

Waves, Surge, and Damage on the Bolivar Peninsula During Hurricane Ike

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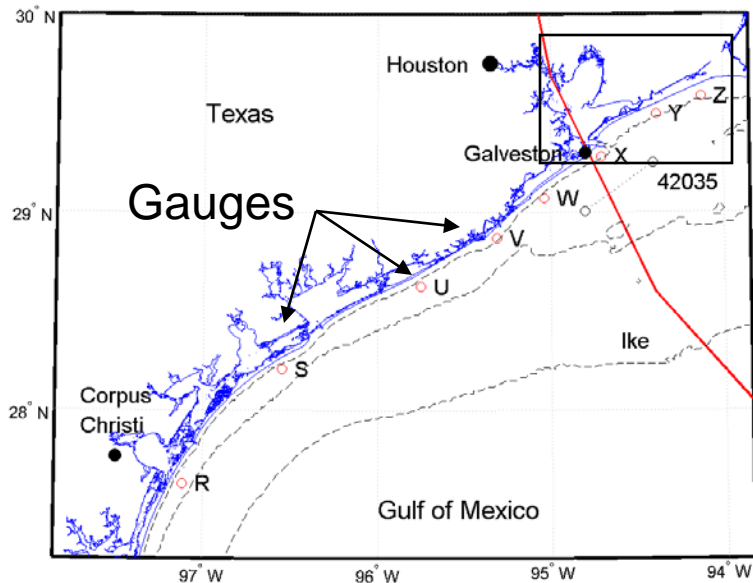


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Summary

- Hurricane Ike (2008) caused great destruction on the Bolivar Peninsula, Texas, elevation ~2m
 - Near-total inundation, massive devastation
 - Early, sustained, surge allowed overland wave penetration
- Temporary wave/surge gauges measured hydrodynamics ~10m depth
- USGS onshore gauges gave surge time series, rough wave climate
- Post-storm building damage surveys relate hydrodynamics vs damage vs building elevation

Hurricane Ike



Landfall at Galveston, TX

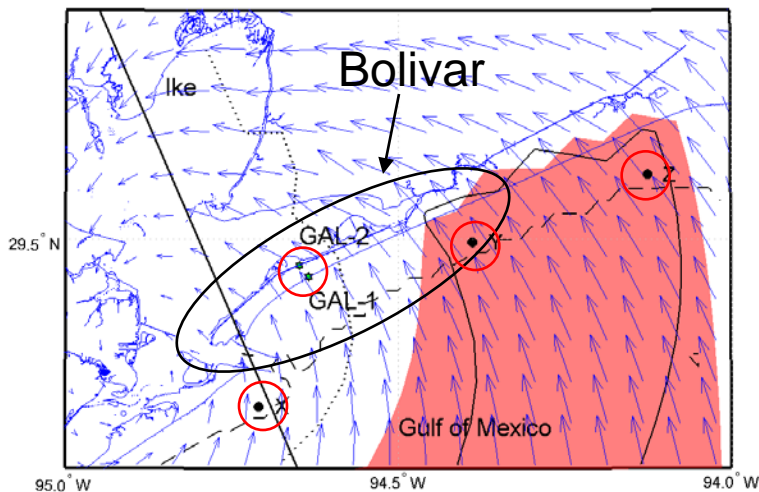
- Category 2, 95 knot winds
- Very large wind field

