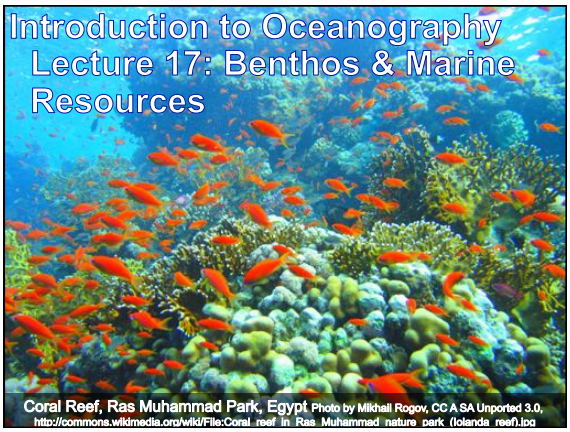
Introduction to Oceanography
Lecture 17: Benthos & Marine Resources



Coral Reef, Ras Muhammad Park, Egypt Photo by Mikhail Rogov, CC A SA Unported 3.0, http://commons.wikimedia.org/wiki/File:Coral_reef_in_Ras_Muhammad_nature_park_(Iolanda_reef).jpg

Jagalchi Fish Market in Busan, South Korea. Photo by L.W. Yang, cc-by-2.0, https://commons.wikimedia.org/wiki/File:Korea-Busan-

Announcements

Lab Finals this Week
in 3820 Geology

Lecture Final
Thur., June 15,
8:00a-11:00a Moore 100

Extra Credit Video
Thursday, 4:00-5:00p,
Moore 100

Lecture Final Review Session
Friday, 3:00-4:30pm,
Moore 100

Course Evaluations until Friday!

Extra Credits due Friday!

Beyond EPSS 15…

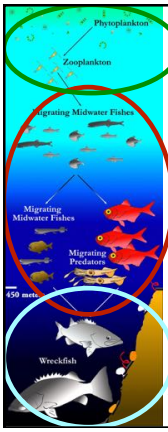
Earth, Planetary, & Space Sciences (*Earth & Environmental Science B.A., Earth & Environmental Science minor*)
Advisor: Lauri Holbrook
3683a Geology (310) 825-3917
holbrook@ess.ucla.edu

Atmospheric & Oceanic Sciences (*AOS minor*)
Student Affairs Officer: Kimberly Perez
7127 Math Sciences (310) 825-1954
kperez@atmos.ucla.edu

Ecology and Evolutionary Biology (*Marine Biology BS*)
Advisors: Jessica Angus, Jessica Gonzalez & Kellie Marie Lavin
Hershey Hall 101 (310) 825-1680
eebundergrad@lifesci.ucla.edu

Institute of the Environment & Sustainability
(Environmental Sci. B.S.: *Earth and environmental science minor*
Non-majors: *Environmental Systems and Society Minor*)
Student Affairs Officer: Royce Dieckmann
La Kretz 300, (310) 206-9193
rdieckmann@ioe.ucla.edu

* Red type indicates minors & majors where EPSS 15 counts towards a program requirement.



Plankton

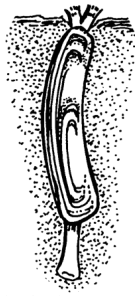
Nekton

Benthos

Food web of Charleston Bump, NOAA/Weaver and Sedberry, 2001, Public Domain(?), http://oceanexplorer.noaa.gov/explorations/03bump/background/lifeonbump/media/foodweb.html

Habitats

Infauna: Live **in** sediment and rocks



Drawing from City of Barnstable, Mass. http://www.town.barnstable.ma.us/Images/ShellfishPics/razrclam.gif

Razor clams burrow into the sand or mud

Photo by David Ansley, Wikimedia Commons, Creative Commons A 2.5, http://en.wikipedia.org/wiki/File:Jackknife_clam.JPG

Habitats

Epifauna: Live **on** the surface

Sea anemone

Photo by Esculapio, Wikimedia Commons, Creative Commons A S-A 3.0, http://en.wikipedia.org/wiki/File:Actinia_equina_0009.JPG

Purple Sea Urchin

Photo by Tomasz Sienicki, Wikimedia Commons, Creative Commons A S-A 3.0, http://commons.wikimedia.org/wiki/File:Woda-5_ubt.jpeg

Habitats

Nektobenthos: Swimmers living on the bottom

Examples: Octopus, shrimp, halibut

Horn shark, La Jolla, CA, photo by Magnus Kjaergaard, Wikimedia Commons, Creative Commons A S-A 3.0, http://en.wikipedia.org/wiki/File:Horn_shark.JPG

Nutrition

Autotrophs are the base of the food web:

Photosynthesizers (usually)

Algae live in the photic zone (not found below the photic zone)

– Kelp beds: autotrophic benthic algae

High productivity or low productivity? Neritic or Oceanic?

