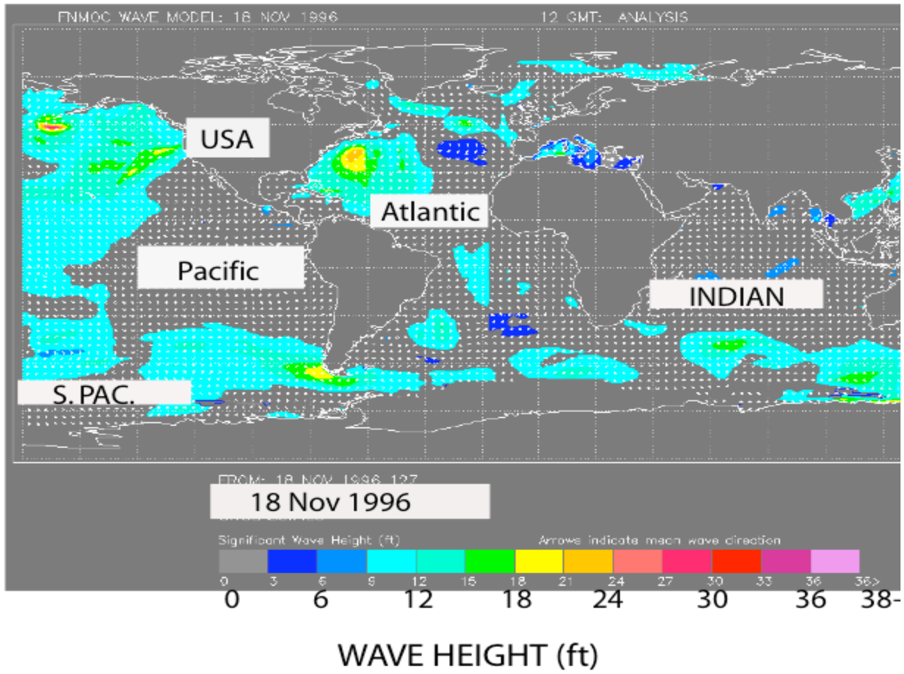
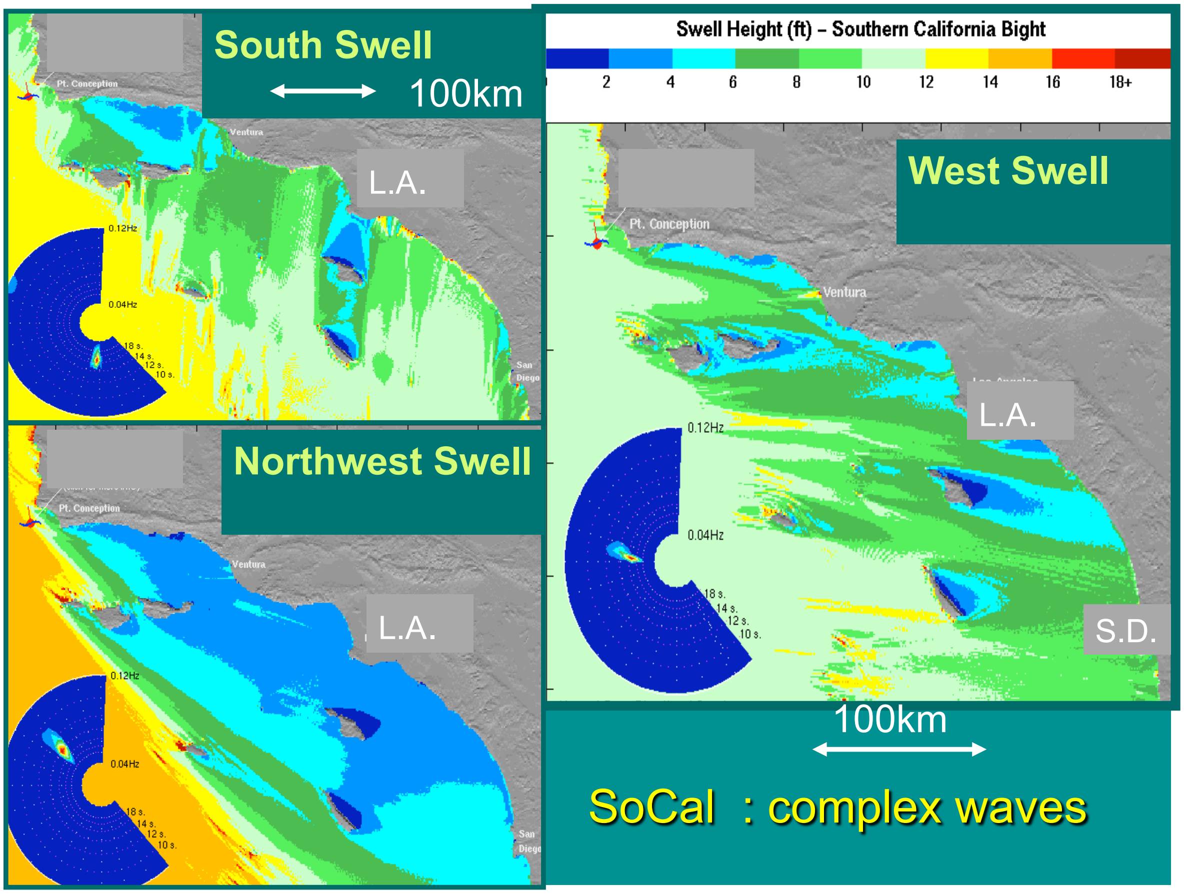
Bob Guza, Scripps   Inst. Oceanography

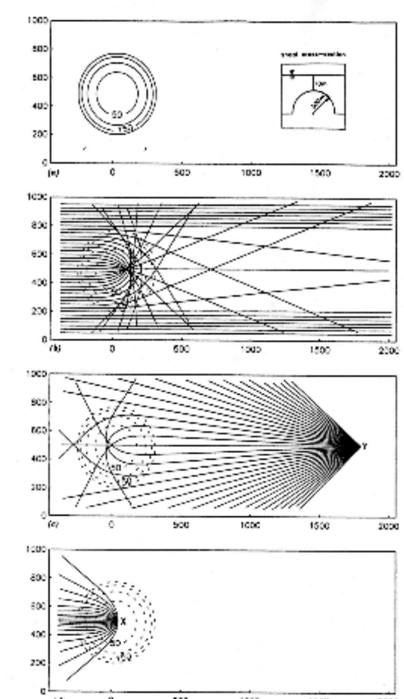
California waves & wave-driven processes

Ocean swell waves, generated by storms,travel across ocean basins in a few days

FNMOC WAVE MODEL







1. Forward (Left to Right) and Back-Refracted Rays over Circular Shoal.
th Contours and Axes are in Meters; Wave Frequency, f = 0.06 Hz: (a) Circular
al Configuration. Bottom Depth around Shoal = 310 m; (b) Forward-Refracted
es, Initial Ray Spacing = 25 m, Initial Angle = 180°; (c) Back-Refracted Waves,
al Angle Spacing = 2.5°; (d) Back-Refracted Rays, Initial Angle Spacing = 10°

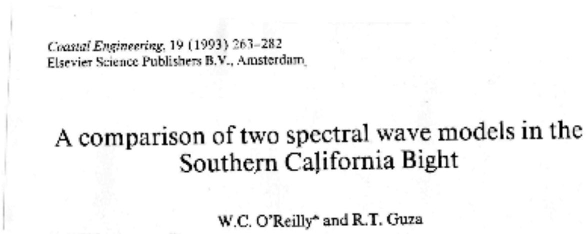
Comparison of Spectral Refraction and Refraction-Diffraction Wave Models

By W. C. O'Reilly,[1] Member, ASCE, and R. T. Guza[2]

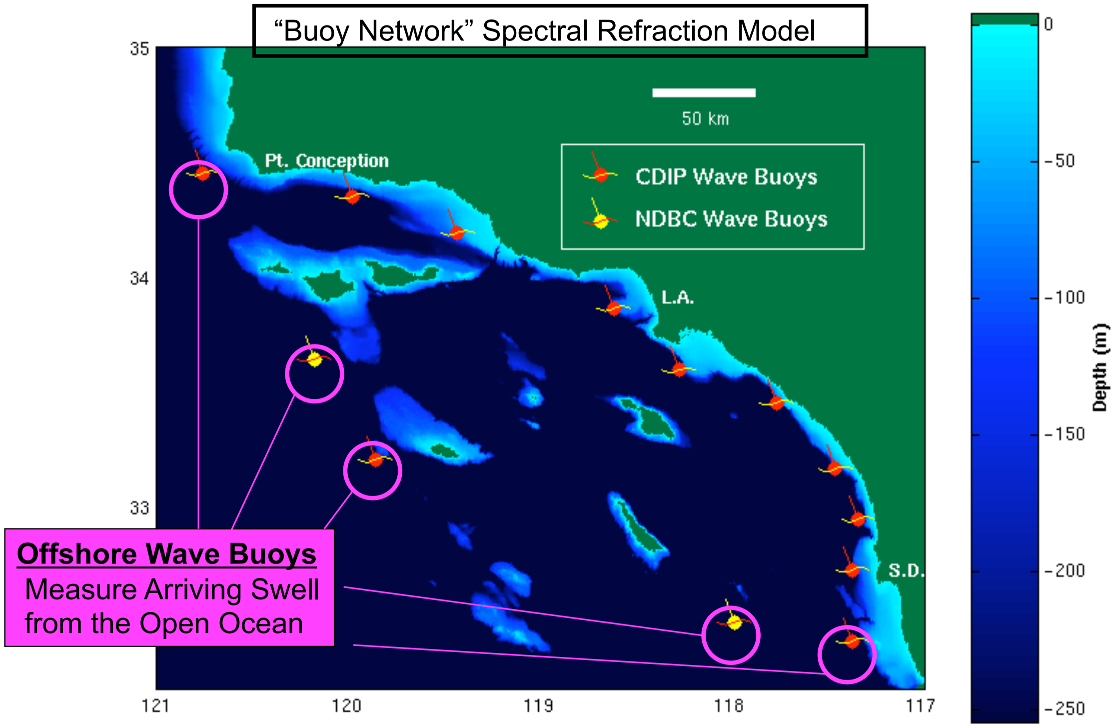
Abstract: Wave energy estimated from linear, spectral wave propagation models incorporating refraction and refraction-diffraction are compared over two bottom configurations: an analytic circular shoal and relatively smooth coastal bathymetry from San Diego, California. The agreement between the two models improves with an increase in the width of the incident directional spectrum and with a decrease in the complexity of the local bathymetry. There are, however, significant differences between the model transformations of directionally narrow spectra on both bathymetries. Pure refraction models are not quantitatively accurate in these cases. These comparisons also demonstrate the importance of directional wave spreading in transformations over even relatively simple natural bathymetry. Data from a fundamentally low-resolution pitch-and-roll buoy, if used as the sole source of directional information for incident waves, can lead to significant uncertainty in wave heights estimated by the refraction-diffraction model.

