CGWAVE: A COASTAL WAVE PREDICTION MODEL

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BACKGROUND

Elliptic CRD Equation:

$$\nabla.(CC_g\nabla\phi) + \{k^2CC_g + i\sigma w + iC_g\sigma\gamma + F_1(kd)\nabla^2 h + F_2(kd)(\nabla h)^2\}\phi = 0$$

- **Theoretical basis: full refraction + diffraction + reflection in all directions**
- **Wave parameters: low to high wave periods, including tsunamis**
- **Monochromatic or spectral wave input**

BACKGROUND (cont.)

- Geometry: handles arbitrary domains and structures
- Flexibility: linear triangular finite elements
- Wavelength-dependent grid resolution
- Interface: Surface-water Modeling System (SMS)

BACKGROUND (cont.)

- Solution: a large system of discretized equations using:

Iterative solvers (Demirbilek et al. 1998, SC98)

Direct solvers (Demirbilek et al. 2000, SC00)

Convergence guaranteed (Panchang et al. 1991)

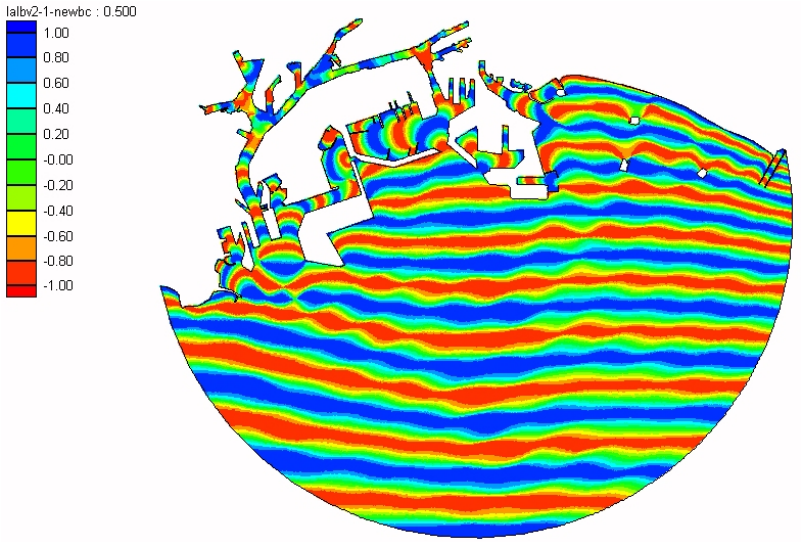
Super-fast dual-level parallelized code (DoD only)

Adaptation to HPC platforms (Ser, MPI, OMP, Hyb)

PC version has conjugate gradient solvers

CGWAVE Capabilities

- Diffraction
- Reflection
- Refraction
- Breaking
- Bottom Friction
- Entrance Losses
- Wave-current Interaction
- Wave-wave Interaction
- No Wind Input



STATUS OF MODEL

- Rigorously validated model
- Controlled physical modeling tests
- Quantitative and qualitative evaluation
- Real field projects
- Model performance documented in:

  ERDC Technical report/User Manual

  Peer-reviewed journal papers

  Book chapters

  Misc. academic publications & reports

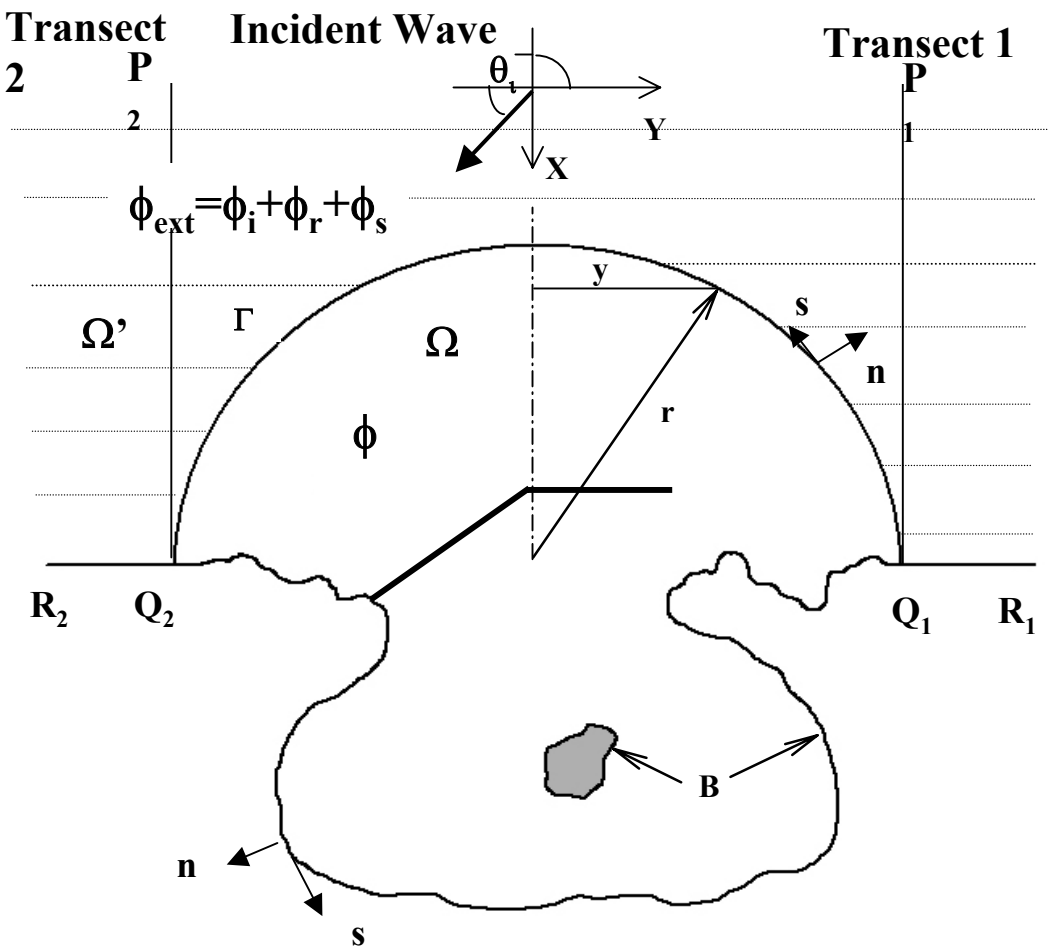
CONTROLLED TESTS

Case	Processes
1. Breakwater gap	Diffraction
2. Rectangular harbor	Diffrac + Reflec + Fric; Resonance
3. BBR shoal	Refrac + Diffrac + N-L disp.
4. CERC shoal	Refrac + Diffrac + irregular waves
5. Battjes et al. slopes	Reflec/shoaling + breaking
6. Sloping beach	Reflect + Refrac
7. Circular pile	Diffrac + Reflec (angular scatter)
8. Homma island + shoal	Refrac + Diffrac + Reflec
9. Island + Steep shoal	Refrac+ Diffrac + Reflec+Steep slopes
10. Sloping beach with jetties (Watanabe)	Reflec/shoaling + breaking

APPLICATIONS

Location	Collaborators / Users
East Caicos & Turks Island Harbors	Coastal Syst. Intl. (FL)
Floating Airport Design (Japan)	Osaka Bay, USA/Japan Project
St. Therese de Gaspe Harbor	Quebec Public Works,University de Laval, Canada
Thangaserai Harbor (India)	Indian Inst. Tech Madras
Europe and Mideast Applications	KMM Engrs. (UK)
Oceanside Harbor (CA)	USACE, Scripps Inst of Oceanogr. (SIO)
Los Angeles/Long Beach (CA)	USACE, USC, FEMA Tsunami Project
Kahului Harbor (HI)	USACE, SIO, NSF,ONR, NRL
Barbers Pt Harbor (HI)	USACE, SIO
Aguadilla Harbor (PR)	USACE
Milwaukee Harbor (WI)	USACE, Univ. Michigan
Army Field Research Facility (NC)	USACE, ONR, SG
Ponce de Leon Inlet (FL)	USACE, SG, ONR
Charleston Harbor (SC)	Ocean & Coast. Consultants Inc. (CT)
Design of LosCabos Harbor, Mexico	Mexico, Applied Technology Management Inc. (SC)
Grays Harbor (WA)	USACE, PIE Inc.
Morro Bay Harbor (CA)	USACE
Brookings Harbor (OR)	USACE, WESTConstultants Inc.
Samoa Flood Inundation Plan	USACE-ERDC-CHL
Pago Pago Harbor/Tutuila	USACE
Military Applications (classified)	DoD

