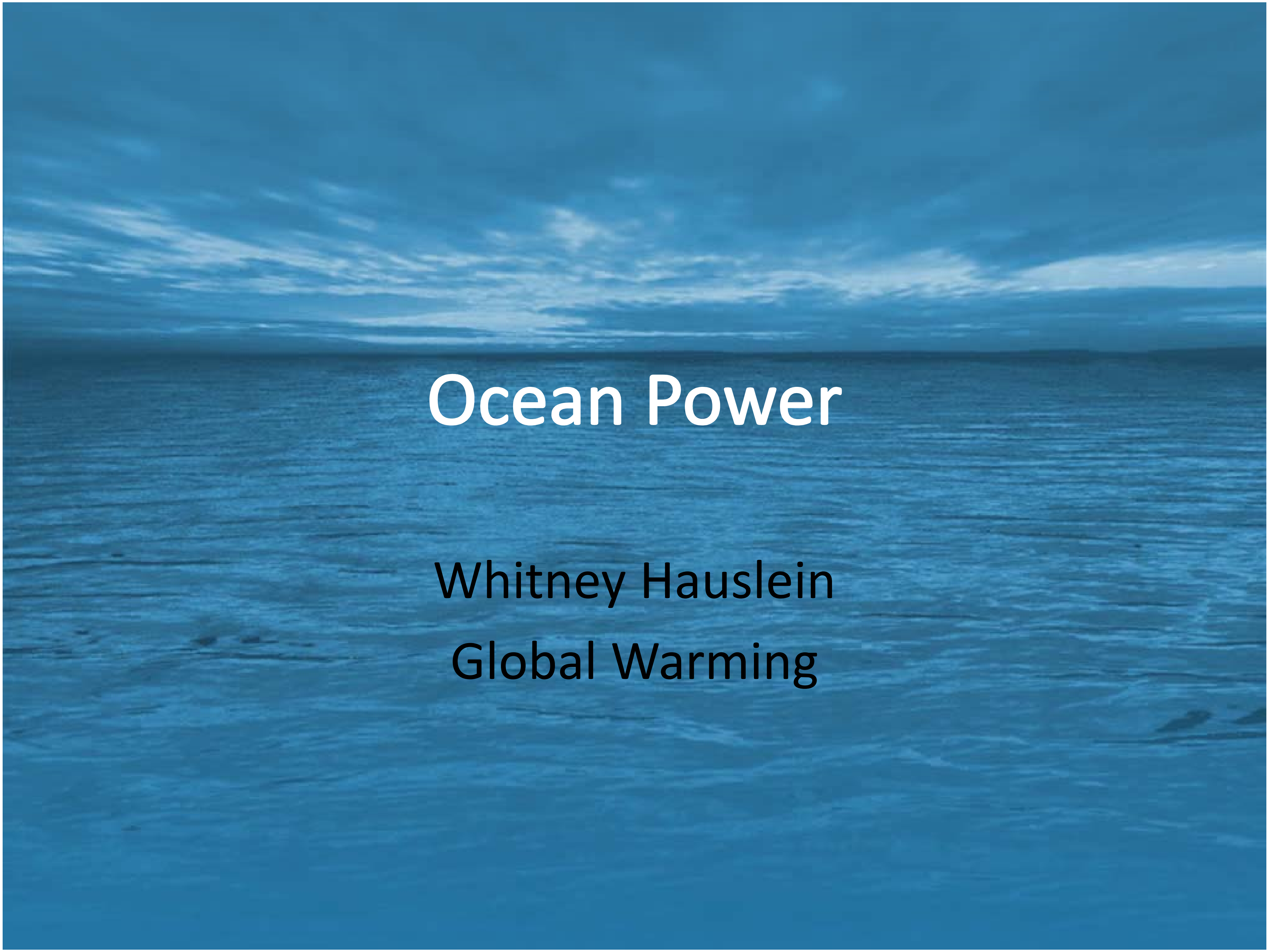

Ocean Power

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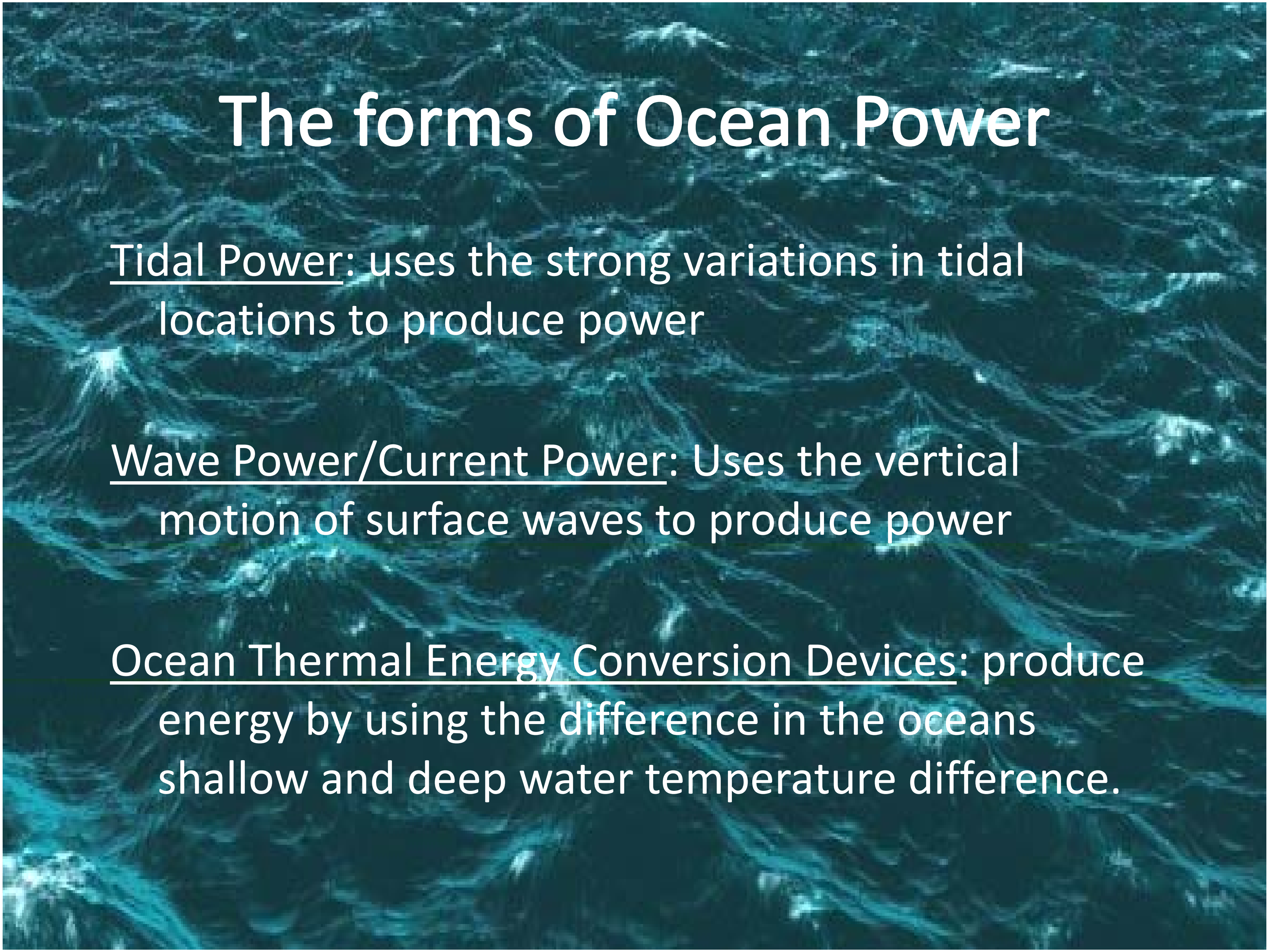
Global Warming

Ocean Power is a new technology…

The Ocean has only recently been used and tested as a new resource to be used as an alternative energy source.

This seems awful late in forthcoming since the ocean covers approximately 71% of the earths surface and is always in movement.

