2016.02.24 제 1차 CNI
환경브라운백세미나





해양생태계서비스 국내외 동향

국립해양생물자원관

생물다양성변화연구팀 박진순

국립해양생물자원관
NATIONAL MARINE BIODIVERSITY INSTITUTE OF KOREA

Contents

해양생태계서비스 개론

생태계서비스

- By Ecological Society of America

  - the **processes** by which the environment produces **resources** that we often **take for granted** such as clean water, timber, and habitat for fisheries, and pollination of native and agricultural plants. Whether we find ourselves in the city or a rural area, the ecosystems in which humans live provide goods and services that are very familiar to us

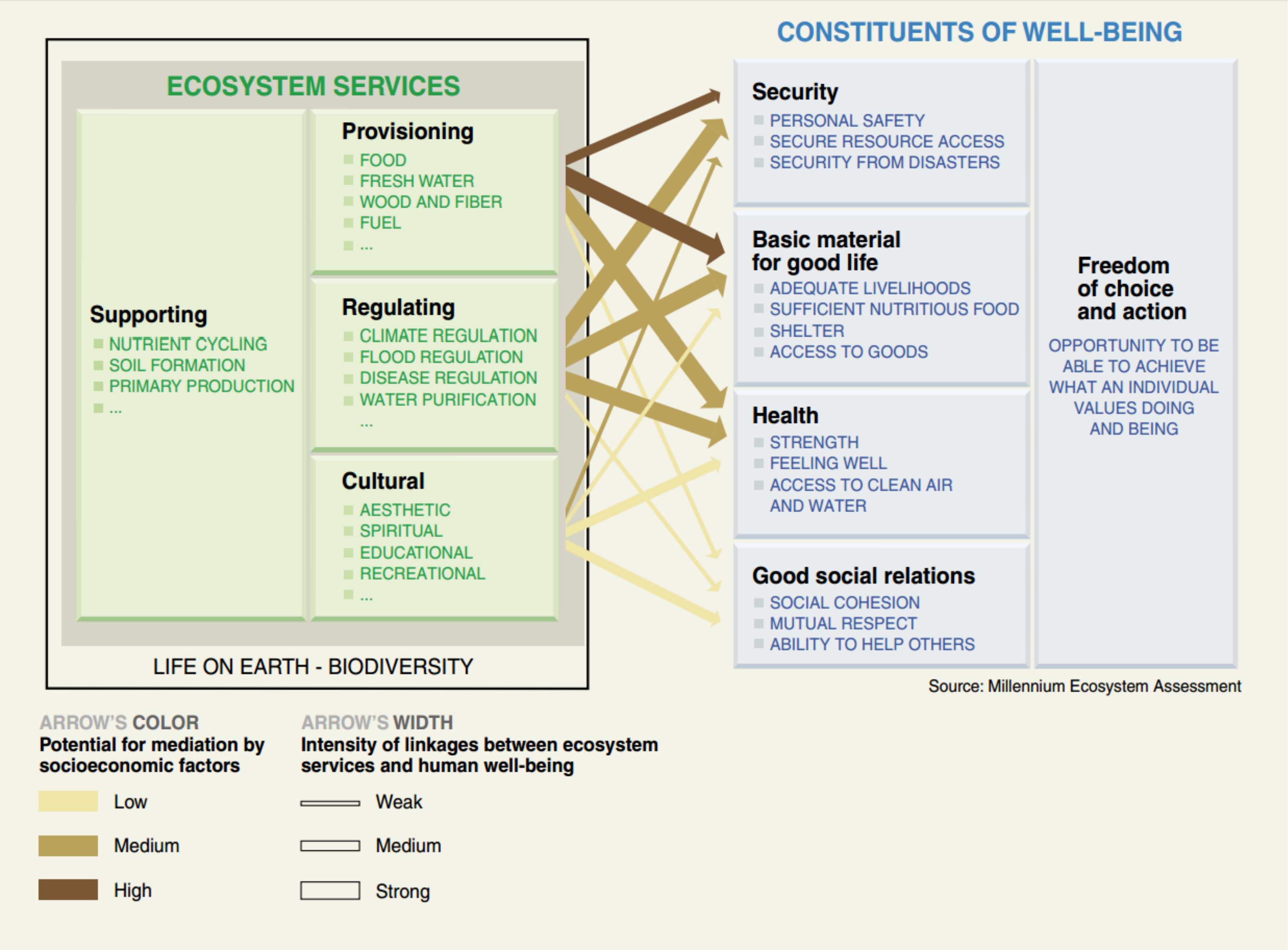
- By Wikipedia

  - **Benefits** from a multitude of **resources and processes** that are supplied by **natural ecosystems**

- 해양생태계 서비스의 정의

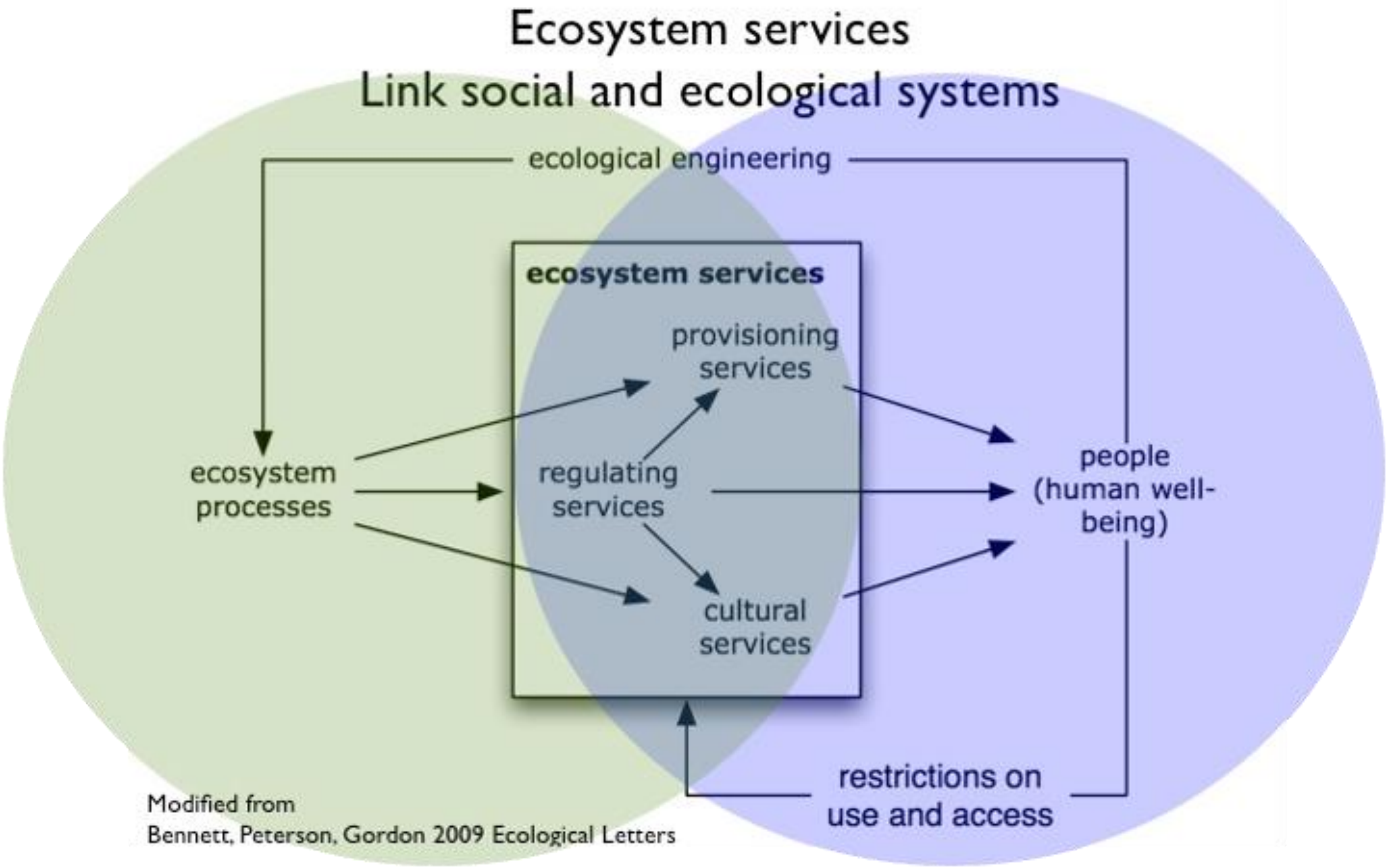
  - Benefits that people obtain from ecosystems, including the open ocean, coastal seas, and estuaries.

생태계서비스

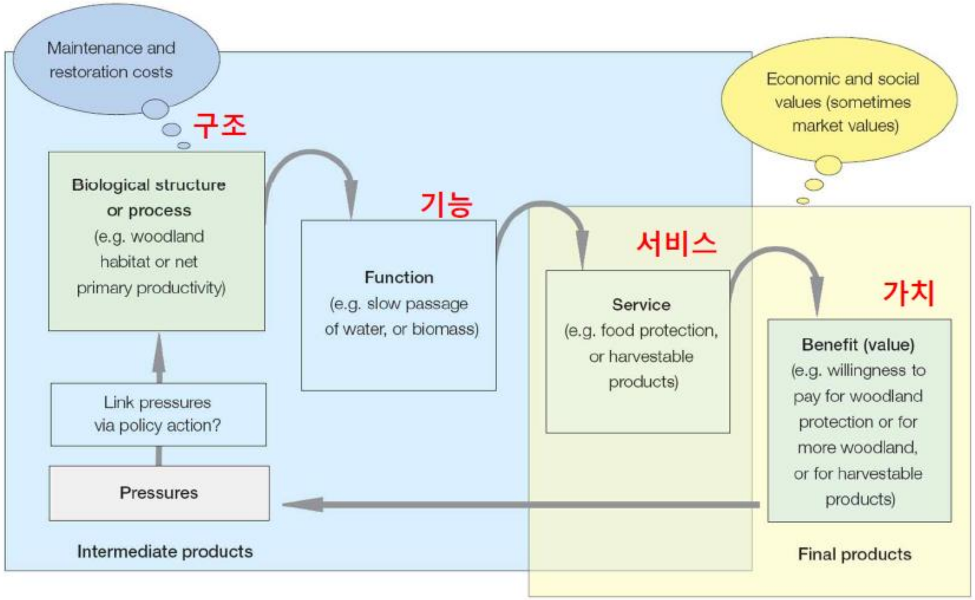


MEA, 2005

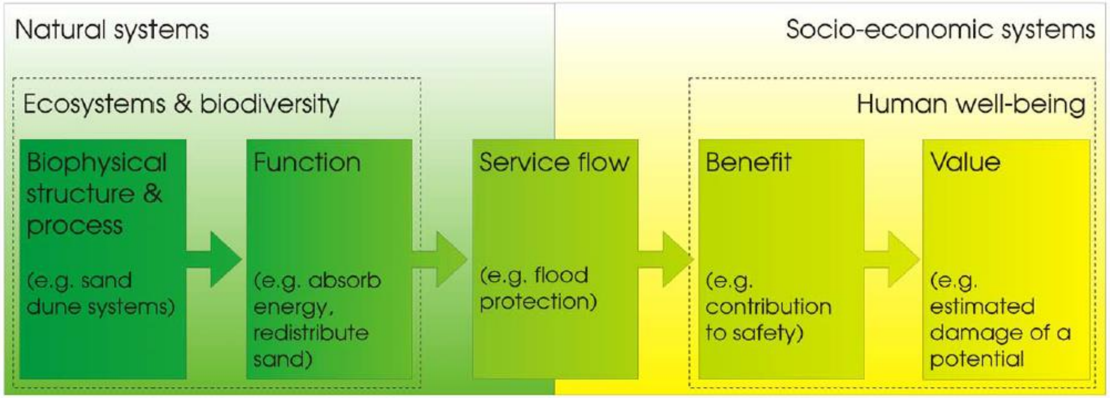
생태계서비스


Ecosystem services
Link social and ecological systems
ecological engineering
ecosystem services
provisioning services
ecosystem processes
regulating services
people (human well-being)
cultural services
restrictions on use and access
Modified from
Bennett, Peterson, Gordon 2009 Ecological Letters