Bolivar experienced strong offshore-onshore winds

Array of 8 temporary gauges across Ike's track

- Helicopter placement, diver retrieval
- Three gauges (X,Y,Z) near Bolivar

USGS gauges GAL-1, 2 on exposed, sheltered side of peninsula

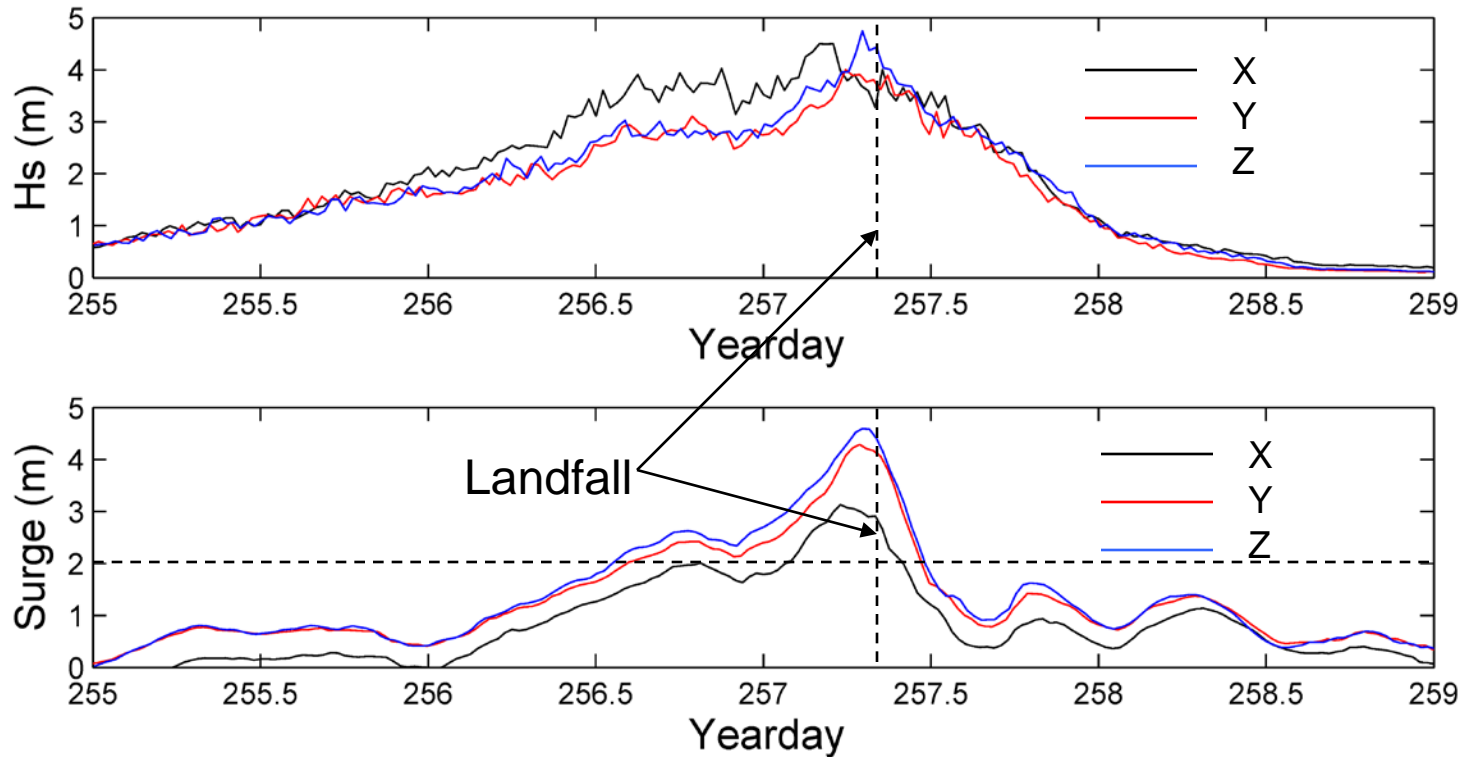


Winds at Landfall



Gauge Deployment

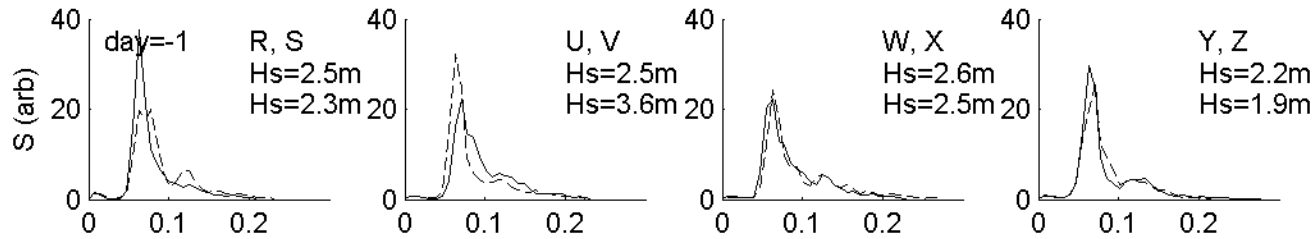
Waves and Surge in ~9m Depth



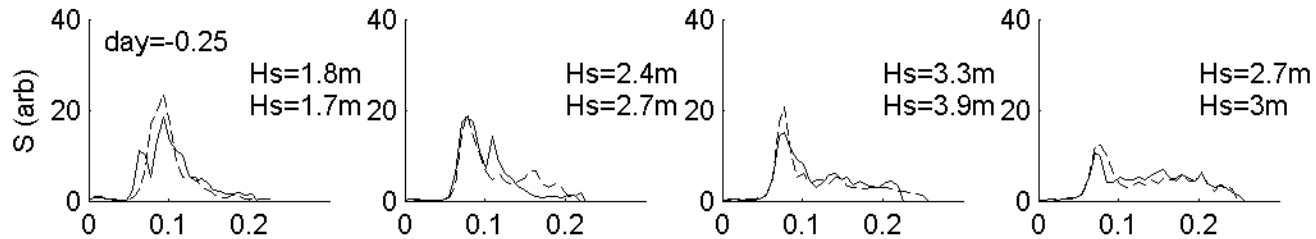