Photo by Stef Maruch, Flickr, Creative Commons A S-A 2.0, http://www.flickr.com/photos/79257269@N00/1228333269/

Nutrition

Heterotrophs: Eat others to live

Eating Styles of Benthic Heterotrophs

–Suspension Feeders

–Filter Feeders

–Deposit Feeders

–Active Herbivores

– Active Carnivores

Crinoid, a suspension feeder, photo by Richard Ling, Wikimedia Commons, Creative Commons A S-A 3.0, http://upload.wikimedia.org/wikipedia/commons/f/f6/Ptilometra_australis_Passion_Flower_feather_star.jpg

Nutrition

Suspension/Filter Feeders- use appendages or siphon to strain particulate food matter from the water

Sponge, photo by Mila Zinkova, Creative Commons A S-A 3.0, http://en.wikipedia.org/wiki/File:Sponge_in_papua_new_guinea.jpg

Coral, photo by Nick Hobgood, Creative Commons A S-A 3.0, http://commons.wikimedia.org/wiki/File:Euphyllia_glabrescens_%28Hard_coral%29_with_polyps_extended.jpg

Nutrition

Deposit Feeders- process mud, removing food particles

Sand dollars- plow through sediment, food particles stick to their mucous coating and are moved towards the mouth by cilia/podia

*Sand dollars, **Dendraster excentricus**, photo by Tewy, Wikimedia Commons, Creative Commons A S-A 3.0, http://commons.wikimedia.org/wiki/File:Sand_dollar_%28Dendraster_excentricus%29_01.jpg*

Nutrition

Active Herbivores (grazers)- seek out primary producers as food

Sea urchin

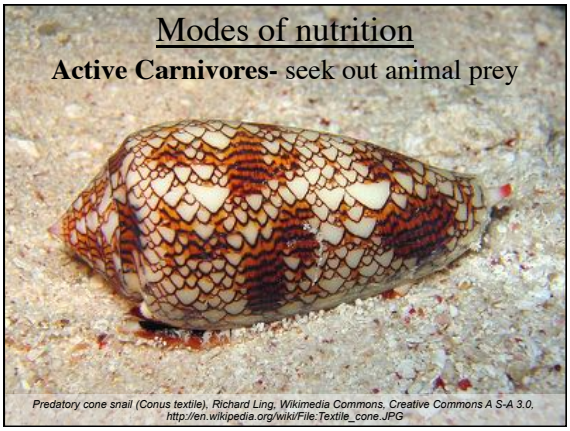
Photo by Kenny Kandola, Wikimedia Commons Creative Commons A S-A 3.0, http://commons.wikimedia.org/wiki/File:Seeigel-Saugfuesse%28Galicien2005%29.jpg

Snails

Photo by Takahashi, Wikimedia Commons, Public Domain, http://commons.wikimedia.org/wiki/File:Euhadra_quaesita_grazing_scar1.jpg

Modes of nutrition

Active Carnivores- seek out animal prey



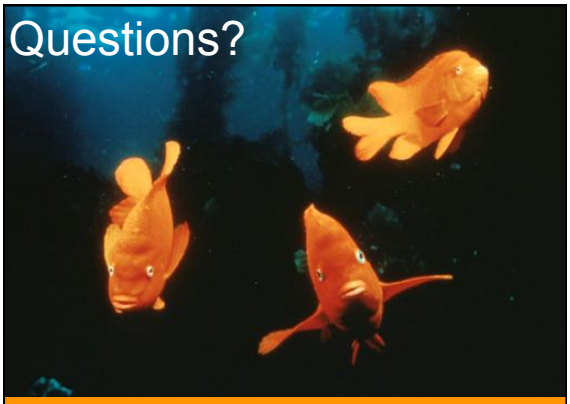
Predatory cone snail (Conus textile), Richard Ling, Wikimedia Commons, Creative Commons A S-A 3.0, http://en.wikipedia.org/wiki/File:Textile_cone.JPG

Nutrition

Active Carnivores- seek out animal prey

Cone snail stalking fish in an aquarium, video by theconesnail, Youtube, http://www.youtube.com/watch?v=AG_As8H8G3Y

Questions?



