A Brief Overview of Tides, Tidal Currents, Winds, and Waves

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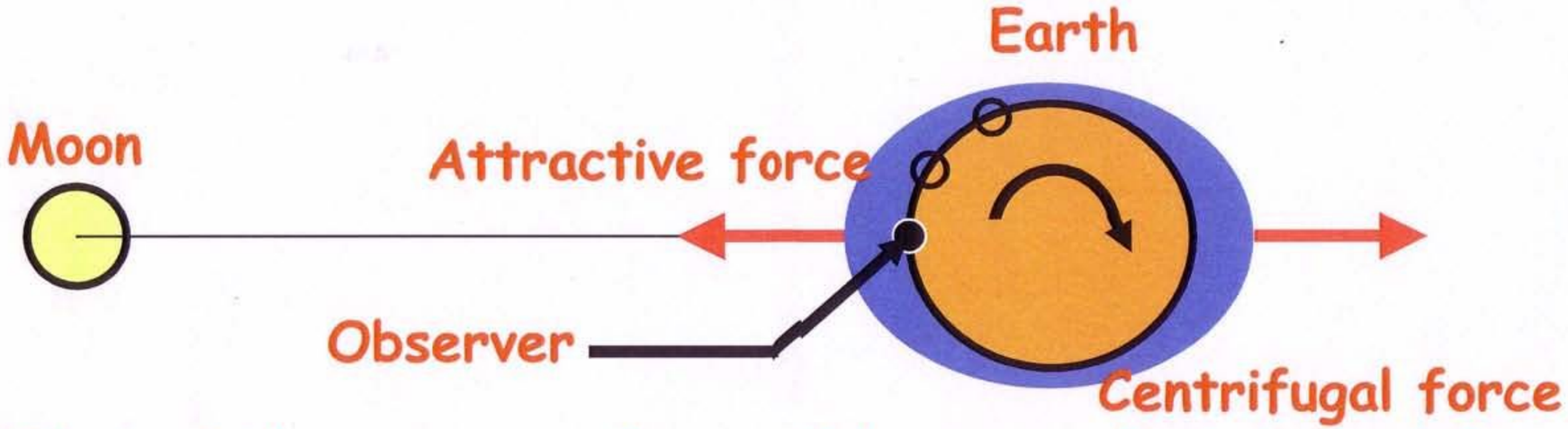
A Brief Overview of Tides, Tidal Currents, Winds, and Waves

- Properties of astronomical tides
- Tides in San Francisco Bay
- Tidal currents in Central Bay
- Wind pattern over San Francisco Bay Region
- Wind-waves and wind driven drift

Tide Definition

- Tide:
  - The <u>vertical</u> rise and fall of the sea level due to the balance of attractive and centrifugal forces between the Earth, the Moon, the Sun.

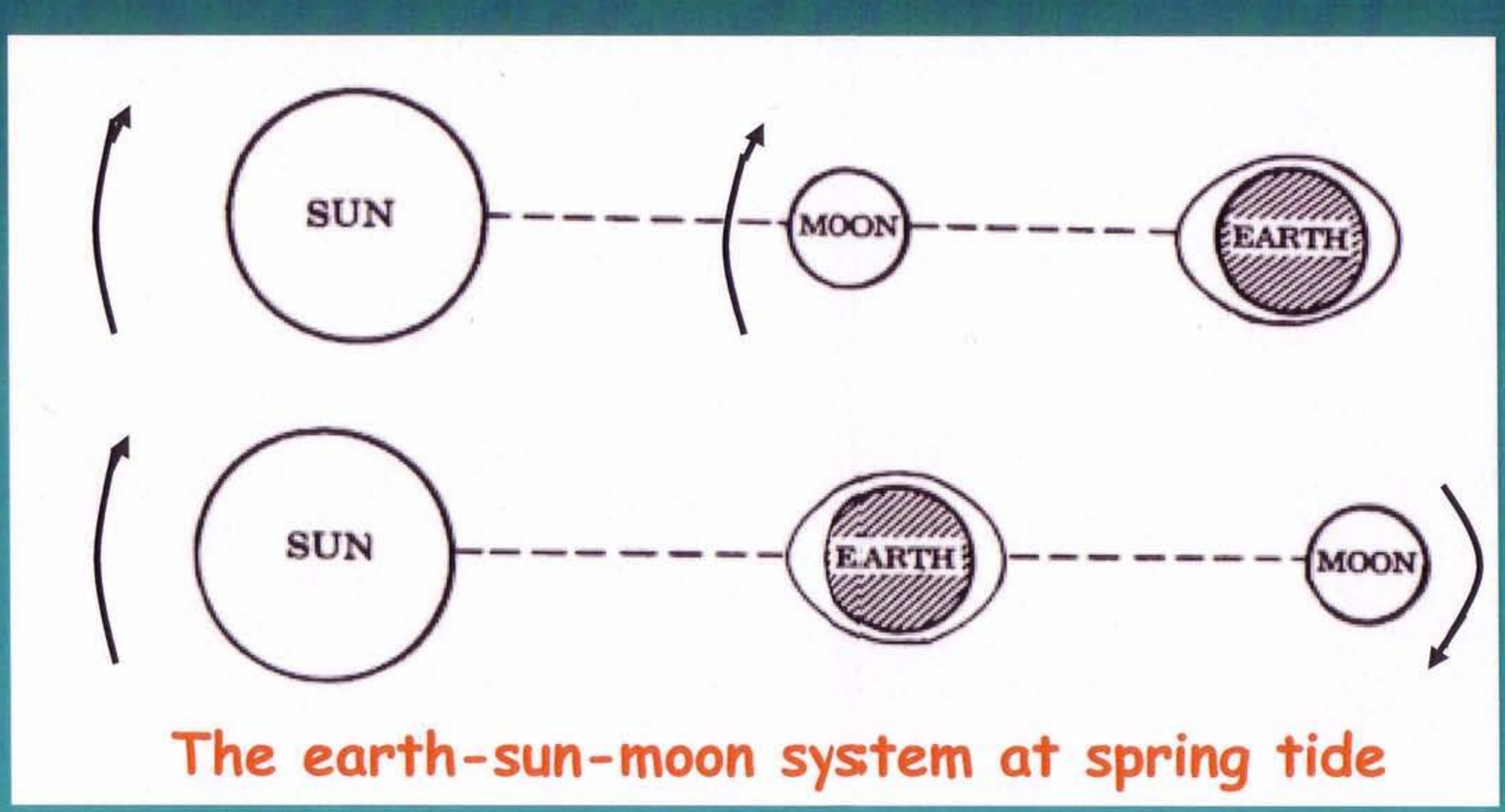


Effect of the moon on the earth's oceans (not to scale)

Spring Tide

- Spring tide:
  - When the tidal effects of the Sun and the Moon act in concert.