Lets turn that movement into a renewable energy source…



The forms of Ocean Power

Tidal Power: uses the strong variations in tidal locations to produce power

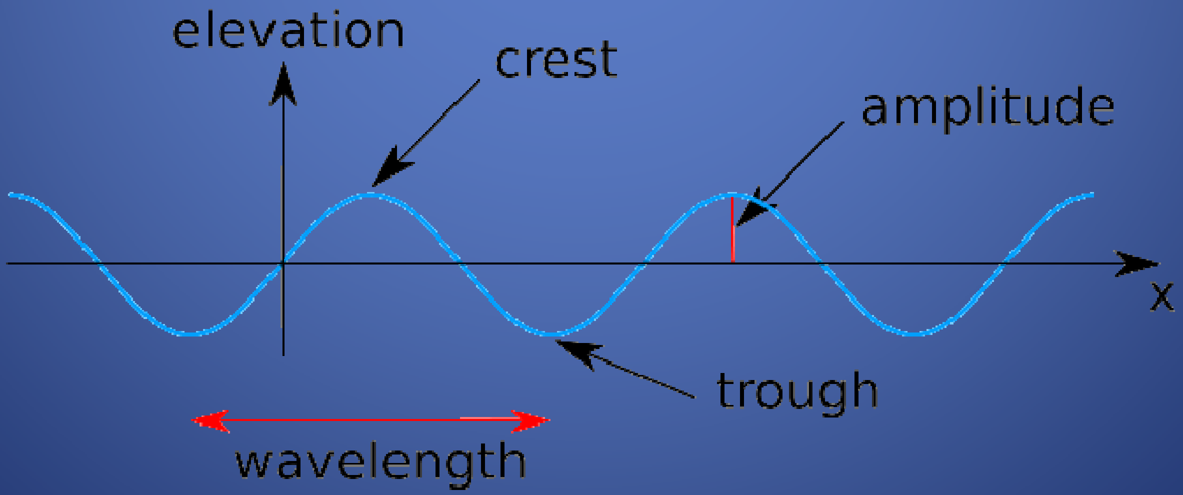
Wave Power/Current Power: Uses the vertical motion of surface waves to produce power

Ocean Thermal Energy Conversion Devices: produce energy by using the difference in the oceans shallow and deep water temperature difference.

Wave Power

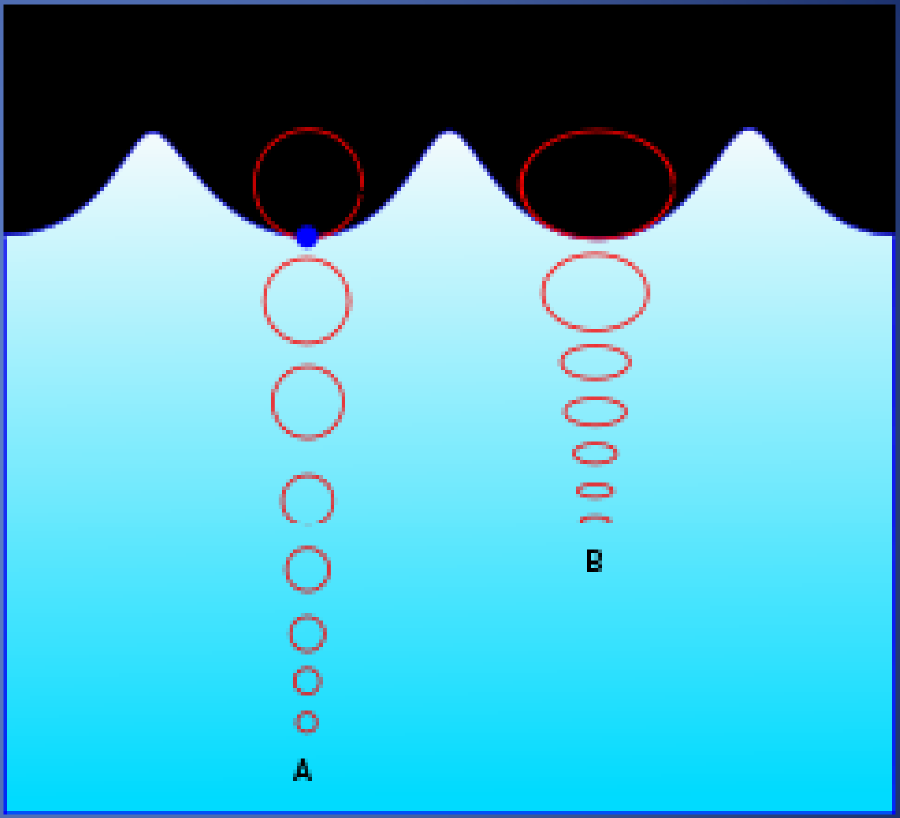
Waves are caused by wind blowing over the surface of the ocean. They travel on the surface in all directions depending on the strength and direction of the wind.