Garibaldis, NOAA image, Public Domain, http://upload.wikimedia.org/wikipedia/commons/7/73/Garibaldi_300.jpg

Kelp Forest Ecosystems

Photo by Fastily, Wikimedia Commons, Creative Commons A S-A 3.0, http://en.wikipedia.org/wiki/File:Kelpforest2500ppx.JPG

Kelp Forest Ecosystem Dynamics

Kelp forests are home to many species of fish and are crucial for the protection of juvenile fish.

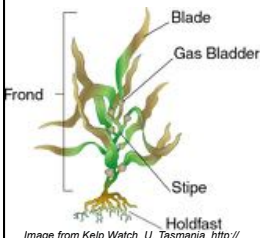
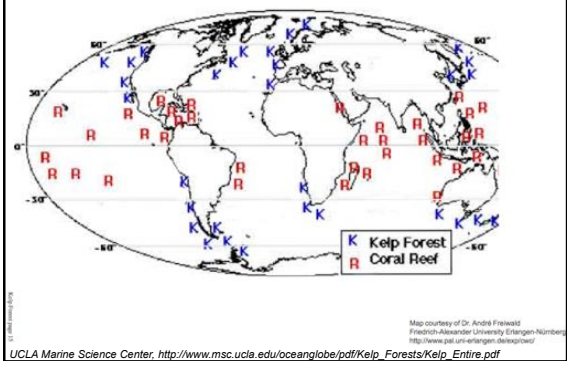


Image from Kelp Watch, U. Tasmania, http://www.geol.utas.edu.au/kelpwatch//facts_b.html#top

Unlike trees, kelp has no vascular system.

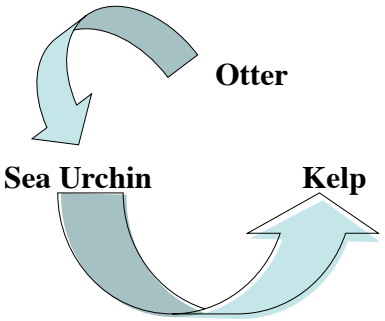
Holdfasts provide anchorage & are NOT a plant root system

Kelp (& coral reef) geography



UCLA Marine Science Center, http://www.msc.ucla.edu/oceanglobe/pdf/Kelp_Forests/Kelp_Entire.pdf

Kelp Forest Ecosystem Dynamics



Kelp Forest Ecosystem Dynamics

Otters eat sea urchins

Photo by Matt Knoth, Flickr, Creative C ommons A 2.0, http://www.flickr.com/photos/18158503@N00/1066160826/

Kelp Forest Ecosystem Dynamics

- Otters indirectly controls health of kelp forests
  - Competition with fishing industry
  - Incredibly thick, warm furs
- Remove otters & then sea urchins grow out of control, destroying the kelp beds
- CA waters: otters and kelp forests are trying to make come-backs

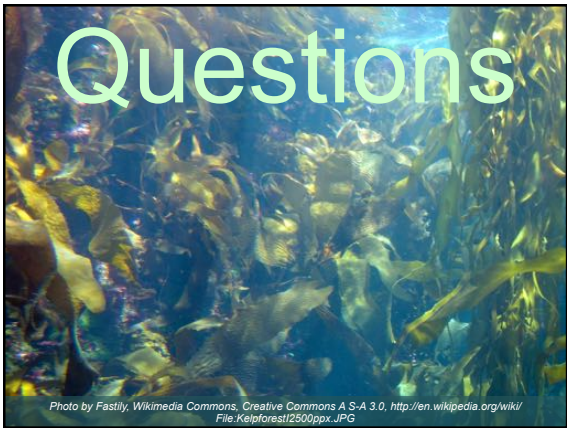


Photo by Fastily, Wikimedia Commons, Creative Commons A S-A 3.0, http://en.wikipedia.org/wiki/File:Kelpforest!2500ppx.JPG

Coral Reef Communities

Diversity and productivity "hotspots" in warm, tropical surface waters.

Most warm tropical surface waters are nutrient poor

– Equator -- upwelling, lots of nutrients, but cold!

