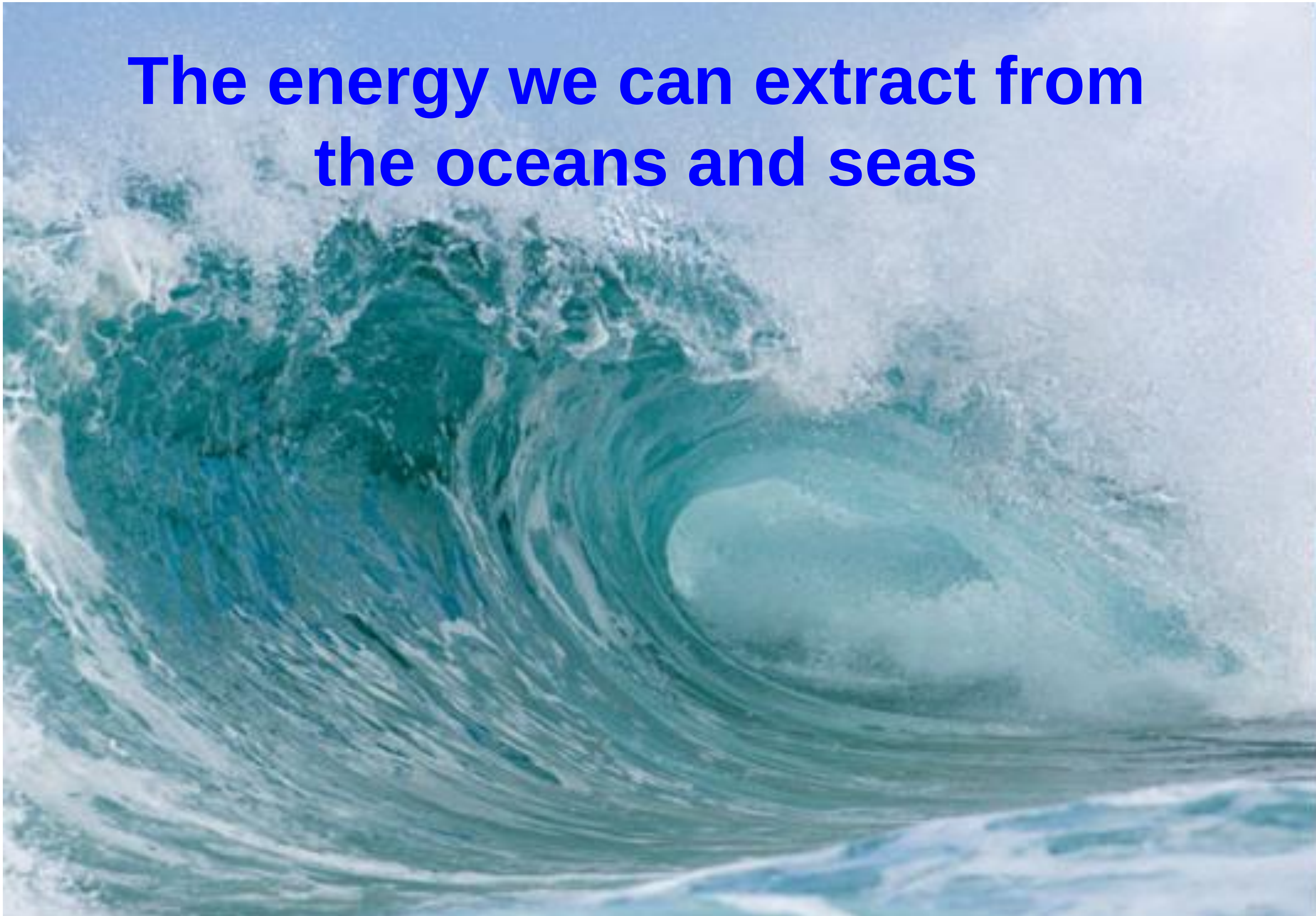