1. 생태계서비스 개론



Maintenance and restoration costs
구조
Biological structure or process (e.g. woodland habitat or net primary productivity)
기능
Function (e.g. slow passage of water, or biomass)
서비스
Service (e.g. food protection, or harvestable products)
가치
Benefit (value) (e.g. willingness to pay for woodland protection or for more woodland, or for harvestable products)
Economic and social values (sometimes market values)
Link pressures via policy action?
Pressures
Intermediate products
Final products

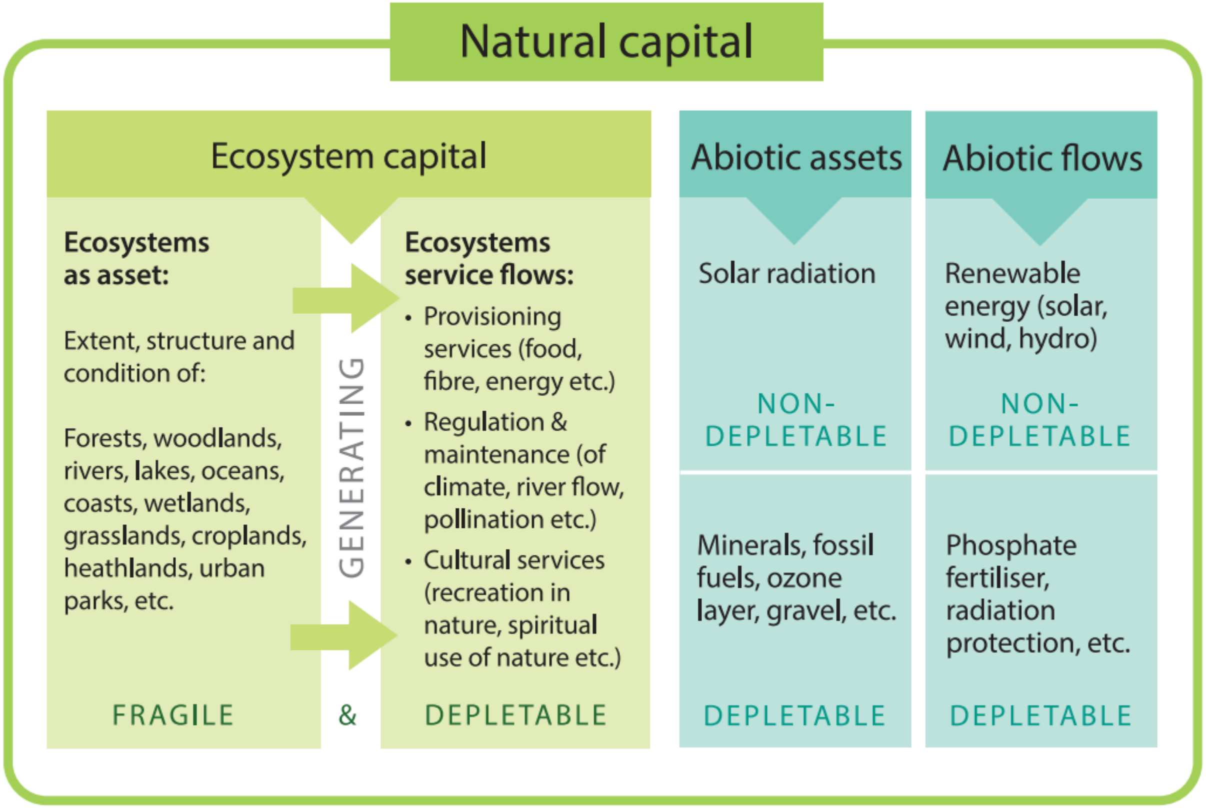


Natural systems
Socio-economic systems
Ecosystems & biodiversity
Human well-being
Biophysical structure & process (e.g. sand dune systems)
Function (e.g. absorb energy, redistribute sand)
Service flow (e.g. flood protection)
Benefit (e.g. contribution to safety)
Value (e.g. estimated damage of a potential

생태계서비스

자연자산(natural capital)의 개요

(EEA, 2015, adapted by Science for Environment Policy, 2015)



해양생태계서비스

Marine ecosystem services according to the Millenium Ecosystem Assessment categories

PROVISIONING SERVICES

Products obtained from ecosystems

- Food provision (fisheries and aquaculture)
- Water storage and provision
- Biotic materials
- Fiber, timbres, and fuel

REGULATING SERVICES

Benefits obtained from the regulation of ecosystem processes

- Water purification
- Air quality regulation
- Flood/storm protection
- Erosion control
- Climate regulation
- Weather regulation
- Ocean nourishment
- Life cycle maintenance
- Biological regulation
- Human disease control

CULTURAL SERVICES

Nonmaterial benefits obtained from ecosystems

- Spiritual and religious
- Recreation and ecotourism
- Aesthetic
- Inspirational
- Educational
- Sense of place
- Cultural heritage

SUPPORTING SERVICES

Services necessary for the production of all other ecosystem services

- Photosynthesis
- Primary production
- Nutrient cycling
- Resilience and resistance
- Biologically mediated habitat

해양생태계서비스

ECOSYSTEM SERVICES	Coastal									Marine		
	Estuaries and marshes	Mangroves	Lagoon and salt ponds	Intertidal	Kelp	Rock and shell reefs	Seagrass	Coral reefs	Inner shelf	Outer shelves edges slopes	Seamounts & mid-ocean ridges	Deep sea and central gyres
Biodiversity	X	X	X	X	X	X	X	X	X	X	X	X
Provisioning services												
Food	X	X	X	X	X	X	X	X		X	X	X
Fibre, timber, fuel	X	X	X						X	X		X
Medicines, other resources	X	X	X		X			X	X			
Regulating services												
Biological regulation	X	X	X	X		X		X				
Freshwater storage and retention	X		X									
Hydrological balance	X		X									
Atmospheric and climate regulation	X	X	X	X		X	X	X	X	X		X
Human disease control	X	X	X	X		X	X	X				
Waste processing	X	X	X				X	X				
Flood/storm protection	X	X	X	X	X	X	X	X				
Erosion control	X	X	X				X	X				
Cultural services												
Cultural and amenity	X	X	X	X	X	X	X	X	X			
Recreational	X	X	X	X	X			X				
Aesthetics	X		X	X				X				
Education and research	X	X	X	X	X	X	X	X	X	X	X	X
Supporting services												
Biochemical	X	X			X			X				
Nutrient cycling and fertility	X	X	X	X	X	X		X	X	X	X	X

UNEP, 2006

해양생태계서비스

OPEN ACCESS Freely available online PLOS ONE

Current Status and Future Prospects for the Assessment of Marine and Coastal Ecosystem Services: A Systematic Review

Camino Liquete[1]*, Chiara Piroddi[1], Evangelia G. Drakou[2], Leigh Gurney[1], Stelios Katsanevakis[1], Aymen Charef[3], Benis Egoh[1]

1 Water Resources Unit, Institute for Environment and Sustainability, European Commission - Joint Research Centre, Ispra, Italy, **2** Land Resource Management Unit, Institute for Environment and Sustainability, European Commission - Joint Research Centre, Ispra, Italy, **3** Maritime Affairs Unit, Institute for the Protection and Security of the Citizen, European Commission - Joint Research Centre, Ispra, Italy