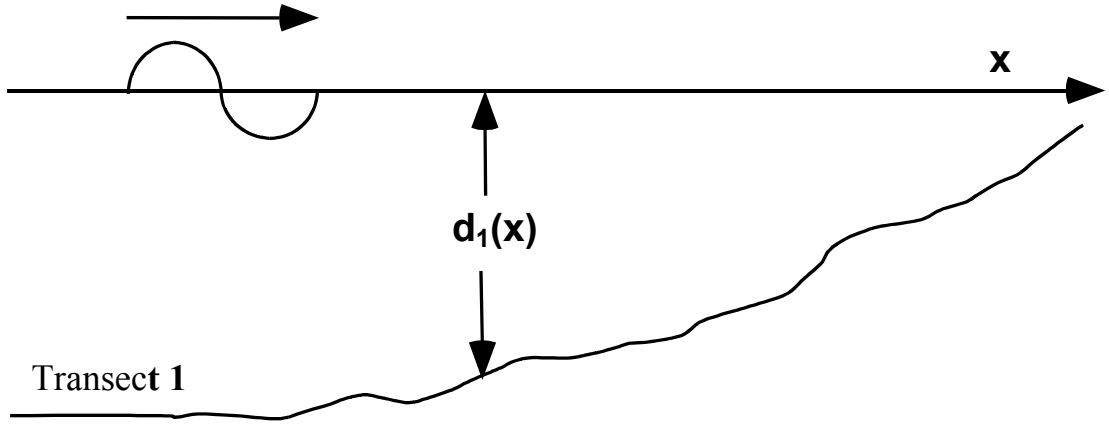
CGWAVE Modeling Domain

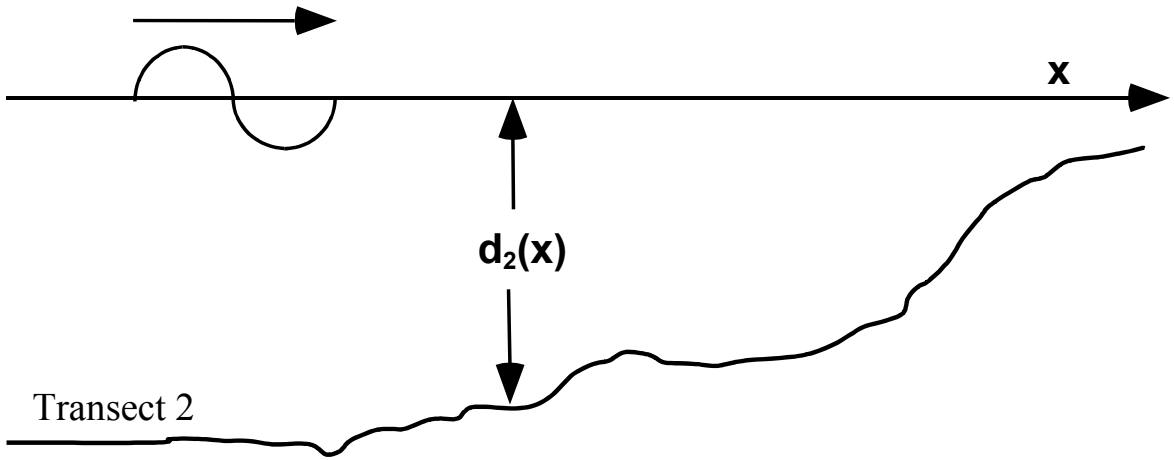


$$\alpha = ik\frac{1-K_r}{1+K_r}$$

$$\frac{\partial\phi}{\partial n} = \alpha\phi$$

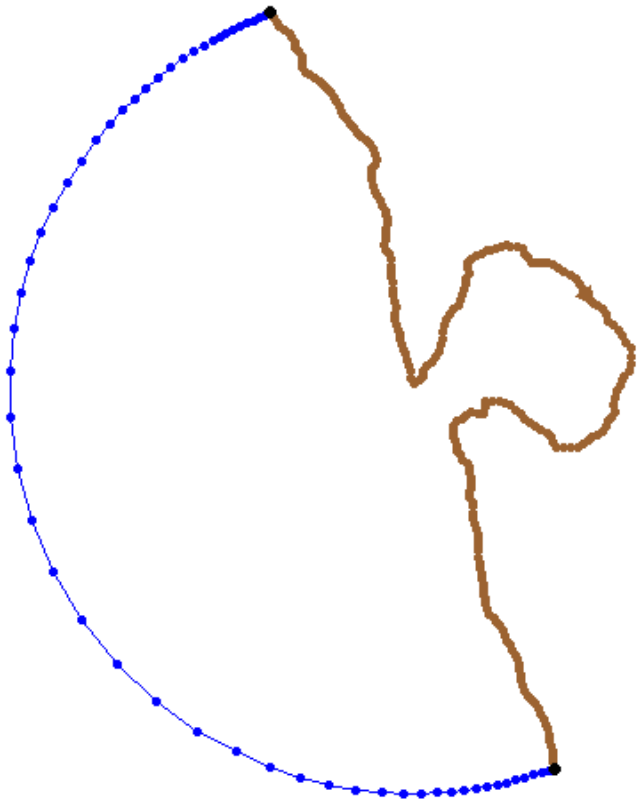
Exterior Domain





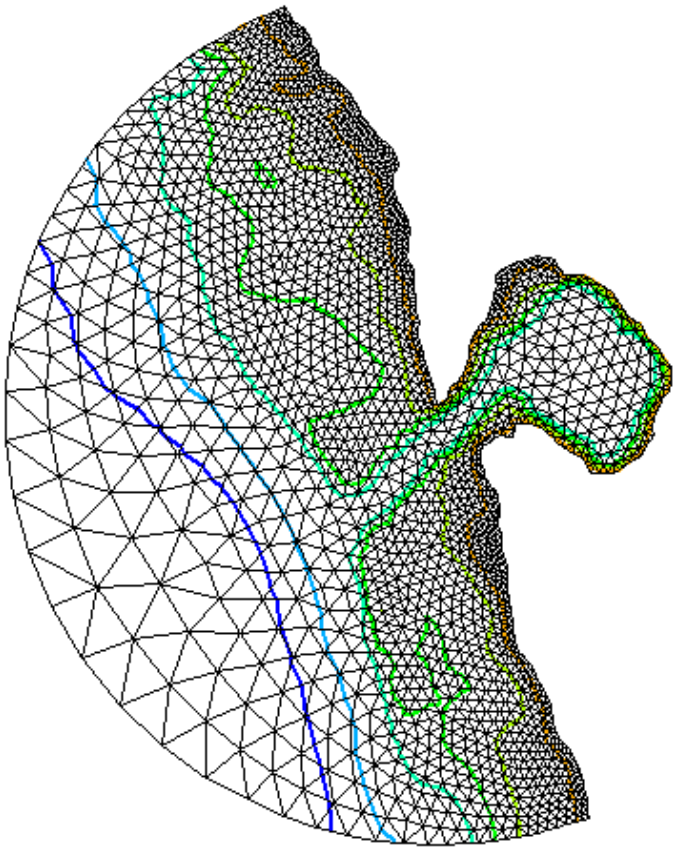
CGWAVE Boundary Gridding

Open Ocean Boundary

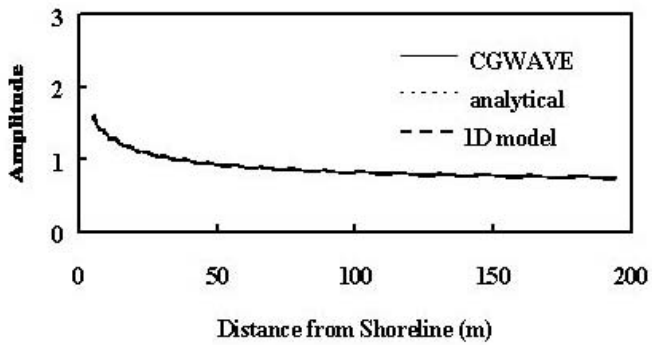


Coastline Boundary (Reflection Coefficient)

