of science and technology to living organisms, as well as parts, products, and models of organisms to produce knowledge and goods by changing biological or inanimate materials. In addition, the definition was supplemented by listing biotechnology techniques by field.

Fireld	Techniques
DNA/RNA	• Use of genetics, drug genetics, gene probes, genetic engineering, DNA / RNA sequencing / synthesis / amplification, gene expression analysis, and genetic manipulation techniques
Protein and other molecules	• Sequencing / synthesis / engineering of proteins and peptides (including polymer hormones), improvement of polymer drug delivery methods, protein physics, protein separation, purification, and signaling
Cell and tissue culture and engineering	• Cell / tissue culture, tissue engineering (including tissue cell carrier and biomedical engineering), cell fusion, vaccine / immunostimulator, embryo manipulation
Process biotechnology	• Fermentation using bioreactor, bio process, bio smelting, bio pulp, bio bleaching, bio desulfurization, biological purification, bio filtration
Gene and RNA mediators	• Gene therapy, virus type vector
Bioinformatics	• DB construction for gene and protein sequences, modeling of complex biological processes, including system biology
Nano bio technology	• Application of nano / micro processing tools and technologies to research biological systems and to create tools for application to drug delivery and diagnosis.

Source: OECD(2005), A Framework for Biotechnology Statistics, p. 9.

In addition, a bio company was defined based on the classification of applied fields of bio technology. In other words, a biotechnology company is a company that participates in biotechnology by using at least one biotechnology technique to produce goods or perform biotechnology R & D. Specifically, “Dedicated biotechnology firms” refers to companies that dominate corporate activities by the application of biotechnology techniques to produce goods or to produce biotechnology R & D. “Biotechnology R & D companies” are companies that perform biotechnology R & D If more than 75% of the total R & D is concentrated on biotechnology, it is considered “Dedicated biotechnology firms” and these companies are included in R & D surveys.

2. Classification of marine biotechnology

The four major areas of marine biotechnology defined by the OECD are: organism-based technology, marine organic matter production technology, new material technology, and marine conservation technology.

Field	Explanation
Organism-based technology	• Biological resource exploration • Marine genome sequence and bioinformatics • Metagenomix and other omics technologies
Marine Organic Production	• Organic culture and collection / disease control and monit • Marine biosafety / mass production (eg seaweed)
New material	• Drug discovery / industrial substances / enzymes • Health supplements, functional foods • Bio fuel and bio energy / bio refining
Marine conservation	• Climate change monitoring • Pollution Prevention and Control • Biodiversity conservation and ecosystem restoration

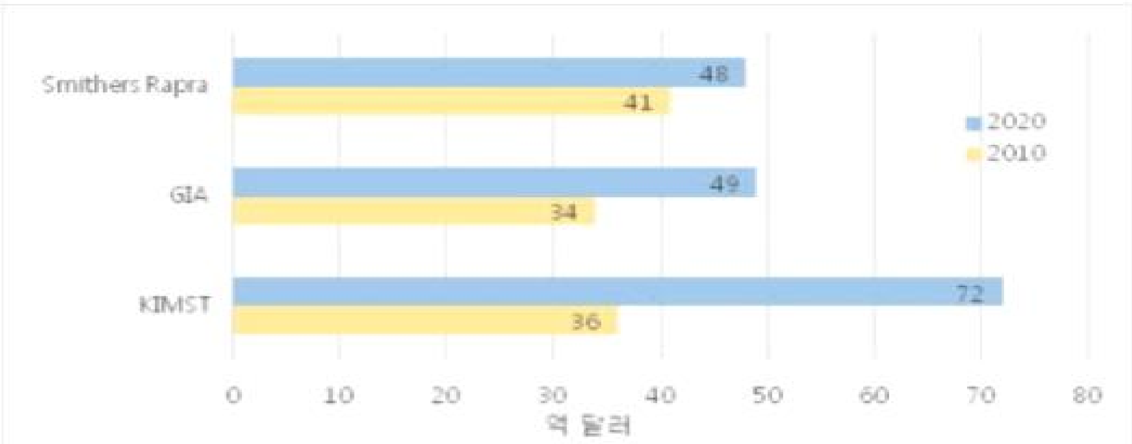
Source: OECD BNCT(2016), Marine Biotechnology in the Bio-economy.

Success stories are needed for the growth of the marine bio industry. It may also be helpful to find international success stories. As it is a growing industry, it may be considered that we have not yet experienced one cycle of industrialization, so it is also meaningful to try all R & D tasks in various fields belonging to marine bio. In order to industrialize the marine bio, it is necessary to aim to create one success case.

Ⅲ. Domestic and Global marine bio industry

1. Status of Global marine bio industry

The growing interest in marine biotechnology has led to the expansion of the global marine biotechnology industry. As a result of GIA analysis, the global marine bio market size is expected to grow from $3.9 billion(4.69 trillion won) in 2016 to $4.8 billion(5.76 trillion won) in 2020. The forecasts of other major institutions differed somewhat, but they also expected to continue to grow.



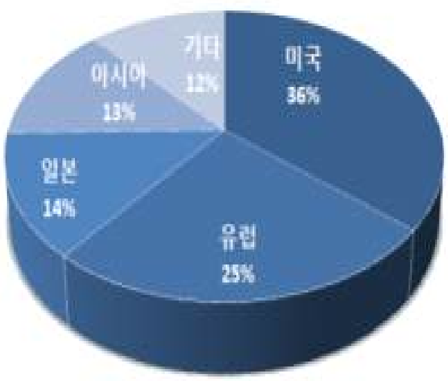
<Figure 3. Global Marine Bio Market Size and Forecast>[1)]

1) Smithers Rapra data include 2015 and 2020 figures for the marine bio industry, including 1) food and feed, 2) energy, 3) biomaterials, 4) the environment, and 5) the health and wellness industry.

The forecast of GIA is 5.2%, the annual average growth rate over the next five years, which is 1.8 times the annual average growth rate (2.9%) of from 2006 to 2015.

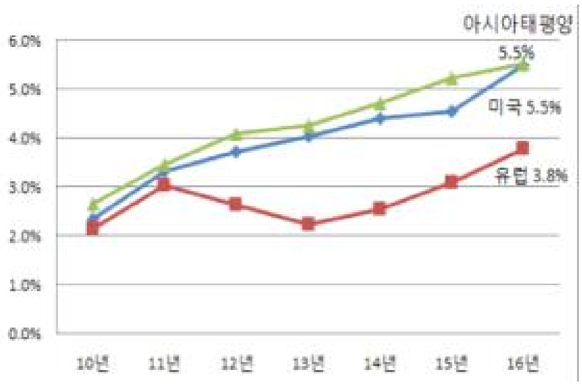
<Figure 4. Comparison of growth rate by period>

By country, the United States, the EU, and Japan account for about 75% of the world market, and the share of the three countries is expected to continue to increase.



< Figure 5. Share by country(%) >

Source : GIA(2015)



< Figure 6. Average annual growth rate by country(%) >

GIA is a marine bio industry 1) industrial materials, 2) pharmaceuticals, 3) consumer goods, 4) public services and infrastructure, 5) other

KIMST's marine bio industry includes 1) industrial materials, 2) pharmaceuticals, 3) consumer goods, 4) public services and infrastructure, and 5) others.

However, the Asia-Pacific region is growing at an average annual rate of about 5.5%, and is likely to become as a emerging region in the global marine bio industry. In Asia, Japan and China's policy for supporting marine bio is expanding and growing.

By industry, bio healthcare and consumer goods such as pharmaceuticals, functional foods and cosmetics are expected to lead growth. In particular, as the aging trend and well-being-oriented lifestyles are settled, the health functional foods, medicines, and cosmetics market is expected to account for more than 80%.

< Figure 7. Average annual growth rate by sector >

자료 : GIA(2015)

< Figure 8. Market share by industry('17)>

Major companies in the marine bio industry are mainly concentrated in the United States and European countries. American companies are distributed in various fields such as resources, medicine, and chemicals, while among European countries, they appear to be particularly active in British and Norwegian companies, and have special characteristics in the functional cosmetics and food industries.

Country	Company	Main Field	Products /Technology
US	CP Kelco	Polysaccharide production through microbial fermentation	GENU Carrageenan
	Sea Run Holdings,Inc	Production and research of biological products and drugs using salmon blood	Sea-Block™ Sea-Grow™
	Cyanotech Corp.	Immunity diagnosis and nutritional supplement production using microalgae extract	BioAstin Natural Astaxanthin
	Nutrex Hawaii	Production of nutritional supplements and functional foods such as Spirulina	Hawaiian Spirulina
	FMC Corp.	Specialized in agricultural and industrial chemical production. FMC Health and Nutrition, specialized in functional foods and nutritional supplements	
	New England Biolabs Inc	Specialized in the development and commercialization of re-binding enzymes	BioLux
	Prolume Ltd	Development and discovery of new genes derived from	

		submarine bioluminescent materials	
UK	PML Applications Ltd.	Specialized in marine biochemistry, biodiversity and research focusing on marine ecosystems, and collection of marine bacteria and cultured extracts	
	Aquapharm Biodiscovery Ltd.	Focusing on the pharmaceutical industry, expanding its scope to functional cosmetics and food	SeaRch™기술 활용제품
	GlycoMar Ltd.	Focus on bio healthcare and cosmetics	
Nor way	Aker BioMarine AS	Specialized in pharmaceutical industry, products derived from krill shrimp	
	Aqua Bio Technology ASA	functional cosmetics	Aquabeautine XL
	Pronova BioPharm ASA	Sales of disease prevention products related to lipid therapies. Leading Company of Omega-3 Related Products	

<Table 4. Major companies and major fields in the marine bio industry>

A total of 7 FDA approvals including antiviral drugs derived from spongy animals (Vira-A) and anti-cancer drugs (Cytosar-U), anti-cancer drugs from molluscs (Adoetris) and yoke (Yondelis) (accumulated, total biopharmaceutical drugs total about 400 cases, as of 2019)

Product (Approval year by FDA)	Main Contents	Sales
Halaven® (2010)	(Japan) Development of anticancer drugs for the treatment of breast cancer and fat sarcoma using substances derived from sponges (black beach sponges)	$ 360 million (KRW 400 billion)
Lovaza® (2004)	(UK) Treatment of hypertriglyceridemia using fish oil (omega-3 fatty acid) mainly used as a raw material for health functional food	43 million euros (KRW 58 billion)
Prialt® (2004)	(Ireland) A drug that utilizes the snail's toxicity. It is a neuro-blocking analgesic that is used in patients at an ineffective stage.	$ 27 million (KRW 33 billion)

<Table 5. FDA-approved drugs using marine materials>

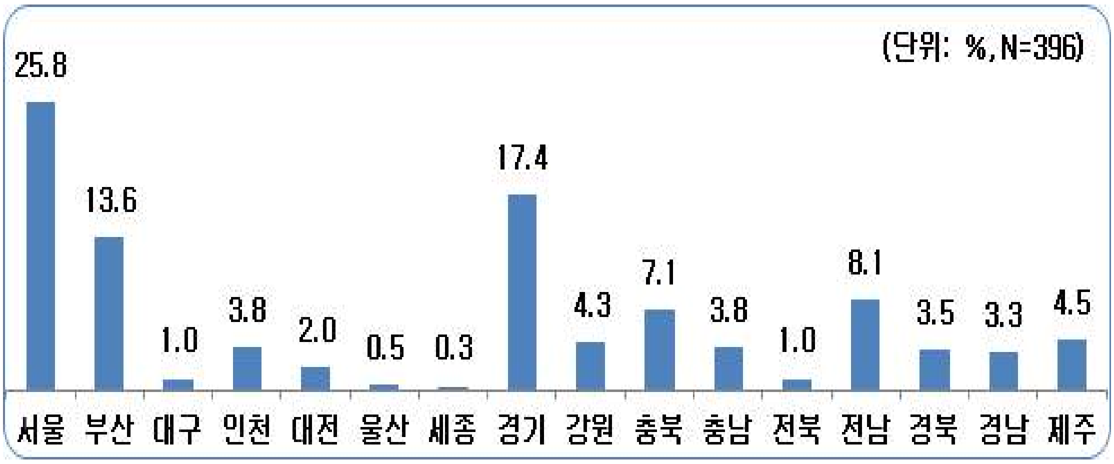
Company	Main Contents	Sales
MEG-3	(Netherlands) Founded in 1902, the brand of multinational company DSM, occupies about 25% of the world's omega 3 market with omega 3 extracted from small fish as its main product	10 billion euros (KRW 13 trillion)

<Table 6. Casess of health functional foods (including marine-derived materials and other fields)>

2. Status of Korea Industry

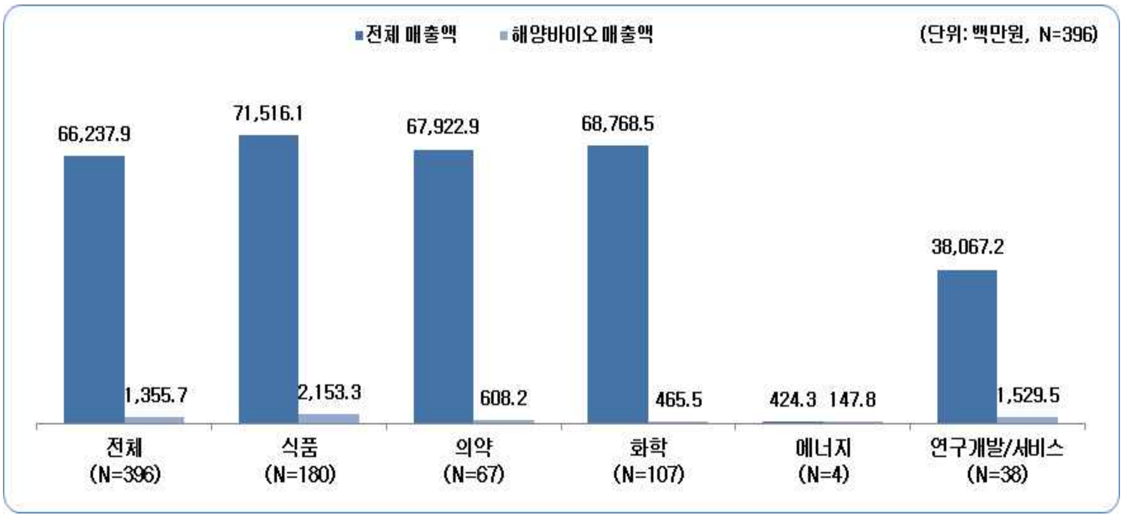
1) Status of Company

According to the results of the marine bio industry survey (2018) conducted by the Ministry of Oceans and Fisheries, as of 2016, 369 companies engaged in the marine bio industry were surveyed. The main fields were food (180) -chemistry (107) -medicine (67) -research and development (38) -energy (4). The distribution by region was 171 in Seoul, Gyeonggi, 54 in Busan, and 32 in Jeollanam-do.



