Energy from the
Ocean’s Biological Resources
Solar Power as a Source of
Marine Energy

Direct solar power?

- Photovoltaics (solar cells) - These are not currently under investigation for large-scale marine applications
  (used small scale on sailboats)

Indirect solar power from photosynthesis

- Long timescale (millions of yrs)
  Fossil fuels (oil and gas)
- Short timescale (seasons to yrs)
  Biodiesel (from algae)

What is Oil? ("Petroleum", "Crude Oil")
What is Natural Gas?
Formation of Oil and Natural Gas Deposits
Where Do Oil and Gas Form?
Finding Oil and Gas

- Oil and gas are found in porous rocks, where they occupy the space between rock particles
- Oil and gas are fluids and are less dense than surrounding materials - they migrate upward over time
- Migration halts when the oil or gas encounters impermeable cap rock

Graphic: See Garrison, Fig. 17.3a

Offshore Oil and Gas Extraction

- Drilling pipes are inserted through the cap rock to reach the deposits below
- Primary recovery uses natural pressure to bring ~25% of oil or gas in a reservoir to the surface
- To recover the remaining amount, the reservoir is pressurized artificially (using, e.g., water, steam or CO\textsubscript{2})

Graphic: See Garrison, Fig. 17.3a

Deep Water Drilling

- Drilling for oil/gas is technically more difficult in deeper water (> 900 m)
  - heavy equipment and remotely operated vehicles are needed to deal with higher water pressures
• platforms cannot be stabilized by anchoring directly to the sea floor
• deep water wells can cost 10 x more than shallow water wells
• The fraction of US production from deep water fields is growing – currently 7 of the top 20 oil fields in the US are in deep water and new technologies are being developed for the future

Future of Ocean Energy Extraction?
• Drilling for oil and gas are currently the primary means of extracting energy from the ocean.
• But... growth of marine algae to make synthetic “biodiesel” is an emerging technology to address the increasing demand for fossil fuels.
• This new technology holds potential, but significant research and development is required.

What is Biodiesel?
- Biodiesel extracts the oils available within plants for use as fuel
- Common sources: soybeans, corn
- Making biodiesel from food resources can raise food prices and increase demand for freshwater (irrigation)

Why Algae?
Microalgal Cultivation

What Are the Requirements?

Resource Requirement: Water
Using Waste CO2 from Coal-fired Power Plants

What Encourages Development of This Technology?
NREL’s Aquatic Species Program
Summary

Preview of Next Lecture
Sustainable Seas - Marine Fisheries

Reading:

9.12
14.7-14.9
17.1, 17.17-17.21, 17.25

Graphic: Chub mackerel catch, Peru, T.Dioses, photographer, courtesy of National Marine Fisheries Service, NOAA.

Oil Production on the Outer Continental Shelf
Natural Gas Production on the Outer Continental Shelf
Natural Gas Production on the Outer Continental Shelf