- Waves on strong side (Y,Z) were large and close to equilibrium with local winds
- Waves near landfall (X) were a combination of swell and sea
- Surge exceeded 2m NAVD88 around 18 hours before landfall
 - Likely caused by Coriolis effect from ~1m/s longshore current

Normalised Wave Spectra

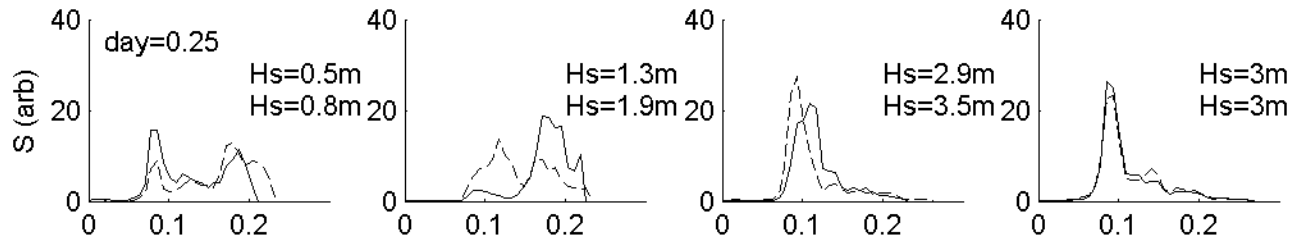
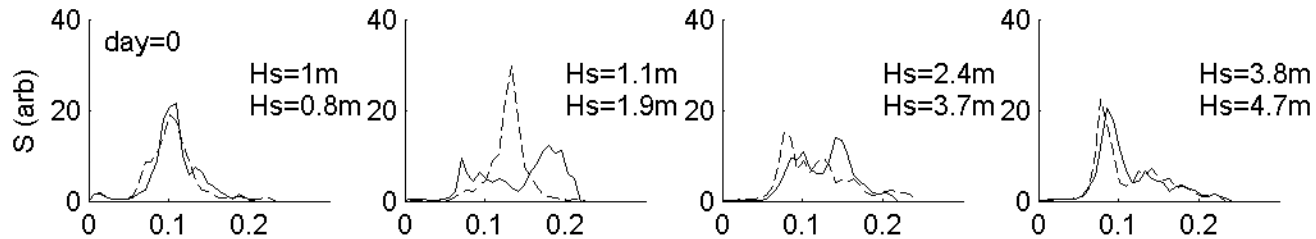
Before
Landfall