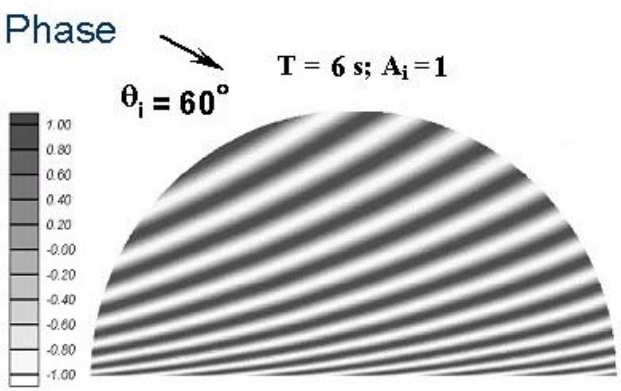
CGWAVE Mesh

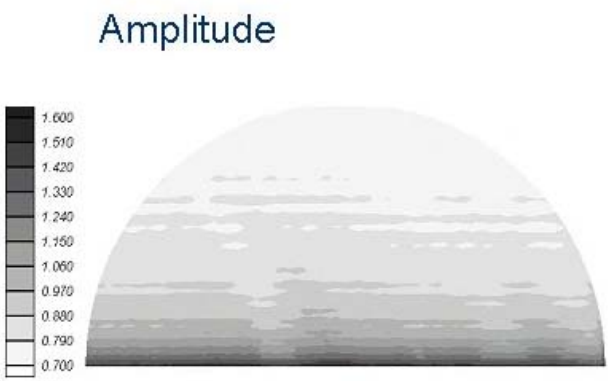


Sloping Beach – Short Waves

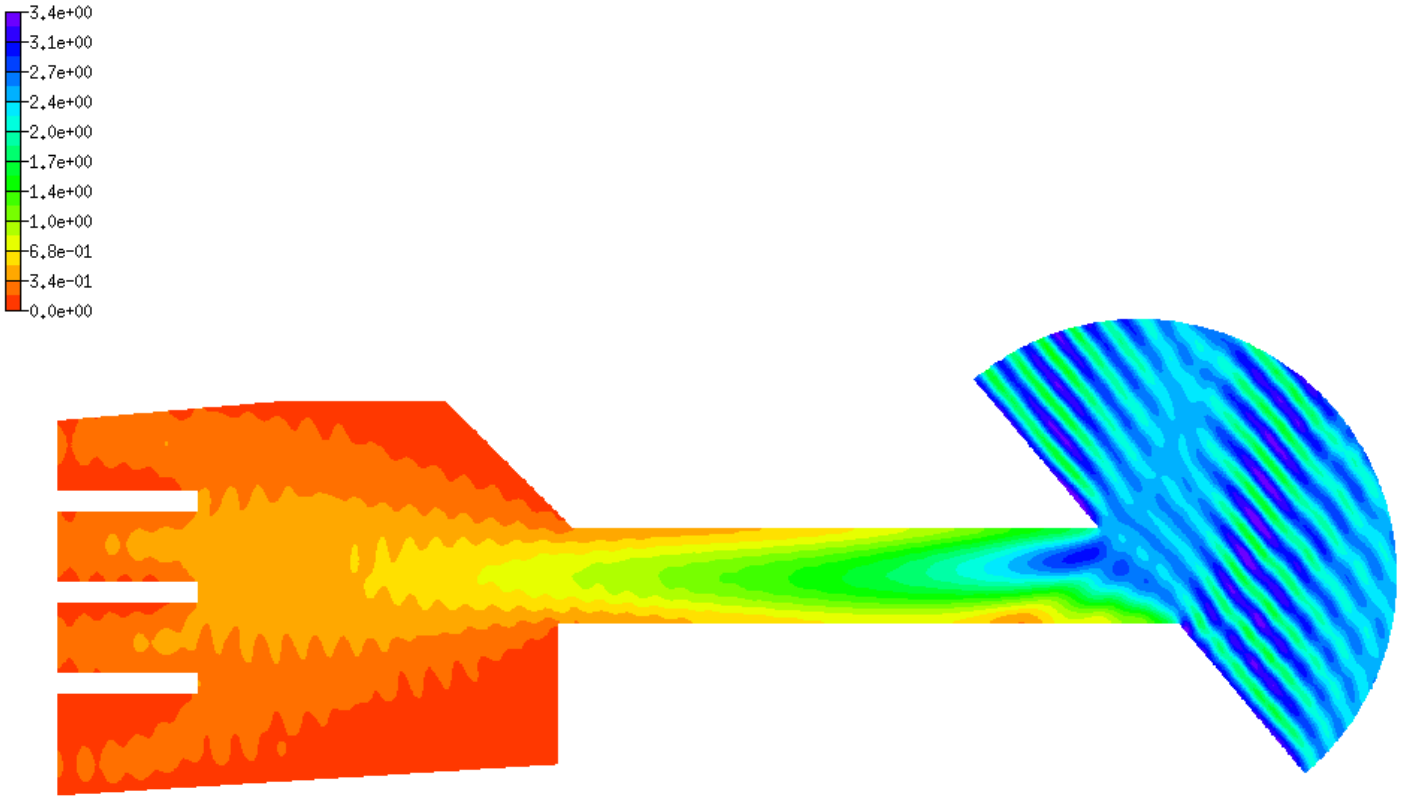


A=1m, T=6s, slope = 0.018
Depth cutoff at x=5m
R = 200 m





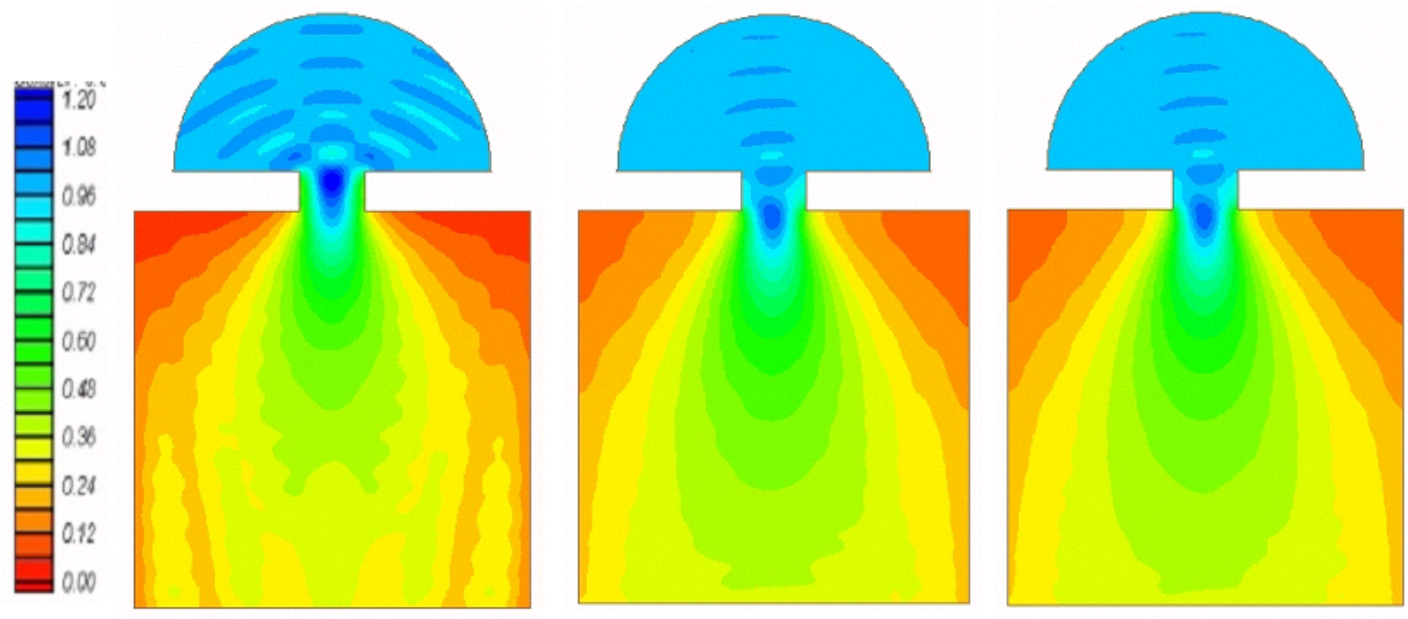
East Caicos & Turks Island Harbors



Rectangular Harbor

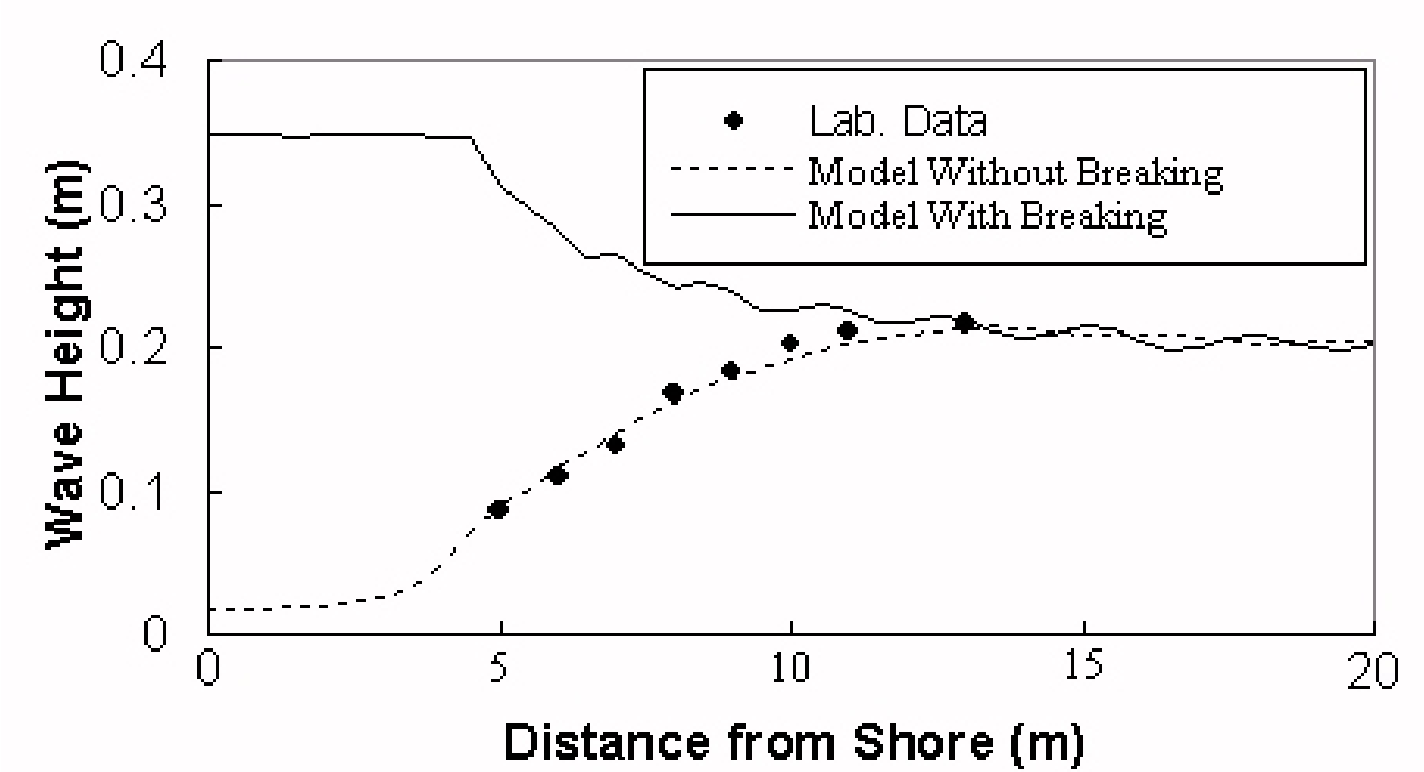
A=1 m, T=5.7 s, K_r=0, constant depth

Amplitude

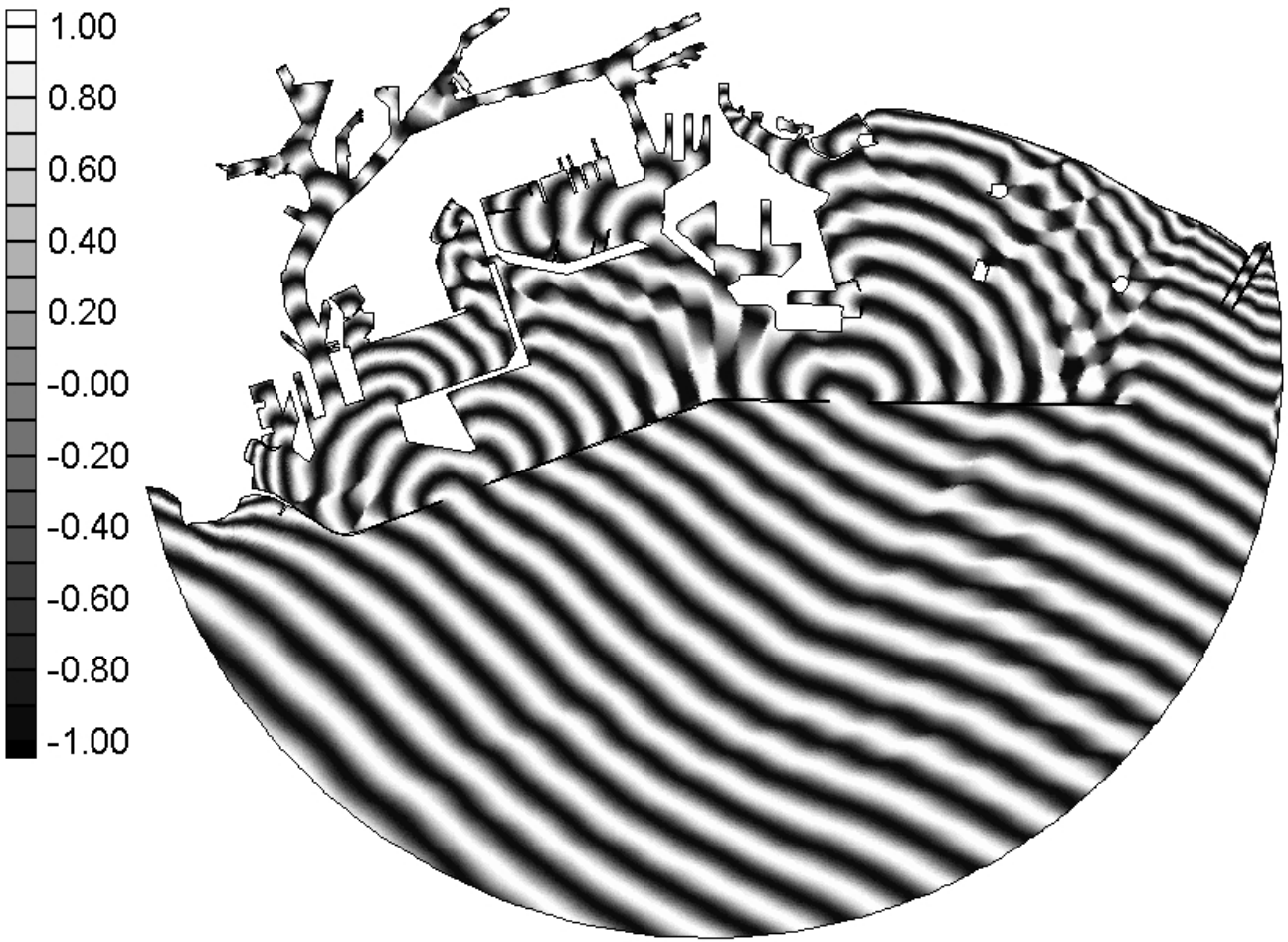


Conventional CBC, linear solution. + incident angle, 4 iters. + divergence,4 iters

