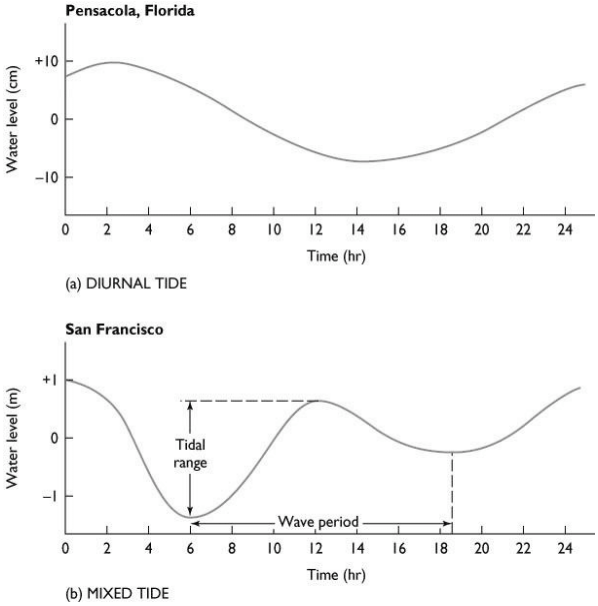
Tides: Key Ideas

- Caused by the gravitational force of the moon and sun and the motion of Earth
- Longest of all waves; wavelength is about half the circumference of Earth
- Behave as shallow-water waves
- Tides are **forced waves** because they are never free of the forces that cause them

1

Tidal Curves



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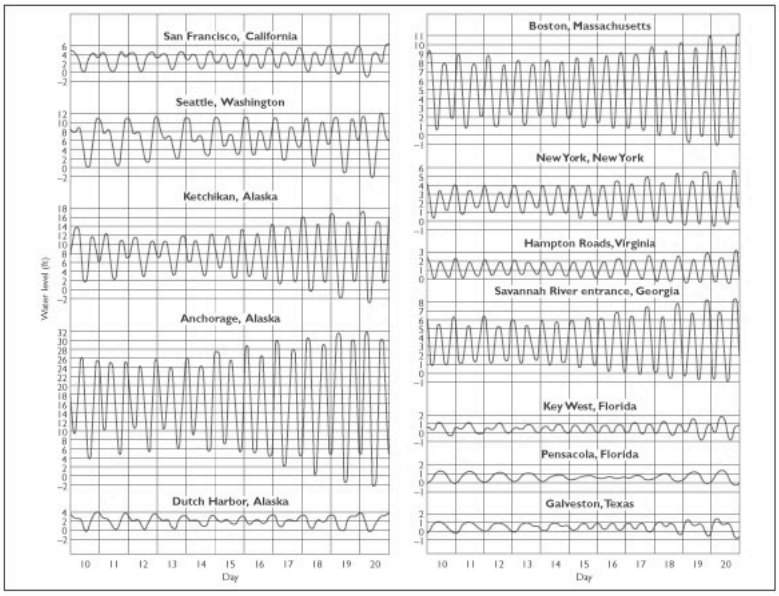

3

Types of Tides and Tidal Range

- Three basic types: diurnal, semidiurnal, and mixed tides
- Over a month the daily tidal ranges vary systematically with the cycle of the Moon causing spring and neap tides.
- Tidal range is also altered by the shape of a basin and sea floor configuration

4

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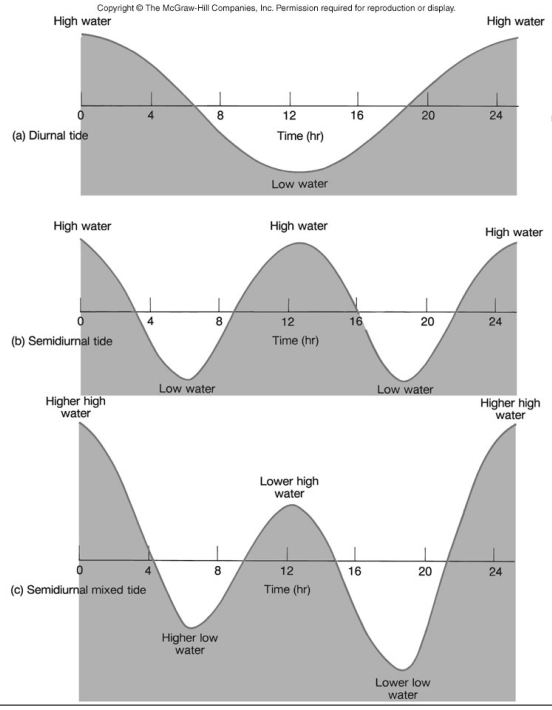