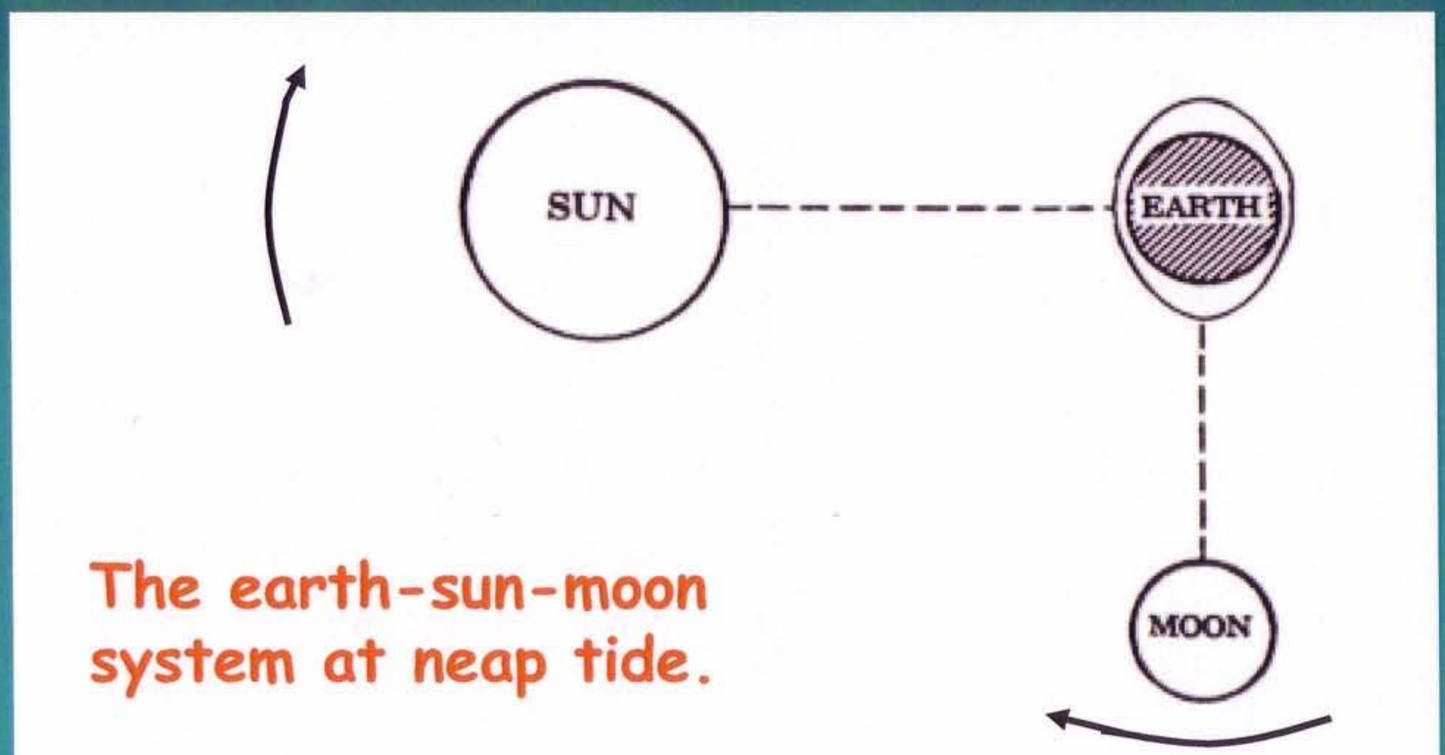
(not to scale)



The earth-sun-moon system at spring tide

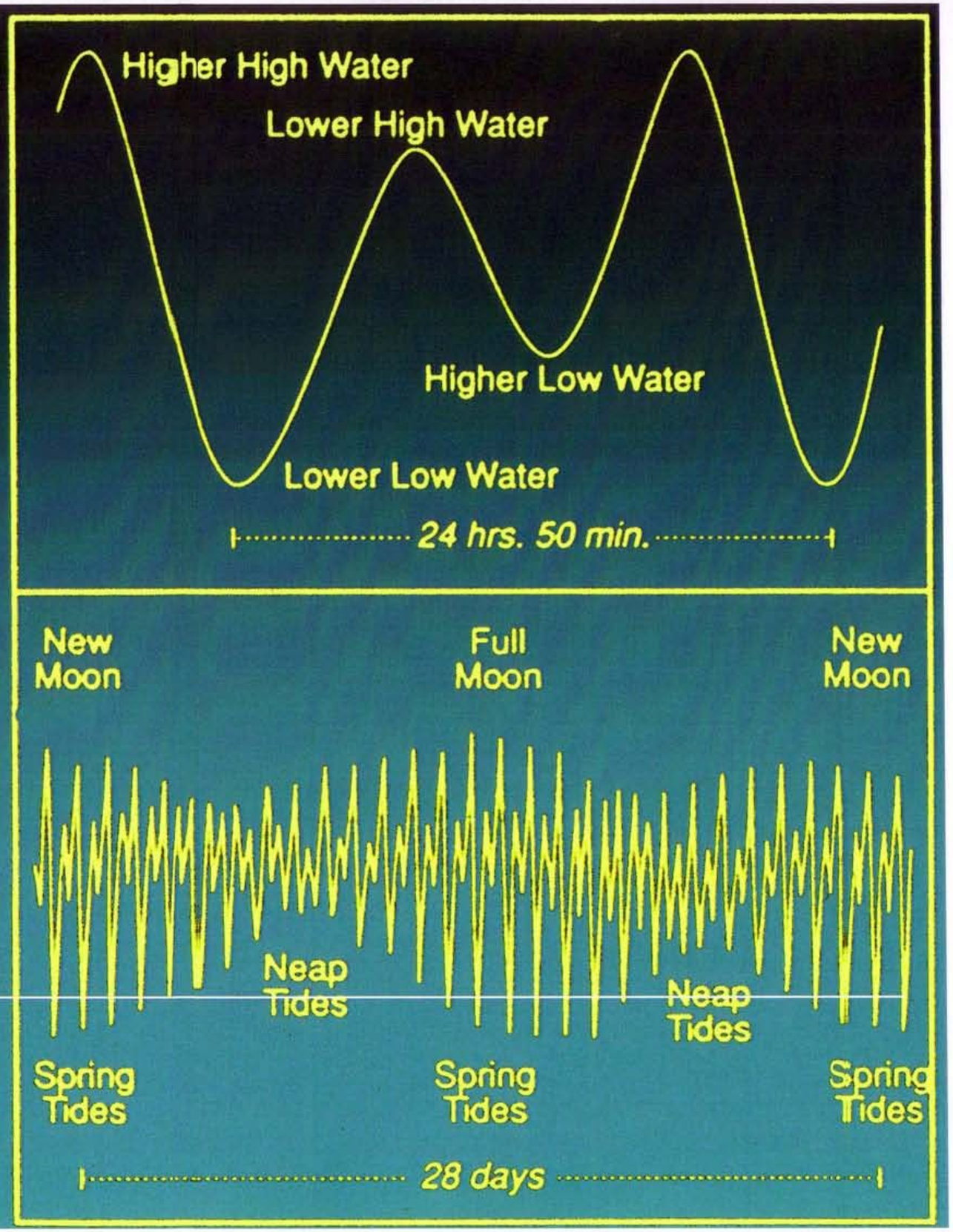
Neap Tide

- Neap tide:
  - When the tidal effects of the sun and the moon act in quadrature to one another.



The earth-sun-moon system at neap tide.