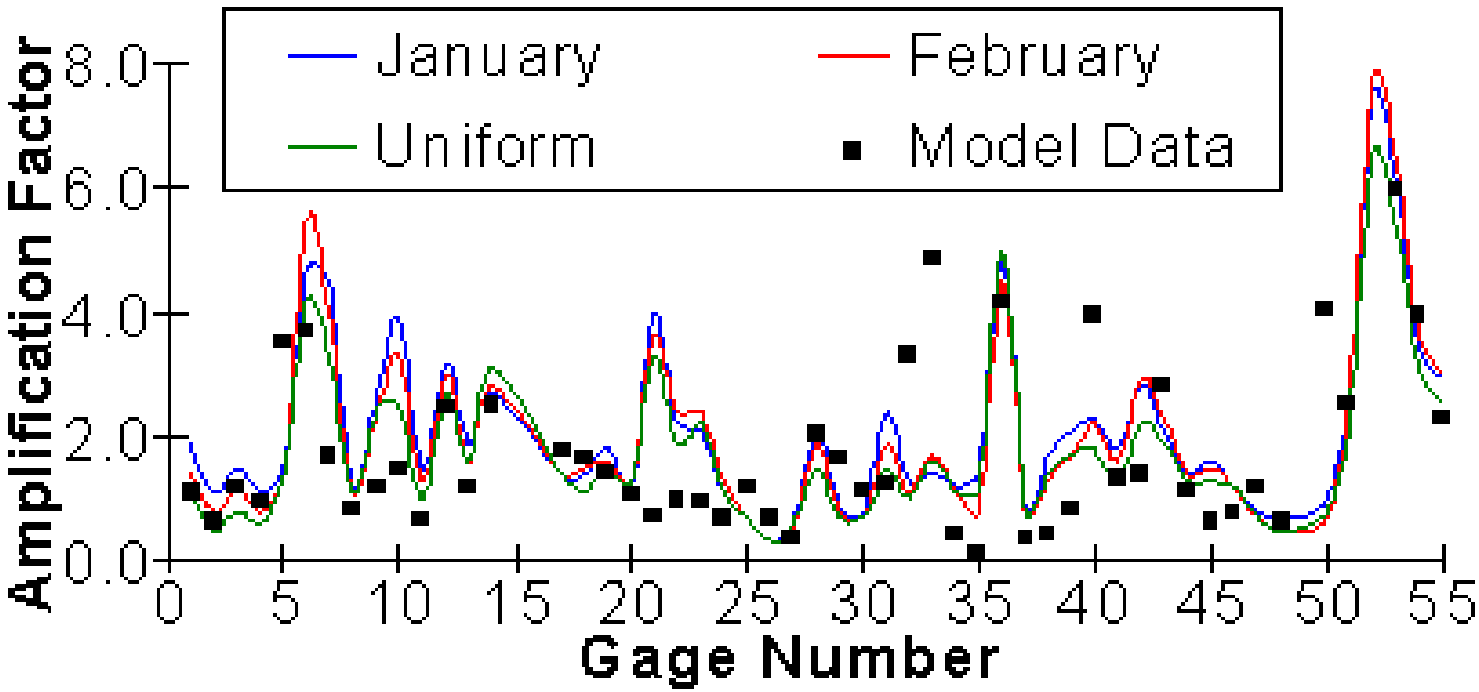
Battjes & Jansen Wave Breaking



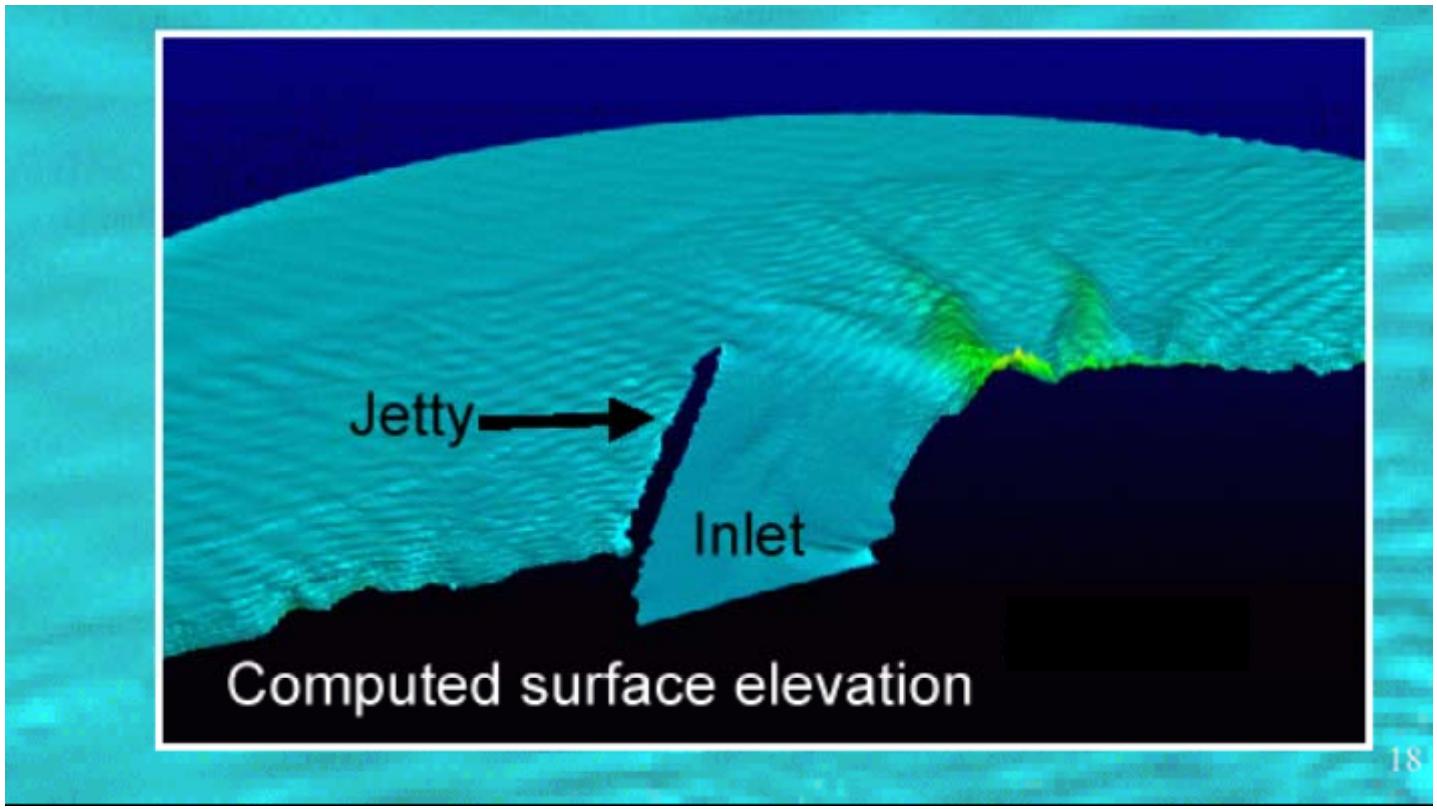
LALB Complex



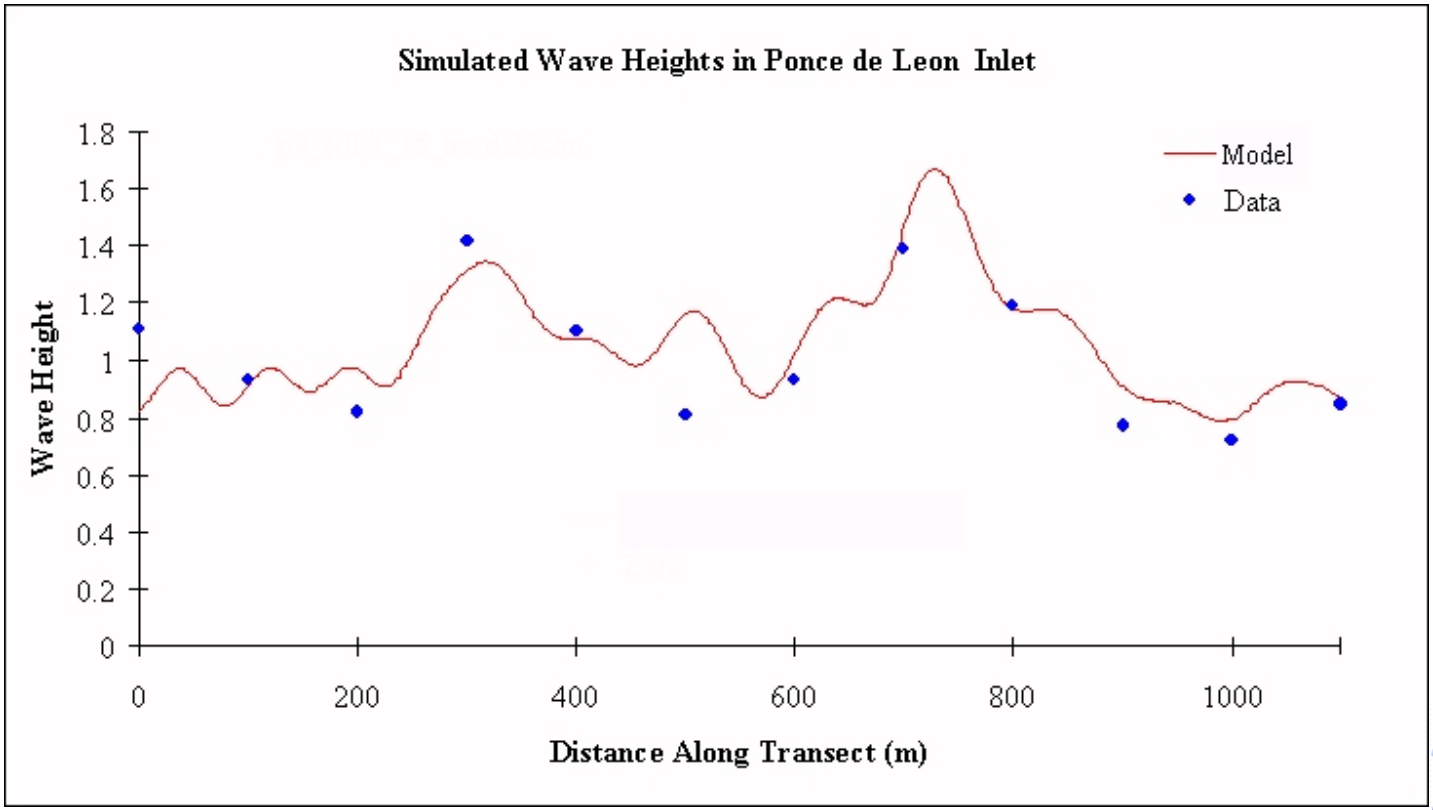
LALB – Model and Lab Measurements



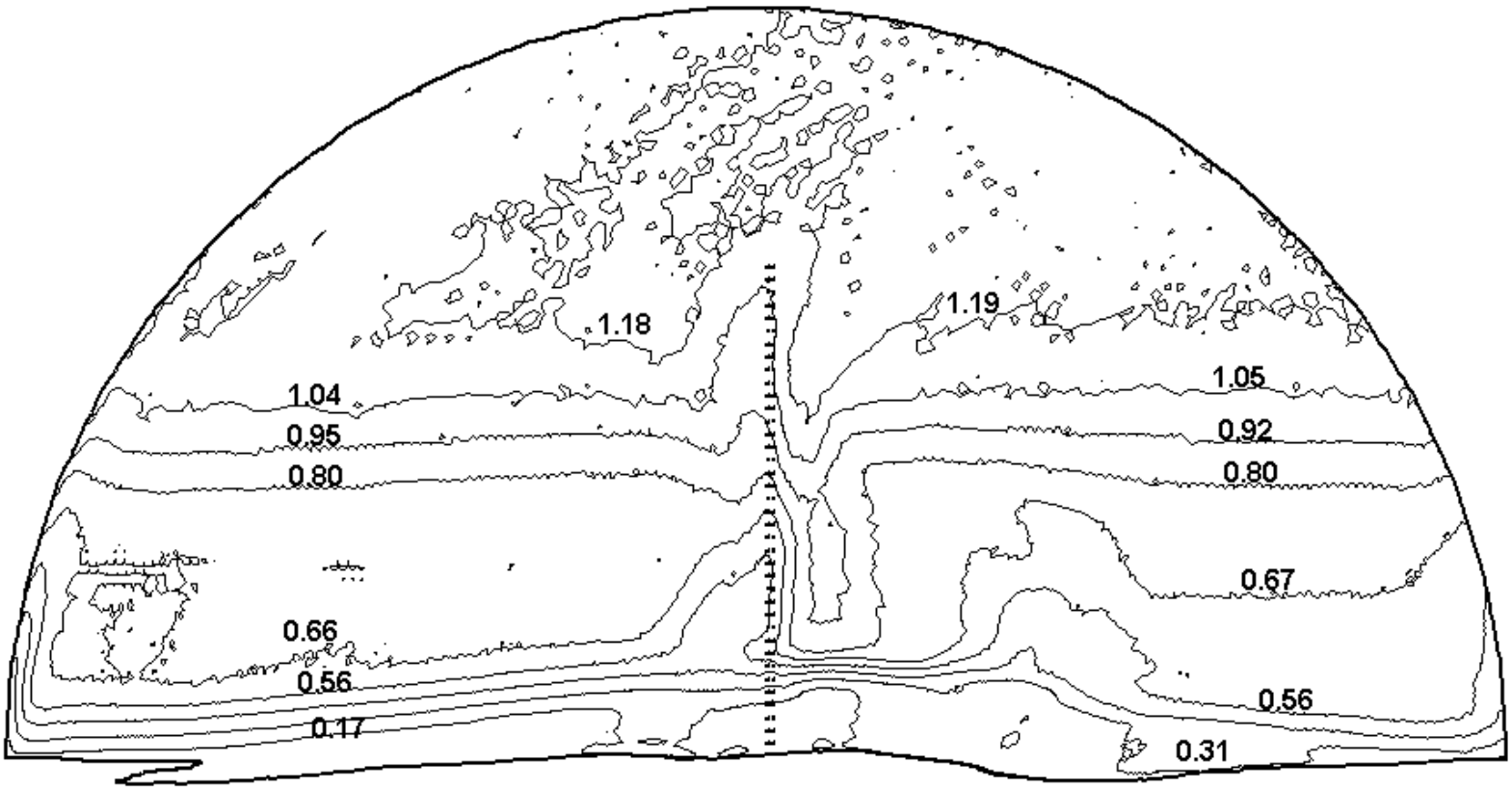
Ponce de Leon Inlet