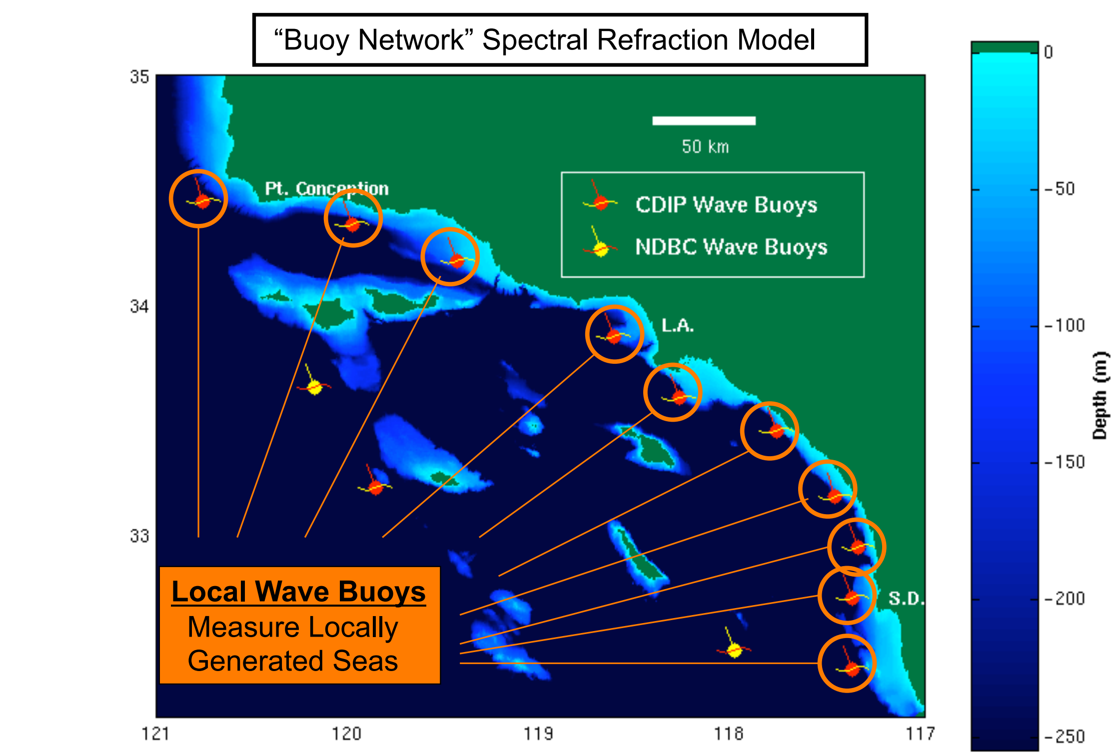
Introduction

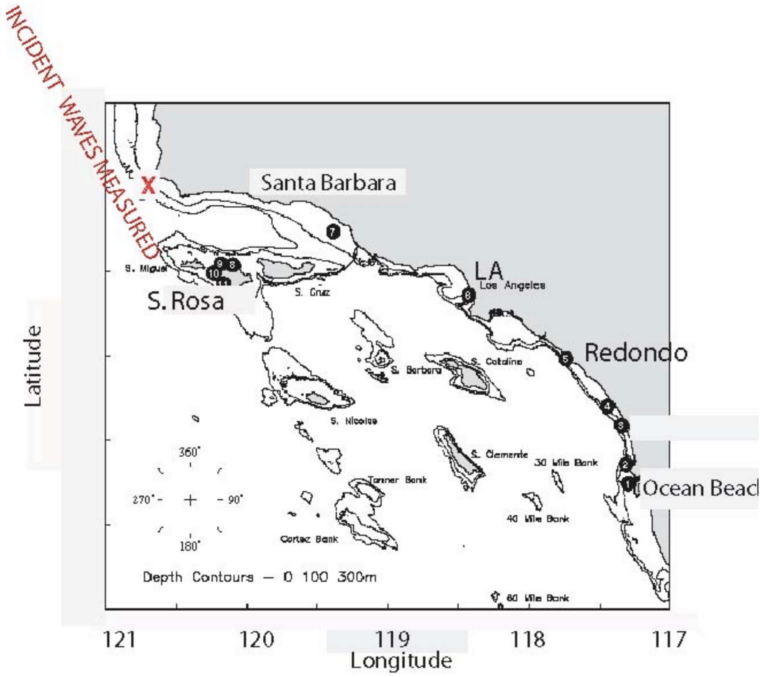
This paper is part of the ***Journal of Waterway, Port, Coastal, and Ocean Engineering***, Vol. 117, No. 3, May/June, 1991. ©ASCE, ISSN 0733-950X/91/0003-0199/$1.00 + $.15 per page. Paper No. 25795.



BILL O'REILLY et al



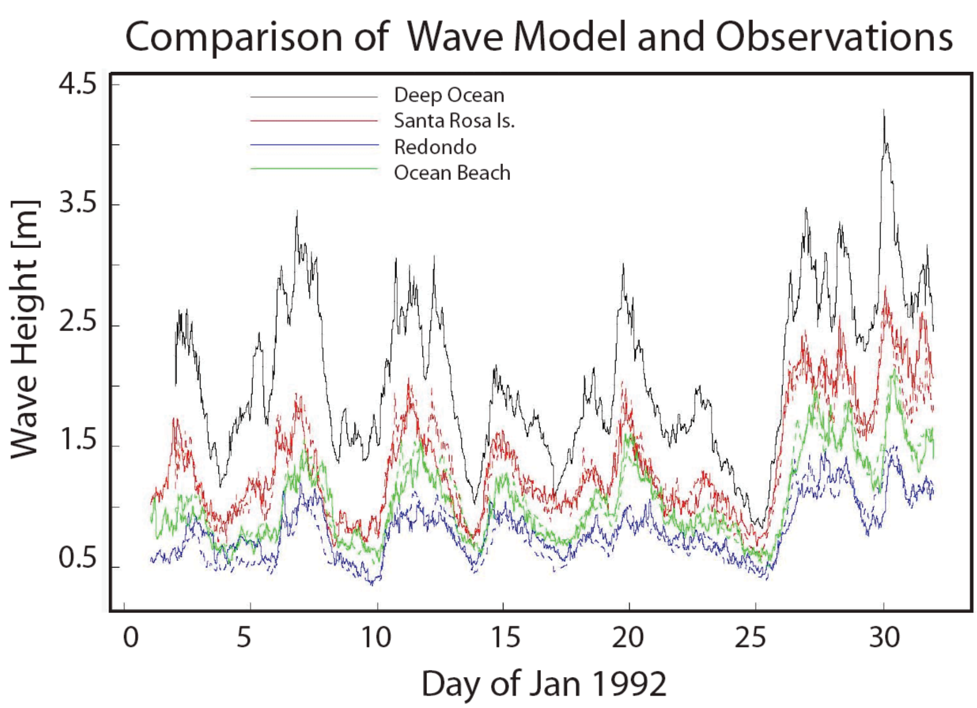




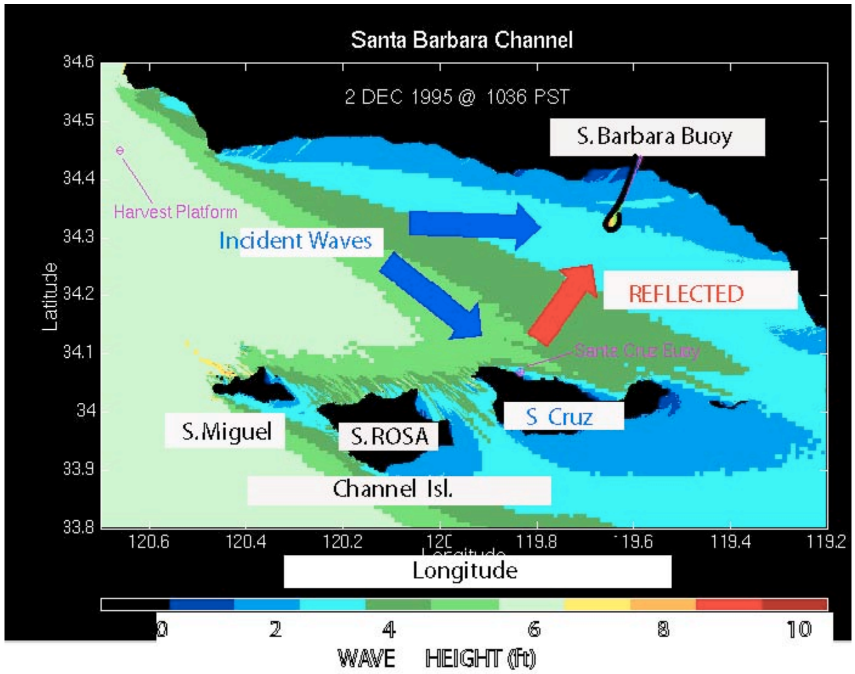
MODEL TEST

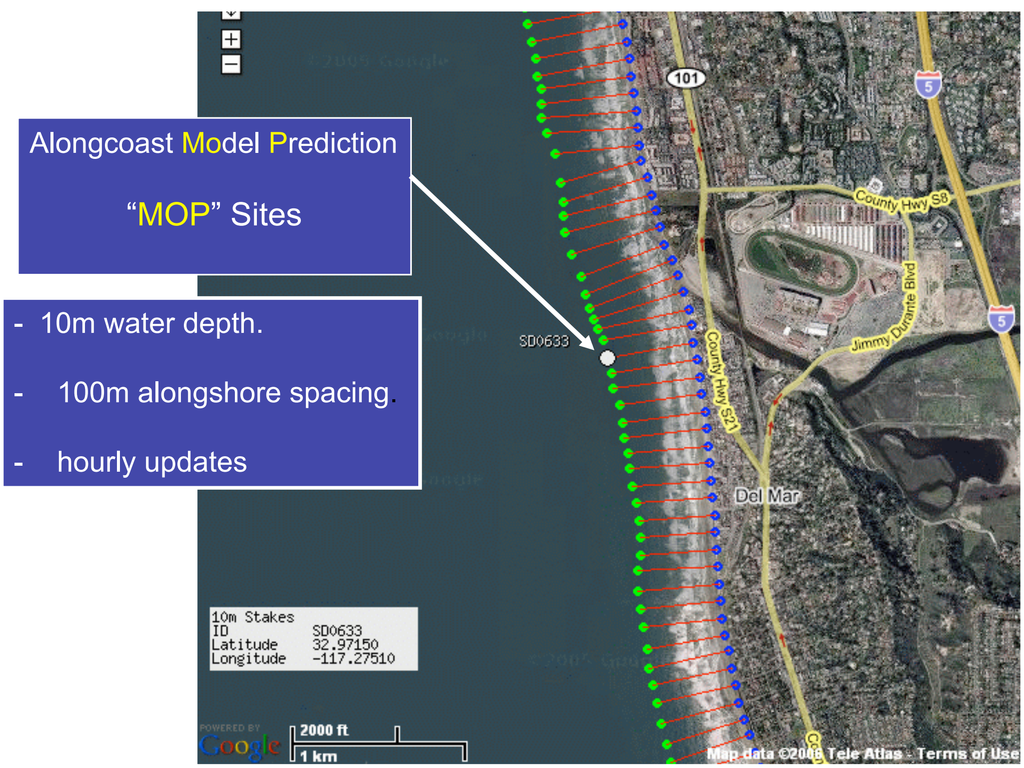
WINTER SITES : SoCal 91 Waves Experiment

O'Reilly et al



Waves reflect from the rocky Channel Islands





*Goal : Couple Regional (basin-scale) waves

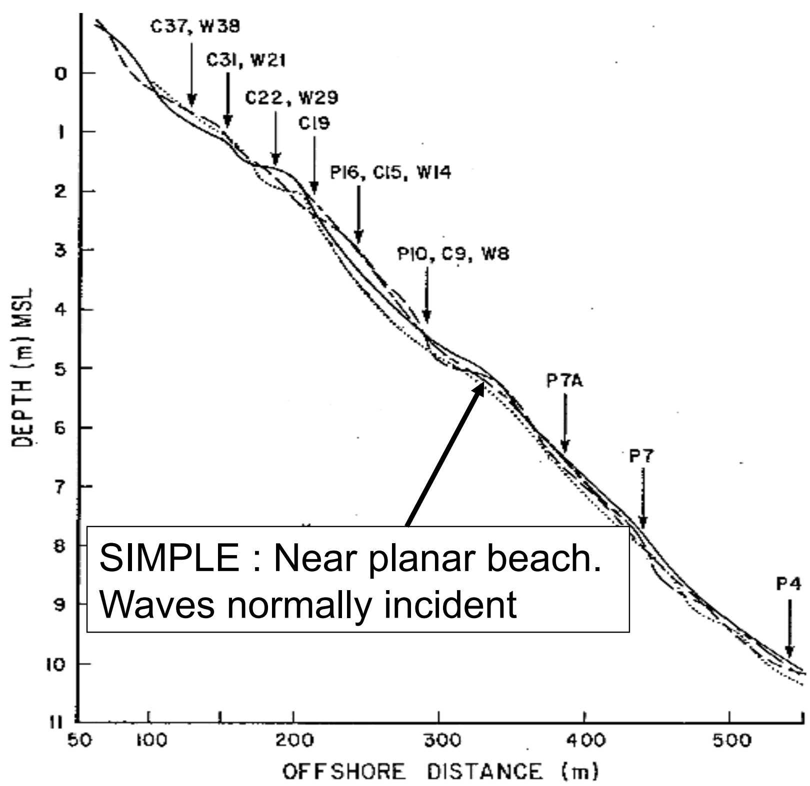
+

models for surfzone processes

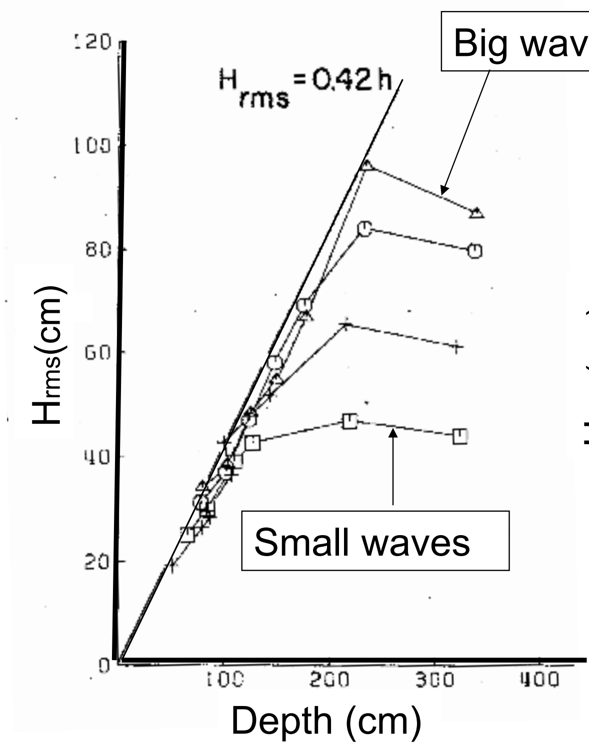
* We have : waves in 10m depth

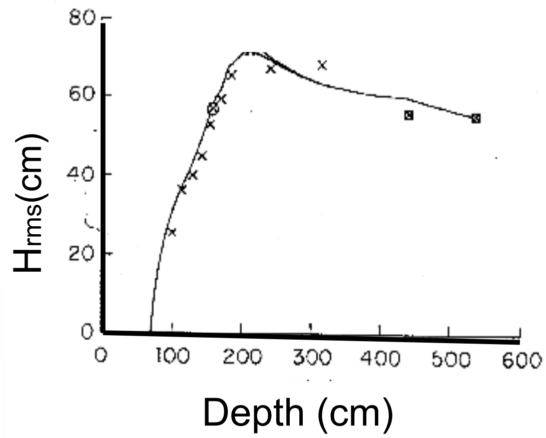
•Next : models for small scale, wave-driven processes.
(Surfzone dynamics in 15 minutes)