Example Tide in San Francisco Bay



NOAA Bathymetry Reference Datum

Mean Lower Low Water

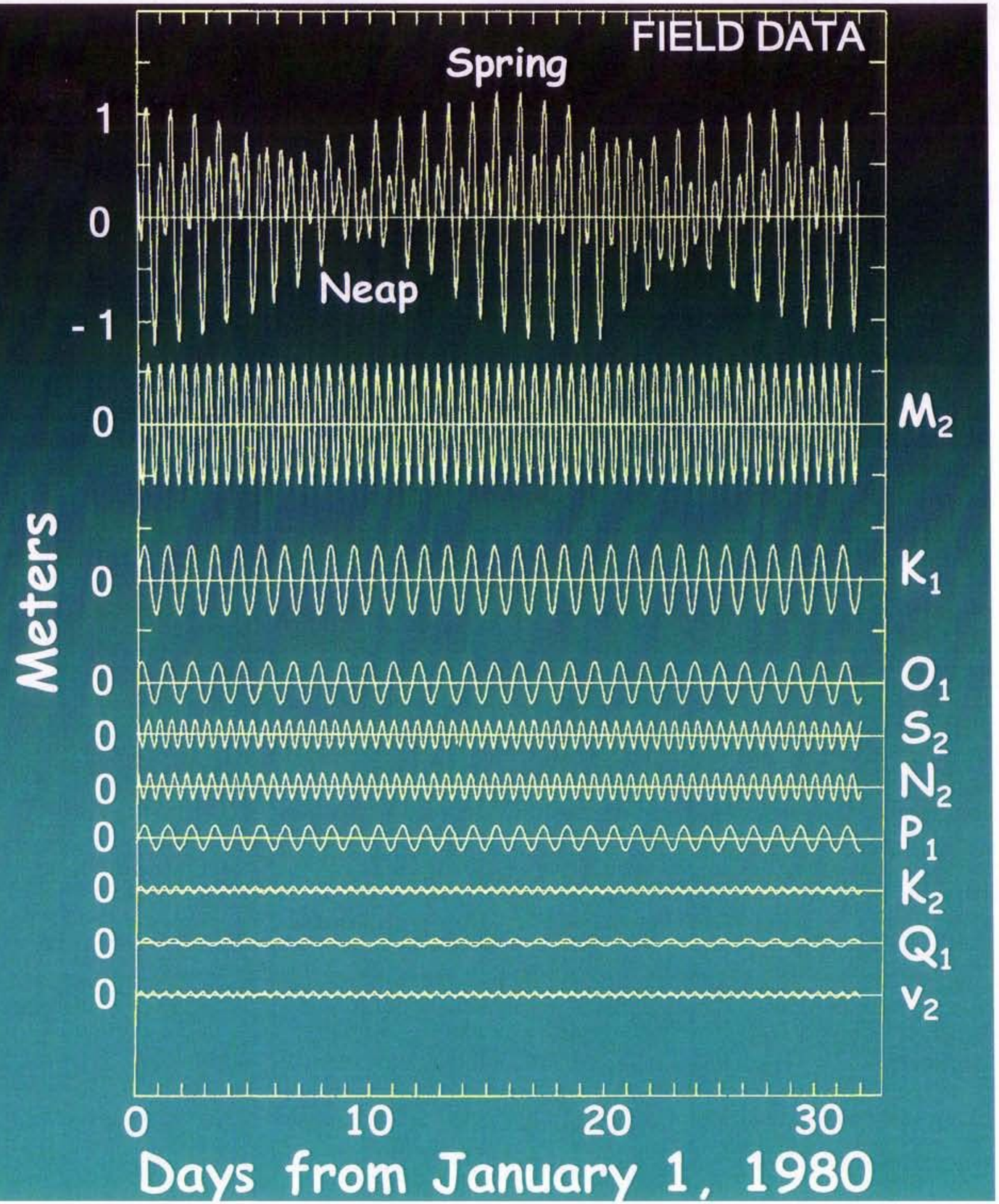
MLLW

Some Principal Tidal Constituents

	Symbol	Period hours
<u>Semi-diurnal (two cycles a day):</u>		
Principal lunar	M_2	12.42
Principal solar	S_2	12.00
Sum of M_2 and S_2 is greater than 90% of energy		
<u>Diurnal (one cycle a day):</u>		
Luni-solar diurnal	K_1	23.93
Principal lunar diurnal	O_1	25.82
Sum of K_1 and O_1 is greater than 90% of energy		

