ONE PLANET - ONE OCEAN
FROM SCIENCE TO SOLUTIONS
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General Reading Material

There are many reports and articles produced by scientific bodies, governmental agencies, the United Nations which will be referred to throughout the course. Use these openly available resources which have a wealth of scientifically sound information on our ocean and browse through some of these listed below at your leisure. Details of selected chapters or sections will also be given as readings for each module to help you complete the weekly quizzes and assignments.

**World Ocean Review**

This series of four reports provides a broad but detailed overview of the state of the ocean. These cover topics from fisheries, marine pollution, and law of the sea, to marine resources and changes in the marine ecosystems. First published in 2010, with contributions from experts in the Cluster of Excellence ‘The Future Ocean’ in Kiel, the International Ocean Institute in Malta and ‘mare’ magazine of the seas, this series aims to provide accurate and robust scientific information on the ocean that is accessible and understandable for the general public.

[Website](#)

Order [free copies of the report](#) in English or German

**German Advisory Council on Global Change (WGBU)**

The German Advisory Council on Global Change is an independent advisory body which provides scientific policy advice to the German Government. It regularly publishes reports on a variety of issues to do with global change, ocean governance and sustainability. On their website, there are report summaries as well as comprehensive reports and Commissioned Expert's Studies. Some relevant reports for this course are:

'**World in Transition: Governing the Marine Heritage**'

'**World in Transition – A Social Contract for Sustainability**'

'**The Future Oceans: Warming Up, Rising High, Turning Sour**'

'**World in Transition - Environment and Ethics**'

'**Human Progress within Planetary Guardrails: a Contribution to the SDG Debate**', a policy paper on sustainable development goals

[Free copies of the reports](#) in English

**United Nations World Ocean Assessment**

This is the first integrated global assessment of the ocean and tackled questions such as: What is the overall state of the world’s oceans and seas? Are marine ecosystems around the world improving or declining? What benefits do we get from the world’s oceans and seas, and how are they distributed? How can we measure the state of the oceans
and seas? And what threatens them? An overview for the results is presented in a 26-page summary available of the World Ocean Assessment website.

Website

Summary of final report available in English

Intergovernmental Panel on Climate Change (IPCC)

Since formation in 1988 as an intergovernmental scientific body, the Intergovernmental Panel on Climate Change has produced reports based on objective assessments and reviews by panels of thousands of experts on scientific information. The most recent Assessment Report (AR5) with brief fact sheets, short summary for policymakers and in depth individual chapters on a multitude of topics can be found on the IPCC website free of charge.

Website

Synthesis Report (AR5) available in English, Arabic, Chinese, French, Korean Russian, and Spanish

Global Ocean Commission

Since its launch in 2013, the Global Ocean Commission has produced two reports, 'From Decline to Recovery: A Rescue Package for the Global Ocean' and 'The Future Of Our Ocean: Next steps and priorities', covering issues relevant to the high seas governance. These reports highlight the drivers of this decline as well as providing short-, mid- and long-term recommendations to improve ocean health.

Website

Summary reports are available in English, French, Spanish, Russian, Japanese, Chinese, and Arabic

Additional links of interest

Sustainable Development
Sustainable Development Goals
Millenium Report

Law of the Sea and UN Programmes
United Nations Division for Ocean Affairs and Law of the Sea
International Tribunal for the Law of the Sea
United Nations Environment Programme (UNEP), Regional Seas Programme
International Maritime Organization

Fisheries and Marine Science
UNESCO Intergovernmental Oceanographic Commission
UN FAO Fisheries & Aquaculture Department
Module 1 introduces you to the MOOC. You learn about the Ocean as a single interconnected system, with finite resources that provide innumerable services to human societies. We speak about human influences on the ocean, and how the ocean can be seen as a common resource to be collectively managed and governed. Lastly, we go into the concepts of sustainability, and understand how solution options may be evaluated as being based on weak or strong sustainability concepts.

Lecture 1.1 The Ocean MOOC

Lecture 1.2 Our Ocean: a Finite Resource

Lecture 1.3 Ocean Evolution

Lecture 1.4 Human influence on the Ocean

Lecture 1.5 The Ocean as a Common Heritage of Mankind

Lecture 1.6 Concepts of Sustainability
General Links for Module One

Marine Protected Area Atlas
Corporate Europe Observatory website
Blue Marine Foundation website
2014 United Nations List of Protected Areas
Global Biodiversity Outlook 4
New Measure shifts Biodiversity Focus
Marine Protected Areas—Smart Investments in Ocean Health
Location of Protected Marine Areas
Salvage Blue Saint Vincent and the Grenadines
Marine Protected Areas in Spain (In Spanish)
Lecture 1.1: The Ocean MOOC

Lecturer: Prof. Martin Visbeck, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“We, as individuals, need to reflect on our personal perception of the role the ocean plays in our lives in our very local regions as well as the world. And with that in mind we need to reconsider how to help govern and sustain our oceans to better support the services the ocean provides us all.”

“My take home message is that the oceans have finally made it to the global arena as a sustainable development goal. It shows increased recognition of the vital role the oceans play in sustaining life. This further underpins the need for a more holistic approach in the management of the ocean system and requires a diverse body of knowledge to aid in decision making.”

“On the one hand, the vital services the ocean provides to us and, on the other hand, the threats that we, as humans, are imposing to the ocean which are also compromising its resilience to climate change. Overfished, polluted, warming-up, acidifying, losing its oxygen.”

Resources:

First assessment of the state of the ocean in the World Ocean Review 1
The Global Ocean Commission report: “A Rescue Package for the Ocean”
‘A Rescue Package for the Ocean’ - Global Ocean Commission

Links added by course participants:

United Nations Convention of the Law of the Sea
Federal Law of Nature Conservation in Germany
Official MPA map
The 2030 Sustainable Development Agenda
Global facts about MPAs and marine reserves
Lecture 1.2: Our Ocean: a Finite Resource

Lecturer: Prof. Martin Visbeck, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

"The ocean is a finite resource on which we are highly dependent. Sustainability is key."

"The new material, for me, included the climate regulating function of the ocean and its potential as a source of renewable energy. I was also amazed that 95% (or was it 99%?) of our telecommunications travel via underwater cable!"

"This lecture really drove home the point that the ocean sustains the planet as we know it."

Resources:

Overview of marine ecosystem services - Chapter 2 of the World Ocean Review 4
Sustainable Development Goals and targets
“Looking to the Future“ (Chapter 4) in the World Ocean Review 4

Links added by course participants:

United Nations Convention of the Law of the Sea
Federal Law of Nature Conservation in Germany
Official MPA map
The 2030 Sustainable Development Agenda
Global facts about MPAs and marine reserves
Sustainable Development GOAL 14
The IUCN Red List of Threatened Species
World Development Indicators: Deforestation and biodiversity
Lecture 1.3: Ocean Evolution

Lecturer: Prof. Thorsten Reusch, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“Intrigued by the diversity of life in ocean. Stunned by how much is still to be learned."

“I learned the importance of the ocean as a both a carbon sink and a provider of oxygen (‘every second breath we take comes from the ocean’). It reminded me of how brilliantly diverse ocean life can be, and how biodiversity is crucial in maintaining healthy ecosystems."

“I enjoyed the striking point that ocean ecosystems are three dimensional in contrast to the two dimensions in land. Not something we do not know, but hadn’t really thought it this way."

“The equilibrium of marine life spent thousands of years to arrive at such level and result from the combination of geomorphological and hydrologic resources specifics of each ocean. But the humankind changed the equilibrium of marine life."

“Life is everywhere in the ocean. Geochemical processes and biology are closely connected. We are just beginning to explore the biodiversity, but ironically, we’re getting to this understanding at a time when we’re also causing an unprecedented decline in the same."