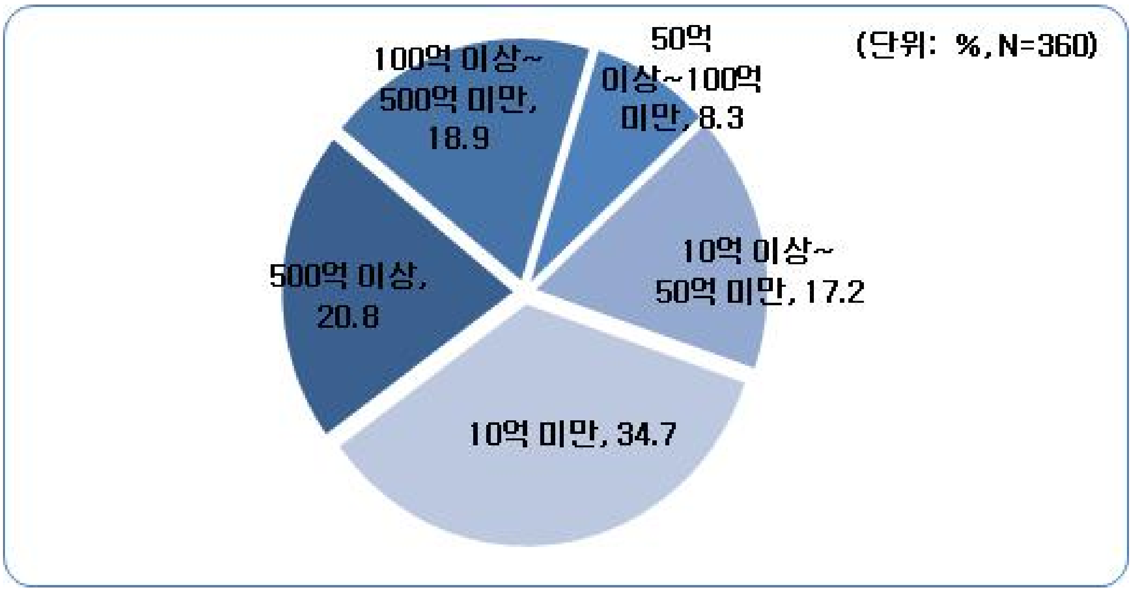
<Figure 9. Distribution of marine bio companies by region>
Source: Ministry of Oceans and Fisheries(2018)

Looking at the sales status, it is estimated that the sales of domestic marine bio companies are estimated at about 536.9 billion won. The sales of marine bio food companies were the highest at 387.6 billion won, and the marine biochemicals were estimated at 49.8 billion won, the marine biopharmaceuticals amounted to 40.7 billion won, and the marine bio services and R & D were estimated at 58.1 billion won.



<Figure 10. Average sales of marine bio companies>

Looking at the distribution by company size, it accounts for the largest portion with 125 (34.7%) of companies with less than 1 billion won. 62 companies (17.2%) with more than 1 billion ~ less than 5 billion, 30 companies (8.3%) with more than 5 billion ~ less than 10 billion, 68 companies (18.9%) with more than 10 billion ~ less than 50 billion More than 100 million companies (20.8%).



<Figure 11. Distribution by Sales Scale of Marine Bio Companies>

(Unit: Cases, %)	cases	Less than 1 billion		1 billion~ 5 billion		5 billion ~ 10 billion		10 billion ~ 50 billion		More than 50 billion	
		cases	%	cases	%	cases	%	cases	%	cases	%
Total	(360)	125	34.7	62	17.2	30	8.3	68	18.9	75	20.8
Food	(180)	64	35.6	30	16.7	16	8.9	41	22.8	29	16.1
Medicine	(67)	8	11.9	6	9.0	7	10.4	17	25.4	29	43.3
Chemistry	(107)	49	45.8	25	23.4	7	6.5	10	9.3	16	15.0
Energy	(2)	2	100.0	0	0.0	0	0.0	0	0.0	0	0.0
R&D/ Service	(4)	2	50.0	1	25.0	0	0.0	0	0.0	1	25.0

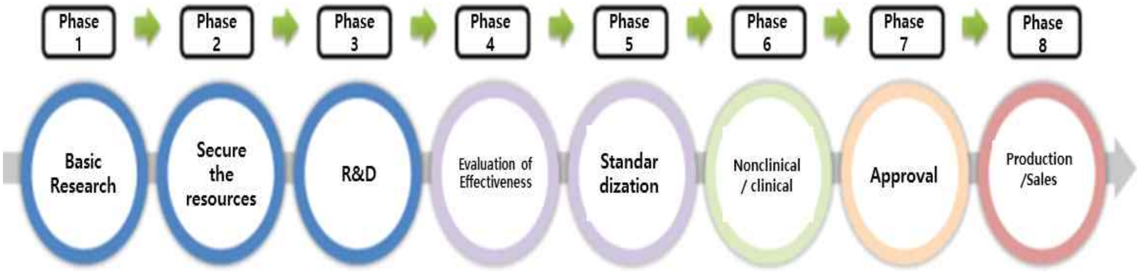
<Table 7. Distribution by Sales Scale by sub-industry of Marine Bio Companies>

In addition, only 45 (12.5%) of the companies with marine bio-related sales accounted for more than 50% of the total sales, and 315 (87.5%) had less than 50% of total marine sales.

(Unit: Cases, %)	Cases	Over 50% of marine bio sales		Less 50% of marine bio sales	
		cases	%	cases	%
Total	(360)	45	12.5	315	87.5
Food	(180)	29	16.1	151	83.9
Medicine	(67)	2	3.0	65	97.0
Chemistry	(107)	12	11.2	95	88.8
Energy	(2)	2	100.0	0	0.0
R&D/ Service	(4)	0	0.0	4	100.0

<Table 8. Distribution by proportion of marine bio sales>

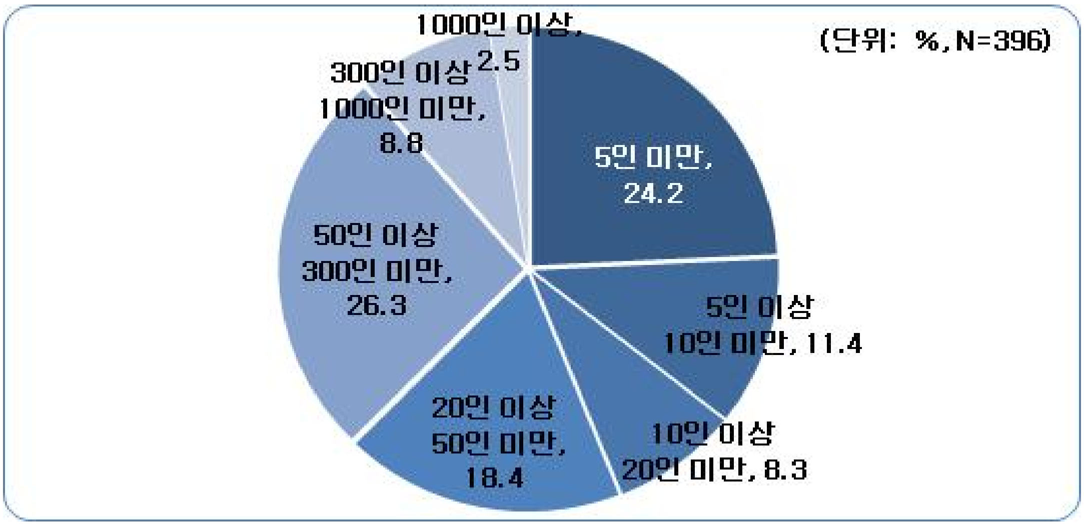
In order to examine the characteristics of marine bio companies a little more, we looked at each process step. The process stage was divided into 8 stages, and includes the entire value chain of the marine bio industry from basic research to production / sales.



	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
Share(%)	43.4	57.8	61.4	32.5	26.5	19.3	15.7	61.4

Among the eight stages, it was found that the proportion of performing basic research ~ development (1 ~ 3 stages) and final production / sales (8 stages) activities was high. Many small biotech companies remained in the basic raw material development stage, and it was the opinion of small companies that it was difficult to pass non-clinical and clinical trials for product production. In addition, companies focusing on the production and sales of finished products were producing and selling finished products using materials that have already undergone functional and death tests rather than the development of new raw materials.

Looking at the workforce status of marine bio companies, the total number of commercial workers is 38,069, of which 2,968 workers are marine workers, accounting for 7.8%. The average number of workers in the marine bio sector per company was 7.6, and the average number of employees in the R & D service sector was 16.3. It was found that 62.4% of the companies were 'less than 50' workplaces, with many small businesses.



<Figure 11. Distribution by Sales Scale of Marine Bio Companies>

The average annual salary of marine bio-enterprises was 35.2 million won, and the chemical industry was the highest at 42.3 million won.

2) Status by technology field

Looking at each of the marine bio sectors, among the four industrial technologies of domestic marine bio, it was found that functional fields and functional cosmetics are relatively high. In particular, there was a clear tendency to commercialize domestic health functional foods. The main ingredients of the highest product in the sales were omega-3, fats and oils, spirulina and glucosamine.

A typical industrial success case in the marine bio-pharmaceutical field can be said to be a bio-adhesive derived from sinol and mussels. It can be said that Seanol, an extract of persimmon from marine plants, was the first in Korea to successfully industrialize through FDI's New Dietary Ingredient (NDI) certification. It is developed and sold by Bota Medi as a super sulfur oxidizer. Mussel-derived medical bioadhesives have shown the possibility of commercialization by succeeding in the transfer of foreign technology.

Although marine bio-energy is slow to commercialize compared to functional foods and cosmetics, industrialization of biodiesel and bio-hydrogen can be expected due to the recent rapid development of technology. The marine biodiesel produced using microalgae began the first phase of commercialization after receiving the quality certification, and analyzed the Omics-based hydrogen production mechanism of the thermococcus onnurineus NA1, a marine bacterium (microorganisms inhabiting the high-temperature submarine volcanic zone), excellent strains development and world-class productivity were secured.

※ Major achievements in biotechnology development

① (New material) Mussel adhesive protein development medical composite hemostatic agent and chitin utilization dental shield fabrication technology development

: Secured mass production technology by combining mussel's adhesive protein with E. coli → Development of medical adhesive capable of harmless and underwater adhesion to the human body

* '16 K-Startup Grand Prize, '17 Invention of the Year(KIPO)

Mussel protein identification and mass culture ('14)

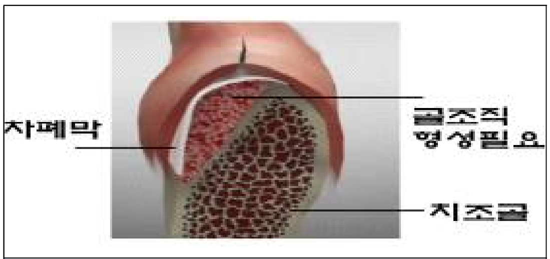
⇨

Development of medical adhesive ('15)

⇨

Start-up of venture business ('16)

: Development of dental shielding membrane technology using composite hemostatic material using mussel adhesive protein and sea anemone silk protein and chitin component, marine organic material('17)

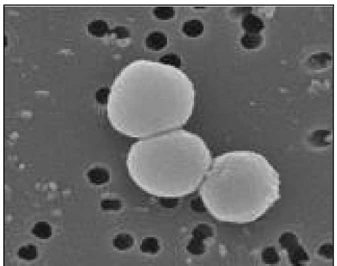


Dental shield

Technology transfer agreement

② (Energy) Development of biohydrogen production technology (KIOST) using deep sea marine archaea and diesel production technology through extraction of microalgae (Inha University)

: Found marine archaebacteria in deep-sea hydrothermal waters in the South Pacific → Investigation of the hydrogen production action of archaebacteria → Successful hydrogen production through a 1-ton reactor ('16)


Hydrogen-producing marine archaea found


Biohydrogen demonstration production (1-ton reactor, '15)


Under construction of a 50-ton plant for mass production of biohydrogen ('19)

: Harvesting, concentrating and drying microalgae in a microalgae mass cultivation site (Yeungheung-do, Incheon) → Extracting microalgae biodiesel (refining) → Succeeding in vehicle driving test ('15)

< 바이오수소 >

Publication on "Nature" ('10)

Biohydrogen production ('16)

< 바이오디젤 >

Mass cultivation site construction ('12)

Diesel vehicle driving test ('15)

③ (Others) Identification of cancer diagnosis treatment method based on iron oxide nanoparticles and detoxification of the world's first marine mammal whale tree full length genome

: Identification of cancer diagnosis and treatment method using magnetic properties of iron oxide nanoparticles (Chemical Reviews published, '15 .10)

: Study on the changes of the mammals living on land by adapting and analyzing the genome of the mink whale (Nature Genetics, published, '14 .01)

3) Promising fields expected

As mentioned earlier, Korean marine bio companies are focusing on the fields of food and cosmetics. However, it also has promising technologies in various fields such as marine bio resources, research and development and services, and environmental fields. Among the resource fields, it has competitiveness in fields such as genome analysis and expression gene analysis technology.

Considering the current status of the domestic industry, many experts have found that the most promising areas are the pharmaceutical and energy sectors[2). In terms of market size,

2) Deokhee Jang et al, Long-term prediction and implications of the domesticand foreign marine biotechnology market(2013)

functional food is most likely, and in terms of growth rate, the pharmaceutical and energy sectors are expected to be promising.