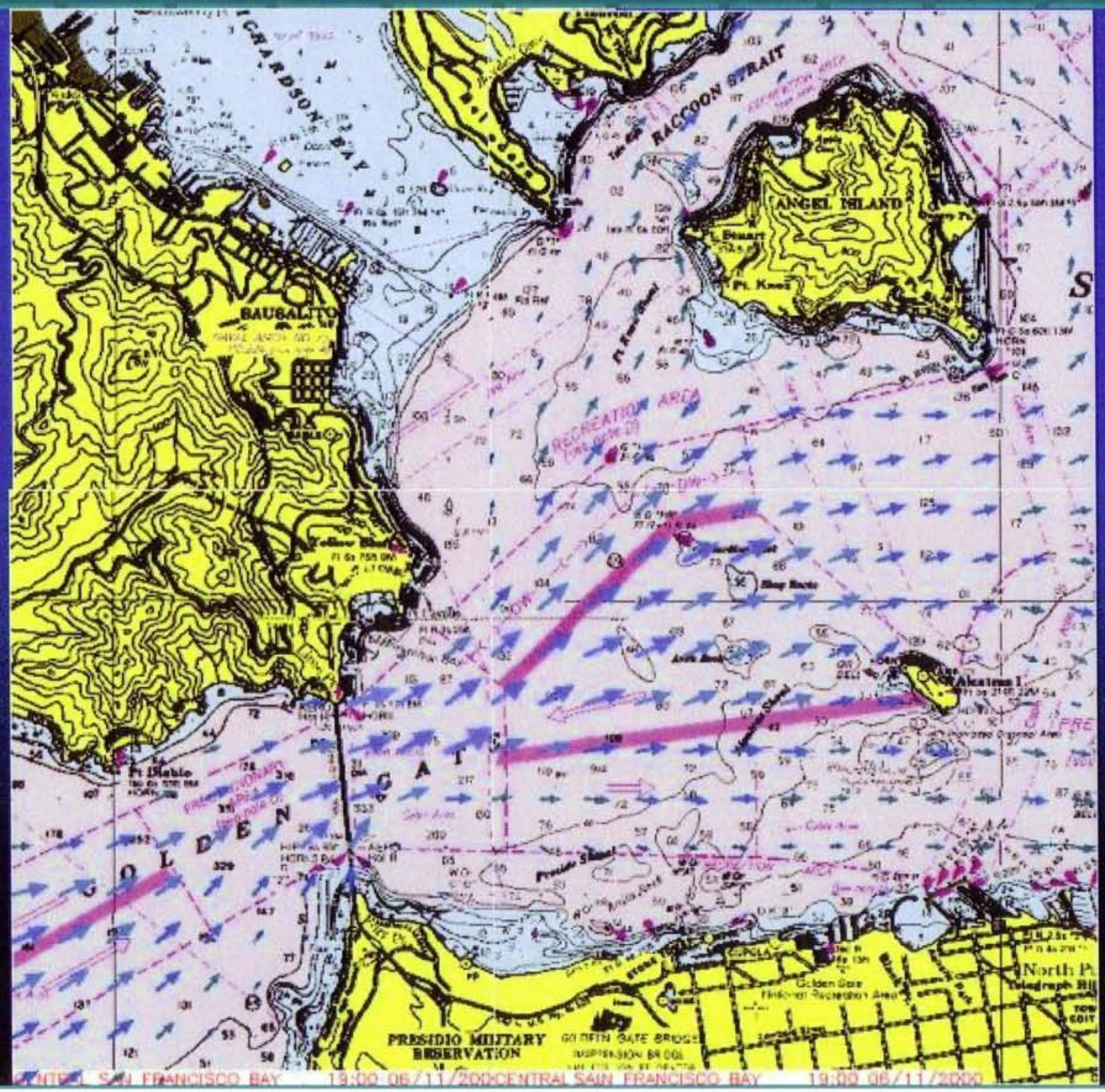
From: Pond and Pickard, 1983

Principal Tidal Constituents at the Golden Gate

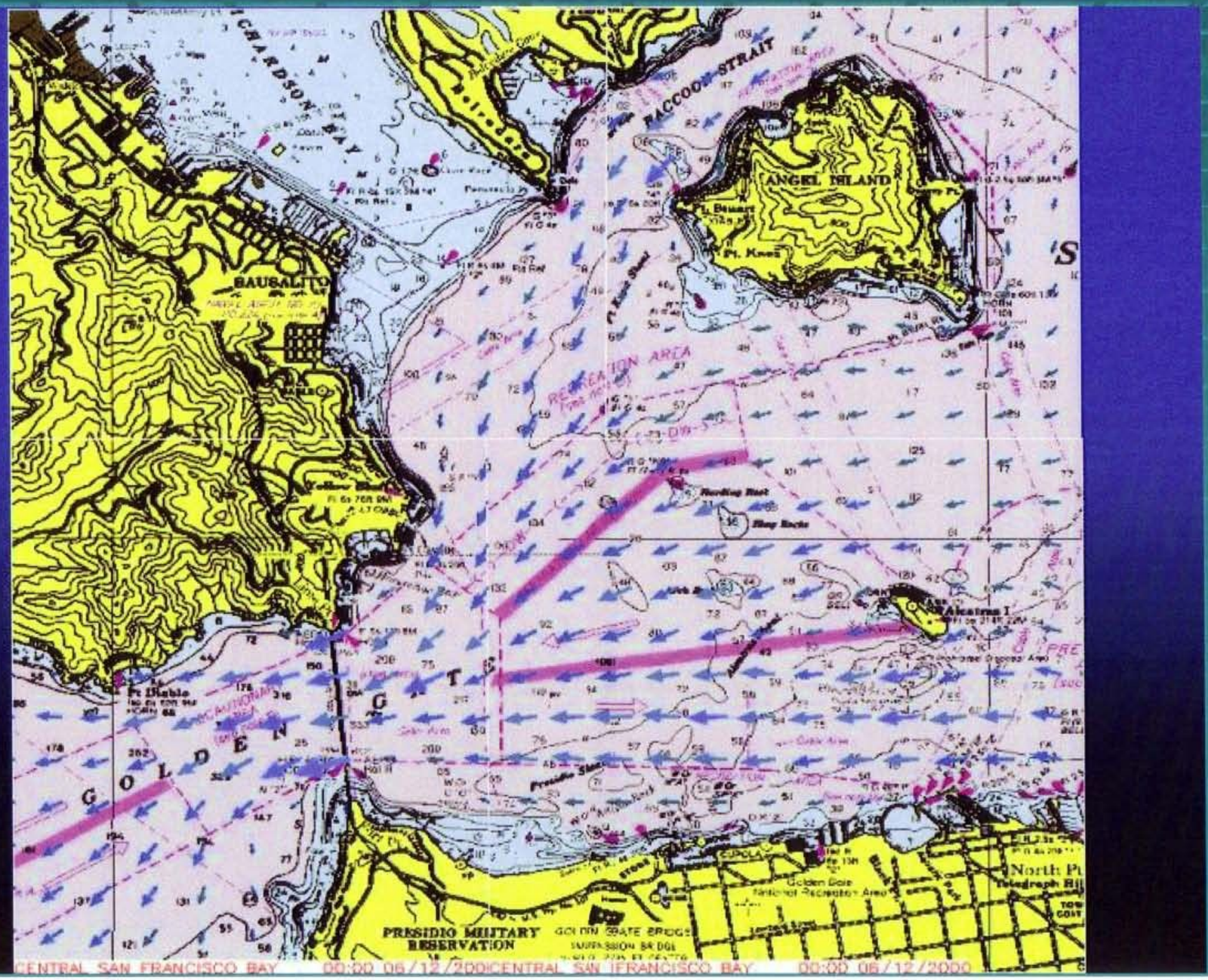


From: Cheng and Gartner, 1984

Rising sea-level in the adjacent ocean "pushes" water into the Bay creating flooding tidal currents



Falling sea-level in the adjacent ocean "draws" water from the Bay resulting in ebbing tidal currents



Concept of Numerical Model of Tides and Tidal Currents

- Based on first principles, fluid motions in the bay are described by a set of conservation equations
- The governing conservation equations are solved numerically giving properties of tides and patterns of tidal currents
- The numerical solutions must be validated against field observations

Concept of Numerical Model of Tides and Tidal Currents

An example of such an application:

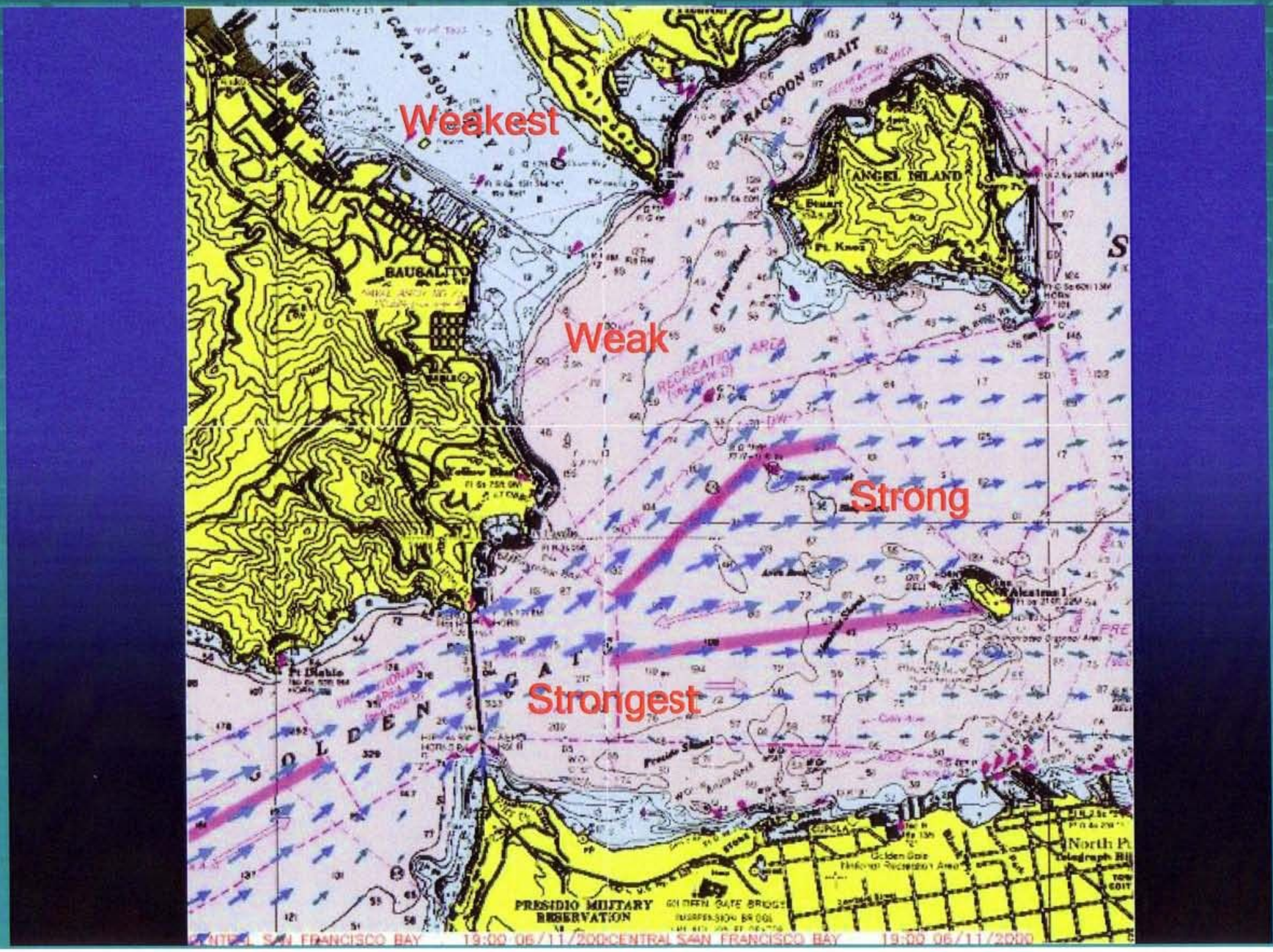
Cheng, R.T., V. Casulli, and J.W. Gartner, 1993, Tidal, residual, intertidal mudflat (TRIM) model and its applications to San Francisco Bay, California, Estuarine, Coastal, and Shelf Science, Vol 36, p. 235-280.