Landfall



After
Landfall

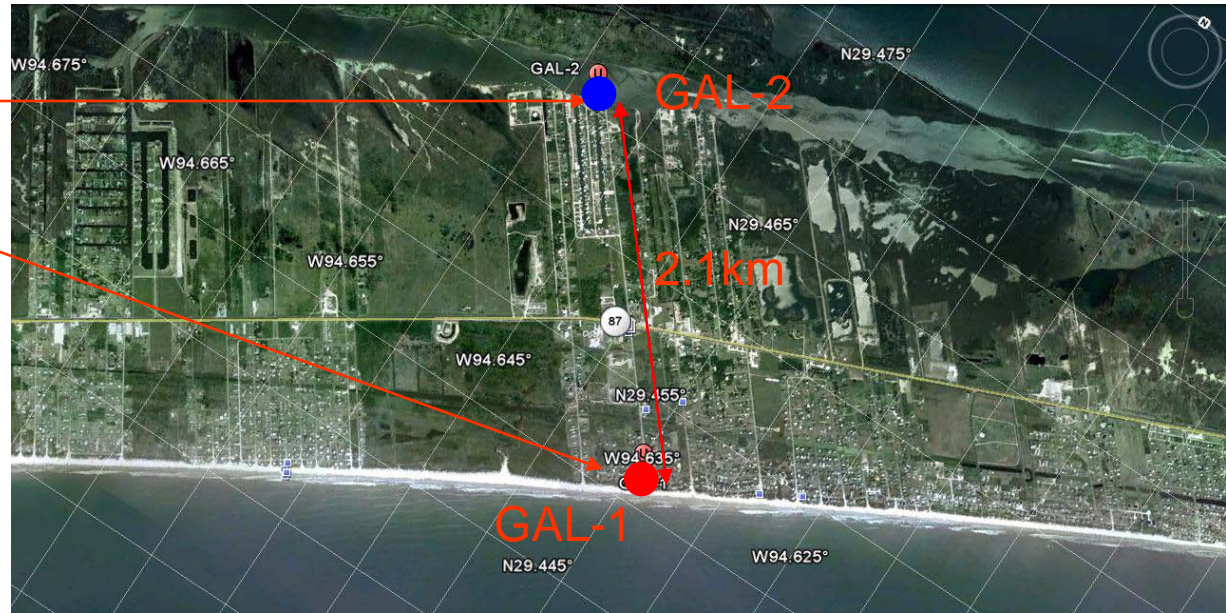


Weak Side

Near
Landfall

Strong
Side

Overland Waves and Surge



--- GAL-2

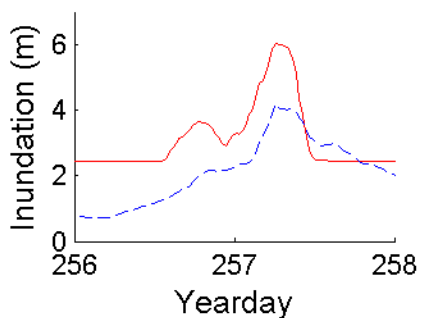
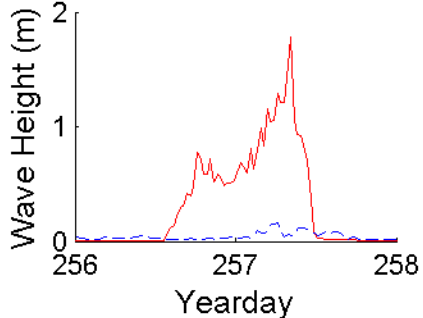
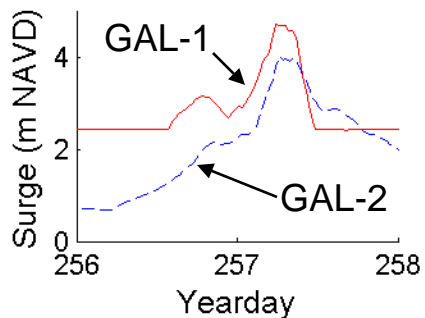
— GAL-1

- Surge large at both gauges

- Large waves at GAL-1

- Very small waves at GAL-2

- Near 6m wave plus surge crest inundation at GAL-1



GAL-1, Pre-Ike



Croaker Ln

Trout Blvd

Pompano Ln

Redfish Ln

Galv-001

S Crystal Beach Rd

96 m

Image NOAA
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Imagery Date: Sep 15, 2007