Tidal Curves for Three Common Types of Tides

5

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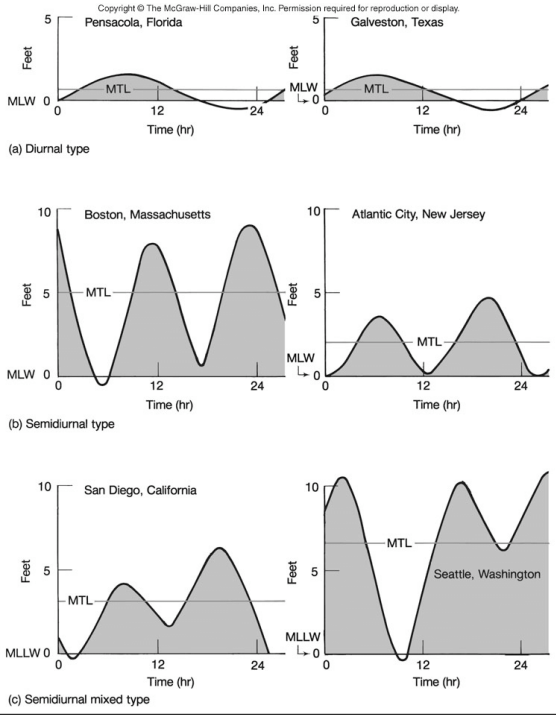

6

Origin of Tides

- Result from gravitational attraction and centrifugal effect
- Moon exerts twice the gravitational attraction and tide-generating force as Sun
- Two tidal bulges form in the ocean (high tides)

7

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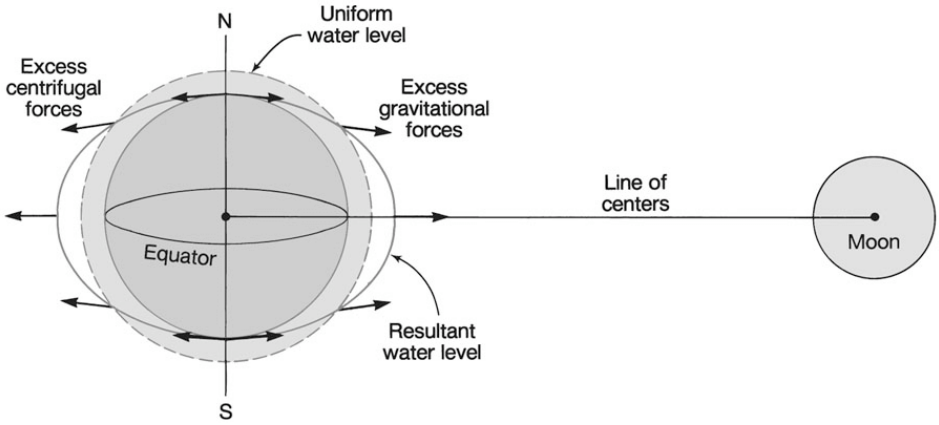

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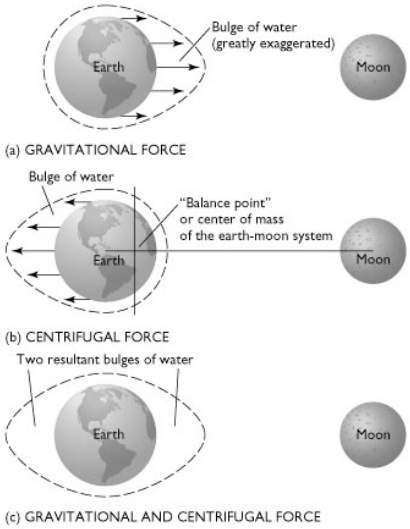
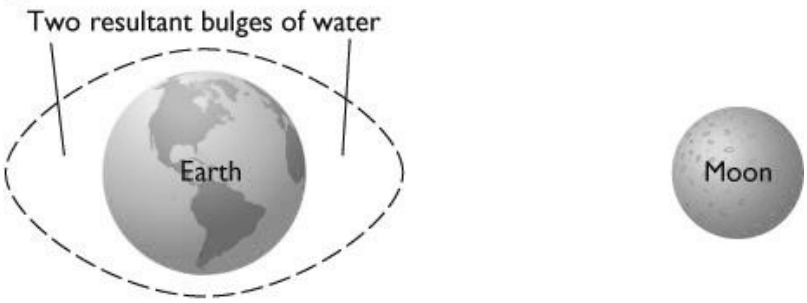
The Equilibrium Theory of Tides



Note the bulges that are aligned with the moon as Earth spins on its axis. The Earth turns beneath these bulges.

9

Gravitational and Centrifugal Force



Gravitational attraction and centrifugal force produce two tidal bulges of water of about the same size, positioned on opposite sides of the Earth.