The numerical model has been carefully calibrated and validated against a large field data set collected by the USGS and NOAA.

One of the important conclusions:

Magnitude of tidal current is generally proportional to water depth.

Rising sea-level in the adjacent ocean "pushes" water into the Bay creating flooding tidal currents



Wind pattern over San Francisco Bay Region

- Summer prevailing wind pattern is due largely to "Sea-Land Breeze"

- Winter winds are weak and variable subject to occasional strong wind due to fronts passing through the area

San Francisco Bay Wind Archives

SITE MAP

USGS

San José State University

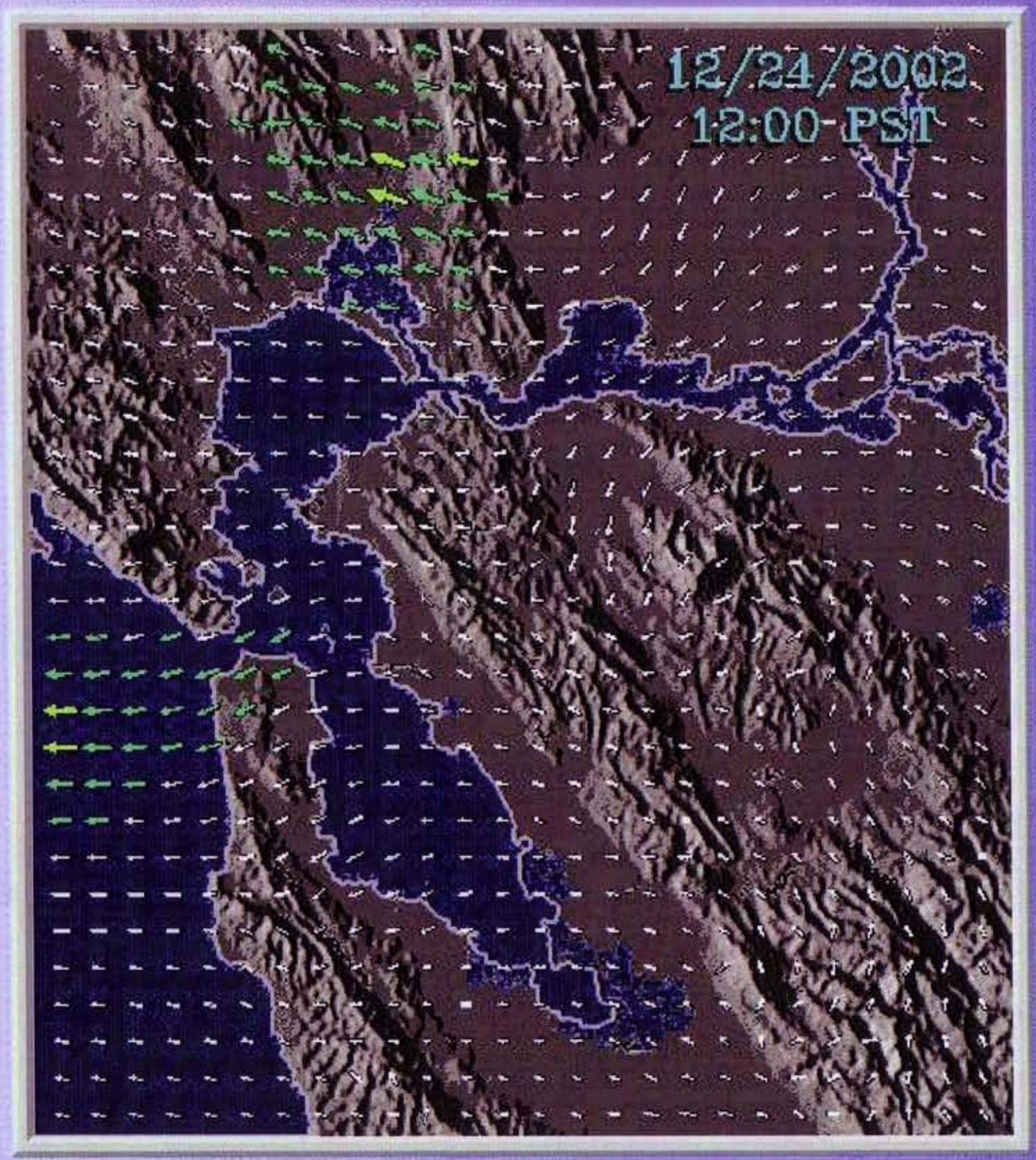
Francis L. Ludwig

Observed Winds for 12/24/2002 1200 PST

HOUR

DAY

MONTH



A typical winter weak wind pattern

Look at

0 - 4.9 | 5 - 9.9 | 10 - 14.9 | 15 - 19.9 | 20 - 24.9 | +25

Click on