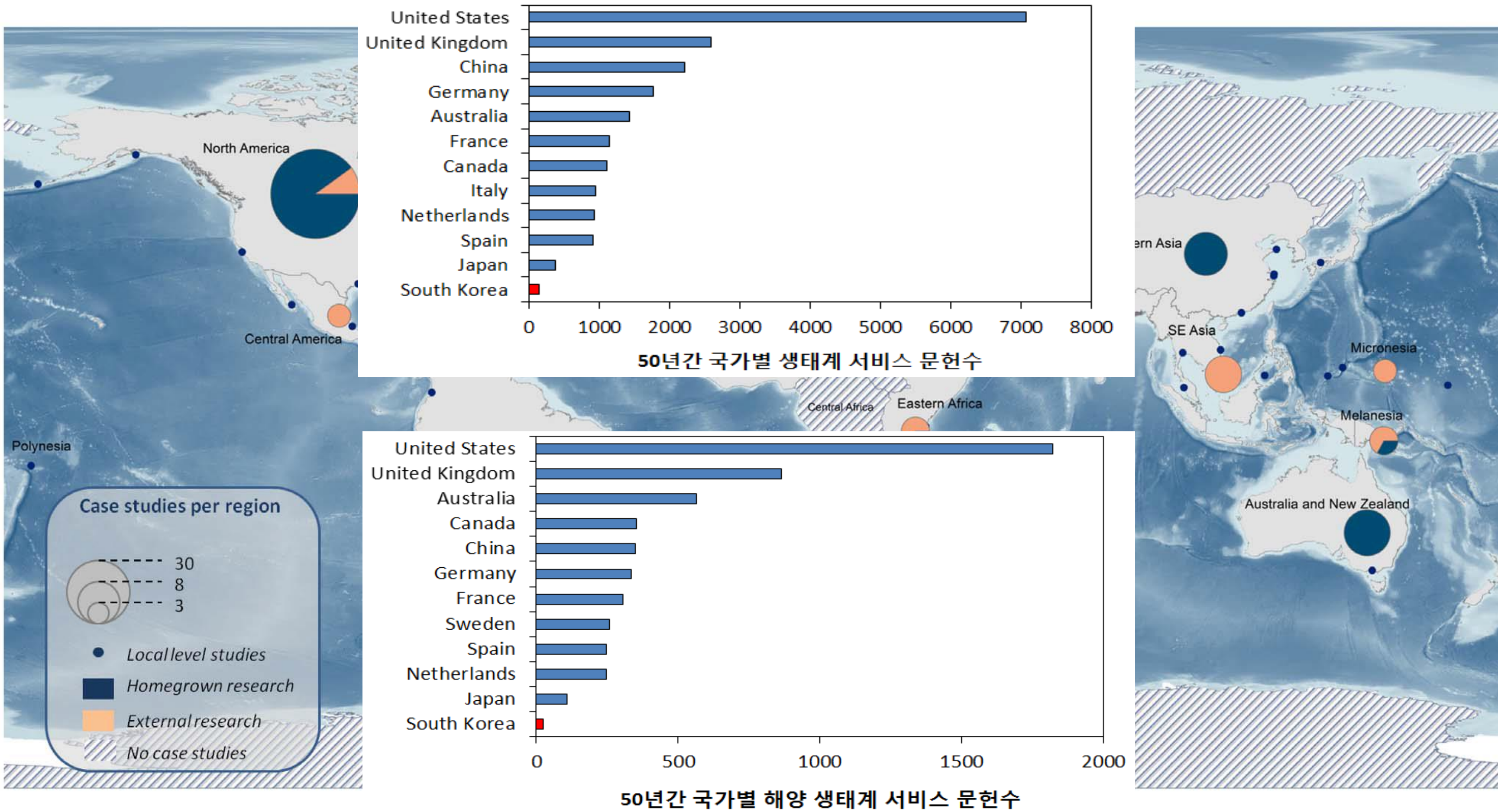
Liquete et al., 2013

해양생태계서비스

<table>
<tr><th></th><th>This paper</th><th>MA</th><th>Beaumont</th><th>TEEB</th><th>CICES</th></tr>
<tr><td rowspan="11">Provisioning</td><td rowspan="3">Food provision</td><td rowspan="3">Food</td><td rowspan="3">Food provision</td><td rowspan="3">Food</td><td>Terrestrial plant and animal</td></tr>
<tr><td>Freshwater plant and animal</td></tr>
<tr><td>Marine plant and animal</td></tr>
<tr><td rowspan="3">Water storage and provision</td><td rowspan="3">Fresh water</td><td rowspan="3">N/A</td><td rowspan="3">Water</td><td>Potable water</td></tr>
<tr><td>Water flow regulation</td></tr>
<tr><td>Water quality regulation</td></tr>
<tr><td rowspan="5">Biotic materials and biofuels</td><td>Ornamental resources</td><td rowspan="5">Raw materials</td><td>Ornamental resources</td><td rowspan="4">Biotic materials</td></tr>
<tr><td>Genetic resources</td><td>Genetic resources</td></tr>
<tr><td>Biochemicals</td><td>Medicinal resources</td></tr>
<tr><td rowspan="2">Fiber</td><td rowspan="2">Raw materials</td></tr>
<tr><td>Renewable biofuels</td></tr>
<tr><td rowspan="17">Regulating and maintenance</td><td rowspan="3">Water purification</td><td rowspan="2">Water purification and waste treatment</td><td rowspan="2">Bioremediation of waste</td><td rowspan="3">Waste treatment</td><td>Bioremediation</td></tr>
<tr><td>Water quality regulation</td></tr>
<tr><td>Nutrient cycling</td><td>Nutrient cycling</td><td rowspan="2">Dilution and sequestration of wastes</td></tr>
<tr><td>Air quality regulation</td><td>Air quality regulation</td><td>Gas and climate regulation</td><td>Air quality regulation</td></tr>
<tr><td rowspan="4">Coastal protection</td><td>Natural hazard regulation</td><td rowspan="4">Disturbance prevention</td><td>Moderation of extreme events</td><td>Mass flow regulation</td></tr>
<tr><td>Water regulation</td><td rowspan="2">Regulation of water flows</td><td rowspan="2">Water flow regulation</td></tr>
<tr><td rowspan="2">Erosion regulation</td></tr>
<tr><td>Erosion prevention</td><td>Air flow regulation</td></tr>
<tr><td>Climate regulation</td><td rowspan="2">Climate regulation</td><td>Gas and climate regulation</td><td rowspan="2">Climate regulation</td><td rowspan="2">Atmospheric regulation</td></tr>
<tr><td>Weather regulation</td><td rowspan="2">N/A</td></tr>
<tr><td rowspan="2">Ocean nourishment</td><td>Soil formation</td><td rowspan="2">Maintenance of soil fertility</td><td rowspan="2">Pedogenesis and soil quality regulation</td></tr>
<tr><td>Nutrient cycling</td><td>Nutrient cycling</td></tr>
<tr><td rowspan="3">Life cycle maintenance</td><td rowspan="3">Pollination</td><td rowspan="3">Biologically mediated habitat</td><td>Maintenance of life cycles of migratory species</td><td>Lifecycle maintenance and habitat protection</td></tr>
<tr><td>Maintenance of genetic diversity</td><td rowspan="2">Gene pool protection</td></tr>
<tr><td>Pollination</td></tr>
<tr><td rowspan="2">Biological regulation</td><td>Pest regulation</td><td rowspan="2">N/A</td><td rowspan="2">Biological control</td><td rowspan="2">Pest and disease control</td></tr>
<tr><td>Disease regulation</td></tr>
</table>

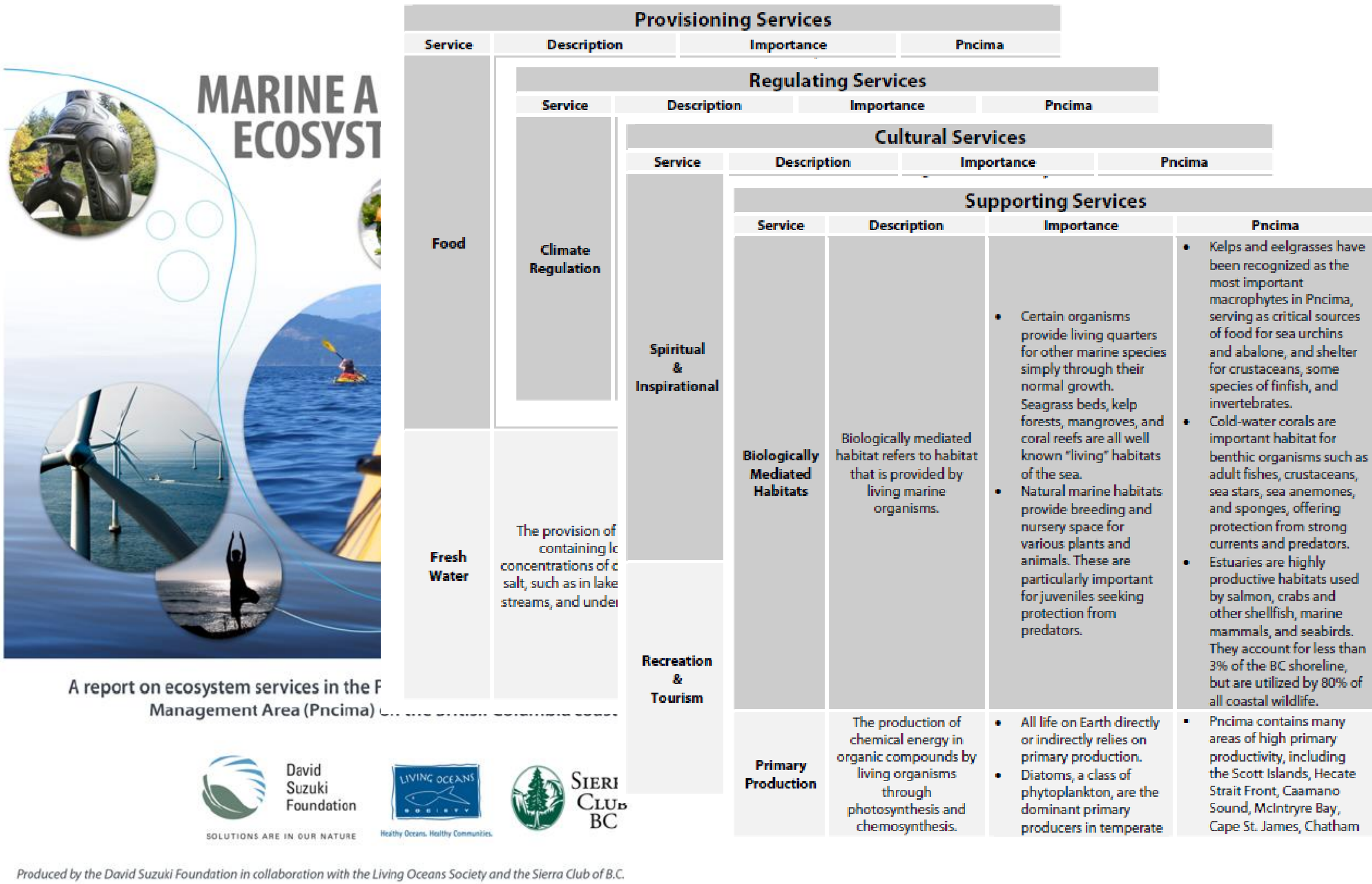
해양생태계서비스 평가 국외동향

생태계서비스 국제 연구 동향



Liquete et al., 2013

해양생태계서비스 연구 동향: 캐나다



해양생태계서비스 연구 동향: 미국

United States Environmental Protection Agency

Table 2. Economic values of ecosystem services in California categorized by ecosystem type and amenability to valuation by avoidance cost or replacement cost methods. All values converted to 2008 US$. Notes in Appendix 1.

Service Category
PROVISIONIN
food
--capture fisherie
--aquaculture
--wild plant and animal products
genetic resources
biochemicals, natural medicine pharmaceuticals
ornamental resources
human habitation
human navigatio
energy (for huma use)

Service Category
REGULATIN
air quality regulation
climate regulation
erosion regulation
water purification, waste treatmen
disease regulation
pest regulation
pollination (anc seed dispersal)
natural hazard regulation
freshwater storage and retention
gas regulation

Service Category	marsh	beach	mud flat	lagoon and salt pond	estuary	rocky intertidal	kelp	rocky reef	shell reef	seagrass	inner shelf	outer shelf, edge, slope	seamount and mid-ocean ridge	inner shelf
CULTURAL					-	-	-	-	-	-	41 – 45	45	-	41 – 45
cultural diversity	-		-	-	-	-	-	-	-	-	-	-	-	-
spiritual and religious values	-		-	-		-	-	-	-	-	-	-	-	-
knowledge systems	-		-	-	-	-	-	-	-	-	-	-	-	-
educational values	-		-	-	-	-	-	-	-	-	-	-	-	-
inspiration	-		-	-	-	-	-	-	-	-	-	-	-	-
aesthetic values	-		-	-	-	-	-	-	-	-	-	-	-	-
social relations	-		-	-	-	-	-	-	-	-	-	-	-	-
sense of place	-		-	-	-	-	-	-	-	-	-	-	-	-
cultural heritage values	-	27	-	-	42	-	-	Note 7	Note 7	-	-	-	-	-
recreation and ecotourism	-	16,945 (Note 2)	-	Note 4	46 – 6,254	-	-	Note 7	Note 7	-	120	Note 10	-	120
SUPPORTING					-	-	-			-	-	-	-	-
photosynthesis	-		-	-	46 – 6,254	-	-	-	-	-	-	-	-	-
primary production	-		-	-	1,351 – 69,671	-	-	-	-	-	-	-	-	-
nutrient cycling	-		-	-	-	-	-	-	-	11,188 (Note 8)	2,081 – 5,350	69	-	2,081 – 5,350
water cycling	-		-	-	13,854 – 69,671	-	-	-	-	-	-	-	-	-
BUNDLED ATTRIBUTES**	(Note 1)	31,500 – 72,900 (Note 2)	Note 3	Note 4	421 – 817 (Note 5)	Note 6								

** "Bundled attributes" refers to cases in which people were asked to value estuarine ecosystem services generally, rather than by category.

해양생태계서비스 연구 동향: 미국

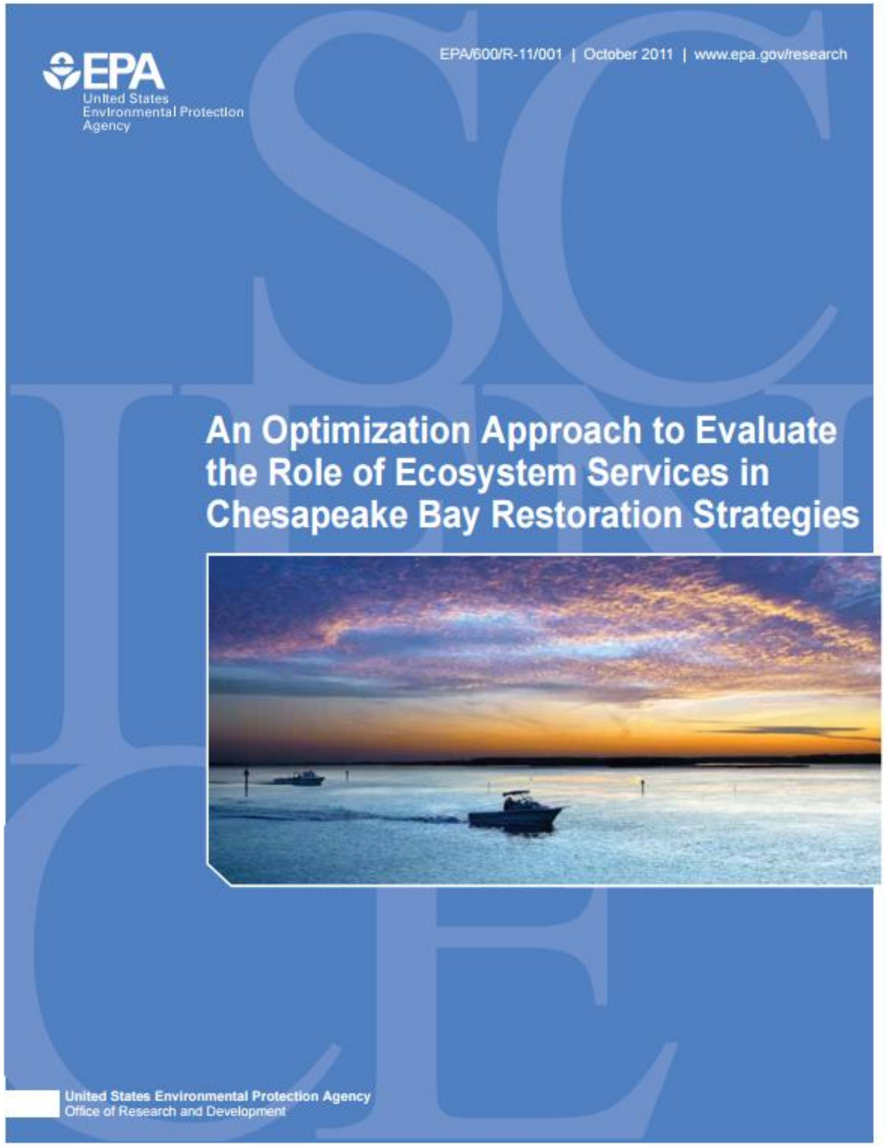


Table ES-1. Load Reduction Targets by Basin (millions of lbs)

Basin	Nitrogen[a]	Phosphorus	Sediment
Eastern Shore of Chesapeake Bay	4.74	0.27	38.88
James River Basin	8.18	0.89	326.23
Patuxent River Basin	0.20	0.05	7.67
Potomac River Basin	6.77	1.03	509.72
Rappahannock River Basin	1.01	0.18	51.90
Susquehanna River Basin	33.14	1.16	529.02
Western Shore of Chesapeake Bay	4.91	0.26	38.24
York River Basin	0.95	0.08	23.80
Total	**59.91**	**3.92**	**1525.47**

[a] Excludes expected reductions in delivered loads attributable to non-tidal atmospheric deposition in the watershed.