According to the another study[3], in terms with the marketability of product or market size, the marine bio food and marine bio medicine sectors were ranked highest. On the other hand, in terms of potential for future development, marine biomedicine, marine biochemistry, marine biofood, and marine bioenergy were evaluated in order. In terms of value-added, the pharmaceutical and chemical sectors are expected to show a predominant growth, but there were also opinions that development strategies for marine bio-resources and marine bio-food sectors would be needed to induce mutual benefits between industries within the marine fisheries industry.

Ⅳ. Current Status of Fostering the Marine Bio Industry

1. Current status of major overseas countries

In this chapter, the major countries that are prominent in the field of marine biotechnology will look at policies.

1) U.S.

The U.S. has a $ 1.2 billion market as of 2013, accounting for one third of the world's marine bio market. It forms the largest market as a single country and is equivalent to the total market in Europe (12.2 billion).[4]

In this way, we will examine the US policy direction and

3) Jang Jeong-in et al., Domestic marine bio-industrialization trend and policy direction (2016)
4) GIA,「Marine Biotechnology A Global Strategic Business Report」, 2013

major research institutes that are leading individual countries in the global market of marine biotechnology. The United States, with the longest history of marine research, is the host country of marine research and a leader in related research. US marine biotechnology research has produced various results since the early 2000s. For example, in 2001, the US Department of Energy (DOE) achieved results such as identifying 1.17 million sequences and 16,000 genes in sea squirrels. The United States can be regarded as the country where the bio industry started, and it can be regarded as the world's strongest country in the field of marine biotechnology due to its strong industrial base and free flow of information between universities, research institutes, and companies. At the federal level, the United States is making full-scale efforts to foster biotechnology research and development. It is pursuing research and technology development around the NOAA and the National Science Foundation (NSF), and supports more than 200 research institutes through the Sea Grant Program.

A feature associated with US marine bio support is that there is no separate federal level policy. However, support for the marine bio industry is continuing within the overall picture of the bio industry. This fact not only includes information on the marine bio industry, such as the biodiesel energy production policy using seaweed, in the 'National Bioeconomy Blueprint' established in 2012, but also the research and development of marine bio on a program-by-program basis. This can be confirmed through the continued support for. It is judged that it is exploring opportunities for industrialization through securing marine life resources, basic and applied research, and the contents of marine biodiesel are most frequently mentioned.

In addition, customized investments are being made to resolve current issues across all fields of biotechnology, and as various public and private collaboration systems are sought, attempts are being made to support spin-offs at universities and to create private investments. The U.S. government's R & D investment is estimated to be $ 64 million per year (NSF) and about $ 72 million per year (NIH), a significant increase in the 2000s.

Despite the high potential of the marine bio industry, the reason the marine bio sector is slower than the general bio sector is the environment. That is, it is relatively difficult to stably control or secure marine life. This involves stimulating genetic means of production or confirming the structure and determining whether chemical synthesis is possible. If the researchers identify interesting properties in marine life, neuroactive or anticonvulsant activity, such as the Pharma Sea, was discovered by testing new compounds in Zebrafish, incorporating genes that isolate active horses and include them in the genetically modified microbial 'working horse' Should be.

In addition, the development of chemical informatics is also important to study materials mined from the ocean. This is because automatically processing large amounts of data can greatly reduce wasted work. This data processing helps to discover known compounds and find new interesting compounds. The automated structure determination work flow eventually leads to the discovery of new drug candidates. However, while this study is very important to clarify the nature of the marine biology process, scientists have also learned how to obtain IP (Intellectual Property) protection for discovered substances and the problems of generating revenue through mass production. To consider. Most of the work done in the ocean is purely scientific and leads to papers published in scientific journals. It can also lead to commercialization. Another uncertainty associated with IP can arise from other governments claiming substances found in their oceans. This was, in principle, regulated by the Nagoya Protocol, but in reality, claims related to

IP can still be very uncertain. Therefore, there is a tendency for scientists to head to the international waters (deep waters) for research where the claims of intellectual property are not clear.

In order to remove these barriers, most of the policy issues raised for the development of the marine bio industry focus on access to and management of resources. This is particularly true in the "Policy Issues in the Development of Marine Biotechnology", which summarizes the research and research conducted by faculty members of the University of Delaware with the support of the Sea Grant program. In particular, this research includes not only research on representatives and scientists of related companies, but also on the evolution of the policy framework in the United States and around the world and its impact on the development of the marine bio industry. Most of the policy frames related to marine biotechnology are concerned with protecting biodiversity. (Biological Diversity or Biodiversity Convention) In the past few years, two important practices have sparked the need to investigate the relationship between marine resource management and the marine biotechnology industry. These appear as "Biodiversity Convention" and "UN Convention on Sea Law".

The "Biodiversity Convention" was signed at the United Nations Environment Development Conference on December 29, 1993 and remains without ratification by the United States Congress. The main objective of the Convention is "fair and equitable sharing of benefits arising from the conservation of biodiversity, the sustainable use of its components and the use of genetic resources through appropriate access to genetic resources" (UNCED 1993, p. 2). Actions to achieve this goal include: identification and monitoring of components of biodiversity; Provide conservation of biodiversity on the spot through the establishment and maintenance of protected area systems. Emphasis is placed on research and training and scientific and technological cooperation to adopt economic measures that serve as incentives for the conservation and sustainable use of biodiversity. Promote public education and awareness on biodiversity (UNCED 1993, p.2).

The main focus of the “Biodiversity Convention” is the need to link the conservation and development of biodiversity as a key to expanding economic benefits and securing incentives for conservation. Clearing the concept of regulating access to genetic resources to take advantage of market incentives for the preservation of genetic information has opened a new chapter in international norms regulating access to genetic resources. This Convention expressly states in Article 15 of access to genetic resources that each country has sovereignty over its own genetic resources: "Recognizing that the sovereignty of a country is greater than its own resources, Give access to national authorities to national authorities and comply with national law "(UNCED 1993, p.8).

The Biodiversity Convention laid the foundation for the establishment of a national system for managing genetic resources. National rights can now be formally tied to genetic resources through regulations regulating access to resources.

It is also argued that an independent research institute is needed for intensive support for the marine sector. In general, science in the U.S. is poorly funded; while the total number of dollars spent here is large, we only rank 6th in world in the proportion of gross domestic product invested into research. The outlook for ocean science is even bleaker. In many cases, funding of marine science and exploration, especially for the deep sea, are at historical lows. In others, funding remains stagnant, despite rising costs of equipment and personnel.

The Joint Ocean Commission Initiative, a committee comprised of leading ocean scientists, policy makers, and former U.S. secretaries and congressmen, gave the grade of D- to funding of ocean science in the U.S. Recently the Obama Administration proposed to cut the National Undersea Research Program (NURP) within NOAA, the National Oceanic and Atmospheric Administration, a move supported by the Senate. In NOAA's own words, "NOAA determined that NURP was a lower-priority function within its portfolio of research activities." Yet, NURP is one of the main suppliers of funding and equipment for ocean exploration, including both submersibles at the Hawaiian Underwater Research Laboratory and the underwater habitat Aquarius. This cut has come despite an overall request for a 3.1% increase in funding for NOAA. Cutting NURP saves a meager $4,000,000 or 1/10 of NOAA's budget and 1,675 times less than we spend on the Afghan war in just one month.

One of the main reasons NOAA argues for cutting funding of NURP is "that other avenues of Federal funding for such activities might be pursued." However, "other avenues" are fading as well. Some funding for ocean exploration is still available through NOAA's Ocean Exploration Program. However, the Office of Ocean Exploration, the division that contains NURP, took the second biggest cut of all programs (-16.5%) and is down 33% since 2009. Likewise, U.S. Naval funding for basic research has also diminished.

The other main source of funding for deep-sea science in the U.S. is the National Science Foundation which primarily supports biological research through the Biological Oceanography Program. Funding for science within this program remains stagnant, funding larger but fewer grants. This trend most likely reflects the ever increasing costs of personnel, equipment, and consumables which only larger projects can support. Indeed, compared to rising fuel costs, a necessity for oceanographic vessels, NSF funds do not stretch as far as even a decade ago.

Shrinking funds and high fuel costs have also taken their toll on The University-National Oceanographic Laboratory System (UNOLS) which operates the U.S. public research fleet. Over the last decade, only 80% of available ship days were supported through funding. Over the last two years the gap has increasingly widened, and over the last ten years operations costs increased steadily at 5% annually. With an estimated shortfall of $12 million, the only solution is to reduce the U.S. research fleet size. Currently this is expected to be a total of 6 vessels that are near retirement, but there is no plan of replacing these lost ships.

The situation in the U.S. contrasts greatly with other countries. The budget for the Japanese Agency for Marine-Earth Science and Technology (JAMSTEC) continues to increase, although much less so in recent years. The 2007 operating budget for the smaller JAMSTEC was $527 million, over $100 million dollars more than the 2013 proposed NOAA budget. Likewise, China is increasing funding to ocean science over the next five years and has recently succeeded in building a new deep-sea research and exploration submersible, the Jiaolong. The only deep submersible still operating in the US is the DSV Alvin, originally built in 1968.

In addition to historical issues of infrastructure and current economic woes, we lacked an understanding of the importance of basic research and ocean exploration to science, society, and often to applied research. As example, NOAA shifted funding away from NURP and basic science and exploration but greatly increased funding to research on applied climate change research. Increased funding for climate change research is a necessity as we face this very real and immediate threat to our environment and economy. Yet, did this choice, and others like it, need to come at the reduction of our country's capability to conduct basic ocean exploration and science and which climate change work relies upon?

Just a few short decades ago, the U.S. was a pioneer of deep water exploration. We are the country that in 1960 funded and sent two men to the deepest part of the world's ocean in the Trieste. Five years later, we developed, built, and pioneered a new class of submersible capable of reaching some of the most remote parts of the oceans to nimbly explore and conduct deep-water science. Our country's continued commitment to the DSV Alvin is a bright spot in our history and has served as model for other countries' submersible programs. The Alvin allowed us to be the first to discover hydrothermal vents and methane seeps, explore the Mid-Atlantic ridge, and countless other scientific firsts. Our rich history with space exploration is dotted with firsts and it revolutionized our views of the world and universe around us; so has our rich history of ocean exploration. But where NASA produced a steady stream of occupied space research vehicles, Alvin remains the only deep-capable research submersible in the service in the United States.

As stated by the Joint Ocean Commission, "Ocean programs continue to be chronically underfunded, highlighting the need for a dedicated ocean investment fund." Captain Don Walsh, one of three men to visit the deepest part of the ocean, recently stated it best: "What we need is an Ocean NASA."

There is much to be gained from creating NASA-style Ocean Science and Exploration Agency (OSEA). Every dollar we commit to science returns $2.21 in goods and services. Meeting the scientific, technological, logistical, and administrative demands of scientific exploration creates jobs and requires substantial personnel beyond just scientists and engineers. The materials purchased for this cause support even further employment. As with NASA, meeting these scientific and engineering challenges will disseminate ideas, knowledge, applications, and technology to rest of society. This knowledge gained from basic research will form the backbone for applied research and economic gain later. And much like NASA has, OSEA will inspire the next generation of scientist and engineers, instilling in the young a renewed appreciation for the oceans of which we are all stewards: our oceans. It will provide a positive focus for society in a time where hope is often lacking and faith in science is low. OSEA will be the positive message that renews interest in our oceans and their conservation.

What Does an OSEA look like? At the core OSEA would need a mission dedicated to basic research and exploration of the >;90% of the world's oceans that remain unexplored. High risk with the potential for high impact would be the norm. Pioneering knows no other way to achieve those truly novel and impactful gains.

To achieve these goals, OSEA would need substantial infrastructure and fleet including international and regional class research vessels, a submersible, remotely operated vehicles, and autonomous underwater vehicles. Funding would need to be secure on decadal cycles to insure both the longevity and permanence of this mission but allow for oversight to ensure OSEA was meeting its mission and financial responsibilities. An ocean exploration center would be staffed with a vibrant community of researchers, engineers, and administrators, postdoctoral fellows, graduate students, and visiting experts with a strong interacting and supportive community working toward uncovering the mysteries of the oceans. Research would be funded internally from a broad OSEA budget, not externally, freeing scientists and engineers to actually do science and engineering as opposed to the only current option, which is writing grants to other agencies with a less than 10% chance of funding.

OSEA would also be a resource both for the research community and the public by being dedicated to open science, i.e. making scientific research, data and dissemination accessible to all levels of an inquiring society, amateur or professional. Publications, data, software, and engineering would be freely available and open to all. All internal processes would be transparent.

The mission of OSEA in the spirit of open science would be equally dedicated to public outreach. For too long have science and society been disconnected. OSEA would involve the public as the ultimate funders of our work. A novel and cutting edge education and outreach group would develop a strategic plan to involve children and adults in the mission. There would be multiple opportunities for anyone to be involved including the public. Citizen scientists would be essential components, allowing adults to take a residence and contribute to OSEA and become life long ambassadors long after their residence.

Although parts of OSEA are realized in other government and private organizations, they do not meet the full mission nor can such a distributed structure be expected to meet the challenges of this pivotal moment. For example, NOAA fills a much-needed role but its mission is largely applied. NOAA's mission statement is "Science, Service, and Stewardship. To understand and predict changes in climate, weather, oceans, and coasts, To share that knowledge and information with others, and To conserve and manage coastal and marine ecosystems and resource". Contrast that to NASA's simple mission, "to pioneer the future in space exploration, scientific discovery and aeronautics research."

In an agency with a chiefly applied mission, those programs that are purely exploratory must eventually invent an applied focus or face the axe. For example, even under NURP, exploration often focused on corals and fish of considerable economic and conservation importance rather than those species of greatest novelty or knowledge deficit. The current situation at NOAA also highlights how less applied scientific programs are likely to be lost. Monterey Bay Aquarium Research Institute also provides another model that comes close to OSEA but is heavily reliant on private funding that can often be significantly reduced during recessions as endowments shrink. Moreover, a private foundation is unlikely to meet the full financial burden to support the full mission of an OSEA or provide a resource to the ocean science community as whole. This is not meant to criticize either NOAA or MBARI, indeed both supported our own research and have made immense contributions to ocean science and exploration, but neither do they fully realize our vision for OSEA.

2) EU

Europe has long been interested in the field of marine biotechnology, and as a result, a variety of specific programs focusing on marine biotechnology research and industrialization have been promoted. The European Commission has made efforts to select and focus on marine bios as the five key areas with high growth potential.