29° 27.083' N 94° 38.135' W elev 0 m

Eye alt 340 m

GAL-1, Post-Ike

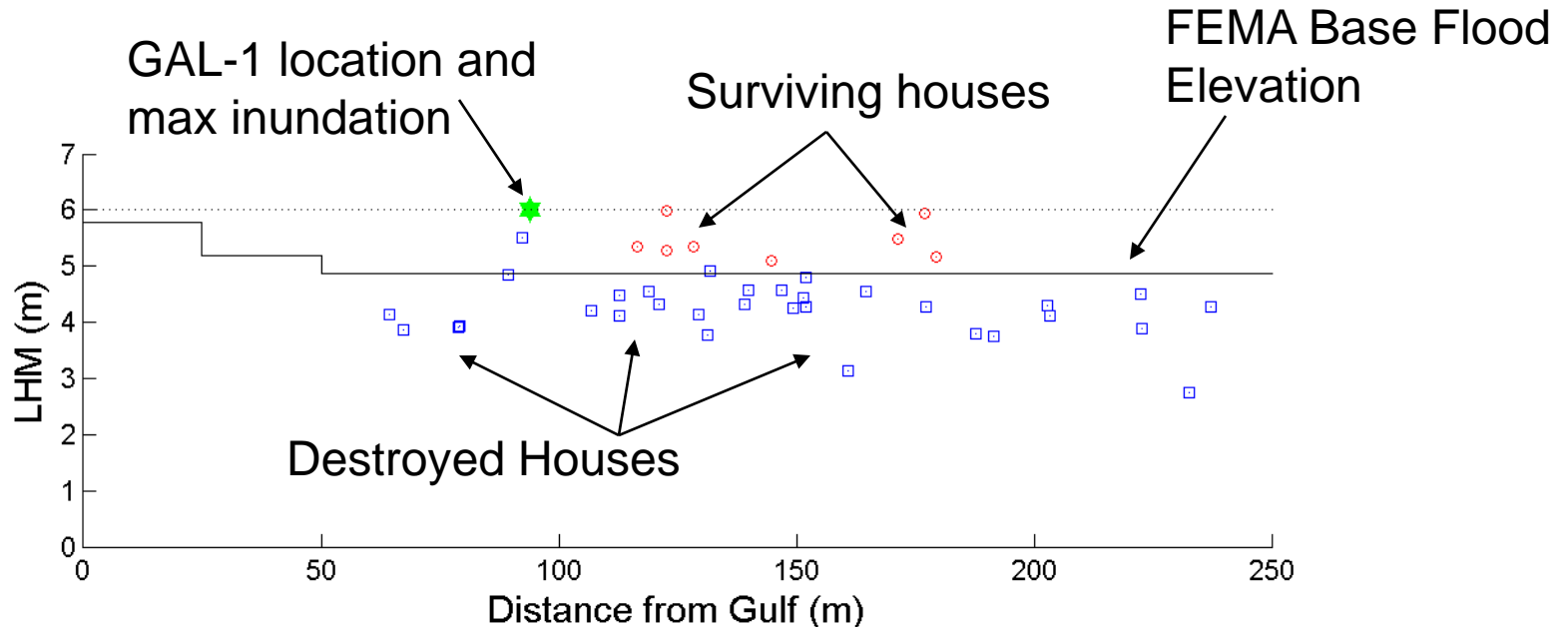


96 m

Image NOAA
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Wave Damage vs Building Elevation, GAL-1



- Survival or Destruction controlled by elevation of Lowest Horizontal Structural Member (LHM)
- Very narrow range in elevation between survival and destruction
- Large waves → $H_{smax} = 1.8m$ at GAL-1
- FEMA Base Flood Elevation of 1992-1993 gives reasonable estimate of survival vs destruction here