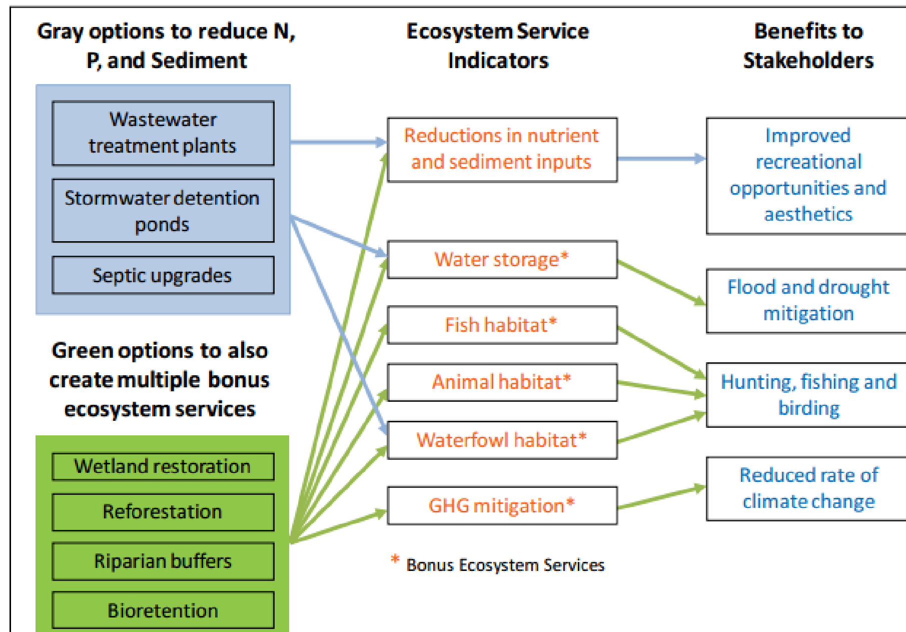


Figure ES-2. Gray vs. green infrastructure pollution controls, associated ecosystem services, and stakeholder benefits.

Evaluating Alternatives for Achieving Pollution-reduction Targets

해양생태계서비스 연구 동향: 미국

Table ES-7. Summary of Optimization Results by Scenario

Scenario	Least-Cost Solution			Least-NET-Cost Solution		
	Annual Control Costs ($ millions/yr)	Bonus Ecosystem Services ($ millions/yr)	Annual NET Costs ($ millions/yr)	Annual Control Costs ($ millions/yr)	Bonus Ecosystem Services ($ millions/yr)	Annual NET Costs ($ millions/yr)
Scenario 1 — TMDL Basin-level Targets	205.4	91.0	114.5	292.8	251.8	40.9
Scenario 2a — Basin-level Targets with 10% BMP Transaction Costs (Base Case)	218.4	89.8	128.6	301.4	238.0	63.4
Scenario 2b — Basin-level Targets with 25% BMP Transaction Costs	237.8	86.9	150.9	307.5	213.5	93.9
Scenario 2c — Basin-level Targets with 2.2x Land Rental Costs	287.8	59.4	228.4	335.1	133.8	201.2
Scenario 3a — Basin-level Targets with 10% BMP Transaction Costs, 2:1 Credit Ratio	1,457.1	287.2	1,169.9	1,487.3	329.3	1,158.0
Scenario 3b — Basin-level Targets with 10% BMP Transaction Costs, 3:1 Credit Ratio	2,020.9	374.4	1,646.5	2,031.0	381.4	1,649.6
Scenario 4a — Basin-level Targets with 10% BMP Transaction Costs, Low Sediment Load Allocation	227.8	91.2	136.6	308.6	232.8	75.8
Scenario 4b — Basin-level Targets with 10% BMP Transaction Costs, High Sediment Load Allocation	218.6	89.8	128.8	300.7	237.4	63.3
Scenario 4c — Basin-level Targets with 10% BMP Transaction Costs, No Sediment Reduction Target	217.1	86.8	130.3	298.7	235.8	62.9
Scenario 5a — Basin-level Nitrogen Target Only with 10% BMP Transaction Costs	199.9	79.4	120.5	282.1	224.0	58.0
Scenario 5b — Basin-level Phosphorus Target Only with 10% BMP Transaction Costs	75.7	42.3	33.4	151.3	176.1	(24.8)
Scenario 5c — Basin-level Sediment Target Only with 10% BMP Transaction Costs	20.1	6.9	13.2	118.0	150.9	(33.0)
Scenario 6a — Basin-level Targets with 10% BMP Transaction Costs, Low Carbon Price	218.4	52.7	165.7	249.2	101.6	147.7
Scenario 6b — Basin-level Targets with 10% BMP Transaction Costs, High Carbon Price	218.4	179.4	39.1	439.2	666.0	(226.8)
Scenario 7a — Basin-level Targets with 10% BMP Transaction Costs, Tier 4 Upgrades	1,024.5	51.4	973.1	1,106.6	190.9	915.7

해양생태계서비스 연구 동향: 유럽

Valmer Project

- 6개 사례지역 대상: 생태계서비스 평가 기술, 방법 및 적용

해양생태계서비스 연구 동향: 유럽

Valmer Project: North Devon 지역 사례

- 사업배경

  1) 유네스코 지정 보호구역 (North Devon Biosphere Reserve, NDBR)
  2) 암반해안, 뻘갯벌, 모래갯벌, 사구 및 염습지 등의 중요 생태계 포함
  3) 얕은 수심과 복잡한 해안선으로 인한 높은 서식지 다양성

해양생태계서비스 연구 동향: 유럽

Valmer Project: North Devon 지역 사례

- 진행과정

1) 해양생태계서비스 평가 항목
  - 지역 내 다양한 서식지의 탄소저장, 폐기물처리, 상업종에 대한 보육장 제공

2) 시나리오 빌딩
  - 다양한 이해관계자들의 모임을 통해 세 가지 주요 시나리를 상정

3) 주요 시나리오별 해양생태계서비스 변화 예측
  - 해양보전구역 지정시: 탄소저장•폐기물처리 ↑ vs 보육장 ↑↓
  - 골재채취: 보육장 ↓↓
  - 굴양식장: 탄소저장•폐기물처리 ↑↑ vs 보육장 ↓↓

해양생태계서비스 연구 동향: 유럽

Valmer Project: North Devon 지역 사례

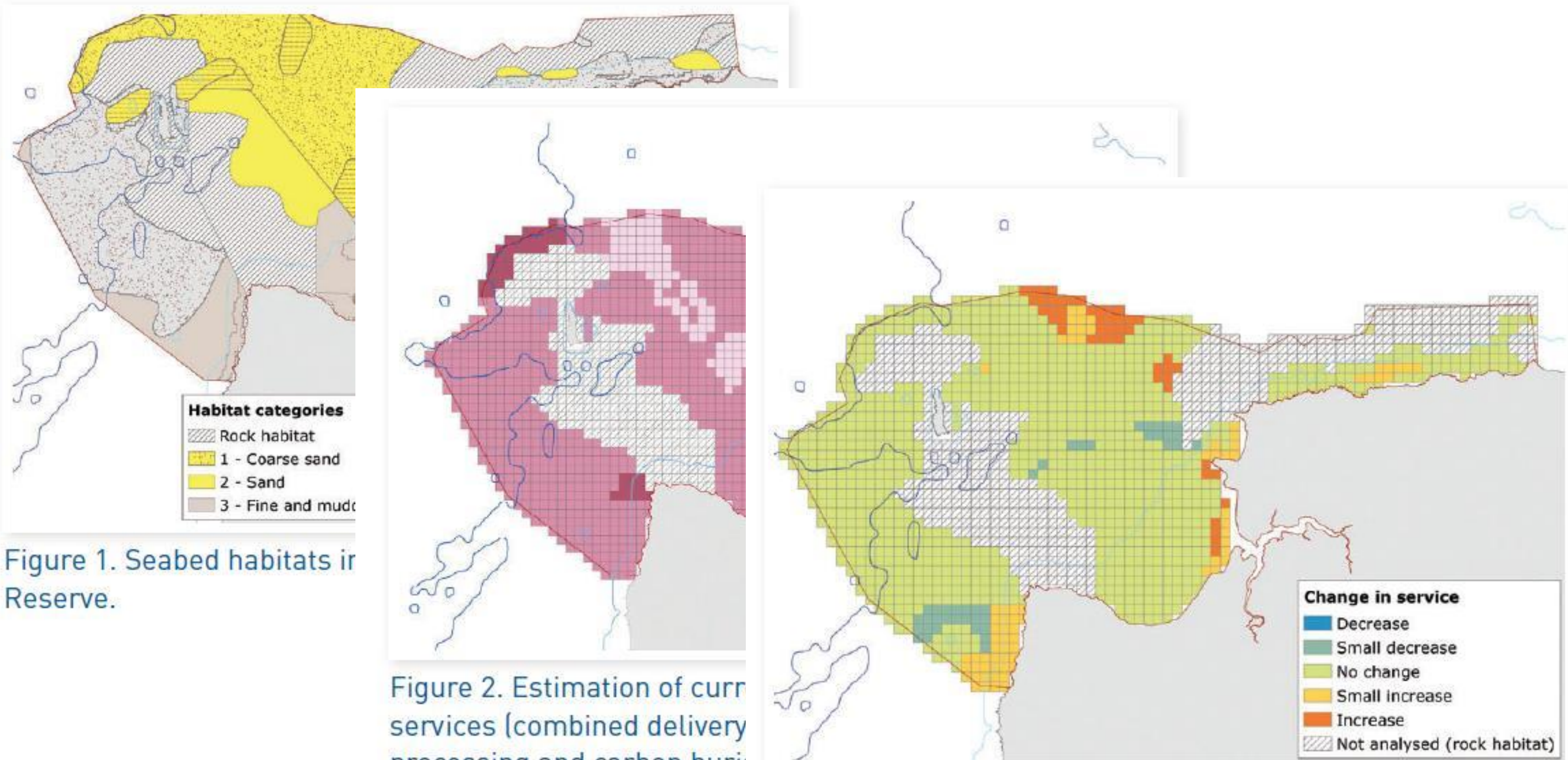


Figure 1. Seabed habitats ir
Reserve.

Figure 2. Estimation of curr
services (combined delivery
processing and carbon buri
of human use.

Figure 3. Recommended Marine Conservation Zones scenario: estimation of the provision of ecosystem services (combined delivery of nursery provision, waste processing and carbon burial).