Unlike the United States, he also established “Marine Bio: Europe's New Vision and Strategy”, a strategy specialized in the field of marine biotechnology. The main tasks of the marine bios presented by the European Maritime Commission are as follows.

Category	Priority and Purpose
Food	- Development of innovative methods based on biomix and biotechnology for culture of aquaculture - Sustainable aquaculture, prevention and treatment through biotechnological applications, development of

	feed and waste-free recycling system aquaculture - Development of new feed for improving human health, improving product quality, and minimizing environmental impact
Energy	- Biofuel production through optimization of strains - Enhancement of basic research of bio function, development of mass cultivation technology, biofuel production and bio refinery, method of metabolism and culture of microalgae, improvement of photosynthetic efficiency, and improvement of lipid productivity - Development of efficient separation and purification process of seaweed
Health	- Basic research on marine organisms living in extreme environments - Strengthening technical aspects such as bio-active agents of marine origin, separation process, and structure determination method - Production of new pharmaceuticals and pharmaceutical products through scientific advances in aquaculture, microorganisms, cells, culture, and biosynthesis engineering
Environment	- Detecting marine life threats, including human health, monitoring the marine environment to solve coastal water quality, and developing bio-sensing technology - Development of high-efficiency non-toxic antifouling technology that combines new antifouling compounds and sea level engineering - Support for development of commercial tools and platforms for organism identification technology development, DNA-based technology, etc.
Products/	- Enzyme screening technology development, marine

Process	protein and enzyme technology development - Development of marine biopolymers for the production of commercial products such as food, cosmetics and health

<Table 9. Priority and Purpose of EU in terms with Marine Bio>

In addition, joint cooperation programs based on cooperation among member countries are well established, and transnational research infrastructures such as EMBL and EMBRC are established to support research on marine biotechnology in the region. Areas of particular interest are promoting various technological developments such as management, protection, restoration, and evaluation technology development for the protection of marine ecosystems, while implementing strategies to promote network formation.

At the national level, it seems that countries in the northern European countries are carrying out more research on marine biotechnology. This is presumed to be because it is advantageous to secure marine resources. For example, Norway ((Norway is a country that has not joined the EU due to concerns about fishery and marine resource infringement, but we do not have enough information to divide it into a separate table of contents, so we will discuss it together). This is one of the countries that have the potential to develop the marine bio industry, which has the potential to be recognized, and is one of the countries that actively recognize and support the importance of marine resources. More than 30,000 people are employed in the food industry.

3) Japan

Japan, a traditional developed country in the field of marine biofood, suggested the development of marine bio energy technology as a key research area through the 2nd Basic Ocean Plan ('13 ~ '17). In particular, the health and medical sector is set as a strategic industry, and in order to foster it, various policies such as fostering bio-ventures and promoting R & D commercialization are being promoted. Japan is taking a strategy to achieve technological industrialization based on the results of basic research by emphasizing the advantages of Japan's basic research in the field of biotechnology. In particular, in view of recent trends, it seems to have a lot of interest in stem cell research and industrialization. In addition, it is pursuing the securing of microorganisms in the deep sea and ocean and the development of new drugs centering on government research institutes such as JAMSTEC (Japan Agency for Marine-Earth Science and Technology) and MBI (Marine Biotechnology Research Institute).

What distinguishes it from other countries is that local governments are actively supporting them as well as those of the central government. Japan's Ministry of Economy, Trade and Industry is promoting Japan's industrialization policies according to regional characteristics by dividing Japan into regions and establishing a bio-industry promotion policy suitable for regional characteristics. The regional-level marine bio characterization policy is actively being implemented in Iwate Prefecture, Toho-ku, Japan, and a base for linking industry-academia-research institutes has been established, and JAMSTEC (Marine Science and Technology Center) and Kitasato University are collaborating. This local government-centered specialization policy is linked to the activation of the local economy, and has a positive effect on policy consumers as well as on the general community.

In Hakodate City, Hokkaido, under the plan of “Universal Marine Industry,” the marine biocluster formation project was promoted, leading to the development of major technologies for the production of high value-added products derived from marine organisms. It was planned to create a cluster that includes all universities, businesses, and local governments. It seems that the major research topics* were selected and intensively pursued in order to create and spread performance in the marine biotechnology field.

* Major research projects in Hakodate City 1) Coastal creatures using marine spatial information, improving the marine environment and information utilization (e.g. marine forecasting system, etc.) 2) Self-supported type of bio farming which is for giant seabed creatures containing high functional substances 3) Research to secure functional materials by utilizing the biological characteristics of giant undersea creatures

<Figure 12. The structure of UMI in Hakodate City>

In addition to Hakodate City, Okinawa's marine bio development strategy is also being systematically progressed. In Okinawa, for the past three years from '08 to '11, the Ministry of Education, Culture, Sports, Science and Technology's regional innovation program was promoted. With the center supported by the Okinawa Prefecture Government and the coordination of science and technology under the organization, the project is being promoted in the form of collaboration between existing research institutes, universities, companies, and commercialization-related organizations and companies in the region.

※ Current Key Issues related to Marine Bio Industry in Japan

(1) Tohoku Ecosystem-Associated Marine Science (TEAMS) Project The Great East Japan Earthquake of 2011 caused immense damage to the Pacific Coast districts of the Tohoku region, and also to offshore waters, etc. The Tohoku Ecosystem-Associated Marine Science (TEAMS) project has involved the implementation of various measures directly linked to the region's recovery, and has been carried out in close collaboration with local communities; the results achieved have been very impressive, unmatched by any similar scheme elsewhere in the world. The priority in the future with regard to the results achieved in the TEAMS project and the new research methods that have been developed (involving close collaboration with local communities) is to ensure the continuation of the implanting in the local community of the know-how etc. developed through TEAMS through the use of clear, explicit messages and taking into account the needs of the period after 2020 (by which time the "Reconstruction and Revitalization Period" will have ended), and also to encourage the adoption of

similar methods in other parts of Japan and overseas.

(2) Advancements in Marine Bio-resource Conservation Techniques Starting from 2011, long-term, systematic survey-based research has been undertaken to develop a more comprehensive understanding of marine ecosystems, along with research aimed at developing revolutionary production technology that pays greater attention to the biological functioning etc. of marine organisms; as implementation of these research plans has progressed, impressive progress has been made. To ensure that the results of this research are used to make a positive contribution to society, there is a clear need for continuing research and for the dissemination of the research results so that they can be implemented in society, focusing on the development of revolutionary cultivation methods for juvenile bluefin tuna, and on the development of a comprehensive understanding of marine ecosystems, etc.

(3) Development of Observation and Monitoring Technology Beginning in 2011, the R&D work on core technologies that can contribute to the conservation and regeneration of marine biodiversity and marine ecosystems that has been undertaken by the Japan Science and Technology Agency (JST) has led to the development of many advanced new technologies that have a great deal to offer. It is important that, looking ahead to the future, these kinds of technologies are widely adopted and utilized.

(4) Cultivation of Human Resources and Dissemination of Information, etc. Efforts to cultivate young research talent

through their participation in research projects – particularly in areas that have been affected by natural disasters – are very important from the perspective of regional recovery and regeneration. It is vitally important that the future development of marine biological research involves the active recruitment and cultivation of young researchers, as well as their participation in international projects, etc., and other measures to cultivate human talent capable of operating effectively on the global stage. Ongoing outreach activities to disseminate research results in a way that makes them easy to understand are also of great importance.

4) China

In the case of China, after the 863 program of marine biotechnology ('96 ~ '05, totaling 300 million yuan) which is focused on securing stable food in the past, China tried to foster the marine bio industry with a focus on new drug development[5]. To this end, the National Ocean Bio Industry Complex was built in Qingdao to provide support to foster companies in the marine bio industry.

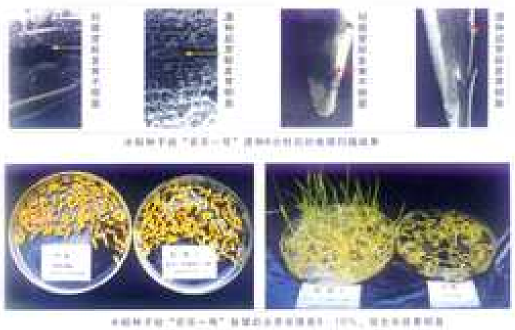
In addition, during the 12.5 planning period, the promotion of the marine bio industry was promoted around the eastern coastal castles. With the focus on Shandong Province, Guangdong Province and Zhejiang Province, investment in the marine biopharmaceutical industry has been increased and it has been actively fostered as a growth point for the marine economy. Subsequently, during the 13.5 planning period, a marine bio-cluster was promoted through the marine economic development pilot zones, such as the development

5) Prepared 2,000 pharmaceutical products from about 1,000 marine life resources, launched over 10 markets (Ministry of Oceans and Fisheries, Strategy for Fostering Marine Bio Industry, 2018)

of marine resources in the South China Sea in Hainan Province and the Blue Silicon Valley in Qingdao, Shandong Province. In these regions, the development of marine biopharmaceuticals and new material marine bio-products has been set as a top priority.

As mentioned earlier, China is actively developing new drugs that utilize marine life resources. The number of marine biological varieties for drugs discovered until recently reaches about 1000, and the separated natural extracts are about 100, and the number of single prescription drugs that have been successfully developed reaches 10. More than 10,000 marine organism-based new structural compounds have been discovered, of which 200 are in the process of patent application or have already been patented.

The R&D Center of Marine Biotechnology aims to build up a high technology platform for the demand in biotechnology from mariculture industries in China. It serves to solve bottleneck problems in strain breeding and environment control for healthy cultures of shellfish, fish, shrimp, algae etc; marine pharmaceutical R&D; marine bio-resources and the agricultural application; disease control and feed formulation; and mariculture environmental protection. The center led and undertook many national backbone projects including “973 Project”, “863 Project” and others. National and international level achievements have been made in the fields of animal genetic breeding, strain cultivation, and aquaculture technology; R&D on all-in-one microparticulated diet; large-scale microalgae cultivation; and bio-active materials utilization. In addition, the center has implemented key technology for strain preservation. The “Dalian-I” hybrid abalone has won nation’s certificate of new marine cultural breed. A “three-step” system was created for quality Ruditapes philippinarum cultivation. The “Nongle-I” marine bio-matter-yield pesticide has been promoted widely in China. Fucoidan (FPS) and Hai Kun Sheng Xi Capsule and other 2 have been certificated as new drugs by the State Food and Drug Administration of China. The outstanding performance marked China with leading roles in the fields of marine bio-chemical R&D and high-value-added marine algae economy, promoting marine industry in a sustainable growth with remarkable economic and social benefits.

<table>
<tr><td>
</td><td></td></tr>
<tr><td>Dalian-I hybrid abalone variety</td><td>New Drug Hai Kun Shen Xi capsule made from kelp</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Successful introduction and artificial breeding of American shrimp</td><td>“Nongle-I”, a pesticide made from marine bio-substance</td></tr>
</table>

5) Singapore

The national Marine Science Research and Development (R&D) Programme (MSRDP) will integrate R&D in tropical marine science and promote active engagement of industry in the drive towards environmental and marine sustainability. It seeks to advance marine science research in Singapore by leveraging Singapore's location in a region with rich marine biodiversity, to develop nationally relevant R&D and to build capabilities that would address the strategic needs of Singapore in the future.

MSRDP is launched in collaboration with the National University of Singapore (NUS). To implement MSRDP successfully, NUS will work closely with partners in our R&D ecosystem, including the Nanyang Technological University (NTU) and the Agency for Science, Technology and Research (A*STAR). The MSRDP will be led by Programme Director Professor Peter Ng Kee Lin from the Department of Biological Sciences at the NUS Faculty of Science. Prof Ng is also Head of the Lee Kong Chian Natural History Museum and former Director of the Tropical Marine Science Institute at NUS.

The programme will leverage Singapore's only offshore marine research facility, the St. John's Island National Marine Laboratory (SJINML), whenever possible. SJINML has been Singapore's key facility for inter-disciplinary marine research for 15 years, and was designated by NRF to become a National Research Infrastructure in March 2016.

Three research themes and one enabling technology theme for MSRDP were identified through discussions with academics, government agencies, stakeholders and industry players. These are:

(1) Marine Ecosystems and Biodiversity

The Marine Ecosystems and Biodiversity research theme seeks to understand and protect the marine ecosystems. MEB will lay the foundation for management and conservation of marine species and habitats, and provide the knowledge base to support proactive and strategic management decisions that will have to be made in years ahead.

(2) Environment Impact and Monitoring

The Environment Impact and Monitoring research theme aims to develop real-time monitoring techniques that are robust, sophisticated and time-sensitive, to capture ecosystem changes. This enables dynamic environmental impact assessments, which are evolving beyond simpler species-based or physical parameter-driven assessments, towards more sophisticated methods and predictive modelling that capture ecosystem changes. This will lead to more informed decisions and enable longer-term planning for development projects.

(3) Coastal Ecological Engineering

The Coastal Ecological Engineering research theme aims to rehabilitate and restore native biodiversity and ecosystem resilience, as coastal development works which modified or replaced Singapore coastlines may have disturbed our coastal ecosystems. It plans to develop solutions to mitigate and "soften" the impact of urban development works, such as designing coastal structures in novel ways to reduce wastage and increase biodiversity.

The Marine Technology and Platforms theme, is about enabling technologies that connect the three research themes and create value. It encompasses the development of high-value novel materials, new processes and services such as integrated dynamic databases, novel marine-based tools, and facilitation of spin-off technologies and translational research.

NRF will invest $25 million over five years in the MSRDP. The programme targets to augment local talent development in marine science research by training research scientists, engineers, and PhD students in the field. There will also be internships and collaborative partnerships with industry for technology development and applications.

The MSRDP is open to all publicly-funded researchers in Singapore, and could include partners who are international experts. 30 white-papers were received when the call for marine science projects was first launched, which led eventually to 16 formal proposals that are being evaluated. Successful proposals are expected to be awarded later in 2016.

Some projects aligned with national initiatives will be pursued in collaboration with agencies like Housing & Development Board and National Parks Board, for example, to "soften" and improve our coastlines and better manage our coral reefs. There will also be an outreach component whereby the outcomes of the research will be shared with the public.