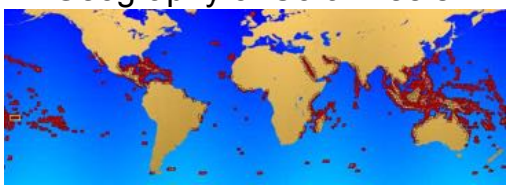
---> Not much phytoplankton

---> Generally clear water, perfect for resorts!

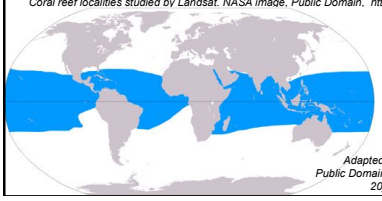
(Hawaii, Cabo, Bahamas, Tahiti, Australia)

Coral reef, East Timor, photo by Nick Hobgood, Wikimedia Commons, Creative Commons A S-A 3.0, http://commons.wikimedia.org/wiki/File:Timor_Coral_Reef.jpg

Geography of Coral Reefs



Coral reef localities studied by Landsat. NASA image, Public Domain. http://oceancolor.gsfc.nasa.gov/cgi/



≥ 20ºC surface temperatures in the ocean

Adapted from CIA World Factbook, Public Domain, http://en.wikipedia.org/wiki/File:20_Grad_Isotherme.png

Coral Polyps

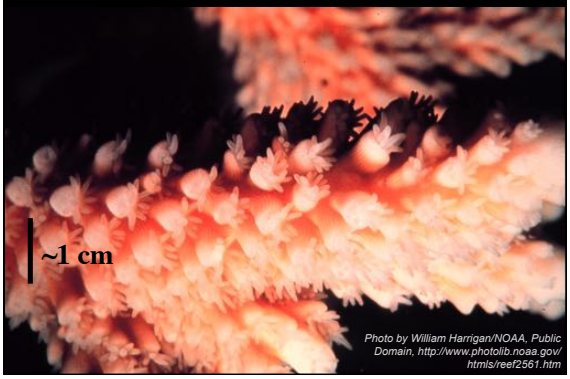
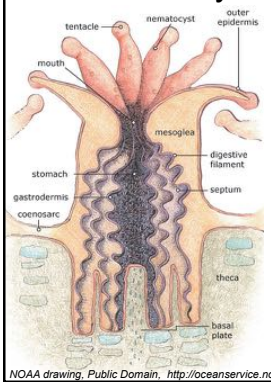


Photo by William Harrigan/NOAA, Public Domain, http://www.photolib.noaa.gov/htmls/reef2561.htm

Anatomy of a coral polyp



Corals are cnidarians, relatives of jellyfish. These organisms have special stinging cells they use to trap food.

Cnidarians are consumers - but live symbiotically with primary producers!

(Reef building, or hermatypic coral)

NOAA drawing, Public Domain, http://oceanservice.noaa.gov/education/kits/corals/media/coral01a_462.jpg

Coral Reefs: ZOOXANTHELLAE

Modified dinoflagellates, called **zooxanthellae**, are imbedded in the outer tissues of coral polyps

Symbiotic relationship: mutually interdependent

Zooxanthellae get stable environs, protection from predation, supply of nutrients (corals waste products)

Coral gets: local oxygen supply, food source & waste removal system.

Very highly productive, under favorable conditions.

Susceptible to disturbance

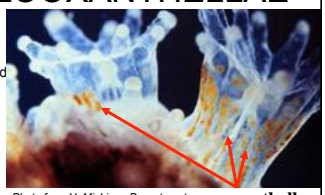


Photo from U. Michigan Department of Molecular, Cellular and Developmental Biology, http://www.biology.lsa.umich.edu/courses/bio255/zooxanthellae.jpg

zooxanthellae

Primary Productivity in Coral Reefs is dominantly benthic, internalized within the corals themselves!

Corals may not thrive in conditions where other primary producers (esp. algae) grow quickly, they get crowded out.