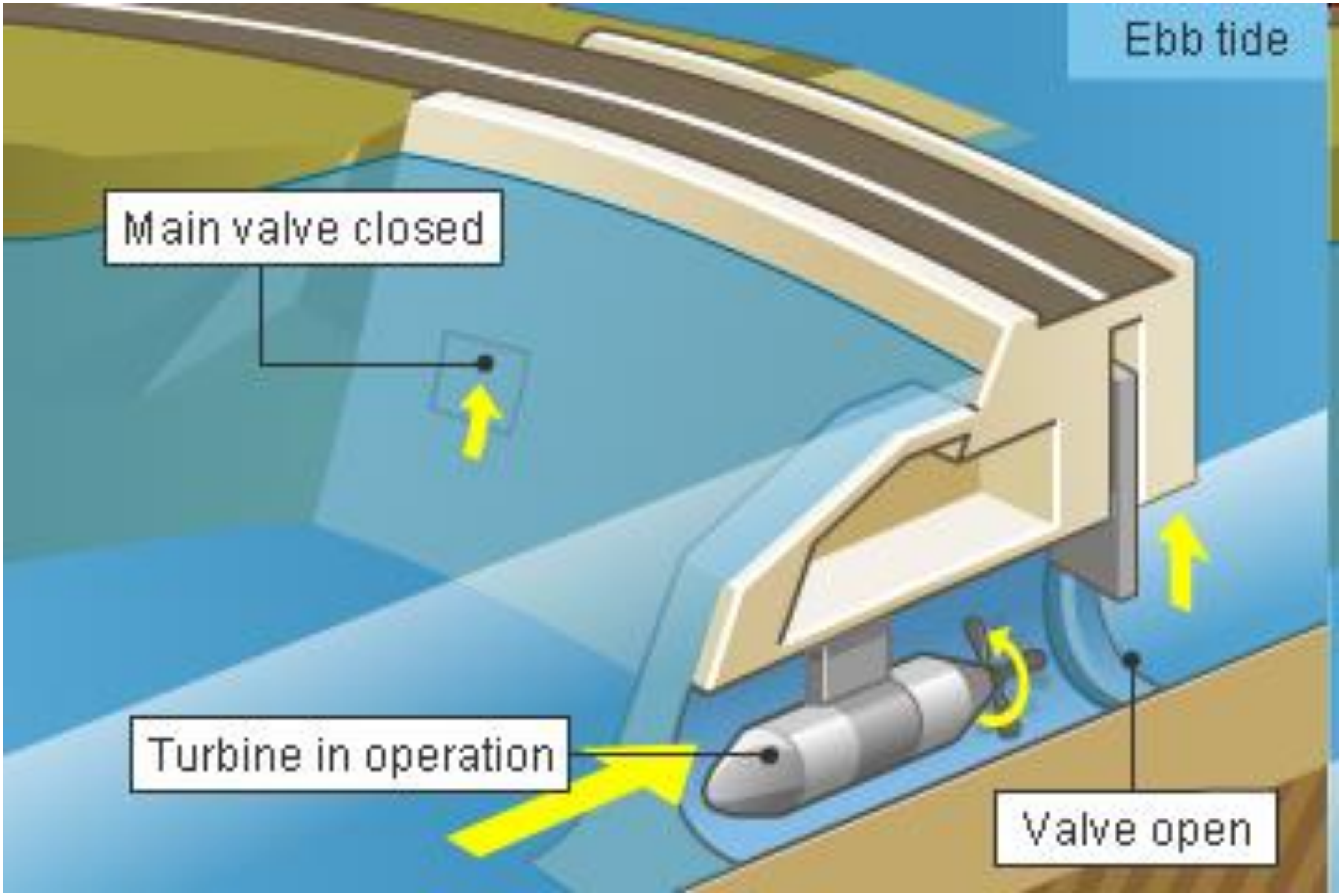