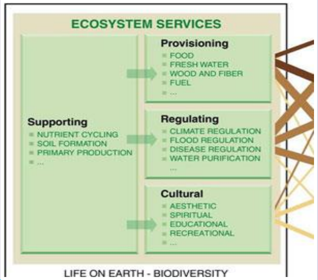
해양생태계서비스 국내동향
: 갯벌을 중심으로

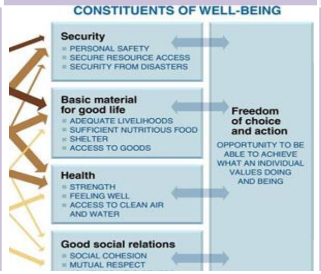
전문가 네트워크

since 2013

MES Research Network in Korea

April 2013





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전문가 네트워크

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Original Article

한국 경제와 자연환경의 에머지 평가: 해양생태계서비스 가치평가 시사점

강대석†
부경대학교 생태공학과

Emergy Evaluation of the Korean Economy and Environment: Implications for the Valuation of Marine Ecosystem Services

Daeseok Kang†
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요 약

우리나라 해양생태계의 가치평가에 에머지 평가법을 적용하기 위한 연구가 일부 진행되었지만, 에머지량으로 나타낸 해양생태계의 가치를 화폐단위로 환산하는데 필수적인 에머지 지수인 에머지화폐비율의 일관성에 문제가 있는 것으로 파악되었다. 이에 따라 이 연구는 우리나라 에머지 평가표의 표준 구조와 자료 형태를 제시함으로써 일관성 있는 에머지화폐비율을 확보할 수 있는 방안을 제시하고자 하였다. 평가대상 대륙붕의 면적 증가는 조석 에너지량을 증가시켰지만, 전체 대륙붕의 등조차도를 기반으로 계산된 면적가중 평균조차의 감소로 조석의 에머지량은 약간 감소하였다. 재생불가능한 자원 이용과 수입한 재화와 용역을 통해 공급된 에머지량은 새로운 평가항목 분류 방식과 평가 자료의 세분화 등으로 인해 기존 연구보다 증가하였다. 이 결과 해양생태계서비스의 가치를 화폐단위로 나타내는데 필수적인 에머지화폐비율이 증가하였으며, 에머지량/에머지화폐비율로 계산되는 화폐가치는 감소하였다. 이는 기존 연구에서 계산된 해양생태계서비스의 가치가 과대평가되었을 가능성이 있음을 의미한다. 국내총생산의 경우 자료의 기준년도에 따라 에머지량의 화폐가치가 달라지므로 기준년도를 명확히 밝힐 필요가 있다. 이 연구에서 제시한 우리나라 경제의 에머지 평가표는 큰 틀에서 에머지 평가법을 이용한 해양생태계서비스의 가치 평가에 일관성이 유지되도록 하는데 기여할 것으로 판단된다.

Abstract – Several emergy researches have been carried out to estimate the value of marine ecosystem services in Korea over the last decade. Their results cannot be compared mainly due to inconsistency in emergy-money ratios used to convert emergy unit into monetary unit. This study aimed at providing a standardized format for the emergy evaluation of the Korean economy and environment for different emergy evaluations to be compatible. Even though the area of the continental shelf increased in this study compared to those of previous studies, area-weighted average tidal range for the entire continental shelf of Korea resulted in smaller tidal range, decreasing the final emergy input from tide. However, emergy inputs from nonrenewable resources and purchased goods and services increased with new categorization and use of more detailed data, combined with updated unit emergy values. This led to higher emergy-money ratio for the Korean economy, indicating that previous emergy valuations might have overestimated the contributions of marine ecosystem to the real wealth of the Korean society. The base year for gross domestic product used in the emergy evaluation needs to be clearly indicated due to its impact on the calculation of the emergy-money ratio. A standardized emergy table for the Korean economy will contribute to ensuring consistency among future emergy researches on the valuation of marine ecosystem services.

한국해양환경공학회 2012년도 추계학술대회 논문집

해양생태계 서비스 가치 평가 및 해양공간관리 적용방향

남정호(한국해양수산개발원), 강대석(부경대학교), 유승훈(서울과학기술대학교), 장원근(한국해양수산개발원)

Valuation of Marine Ecosystem Services and its Application to Marine Spatial Management

Nam, J., D. Kang, S.H. Yoo, and W.K. Chang

요 약

생태계가 제공하는 서비스 가치를 평가하기 위한 시도는 1990년대 중반에 시작되었고, 2000년대 이후 새천년생태계평가, 생태계 및 생물다양성의 경제학(TEEB) 등을 통해 생태계 가치에 대한 인식이 달라지고 있다. 또한 과거 육상생태계에 한정되었던 연구는 해양으로 확산되었고, 사회경제활동의 해양생태계 영향, 해양생태계 건강성 평가가 주목을 받고 있다. 우리나라는 갯벌생태계, 하구생태계 등 일부 단위 생태계에 대해 경제학적·생태학적 방법을 이용하여 가치를 평가를 수행하였다. 그러나 우리나라 해양생태계와 이에 영향을 미치는 사회경제활동의 특성을 반영한 해양생태계 서비스 가치평가 방법은 미개발 상태에 있다. 한편 중요 국책사업, 대규모 연안·해양개발사업에 대한 평가과정에서 비시장 재화 및 서비스에 대한 가치평가를 활용하고 있으나 여전히 제한적이다. 따라서 해양생태계 서비스 가치평가를 활용한 해양공간관리 체제는 향후 우리나라 해양공간 관리의 과학성과 합리성을 제고하는 데 기여할 것으로 판단된다. 본 연구는 해양생태계가 제공하는 서비스 가치 평가 및 건강성 평가의 국내외 사례를 토대로 해양생태계 서비스 가치평가를 해양공간관리에 활용하기 위한 방향을 제시하였다.

ABSTRACT

Valuation of ecosystem services has been conducted since the mid 1990s. Global society has witnessed importance of ecosystem services through MEA (Millenium Ecosystem Assessment), TEEB(the Economics of Ecosystems and Biodiversity) and the like. Efforts to evaluate the services has been expanding its scope from terrestrial areas to marine and coastal areas. Recently emerging issues include assessment of cumulative impacts on marine ecosystem of socio-economic activities, and development of ocean health index. Korean society has evaluated marine ecosystem services, mainly focusing on tidal wetlands and estuaries. Valuation of marine ecosystem has been applied, in limited manner, to large-scale national development projects in marine and coastal areas. However, evaluation methods need to be developed, adjusted to Korea's natural environmental characteristics and socio-economic features. In this regard, marine spatial management by applying valuation of marine ecosystem is expected to contribute to enhancing science and rationality-based approach. This study aims to develop a framework on the application of ecosystem valuation to marine spatial management in Korea.

Keywords : Ecosystem services(생태계 서비스), valuation (가치평가), Marine spatial management(해양공간관리),

갯벌의 생태적 가치

The value of the world's ecosystem services and natural capital

Robert Costanza[*†], Ralph d'Arge[‡], Rudolf de Groot[§], Stephen Farber[||], Monica Grasso[†], Bruce Hannon[¶], Karin Limburg[#*], Shahid Naeem[**], Robert V. O'Neill[††], Jose Paruelo[‡‡], Robert G. Raskin[§§], Paul Sutton[|||] & Marjan van den Belt[¶¶]

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- Nature(1997)에 따르면 갯벌의 생태적 가치는 1ha당 US$ 9,990
- 해수부(1998)에 따르면 한국 갯벌의 생태적 가치는 전세계 평균보다 훨씬 더 높은 1ha당 US$ 27,316으로 평가됨

갯벌 현황


120° E
130°
40° N
35°
river
tidal flat
reclaimed area
bathymetry
sand
muddy sand
sandy mud
mud
HMB Heuksan Mud Belt
Liao He R.
Liadong Bay (130 km²)
Liaoning
Beijing
Tianjin
Hebei
Bohai Bay (530 km²)
Bohai Sea
Liaodong Peninsula
Yalu Jiang Estuary (100 km²)
Yalu R.
DPR KOREA
Seohan Bay
Daedong R.
Huanghe R.
Laizhou Bay (230 km²)
Shandong Peninsula
CHINA
Shandong
20
40
60
80
Yellow Sea
Han R.
Gyeonggi Bay
Sihwa (180 km²)
RO KOREA
West Sea
Geum R.
Saemangeum (400 km²)
Yeongsan R.
East Sea
Haizhou Bay
HMB
South Sea
JAPAN
Kyusu
Isahaya (36 km²)
Jiangsu
Yancheong (600 km²)
Chang Jiang R.
Shanghai
Status quo of Reclamation
China: Korea: Japan
50: 10: 1

갯벌 생물다양성

A Census of Marine Biodiversity Knowledge, Resources, and Future Challenges, *Costello et al., 2010, PLoS One*

Alaska[1]	5,925	3,654,304	8,666,714	1.6
Antarctica[3]	8,200	21,186,153	70,628,284	0.4
Atlantic Europe[4]	12,270	3,572,655	4,553,917	3.4
Australia[1]	32,889	6,819,501	15,272,583	4.8
Baltic[5]	5,865	411,218	26,353	14.3
Brazil shelves[2]	9,101	2,520,420	6,797,196	3.6
Canada Arctic[2]	3,038	3,233,113	2,769,789	0.9
Canada Eastern[2]	3,160	823,799	705,744	3.8
Canada Western[2]	2,636	317,363	271,883	8.3
Caribbean[3]	12,046	2,828,125	7,219,167	4.3
China[1]	22,365	831,966	66,825	26.9
Gulf of Mexico[3]	15,374	1,518,067	2,344,179	10.1
Hawaii[1]	8,244	2,459,609	11,212,445	3.4
Humboldt Current[2]	10,186	3,127,380	8,434,076	3.3
Japan[1]	32,777	3,970,743	14,721,516	8.3
Mediterranean[6]	16,848	2,451,059	3,833,673	6.9
New Zealand[1]	12,780	4,073,895	10,004,545	3.1
Patagonian Shelf[2]	3,776	2,693,614	7,264,273	1.4
SA Trop West Atlantic[2]	2,743	604,068	1,629,080	4.5
South Africa[1]	12,915	846,463	1,758,244	15.3
South Korea[1]	9,900	306,674	166,752	32.3
Trop East Pacific[2]	6,696	905,540	2,442,107	7.4
USA California[2]	10,160	1,053,172	1,933,718	9.6
USA Northeast[2]	5,045	692,073	1,270,708	7.3
USA Southeast[2]	4,229	624,984	1,147,525	6.8