10

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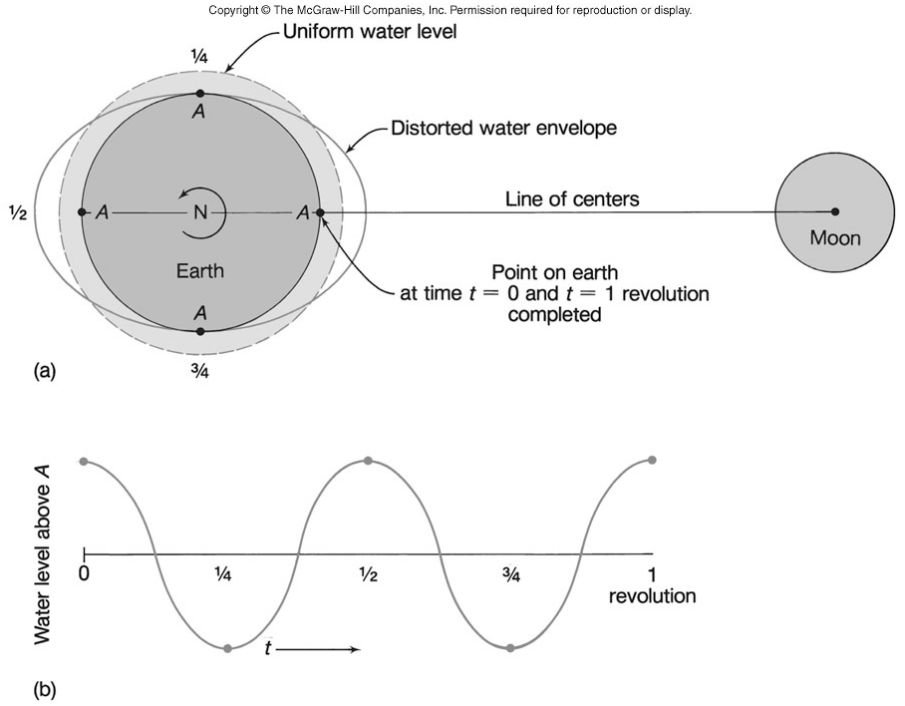

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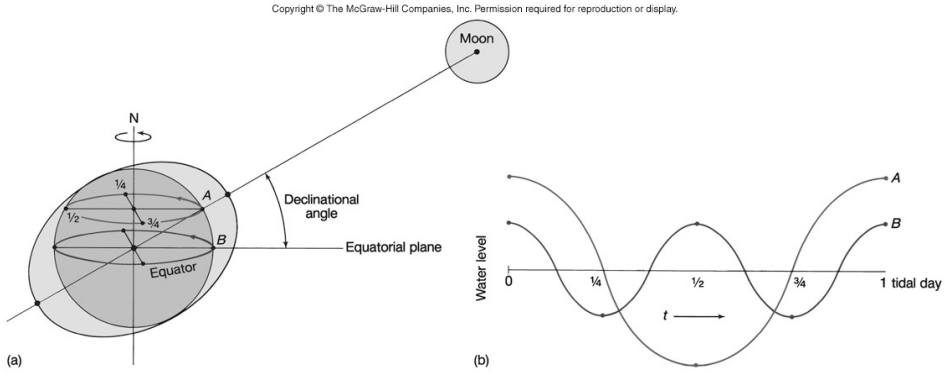

Moon's declination varies +/- 5^{o} from plane of Earth's orbit.

12

Tidal Day: 24 Hours and 50 Minutes

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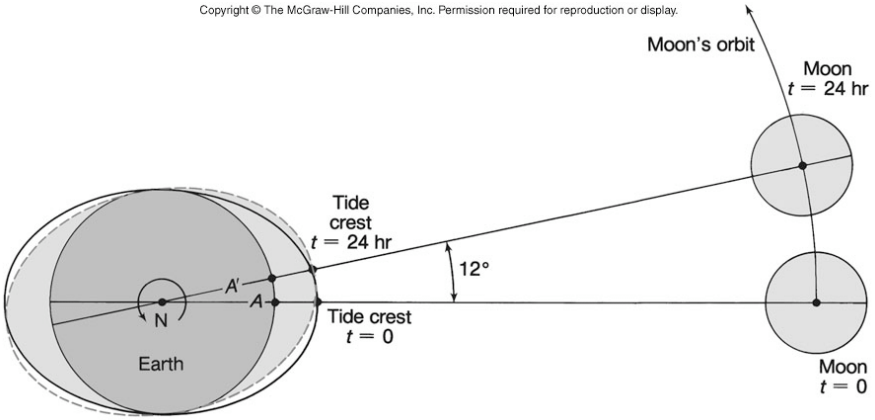

Earth and Moon both revolve eastward; causes tides to occur 50 minutes later each day

13

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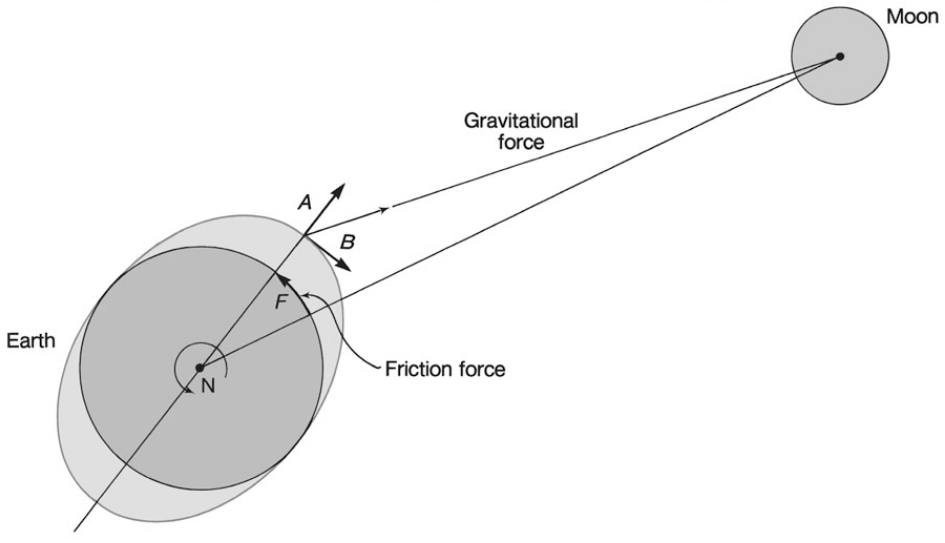