Resources:
Census of Marine Life
“Climate change impacts on marine ecosystems” in the World Ocean Review 1.

Links added by course participants:
The IUCN Red List of Threatened Species
World Development Indicators: Deforestation and biodiversity
Lecture 1.4: Human Influence on the Ocean

Lecturer: Prof. Mojib Latif, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“How MOOC participants summarised this lecture:

“Anthropocene, that is definitely a word I will try to remember from this lecture, as well as thermal expansion effect.”

“Intense and precious lesson (not that the others are not), I loved it so much that I played it twice. Water column expansion, sea ice vs. land ice, sea level does not rise uniformly... Thank you very much Prof. Mojib Latif!”

“Wow, what a strong reminder of how sensitive the natural balance in life is. I’ve read a great deal on ocean acidification, and feel this is one big consequence which current societies are taking for granted or is oblivious to. The anthropocentric impact is a multifarious one, there is no effective solution which focus on a singular consequence. More people must be aware of this and take it into account.”

“I feel an increased sense of alarm after listening to this lecture. I too have seen the impact on coral reefs and disappearing ice/snow in mountains I use to frequent as a kid. I hope that we individually and as nations can become better informed and actively able to influence what happens in the future.”

“I already knew that the planet is in big trouble, but upon seeing how humans have not only decreased biodiversity, but also influenced the atmosphere and the waters to this extreme extent I am quite amazed by the changes humans have generated. [...] Now I’ve seen the mechanisms behind climate change in more detail, the task of reversing the effects seems even more daunting.”

Resources:

“Ocean observations” chapter of the Intergovernmental Panel on Climate Change (IPCC) assessment report (AR5)
Climate Change 2013: The Physical Science Basis

Links added by course participants:
United Nations Convention of the Law of the Sea
Federal Law of Nature Conservation in Germany
Official MPA map
The 2030 Sustainable Development Agenda
Global facts about MPAs and marine reserves
Sustainable Development GOAL 14
The IUCN Red List of Threatened Species
World Development Indicators: Deforestation and biodiversity
Lecture 1.5 The Ocean as a Common Heritage of Mankind

Lecturers: Prof. Nele Matz-Lück, Dr. Awni Behnam, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University
Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“This was the first time, I heard of Elisabeth Mann Borgese and her work to sustainable oceans. I learned the battle between national (territorial seas) and international ocean areas and the goals of national jurisdiction of freedom of shipping etc. and the coastal power over waters.”

Resources:

Official treaty text “Agreement Governing the Activities of States on the Moon and Other Celestial Bodies”
“Law of the Sea” in the World Ocean Review 1
International Seabed Authority website

Links added by course participants:

United Nations Convention of the Law of the Sea
Federal Law of Nature Conservation in Germany
Official MPA map
The 2030 Sustainable Development Agenda
Global facts about MPAs and marine reserves
Sustainable Development GOAL 14
The IUCN Red List of Threatened Species
World Development Indicators: Deforestation and biodiversity
Lecture 1.6 Concepts of Sustainability

Lecturers: Prof. Konrad Ott, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University
Click here to watch the video of this lecture.

Resources:
Video: “What is sustainability?”
Video: “Provosts Lecture: Carl Safina - In the Same Net: Ocean Life, Ethics, and the Human Spirit”,

Links added by course participants:
United Nations Convention of the Law of the Sea
Federal Law of Nature Conservation in Germany
Official MPA map
The 2030 Sustainable Development Agenda
Global facts about MPAs and marine reserves
Sustainable Development GOAL 14
The IUCN Red List of Threatened Species
World Development Indicators: Deforestation and biodiversity
Module 2: Ocean Circulation and Physics

In this module you will learn about the physical processes in our ocean, How this makes our ocean ONE ocean and how physics sets the stage for Understanding so many other processes.

Lecture 2.1: Drivers of Ocean Currents

Lecture 2.2: Changes in Ocean Circulation

Lecture 2.3: Ocean Heat Storage and Sea Level Rise

Lecture 2.4: Water Cycles and Salinity
General Links for Module Two

The Great Ocean Conveyor Belt in Chapter 1 of the World Ocean Review 1

Ocean Circulation and Climate: Observing and Modelling the Global Ocean (2001), International Geo-physics

Classical textbook ‘Introduction to Physical Oceanography’ by R. H. Stewart

‘Regional Oceanography: an Introduction’: a textbook for marine science students

List of e-books on oceanography

Oceanography research

‘Hands-on experiments for teaching and outreach’ by Dr. Mirjam Glessmer

How do oceanographers measure the ocean?

Ocean Circulation Videos

Bill Nye demonstrates how salinity impacts the density of water and introduces thermohaline currents.

Ocean currents
Lecture 2.1: Drivers of Ocean Currents

Lecturers: Prof. Martin Visbeck, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“Wow! Really interesting to learn how the wind and the rotation of the planet work together to affect the ocean currents. [...] I have a particular interest in marine pollution so it was interesting to see the issue incorporated into this discussion of [ocean] physics.”

“I love how all the ocean currents are so interconnected: it really is just one big ocean!”

“The ocean conveyor belt, and meridional overturning cycle is, for me, again a highlighter that there needs to be continued collaboration between scientists from all countries - the problems and solutions of one country, are not staying there, but being transported throughout the globe with ocean circulation.”

Resources:

Please see module resources on Page 16

Links added by course participants:

Mediterranean Sea Circulation
The Ocean Cleanup
Expedition 7 Continent
Lecture 2.2: Changes in Ocean Circulation

Lecturers: Prof. Martin Visbeck, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“We know that [...] close interactions [exist] between oceanic and atmospheric circulations [and that] those interactions can operate on a global scale becomes obvious in phenomena like the monsoon system, El Niño/La Niña or the North Atlantic Oscillation.”

“Depending on the wind direction and temperature, there is either winter or summer monsoon, which changes conditions in India or the African coast respectively. It also explains how Omani sailors were able to travel as far as they did. Brilliant!”

“Wind is pretty powerful, in addition to creating waves on the surface, it drives oceanwide cir-culation.”

“Changes in the atmosphere affects the climate and our ocean on a yearly, [decadal] and even longer time scales. Studying these processes helps us to understand what effects climate change may have on our ocean.”

Resources:

Please see module resources on Page 16
Lecture 2.3: Ocean Heat Storage and Sea Level Rise

Lecturers: Prof. Martin Visbeck, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University
Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“What stood out for me was the fact that over 90% of the heat is absorbed by the ocean.”

“I have now learnt that everything that affects the ocean even if I am several hundred miles away can have an effect on our environment.”

“[..] sea level rise is not only caused by melting ice caps but more importantly by expansion of heated up sea water!”

“I thought that the sea level would rise when the glaciers melted, but I didn’t actually realise that it was caused by the water actually expanding when it gets warmer, and that it is rising and falling at different rates around the world. Fascinating!”

Resources:
Please see module resources on Page 16

Links added by course participants:
The Deep Decarbonization Pathways Project
The Claude "Bud" Lewis Carlsbad Desalination Plant
Encina Power Station
Sea-Level Rise Has Claimed Five Whole Islands In The Pacific: First Scientific Evidence
Lecture 2.4: Water Cycles and Salinity

Lecturers: Prof. Martin Visbeck, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University
Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“Water salinity is another critical component of the ocean. It [...] not only determine[s] water density (being therefore an important factor in the thermohaline circulation), but also the freezing point of water (possibly interfering with ice formation [...] ), and the local variety of marine organisms. That observed variations in salinity could be a mean to measure climate change [...] was [...] interesting learning.”

“Ocean temperature and salinity both affect density and density affects circulation, so both of these must also have an effect on current.”