Coral Reefs

Built up from $CaCO_3$ skeletal remains of corals

Forms limestone structures

Reefs grow from the top ---on top of the massive limestone deposits of the reef itself

Living skin that will later die and become part of the reef structure

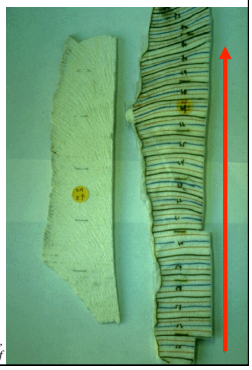
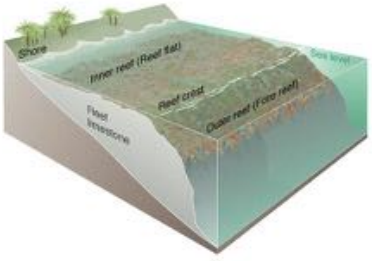


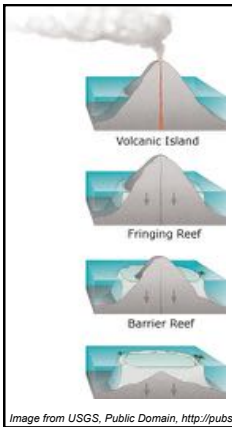
Photo by Darin Toohey, U. Colorado, http://paos.colorado.edu/~toohey/climate11.gif

Coral Reefs



USGS image, Public Domain, http://pubs.usgs.gov/fs/2002/fs025-02/

Geological evolution of Coral Reefs



Young: volcanic island

Bedrock sinks isostatically as rocks cool and reef mass increases

Old: ring-shaped atoll

Image from USGS, Public Domain, http://pubs.usgs.gov/fs/2002/fs025-02/images/atollfinal.jpg

Geology of Coral Reefs

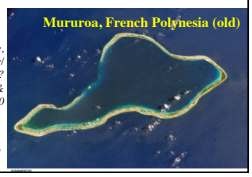
Fringing reef around new island
isostatic subsidence of island

Barrier Reef
Island subsides and erodes into seamount

NASA image, http://eol.jsc.nasa.gov/sseop/EFS/photoinfo.pl?PHOTO=STS51J-41-32

Atoll

NASA image, http://eol.jsc.nasa.gov/scripts/sseop/photo.pl?mission=ISS004&roll=E&frame=6730



NASA image, http://photojournal.jpl.nasa.gov/catalog/PIA06660

Coral Reefs in Global Decline

- **Recent & Ongoing Reef Loss:**
  1. Increasing global temperatures
  2. Habitat disturbance through tourism, fishing.
  3. Pollution.
  4. Increased exposure to ultraviolet light.

Band advances mm-cm per day

Photo by Andy Bruckner, NOAA, Public Domain, http://oceanservice.noaa.gov/education/kits/corals/coral10_disease.html

Black band disease, discovered in 1972 in Florida

Bacterial Consortium

NOAA image, Public Domain, http://www.noaanews.noaa.gov/stories2008/20081009_coralbleaching.html

Photo by Andy Bruckner, NOAA, Public Domain, http://coris.noaa.gov/about/diseases/#coral%20bleaching

Coral Reef Bleaching

In response to stress, especially high temperature, corals can consume or expel their zooxanthellae.

The remaining coral organism is nearly colorless and transparent.

White carbonate coral skeletons become visible

Loss of primary productivity undercuts coral food supply, over time can lead to colony death.

NOAA coral reef bleaching: https://coralreefwatch.noaa.gov/satellite/index.php

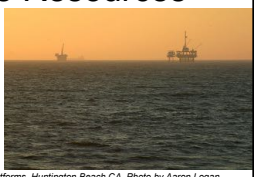
Great Star Coral *Montastraea cavernosa* Photo by: Nick Hobgood, Creative Commons A S-A 3.0 Unported, *http://commons.wikimedia.org/wiki/File:Montastraea_cavernosa_(Great_Star_Coral)_with_polyps_partially_open.jpg*

Mururoa coral lagoon, Georges Martin, Creative Commons A 3.0, http://commons.wikimedia.org/wiki/File:Mururoa_lagon.jpg

Fish market, Essaouira, Morocco. Photo by Donar Reiskoffer, Wikimedia Commons, CC A S-A 3.0, http://commons.wikimedia.org/wiki/File:Essaouira,_Fish_Market.JPG

Types of Marine Resources

- Physical Resources
  - Mineral deposits, petroleum & natural gas (methane), etc
- Biological Resources
  - Animal and plant life collected for our use
- Nonextractive Resources
  - Transportation, recreation, waste disposal



Oil platforms, Huntington Beach CA. Photo by Aaron Logan, CC A 2.0, http://commons.wikimedia.org/wiki/File:Lightmatter_oilrigs.jpg