Ground Level Photos Near GAL-1

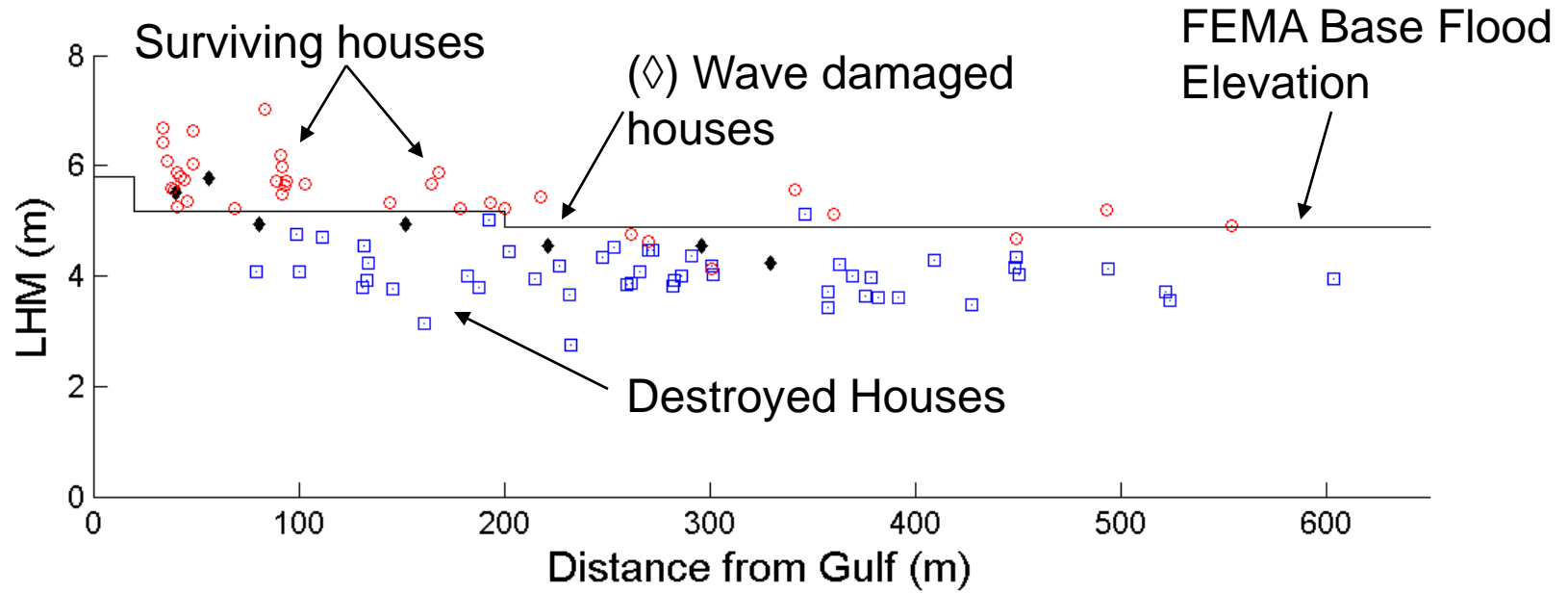


Immediately pre-Ike

Post-Ike

Photos courtesy of USGS

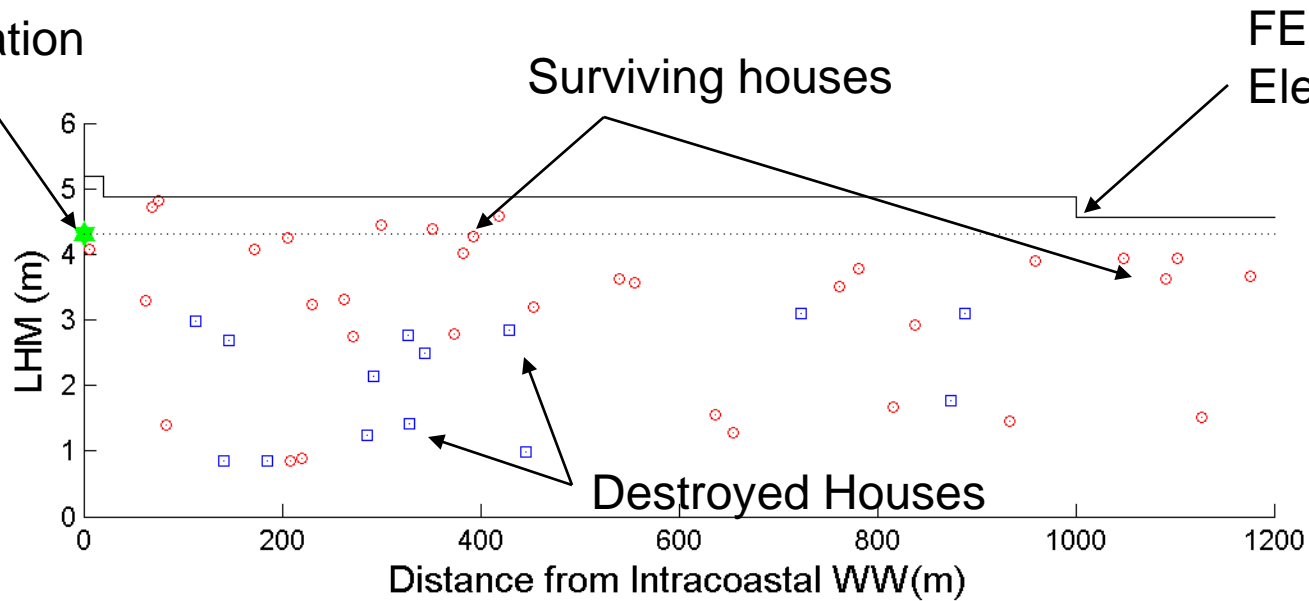
Damage at another Open Gulf Location



- Again very small range in elevation between survival and destruction (~0.5m)
- Large waves here but exact heights uncertain
- Similar results at many more open coast exposed locations