“Here I was served by the connection of the temperature change in the ocean leads to a water cycle change on land, due to different evaporation for example. The evaporation makes the water [in the ocean] saltier [...]”

Resources:

Please see module resources on Page 16

Links added by course participants:

IPCC Fourth Assessment Report: Climate Change 2007—The Physical Science Basis—Ocean Salinity
The Chemistry of Ocean Acidification
IPCC Intergovernmental Panel on Climate Change—The Physical Science Basis—Frequently Asked Questions
Lecture 2.5: Ocean Prediction

Lecturers: Prof. Martin Visbeck and Prof. Mojib Latif, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“Models are very important to come near the real nature but they must join with the observations of real events [...]”

“Very interesting lesson that highlights the fact that modeling needs measurements and observation on the field, and the mutual collaboration can improve the work of both activities.”

“Combining field measures in the different ocean basins and mathematical models seems to allow rather accurate estimates of the different features of the ocean system, including life cycles. This is helpful to have in-time view of the current state of the ocean, as well as to predict on more or less longer time-scales the evolution of the overall climate system.”

Resources:

Please see module resources on Page 16

Links added by course participants:

Argo—Part of the Integrated Global Observation Strategy
Lecture 2.5: Ocean Prediction

Lecturers: Prof. Martin Visbeck and Prof. Mojib Latif, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

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Resources:

Please see module resources on Page 16

Links added by course participants:

Argo—Part of the Integrated Global Observation Strategy
Module 3: Drivers of Life in the Ocean

In this module you will learn about marine phytoplankton, what drives life at the bottom of the food web, and how these incredible microscopic photosynthetic machines in the ocean shape environmental conditions on a global scale.

Lecture 3.1: Marine Elemental Cycles

Lecture 3.2: Dance of the Plankton

Lecture 3.3: The Ocean’s Biological Pump

Lecture 3.4: Ocean Change: a Mix of Interacting Stressors

Lecture 3.5: Climate Engineering: No Easy
Lecture 3.1: Marine Elemental Cycles

Lecturers: Prof. Ulf Riebesell, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“All compartments of the Earth (cryosphere, hydrosphere, lithosphere, biosphere) are linked through their basic elements such as oxygen, hydrogen and carbon. Understanding the biogeochemistry of the earth will help us to understand the “future” of our planet.”

“Our knowledge of the biogeochemistry of the ocean is still limited. Although we have a good understanding of the major sources and sinks, and we are able to measure element concentrations in the ocean, how these are all interlinked and balanced is still unknown. Therefore it is also unknown what will be the exact outcome of the risks we can afford with our planet and ocean.”

“For me it was good to get a feel over the three types of elements: conservative, particle reactive and bioreactive elements. The latter is driving biological productivity (because organism[s] rely on them). It is now a dimension more that plays in the orchestra of understanding the earth system cycling elements!”

Resources:

The Global Carbon Project
Video on how ice cores are used to track climate over the past
Lecture 3.2: Dance of the Plankton

Lecturers: Prof. Ulf Riebesell, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“Phyto-plankton is something that I haven’t really considered before in the context of global warming. [...] It is certainly concerning that the changing temperatures of the ocean could seriously affect the production of phytoplankton and the knock on effects of this in terms of fish stocks could be quite catastrophic.”

“Photoplankton are the first stage in the marine foodweb and the vast majority of marine life are reliant on them. However the changing climate will have an effect on their abundance [...]”

“What really fascinated me was that there is such a vast range of [phytoplankton] sizes that it can be measured like the [size] difference between a fish and Manhattan. That is incredible when you think of the fact that you don’t even see it with your eyes.”

Resources:

Watch the dance of the plankton
Animation of chlorophyll concentrations and the contribution of phytoplankton in three different size classes (small = picoplankton, medium = nanoplanckton, large = microplankton).
‘Ocean Science: The power of plankton’
Tara Oceans, a global assessment of plankton diversity and function
The Plankton Chronicles, short videos introducing you to major plankton groups

Links added by course participants:

How Whales Change Climate
Spectral niches in the ocean for phytoplankton
Trophic transfer of energy
Lecture 3.3: The Ocean’s Biological Pump

Lecturers: Prof. Ulf Riebesell, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“These single-cell micro-algae are really amazing microscopic organisms. Not only do they produce about half of the oxygen we breathe (one of the end-products of photosynthesis), but they are also responsible for consuming large amounts of atmospheric carbon dioxide. This so-called Biological Carbon Pump is in fact an efficient process for rapid removal of carbon in the deep ocean (e.g. through sequestration in sediments or feeding of deep sea fauna).”

“Phytoplankton is very interesting: a totally photosynthesis machine without leaves[,] roots [or] branches!”

“So, a staggering amount of oxygen we breathe comes from phytoplankton in the surface layer of the ocean, and they consume huge amounts of carbon dioxide[:] any adverse changes to the biological pump will have a knock-on effect for the climate.”
Lecture 3.4: Ocean Change: a Mix of Interacting Stressors

Lecturers: Prof. Ulf Riebesell, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“This lecture encouraged me to think about how ocean change is having a knock on effect on food webs and ecosystems. I did not realise how multiple stressors, including hypoxia, acidification and rising ocean temperatures can have such varying effects on ocean creatures.”

“For me this lecture really just echoes and reinforces the ones before it – this is the start of the Anthropocene, a time where human kind is having an unprecedented effect on the world around it, the marine ecosystem included.”

Resources:

Overview on changes in ocean chemistry and the response of marine ecosystems in the World Ocean
Review Chapter 2 and Chapter 5
Impacts of climate change on the oceans in the 5th Assessment Report (AR5) from the Intergovernmental Panel on Climate Change (IPCC)
'Mix and Match: how climate selects phytoplankton', the connection between temperature and phytoplankton cell size from the fossil record
Satellite observations show link between chlorophyll and surface ocean temperature and stratification
Article summary and Original research article
20 Facts you need to know about Ocean Acidification
‘Ocean Acidification – Summary for Policymakers’
‘Ocean Acidification: An Ecosystem Facing Dissolution’
‘Ocean Acidification: The other CO2 Problem. Eight Experiments for Students and Teachers’ English version and German version
Hot, Sour, Breathless: Ocean under Stress: How is the biggest ecosystem on Earth faring?
BIOACID, a large German research project on the biological effects of ocean acidification on marine species and marine ecosystems: from bacteria to phytoplankton, to shellfish, macroalgae and fish

Links added by course participants:

Marine Debris as a Global Environmental Problem
Lecture 3.5: Climate Engineering: No Easy Fix

Lecturers: Prof. Ulf Riebesell, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“I enjoyed learning about the different geo-engineering methods which could possibly be used to reduce the negative impact of global warming on the ocean. However, whether it’s reduction of the sun’s rays or various methods of CO2 removal, it is clear there is no quick fix that will not result in drastic side effects.”

“I really like the analogy of a quick fix for the ocean system being like taking a painkiller – something to mask the pain but not deal with the underlying problem. I think the most important thing to stress here is that we do not understand the potential consequences that any of the proposed ‘geo-engineering’ suggestions for dealing with ocean related climate change will cause.”

Resources:

‘Assessing the potential of calcium-based artificial ocean alkalinization to mitigate rising atmospheric CO2 and ocean acidification’
Geo-engineering in the latest Intergovernmental Panel on Climate Change (IPCC) Assessment Report
http://www.frontiersin.org/files/Articles/18273/fmicb-03-00043-HTML/image_m/fmicb-03-00043-g001.jpg

Links added by course participants:

Dumping a Bunch of Iron in the Ocean won’t Fix Our Climate
Ocean Science—The Rise of Rhizaria
Intended Nationally Determined Contributions
ECO2—Sub-seabed CO2 Storage: Impact on Marine Ecosystems
19-year-old Invents Feasible Solution to Cleanup Ocean Garbage Patches
How scientists plan to clean up plastic waste threatening marine life
Cleaning up plastic litter in remote, open ocean areas: Guidance for prospective inventors of plastic-capture systems
Module 4: Ocean Ecosystem

The clarity of seawater can be dazzling, so how can this seemingly empty ecosystem spawn large fish populations which we collect for food?