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Spring and Neap Tides

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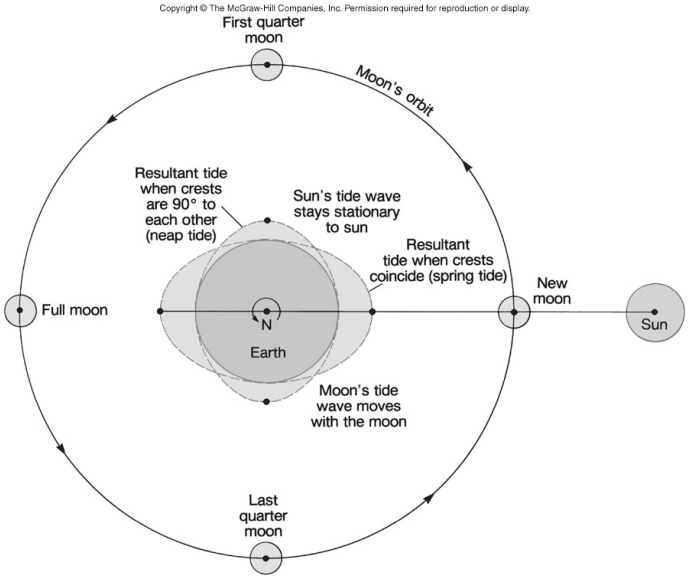

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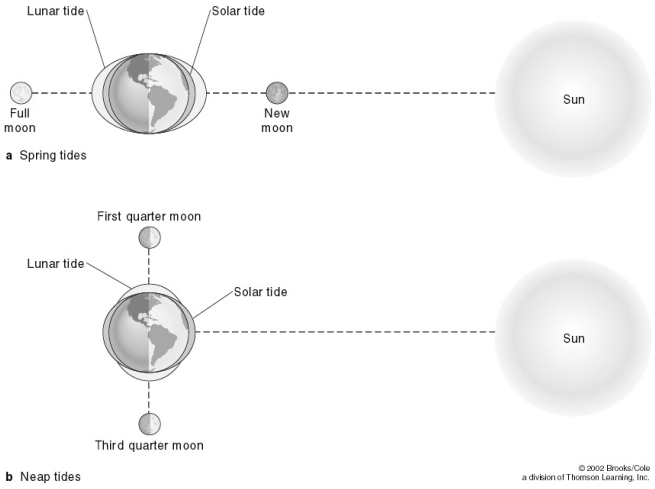
Sun and Moon Together

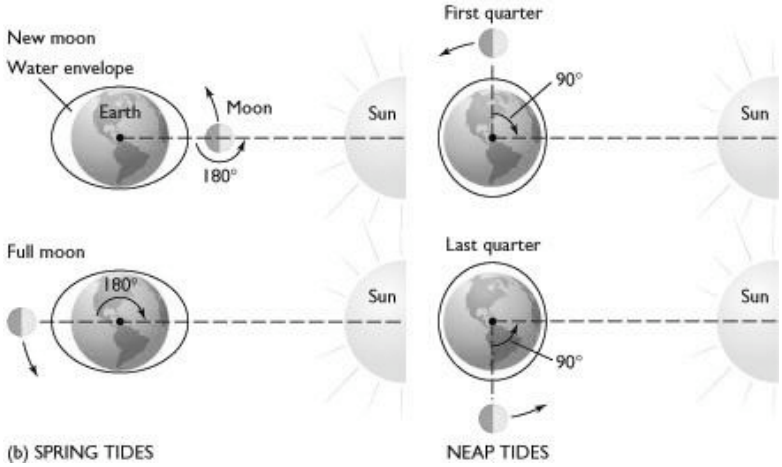


Top: The positions of the Sun, the moon and Earth during a **spring tide**.

Bottom: The positions of the Sun, the moon and Earth during a **neap tide**.

16

Spring and Neap Tides



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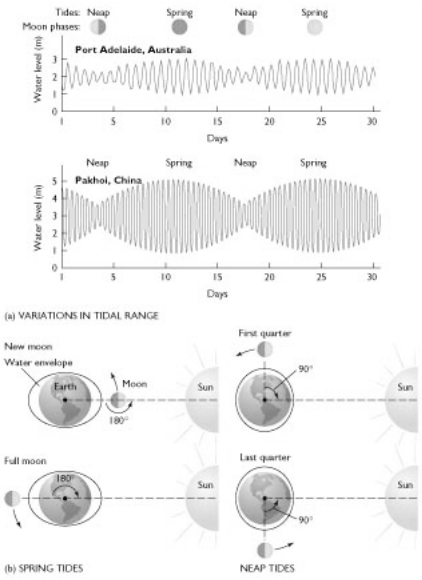