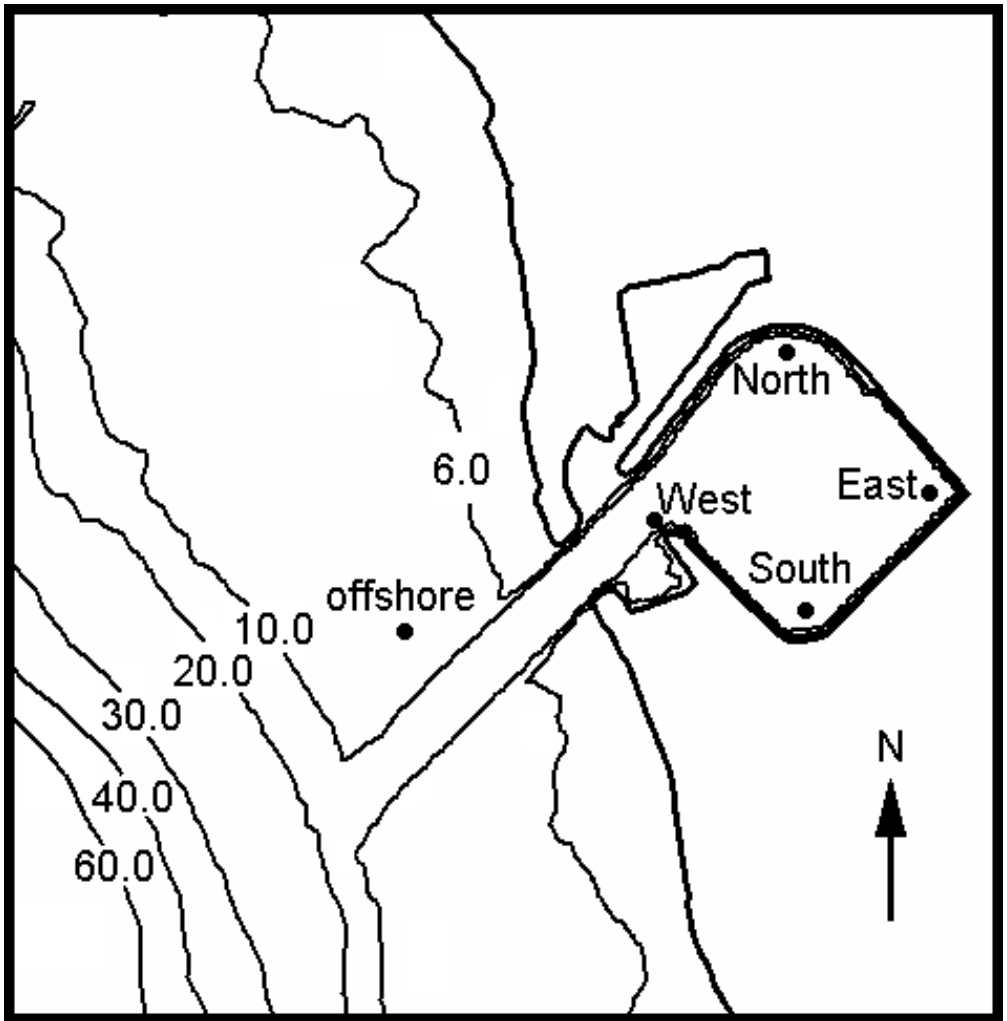
Ponce de Leon Inlet



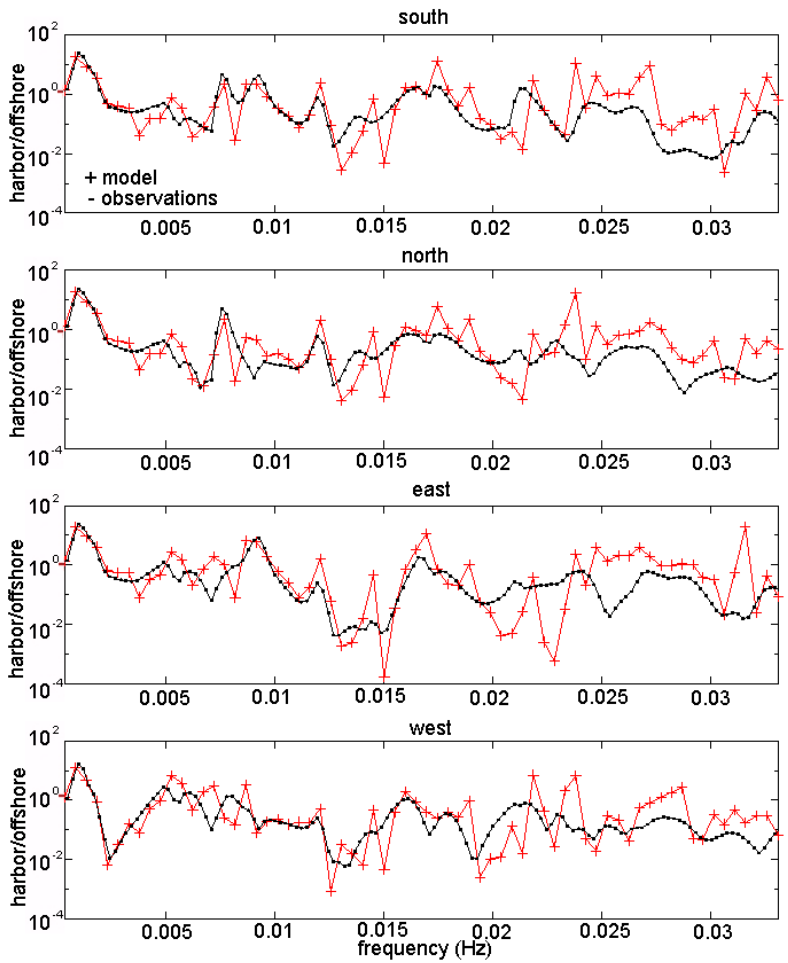
Waves at FRF Pier



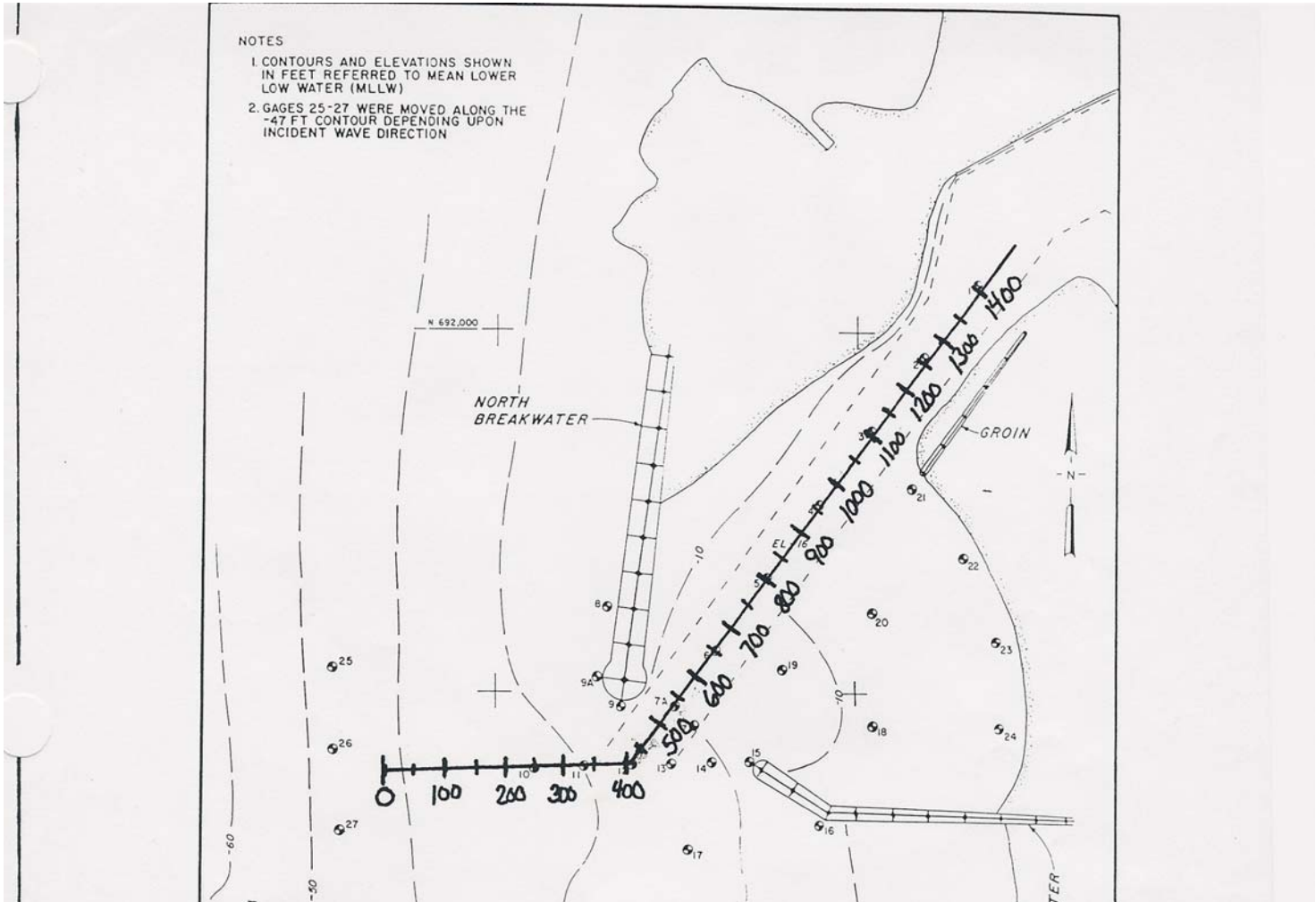
BARBERS POINT HARBOR, HI



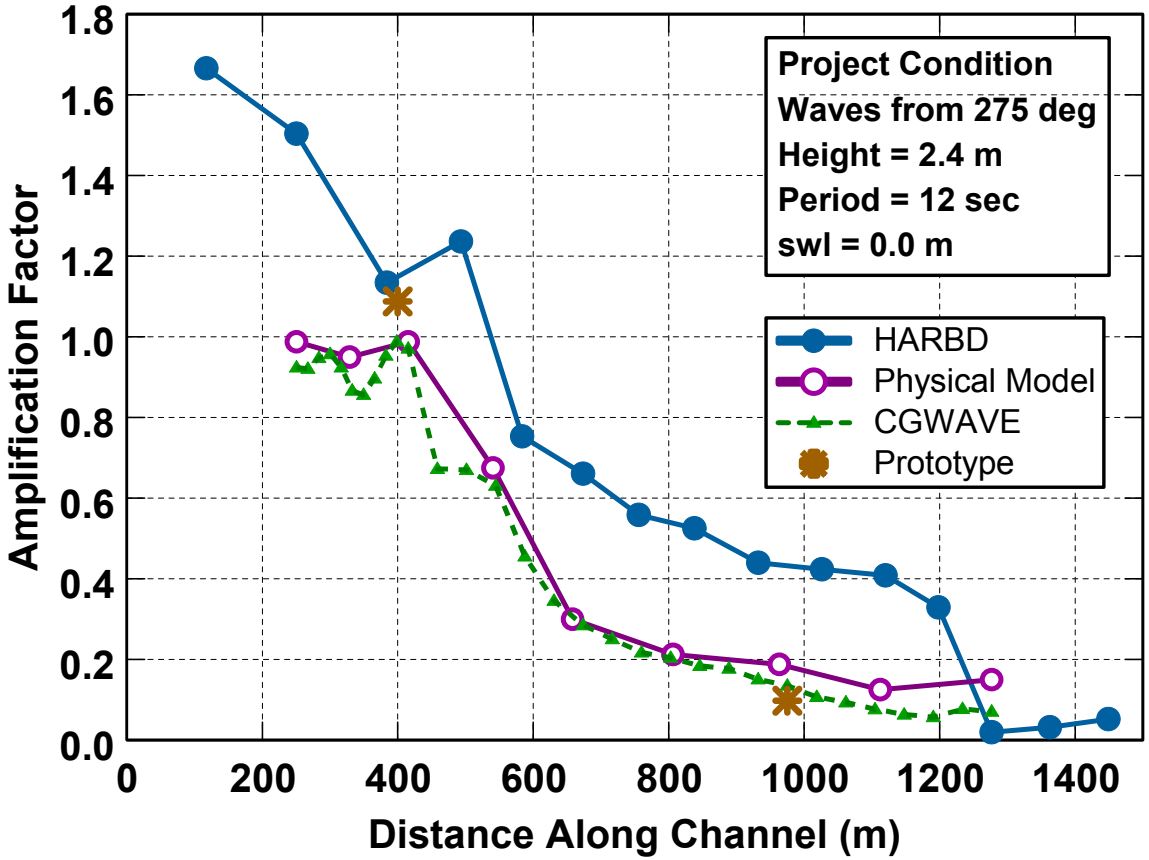
BARBERS POINT HARBOR, HI



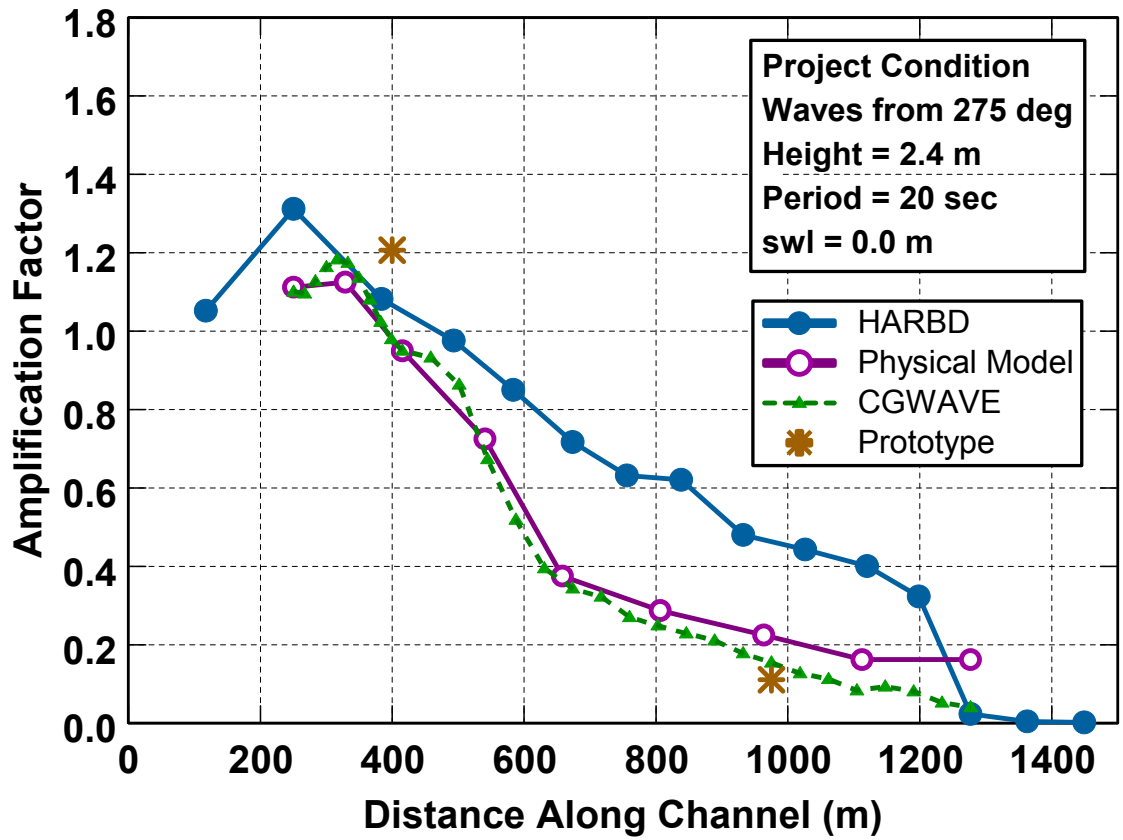
Morro Bay, CA


NOTES
1. CONTOURS AND ELEVATIONS SHOWN IN FEET REFERRED TO MEAN LOWER LOW WATER (MLLW)
2. GAGES 25-27 WERE MOVED ALONG THE -47 FT CONTOUR DEPENDING UPON INCIDENT WAVE DIRECTION
N 692,000
NORTH BREAKWATER
GROIN
N
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400