Jack mackerel net. Photo by C. Ortiz Rojas, NOAA, Public Domain, http://www.photolib.noaa.gov/htmls/fish2172.htm

Cargo ship MV Lehmann Timber. US Navy photo, http://www.navy.mil/view_single.asp?id=61335

Sustainability of Marine Resources

Renewable Resources

Replaceable on a relatively short timescale, if harvested responsibly

i.e., wind, seaweed

Nori seaweed nets, Japan. Made based on [http://w3land.mlit.go.jp/WebGIS/ National Land Image Information (Color Aerial Photographs)], Japan Ministry of Land, Infrastructure, Transport and Tourism

Nonrenewable Resources

Present in the ocean in essentially fixed amounts on a human timescale

i.e., oil deposits

Oceanic Biological Resources

- BIG PICTURE:
  7.40 x 10^9 Humans as of June 4, 2017
  (US Census Bureau projection model)
  - + 82 million more every year
    - i.e., a 1.1% Growth Rate

One new Rose Bowl-full every 10 hours!

Many depend on food and other products of life in the ocean…

Rose Bowl image from UCLA Bands, www.uclaband.com/

Oceanic & Aquatic Biological Resources

- ~20% or more of animal protein for 3.0 billion people
- at least 15% of animal protein for 4.3 billion people
- 65%* of from oceans, 35% from fresh water

Global Commercial Harvest

- 158 Million metric tons in 2012
  - increasing ~3% per year (but wild harvest stagnant!)
- Direct Human Consumption: 86%
- Other uses (e.g., feed for livestock): 14%
  - "Trash" fish: anchovies, herrings, sardines, etc.

*Most statistics are from the 2014 World Fisheries Report of the Food and Agriculture Organization of the United Nations

Global Wild Catch

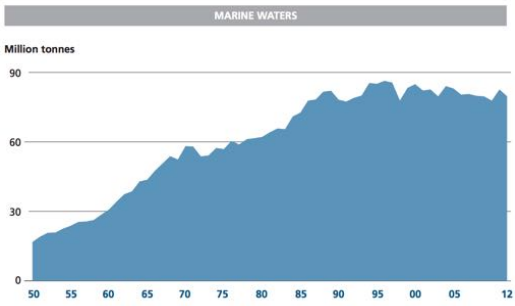


Figure from UN Food and Agriculture Organization World Review of Fisheries and Agriculture 2014,
http://www.fao.org/3/a-i3720e.pdf

Fisheries Management

- Maximum Sustainable Capture
  - Maximum wild harvest of an organism that will not irreparably harm future generations
  - Estimated Value ~100 Million metric tons
    (fresh & salt water combined)

It is likely that we have reached or over-reached the sustainable limit

Fisheries Management

- **Overfishing**
  - When a fish stock has been harvested to the point that there is not enough breeding stock left to replenish the species
  - FAO estimates ~1/4 of global fisheries are presently unsustainable
  - Common Fix: Reduce harvest until species recovers, rough on regional fishing economies.

- Commercial Extinction
  - Depletion of a species to the point that it is no longer profitable to harvest

Overexploitation & collapse of fisheries

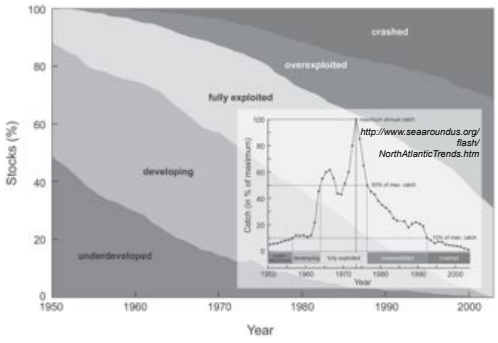


Figure by Rainer Froese, Kiel U./Sea Around Us, http://www.seaaroundus.org/newsletter/Issue37.pdf