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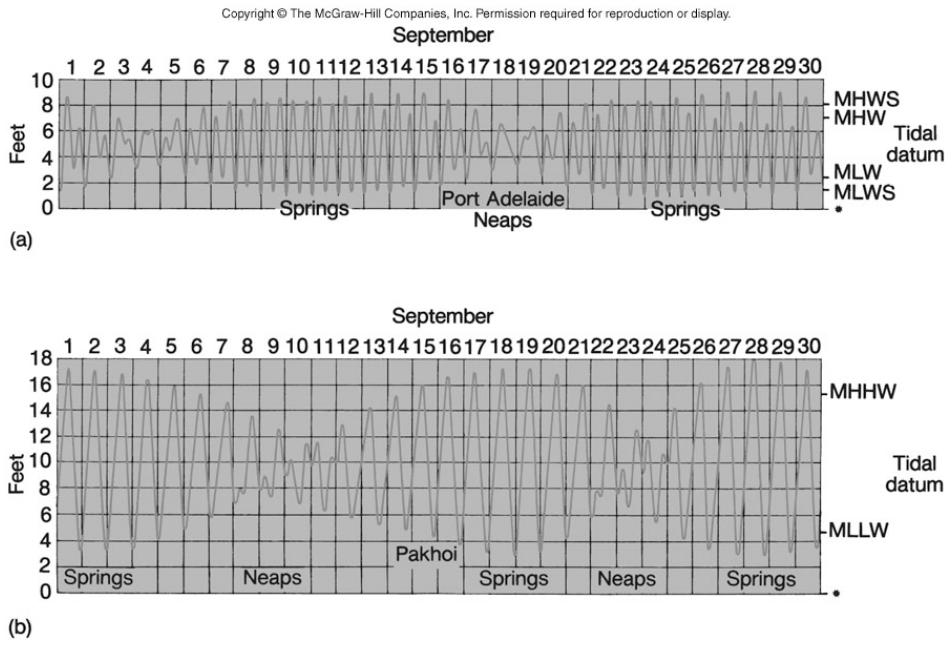
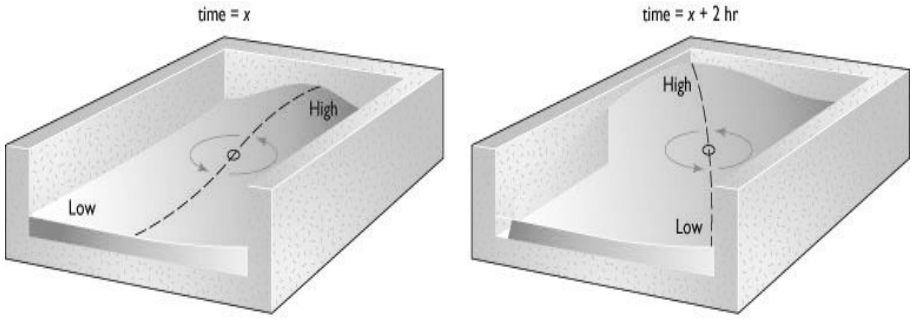


Rotary Tidal Motion



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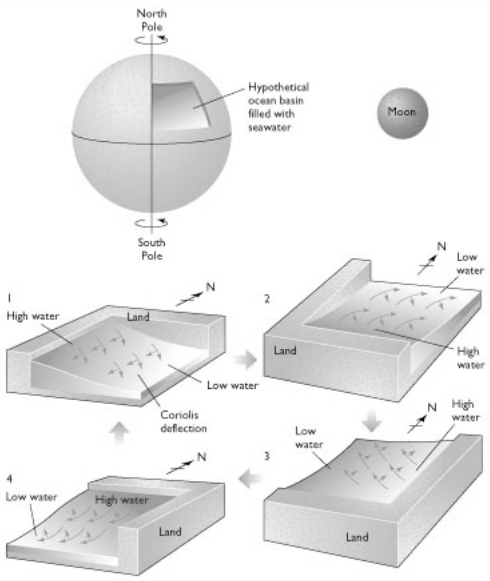
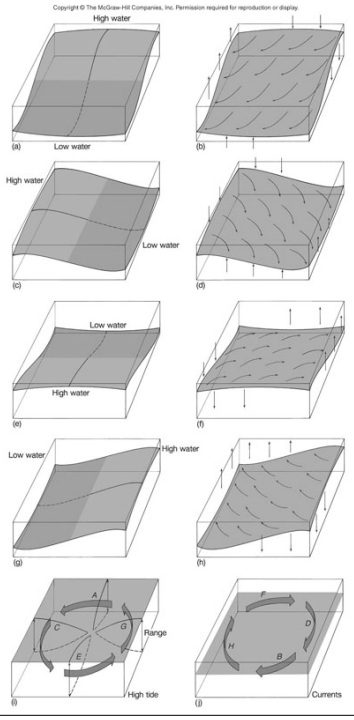

North Pole
Hypothetical ocean basin filled with seawater
Moon
South Pole
1
High water
Land
N
Low water
Coriolis deflection
2
N
Low water
Land
High water
3
N
High water
Low water
Land
4
Low water
High water
N
Land