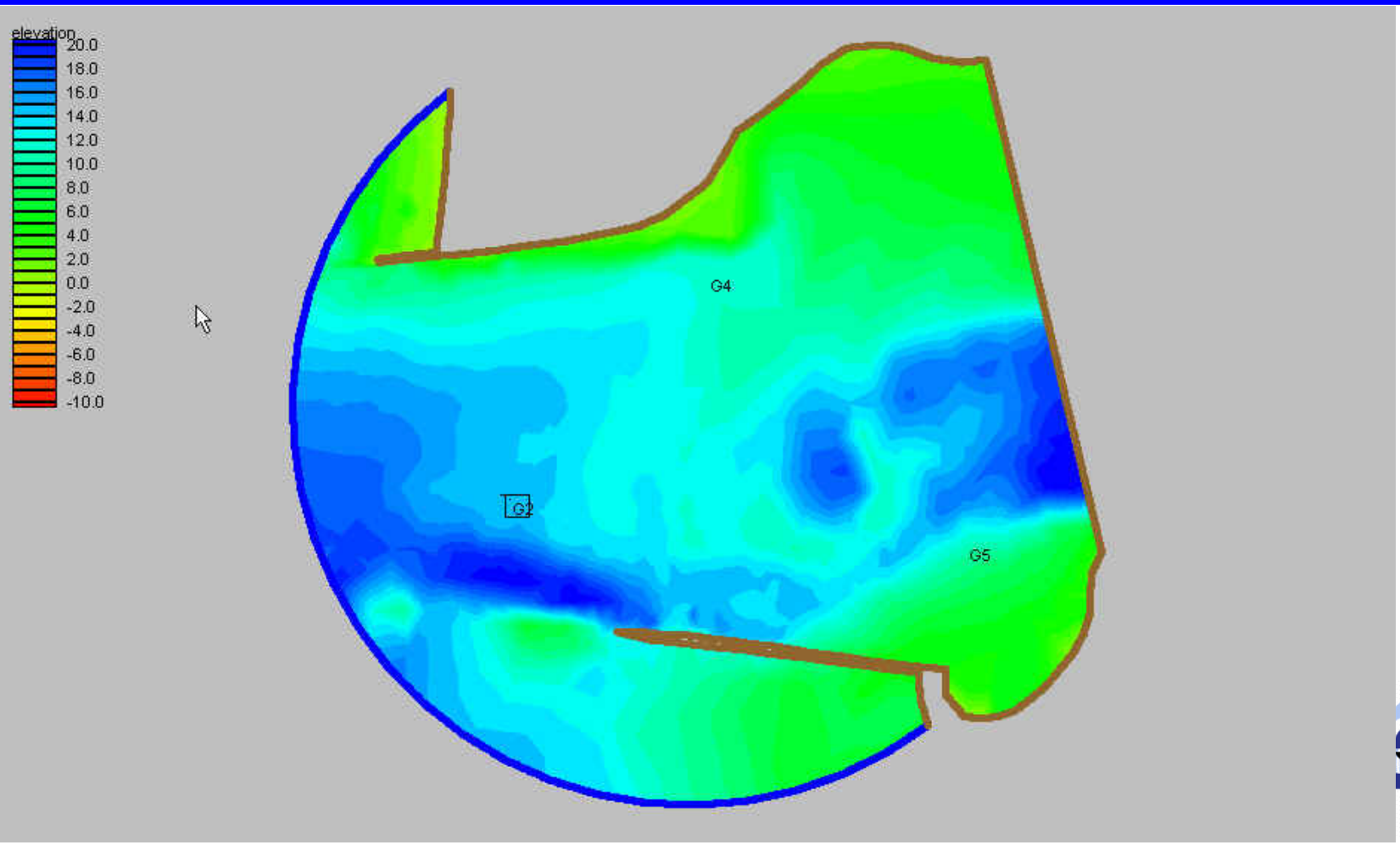
Morro Bay, CA


Project Condition
Waves from 275 deg
Height = 2.4 m
Period = 12 sec
swl = 0.0 m
HARBD
Physical Model
CGWAVE
Prototype
Amplification Factor
Distance Along Channel (m)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
0
200
400
600
800
1000
1200
1400

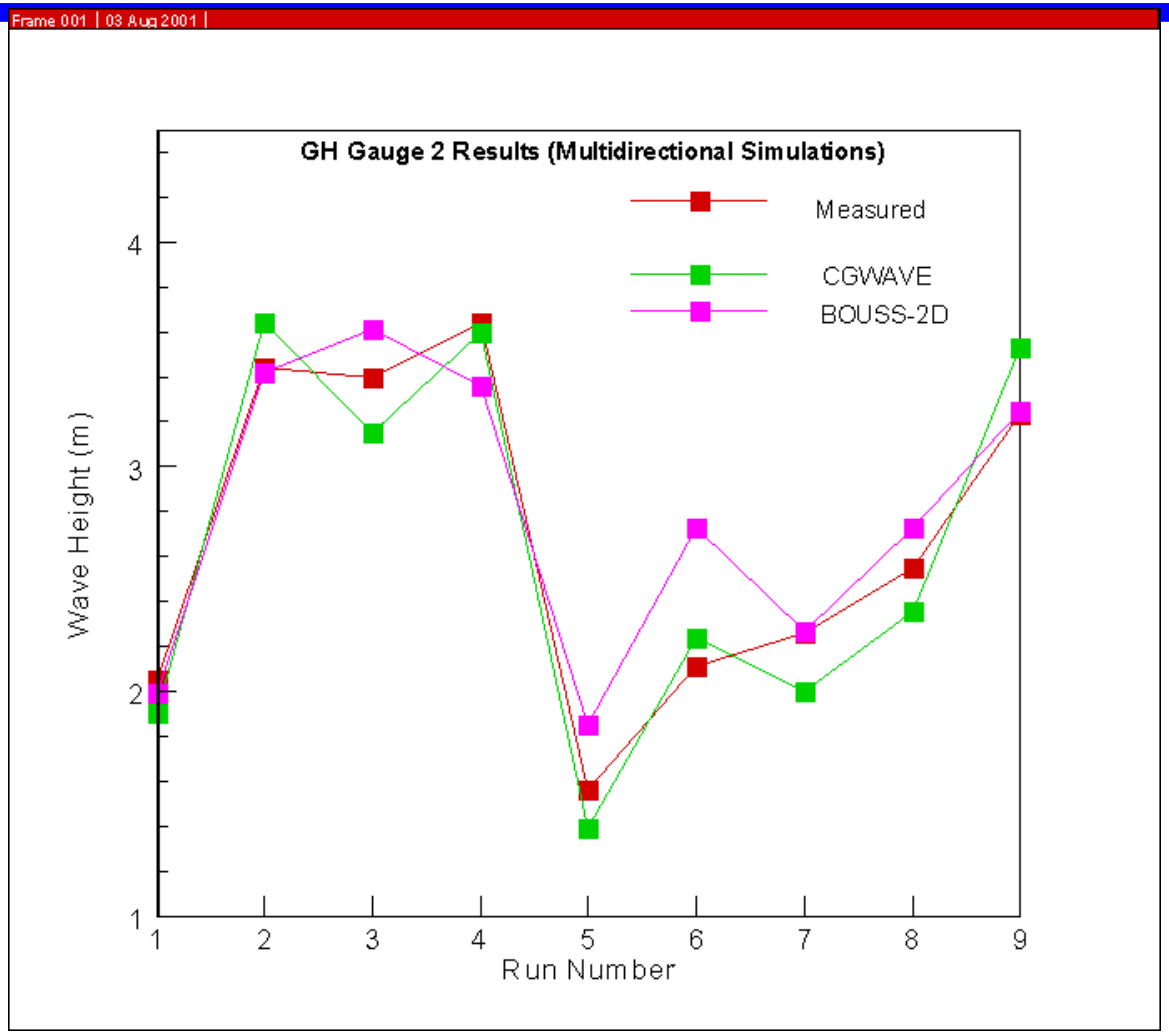
Morro Bay, CA


Project Condition
Waves from 275 deg
Height = 2.4 m
Period = 20 sec
swl = 0.0 m
HARBD
Physical Model
CGWAVE
Prototype
Amplification Factor
Distance Along Channel (m)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
0
200
400
600
800
1000
1200
1400