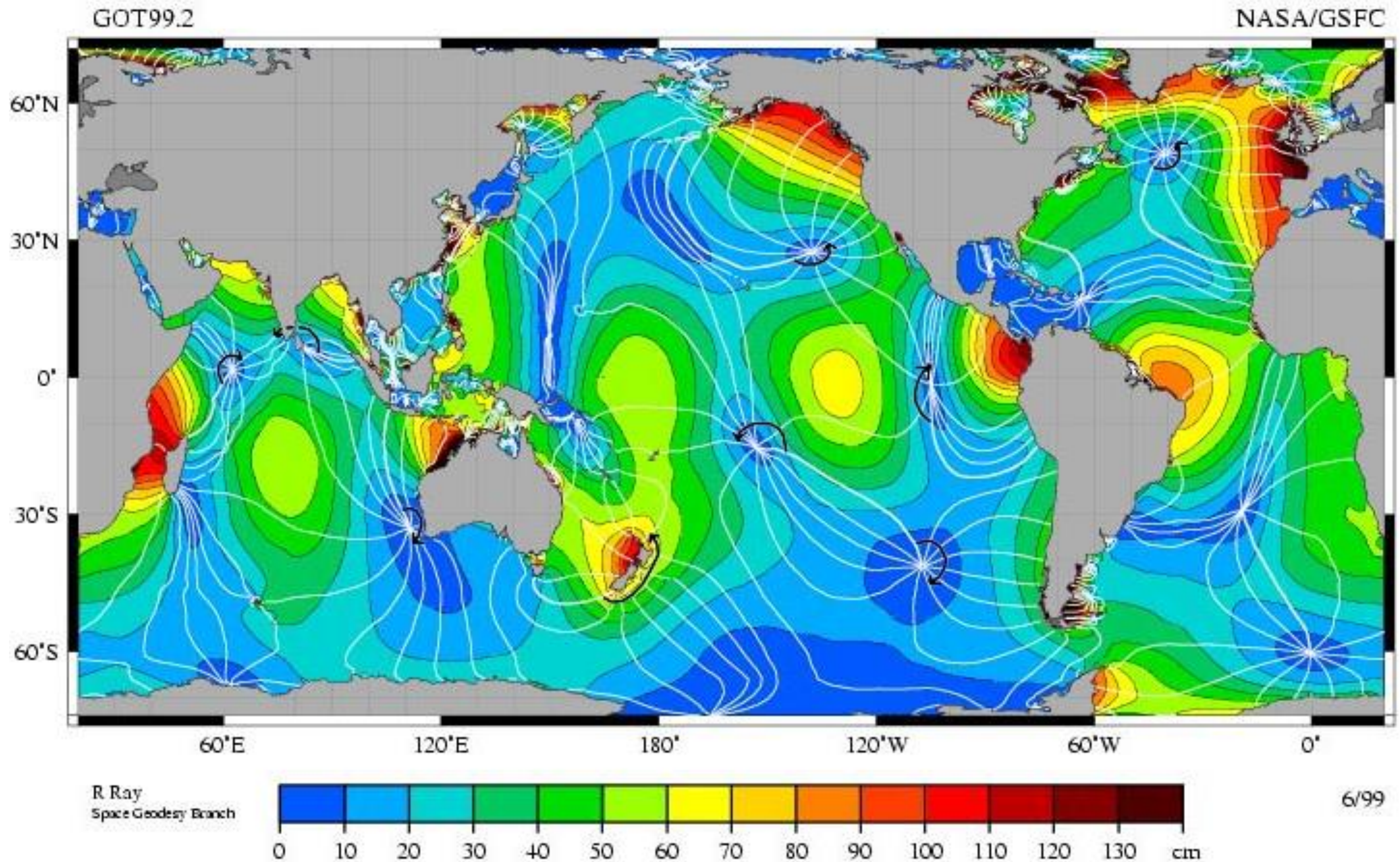
