

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 CO₂)**

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

Graphic: Garrison, Fig. 17.4b

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)

Graphic: Soybean field, courtesy of USDA.

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**