Wave Evolution from ‘deep’ (10m) to the Shoreline

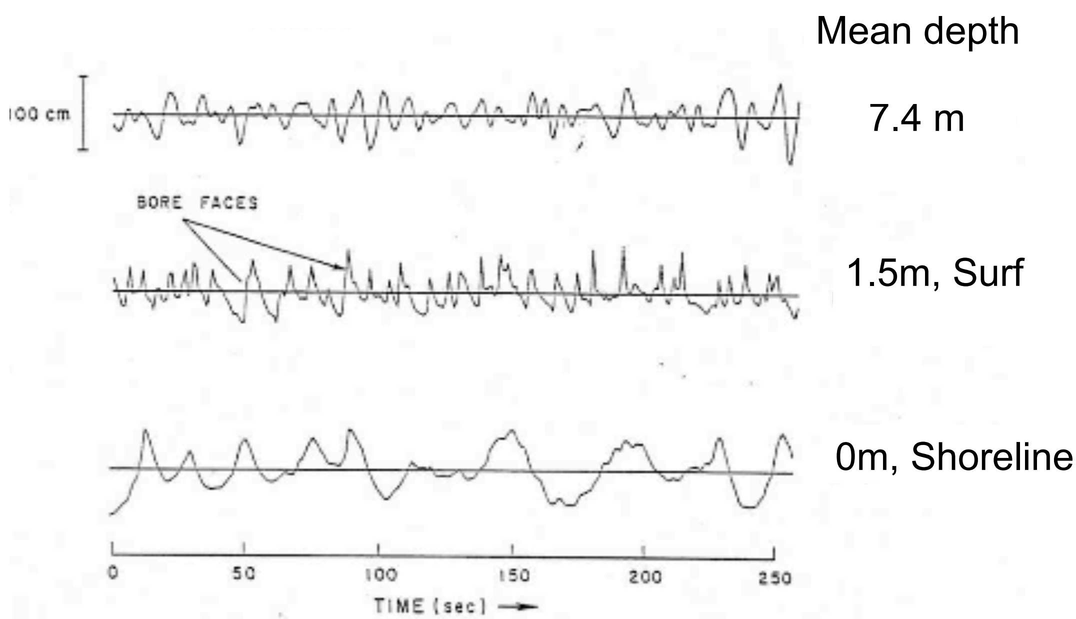


Sea-swell wave heights = depth limited = Operational model



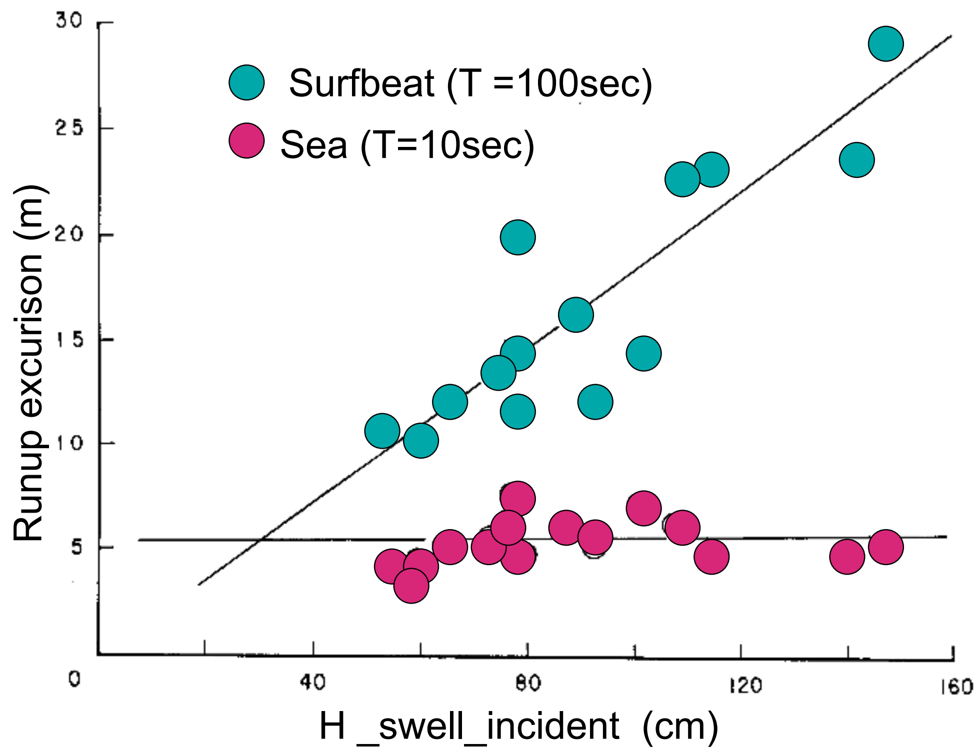


Wave shoaling & breaking : nonlinear energy transfer



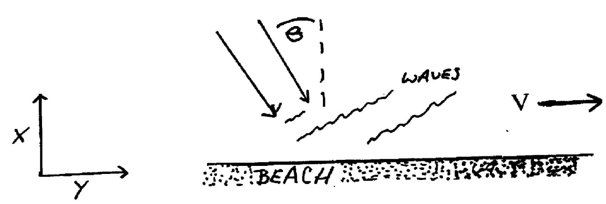
Low frequency (1 min)
waves can dominate

With Big Waves, Shoreline swash dominated by surfbeat



LONGSHORE CURRENTS ON SIMPLE BATHYMETRY

Time & depth-averaged longshore (V) currents



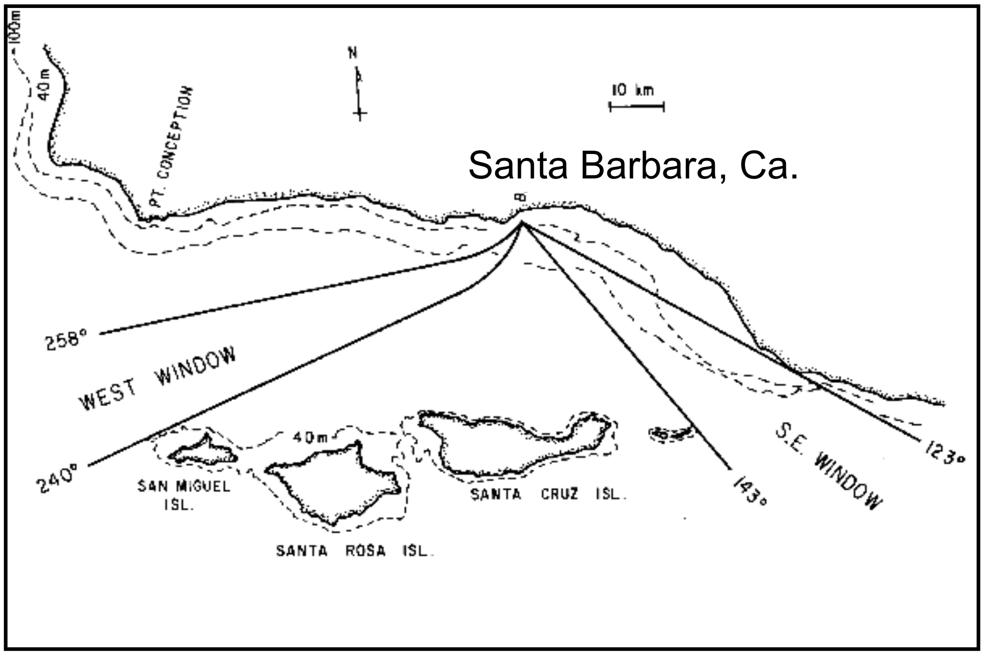
$$\frac{\tau_y^B(\mathbf{V})}{\rho} = -gh\frac{\partial \bar{\eta}}{\partial y} - \frac{1}{\rho}\left(\frac{\partial S_{yy}}{\partial y} + \frac{\partial S_{yx}}{\partial x}\right)$$ **+ roller + mixing**

drag tilt breaking

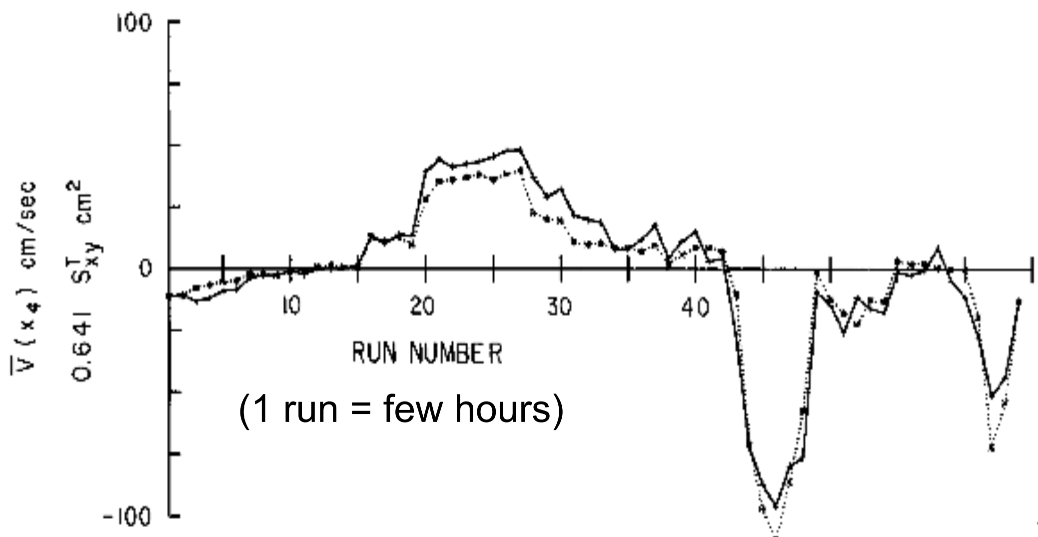
$$V \approx \frac{\partial (E\ \theta)}{\partial x}$$

E is wave energy, θ is wave angle

V depends only on dissipation rate and angle of breaking waves!



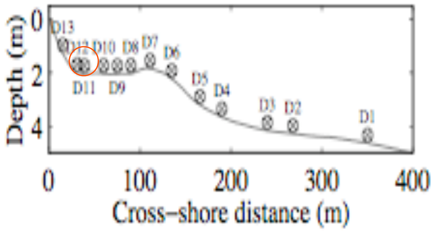
Obliquely incident waves = alongshore current

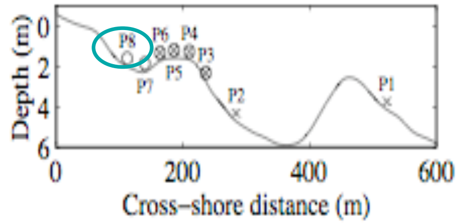


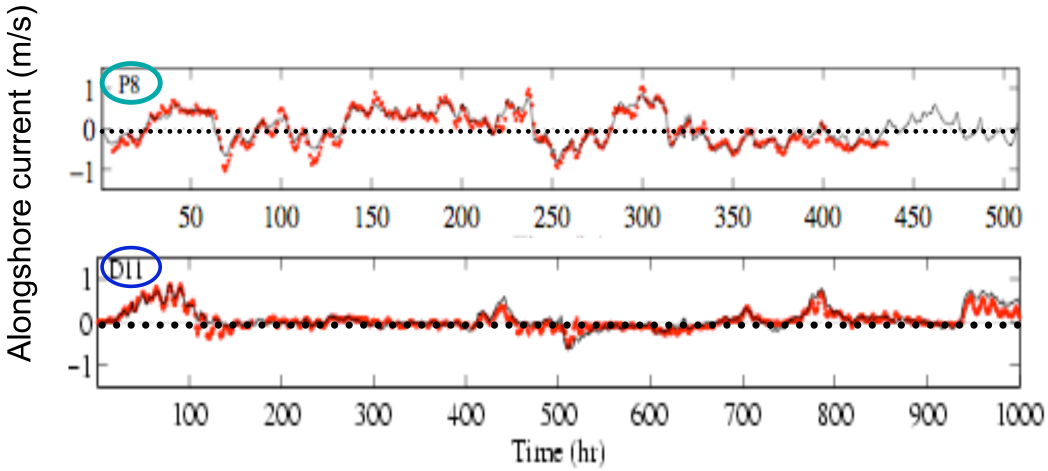
Sxy_total STRONGLY correlated with V_alongshore.