※ Status and Features by Continent

1. Summary

A recent market research report estimates that the global market for products resulting from marine biotechnology might exceed US$ 4B by 2015, of which marine biomaterials (including seaweed hydrocolloids) could contribute over 40%, and marine bioactives for healthcare would be the most important and fastest-growing sector. The size of this, even if it is an over-estimate, suggests that the harnessing of marine bioresources through biotechnology and development of products and services should be a serious target for any country with significant aquatic biodiversity. It is of interest that the report noted that very few countries have national marine biotechnology R&D programmes; it also identified the USA as the world leader in marine biotechnology.

That marine bioresources can give rise to specific molecules of tremendous use or potential for human medicine is undeniable. There are now 4 approved products, 13 in clinical trials and a large number in pre- clinical investigation , coming from a wide range of organisms from many different parts of the world. The route to market involves isolation and chemical characterisation, followed by synthesis or semi-synthesis of the molecule or an active analogue. Prialt® ziconotide, a painkiller originally isolated from a Pacific (Philippines) cone snail, Yondelis® trabectidin, an anti-cancer molecule from a Caribbean tunicate Ecteinascidia turbinata, and anabaseine (DMXBA) from the ribbon worm Paranemertes peregrina, from the Pacific Rim, are examples.

This CSA MarineBiotech report brings together as much information as can initially be found on national strategies for biotechnology and marine biotechnology, programmes and major research centres. It is intended to be a high-level overview and analysis of research, investments, research programmes and trends. It is also a 'living document', through the medium of the WIKI-pages of the MarineBiotech website to be corrected, expanded and brought up to date by interested parties who have access to direct knowledge and accurate information. It is also intended to raise interest in transnational collaborative possibilities between European countries and others.

The countries that are the focus of this report include those that are relatively highly active, such as USA, Brazil, Canada, China, Japan, Republic of Korea and Australia, as well as others where activities are growing from a smaller base (Thailand, India, Chile, Argentina, Mexico, South Africa) and where there are signs that marine biotechnology is increasing in importance as a research priority. Multinational regional approaches and infrastructures are also included where appropriate. It is notable that the major international effort, the Census of Marine Life (CoML), involved 2700 researchers, about 31% from Europe, 44% from USA and Canada, and 25% from the rest of the world, notably Australia, New Zealand, Japan, China, South Africa, India, Indonesia and Brazil.

Perhaps the most important strategic move is that OECD is now involved in marine biotechnology considerations. OECD has established a steering group to develop a strategy for marine biotechnology, initiated by Norway in 2010 and now including Belgium, Canada, Denmark, France, Korea, Israel, Mexico, USA, the EU and the OECD's BIAC (Business and Industry Advisory Committee). In addition, OECD maintains an interest in facilitating the international networking of Biological Resource Centers, to ensure that collections are properly managed.

2. Africa

Mozambique has a coherent biotechnology plan. Otherwise, only Nigeria, South Africa and Tunisia seem to have any elements of biotechnology or marine sciences plans, policies or strategies. Kenya launched a national bioprospecting strategy in 2011 in response to biopiracy.

In Africa, Tunisia seems most forward in creating a programme that utilizes the relevant expertise of national research institutes.

In terms with research priorities, biofuels and marine bioactives are the main research priorities. Aquaculture is important but there is not so much evidence of biotechnology applications as part of national programmes (see though Nigeria).

For the infrastructures and coordination and support capacities/initiatives, the Mediterranean Science Commission (CIESM), the Inter-Islamic Science and Technology Network on Oceanography (INOC) and the Ocean Data and Information Network of Africa are three notable integrational initiatives with involvement in marine biosciences.

3. Central & South America

Brazil and Chile have national biotechnology plans. Chile also has a national Innovation Plan (2012-2014). Argentina's Law 26270 focuses on building the economy through facilitating biotechnology enterprise. Mexico has PECiTI (the national Science, Technology & Innovation programme), and a National Development Plan 2007-2012. No country has a marine biotechnology strategy, but Brazil carries out strategic R&D through a specific programme BIOMAR, established in 2005, and Costa Rica has an institute to manage the exploration and use of biodiversity, INBio, established in 1989.

National schemes and programmes, with the exception of Brazil's BIOMAR, are generic, though many of them do support marine biotechnology. BIOMAR began road-mapping marine biotechnology in Brazil in 2007. It is a good case study for national marine biotechnology support programmes. Marine biodiscovery is recognized in Costa Rica's Bioprospecting programme (1991).

The countries' focus is very broad, including biodiscovery, bioenergy, bioremediation and biofouling. In Chile, there is also activity in molecular aquaculture, because of the importance of this sector to the economy. There are numerous universities and research centres involved in marine biotechnology in Brazil, Chile and Mexico.

The best examples of academic infrastructure and support are to be found in Brazil, the government-funded networks RedeAlgas (macroalgae), Rede interinstitucional de algas bentônicas (microalgae) and Rede Brasileira de Tecnologia de Biodiesel (biodiesel).

4. North America

Canada published its first National biotechnology strategy in 1983 and renewed it in 1998. Genome Canada was founded in 2000 as 'a catalyst for developing and applying genomic sciences that create economic wealth and social benefit '. The USA announced in 2011 a National Bioeconomy Blueprint. Neither country has a specific marine biotechnology strategy, plan or policy. The Canadian marine strategy of 2002 and Healthy Oceans Initiative of 2007 contain some elements that might be relevant but the overall focus is on sustainability and integrated approaches to oceans. In North America, Fisheries and Oceans Canada has a strong programme in aquatic biotechnology and genomics and the National Research Council supports the Institute for Marine Biosciences in Nova Scotia. Genome Canada, through its regional activity in British Columbia, is a partner in the international Salmon Genome project and has other fisheries and environmental activities that are relevant for marine biotechnology. Québec supports the Marine Biotechnology Research Centre in Rimouski, which is an industry-facing development organization. In the USA, the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), the Department of Energy and Department of Defense support aspects of marine biotechnology, the last 2 focusing strongly on algal biofuels. NSF was the main supporter of the enormous Microbial Observatories programme, and NOAA has 3 relevant programmes, national Sea Grant, Ocean Explorer and National Undersea Research.

In North America, although there is effort on biodiscovery and other aspects of marine biotechnology, including molecular aquaculture in Canada (salmon) and Atlantic Coast of USA (shellfish), the picture is heavily skewed by Dept of Energy and Dept of Defense support for algal biofuels, and private investment in algal biorefineries. There are individual units and centres with a strong marine biotechnology focus (Harbor Branch, Scripps, Bigelow and Maryland spring to mind). Most recently, the state of North Carolina has established a Marine Biotechnology Center of Innovation as part of its economic development plan.

In North America, there are some regional initiatives (ArcticNet in Canada, GulfBase in the USA for example) but the most important US-stimulated contribution to international support for marine biotechnology has been the Census of Marine Life (CoML).

5. Asia

Four of the most important players in marine biotechnology can be found, China, India, South Korea and Japan. Taiwan, Korea, Japan and India have specific national biotechnology strategies; in China, biotechnology is an integral part of the Five Year Plans. Individual Indian states have also established biotechnology policies (Gujarat for example). There are no separate national marine biotechnology strategies or policies except in Korea, where there is Blue-Bio 2016. In other major countries, marine biotechnology is mentioned as a specific topic in strategic plans or programmes (such as China, Japan's BioStrategy 2002 or India's 11th Five Year Plan). India also has a National Policy on Biofuels (2009) to which marine biotechnology is contributing. Korea has a plethora of strategies, policies and plans and marine biotechnology is an explicit part of the Biotechnology Fostering Policy.

Marine biotechnology is a specific part of China's National Hi-Tech R&D Programme '863'. The Chinese Academy of Sciences and Chinese government support Key Laboratories, some of which are focused on topics relevant to marine biotechnology. In India, DBT, the Department of Biotechnology, has a Task Force on Aquaculture and Marine Biotechnology, set up in 1998, which has funded over 200 projects since then. Japan was a leader in the area, establishing the Marine Biotechnology Institute in 1990, a public-private partnership, the lasting legacy of which appears to be only the national culture collection. Korea's Marine Bio 21 project (2004) has generated two genomics programmes, and the National S&T Plan 2008-2012 has Core technologies for New Industry: Marine Organism Conservation and Marine Biotechnology as one of its 7 investment areas.

In Asia, there is also a broad range of topics across the countries. There is an increasing focus on biofuels in India but elsewhere, biodiscovery for human pharmaceuticals, food, feed and cosmetics is predominant. The Korean Institute of Ocean Science and Technology is a world-leader in marine biosciences and biotechnology. There are numerous institutes, research centres and universities in China, India and Korea substantially involved in marine biotechnology but they do need more complete profiling to understand how competitive they are with European activities and whether there are broader opportunities for international collaboration.

In Asia, linkages are mainly attained through organised structures such as the key laboratories of China. In India, the Department of Biotechnology created a national Algal Biofuel Network in 2008.

6. Middle East

There appear to be no national biotechnology or marine biotechnology strategies, policies or plans. Israel had an economic development Bio-Plan 2000-2010.

In the Middle East, marine biotechnology seems to be fragmented and buried inside national research plans and programmes.

It is difficult to see what research topics might predominate in the Middle East. Israel is involved in sponge biotechnology, marine bioactives and marine biofuels. Turkey has activities in bioactives and in algal culture for bioenergy and biorefineries. Individual institutions are involved in a number of EU-funded consortia in marine biotechnology. Oman hosts the UNESCO chair in Seafood Biotechnology, at Sultan Qaboos University. There are probably new opportunities for algal biotechnology and molecular aquaculture in the region.

CIESM and INOC represent the most important trans-regional activities; CIESM brings eastern Mediterranean countries together with North African and southern European countries; INOC brings the Middle East into contact with other Muslim nations spread across the world.

7. South-East Asia & the Indian Ocean Islands

Thailand and Vietnam stand out as the countries most focused on marine biotechnology. Indonesia, Malaysia, Singapore, Sri Lanka, Vietnam and Thailand have national biotechnology strategies, plans or policies. Only The Philippines, with NARRDS, the National Aquatic Resources Research & Development System, and Vietnam, with a recently-issued letter from the President of VAST (Vietnam Academy of Science and Technology) explicitly calling for increased efforts in marine biotechnology, have anything resembling a marine biotechnology policy or strategy.

There is evidence of strong investment in biotechnology, but less so in marine biotechnology. The Ninth Malaysia Plan 2006-2010 allocated almost US$550M to industry development through biotechnology and Thailand's National Biotechnology Policy Framework (2004-2009) allocated about US$125M to biotechnology. There are few specific programmes involving marine biotechnology; one is the PharmaSeas Drug Discovery program, funded by the Philippines under NARRDS (National Aquatic Resources Research & Development System). Indian Ocean islands are sometimes involved in marine biotechnology activities, notably Madagascar, but more information is needed.

In South-East Asia and the Indian Ocean Islands, much of the focus seems to be on exploitation of natural biodiversity for novel bioactives. In Vietnam and Thailand, there is however significant molecular aquaculture, especially for crustacea (shrimps, prawns).

Regionally-important research resources include University of Diponegoro Indonesia, the University of the Philippines Marine Science Institute and UP-Visayas, Thailand's National Center for Genetic Engineering and Biotechnology (BIOTEC), the Center of Excellence for Marine Biotechnology at Chulalongkorn University Bangkok, and several institutes within the VAST network in Vietnam.

The Association of South East Asian Nations (ASEAN) may assist in trans-regional activities but this is not clear. The Indonesian Dept of Marine Affairs and Fisheries established a scientific forum for Indonesian Marine Biopharmaceuticals in 2005, and in Vietnam the Ho Chi Minh City Biotechnology Park was started in 2010, with the intention of housing biotechnology start-ups in the aquaculture, seafood and environmental sectors.

8. Australia-Pacific

Both Australia and New Zealand have biotechnology strategies but neither has a specific marine biotechnology strategy. In New Zealand, the Biotechnology strategy includes marine biotechnology within environment/industry, and MoRST (Ministry of Research Science and Technology) produced a roadmap for biotechnology research in 2007, which included marine biotechnology as a specific component. In Australia, enhancement of access to marine resources and marine science are mentioned in the National Biotechnology Strategy (2000-2008) and its successor 'Powering Ideas - An innovation agenda for the 21st century', but marine biotechnology is not explicitly included. Australian States including Queensland and Tasmania do however include marine biotechnology as part of their research and economic development strategies. Marine Innovation South Australia includes and

Aquaculture, Biotechnology and Biodiscovery Science group. Of the Pacific Islands, Guam and Fiji seem the most active in marine biotechnology. There are no obvious national strategies, but Fiji was an early mover in biodiversity (Access and Benefit-Sharing) policy development.

Australia's 'Super Science Initiative' plans to put A$1.1B into innovation science 2009-2013, approximately 45% into biotechnology, including marine biology in one of the 'Future Industries' themes. Australia already supports a world-class basic and applied research institute, AIMS (Australian Institute of Marine Sciences). Australia has also established the Industrial Transformation Research Program in 2011, with $236M funding, though it isn't yet clear how much of this might be applied to marine biotechnology.

In Australia-Pacific, the New Zealand Ministry of Research, Science & Technology's roadmap for biotechnology research recognises molecular aquaculture and marine bioactives as two of New Zealand's research strengths.

The Australian Cooperative Research Centres (CRCs) provide translational services for industry and several of these have taken part in marine biotechnology-orientated work, in seafood genetics, Antarctic microbiology and bioremediation.

9. International Activities

The Working Party for Biotechnology of OECD (the Organization for Economic Cooperation and Development) established a work group in the area of marine biotechnology in 2010 as part of OECD's biotechnology policies activities, with considerable input from Canada, Norway, South Korea, Belgium, Switzerland and the OECD's BIAC (Business and Industry

Advisory Committee). This work has taken place within the context of OECD's report 'The Bioeconomy to 2030) . The OECD marine biotechnology Global Forum in Vancouver in May 2012 moved this area forward and established marine biotechnology development and valorization as a specific project for forthcoming OECD action. The Forum report is about to be published (end 2012-beginning 2013).