What do the ocean’s natural biological buffering systems do to dampen the impact of human activities on marine ecosystems?

In this module, find out the answers to these questions and more as we explore the rich diversity of life in the sea and the valuable services the ocean provides to humans.
Lecture 4.1: Marine Food Chains

Lecturers: Prof. Thorsten Reusch, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“Sustainable harvest of many fish populations is actually much lower than what we would think. This highlights the issue of using terrestrial thinking to understand or manage the unique oceanic ecosystem.”

“[...] when I’ll eat a tuna steak I’ll think about the ton of plankton to produce this piece!”

“To eat a makarel is as if you eat a wolf that has only fed on foxes... not to talk about the wolf-eater when you eat a tuna!”

Resources:

Fishwatch website for information on seafood sustainability
Track top predators in the ocean
Video on Antarctic food webs

Links added by course participants:

A short video explaining what Ecological Economics is
Polluted dust can impact ocean life thousands of miles away, study says
Lecture 4.2: Evolution and Marine Biodiversity

Lecturers: Prof. Thorsten Reusch, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“It’s amazing to think of the many millions of years of evolution that have [led] to the life in the oceans today, and the massive changes that humankind is making through the big 5 dangers to diversity.”

“[…] the 200,000 species that are currently known represent just 1/5 of the overall marine life th[at] we may expect to be present in the ocean.”

“[…] all the diversity we see on land, it’s just a small fraction of what’s in the ocean.”

Resources:

UNESCO fact sheet on marine biodiversity
’Sustaining life on Earth’: an introduction to the Convention on Biological Diversity
‘Census of Marine Life’ mapping and visualisation website and Video
Instructions on how to explore the diversity of life in the ocean using the Census of Marine Life layer in Google Earth
Global Ocean Biodiversity Initiative
Ocean Biogeographic Information System (OBIS) database
‘Comparative Marine Ecosystem Structure and Function: Descriptors and Characteristics’
The Millennium Ecosystem Assessment Report on ‘Ecosystems and Human Well-being: Biodiversity Synthesis’
Explore the issues facing the Ocean

Links added by course participants:

Biodiversity maps
Hot-vent fauna
Evolution: Life on Earth is one big extended family
Future Ocean Atlas
Lecture 4.3: Resilience and Adaptation in the Ocean

Lecturers: Prof. Thorsten Reusch, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“The ocean is a delicate eco-system and the balance can be so easily tipped, be it with over fishing, pollution, or global warming. Ecosystems with more biodiversity are able to recover more quickly from unusual events.”

“If an equilibrium is upset, a new equilibrium may be entered from which it may be difficult to return. Diversity increases the likelihood that the system as a whole can adapt.”

Resources
Lohbeck et al. (2012), ‘Adaptive evolution in a key phytoplankton species to ocean acidification’, Na

Resources:
UNESCO fact sheet on marine biodiversity
‘Sustaining life on Earth’: an introduction to the Convention on Biological Diversity
‘Census of Marine Life’ mapping and visualisation website and Video
Instructions on how to explore the diversity of life in the ocean using the Census of Marine Life layer in Google Earth
Global Ocean Biodiversity Initiative
Ocean Biogeographic Information System (OBIS) database
‘Comparative Marine Ecosystem Structure and Function: Descriptors and Characteristics’
The Millennium Ecosystem Assessment Report on ‘Ecosystems and Human Well-being: Biodiversity Synthesis’

Links added by course participants:
Biodiversity maps
Hot-vent fauna
Evolution: Life on Earth is one big extended family
Future Ocean Atlas
Lecture 4.4: Alien Species Migrations and Range Shifts

Lecturers: Prof. Thorsten Reusch, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click [here](#) to watch the video of this lecture.

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**How MOOC participants summarised this lecture:**

“Invasive species is a much bigger problem than I previously thought. Whole food webs can be changed by their presence, causing loss of biodiversity. [...] Species reconfiguration of an ecosystem can be caused by range shifts due to climate change, by accidental introduction of non-native species through transport or by aquaculture escapees.”

“For me, this lecture emphasizes the importance of the consequences arising from any man-made decision. At first sight, the ship-owners and managers probably didn’t even realize the great damage they could cause with actions that might not even be intentional.”

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**Resources:**

- Marine invasive alien species: a threat to global biodiversity
- UNEP brochure on ‘Invasive alien species – a growing threat in Regional Seas’
- UNEP guide ‘Taking Steps toward Marine and Coastal Ecosystem-Based Management: An introductory guide’
- Spread of the Pacific Oyster in the Wadden Sea. Causes and consequences of a successful invasion
- Climate Change and Distribution Shifts in Marine Fishes

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**Links added by course participants:**

- Climate change effects on fishes and fisheries: towards a cause-and-effect understanding
Lecture 4.5: Marine Ecosystem Change and Services

Lecturers: Prof. Thorsten Reusch, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“Everything is connected, so if we continue overexploiting services & goods from the ocean, based on lack of regulations to fix limits, we would be compromising its resilience and ours.”

“The lesson here is that eco-services in the oceans are hugely important to our whole existence, and create enormous economic value absolutely free.”

Resources:

“Valuing Ecosystem Services” figure produce by UNEP
Estimate the monetary value of key marine ecosystem services using the WWF website
Impacts of climate change on the ocean: ‘6.4 Human Activities in Marine Ecosystems: Adaptation Benefits and Threats’ on p. 451, and ‘6.6 Chapter Conclusions and Key Uncertainties’
Ocean Health Index

Links added by course participants:

Blog on art exhibition called Vertigo Sea
How we wrecked the Ocean
Impacts of Biodiversity Loss on Ocean Ecosystem Services
Module 5: The Deep Sea

So far we have just skimmed the ocean surface, but in this module we take a real dive into the depths and darkness of the ocean.

What is life like in the deep? What are the invisible threats from the seafloor? What kinds of natural marine resources exist in the deep ocean and should we use them?

Lecture 5.1 Seafloor Dynamics and Plate
Lecture 5.2 Threats from the Sea Bed
Lecture 5.3 Submarine Landslides and Tsunamis
Lecture 5.4 Seafloor Resources: Energy and Minerals
Lecture 5.1: Seafloor Dynamics and Plate Tectonics

Lecturers: Prof. Colin Devey, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“It is fantastic to think of the planet moving beneath our feet, continents drifting at the speed of fingernails growing, hot spots giving rise to chains of habitable islands.”

“It was fascinating to learn that, in close vicinity to these so-called “black smokers”, there is so large amount of deep-sea organisms which manage to cope with extreme conditions such as high temperature, high pressure, poor oxygen level, absence of sunlight.”

“In this lecture I heard for the first time of hydrothermal circulation system and was amazed by the fact that the amount on life on the black smokers is about the same as the amount of vegetation biomass in the Amazon rain forest.”

Links added by course participants:

Endeavour Hydrothermal Vents
Extreme weather events of 535–536
The Power of volcanoes
Lecture 5.2: Threats from the Sea Bed

Lecturers: Prof. Colin Devey, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“For me the interesting point of this lecture was that actually very major tsunamis can happen from relatively minor earthquakes as the important factor here is the quantity of ocean floor displaced/moved and not the strength of the earthquake. Also interesting is that a pressure point can either result in an earthquake or can naturally release its tension in a benign way.”