San Francisco Bay Wind Archives

SITE MAP

USGS

San José State University

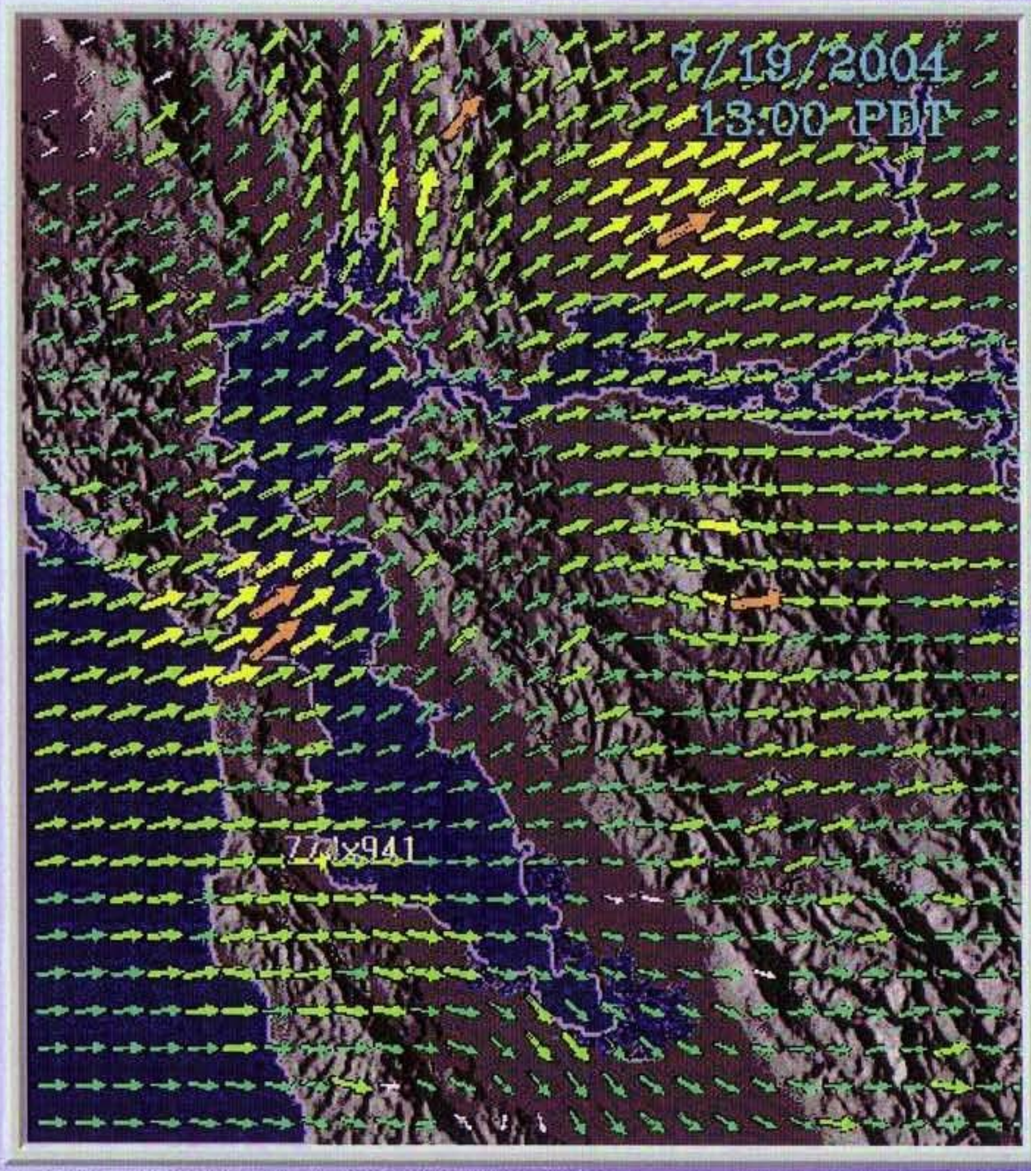
Francis L. Ludwig

Observed Winds for 7/19/2004 1200 PST

HOUR

DAY

MONTH



A typical summer prevailing wind

Look at Most

0 - 4.9 | 5 - 9.9 | 10 - 14.9 | 15 - 19.9 | 20 - 24.9 | +25

Wind Speed: 14 knots

San Francisco Bay Wind Archives

SITE MAP

USGS

San José State University

Francis L. Ludwig

Observed Winds for 4/12/2003 1200 PST

HOUR

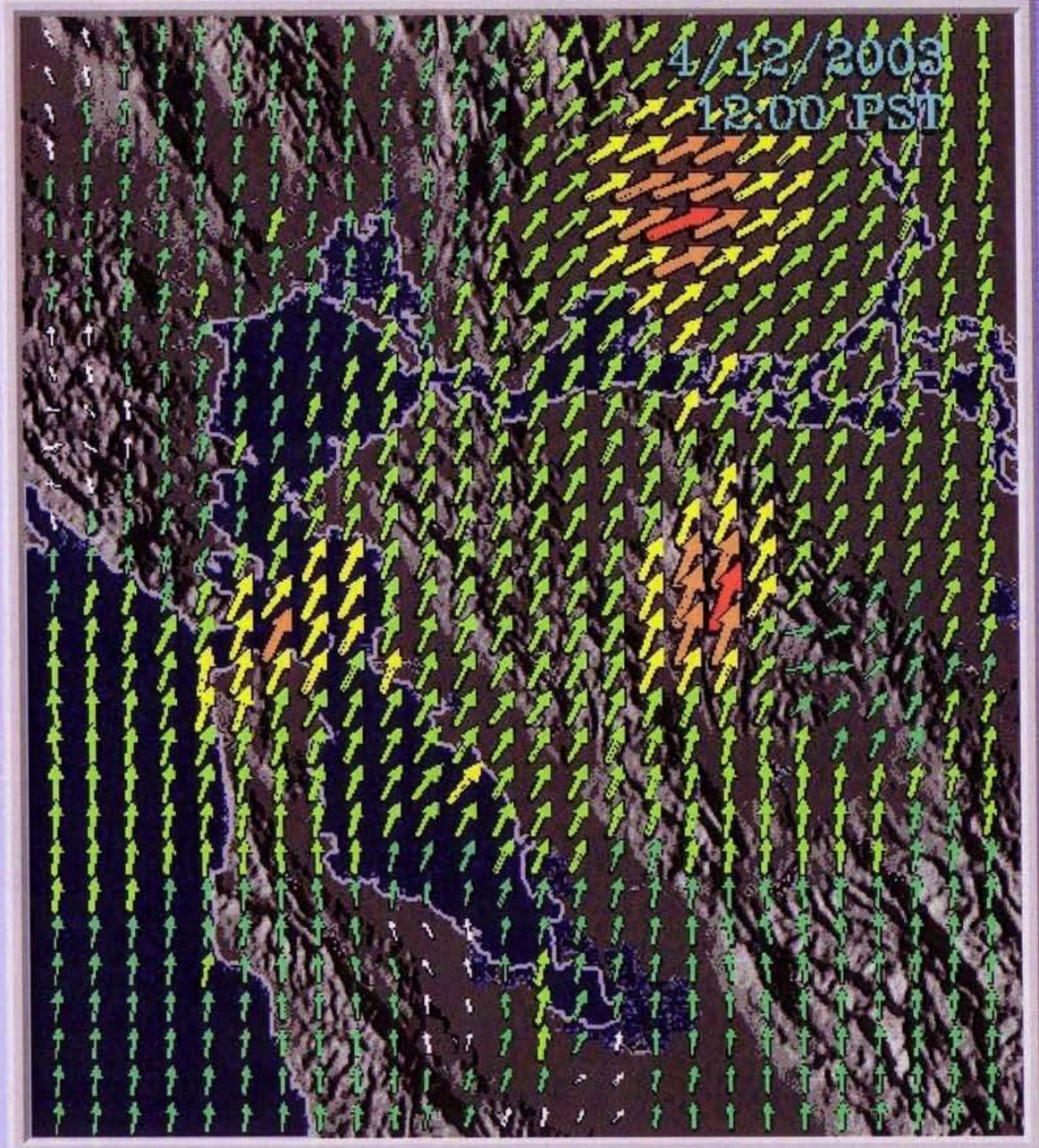
-4 -2 +2 +4

DAY

-4 -2 +2 +4

MONTH

-4 -2 +2 +4



An example of winter storm front

0 - 4.9 | 5 - 9.9 | 10 - 14.9 | 15 - 19.9 | 20 - 24.9 | +25

Wind Speed:
16 knots

Look at

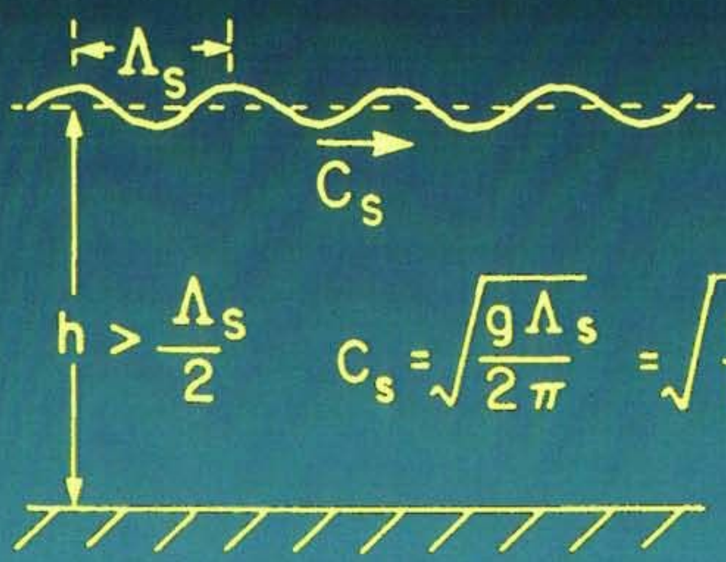
Effects of Wind over water

- Winds create short waves whose energies propagate to the bottom of the water column may cause erosion and suspension of sediments (or debris)