21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High water
(a)
Low water
(b)
High water
Low water
(c)
(d)
Low water
High water
(e)
(f)
Low water
High water
(g)
(h)
A
C
G
Range
E
High tide
(i)
F
D
H
B
Currents
(j)

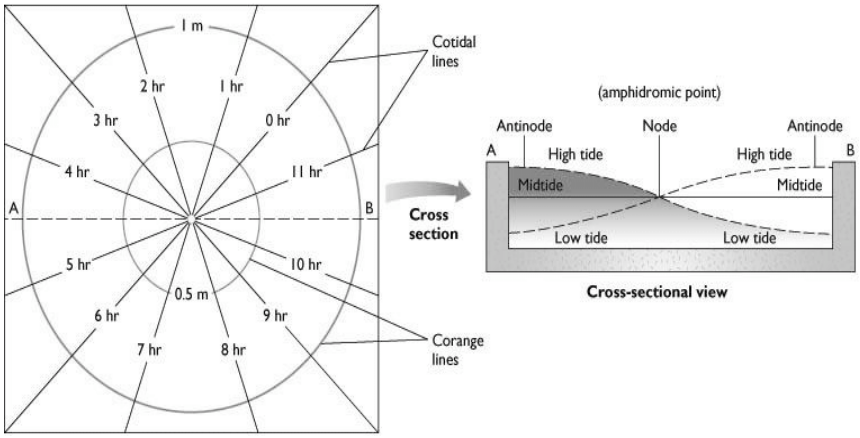
22

Rotary Tide

A rotary wave is part of an amphidromic system in which the wave progresses about a node (no vertical displacement) with the antinode (maximum vertical displacement) rotating about the basin's edges.

23

Amphidromic System



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Amphidromic Systems

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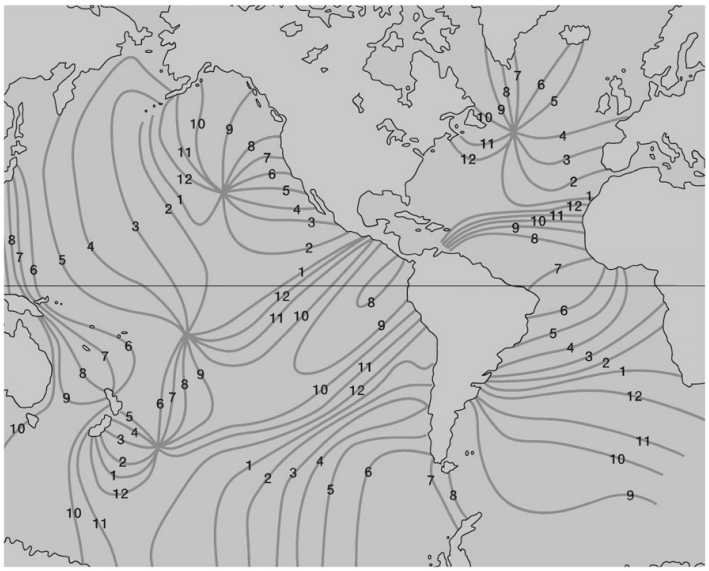


25

Amphidromic Tide

- Cotidal lines connect points on the rotary wave that experience high tide at the same time.
- Corange circles are lines connecting points which experience the same tidal range.
  - Tidal range increases outward from the node.

26

Amphidromic Systems

- Rotate clockwise in the southern hemisphere and counterclockwise in the northern hemisphere because of Coriolis deflection.
- Irregular coastlines distort the rotary motion.
- Actual tide at any location is a composite of many different tidal components.

27

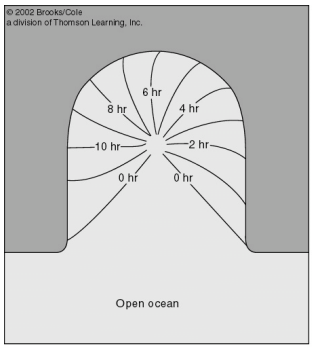
Tides in Elongated Basins

- Cannot rotate
- Currents in these basins reverse direction flowing in with high tide and out with low tide.
- Cotidal and corange lines are nearly parallel to each other.
- Tidal ranges increase if a bay tapers landward because water is funneled towards the basin's narrow end.

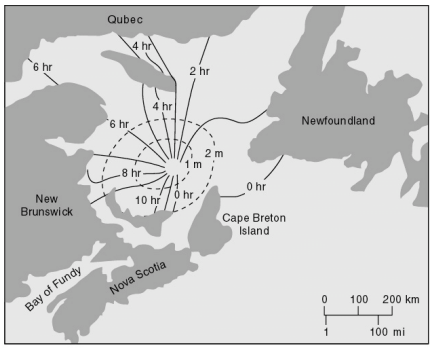
28

Tides in Confined Basins

The tidal range is determined by basin configuration.