“Never thought of landslides as a cause of tsunamis.”

Resources:

Explanation of how the Pacific tsunami warning system works
Website from the US Geological Survey on earthquake preparedness and mitigation, providing ex-amples on emergency preparedness, response actions, survival programs
Video from NOAA on Tsunami basics and preparedness
Wang, K., and Rogers, R. C. (2014): Earthquake preparedness should not fluctuate on a daily or weekly basis

Links added by course participants:

Lyttelton Tides for 18/09/2015
Tsunami Facts and Information
Tsunamis toss Japanese buoys and hard hats into B.C. forest
Lecture 5.3: Submarine Landslides and Tsunamis

Lecturers: Prof. Colin Devey and Dr. Morelia Urlaub, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“[T]wo facts seem interesting: the uncertainty of predicting landslides behaviour and the role of gas hydrates in the sedimentation - the earth is an organism and the sediment[s] are alive and mobile [...]”

“That very destructive and massive slides occur on 1-2° steep slopes is an impressive thing! [D]idn’t expect it to happen on such a small angle already!”

Resources:

Blog from landslide expert Professor Dave Petley
Project and Twitter

Links added by course participants:

Temporal Constraints on Hydrate- Controlled Methane Seepage off Svalbard
Earthquake Data Dashboard
Lecture 5.4: Seafloor Resources: Energy and Minerals

Lecturers: Prof. Mark Hannington, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“Is sea floor mining a solution for the raw material needs of the future?” That is a very good question.”

Resources:

‘Marine Resources – Opportunities and Risks’
A collection of physical, biological, environmental and technical reviews on deep sea minerals as well as a publications on deep sea mining

Links added by course participants:

Nationalpark erhalten—Goldmine stoppen
Lecture 5.5: Life in the Deep-Sea

Lecturers: Prof. Ute Hentschel-Humeida, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“It is incredible to which conditions living beings can adapt. Even in deep sea under high pressure, in the cold and without light a huge diversity of animals can be found. And there are not only microbes and very tiny creatures. Also huge octopusses can be found. There are a lot of luminescent animals and some animals live in symbiosis with microbes that are able to chemically build sugar out of minerals provided from black smokers. It’s amazing.”

“Life in the deep sea is actually very diverse contrary to what we might expect, given its hostile (to us) environment...dark, cold, extraordinary pressure, lack of food.”

Resources:

What kind of creatures have been discovered in the deep ocean?
Deep-Sea Fishing in the World Ocean Review, read about ecosystems in the deep Sea
Symbiotic diversity in marine animals: the art of harnessing chemosynthesis.

Links added by course participants:

Deep Ocean Creatures
Detoxification mechanisms in shrimp: comparative approach between hydrothermal vent fields and estuarine environments.
School-Bus-Size Giant Squid May Be Lurking Deep in the Sea
Black Scabbardfish
Animals in a bacterial world, a new imperative for the life sciences
Atlantic Action Plan
Lecture 5.6: Ocean Exploration and Sustainable Use of Marine Resources

Lecturers: Prof. Colin Devey, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“After listening to this lecture I realized how difficult and costly it is to explore the deep sea resources. In spite of many technology advances, there is still a vast amount of sea floor that is not mapped, and we know nothing about the geology and biology of those immense areas of the deep sea.”

“It is amazing to be introduced to the technology required to map the sea bed in a very high resolution. We still have so much to learn about the ocean!”

Resources:

Scientists are producing a model of a hydrothermal vent field which the public (i.e. you!) can explore
InterRidge Vents Database
Managing Impacts of Deep-seA resource exploitation (MIDAS)
The ‘Blue Mining’ consortium
Ocean Networks’ project in Canadian waters
The Ocean Explorer website from the National Ocean and Atmospheric Administration (NOAA)
Deep-Sea Challenger exploration

Links added by course participants:

Explore the issues facing the oceans
Sonic Sea—The Film
Berkley Canyon, Neptune Observatory Ocean Networks Canada
In Modules 2-5, the focus was on the science of our ocean system. But we don’t manage the ocean, we manage humans. For an introduction to Module 6: Human-Ocean Interaction, see this short presentation.
Lecture 6.1: Values and Attitudes to the Ocean

Lecturers: Prof. Jörn Schmidt, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“I was surprised by some of the answers of Europeans. It is not only the question of living by the sea or inland. It is sadly, a very careless attitude, to know so little about the value of the ocean. Attitudes, do matter for management.”

“It’s management of humans, not management of the resource—how true!”

Resources:


Links added by course participants:

One World, One Ocean---Adventures of Ed the Bear
Amazing fish paradise called Argulus
Explore the issues facing the Oceans
Lecture 6.2: The Ocean Through History

Lecturers: Prof. Jörn Schmidt, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click [here](#) to watch the video of this lecture.

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**How MOOC participants summarised this lecture:**

"Coming from a coastal fishing area myself, I've always been aware how fundamental the sea has been to culture and even religion, however it was particularly interesting to explore back into the ancient religions to see how long this has been the case."

"With the incredible gifts of the sea along with the dangers, there is no wonder that so many myths and stories have developed around the ocean."

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**Resources:**

Learn more about modern human societies that existed even before the Last Glacial Maximum (LGM) in this book chapter: Rethinking the human revolution. O'Connor, S., Ono, R., Clarkson, C. (2011). Pelagic fishing at 42,000 years before the present and the maritime skills of modern humans.

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**Links added by course participants:**

- [Coding Early Naturalists' Accounts into Long-Term Fish Community Changes in the Adriatic Sea (1800–2000)](#)
- [Fisheries communities at the heart of local development](#)
- [Eating fish in Italy: what you need to know](#)
- [National Aquaculture Sector Overview Italy](#)
- [NAZCA Culture—Vessel Depicting Fish](#)
- [World wide Vessel Tracking by VesselFinder](#)
- [Solutions for Recovering and Sustaining the Bounty of the Ocean: Combining Fishery Reforms, Rights-Based Fisheries Management, and Marine Reserves](#)
Lecture 6.3: Cultural Perspectives

Lecturers: Prof. Jörn Schmidt, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“I was impressed by Kuna culture, first because they understood the necessity to protect the marine environment when they moved to the coast, and moreover how they change when they see the behavior of young generation not believing anymore on bilias. When young generation have started fishing in the protected areas they incorporate the idea of environmental conservation to protect marine resources from over-use.”

“What I found else very interesting of the lecture, was that such survival strategies do not need much time to develop, like the example of the Kuna has shown forced to move to the coast of Panama. They only need 100 years to learn fishing methods and gather the necessary knowledge to protect their environment.”

“Culture often has much more influence on behavior than laws or regulations.”

Resources:


Links added by course participants:

Malaysia establishes a 1-million-hectare marine park
MSEAS 2016 Simon Levin: Dealing with public goods and common-pool resources
Marine socio-ecological science seen though the eyes of cartoonist Bas Kohler
Lecture 6.4: From Attitude to Action

Lecturers: Prof. Jörn Schmidt, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“[...] the example of the three Mexican villages [...] show[ed] how good management was the difference between an economically stable and sustainable resource, and one that will ultimately go bust.”

“A local transition must contain, education, exchange of experience between generations, acceptance, participation and fair distribution.”

“The lessons are, for the success of sustainable development, we must engage people at the local level, not least the children who will take over after our generation [...]”

Resources:

In this lecture, Jörg talks about three examples of how attitudes of people have been taken into account and transformed into action. Here are the websites/links for each example so you can find out more or get involved.

1) Fish Fight
2) Sitka Conservation Society
3) Collectivo Memórias do Mar

Lecture 6.5: Regional Voices

Lecturers: Prof. Dr. Awni Behnam, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“I found this set of interviews to be very interesting, to hear the contrasting views of people from China, Turkey, Algeria and Kazakhstan. All of them seemed to express strongly anthropo-centric views, but all expressed the importance of education on the topic of sustainability.”