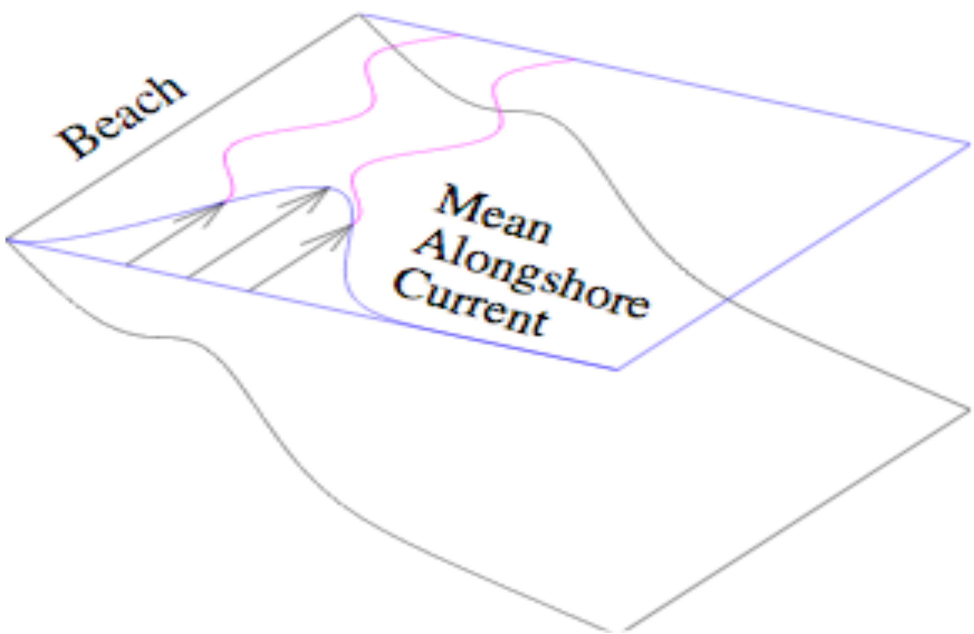
Waves from opposing quadrants can cancel (V=0)

Duck, NC. SAND BARS Egmond, Holland



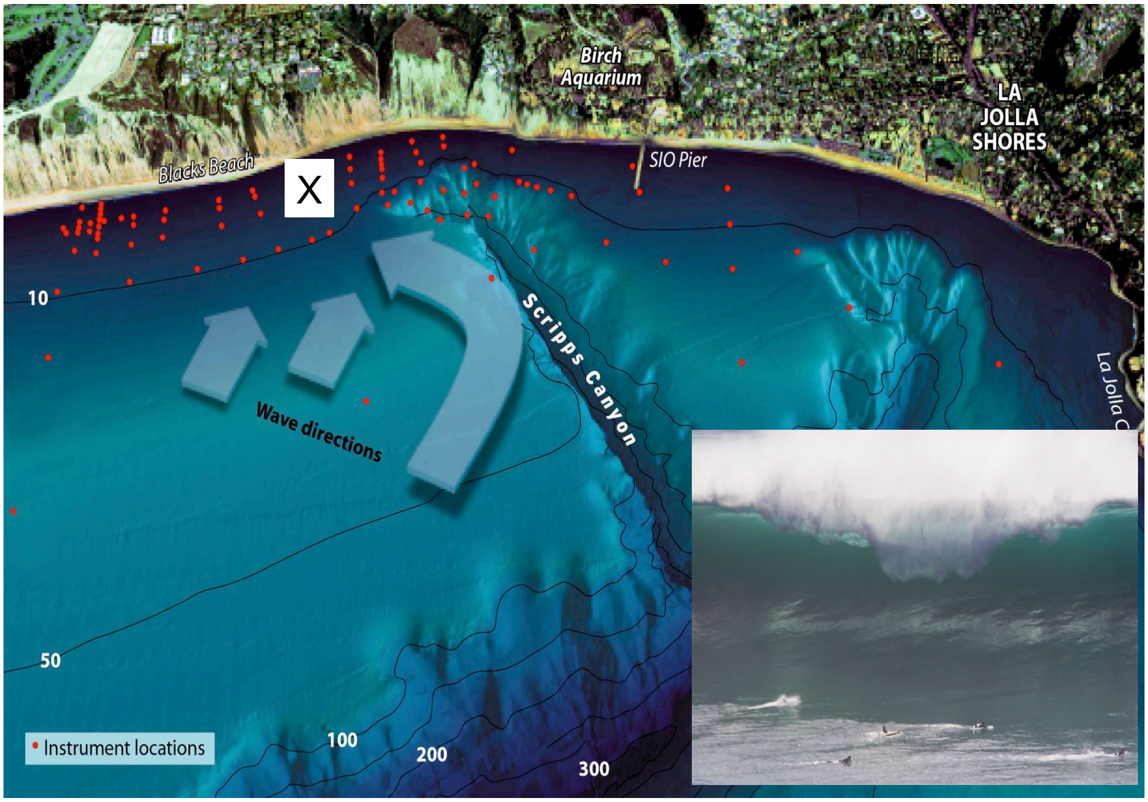


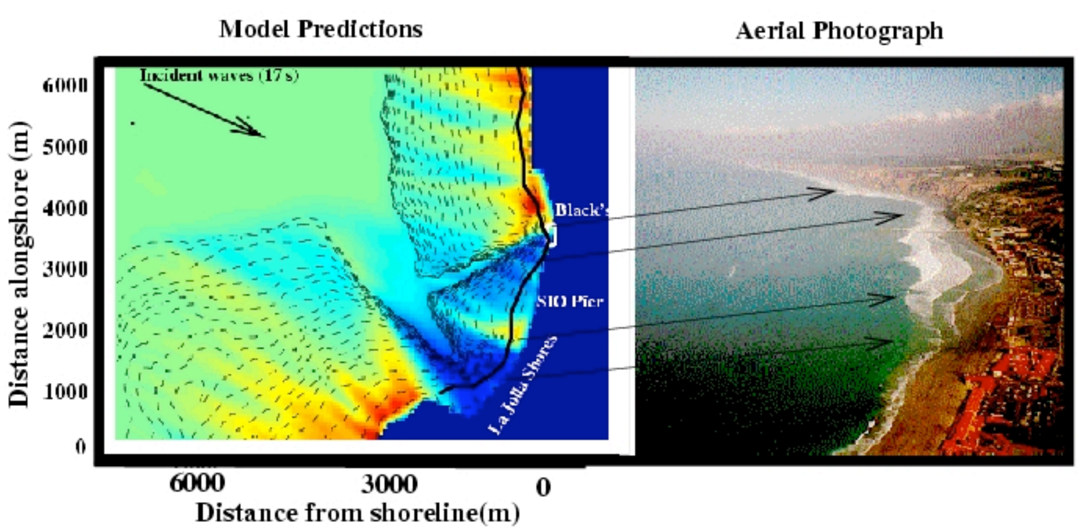


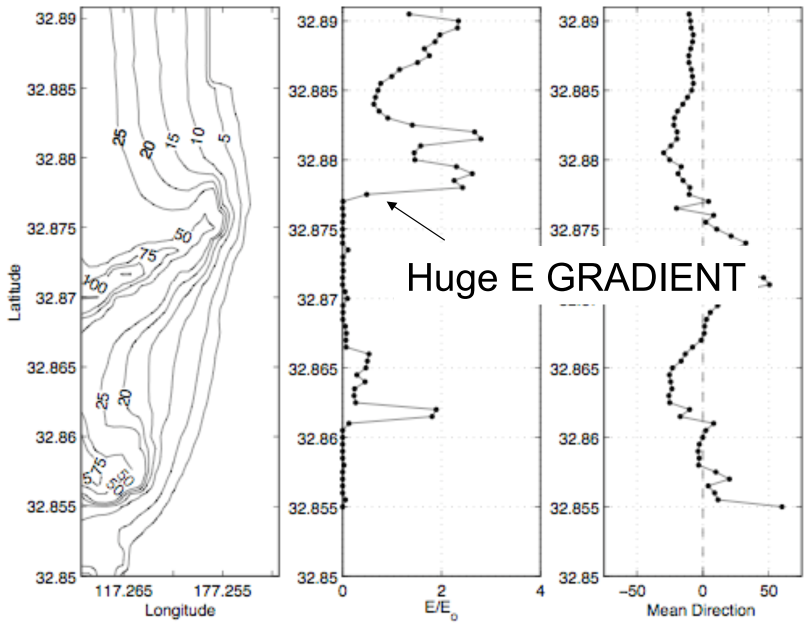


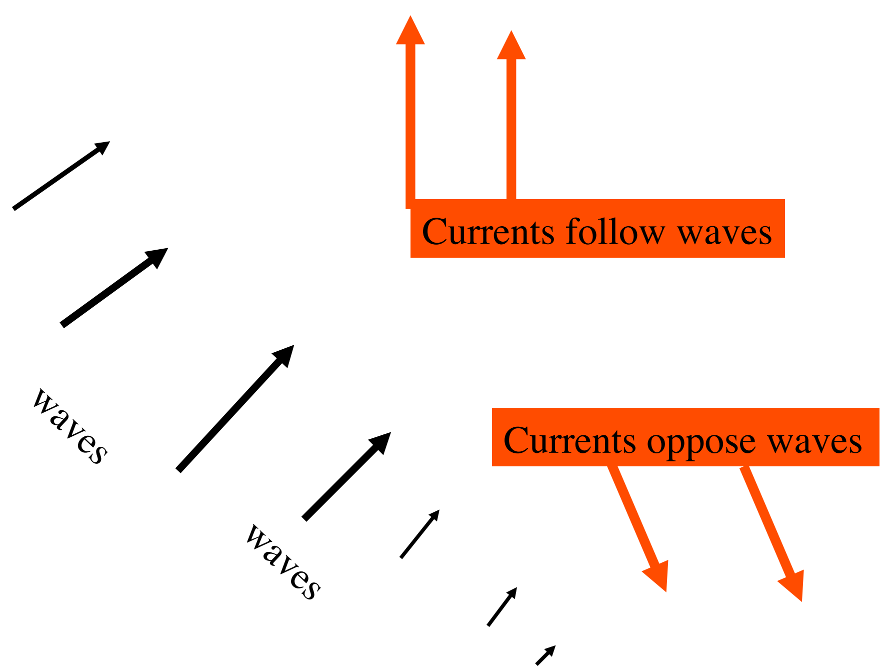
Sheared Mean current is unstable = meanders

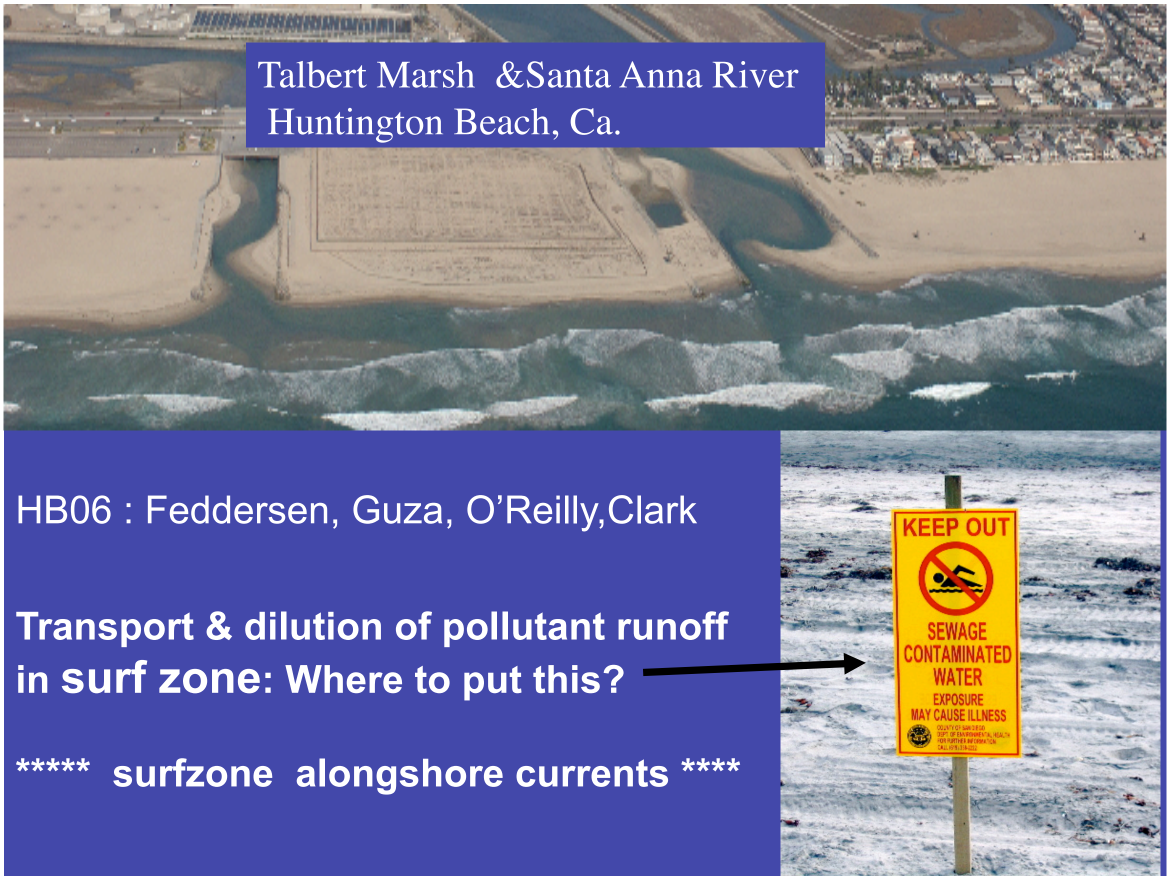
Nearshore Canyon Experiment (NCEX) : strong alongshore variations