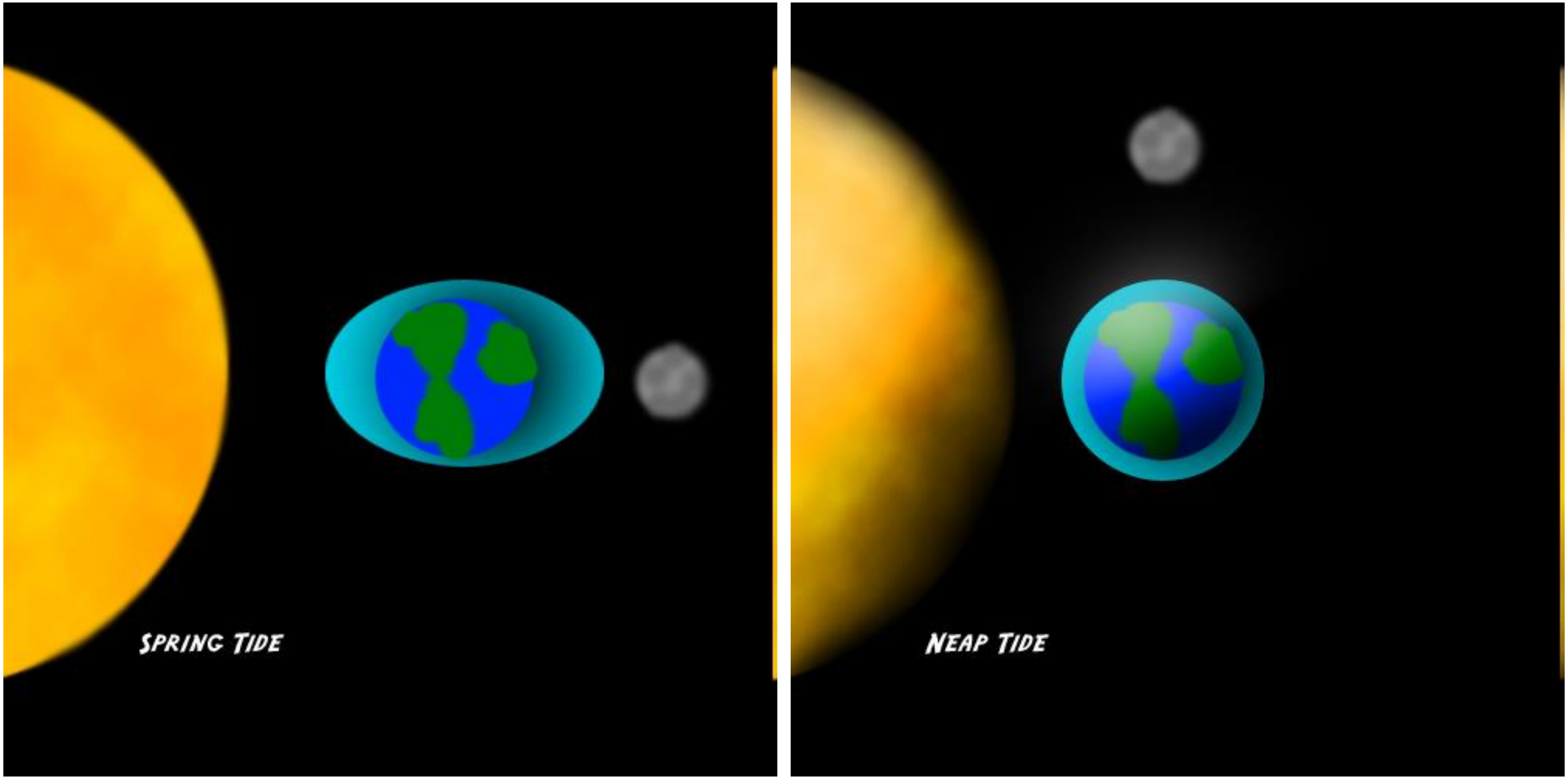