a Broad basin

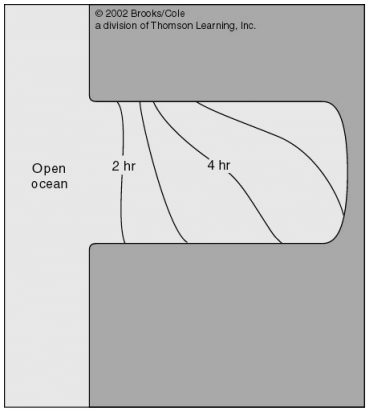


b Amphidromic system: Gulf of St. Lawrence. Dashed lines show tide height

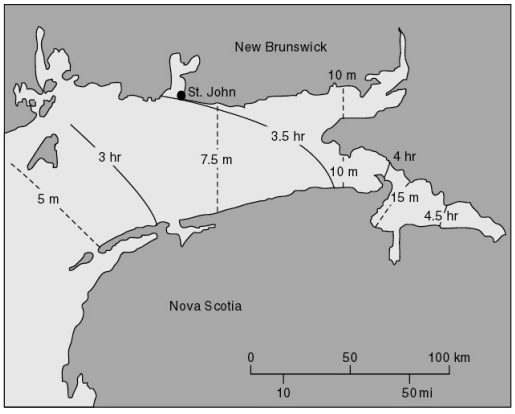
An imaginary amphidromic system in a broad, shallow basin (left) and a natural system (right).

29

Tides in Confined Basins

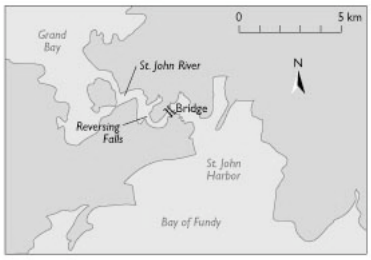


a Narrow basin

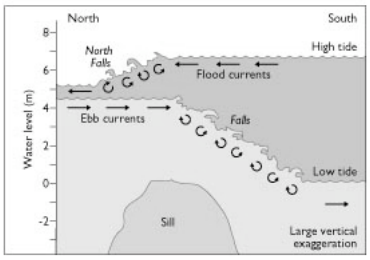


b Tidal crests: Bay of Fundy

30



(a) ST. JOHN, NEW BRUNSWICK, CANADA



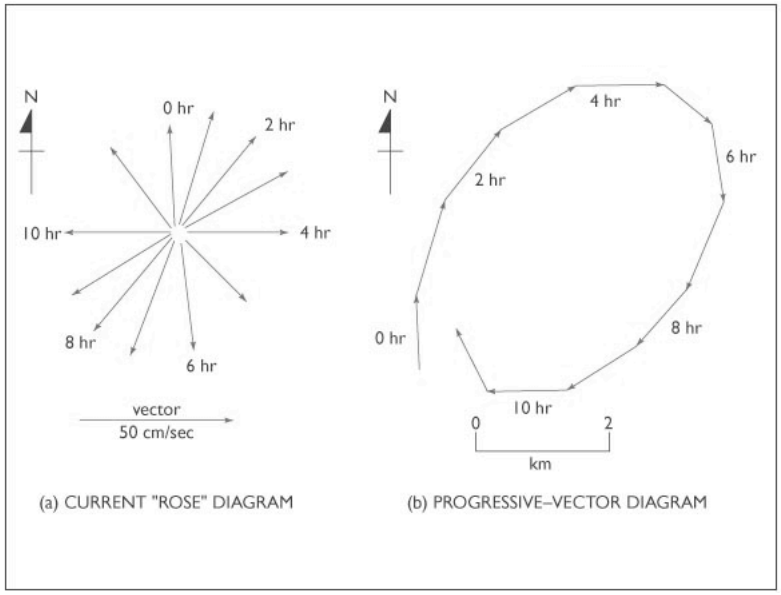
(b) REVERSING FALLS

31

Tidal Currents: Flood and Ebb

- Movement of water towards and away from land with high and low tides
- Offshore, the tidal currents inscribe a circular path over a complete tidal cycle.
- Nearshore, the tidal currents produce simple landward and then seaward currents.

32



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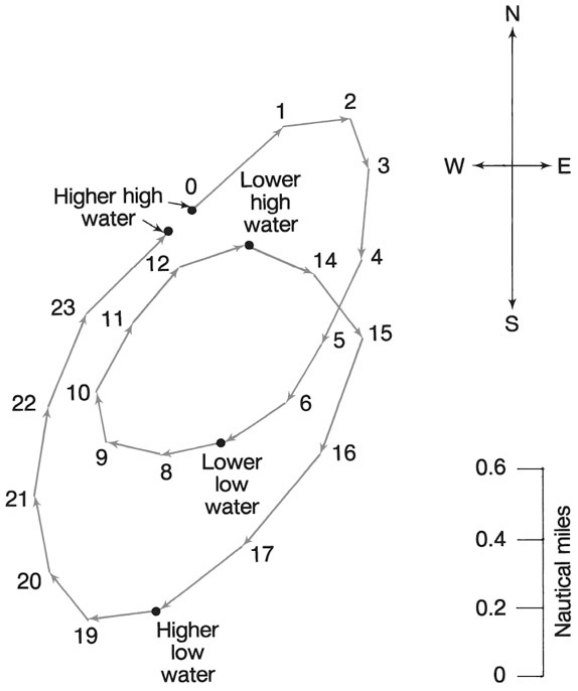