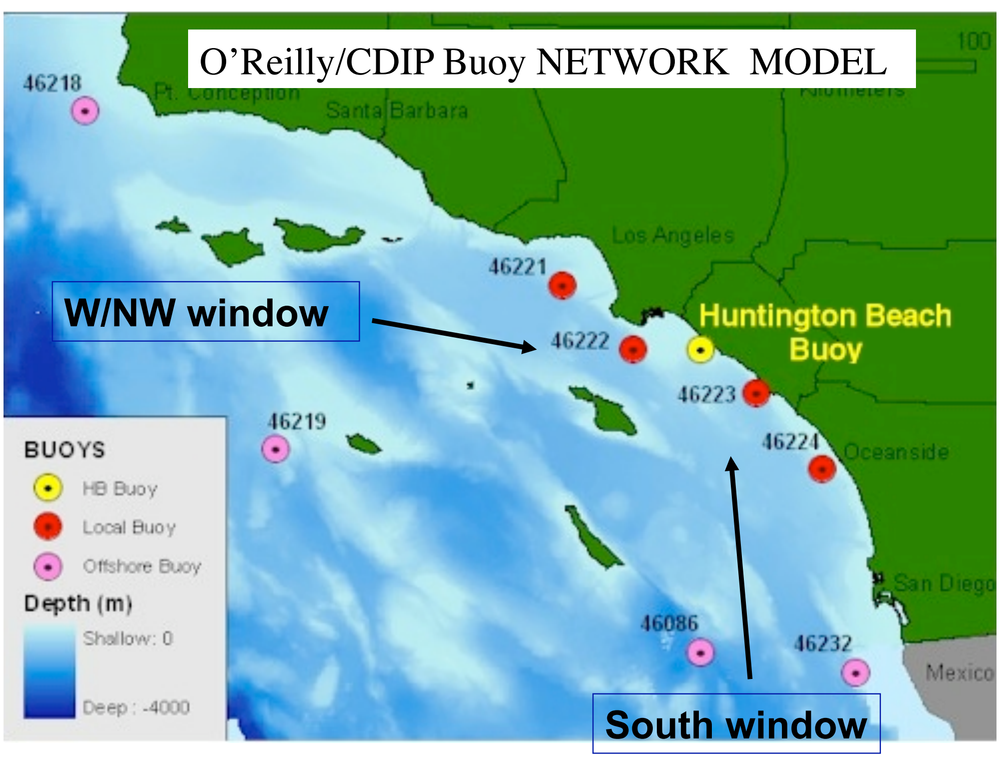


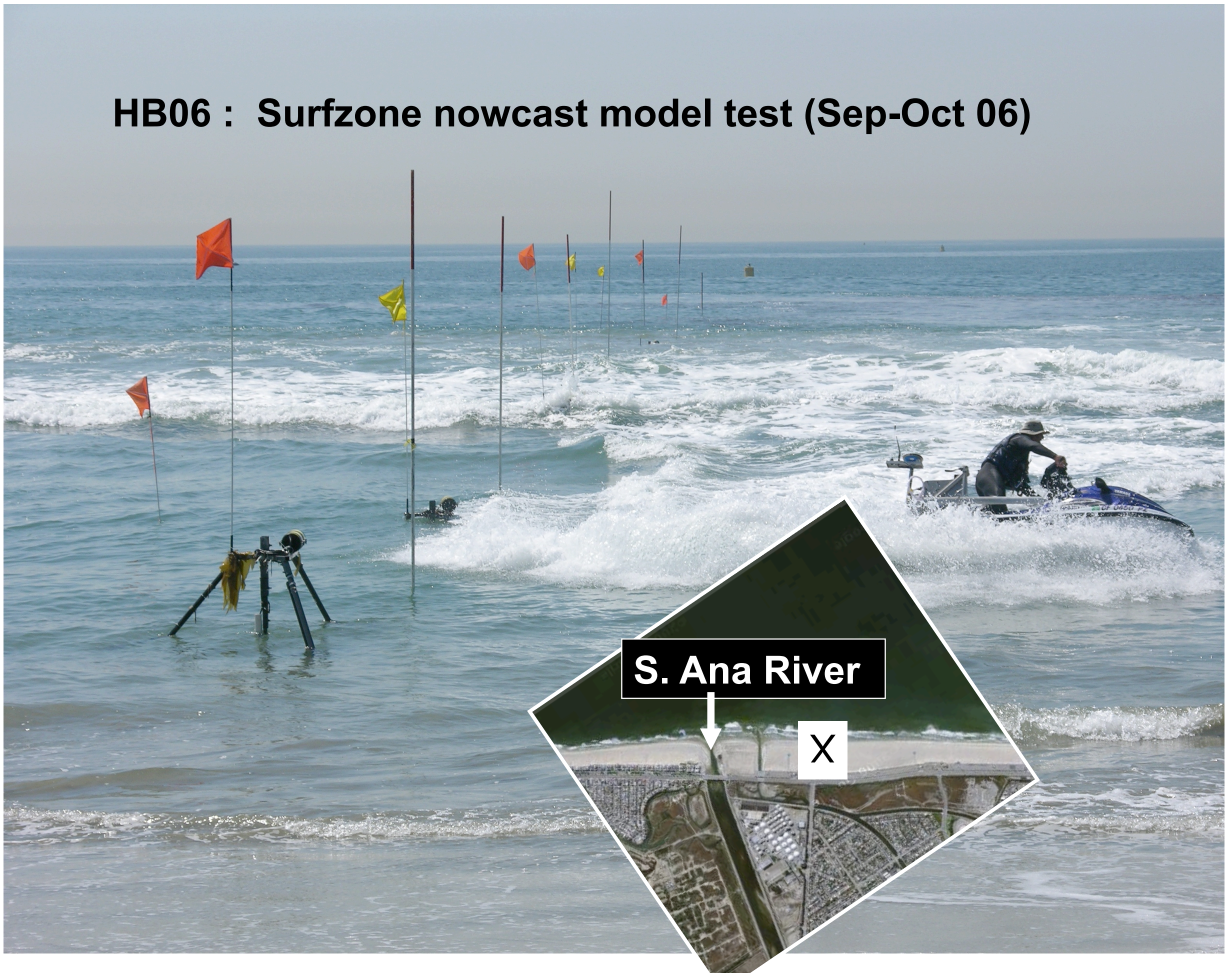


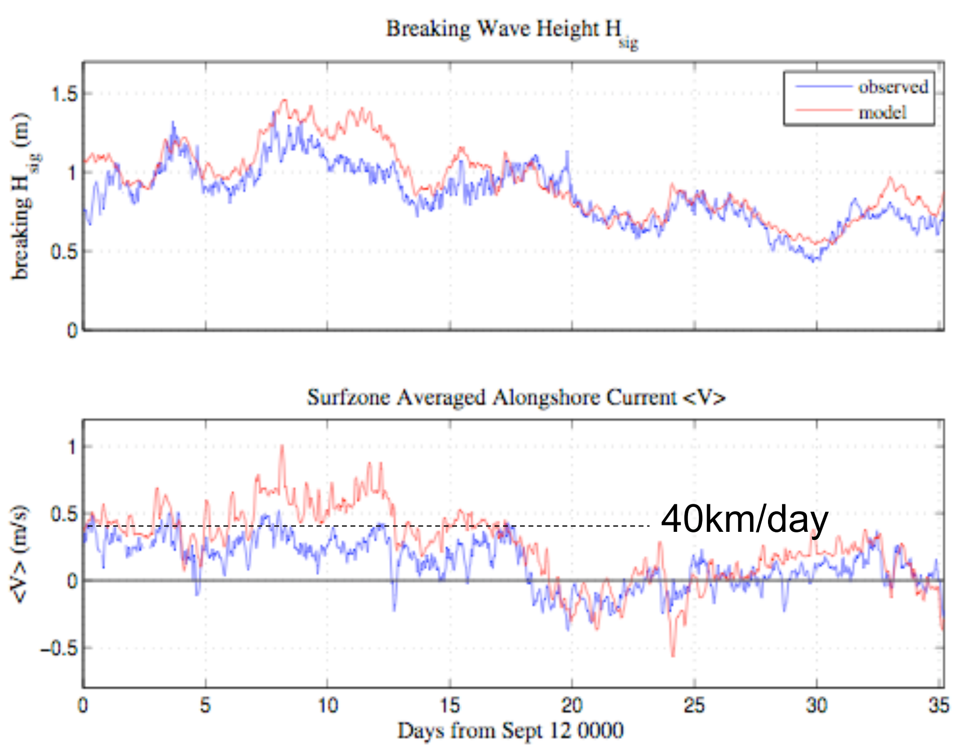

Latitude
Longitude
117.265
177.255
E/E$_0$
Mean Direction
Huge E GRADIENT

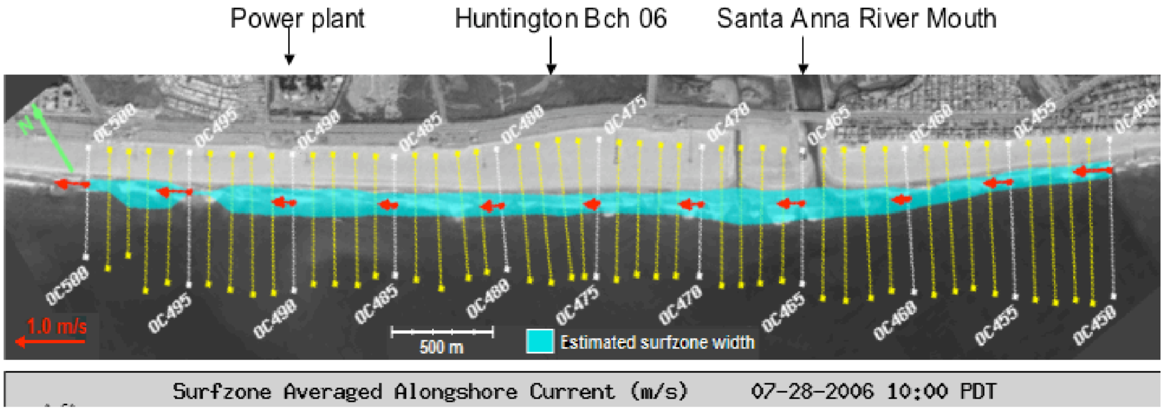

Currents follow waves
waves
waves
Currents oppose waves


Talbert Marsh &Santa Anna River
Huntington Beach, Ca.
HB06 : Feddersen, Guza, O'Reilly,Clark
Transport & dilution of pollutant runoff in surf zone: Where to put this?
***** surfzone alongshore currents ****
KEEP OUT
SEWAGE CONTAMINATED WATER
EXPOSURE MAY CAUSE ILLNESS


O'Reilly/CDIP Buoy NETWORK MODEL
46218
Pt. Conception
Santa Barbara
Los Angeles
46221
46222
Huntington Beach Buoy
46223
46224
Oceanside
46219
46086
46232
San Diego
Mexico
W/NW window
South window
BUOYS
HB Buoy
Local Buoy
Offshore Buoy
Depth (m)
Shallow: 0
Deep: -4000