The energy we can extract from
the oceans and seas

There are several ways of extracting energy from the oceans and seas:

- **Energy of oceanic currents (not yet harnessed);**
- **Thermal methods (based on the difference of surface water temperature, and deep water temperature (prototypical installations);**
- **Tidal energy (already being used, but at small scale)**
- **Wave energy (the most realistic option!)**



Ebb tide
Main valve closed
Turbine in operation
Valve open


GOT99.2
NASA/GSFC
60°N
30°N
0°
30°S
60°S
60°E
120°E
180°
120°W
60°W
0°
R Ray
Space Geodesy Branch
0
10
20
30
40
50
60
70
80
90
100
110
120
130
cm
6/99

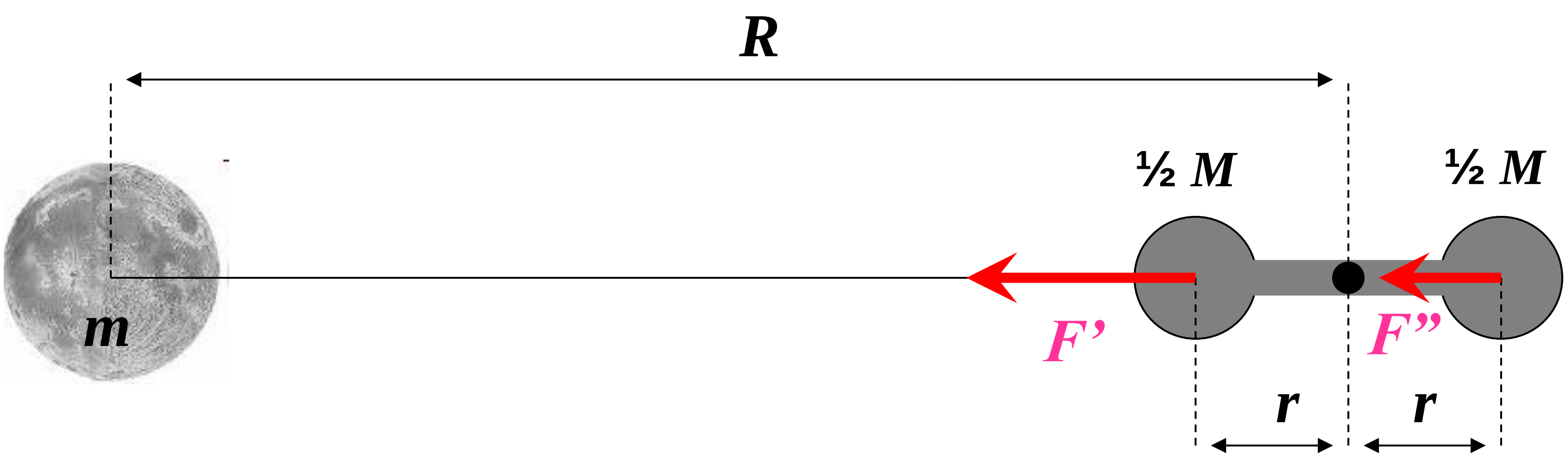


Misleading conceptions about the tide mechanism

A simple-minded theory of tidal forces

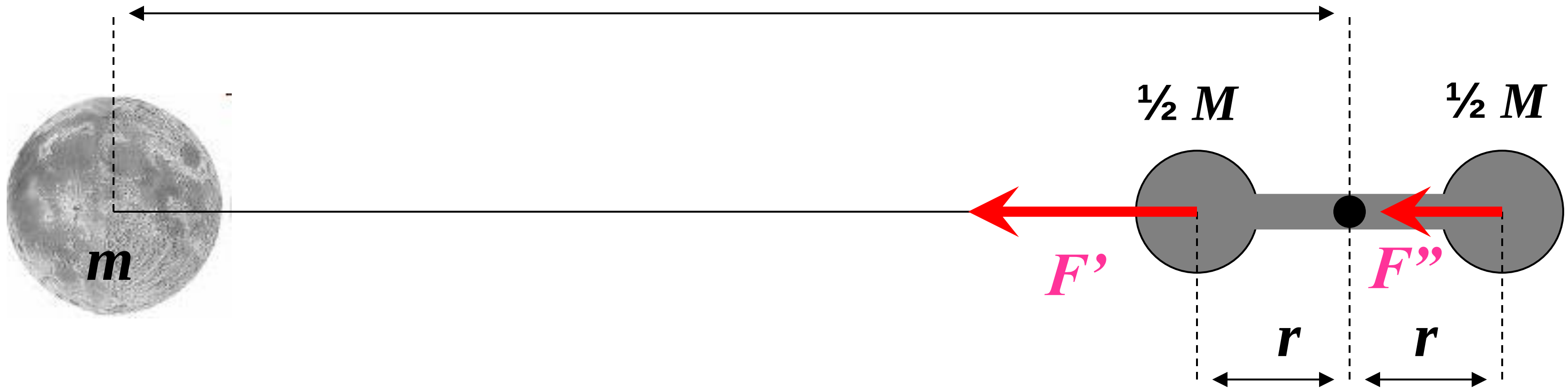
The exact theory is very complicated and highly "mathematized". But even a theory that is much simplified cannot survive without a bit of math!