“Encouraging that it seems there are more agreements than differences among people.”

“We need to think about the future of the oceans, our future, together across national boundaries, but with an eye to local perspectives.”

Resources:

National Geographic article on Kiribati and the life of the islanders in the face of sea level rise
Video from UNESCO about sand drawings in Vanuatu as a means of communication and story-telling between the many distinct dialects of neighbouring communities
Module 7: Ocean Governance

This module explores aspects of ocean governance. The ocean is a huge space with a huge amount of resources to be extracted and exploited. But who owns the ocean and the valuable fisheries assets contained in the ocean and minerals found on the sea floor? What legal frameworks exist to deal with the dumping of waste on the open ocean or protection of marine biodiversity?
Compare the territory of many countries around the globe on this interactive website. What proportion of territory is land and what proportion is exclusive economic zone (i.e. the sea) in your country?

More videos on specific topics within the law of the sea in the United Nations Audiovisual Library of International Law

The International Tribunal for the Law of the Sea

Get to know the regional fisheries bodies in your part of the world

Learn more about how the Convention on International Trade in Endangered Species of Wild Flora and Fauna tries to protect sharks and rays (among much more species of marine life)

The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection was established almost fifty years ago and was instrumental in many developments concerning ocean governance.

Who is going to pay for the damage caused by accidents with oil tankers? The international community set up funds in this regard

The environment around the poles requires more than usual protection for both ships and the environment. The International Maritime issued a Polar Code to cover many of these aspects, listing the Polar code as a ‘Hot Topic’

The Arctic states are united in the Arctic Council.
Lecture 7.1: Governing Global Commons

Lecturers: Prof. Nele Matz-Lück, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“As I understand it, the international laws governing the high seas are complicated, almost impossible to police and not enforced well enough. [This] means that even when states breach these laws there’s almost no action taken against them, as perhaps there’s no evidence, it’s too difficult to prove or other states simply don’t know what is happening out there.”

“It becomes clear that the law that will govern and protect the oceans is both complex but also quite weak, both [in] current regulations but also in compliance.”

“This lecture highlighted for me the difficulty of managing and protecting the high seas, because there is no international authority responsible for monitoring and enforcement.”

Resources:

Please see module resources on Page 49

Links added by course participants:

International Court of Justice
Questions & Answers – Whales and whaling in the Faroe Islands
Marine Mammal Conservation and the Law of the Sea
Lecture 7.2: The Law of the Sea’s Conceptual Framework

Lecturers: Dr. Awni Behnam, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University
Click here to watch the video of this lecture.

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How MOOC participants summarised this lecture:

“[...] the constitution of UNCLOS has a high importance when it comes to governing the use of the ocean. It is unbelievable that it took about 10 years of negotiation to pass a common law of the sea.”

“It was interesting for me to learn that UNCLOS developed within a context of a larger global effort to find new approaches to collective decision making, which could avert armed conflict.”

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Resources:

Please see module resources on Page 49

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Links added by course participants:

The Great Barrier Reef: a catastrophe laid bare
Lecture 7.3: Governing Ocean Pollution

Lecturers: Prof. Nele Matz-Lück, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University
Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“Most ocean pollution is land based and that is up to each country to regulate as they see fit. It seems like there are no real functioning mechanisms to prevent or punish polluters.”

“[…] the law is static while the nature is a trend dy[yn]amic.”

Resources:

Please see module resources on Page 49

Links added by course participants:
Midway, a Message from the Gyre
Lecture 7.4: Governing Marine Biodiversity

Lecturers: Prof. Nele Matz-Lück, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University
Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“On land we can reasonably expect the boundaries to still be in the same place tomorrow. The ocean is a dynamic habitat, and an MPA’s water may change daily. If species are protected within the MPA, presumably they lose protection as soon as they shift elsewhere.”

“I’m shocked to hear that if a country creates an MPA at the high seas, all other countries still are allowed to waste this area or catch fishes there. It is really frustrating that countries can decide if they want to follow or not follow rules which are good for everyone of us.”

Resources:
Please see module resources on Page 49

Links added by course participants:
How do we weigh the moral value of human lives against animal ones?
Lecture 7.5: Governing Ocean Shipping

Lecturers: Prof. Nele Matz-Lück, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University
Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“[S]hips can have two types of fuel, the green “safe” fuel and the “bad” fuel. They just switch from bad to good if they need to like in the EU where control areas are and when there out of the control area in the ocean they just switch back.”

 “[A]we struck and bewildered by the fact that vessels change their environmental footprint depending on the regulations at the location of current operation.”

Resources:

Please see module resources on Page 49

Links added by course participants:

Introduction to IMO-The International Maritime Organization
When will oil, natural gas, and coal peak?
InforMEA
Module 8: Ocean Wealth and Sustainability

In this module, we consider the value of the ocean and the resources it provides: What makes exploitation of a resource economically viable? What are key economic principles behind fisheries management?

Lecture 8.1 | Economic Models for Sustainability

Lecture 8.2 | Fisheries Economics and Management

Lecture 8.3 | Aquaculture and Mariculture

Lecture 8.4 | Non-renewable Ocean Resources: From Exploration to Exploitation?
General Links for Module 8

Heard about the Natural Capital Project?

Open access software and models are available through their website which you can use find out what effect ecosystem change may have on the value of this natural capital and more.

What is experimental ecosystem accounting? Learn more about the project „System of Environmental-Economic Accounting (SEEA) Experimental Ecosystem Accounting (EEA)“

Basis of fisheries management in the World Ocean Review 1

“The Future of Fish” in the 2nd World Ocean Review

Experience for yourself how fisheries management can work in an online game simulating over-fishing
Lecture 8.1: Economic Models for Sustainability

Lecturers: Prof. Martin Quaas, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University
Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“Interesting lecture, [which] deals with the attempt to give human and natural goods and services an economic abstract value, so that their value can be calculated on long-term as a form of justice between humans of present and future generations.”

“With strong sustainability, there seems to be more of an emphasis on sustainability for all components of the system, making sure that none are compromised below minimal thresholds. On the other hand, weak sustainability suggests that some components could perish or be sacrificed so long as the overall composite value of the system is maintained.”

“The concepts of strong vs. weak sustainability remind me of the concepts of biodiversity preservation vs. ecosystem function preservation.”

Resources:

Please see module resources on Page 55

Links added by course participants:

Global Wealth Inequality - What you never knew you never knew
Poverty Line of the Milenium Goals
Lecture 8.2: Fisheries Economics and Management

Lecturers: Prof. Martin Quaas, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University
Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“In this lecture we learned some basic economic theory that explained why profitable fisheries tend to be overfished. One important reason is that fishing costs do not exceed profits until well past the point of maximum sustainable yield.”

“The FAO has been keeping track of reported global fish takes since 1950. They have quadrupled since then, and are most likely grossly under-reported. For the last 25 years they have stagnated because of overfishing.”

“This lecture emphasized that subsidies for fisheries are detrimental, from both the point of view of economics and biology. Subsidies to fisheries have contributed to increased fishing effort, and lead to over-exploitation of fish stocks.”

Resources:

Please see module resources on Page 55

Links added by course participants:

Composition and diversity patterns of megafauna discards in the deep-water shrimp trawl fishery off Brazil
Sustainable Fishing—WWF
Lecture 8.3: Aquaculture and Mariculture

Lecturers: Prof. Thorsten Reusch, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University
Click [here](#) to watch the video of this lecture.