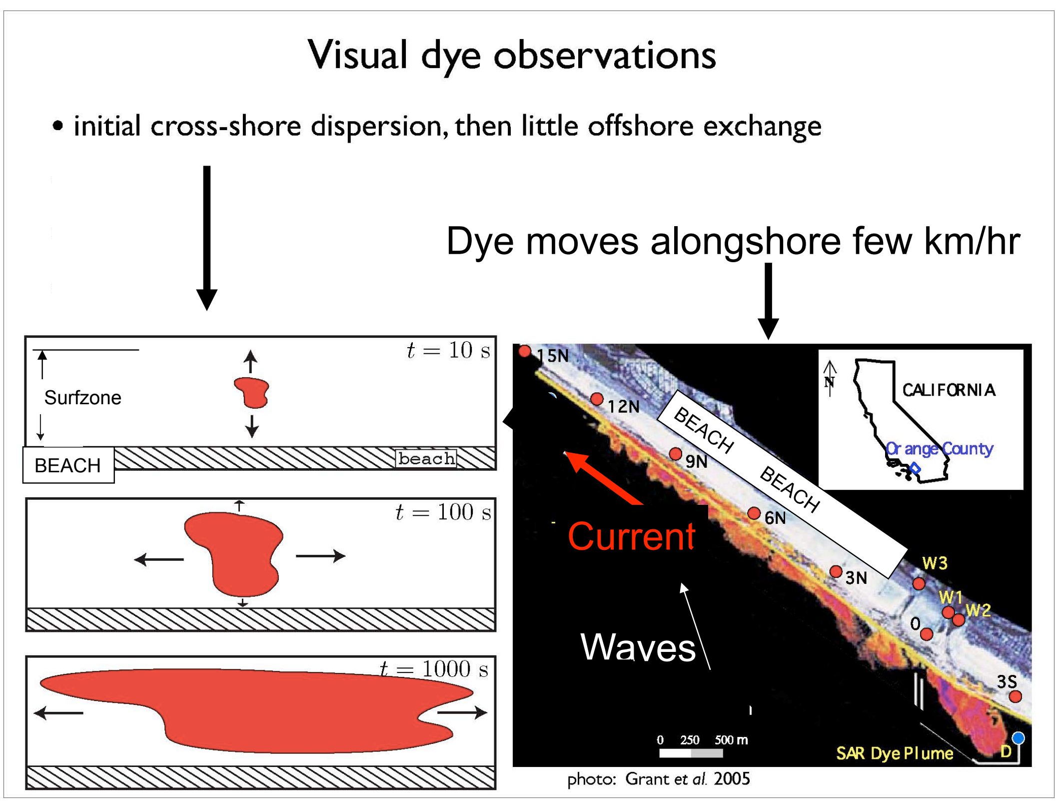

HB06 : Surfzone nowcast model test (Sep-Oct 06)
S. Ana River
X

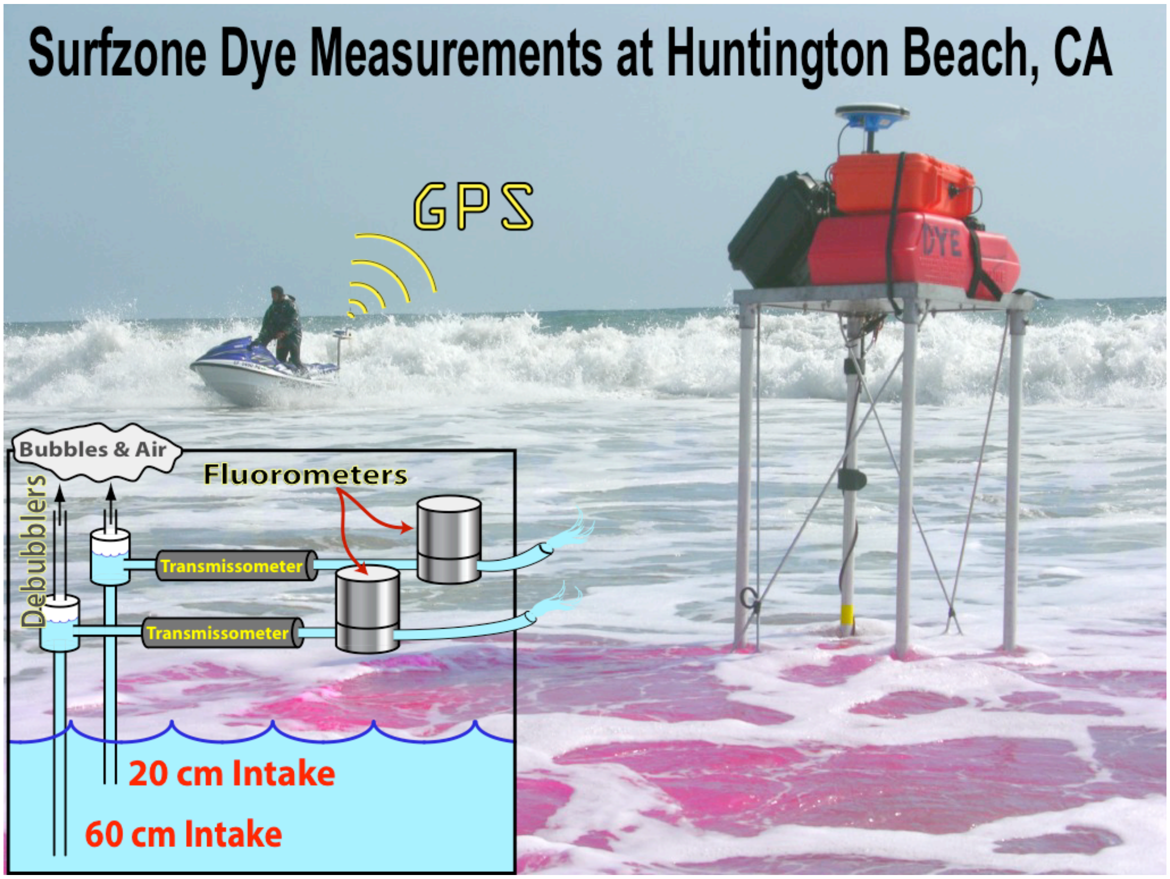

Breaking Wave Height H_{sig}
breaking H_{sig} (m)
observed
model
0
0.5
1
1.5
Surfzone Averaged Alongshore Current <V>
<V> (m/s)
40km/day
-0.5
0
0.5
1
0
5
10
15
20
25
30
35
Days from Sept 12 0000

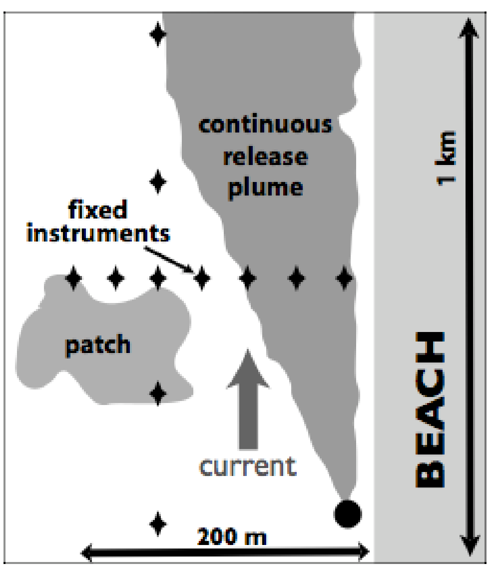


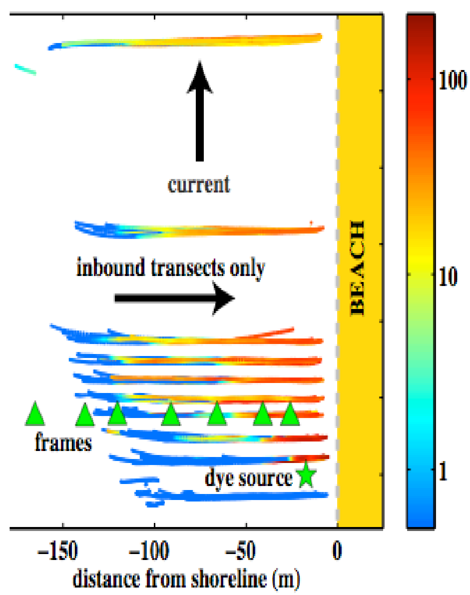
NOWCAST Alongshore currents http://cdip.ucsd.edu/hb06

But .... dilution is key........ how does "stuff" mix in the surfzone?

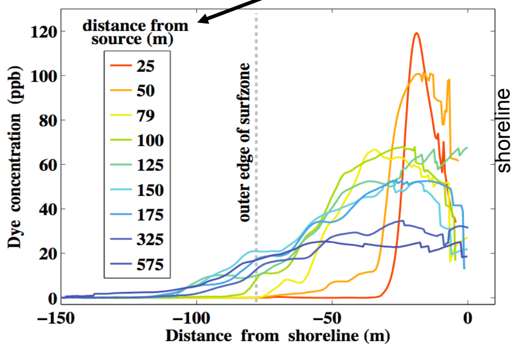



Surfzone Dye Measurements at Huntington Beach, CA
GPS
DYE
Bubbles & Air
Debubblers
Fluorometers
Transmissometer
Transmissometer
20 cm Intake
60 cm Intake

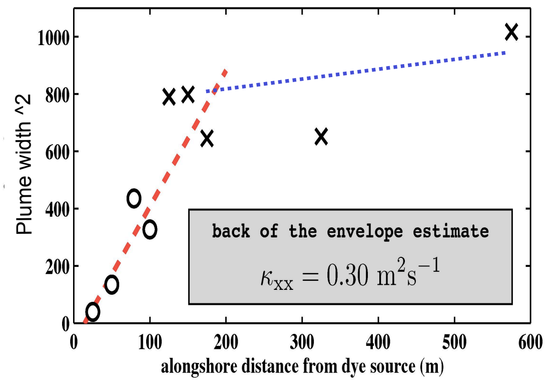

continuous
release
plume
fixed
instruments
patch
current
200 m
1 km
BEACH

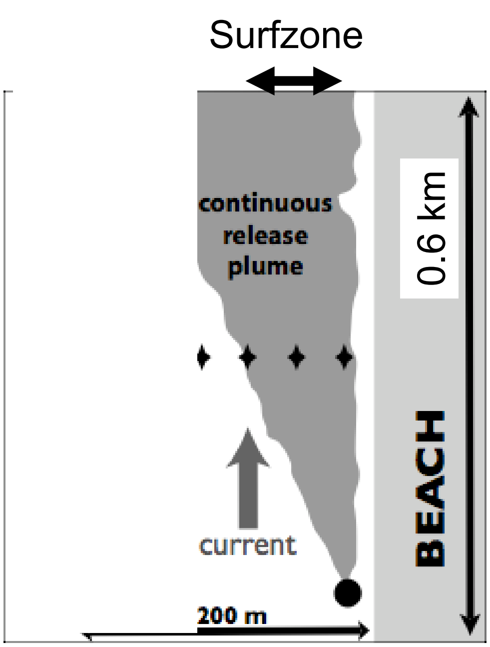

current
inbound transects only
frames
dye source
BEACH
100
10
1
−150
−100
−50
0
distance from shoreline (m)

Dye concentration vs offshore distance
(for different distances from source)