We will use a model in which Earth is represented by a "dumbell" with the same mass and radius as those of Earth.



$$F_{\text{gravity}} = G\frac{m_A \cdot m_B}{r_{AB}^2}$$

$$F' = G\frac{m \cdot M}{2(R-r)^2} \quad \text{and} \quad F'' = G\frac{m \cdot M}{2(R+r)^2}$$



The sphere closer to Moon is attracted by it by a larger force, And the ball farther away from it by a smaller force.

The difference between the two forces, $\Delta F = F' - F''$, can be thought of as an effective force that tends to rip apart the dumbell. Let's do some calculations:

$$\Delta F = G\frac{m \cdot M}{2(R-r)^2} - G\frac{m \cdot M}{2(R+r)^2} = G\frac{m \cdot M}{2}\left[\frac{1}{(R-r)^2} - \frac{1}{(R+r)^2}\right]$$

On the next slide we will do some work on the expression in the square brackets.

$$\left[\frac{1}{(R-r)^2}-\frac{1}{(R+r)^2}\right]=\frac{(R+r)^2-(R-r)^2}{(R-r)^2(R+r)^2}$$

$$=\frac{R^2+r^2+2Rr-R^2-r^2+2Rr}{\left(R^2-r^2\right)^2}$$

$$=\frac{4Rr}{R^4\left(1-\frac{r^2}{R^2}\right)^2}$$

Let's take some realistic values: let *r* be equal to the Earth radius (6,500 km) , and *R* be equal to the Earth-Moon distance (380,000 km). For such numbers, the value of the expression in the denominator is:

$$\left(1-\frac{r^2}{R^2}\right)^2=0.9994$$

It's value is so close to one that one can skip it (the value of the expression changes then by 0.06% only):

$$\frac{4Rr}{R^4\left(1-\frac{r^2}{R^2}\right)^2} \approx \frac{4Rr}{R^4} = \frac{4r}{R^3}$$

And the entire formula can be written as :