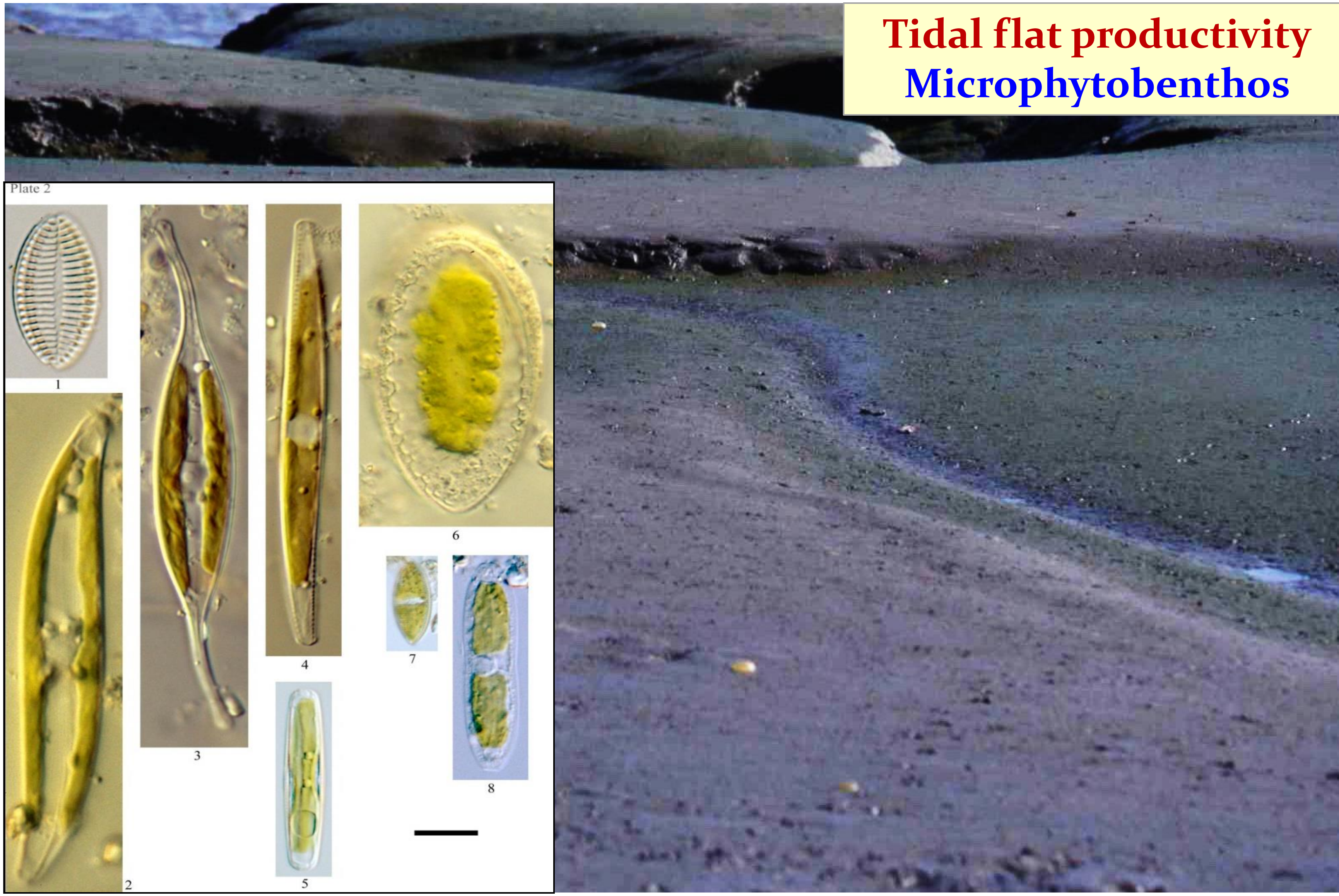
Data sources cited in Methods. SA = South America (excluding Caribbean coasts); Trop = tropical. Spatial statistics based on (1) Exclusive Economic Zone, (2) portion of all EEZ for South America, USA, or Canada, (3) sea area, (4) combination of Norwegian, North, Irish, Greenland, and Celtic seas; Bay of Biscay; English, St. Georges, and Bristol channels; Inner Seas off West Scotland, (5) combination of Baltic Sea, Kattegat, Gulf of Bothnia, Gulf of Finland, Gulf of Riga, and (6) combination of Mediterranean Sea, Tyrrhenian Sea, Aegean Sea, Ionian Sea, Adriatic Sea, Ligurian Sea, Strait of Gibraltar, Alboran Sea [31].

doi:10.1371/journal.pone.0012110.t001

China
2nd ranked for spp/area

South Korea
1st ranked for spp/area

갯벌 생물다양성


Tidal flat productivity
Microphytobenthos
Plate 2
1
2
3
4
5
6
7
8

갯벌 생물다양성

▶ 신속(new genus): 다수의 신속 예상

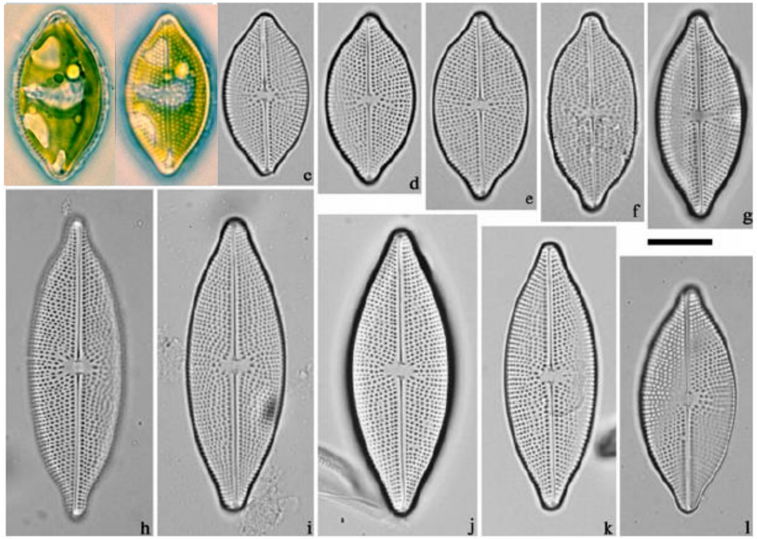


FIG. 2. *Moreneis coreana*. LM. (a, b) Untreated material showing plastid structure. (c–l) Size diminution series of the cleaned valves. Note the external central and apical raphe endings. Scale bar, 10 μm.

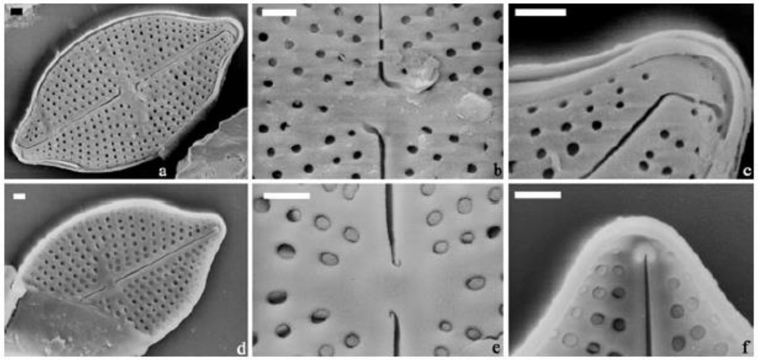
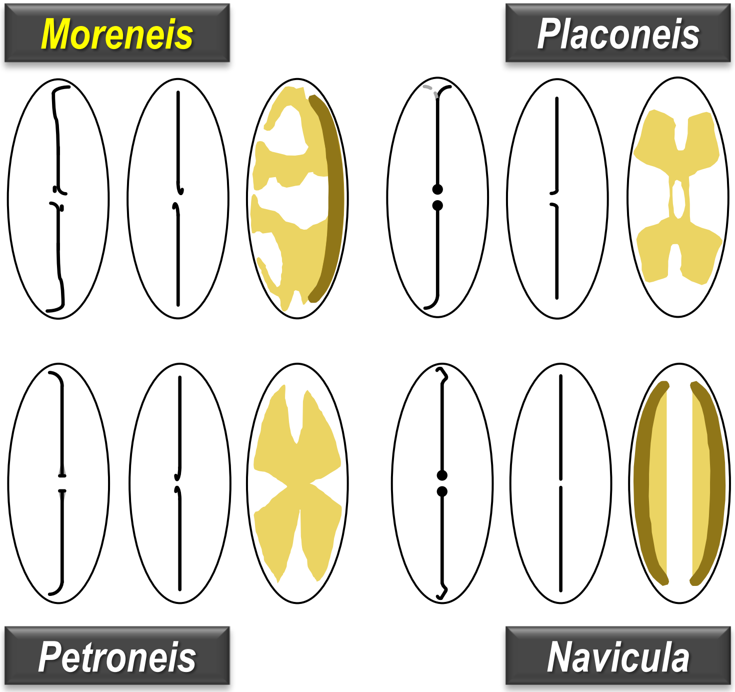


FIG. 3. *Moreneis coreana*. SEM. (a–c) External views of a single valve. (a) A whole specimen showing the gross morphology with narrow girdle bands, note the regular perforations on a partially broken band. (b, c) Valve center, note the shape of the external central raphe endings. (c) Valve apex, note the external terminal raphe ending. (d–f) Internal views of a single valve. (d) The whole specimen showing the gross morphology. (e) Valve center interior, note peculiar internal central raphe endings and internally positioned areola occlusions. (f) Valve apex internal view showing a small, simple helictoglossa. Scale bar, 1 μm.

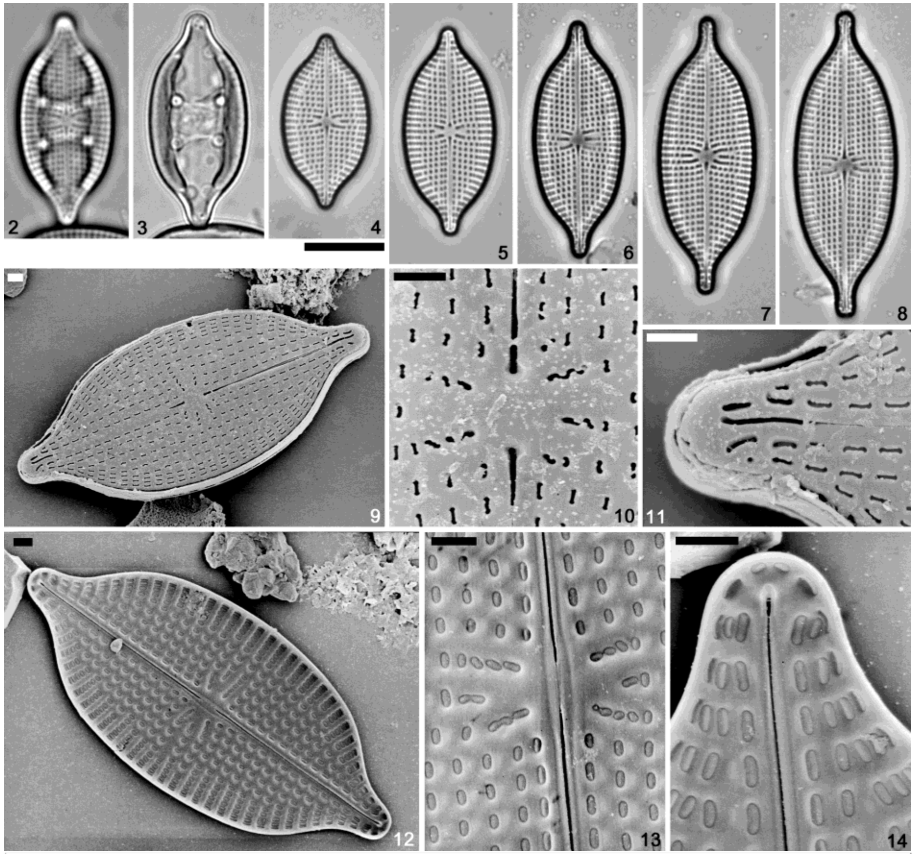
- ✓ A new diatom genus from Saemangeum, Korea
- ✓ Found on sand(모래-more), thus nomenclature given as ***Moreneis***