These devices get their energy from the troughs and crests of waves as they pass by and the pressure difference caused by the blowing wind over the water.



Highest energy waves…

- Wind speed
- Duration of time that the wind is blowing
- Fetch: the distance of open water that wind can blow over
- Water depth (deep water = larger than half the wave length)



To sum it up, large waves are the most powerful and contain the most potential energy to be turned into electricity.

Calculate the power provided by a wave

$$P = \frac{\rho g^2}{64\pi} H_{m0}^2 T \approx \left(0.5 \frac{kW}{m^3 s}\right) H_{m0}^2 T$$

- P = the energy flux per unit wave crest length (kW/m)
- H_{m0} = the significant wave height (m)
- T = wave period (s)
- ρ = density (kg/m^3)
- g = acceleration of gravity (m/s^2)

Lets look at an example…

We will use the area were my parents live in Corpus Christi, Texas. On March 20, 2009 at 12:50 pm the wave height was 1 meter and wave period of 6 seconds with a water depth of 88.1 meters.

$$P \approx \left(0.5 \frac{kW}{m^3 s}\right)(1m)^2(6s) = 3 \frac{kW}{m}$$

This means that there is a potential of about 3 kW per meter of coast line along the Corpus Christi shoreline.

Would this work for my parents neighborhood?

There are approximately 150 houses that are in my parents neighborhood and it is growing larger everyday.

From an article about energy consumption written by Al Gore, the average household consumes 10,656 kWh of electricity every year, which is about 888 kWh per month.

Would this work for my parents neighborhood?

Take the amount of power provided by these waves in one meter of shoreline over the 6 second wave period to the amount of power provided by these waves in one meter of shoreline for one month.

$$P \approx \left(3\frac{kW}{m}\right)(1month)\left(\frac{31days}{1month}\right)\left(\frac{24hr}{1day}\right) = 2232\,\frac{kWh}{m}$$

This means that one meter of shoreline would provide energy for 2.5 households per month.

$$\frac{2232\,\frac{kWh}{m}}{888\,\frac{kWh}{house}} = 2.514\,\frac{houses}{m}$$

Would this work for my parents neighborhood?

So how many meters of shoreline would these houses require?

$$\frac{150 houses}{2.5 \frac{houses}{m}} = 60 meters$$

So only 60 meters of shoreline would provide enough power to sustain my parents neighborhood.

What makes a good region for a farm of wave-energy conversion devices?

Western Coast of Scotland

Northern Canada

What makes a good region for a farm of wave-energy conversion devices?