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How MOOC participants summarised this lecture:

“[,] cultivation of marine fish is both uneconomical and risks destroying the environment in the area. We use more proteins to breed fish than what we get out of the cultivation.”

“Aquaculture uses a considerable fraction of the wild fish catch to convert into fish feed, making us to lose protein that could be available for human nutrition in poorer countries. Also, in reality marine aquaculture does not save marine fish stocks, instead we have severely over-fished fish stocks to make aquaculture profitable.”

“Sustainable solutions are to farm down the food chain using bivalves and filter feeders and algae. In development but not yet economically viable are self contained multi trophic aquaculture systems.”

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Resources:

Please see module resources on Page 55

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Links added by course participants:

FARMED FISH FLOAT (ALMOST) FREE IN CLEVER GEODESIC DOMES
The Case for Fish Farming
Lecture 8.4: Non-renewable Ocean Resources: From Exploration to Exploitation?

Lecturers: Prof. Martin Quaas and Prof. Mark Hannington, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University
Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“There is mining of the shallow sea bed primarily for sand. There is no deep sea bed mining now, but there is lots of exploration. Contracts for this have existed for 13 or so years. We are not running out of land resources for metals, the drivers for deep sea bed exploration are complex, some strategic, some political, some potentially economic.”

“[M]ineral resources of the deep-sea [can] take a huge number of years to build up (i.e. manga -nese nodules take 10,000 to reach the size of a potato).”

“ISA [International Seabed Authority] regulates and administers any exploration of resources. To mine the deep-sea will require technological developments that are not available at the moment. It is not yet established whether mining in the deep-sea will be profitable.

"I learned that deep sea mining won't NEED to happen for quite some time. The earth still has enough minerals above the ocean for making metals. However there are studies happening right now to see if this resource could be mined economically. But at what cost to the environment?"

Resources:

Please see module resources on Page 55

Links added by course participants:
Lecture 8.5: Valuing Ocean Assets

Lecturers: Prof. Martin QuaaS, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University
Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“[…] there are different methods for valuing natural capital, which can produce very different valuations. And even the same method can produce different valuations at different times or contexts.”

“My great take home from this lecture is the fact that there are different economic values - exchange value determined by the market price, use value which can be a measure of the consumer/producer surplus, and the accounting which is obtained by multiplying the total quantity of that good on the market with the market price. Thus, just having a dollar value that often mean little without saying how it’s obtained and what exact type of value is meant.”

Resources:

Please see module resources on Page 55

Links added by course participants:

The Economics of Ecosystems & Biodiversity
IPBES Pollination Report Media Coverage
Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
Coastlines are some of the most heavily populated regions around the globe and coastal communities have intimate connections to the ocean. However, these communities are also some of the most vulnerable to the threats of sea-level rise and human activity. So what are the main hazards from sea-level rise? What does the future of our coasts and river deltas look like?

Lecture 9.1: Coastal Systems: Physical and Socioeconomic Dimensions

Lecture 9.2: Coastal Ecosystems

Lecture 9.3: Coastal Hazards

Lecture 9.4: Deltas Under Pressure
General Links for Module 9

Browse the coastal picture database

‘Battle for the Coast’ in Chapter 3 of the World Ocean Review

Sea-level rise and its impact on coastal zones

Sinking deltas due to human activities

Shifting perspectives on coastal impacts and adaptation

Coasts: the high-risk areas of the world
Lecture 9.1: Coastal Systems: Physical and Socioeconomic Dimensions

Lecturer: Prof. Nassos Vafeidis

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“...we should look at the definition of the coast in a broader sense than just a place where the land and the ocean meet. Although it represents only 2% of the global land area, it contains more than 10% of the global population.”

“[this lecture] divides the coast in a natural and human subsystem and invites [...] study of the interactions of those two subsystems in order to understand the future impacts of climate and socioeconomic changes on the coast.”

Resources

Please see module resources on Page 63

Links added by course participants:

ZeroCarbonMaking itHappen

The Monachus Guardian – Headlines – News – Articles
Lecture 9.2: Coastal Ecosystems

Lecturer: Prof. Thorsten Reusch

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“Marsh plants and mangroves catch sediments and thus protect the coasts. Reefs act as wavebreakers. These services have to be accounted when calculating the real expenses and revenues of the system. “

“For me the most important insight is that living coral reefs and biota along the foreshore will continue to grow as sea level rises. A concrete wall will not. Long live Bio-engineering :) “

Resources

Please see module resources on Page 63

Links added by course participants:

Cost-Benefit Analysis of Options to protect Old Bar from Coastal Erosions
Lecture 9.3: Coastal Hazards

Lecturer: Prof. Nassos Vafeidis

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“[Average] sea levels [rise] around 3 millimeters per year presently, as compared to 1.7 millimeters during the last hundred years. Adaptation is therefore becoming an essential aspect of managing risk, and includes aspects of protection, accommodation and retreats.”

“Coastal hazards compromises storms, erosions, sea level rise, floods, loss of lowlands and wetlands, salt water intrusions into aquifers etc. The risk for coastal communities of such hazards is calculated by the product of the probability of a certain event and the consequences for the population, which depends not only on the hazards itself, however as well as on the socioeconomic development of the coastal communities.”

Resources

Please see module resources on Page 66

Links added by course participants:

Country overview and assessment
Coastal Impacts Due to Sea-Level Rise
Climate change adaptation in the Schleswig-Holstein sector of the Wadden Sea: an integrated state governmental strategy
Lecture 9.4: Deltas Under Pressure

Lecturer: Prof. Karl Stattegger

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“The delta area is used a lot by humans, for example for shrimp farms. This is a short term danger to this area while the sea level rise due to the climate change would be a long term consequence. Coastal erosion and salt water intrusion are problems one will have to deal within the future in the delta plain.”

“This lesson provides a clear picture of how we humans are destroying the area we ourselves live in, in this case the deltas. The human impact[s] from the extraction of groundwater, buildings, dams, etc. were so [...] much bigger than I thought.”

Resources

Please see module resources on Page 63

Links added by course participants:
Lecture 9.5: Future Coasts

Lecturers: Prof. Nassos Vafeidis and Prof. Horst Sterr

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“I like the concept of letting nature do the work. It’s probably smarter as well as self-adapting. And managing drainage basins makes more sense than just managing a coastal area.”

“One very important point in the chapter was to include all local stakeholders ~ all too often poor people are assumed to be stupid and thus excluded from a process decided by ‘clever politicians’. Because all human activities have some impact, those people at risk should be involved in the discussions and decision making.”

Resources

Please see module resources on Page 63

Links added by course participants:

Ecological and economic cost-benefit analysis of offshore wind energy
Module 10: Ocean Solutions

In this module you will learn about marine phytoplankton, what drives life at the bottom of the food web, and how these incredible microscopic photosynthetic machines in the ocean shape environmental conditions on a global scale.

Lecture 10.1: From Ocean Science to Ocean Sustainable Development

Lecture 10.2: Ecosystem and Nutrient Management

Lecture 10.3: Climate Engineering

Lecture 10.4: Sub-Seafloor CO₂ Storage

Lecture 10.5: Sustainable Energy from the Ocean

Lecture 10.6: Marine Spatial Planning
Lecture 10.1: From Ocean Science to Ocean Sustainable Development

Lecturer: Prof. Martin Visbeck

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“An important lesson where Martin explains that we all have to pull together to spread the knowledge of how to create sustainable oceans and the planet. We must have a partnership that works on all levels locally, regionally and at the UN level.”

“It’s unbelievable that so many people and so many jobs are connected to the ocean and still it is not possible to convince people that the ocean has to be protected.”