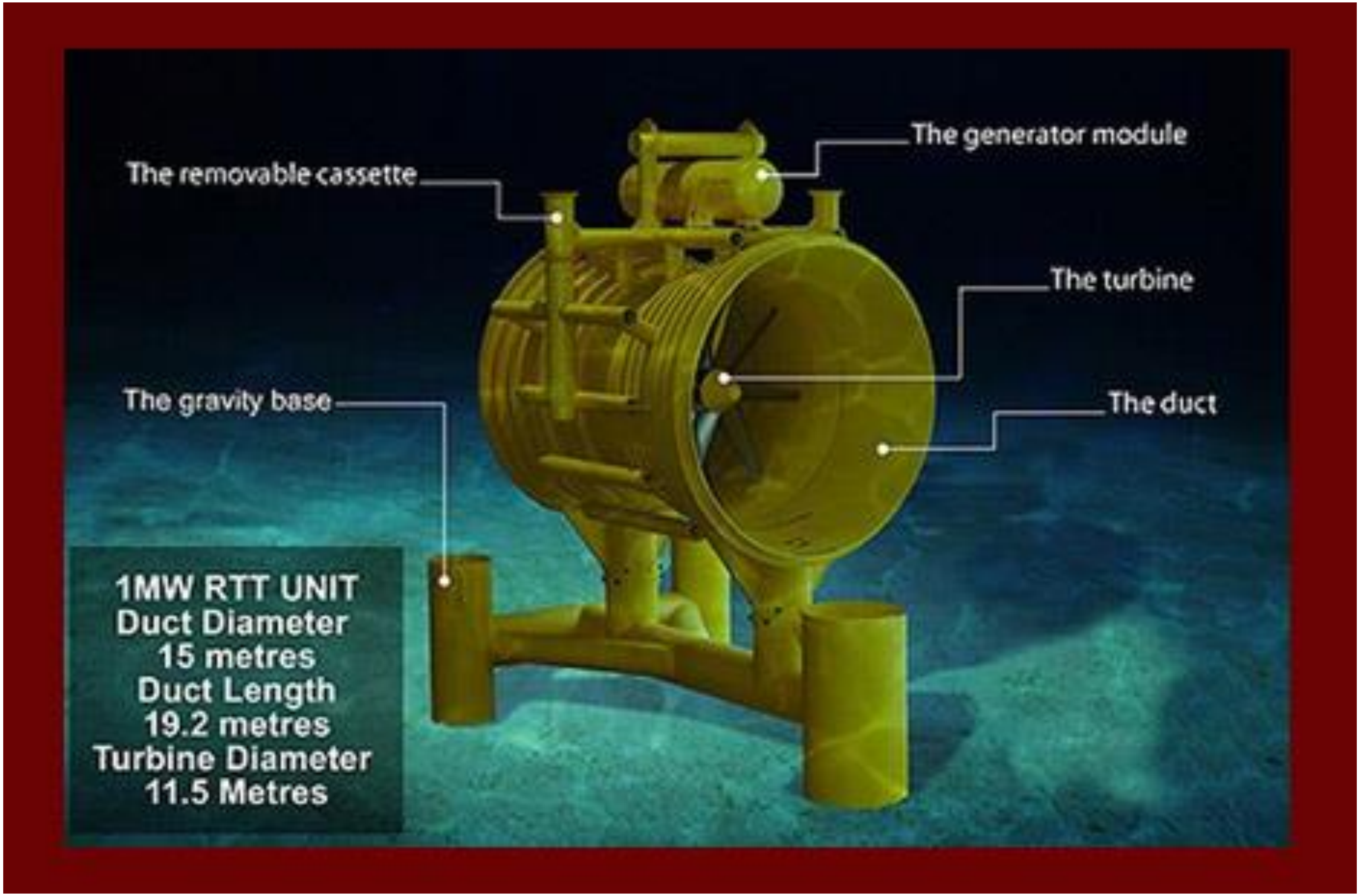
$$\Delta F = G \cdot M \cdot m \frac{2r}{R^3}$$

This force is called the tidal force. Any object of finite size experiences a tidal force in a gravitational field – a force that tends to "rip it apart" (because of the R^{-3} dependence, it may really happen – read about the "Roche Limit" here: tidal forces and the Roche limit.

Conclusions: tidal forces have always tend to stretch a body. The sturdy rock structure of Earth resists, but Water yields to that force, and therefore there are TWO BULGES – this fact has little to do with any “inertial forces” or “centrifugal forces”.

By the way, Earth solid surface also react to tidal forces – it raises about 30 cm at the “high tide”, but we don’t see it.