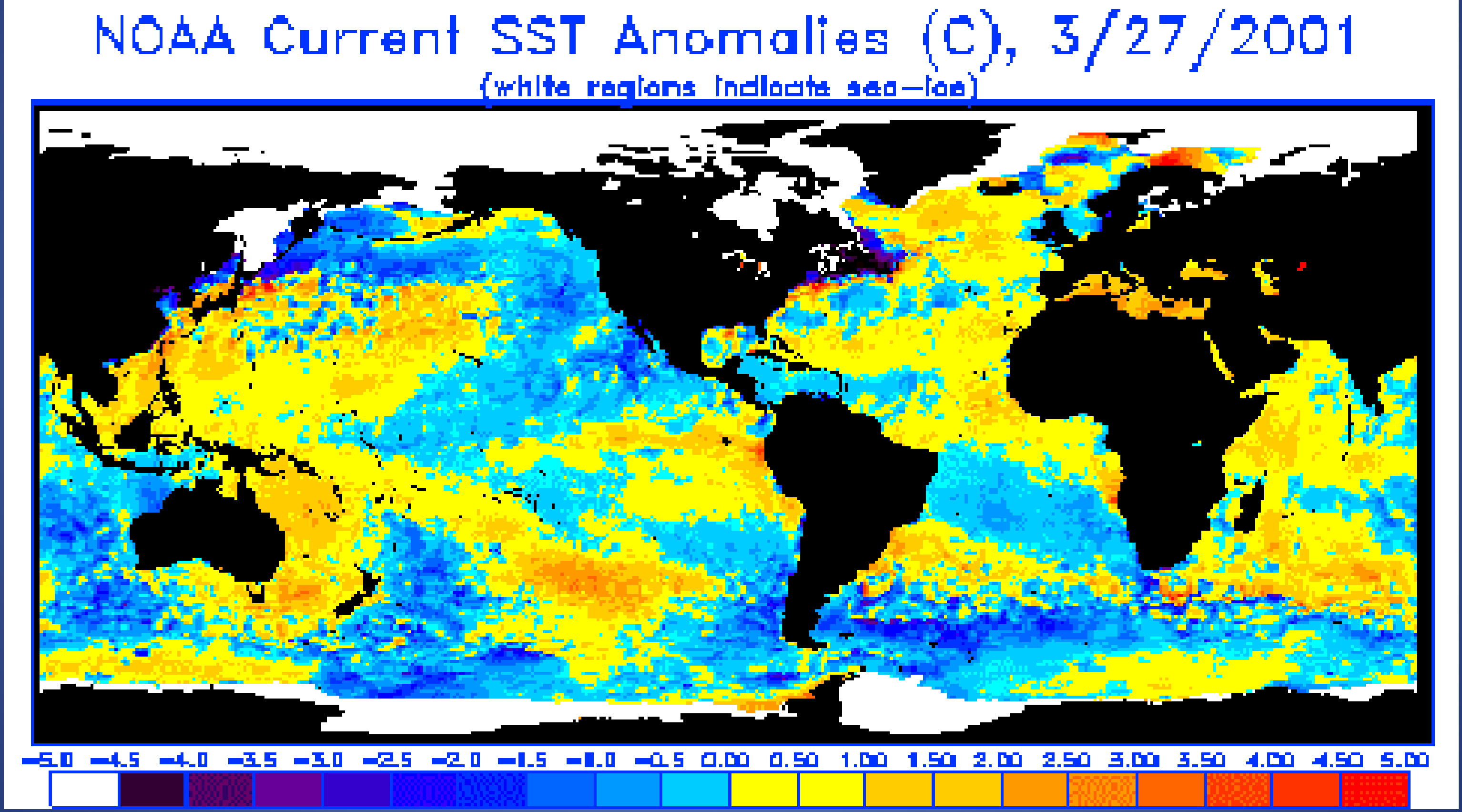
Southern Africa

Australia

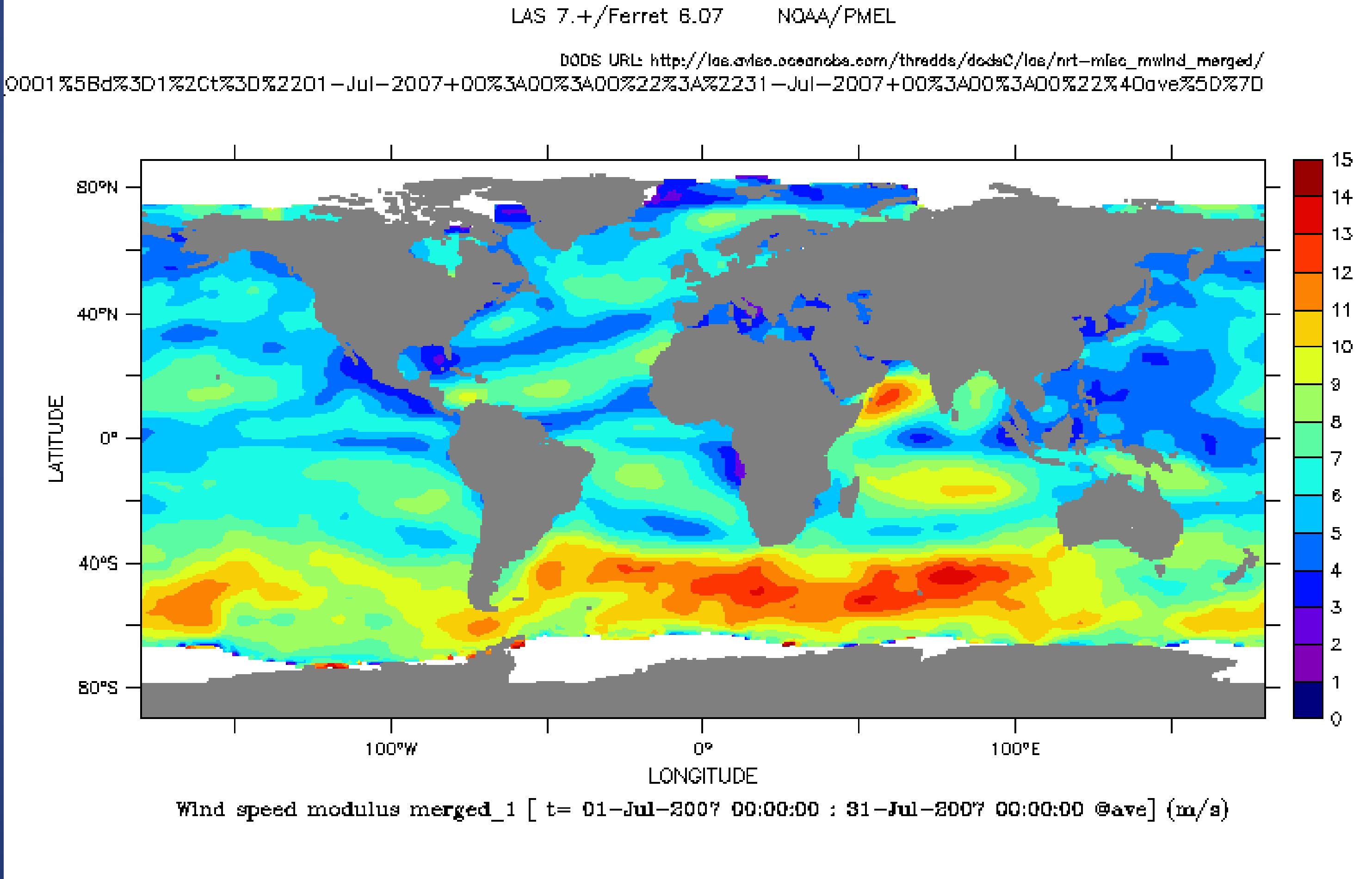
What makes a good region for a farm of wave-energy conversion devices?

Northeastern Coast of United States

Why those regions?



Why those regions?



What devices are out there?

The first invented of this kind is the Archimedes Waterswing that was created by the Scottish Company, AWS Ocean Energy, Ltd.

This device uses the passing waves to move an air-filled upper casing against a lower fixed cylinder

What devices are out there?

The most advanced of the technology available is the Pelamis which was created also by Scottish company, Ocean Power Delivery, Ltd.

This device floats on the surface of the water and converts incoming waves of all directions, not just vertical waves into electricity.

What devices are out there?

Ocean Power Technologies, Inc. in New Jersey is close behind in developing the next wave energy conversion device, the PowerBuoy.

The PowerBuoy has been deployed in several areas like Hawaii, Spain and New Jersey, but has not been able to compete with the output power of other competing devices. The PowerBuoy has only been able to produce 40 kW of electricity with hopes to be scaled up to 250 kW with future projects.