Park et al., 2012. *J Phycol. 48, 186-195*

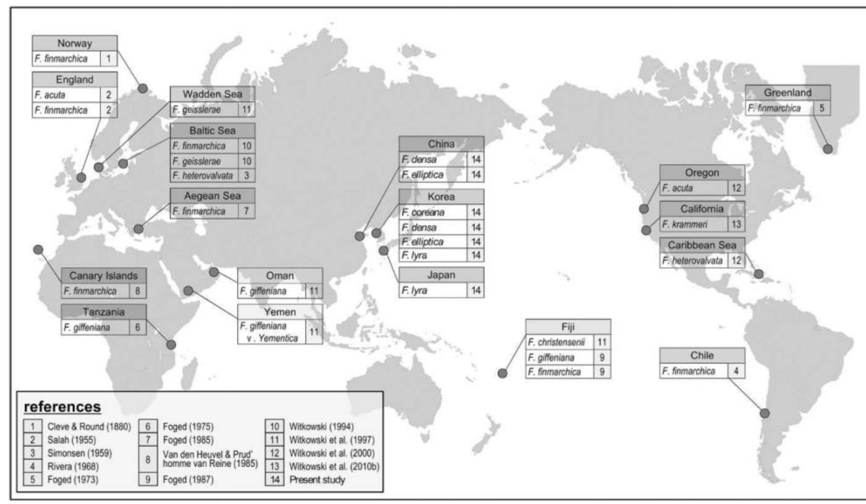
갯벌 생물다양성

▶ **신종(new species): 군집의 30-50% 예상**



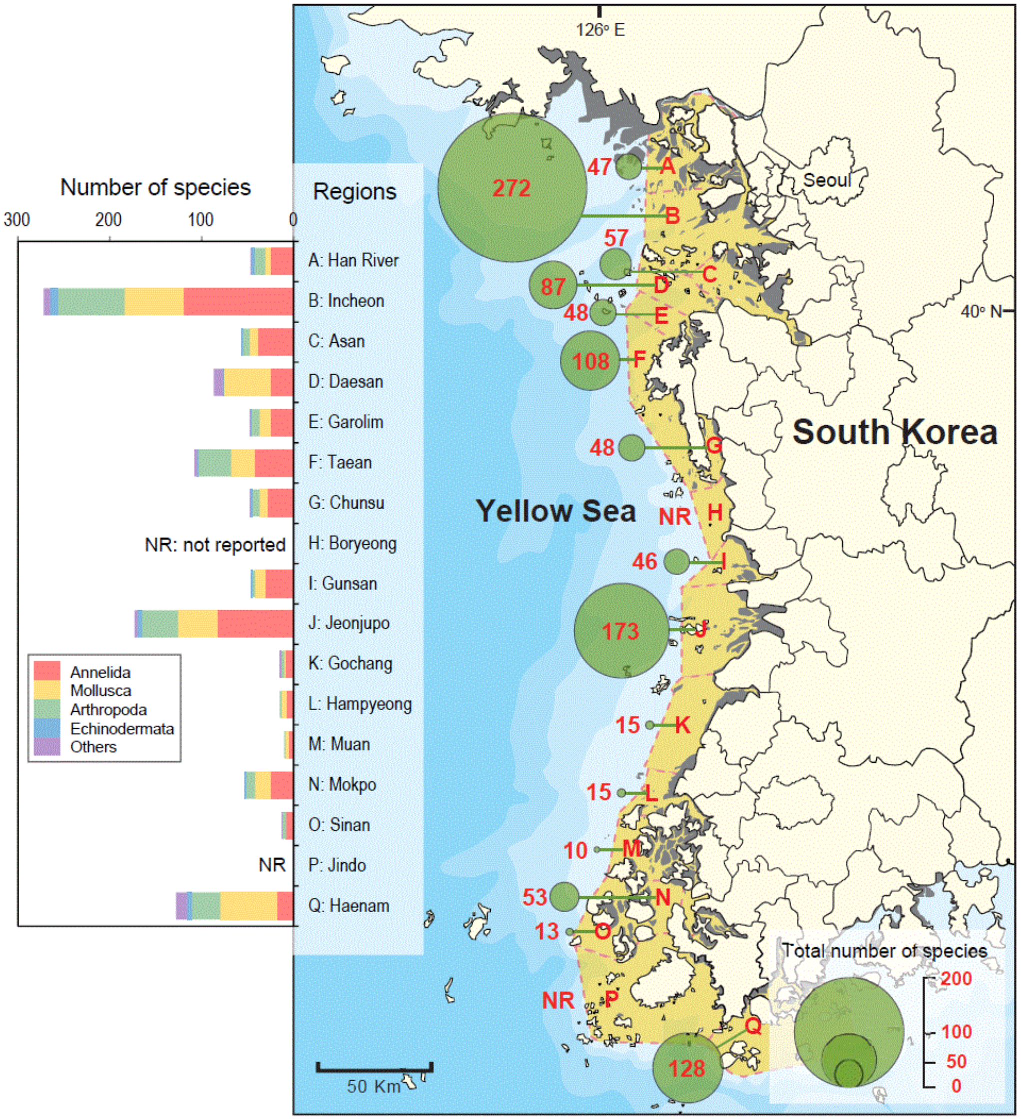
LM and SEM photos of *Fogedia coreana*

- ✓ Four new species found and described from Saemangeum, Korea
- ✓ First observation of *Fogedia* dominance in a given habitat



Park et al., 2012. *J Phycol 48, 186-195*

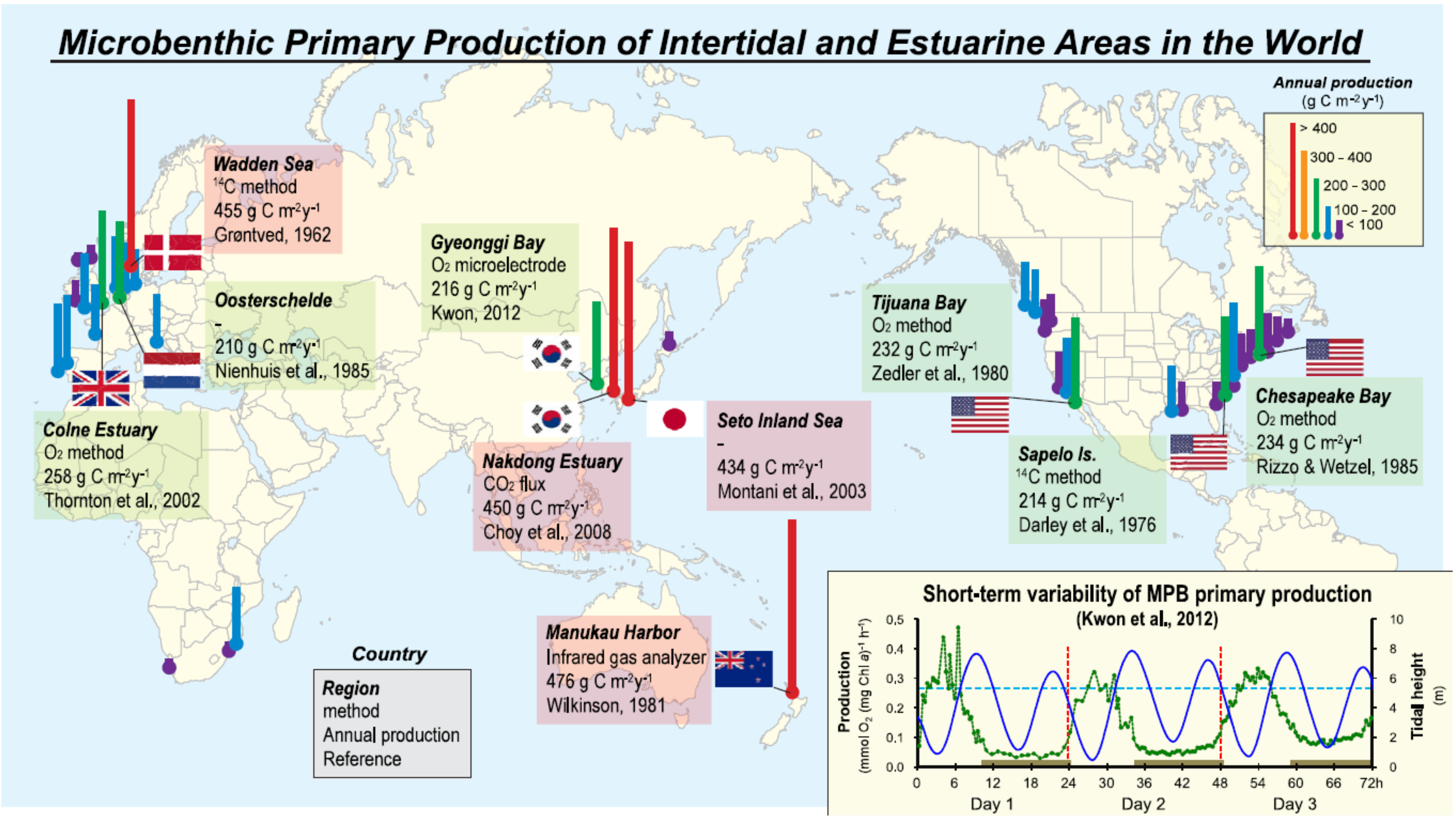
갯벌 생물다양성



- Incheon area (region B) exhibited the most diverse faunal assemblages with 272 species recorded
- Polychaetes (Annelida) showed predominance of 120 species followed by crustaceans and mollusks with 73 and 64 spp.
- 272 species, approximately half of the total number of reported species (624)
- Jeonjupo (region J) to be next in diversity (173) with also next in sampling intensity
- Next ecological hotspot being highlighted areas : Haenam (region Q), Taean (region F), and Daesan (region D),

갯벌 생산성

High MPB productivity zones
Asian tidal flats, Wadden Sea, & New Zealand



갯벌 생산성

razor clam survey at Hwaseong tidal flat

~200 indv./m²

갯벌 생태계서비스

- **공급(Provisioning)**

  - *Food, sand, 광물, 석유/가스, 의약재료*
  - *해양에너지*

- **조절(Regulating)**

  - *수질정화(Water purification): 영양염 순환, 생지화학*
  - *침식조절(Coastal protection): 침식, 퇴적*
  - *기후조절(Climate regulation): CO_2 흡수, 저장, 격리*