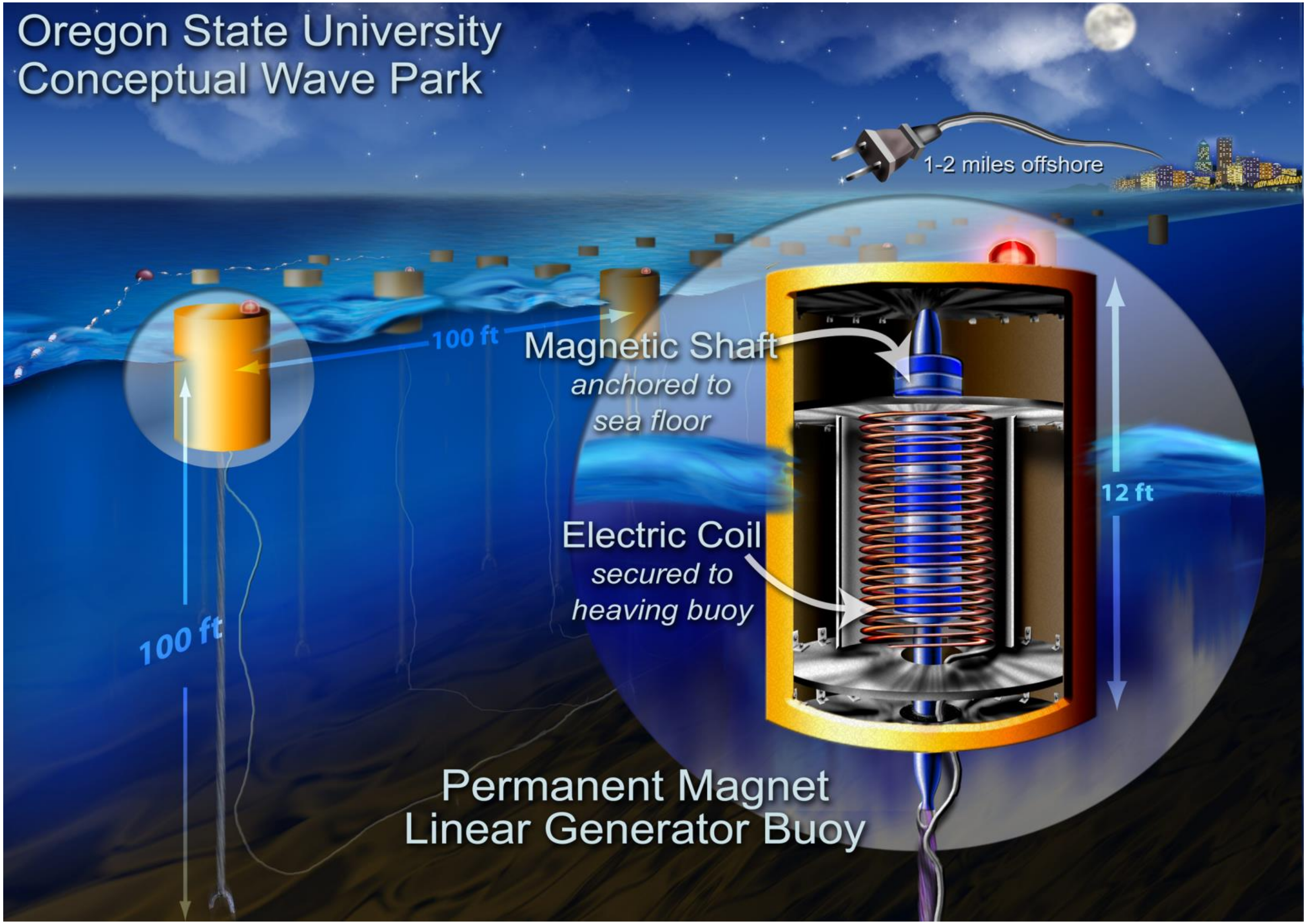
Another possible method of harnessing the tidal energy: underwater turbines placed on the bottom – good where strong tidal currents occur



Ocean Thermal Energy Conversion (OTEC)

Pilot 250 kW installation at Kona Island (Hawai)

Wave Power



Oregon State University
Conceptual Wave Park
1-2 miles offshore
100 ft
Magnetic Shaft
anchored to
sea floor
12 ft
Electric Coil
secured to
heaving buoy
100 ft
Permanent Magnet
Linear Generator Buoy

A youtube movie demonstrating several different techniques of harnessing wave energy

OSU successes with harnessing wave power:
Professor Annette von Jouanne, Ph.D., P.E.