Tidal Power

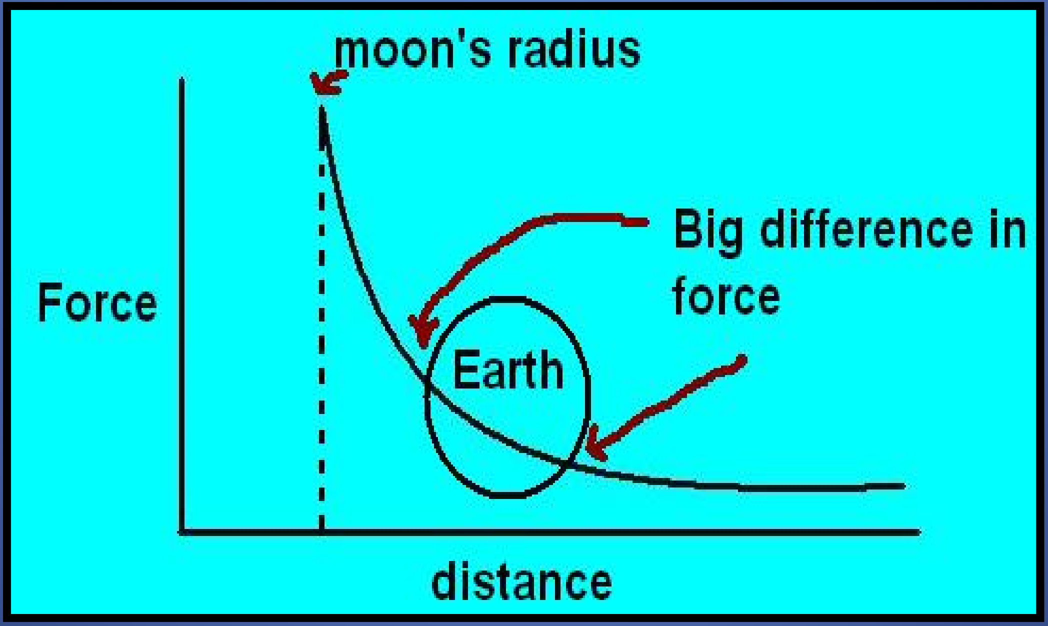
A form of hydropower that converts the energy provided by the tides into electricity.

Tidal Stream Systems:
Work in a similar fashion as wind turbines/windmills. Turbines are placed underwater and convert the tides kinetic energy of the moving water into electricity.

Barrages:
Similar to dams, where a large structure is place across a river opening to the ocean and use the potential energy of the tides to generate electricity.

Benefit of Tidal Power

- Tides and currents are more predictable than wind or sunlight.



Benefit of Tidal Stream Systems

- Clean, renewable energy
- Water is more dense than air, so a turbine can generate more electricity.

Finding the potential power for currents passing through a turbine.

$$P = \frac{Cp}{2} \times \rho \times A \times v^3$$

Cp: turbine coefficient of performance
ρ: density of fluid
A: sweep area of the turbine
v: velocity of flow of fluid

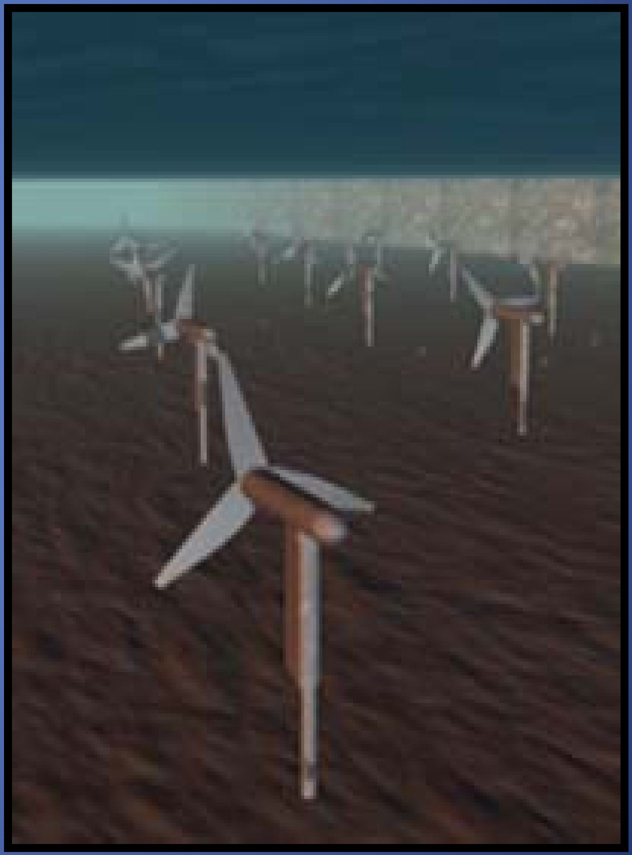
Example of Potential Power

The mighty Mississippi River flows at an average velocity of 1.2 mph. Using the average density for water, 62.4 lb/ft^3 and a turbine that is 60% efficient. The turbine blades have a diameter of 4 ft, so the sweep area is 12.6 ft^2.