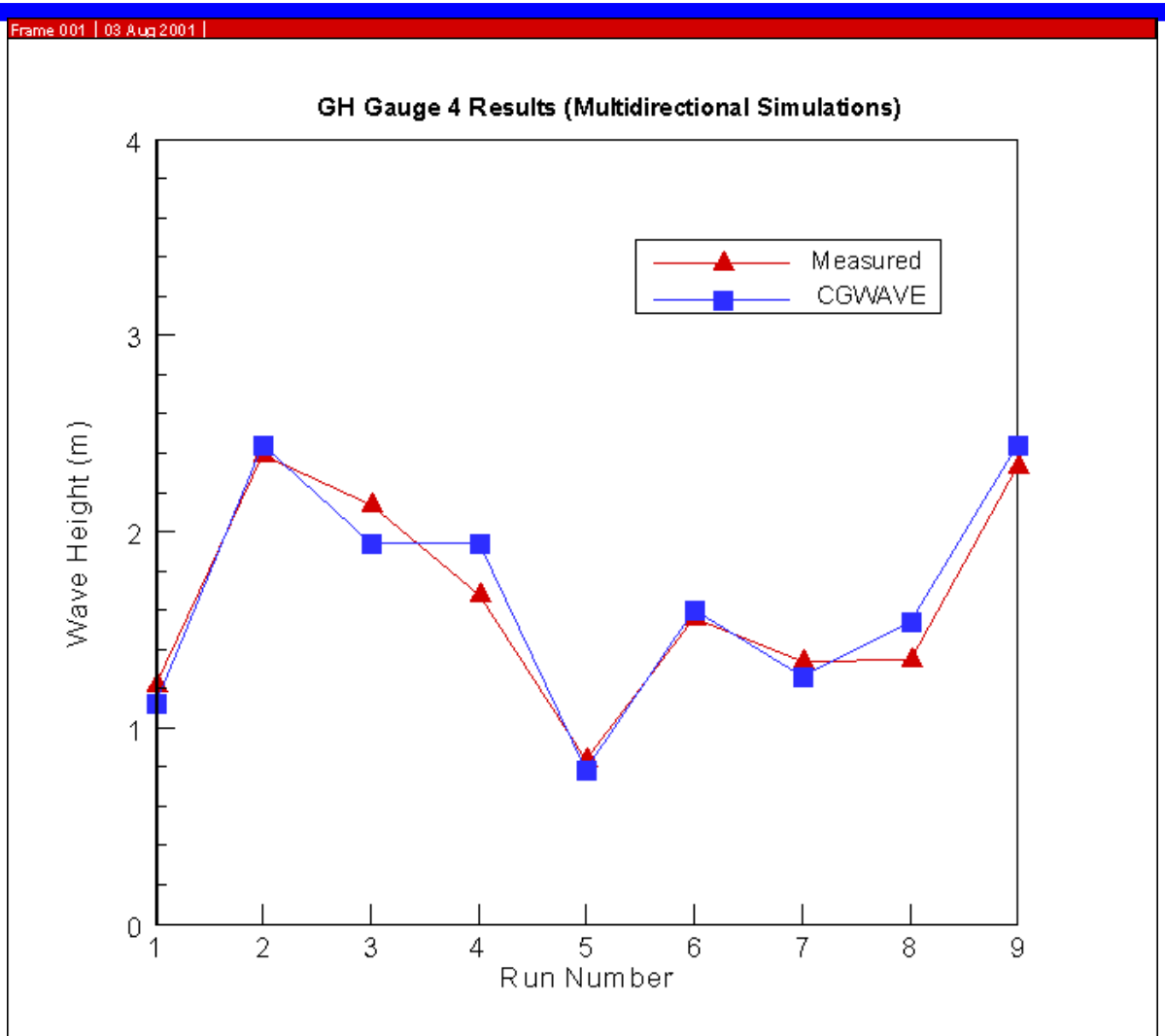
Grays Harbor Gauges



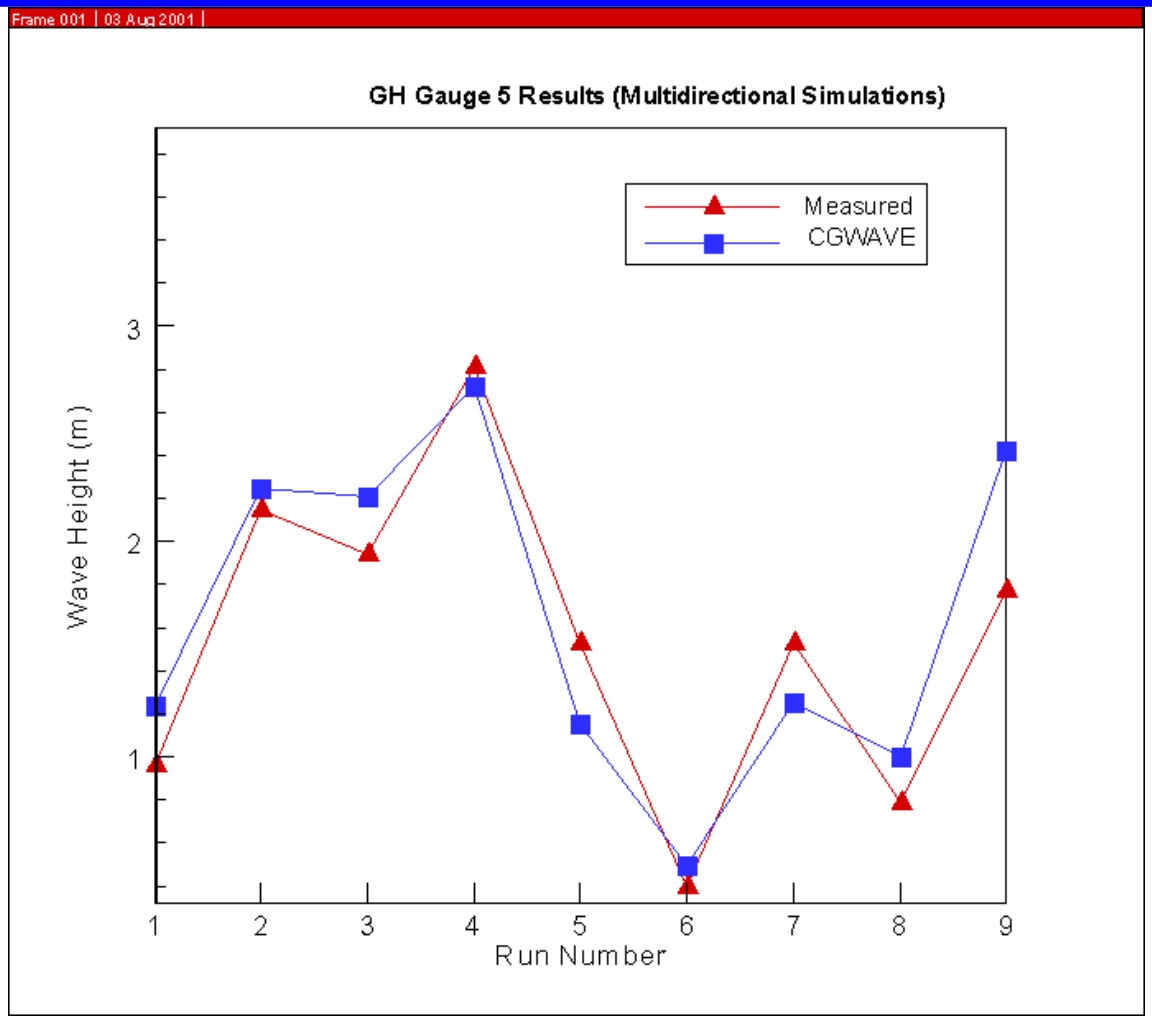
Grays Harbor, Gauge 2

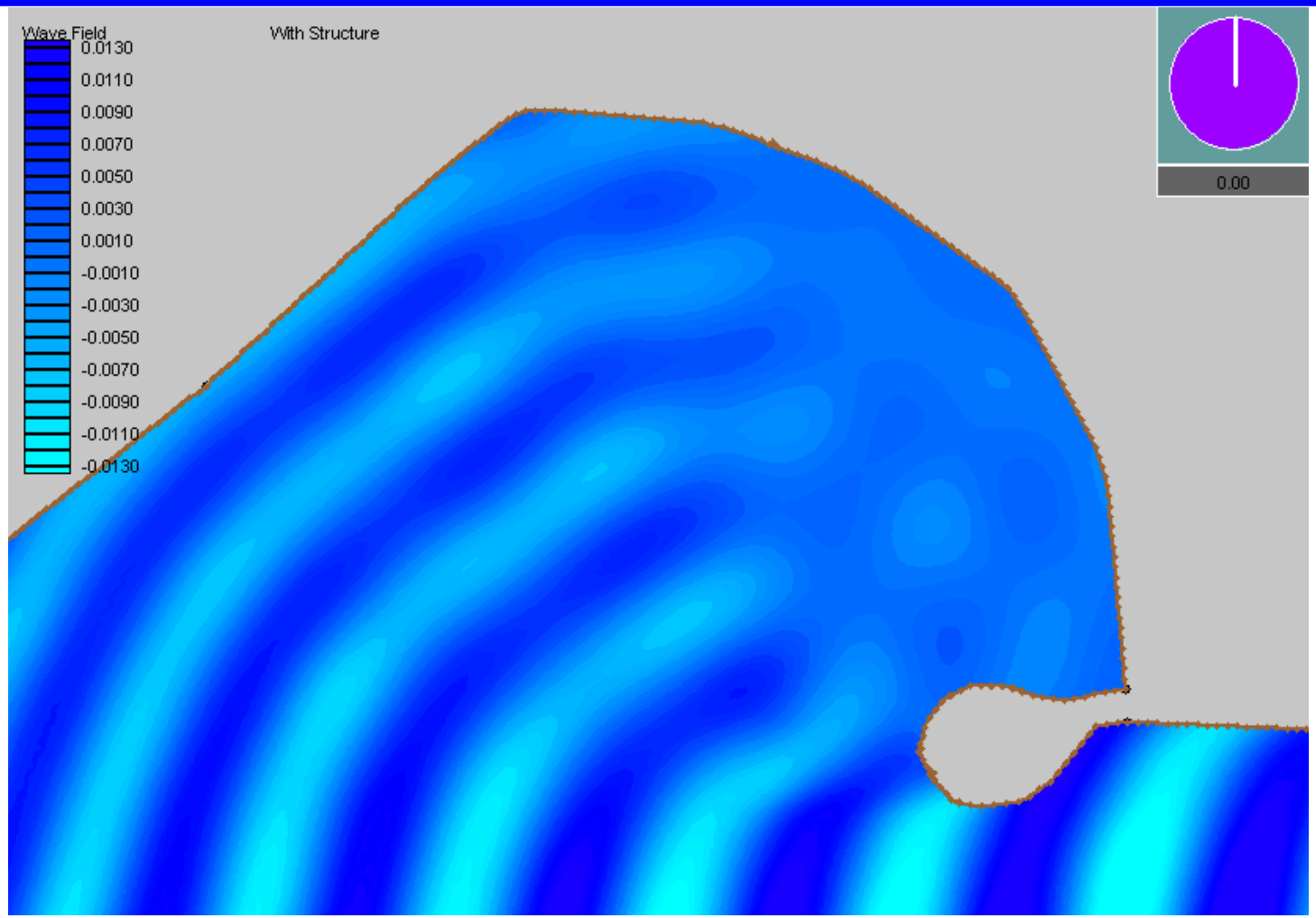


Grays Harbor, Gauge 4



Grays Harbor, Gauge 5



Grays Harbor, South Jetty

South Jetty at Grays Harbor, WA