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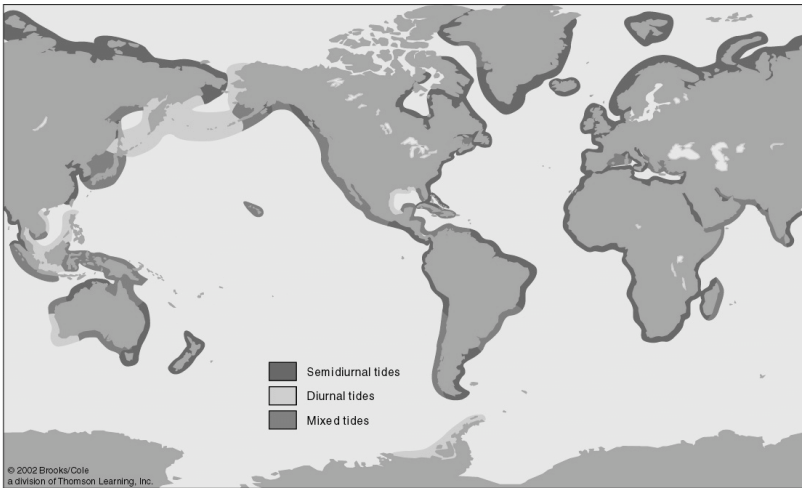
The Worldwide Distribution of the Three Tidal Patterns



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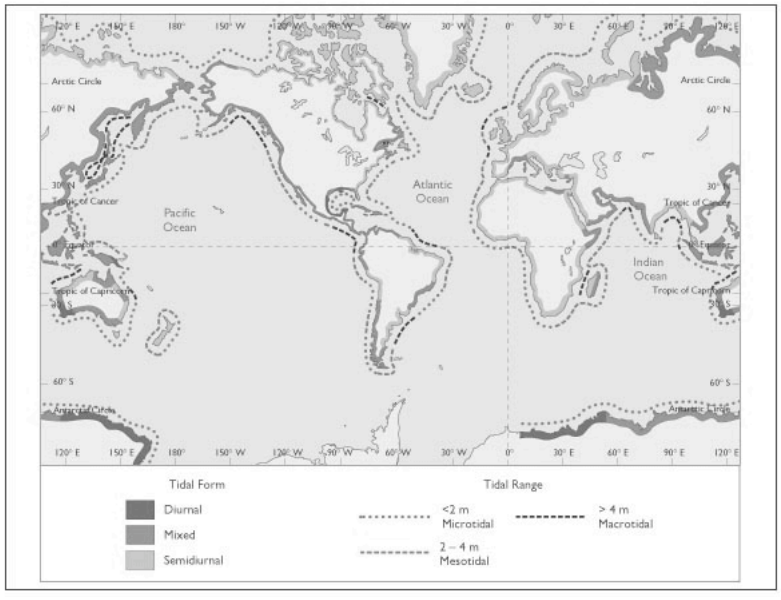

36

Tides and Marine Organisms

Tides have a profound affect on coastal marine life.

Coastal life is sorted into zones and subzones, depending on the amount of emergence and submergence the organisms can tolerate.

37

Power from Tides

- Electricity can be generated from tidal currents if the tidal range is greater than 5 m in a large bay connected to the ocean by a narrow opening
- A dam is constructed across the opening and water is allowed to flow into and out of the bay when sufficient hydraulic head exist to drive turbines and generate power
- The first major tidal power station, in France, is capable of generating 544 million kilowatt hours of electricity annually

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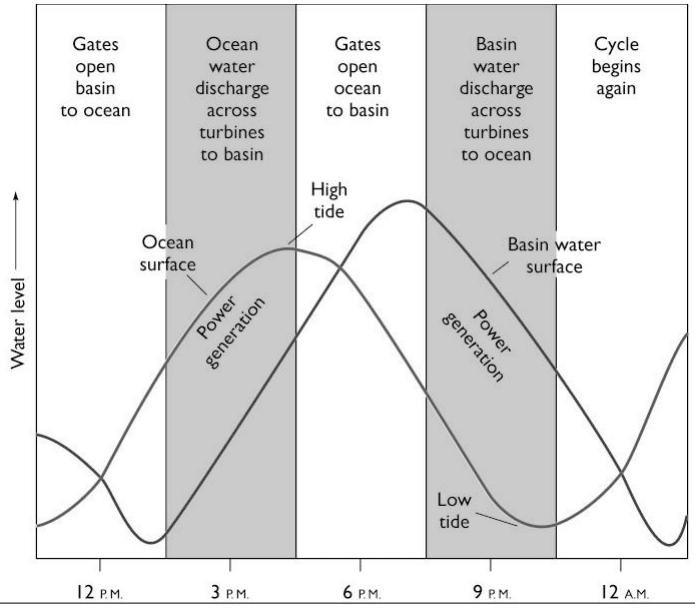
Power from the Tides



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Summary

The dynamic theory of tides explains the characteristics of ocean tides based on celestial mechanics (the gravity of the sun and moon acting on Earth) and the characteristics of fluid motion.

Semidiurnal tides occur twice in a lunar day

Diurnal tides occur once each lunar day

Mixed tides describe a tidal pattern of significantly different heights through the cycle

Amphidromic points are nodes at the center of ocean basins; these are no-tide points.

40