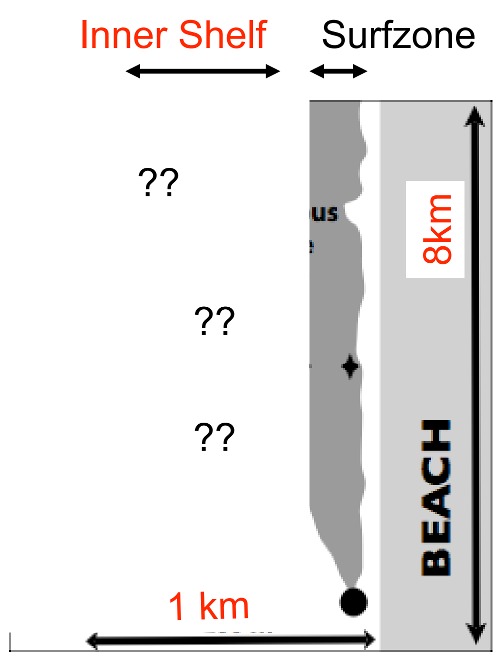


Plume width ^2 versus alongshore distance

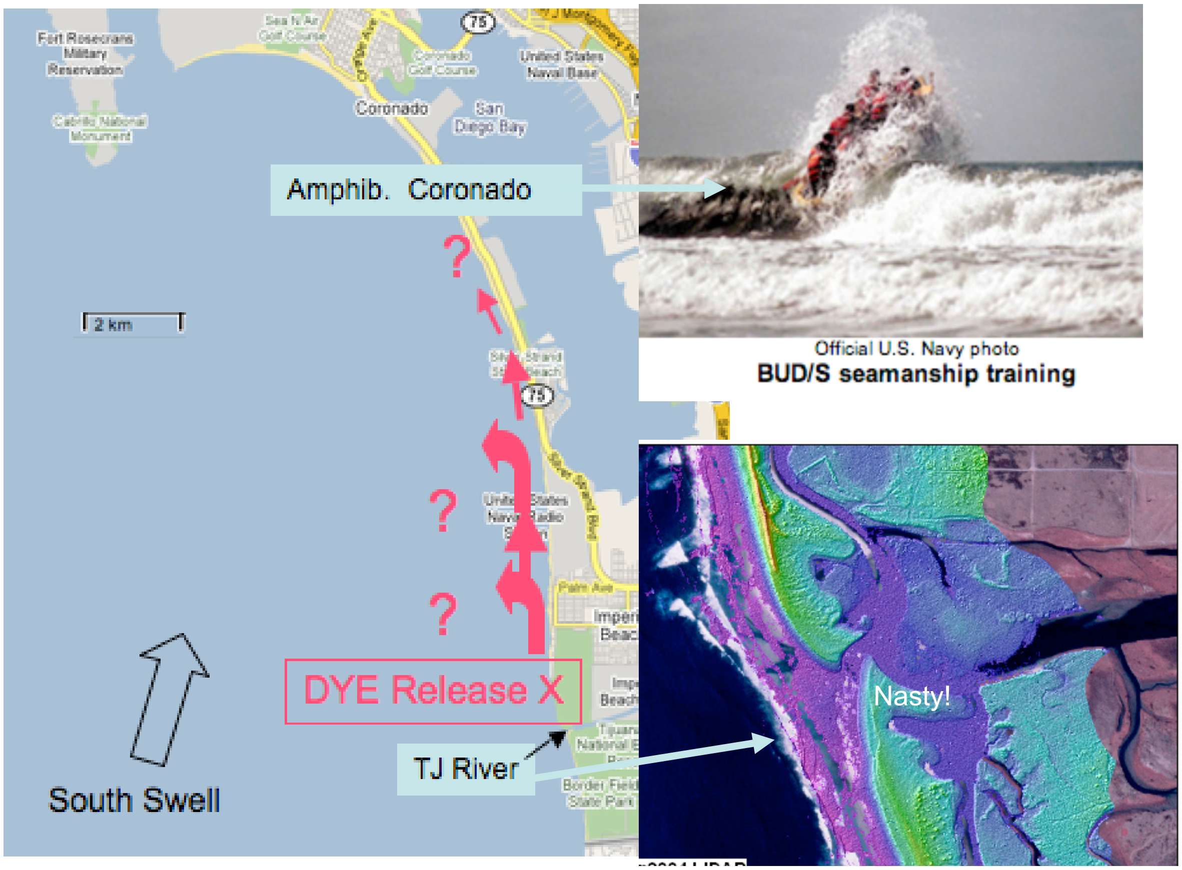




HB06

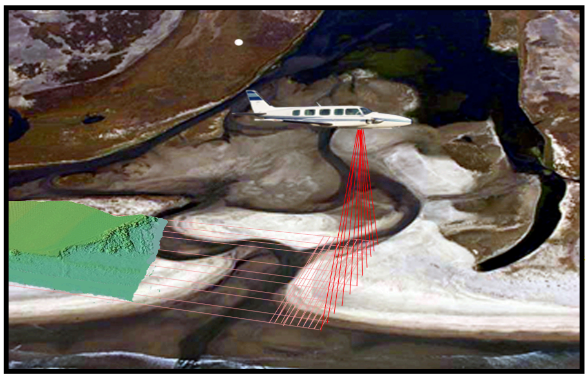


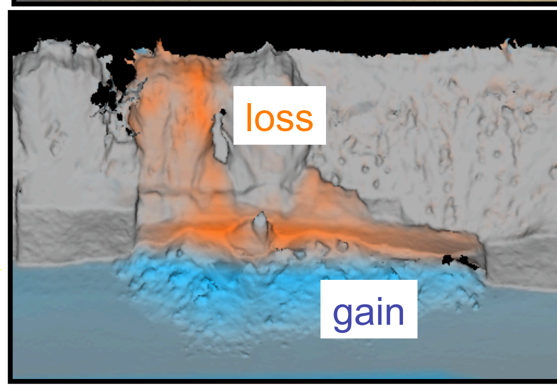
IB09

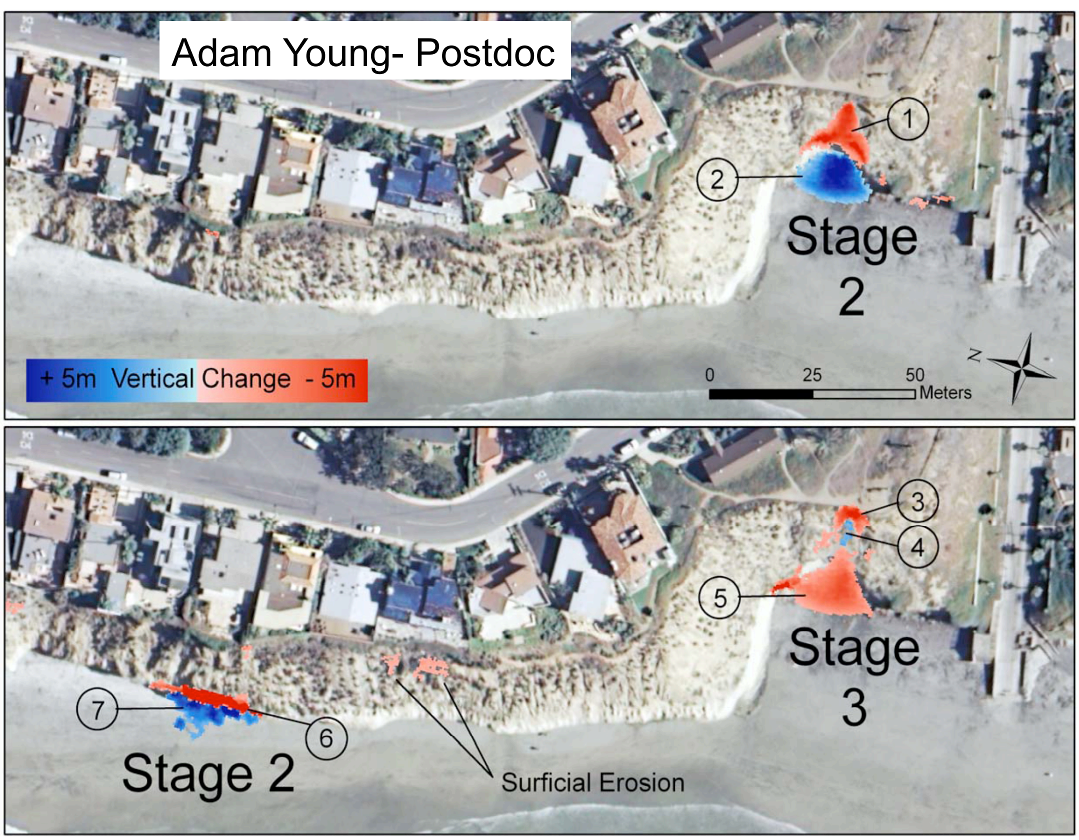

Fort Rosecrans Military Reservation
Cabrillo National Monument
Coronado
San Diego Bay
United States Naval Base
Amphib. Coronado
Official U.S. Navy photo
BUD/S seamanship training
2 km
?
?
?
DYE Release X
TJ River
South Swell
Nasty!

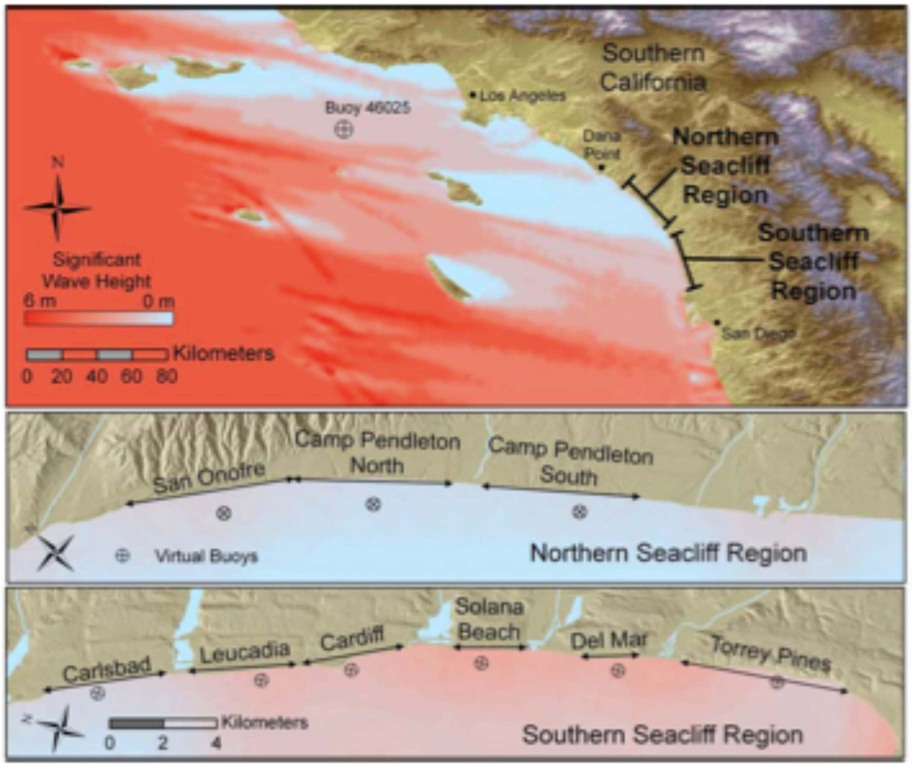

Newport
jetty
Jetty plume?
Abalone Cove, Palos Verdes
Transport past headland?
El Segundo
Hyperion Sewage Plant
Transport?
Rincon
Radical orientation change :Circulation unknown

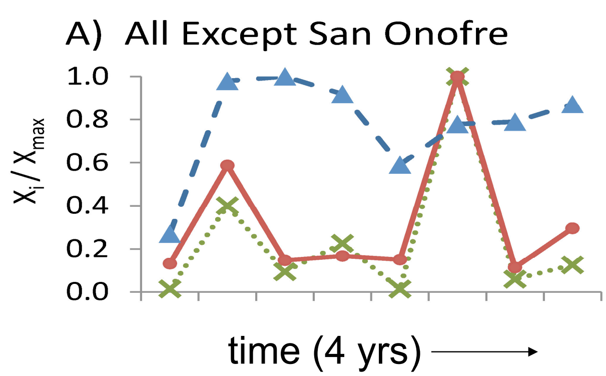
Monitoring Beach & Cliff Change in Southern California with Airborne LIDAR



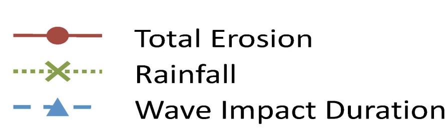








Rain =erosion

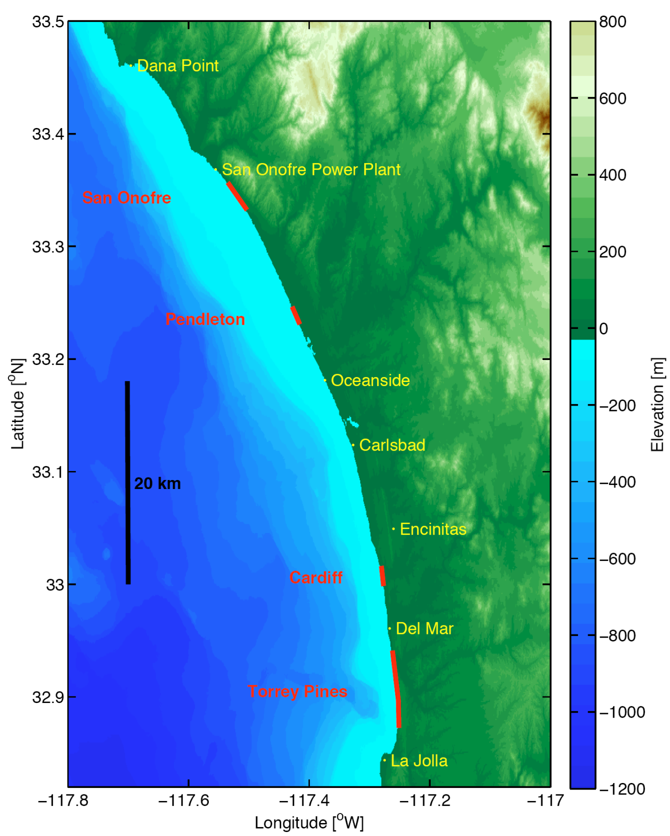


Rivers and Cliffs Provide(d) Beach Sand

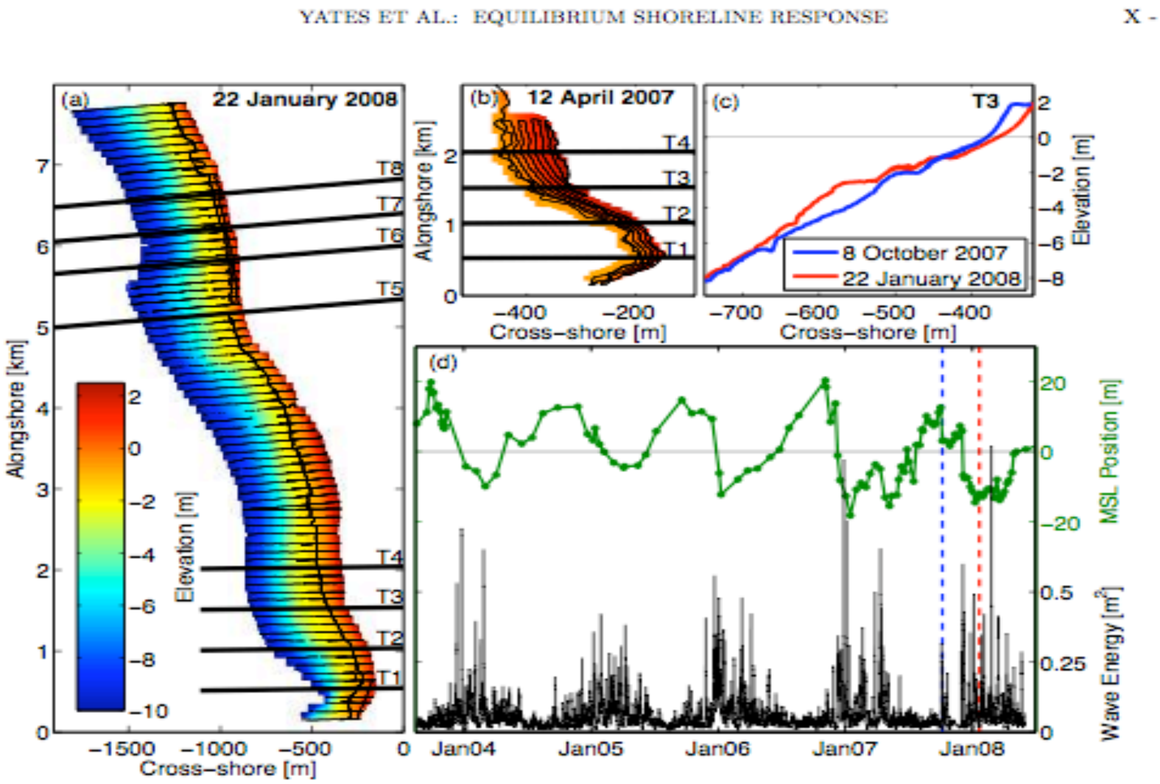
Solana Beach,'04

Sand elevation surveys
*Beach face: Monthly
*To 8m depth: Quarterly

Torrey Pines (8 km, 7yrs)
San Onofre (4 km, 1yr)
Pendleton (2.5 km, 2.0 yr)
Cardiff (2 km, 1.5 yrs)



Torrey Pines



Profile h(x) and/or Shoreline (e.g. MSL) change models

Operational : No Computational Pigs allowed.