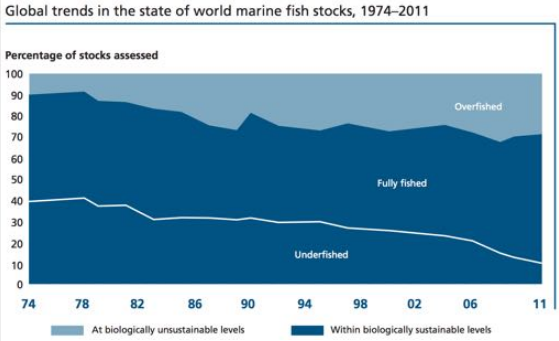


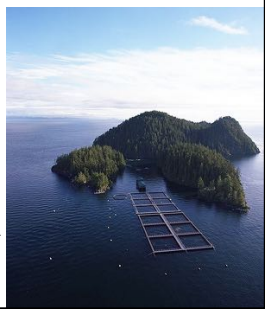
Figure from UN Food and Agriculture Organization World Review of Fisheries and Agriculture 2014, http://www.fao.org/3/a-i3720e.pdf

Solutions

Improved Fisheries Management

Sensible harvesting, characterization of resources

Aquaculture/mariculture (Especially catfish, tilapia, crayfish)



Salmon pens, British Columbia CA
Photo by BC Salmon Farmers Association, reproduction allowed with attribution, http://en.wikipedia.org/wiki/File:Salmon_farming.jpg

Aquaculture…

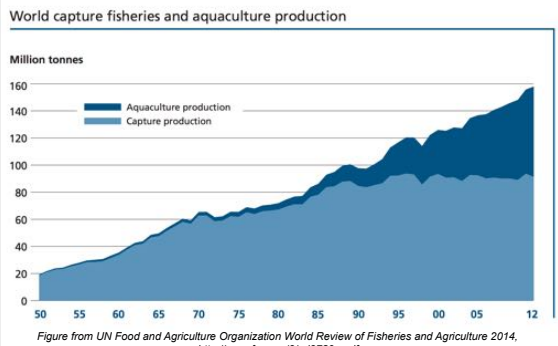
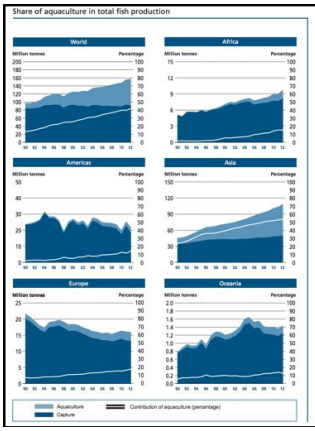


Figure from UN Food and Agriculture Organization World Review of Fisheries and Agriculture 2014, http://www.fao.org/3/a-i3720e.pdf



Aquaculture/ mariculture

Accounts for 40% of world harvest for human consumption as of 2012: our oceans, rivers and lakes are being domesticated!

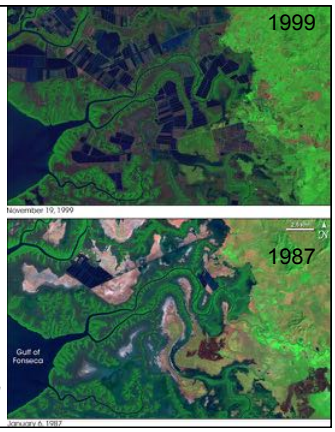
Figure from UN Food and Agriculture Organization World Review of Fisheries and Agriculture 2014, http://www.fao.org/3/a-i3720e.pdf

Mariculture

The growth segment of modern fisheries.

Very important where wild fisheries have already collapsed (e.g., Bangladesh)

Shrimp farming in particular may occur at expense of mangrove swamps & other sensitive areas



Growth of shrimp farming, Honduras, 1987-1999. Image by Jesse Allen, NASA Earth Observatory, Public Domain, http://earthobservatory.nasa.gov/IOTD/view.php?

Salmon

Almost all fish sold as “Atlantic” or “Norwegian” Salmon is farm raised -- and fed synthetic astaxanthin pigment (a chemical cousin of vitamin A found naturally in some zooplankton) to look like wild salmon.

The same pigment may be fed to chickens to make egg yolks orange.

Photos of wild (left) and farmed (right) by Neeta Lind, Flickr, Creative Commons A 2.0, / http://www.flickr.com/photos/neeta_lind/sets/72157601103903581/

Salmon Mariculture

- Mostly Atlantic salmon species, **farmed** in pens in wave-protected coves, but inevitably porous to the environment

Feed includes fish meal/ fish oil, ~ 2.5 kg / 1 kg Salmon

- Salmon farming still requires ocean extraction of feed
- Development of vegetarian feed ongoing

High population density and genetic uniformity can foster disease and parasites

Farmed salmon escape pens..
Spread disease , breed with wild populations?

One solution: inland tank farms