The EU is a strong actor in promoting and supporting international links. The review of 59 marine-related projects supported by EU funding, of which 16 are more closely biotechnology-associated, reveals that 14 of those with explicit marine biotechnology or genomics involvement include 26 different research institutions or companies in 18 different countries as consortium partners . In addition, the EU's Joint Research Centre maintains a useful web-site listing research structures and policies around the world. Many of the countries with potential for collaboration with EU institutions and companies in marine biotechnology, or in which the EU could have a favourable impact by capacity-building, are ICPC (International Cooperation Partner Countries). Strategic recommendations for Horizon 2020 projects involving marine biotechnology might include nominations of appropriate countries as ICPCs for specific calls.

The EU-US Task Force on Biotechnology research has had several conferences on marine biotechnology topics, one of those in collaboration with CIESM.

Meeting the innovation challenge In addition to funded projects and programmes that tackle specific areas of marine biotechnology, clusters and networks are recognised as tools to enhance the knowledge transfer that can lead to more efficient innovation. Examples include the joint EU-US Task Force on Biotechnology, the Mediterranean Science Commission CIESM or the Brazilian network RedeAlgas.

Innovation appears to be effected by a four-fold mechanism in the field of marine biotechnology. One is the drive to exploit a country's biodiversity sustainably, another is to join the trend for algal bioenergy and a third is to regard the marine sector as one that can be used as part of a general improvement in biotechnology capability in a country. The fourth, enhancement of food production from the seas through aquaculture, is well-established in those countries which have strong export markets for farmed fish and shellfish and is beginning to become more important in other countries where raising the general nutritional level of the population is important.

The CoML showed the power of public-private partnerships for moving marine biosciences forward. Without the intensive financial support of the Alfred P Sloan Foundation, this US$650M 10-year project would not have got off the ground. The involvement of OECD's Business and Industry Advisory Committee in the marine biotechnology initiative signals a serious intent in marine bioexploration for sustainable economic growth. Slow emergence of interest in aspects of marine biotechnology as economic drivers can be seen elsewhere, with new institutes (Marine and Microbial Biotechnology in India), industry-facing activities (CRCs in Australia, the Biotechnology Research & Development Center in Quebec, the Marine Biotechnology Center of Innovation North Carolina, the Marine Biological Products Industry Strategic Alliance announced in China in 2012, Indian State Government marine biotechnology parks) or translational networks (RedeAlgas in Brazil, the Algal Biofuels network in

India).
Specific trends in strategy and policy are more difficult to bring into focus, and would be more suitable for updating via the envisaged MarineBiotech InfoPages .

When looking at the trends of major countries' policies and industries, it is possible to roughly predict the development of the marine bio industry.

First, as the marine bio industry expands, it is becoming increasingly important to preempt related resources. The preemptive activities of marine life resources that can be used industrially will be strengthened, especially in developed countries that are relatively competitive in technology development. In this process, joint research is expected to spread.

Second, joint research between developing countries with superior marine biodiversity and advanced countries with excellent technology, and technology research based on industry-university cooperation will become active. Various joint researches have already been conducted, including the EU Joint Programming Initiative, EMBRC (European Marine Biological Resource Center), and BioMarks (Biodiversity of Marine Eurakyotes). The spread of joint research using relative advantage is expected to be a great help for the development of the marine bio industry as a strategy that benefits all participants.

The last trend that can be confirmed is that interest in marine life materials has increased significantly. In particular, interest in ingredients such as marine algae and fungi, which are required for the production of pharmaceuticals and cosmetics, which are actively used in marine biotechnology, is increasing. In addition to the unique mechanism of marine life resources, biomass can be secured through the development of the latest technologies such as genomes, and the likelihood of commercialization of marine materials will increase. More than 1,000 new materials are discovered every year, and more than 30,000 useful substances are extracted from marine life resources.

2. The Current Status of Korea

1) Technology level

Although many achievements have been made in the R & D field through continuous support for the marine biotechnology sector, the technological gap is still large compared to the highest technology level in developed countries. In the past 10 years ('04 ~ '13), approximately 160 billion won has been invested, resulting in 1,412 research papers (including 1,183 SCI-class), 773 patent applications and registrations, and 24 technology transfers[6]. This can be evaluated as a much better performance than the whole bio sector.

However, despite these achievements, it was found to be 60.6% of the highest technology holders (as of '18 years), and the technological gap was 5.9 years. In detail, the health functional food group reached 67.2% level, and the technology gap was narrowed compared to other fields. However, the medical device remained at 50% level, indicating that the technology gap was still large.

Compared within the domestic marine science and technology field (marine resource and energy, marine observation and forecast, polar marine, and marine product processing distribution, etc.), the

6) Ministry of Oceans and Fisheries, Next-generation marine biotechnology development strategy (2014)

rate of development of technology level is relatively slow, and it is evaluated to remain at the lowest level.

2) Investment scale

Until 2003, it invested less than 2 billion won a year, but has been expanding its investment significantly since 2004(annually 23% increase). By research area, Korea is investing the most in new materials (37%) such as food and cosmetics, after these area, investing in order of securing resources and utilization infra (24%), energy (24%), and life phenomenon utilization research (15%). The main actors of R & D are usually universities (50%), research institutes (40%), and companies (5%). Despite the expansion of the budget, the proportion of marine bios in all bio R & D is very small. Although the performance of the marine sector is superior to that of the nation's general bio sector, the scale of investment is still small.

3) Status of support policy

(1) Establishment of management base for marine fisheries life resources

In response to the trend of strengthening sovereignty over marine biological resources such as the Nagoya Protocol (2018), the National Marine Biodiversity Institute of Korea(MABIK), which is responsible for marine biological resources, was established in April 2015. The National Marine Biodiversity Institute of Korea is working to lay the foundation for the expansion of national self-sufficiency of marine resources and industrialization of marine bios by promoting the investigation, securing, preservation, management, and utilization of marine biological resources.

※ Major achievements of MABIK

① (Sales Performance) Promoting utilization through the sale of marine life resources

- (by institution) In the past three years, 796 cases ('15 .1~ '18 .3) have been sold, in details, university(464 cases, 58%), research institutes (208 cases, 26%), companies (59 cases, 7%)

	University	Research Institute	Company	Educational Institute	Exhibition Facility	Total
Cases (%)	464 (58.3)	208 (26.1)	59 (7.4)	49 (6.2)	16 (2.0)	796 (100.0)

- (By resource) phytoplankton (246 cases, 31%), extract (115 cases, 14%), green algae plants (57 cases, 7%)

	phytoplankton	extract	green algae plants	Fish	Others	Total
Cases (%)	246 (30.9)	115 (14.4)	57 (7.2)	56 (7.0)	322 (40.5)	796 (100.0)

② (Results of help desk) Promoing the vitalization of the marine bio industry by improving access to marine bio raw materials ('17 .3 ~ 12)

-115 cases of marine life resource provision (865 points), 21 cases of marine life resource consulting*, 322 cases of technology and industrialization information service (32 cases of institutional linkage)**, 12 publicity results

* 5 cases of basic physiological activity, 11 cases of indicator ingredients, 2 cases of general ingredients, 3 cases of other services such as extract preparation

** A total of 322 support projects are registered and linkage with 32 organizations that are available for commercialization support.

③ (Other) Technology transfer and patent performance

- The result of the research conducted at the MABIK was 2 cases of technology transfer (1 case, 1 case planned), and the value of technology transfer was 25 million won ('17 ~'18)

- A total of 24 patents were filed, of which 1 patent registration was completed and 1 international application ('15 ~'18)

In addition, laws and regulations related to marine and marine life resources are integrated and enforced to strengthen management of overseas export and profit sharing of marine and marine life resources. This is an improvement that reflects the point that systematic and integrated management was difficult because it has been managed under different laws by maritime and fisheries.

Ⅴ. Conclusion and Policy Suggestions

(2) Expansion of infrastructure for securing resources

For the development of the marine bio industry, securing useful marine life resources is the most essential, basic and important step, so it is necessary to have basic infrastructure facilities for this. To this end, Korea is gradually increasing the resource survey vessels for the investigation of marine aquatic resources in the near sea, oceans and polar regions of Korea. In 2000, the number of resource survey vessels, which were only two, increased to eight in 2017. In addition, a scientific base was built in the Antarctic and North Pole to establish a research system for polar biological resources, thereby establishing the foundation for the development of the marine biotechnology field.

3. Problem

1) Securing and supplying raw materials

It is one of the most important factors for R & D and industrial growth whether the amount of biological materials, materials, materials, etc. as raw materials can be sufficiently secured. The smooth supply of raw materials is also a major challenge in the industrialization of marine biotechnology. To be commercially successful with price competitiveness, the cost of supplying raw materials must be lowered and the production process must be simplified. In real situation, even though the company developed actual technologies and processes, due to the expensive cost of raw materials, there were many cases where commercialization failed. In the past, if R & D commercialization failed, the reasons of failure are usually the lack of synthesis or mass production of the necessary raw materials, or the unsuitable raw materials for commercialization. For example, in the case of large algae such as seaweed and kelp, almost all the food produced through aquaculture is consumed as food, and the rest are used as food for aquaculture abalone. As a result, it is difficult to supply marine bio raw materials at low prices. For industrialization, it is necessary to fully consider the aspects of supplying raw materials from the project planning time.

In the case of a company, it is less problematic than R & D project lead by research institute or other organizations, because it is starting to develop with the economic aspect of raw material supply, that is, the expected unit price or marketability. However, despite various efforts such as commercialization of domestic raw materials, research on utilization of unused fish, and contract cultivation of seaweeds, it is inevitable that there will be difficulties in supplying raw materials in the long term.

In order to industrialize marine bio, it is necessary to expand the production and supply of raw materials available in the market. Currently, of the 36 registered functionalities of the Ministry of Food and Drug Safety, the functionality of marine-derived raw materials is only 11, and among 67 raw materials based on raw materials, 9 of marine-derived raw materials and 18 of 263 individual-recognized raw materials are derived from the ocean. It stops. Hyangjang materials have no functional marine materials listed in the Ministry of Food and Drug Safety. In order to industrialize the marine bio, it is necessary to expand the raw material items available in the market. Marine bio R & D should focus on areas that actively discover marine functional materials in the case of functional stone food and cosmetic materials.

On the other hand, in the case of natural new drugs, it is pointed out as a problem that the protection of intellectual property rights is not enough. Only a single substance can be protected by intellectual property rights, but in general, most natural substances are complex substances. Dong-A Pharm's natural product styrene is not a single substance, and it is the same with the case of using shim extract. You need to change the molecular structure to get a patent for the substance. As an alternative, marine bio companies are taking a strategy to protect intellectual property rights through patents on unique production processes.

In the case of marine natural products, access to genetic resources and profit sharing (ABS) under the Nagoya Protocol are also considered as problems. The Ministry of Oceans and Fisheries continued to pursue overseas resource acquisition projects, but due to problems related to profit sharing, most companies prefer domestic resources.

2) The problem of professional manpower, regional gap, and professional consulting

The area of marine biotechnology has a large regional gap, especially in terms of professional manpower. One local agency is focusing on the food and cosmetics sector, and as a corporate support project, it supports small-scale production of multiple varieties in the food manufacturing process, beverage process, and cosmetic process. In addition, the agency is also pursuing product quality management. To do this, it must be certified as a test and analysis agency by the Ministry of Food and Drug Safety. This field is composed of physics and microbiology. However, due to the lack of human resources in the microbial area, it has not been realized yet.

The same is true for companies that are having difficulties due to lack of professional manpower. In particular, local companies have a weak in capital, and it is difficult to find a manpower, so it is difficult to enter marine bio-related fields such as food processing.

On the other hand, R & D performers including marine bio companies asked various consulting support to the Ministry of Oceans and Fisheries. First, consulting on IP management is necessary. The cost of maintaining existing domestic and foreign patents is also substantial, it would be very helpful if it could provide national support to defend against direct infringement and bypass attacks on patents. For this, systematic consulting by a specialized patent attorney group is necessary.

Depending on the field, support for clinical trials is required, and since clinical expertise is required, it is also necessary to inform related specialized institutions and ministries so that they can provide interest and support.

In the case of functional food, a new business field is booming due to the "functional labeling food system" introduced by the Japanese Abe government. In Korea, related laws have been proposed to the National Assembly, but laws are pending due to the concern on the safety. In this way, domestic companies are considering entering the Japanese market because of the weaker regulations in Japan in the functional food sector. In this situation, it would be very helpful for companies to get consulting support to export functional foods to Japan and abroad. For example, it introduces related systems in each country and provides consulting for preparing reports required for approval. Currently, it is known that it is necessary to cost about 15 million to 20 million won per item in preparation for export.

3) Insufficient resource management

Despite the diversity of marine territories and marine life, which is 4.5 times the land area, due to realistic constraints such as budget, there are limitations to existing resource surveys, such as surveying only part of the coast. Since the entry into force of the Nagoya Protocol, competition in major countries for securing vital resources has intensified, but the rate of habitat confirmation for marine life resources in Korea is poor.

Although the infrastructure for securing resources is largely equipped, it has been focused on the aspect of quantity. In other words, the lack of securing strategic resources that can be used as industrial materials led to the result that the research in the marine biotechnology field did not lead to the commercialization stage (mass production technology development, etc.).

Industry demand for strengthening government management and support for marine resources is high. Because marine resources are difficult to secure compared to terrestrial resources, and the acquisition process is expensive, there are limits to individual companies' voluntary promotion. Therefore, many companies require the Marine Biological Resources Center to secure resources and provide standard extracts to industries. In order to revitalize the marine bio industry as well as the needs of the business community, it is necessary to support the standardization and mass securing of raw materials.

4) Limit of information sharing and use

There are problems in the process of securing and managing resources, but another problems exist in the process after securing resources. First of all, the integrated management of information on resources is not sufficient. Each institution has distributed information on marine life resources, which limits the access of private companies to resources. Also, there is a point that there is no prior demand survey on useful information (resource distribution, function / safety, etc.) that the consumer needs, so information is provided on a supplier-by-supplier basis.

In addition, the sale of marine life resources secured to companies is also in progress, but the demand for materials is not high because only some materials (natural extracts) are available to be sold.

5) Vulnerable industrial ecosystem

In the bio industry, materials and technology are key, but due to the closed nature, voluntary sharing and cooperation among private companies is not easy. In addition, research results and business items are often lost due to the absence of an on-offline information network linking technology and product supply and demand sources. This is a phenomenon that frequently occurs in the industrial stage.