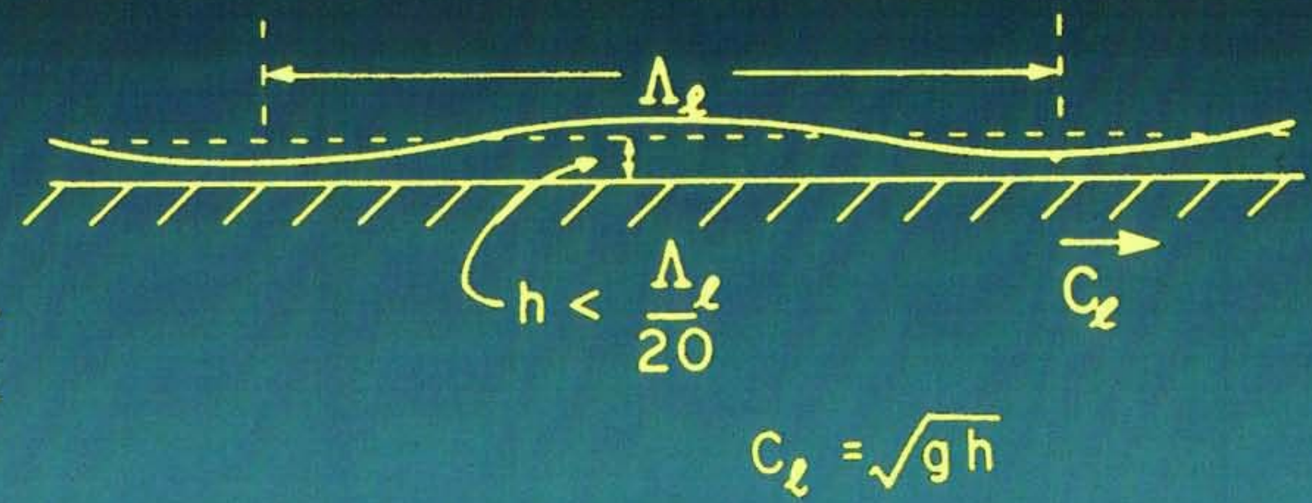
- Wind stress on free-surface "drags" the water mass in the direction of wind (wind drift) at approximately 2-3% the wind speed

Short and Long Waves

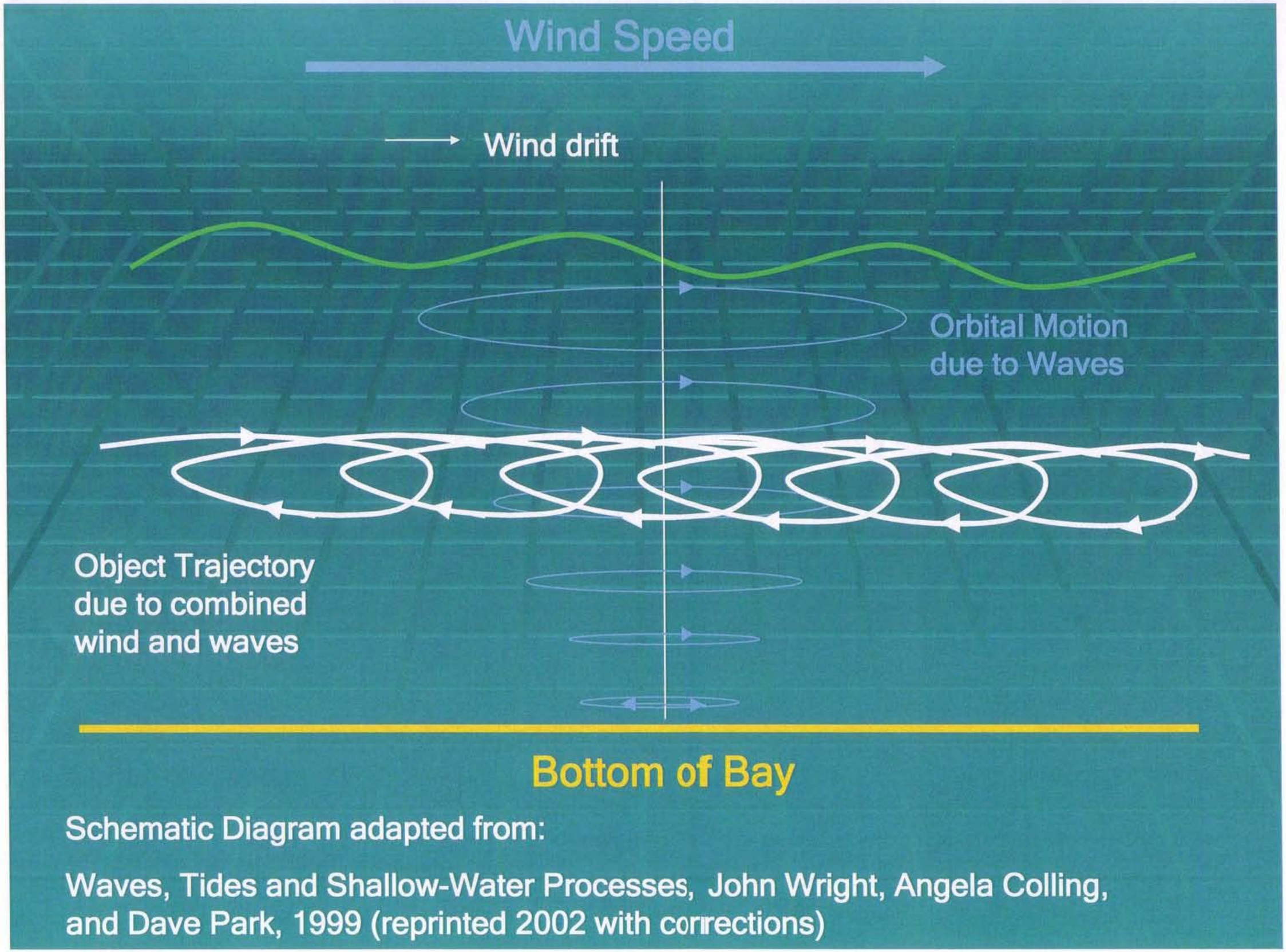
Short (Deep Water) Wave



Long (Shallow Water) Wave



Schematic diagram not to scale



Schematic Diagram adapted from:

Waves, Tides and Shallow-Water Processes, John Wright, Angela Colling, and Dave Park, 1999 (reprinted 2002 with corrections)

Summary

- Tides, tidal currents, winds and waves are important factors affecting the movement of an object in the bay

- The astronomical tides and tidal currents are predictable by a validated numerical model. The magnitude of tidal current is generally proportional to local water depth