'Process' & ' Data-driven'

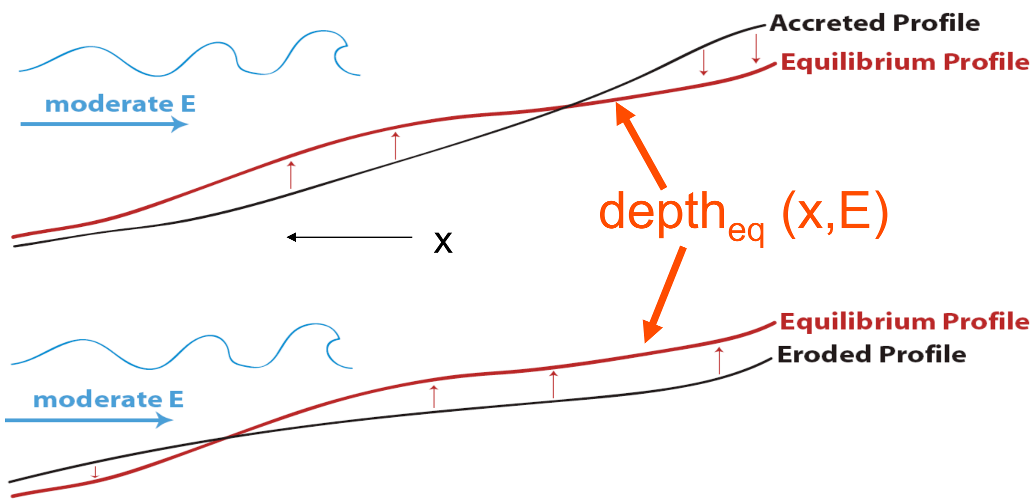
Process : simulate waves/currents/sed xport
(u sort-of-integrate mass & momentum eqs)
Delft3D, Xbeach, "Energetics (skewness)"………

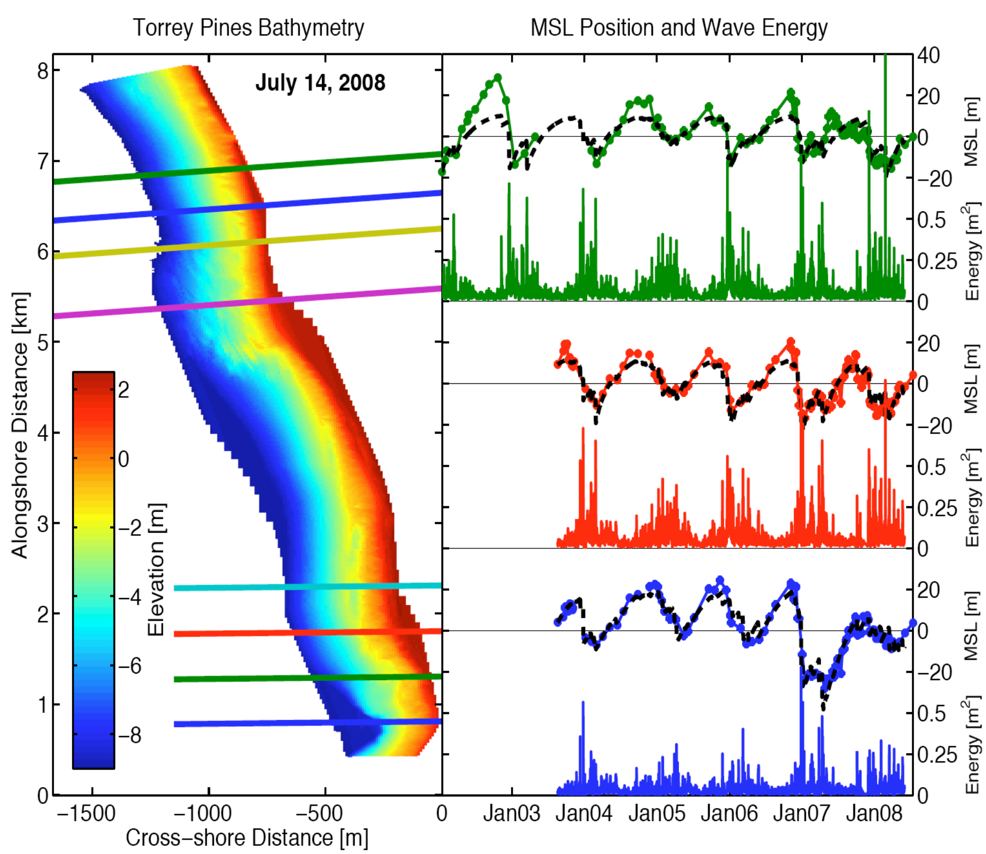
Data-driven : observations constrain heuristic, outcomes
(e.g u guess 'rules' nature follows when integrating).
Equilibrium, statistical, ………

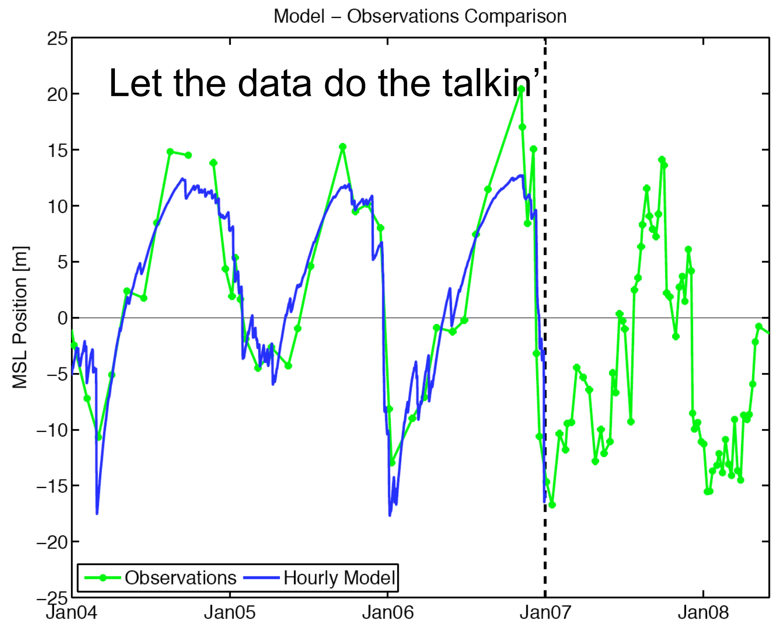
Input : Initial h(x), 'parameter values' (a.k.a tuning),
waves(time).

Output : h(x, time)

Equilibrium Beach 'Rules' : Bruun, Dean, Inman, **Wright**, ……
every E has a no-change h_{eq} (x,E)
given E (t_{now}), h(x,t_{now}) evolves to h_{eq}(x,E)
fastest change for biggest dis-sequilibrium

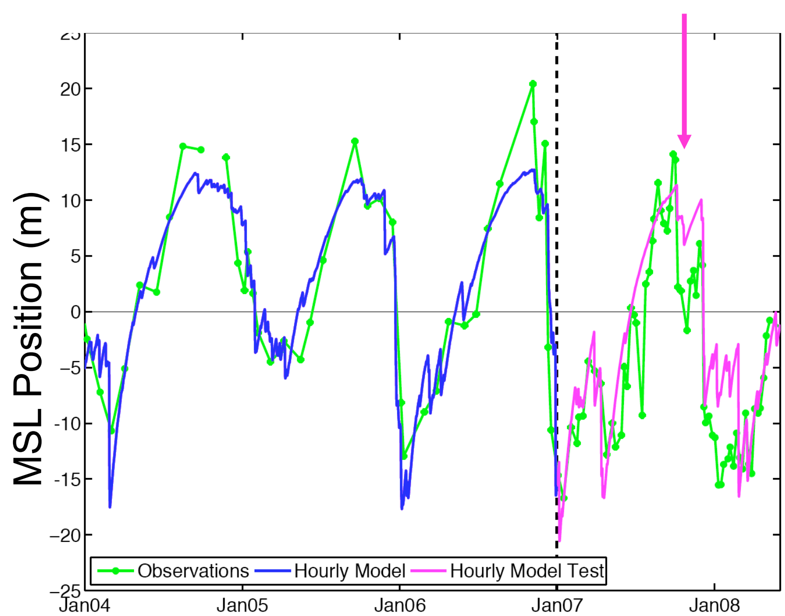






Tune model with a few years of MSL and E

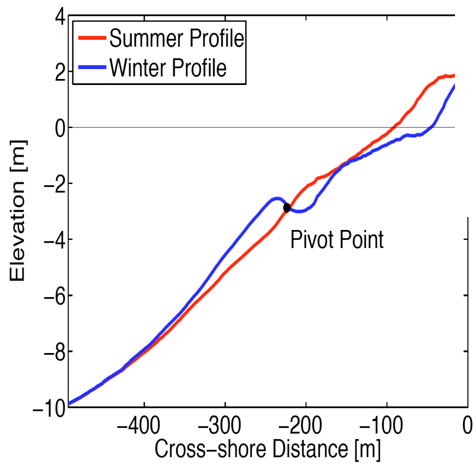
Observed waves do the walkin'



Predict future change using pre-tuned model, and E

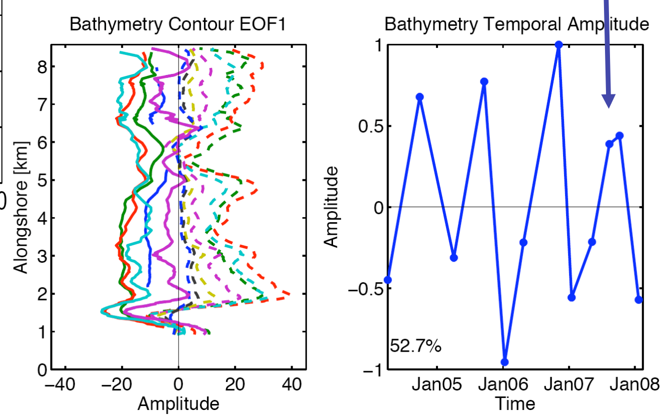
Torrey Pines

4/yr bathy surveys



Yates et al :
Temporal EOF of all beach contours ~ MSL(t)

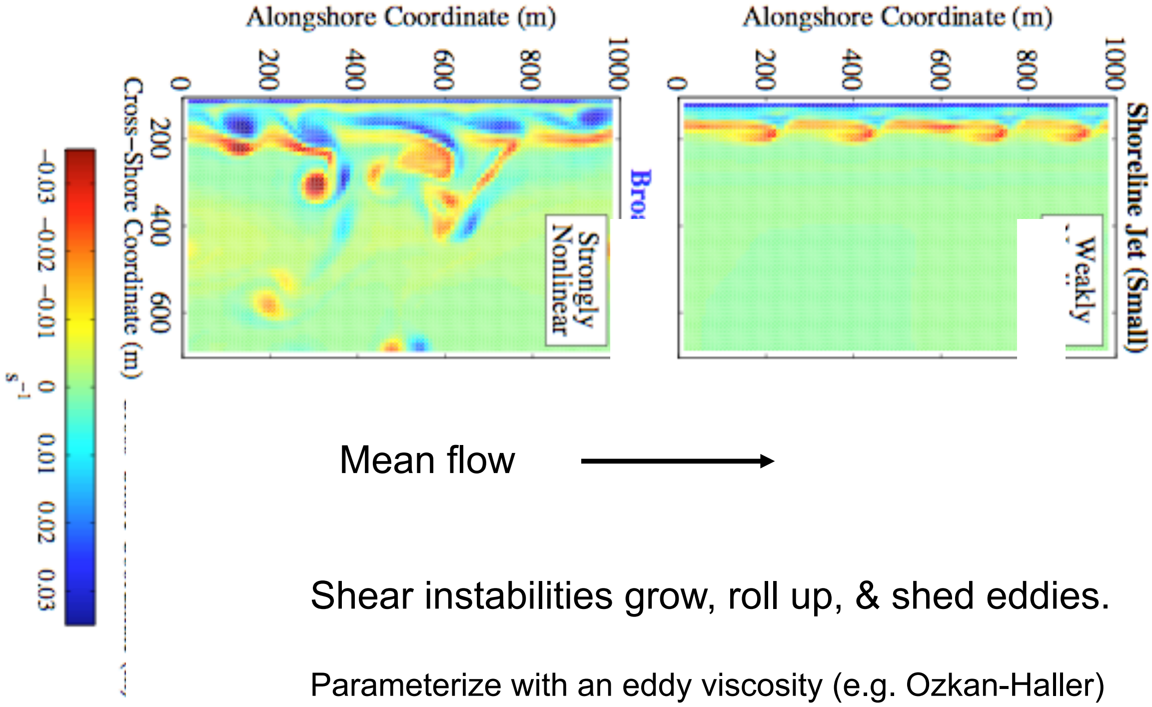
MSL is coherently attached to rest of profile (not always true!)



≈ 1 meter

SoCal beaches already sand starved:future ?

From IPCC 2001
report on climate change,
based on SRES scenarios.



Mean flow →

Shear instabilities grow, roll up, & shed eddies.

Parameterize with an eddy viscosity (e.g. Ozkan-Haller)