In order to solve these problems, it is hoped that the government will take steps to establish a network that can connect academic knowledge and research results to commercialization by holding forums, technical exchange meetings, etc. In addition, in order to commercialize marine bio research results, it is also required to play a role of technical certification support and start-up consulting at an intermediate stage.

4. Summary

The current situation of the Korean marine bio industry is summarized as follows based on SWOT analysis.

Strength	Weakness
- Continued support for the marine bio sector('04 ~) and establishment of R&D infra such as development of KIMST - Wide ocean territory and abundant species - Opened the National Marine Biodiversity Institute of Korea(MABIK)	- Still weak industrial base and small domestic market size - Insufficient linkage between market demand and researchers - Lack of professional manpower - Lack of visible performance of R & D business

Opportunity	Threat
- Increased opportunities for diversification of the bio industry due to the spread of well-being trends - Continuous government-level support for the bio sector	- Technological gap and smaller R&D investment compared to developed countries - No international IP strategy - Weak industrial linkage and institutional infrastructure - Continuous changes in the international environment such as ABS and CBD

(1) SO Strategy: A strategy that actively utilizes Korea's strengths and opportunity factors in the marine bio global market

By utilizing the results of R & D support centered on the Ministry of Oceans and Fisheries, it will be possible to create technological convergence and concrete results between researchers in the marine and marine biotechnology and general bio fields. The general bio industry is facing limitations such as the depletion of new materials based on land and technology monopoly centering on developed countries, and it may be possible to consider expanding to the marine bio industry as a way to solve this.

Such an "open and convergent support" could lead to the establishment of a mass production system in the food and cosmetic sector, where industrialization is being practiced. In addition, diversification of products through diffusion of R & D technology performance can be expected to increase fishermen's income in the fisheries and aquaculture sectors.

In addition, a strategy to lead companies and researchers in the general bio sector to the marine bio sector will be necessary for the continued growth of the marine bio sector.

(2) WO strategy: A strategy to overcome the weaknesses of the domestic industry and utilize global market opportunities

The reality is that the marine bio industry, where technology development is important, has various weaknesses in R & D support and management in Korea. To overcome this, it is necessary to discover and support R & D projects that can reflect market demand. It is also required to expand the current projects which focus on the university and research institute for specialized in marine biotechnology to the problem-solving business through increasing participation of companies.

In addition, it is necessary to find ways to expand the scale of R & D through inter-ministerial or central-local government linkages. Although the investment scale for offshore bio R & D continues to increase, the absolute size is still small, so the absolute amount of investment should be increased. To do so, it will be necessary to discover large-scale R & D projects through cooperation with related ministries and discover local government-linked projects.

(3) ST Strategy: A strategy to avoid the threats of the marine bio market and utilize strengths of domestic market

It will include strategies to utilize the functions of the MABIK, which is responsible for securing and supplying marine life resources. From the industrial point of view, it is necessary to find ways to secure marine natural extracts, genetic resources, useful source materials, etc., and to support companies and research institutes.

In addition, there is a need for a way to industrialize the research results secured through R & D projects that have been supported since 2004. In order to promote profit-generating R & D business focused on business strategy, experts and companies must be engaged from the initial planning stage. It is necessary to select excellent technologies that can be industrialized through expert review of patents, research results, and infrastructure derived through the existing support projects, and to apply in stages of industrialization. In addition, in order to support technology transfer by companies, patent information transfer, technology fairs, and commercialization consulting must be supported.

(4) WT strategy: A strategy to avoid the threats of the marine bio industry and overcome Korea's weaknesses

The standards and rules of the international community related to the marine bio industry, such as the entry into force of the Nagoya Protocol and the Convention on Biodiversity, are rapidly changing. It is difficult to preemptively respond to these changes in the market because domestic marine bio companies are still at the level of startups. Therefore, it is necessary to establish a support system that can actively cope with such environmental changes. At this point, it is time to establish a localization system for raw materials and materials that rely heavily on foreign imports, and also seek ways to support policies for export companies.

R & D is so important to plan and implement tasks that reflect current market demands. If the project has been created and supported by the central government, it should now support the issue-driven or current problem-solving R & D with high interest in the industry by reflecting the demand of the company. In other words, it is necessary to promote hands-on support, such as R & D support based on the needs of the company, participation in R & D by companies with high interest in the technology, and transfer of company licenses for research results.

Ⅴ. Drawbacks of Current Policies

1. Problems of R & D support

1) Ineffective role sharing among research institutes

The major research institutes involved in the marine biotechnology R&D project are universities, government-funded research institutes, and companies. Universities, government-funded research institutes, and companies have different characteristics(both strengths and weaknesses) in research and development projects.

Currently, colleges and government-funded research institutes are performing the most tasks in R&D projects. As discussed in the previous chapter, although there are some differences in the tasks performed by each institution, the division of roles according to the characteristics of the institution is not clear. Government-funded research institutes have a more stable research budget than universities and have a particularly strong strength in research workforce. In the university, the majority of researchers consist of graduate students in the master's or doctoral programs. These are people who are still in the process of learning, so their research abilities are inferior to those of professional research institutes. In addition, there is a problem of frequent change of researchers due to graduation. On the other hand, government-funded research institutes have the advantage that researchers who have already obtained a degree can do research stably.

The company should play the most important role in industrialization after the R&D projects are done. If an R & D project is conducted by a company, it is necessary to consider marketability and economics because the top priority of company is making profits. Therefore, the research and development that the company envisions and plans ahead is much more clearly aimed at industrialization. Companies are less likely to create unrealistic research projects because they know the market reality well. However, despite these advantages, it is not uncommon for companies to take the lead in R & D. In general, it is common to participate in a project where a university or a cast is the main research institute. Another problem is that there are very few companies in the offshore biotechnology sector that can promote and lead R & D projects in earnest.

2) Heterogeneous composition in R & D business

The key parts of the concept of marine bio are 'Marine Life Resources' and 'Biotechnology'. In particular, because marine life resources are important for marine bio, a number of tasks to secure resources are included in the marine bio R & D project.

As such, the emphasis on marine life resources is to develop biotechnological technologies in the marine biotechnology development project, as well as to develop technologies to discover and preserve life resources in the domestic and foreign seas, and to secure sufficient quantities. The result was a combination of research projects on technology. The tasks of using biotechnology and the tasks of supplying life resources have different characteristics. However, because tasks of different personalities exist within a single project, they must be managed in different suitable ways. If an expert in the resource supply field becomes a biotechnological research project evaluator, the correct evaluation will not be achieved because it does not have the necessary expertise.

On the other hand, among research and development tasks applying biotechnology, there are differences according to fields. As confirmed through in-depth interviews with experts, fields such as new drugs, medicines, functional beverages and foods, functional cosmetics, and other functional materials are different even if they use similar or the same biotechnology. Institutional differences such as safety testing, clinical trials, and approval for the developed raw materials and products, and differences in production, promotion, marketing, and market characteristics, etc., should also be considered in the R & D process. However, due to the fact that different government ministries use marine life resources for tasks of various natures that are planned and managed in their own way, they are all included in a single project, the marine fisheries biotechnology project. There is a need to find ways to differentiate management and support according to the nature of the tasks.

3) Lack of R & D investment scale and lack of consistency in investment strategy

The national R & D investment in the marine bio sector has been somewhat ups and downs, but has been gradually increasing since 2004, and the rate of increase has been faster than other sectors. But the problem is the absolute amount. Investment in offshore bio R & D projects is much less than in general bio businesses. Ocean bio research is more expensive than other research fields due to the complexity and process of securing and managing marine resources. Therefore, the lack of budget is bound to result in insufficient support for research projects, insufficient research per project, and insufficient support for the entire process leading to industrialization. Insufficient government investment is the primary factor hindering the expansion of maritime bio R & D, performance improvement, and activation of industrialization.

On the other hand, in terms of industrialization, it seems that the investment strategy is not properly reflected. In recent years, while the investment in the marine bio energy field has increased, it has been confirmed that the investment in the chemical field including functional foods or cosmetics is relatively small and the growth trend is also moderate. However, this does not fit well with the government's recent policy of strengthening support in the field of materials, such as food and cosmetics, for the prompt calculation of industrialization results. In the case of the energy field, it is difficult to commercialize in the near future because it is difficult to commercialize because it is difficult to secure economic feasibility in the state that technology development has been completed to some extent.

4) Problems in managing R & D projects

Development and promotion of appropriate R & D policy is essential for the industrialization of marine biotechnology. However, there is a lack of current R & D policy and task management in Korea. First, it is necessary to improve the evaluation criteria in terms of R & D management. For example, it is necessary to lower the weight of papers and put a high weight on commercialization performance, such as technology transfer performance. It is also important to plan the R & D project and how to select the evaluation committee members. Many people point out that the same people often participate as committee members, regardless of the nature of the assignment. For example, the tasks for the purpose of securing resources have different characteristics from the general tasks, so different management methods are needed in planning and composition of evaluation committee members. On the other hand, in the case of tasks with characteristics similar to general bios, it is necessary to include experts in the non-marine sector when forming the evaluation committee.

In addition, in order for industrialization to work well, experts in the relevant fields need to lead from the initial planning stage. For example, the development of new drugs must start with a problem awareness of the human body or disease. This is called a rational drug discovery process. Therefore, a major in pharmaceutical chemistry should lead the entire R & D process. Likewise, in marine bio R & D, experts in the field where the final product is applicable should participate with a comprehensive plan from the beginning.

On the other hand, new R & D should be pursued on topics with sufficient research demand. When researchers and research institutes that can perform specific tasks are limited, competition is eliminated and results in supporting specific people and specific fields.

2. No successful case of industrialization

The Ministry of Oceans and Fisheries has supported marine bio R & D projects since 2004, and through this, significant R & D results have been obtained. Nevertheless, there have been no cases where products developed and produced through the Marine Bio National Research and Development Project have become successful products in the market and have raised enough sales to contribute to corporate growth and national economic development. Due to this lack of experience, domestic maritime bio R & D related organizations have not yet established a model for the R & D project promotion method leading to industrialization.

Although it is possible to refer to cases from other fields at home and abroad and from other institutions, it has yet to have a paradigm of success in what to do in the unique conditions of the Korean marine bio sector. If you make such efforts to promote industrialization without your own success stories, you will experience unnecessary trial and error. If a successful industrialization case emerges as soon as possible, a thorough analysis of this will help in the development of support policies in the future.

3. Lack of functional substance data sharing system

A number of useful substances have been identified through marine fisheries R & D projects, including marine fisheries biotechnology development projects. These materials are functional materials, and are likely to be used as food, beverages, cosmetics, and medicines. New national R & D projects aimed at the use of useful substances may be promoted, or companies may receive technology transfer for commercialization. Therefore, if we manage information on useful substances discovered through R & D and have a shared system that can be easily accessed by various consumers, we believe that it will be possible to promote the industrialization of marine bios.

4. Protection of intellectual property rights of marine natural materials

One of the things that is necessary for the industrialization of the marine bio industry is that various intellectual property rights related to the developed product should be sufficiently protected. Marine bio R & D projects are studies that utilize marine life resources in various ways. Many of them utilize natural products derived from marine life. However, in the case of natural products, there is a problem that it is difficult to protect intellectual property rights. This is because most marine natural materials are complex materials, not single materials. In areas with high added value, such as pharmaceuticals, the pursuit of latecomers is inevitably strong, and the protection of intellectual property rights becomes more important.

5. Lack of experts in marine biotechnology

In order for maritime bio R & D and industrialization to work well, it is essential to have a quality and quality and abundant professional manpower. Many universities in Korea have majored in biotechnology to educate college students and graduate students. As a result, if you look at the whole of Korea, it may seem that there is not a shortage of experts in the field of biotechnology. However, it is still a necessary support policy to cultivate experts in marine biotechnology that can contribute to the industrialization of marine biotechnology. This is because biotechnology knowledge and research techniques may be similar in the marine and other fields, but it is necessary to understand the uniqueness of marine life and the environment of their habitat, the sea.

On the other hand, it is also a problem for companies and research institutes located in the region that the biotechnology majors who can engage in the marine biotechnology field are concentrated in Seoul or the metropolitan area. Institutions located in the provinces are limited in their internal business due to the absence of professional manpower, and they are forced to settle in large cities such as Seoul or Busan in terms of expanding the workforce of companies in the marine biotechnology sector.

Ⅵ. Marine Bio Industry Policy Direction

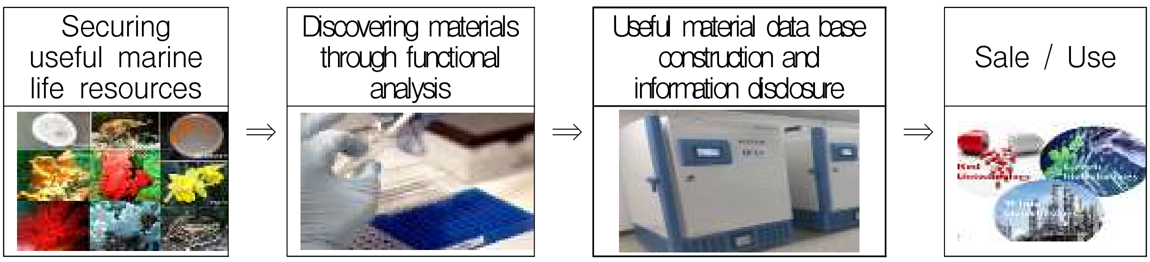
As a result of comprehensively reviewing the current status of domestic and global policy implementation, the direction of industrial development, and current problems in Korea, the direction of industrial policy to develop the marine bio industry is largely 1) Reinforcing resource security and enhancing utilization, 2) R & D support system Improvement, 3) It can be divided into the creation of an industrial ecosystem.

1. Reinforcing resource security and enhancing utilization

As mentioned earlier, the most basic and first step for the sustainable development and growth of the marine bio industry is securing and managing useful resources. Therefore, it will be necessary to upgrade the support policies related to securing resources that have been promoted so far, and to find and add parts that have not been done so far. First, it is necessary to expand the basic survey for securing resources. Due to realistic problems such as budget constraints, it has only been investigated for coastal areas, and it can be said that the three sides have not utilized Korea's environmental strength at all. Therefore, the habitats of unidentified marine life resources are expected to be screened and investigated, but the survey area should be expanded to the exclusive economic zone.