Resources

Links added by course participants:

Project Noah (a tool to explore and document wildlife and a platform to harness the power of citizen scientists everywhere).
Lecture 10.2: Ecosystem and Nutrient Management

Lecturer: Prof. Thorsten Reusch

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“*This lecture really explained the fact that point sources, unlike I thought, often only contribute to 50% or less of the total additional nutrient influx into ocean (as in the case of the Baltic Sea), with the bigger chunk coming from diffuse sources, mainly from agriculture practices and from traffic.*”

“I never thought that the NOx from the exhaust fumes affects the ocean in terms of nutrients. So implementing catalysts to reduce NOx to N2 should work easily. This example of the Baltic Sea shows how important it is, that we all work together to reach a sustainable and healthy ocean which would be good for all of us.”

Resources

Prof. Reusch touches upon the Baltic Sea Action Plan and how this governance structure is used to manage nutrients in the Baltic Sea across the 9 contracting countries and the European Union.

Links added by course participants:

EU Strategy for the Baltic Sea Region
Cultured Aquatic Species Information Programme
Lecture 10.3: Climate Engineering

Lecturer: Prof. Andreas Oschlies

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

‘I was simply fascinated by all methods proposed for climate engineering - space mirrors, cloud seeding, reflecting with aerosols, artificial trees, iron enrichment, making the ocean more alkaline, etc. [... however] none of the methods, even large scale maximum deployment that we assume, can make a large dent into the rapid rise of atmospheric CO2.’

“Scientific fiction program? Making clouds brighter and having space mirrors? Mr. Spock would love it.”

“Although the climate engineering options are well thought out ~ & I liked that the side effects were given ~ it seems that very little is going to have sufficient power to halt our GHG [GreenHouse Gas] emissions. The wake up was that even doing climate engineering merely delayed the impacts, and quickened them [if stopped in 2070].”

Resources

In 2009 the Royal Society produced a substantial report titled ‘Geoengineering the Climate: Science, governance, and uncertainty’.
The entire report
An update to the report was published in 2012
For more information on iron fertilization, see “Iron fertilization for geoengineering: A review of effectiveness, environmental impacts and emerging governance”

Links added by course participants:
Lecture 10.4: Sub-Seafloor CO₂ Storage

Lecturer: Prof. Klaus Wallmann

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“The technology for sub-sea-floor CO₂ storage is obviously well understood and has been in practical use for two decades or more.”

“The lecture clearly illustrates the possibility of leakage through seismic chimneys or abandoned wells, and concludes the effects would be minimal if compared to releasing the CO₂ into the atmosphere.”

“It is clear that the risk [of leakage from sub-seafloor CO₂ storage sites] is high […], but that the effects are limited and local.”

Resources

Which geological characteristics distinguish successful locations for sub-seabed CO₂ storage?

Links added by course participants:

ECO2-Subseabed CO₂ storage: Impact on Marine Ecosystems
Lecture 10.5: Sustainable Energy from the Ocean

Lecturer: Prof. Martin Visbeck

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“So many different ways to produce renewable and clean energy from the ocean - differences in tidal elevation, ocean currents, waves and swell, the difference between the warm and the cold temperature of the ocean and also the salinity gradients between fresh water on land and ocean water.”

“[…] except for current and thermal energy, the energy can be produced in the part of the oceans of national jurisdiction, so that ecosystem assessments about their impact on marine biodiversity can be implemented.”

Resources

Researcher on the power of waves.
Relevant chapter in the World Ocean Review:
More information on sustainable energy from the ocean

Links added by course participants:
Lecture 10.6: Marine Spatial Planning

Lecturer: Prof. Nele Matz-Lück

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“My take home message is that unlike other marine management initiatives, marine spatial planning takes a holistic approach, not limited to a single entity, say fishing, for example. Again, it is a process and so not static. Consequently, even the final plan itself must be adapted to ongoing changes.”

“Knowledge and participation are the most important parts when we try to find solutions that can be accepted by all. If we inform people it is easier for them to accept decisions. Much better is to let everybody take part on the decision finding process.”

Resources
Chapter in the World Ocean Review on Hope for the ocean.

Links added by course participants:
Lecture 10.7: Negotiating for Distributive Justice

Lecturer: Dr. Awni Behnam

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“Although UNCLOS was adopted in 1982, it took 12 years to effectively be implemented and further 2 years to provide legal basis for the International Tribunal of the Law of the Sea to make sure that the Law of the Sea was been respected.”

“Julius Nyerere position made a change in the course of the UN policies. A group of 77 countries came together forming the G77 and later EU came on board. UN started having informal meetings and co-sharing of meetings with representatives from developed and less developed countries.”

Resources

What happened during the first session of the negotiations for a new implementation agreement.

Links added by course participants:
Lecture 10.8: Coastal Solutions: Ecosystem-Based Management

Lecturer: Dr. Mark Schürch

Click [here](#) to watch the video of this lecture.

How MOOC participants summarised this lecture:

“Building the dikes higher and higher with rising sea levels, will end up causing problems with water drainage. An alternative solution is ecosystem based management (allowing nature to do the work for us, making it cost effective and self-adapting). Current practices include the removal, the breaching or the realignment of present coastal defense structures in order to create coastal wetlands in the newly flooded areas.”

“Dikes, sand beach nourishment and coastal wetlands are three options to protect a coast. The building of dikes has the disadvantage that they are cost intensive. Sand beach nourishment have the disadvantages that they are ecological questionable, cost intensive and labor intensive, because the sand has to be replaced [regularly]. Coastal wetlands have the advantage that they are cost-effective and self-adapting, i.e. that they increase in elevation with sea level rise and attenuate [storm] surge and [large] waves.”

Resources

Initial spreading of a mega feeder nourishment: Observations of the Sand Engine pilot project
The Protective Role of Coastal Marshes: A Systematic Review and Meta-analysis
Unravelling interactions between salt marsh evolution and sedimentary processes in the Wadden Sea (southeastern North Sea)

Links added by course participants:
Lecture 10.9: Sustainable Management of Fisheries

Lecturer: Prof. Martin Quaas

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“[…] the economic idea for a solution to the over-fishing problem is to establish a price for the fish in the ocean by establishing individual quotas that give the permission to catch a certain quantity of fish from the ocean or even issue to individual fishermen the permanent right to catch a certain fraction of the total allowable catch in each year - the so-called ITQ, or individual transferable quota system (catch share system).”

“[…] it is a very good idea to make fisherman shareholders of the ocean. Then it is in their own interest to reduce overfishing.”

Resources
The World Ocean Review 1 also provides suggested reforms to support more sustainable fisheries.

Links added by course participants:
Lecture 10.10: Ocean Literacy

Lecturer: Dr. Avan Antia

Click here to watch the video of this lecture.

How MOOC participants summarised this lecture:

“Emotive power and knowledge of the marine environment provides a powerful tool for action.”

“As you say it is important to r[a]ise awareness in our children, because what you learn when you are a child, will not be easily forgotten, and will shape your character. So science education to children is very important, simple textbooks and books that they can understand, and small projects, where they can be involved and participate.”

Resources

Links added by course participants:

Project Noah
Hangouts

Q&A session with Prof. Martin Visbeck on the Ocean MOOC

Q&A session with Prof. Martin Visbeck on ocean circulation and physics

Q&A session with Dr. Erik van Sebille and Veronica van der Schyff on plastic in the ocean

Q&A session with Prof. Ulf Riebesell and Dr. Lennart Bach on ocean change biology

Q&A session with Prof. Thorsten Reusch on marine ecosystem services, biodiversity

Q&A session with Prof. Nele Matz-Lück on ocean governance

Q&A session with Prof. Martin Quaas on ocean wealth and sustainability

Q&A session with Martin Knoche and Dr. Alexandra Price on ocean energy

Q&A session with Prof. Martin Visbeck on ocean solutions and the transfer of scientific knowledge