- **문화(Cultural)**

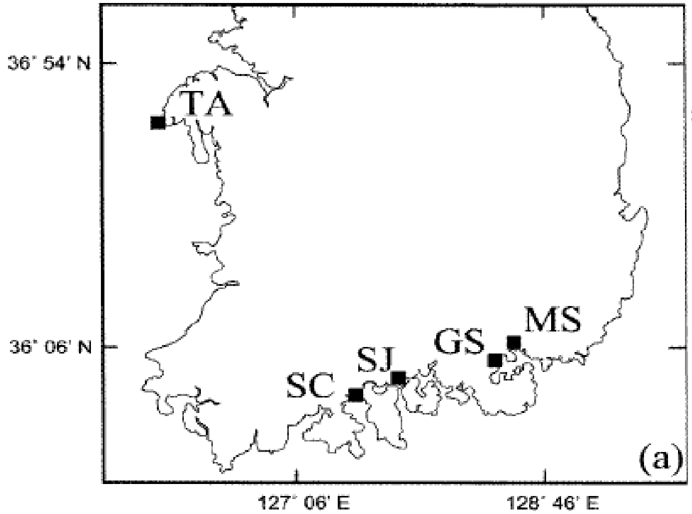
  - *레저& 여가, 심미기능, 교육/연구, 문화 및 어메너티*

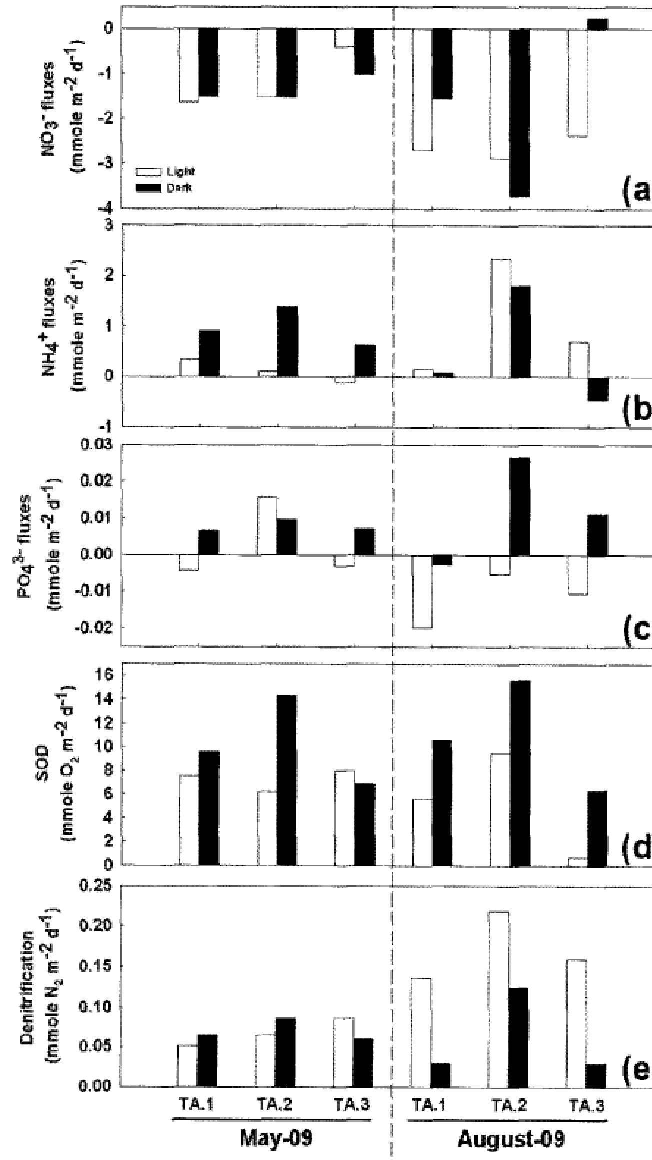
- **지원(Supporting)**

  - *생화학적, 영양염 순환 및 fertility*

갯벌 생태계서비스 – 영양염 순환

부산대 안순모교수

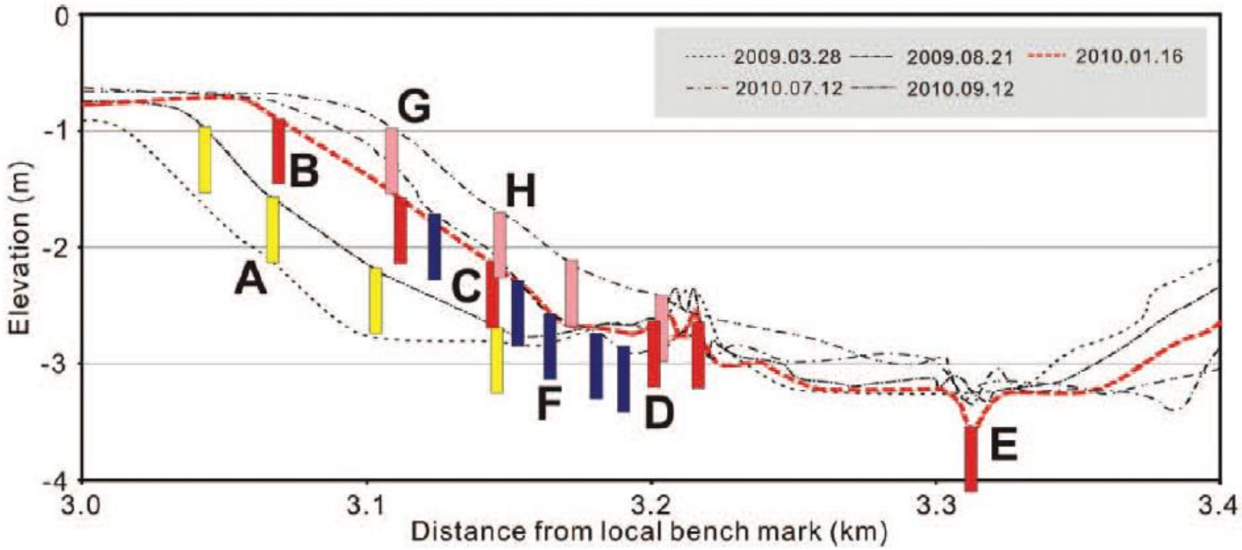


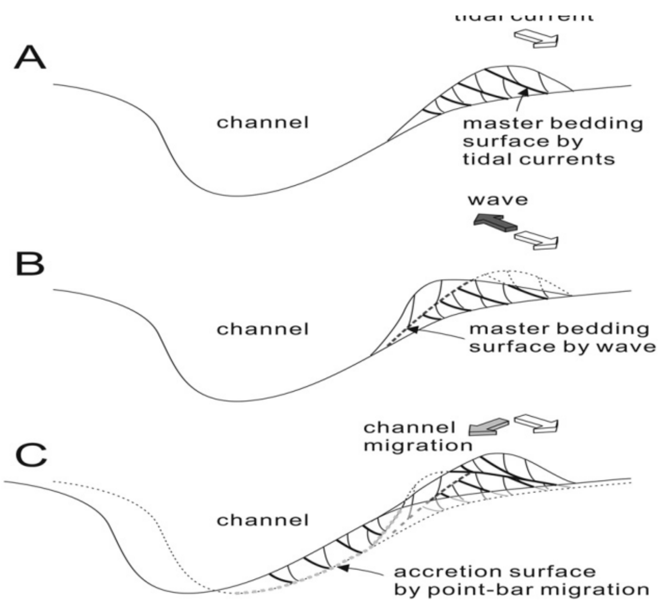


허낙원, 안순모외, 2011

갯벌 생태계서비스 – 침식 방지

서울대 최경식교수





Choi and Jo, 2015a, b

갯벌 생태계서비스 - CO_2 흡수

서울대 권봉오박사

날짜/시간	조위	퇴적물 표면온도	현장광도	이산화탄소 소모량
	m	°C	μmol m-2 s-1	mgCO2 m-2 h-1
2010-06-07 0:00	6.0	20.6	0	-27.3
2010-06-07 1:00	5.7	20.2	0	-25.4
2010-06-07 2:00	5.1	18.3	0	-24.9
2010-06-07 3:00	4.4	17.6	0	-24.9
2010-06-07 4:00	3.6	17.2	0	-24.9
2010-06-07 5:00	3.0	16.9	0	-24.9
2010-06-07 6:00	2.9	17.8	29	-9.2
2010-06-07 7:00	3.2	19.6	224	96.4
2010-06-07 8:00	3.8	23.4	620	184.4
2010-06-07 9:00	4.6	27.1	964	395.1
2010-06-07 10:00	5.4	27.0	0	-60.8
2010-06-07 11:00	6.0	22.0	0	-34.4
2010-06-07 12:00	6.2	21.9	0	-33.4
2010-06-07 13:00	5.9	23.8	0	-42.4
2010-06-07 14:00	5.3	28.2	0	-67.6
2010-06-07 15:00	4.5	30.2	1504	557.1
2010-06-07 16:00	3.6	29.1	1372	512.7
2010-06-07 17:00	2.8	26.8	1073	369.8
2010-06-07 18:00	2.4	25.4	327	96.8
2010-06-07 19:00	2.4	21.7	52	-6.1
2010-06-07 20:00	2.9	20.2	29	-9.7
2010-06-07 21:00	3.7	19.1	0	-24.9
2010-06-07 22:00	4.7	18.3	0	-24.9
2010-06-07 23:00	5.5	19.9	0	-24.9

월	이산화탄소소모량 ($g\ CO_2\ m^{-2}$)
2009년12월	17.7
2010년1월	11.5
2월	77.0
3월	104.2
4월	190.1
5월	105.9
6월	93.4
7월	73.7
8월	71.3
9월	46.5
10월	72.7
11월	38.4

서울대 산학협력단, 2010

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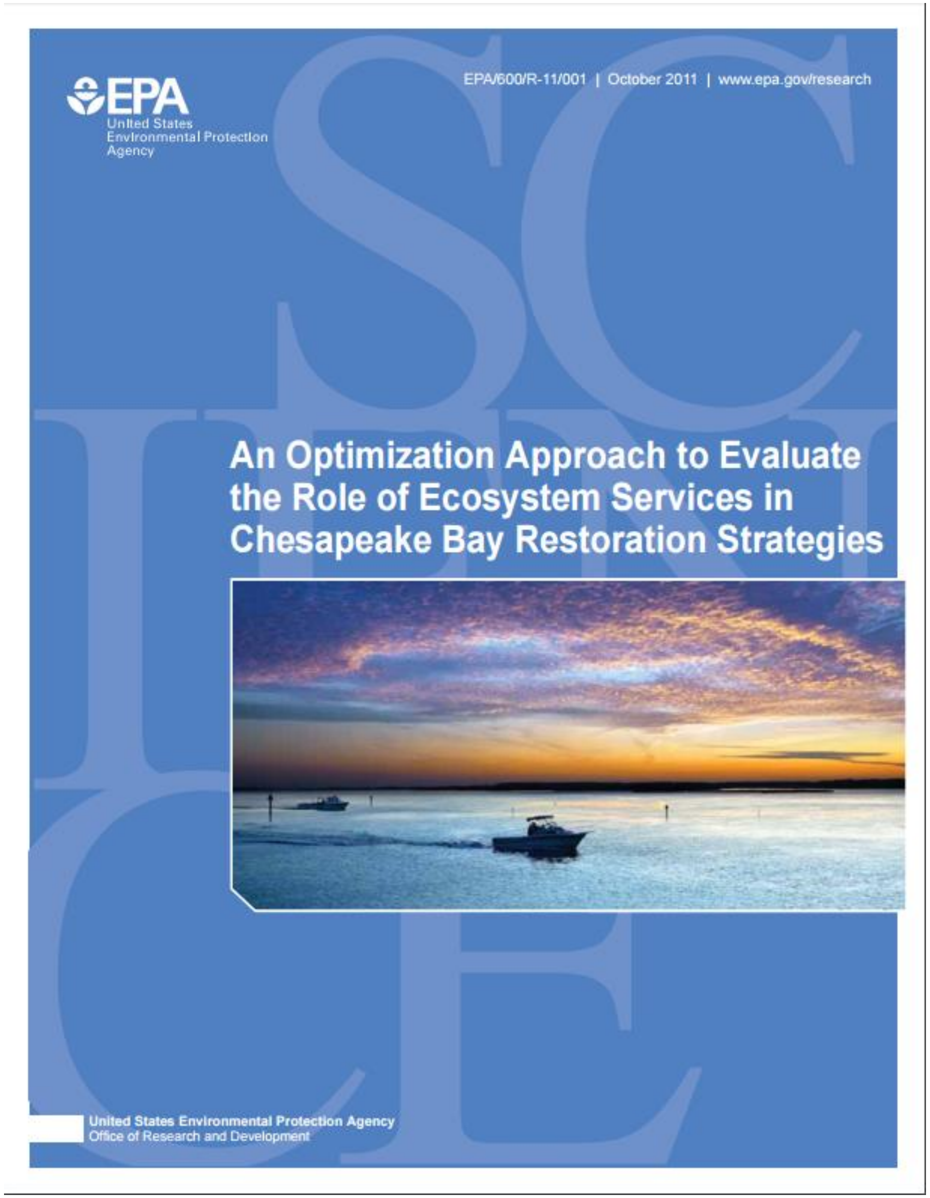

Table ES-1. Load Reduction Targets by Basin (millions of lbs)

Basin	Nitrogen[a]	Phosphorus	Sediment
Eastern Shore of Chesapeake Bay	4.74	0.27	38.88
James River Basin	8.18	0.89	326.23
Patuxent River Basin	0.20	0.05	7.67
Potomac River Basin	6.77	1.03	509.72
Rappahannock River Basin	1.01	0.18	51.90
Susquehanna River Basin	33.14	1.16	529.02
Western Shore of Chesapeake Bay	4.91	0.26	38.24
York River Basin	0.95	0.08	23.80
Total	**59.91**	**3.92**	**1525.47**

[a] Excludes expected reductions in delivered loads attributable to non-tidal atmospheric deposition in the watershed.

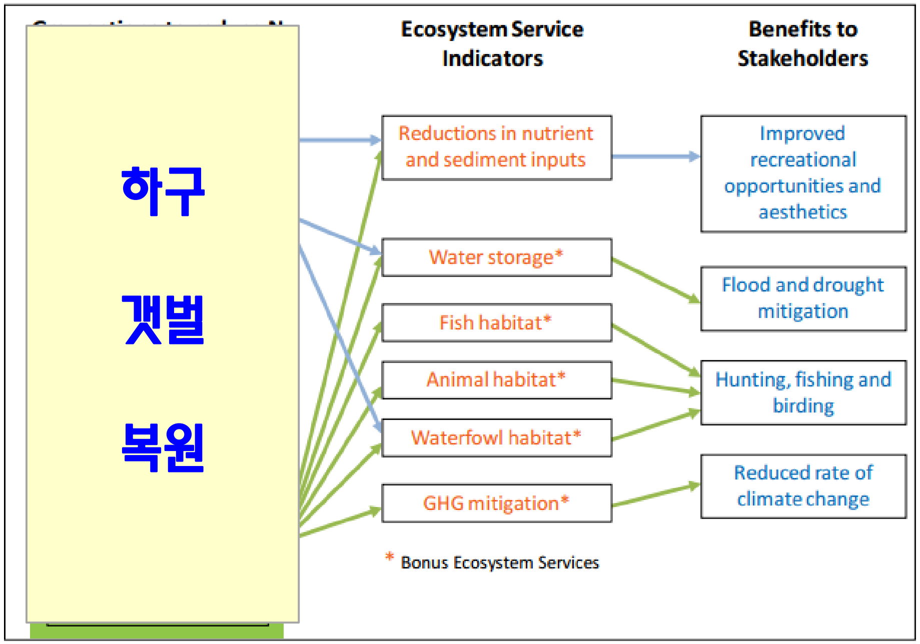

Figure ES-2. Gray vs. green infrastructure pollution controls, associated ecosystem services, and stakeholder benefits.

Evaluating Alternatives for Achieving Pollution-reduction Targets

Thank you for your attention