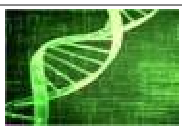
Also, it is necessary to find ways to make good use of these findings. This is because the final purpose of the investigation is to use the results to help companies and to develop the industry. We need to publish a catalog of all resources identified through research every year, as well as our existing resources, and create an online-based distribution map to help easy access to marine bio companies or companies seeking to enter the marine bio industry. something to do. I think these marine and marine life resource maps are absolutely necessary data not only for companies, but also for research institutes.

Another thing to think about in relation to marine life resources is to increase utilization. Although publication of resource catalogs and mapping and distribution of marine and marine life resources are good policies, they can be a rather naive resource for companies that actually want to develop and commercialize marine biotechnology. They need a more practical policy. Therefore, it is necessary to provide more advanced information through cultivation and fermentation characteristics, physiological activity analysis, etc., rather than simply providing information about the needs of the marine bio industry or highly utilized materials.



<Figure 13. Overview of Marine Bio-Bank>

Based on this necessity, the Ministry of Oceans and Fisheries has been implementing a one-stop pre-sale service by building a bank for marine bio materials in the National Marine Biodiversity Institute of Korea since 2019. It will be necessary to establish and promote banks for each of the five major materials, such as extracts, microorganisms, microalgae, genetic resources, and proteins.

Categories	Main Contents
 extracts	▪ Discovering functional materials through investigation of useful components and basic physiological activity (antibacterial, antioxidant, etc.) for marine-derived extracts
 microorganisms	▪ Providing characteristics and functional information such as culture conditions through provision of source materials (strains) with high industrial utilization and usefulness evaluation
 microalgae	▪ Providing industrial materials for bioenergy (diesel), health functional food (chlorella, spirulina, etc.) and medicine (antibacterial, anti-inflammatory)
 genetic resources	▪ Genetic information / real (DNA, organization) through genetic diversity analysis and genetic resource discovery
 proteins	▪ Provide useful information on peptides and proteins derived from marine organisms and provide information related to recombinant protein production technology

<Table 10. The main 5 category for Marine Bio-Bank>

In addition to the operation of the marine biobank, the Marine Biological Resource Center also operates the Marine Bio Resources Information System (MBRIS) for the management and utilization of marine life resources. An integrated management plan to improve the utilization of this system could be an alternative. Currently, useful substances acquired through various R & D projects are managed by a number of related organizations. In this situation, no matter how much information is secured, it is difficult to use it effectively. It is necessary to establish an integrated management system such as promoting DB standardization so that information on resource acquisition by each institution and information can be efficiently linked.

International cooperation measures to secure useful marine life resources also need to be sought. For example, cooperation can be expanded to countries that do not have the Nagoya Protocol or to areas with high biodiversity (such as Russia, the Philippines, Southeast Asia, Colombia, and the Indian Ocean). In addition, through cooperation with international organizations and research institutes in each country, it is possible to study ways to secure more efficient resources.

One of the measures to be considered among cooperation plans with other countries to secure resources is the cooperation plan through ODA. Korea will play the role of joint exploration and research, map production, and education programs, and the ODA beneficiary country will be able to provide the site for establishing the cooperation center and approve the export of marine life resources in the jurisdiction. In addition, it is necessary to expand the investigation of deep seabeds and polar regions that have not been investigated, to secure life resources, and to find a way to secure resources in the high seas in preparation for the BBNJ agreement.

There is something to keep in mind when looking for ways to secure and utilize resources for the sustainable development of the marine bio industry. That is, it is necessary to secure resources based on strategic resources. Quantitative expansion is also important when it comes to securing resources, but if the resources actually needed by industry and research are secured, the effect of output compared to input will increase. In particular, in the case of resources with high industrial applicability, if the purpose of use is subdivided and secured and transferred with new drugs, energy, and chemical materials, the demand of the industry can be met and utilization will be much higher.

2. Improvement for the R & D support system

Development and diffusion of related technologies are absolutely necessary for the development of the marine bio industry. In order to enhance the effectiveness of technology development support, it is necessary to consider the characteristics of the marine bio industry, as well as reflect the demands of current companies.

First of all, in order to improve the effectiveness of support, I think that R & D management and support should be considered in consideration of the nature of R & D. R & D in the marine biotechnology field differs not only in terms of technical aspects of research and development, but also in terms of market characteristics, consumers, and clinical trials, depending on the nature of the target industry, such as medicine, energy, materials, food and cosmetics. Therefore, research management and support considering the characteristics of each project will be necessary. In this process, the Ministry of Oceans and Fisheries is in charge of the marine bio industry, but since it does not support R & D related to clinical trials, cooperation with related departments such as the Ministry of Health and Welfare will be essential. In addition, it is necessary to consider the expansion of the marine bio range. The concept of marine bio focuses on the use of marine life resources. However, the legal definition of marine and fisheries biotechnology is “to make industrially useful products using marine and marine life resources” and “to study and utilize biological systems, biodielectrics or substances derived from them for the purpose of improving production processes. "Study and skill to do".[7)]

Therefore, even if marine life resources are not used directly, R & D using unique systems or processes of marine life or R & D using genome-derived materials of marine life should also be considered as research and development of marine biotechnology. If the existing R & D projects focused on the discovery and use of useful marine-derived materials, there is a need to broaden interest in the marine life process in the future.

In addition, it is necessary to clarify the R & D strategy of maritime bio-state. The R & D in the field of marine bio-medicine, marine bio-energy, and marine life resources, which had been focused on in the past, should be made with a long-term outlook considering the lack of industrialization. It is clear that the effectiveness of support will increase if a differentiated support strategy is established by dividing it into a base construction study and an immediate industrialization study.

In the case of the research for establishing the basic infrastructure, it would be possible to support the securing of materials by focusing on standardization research such as functional and safety evaluation of marine bio materials and securing large-scale culture technology. On the other hand, projects that are easy to industrialize or projects that have already been conducted through basic research through existing support or projects can be promoted in the direction of supporting the steps of “prototype production → pilot production → industrial production and company evaluation → standardization → commercialization”. Many marine bio companies are still small and small, so they lack the ability to

7) 「ACT ON SECURING, MANAGEMENT, USE, ETC. OF MARINE AND FISHERIES BIO-RESOURCES」 Article 2(Definition)

focus on clinical trials and the Ministry of Food and Drug Safety and often fail to commercialize. In order to promote commercialization, if you focus on the latter stage of the technology development stage, but evaluate the R & D performance every year and promote it as a competitive R & D that focuses on excellent projects, you will increase the probability of leading to commercialization.

In the short term, it will be necessary to focus on tasks that are highly likely to succeed in commercialization, and in the long term, it will be necessary to strategically support R & D projects that increase the value of the marine bio industry and solve the needs of society.

For example, it is to assist in the development of high value-added commercialization technologies, such as the development of energy, pharmaceutical materials that require long-term investment, and research of marine life in extreme environments such as deep sea and polar regions. In the case of pharmaceutical materials, it will be possible to discover new materials for pharmaceutical materials and link them to commercialization technology development by utilizing the high bio-stability and useful ingredients of marine organisms. Through commercialization of bio-hydrogen and development of micro-algae-based bio-refinery technology, it is possible to secure a sustainable clean energy source and contribute to the development of the marine bio energy industry.

By fostering the marine bio industry, which is the representative of the new marine industry, it is also possible to solve the problems demanded by society, such as job creation. For tasks with excellent job creation performance, it can be converted into job creation R & D by giving incentives such as giving points and expanding the budget. Since the bio industry is a field that has high employment induction effects and requires high-education specialists, it is possible to secure high-quality jobs. This can also be confirmed through a marine bio research venture called "Nature Glutech" that was founded in 2016 and won the 2017 Job Special Award.

In order to improve R & D performance, it is necessary to select and promote R & D projects suitable for institutional characteristics. The main performers of marine bio R & D are universities, government-funded research institutes, and companies, each of which has different characteristics and needs. Currently, universities and participating research institutes are conducting all basic, applied, and development research, but it may be effective to focus on basic research. On the other hand, companies need to take the leading role in industrialization. This is because the larger the role of a company, the more research and development focused on industrialization will be expanded, rather than research for research, research for knowledge accumulation, and theoretical research. Rather than simply participating in a company, it is possible to broaden the opportunity to lead from the planning stage of R & D projects to industrialization research as a leading research institute.

In addition, in order to strengthen the capabilities of marine bio companies, it is also possible to consider ways to incentivize companies with excellent research capabilities in the selection and evaluation of marine bio R & D projects. Accordingly, companies will try to secure the professional manpower necessary for industrial R & D, which will lead to the strengthening of marine bio-enterprises and create a virtuous cycle system.

I believe that participation of large and mid-sized companies in the bio field will be effective in terms of promotion, marketing, and market expansion. The market for offshore bio products is not mature enough, and there are limits to existing offshore bio companies that are mostly small. If a large company enters the marine bio industry, it will be an opportunity to increase the reputation of the marine bio.

3. Creating an industrial ecosystem

Securing useful resources and improving R & D support methods mentioned above are essential policy directions for the growth of the marine bio industry. However, in order for these support policies to continue to produce results and to have a positive impact on marine bio-enterprises and the entire industry, an ecosystem around the industry must be created. The basic things to create an industrial ecosystem will include establishing a network for cooperation within the industry, fostering professional manpower, and establishing a virtuous cycle structure to promote the commercialization of promising materials and technologies.

The most basic alternative is to create and operate an association or a society to build a network within the industry. It is possible to strengthen the ties between marine bio companies in the same industry, and to promote the network through policy suggestions through opinion gathering and information provision among member companies. In addition, the offshore bio industry forum or conference will be held regularly to identify and analyze recent technology and policy trends in a timely manner and provide them to related companies. These associations will be able to become the center of network construction in the marine bio sector by strengthening cooperation with existing regional marine bio centers, aquatic sciences and marine life resource centers.

There are a number of alternatives that can be pursued to promote commercialization and commercialization of marine bio research and development results. First of all, it is necessary to establish a support center or an incubator center that can assist in obtaining patents and start-up consulting that are most needed in the commercialization process. In addition, it can also match industrial consumers such as mid-sized companies that need the skills of small companies. In order to enhance the matching effect, it would be helpful to run a technology exchange or an unline platform. In the case of online platforms, it is expected that it will be useful because industrial consumers and material and technology holders can meet at all times.

In addition, efforts are needed to create an investment foundation. The cost of developing and commercializing offshore biotechnology is not small. As it is an industry that requires large-scale investment for a long time, active private investment is essential. However, the investment system has not been established due to the lack of information on the marine bio industry and the lack of experts. In order to attract private investment, it is possible to use government fund funds first. In other words, a government fund is used to create a mother fund, and the mother fund and the private sector create a matching fund to invest in maritime bio companies. It is expected to create a virtuous cycle structure, such as post-management and recovery of investment funds, to create a starting point to attract continuous private investment.

Indispensable for fostering an industrial ecosystem is training professional manpower. In particular, it is not an exaggeration to say that attracting high-quality human resources is the key to maintaining companies and revitalizing industries in industries that require technology, such as marine biotechnology. As a support method for nurturing professional manpower, the first step is to run a degree program. It is to create a cooperative program jointly participated by the University and the Marine Biological Resources Center, which are running the Department of Marine Bio

Engineering. It is expected that such a cooperative program can create synergies by converging the strengths of universities and marine life resource centers. Universities can open related subjects such as marine biology, biotechnology, and genetic engineering, and the Marine Biological Resource Center allows students to utilize research equipment and facilities, and provides students with field experiences through research participation, field training, and joint thesis guidance. You can apply in advance. Such cooperative programs have been implemented in other countries and are known to have performed well.

Representative cooperative program is “IMBRsea” in EU. The International Master of Science in Marine Biological Resources (IMBRSea), is a joint Master program organized by ten leading European universities in the field of marine sciences, supported by the European Marine Biological Resource Centre (EMBRC). The IMBRSea program takes the strengths from the previous International Master of Science in Marine Biodiversity and Conservation (EMBC+), and prepares students for the rapidly evolving demands of the blue bio-economy and research on the sustainable use of marine biological resources.

Furthermore, there is a need for a policy alternative that provides practical opportunities for marine bio-related majors. Since the industry itself is still in its infancy, there are not many opportunities to access necessary information at the industrial site, so majors often have difficulty entering the industry after graduation. This is because there is a gap in using theoretical education-oriented school education in industrial fields. You will need to find a way to engage the master's, doctorate or undergraduate students in the degree program in actual research and practice. This process can be an incentive to bring biotech experts into the marine biotechnology sector.

In particular, the lack of local research manpower is more serious than that of large cities such as the metropolitan area and Busan, so strategic R & D support for local universities, research books, and companies is also expected. Although regionally grown specialists may be leaked to other sites, continued support from local institutions can lead to the strengthening of regional marine bio capabilities.

Ⅶ. Conclusion

The offshore bio industry is a promising industry where high growth is expected, and is a representative new industry that is pursuing various policies to take the initiative in major countries. Korea also recognizes the importance and growth potential of the marine bio industry and provides various supports, but the industry has not been able to grow rapidly due to lack of commercialization. It is necessary to study the policies and support methods of technologically leading countries such as the United States and the EU to correct problems in Korea, create high added value, and become a new industry that can contribute to the expansion of industrial scale. Considering that it has been supported for basic, short-term, and small-scale R & D, it is necessary to induce application technology that can be connected to commercialization and performance improvement through the introduction of competitive R & D. In addition, in order to increase the possibility of commercialization, it is necessary to discover a lot of projects in which companies, rather than universities and research institutions, participate in planning projects and developing technologies.

Although the marine bio industry is an industry where technology development should be a premise, I believe that policy support should be prevented from being buried only in R & D. In order to commercialize the basic technology developed through government support as a product and to have economic feasibility, support for the creation of an industrial ecosystem is also necessary. The representative support measures include the use of the mother fund to create an investment foundation and the industry-academia linkage program to cultivate professional manpower. In addition, in order to create opportunities for related companies, academia, and research communities to gather together to communicate and provide ideas on policy, we should also try to build a network for the marine bio sector through the establishment of the Marine Bio Association, regular hosting of related forums and conferences, etc. something to do.

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