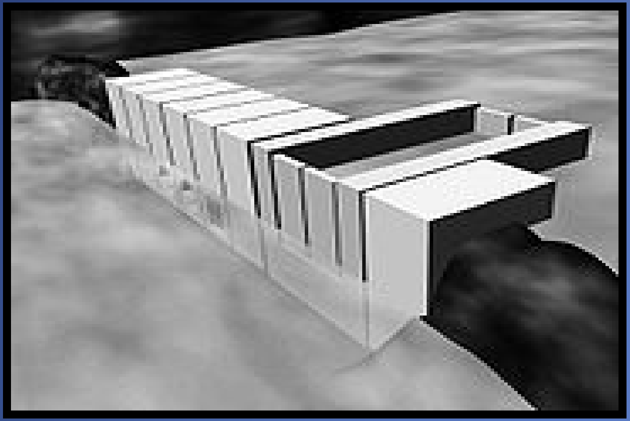
Tidal Stream Systems

First implementation of tidal stream system was the RITE project in 2006 by Verdant Power into the East River of New York City.

There move is the CORE project which plans to generate electricity for Cornwall, Ontario commercial businesses from the natural currents of the St. Lawrence River.



Barrages

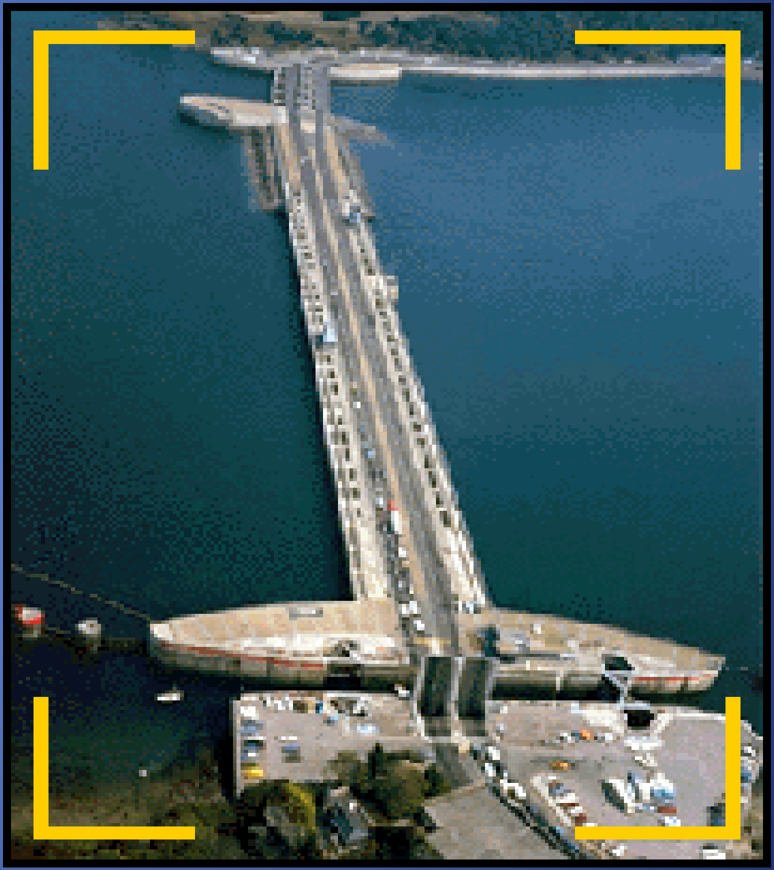


Like a dam, a barrage traps the water at high tide, then releases it back to the ocean at low tide through a turbine that generates electricity.

Unfortunately, like dams, barrages are not cost efficient and affect the ecosystem.

La Rance, France

The first barrage constructed for commercial use began in 1960 and was completed in 1967 in La Rance, France. It is a 330 meter dam with 10 MW turbines that produces 240 MW of electricity.



Example for Scotland Location

$$P = 240 \times 10 \times h \times C_F$$

The amount of power that could be generated by the same plant as the one in La Rance, France if constructed in Scotland. The energy generated in kWh (P) is proportional to the number of hours in a year (h), 240 MW total capacity generated by the 10 MW turbines and the capacity factor (C_F)

Barrage Location

A dam like structure is being considered for the Bay of Fundy in Nova Scotia, Canada that could provide 20 MW of power.

Tidal Energy

Both types of tidal power can effectively provide energy for large areas close to water. However, it is not yet an available alternative energy source to commercial and private businesses because the costs to produce these energy devices are still too high for mass production, especially for barrages.