- The Wind and Tides near Richmond, CA are plotted in the following two slides

Tides and Winds near Richmond, CA

San Francisco Bay Wind Archives

SITE MAP

USGS

San José State University

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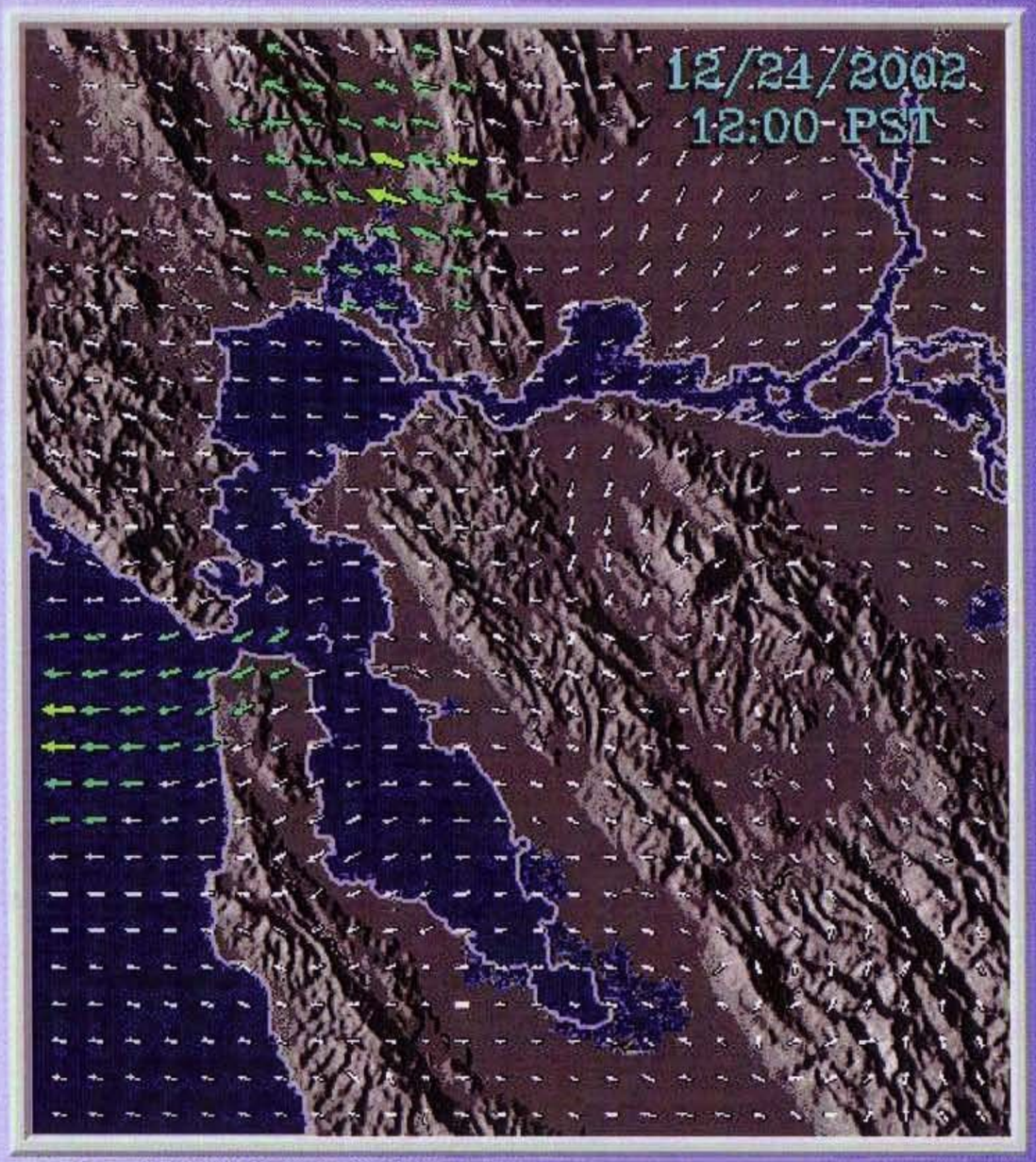
Observed Winds for 12/24/2002 1200 PST

HOUR

DAY

MONTH



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Look at

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Click on

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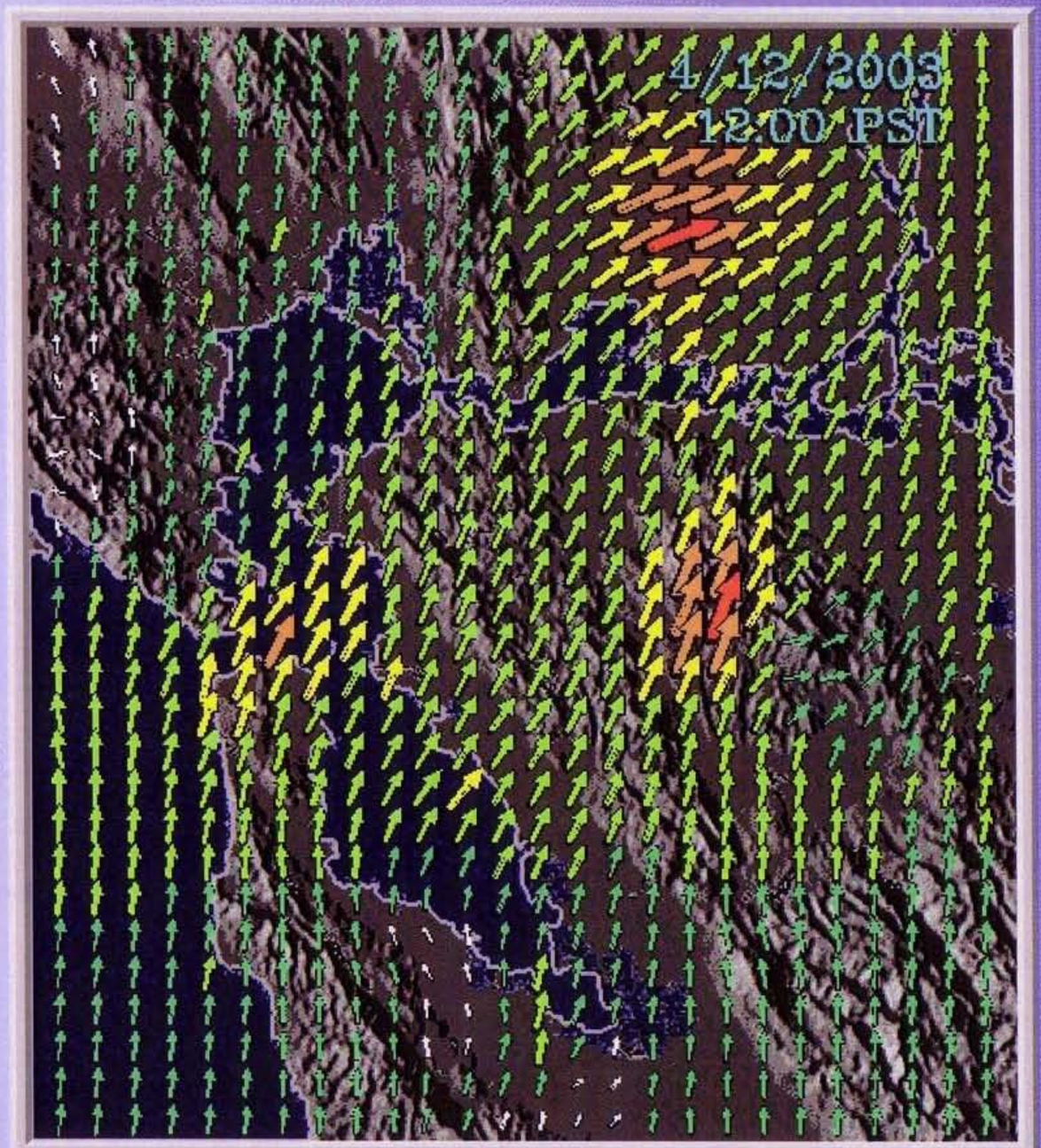
Observed Winds for
4/12/2003 1200 PST

HOUR
-4 -2 +2 +4

DAY
-4 -2 +2 +4

MONTH
-4 -2 +2 +4



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