Wave Damage vs Building Elevation, GAL-2

GAL-2 location and max inundation



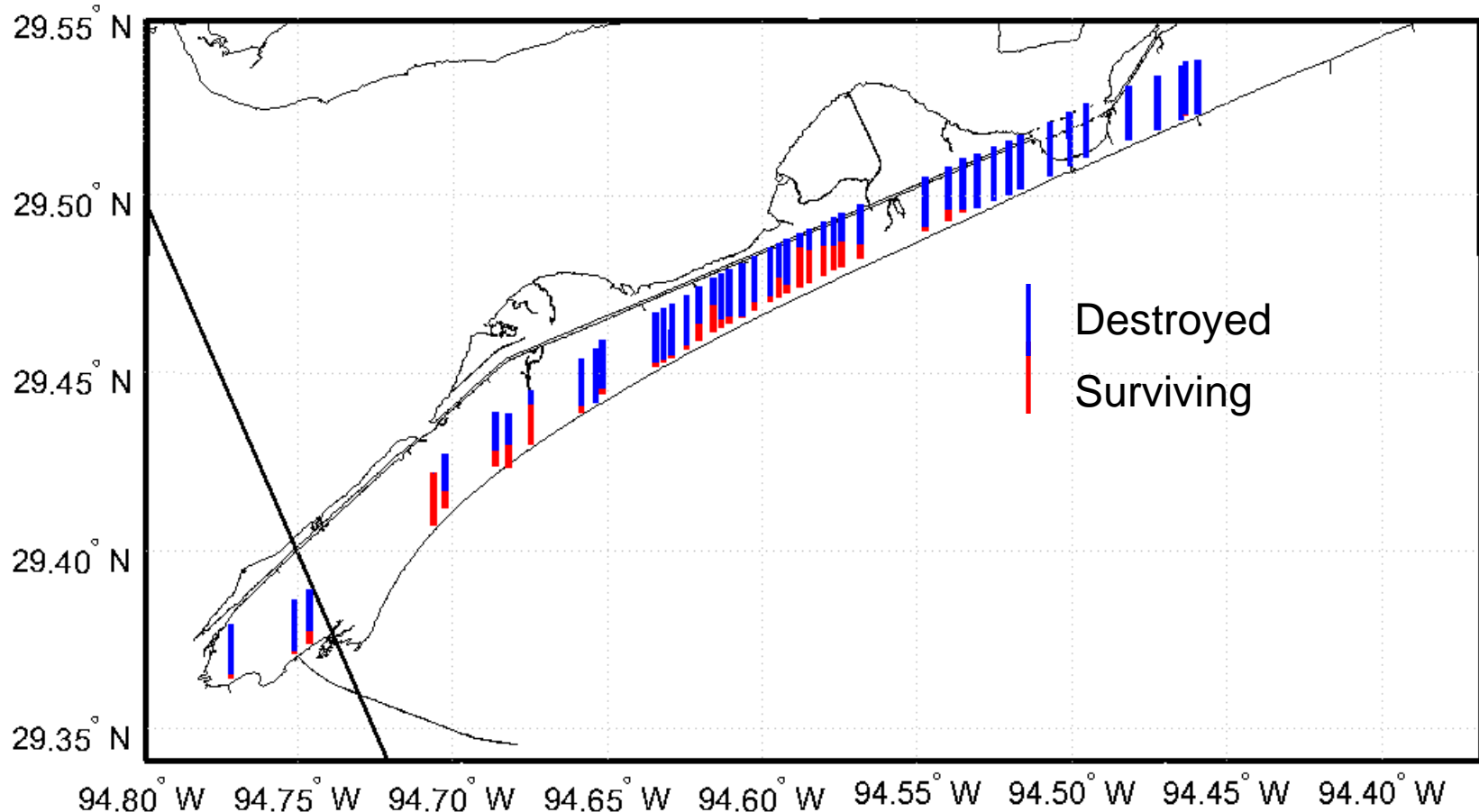
- Survival can occur at any elevation
- No clear elevation dividing survival and destruction
- Small waves → $H_{smax} < 0.2m$ at GAL-2
- FEMA Base Flood Elevation of 1992-1993 higher than elevation of many surviving buildings
- Supposed to be V-Zone ($H > 3ft$) but no evidence of large waves

House Near GAL-2



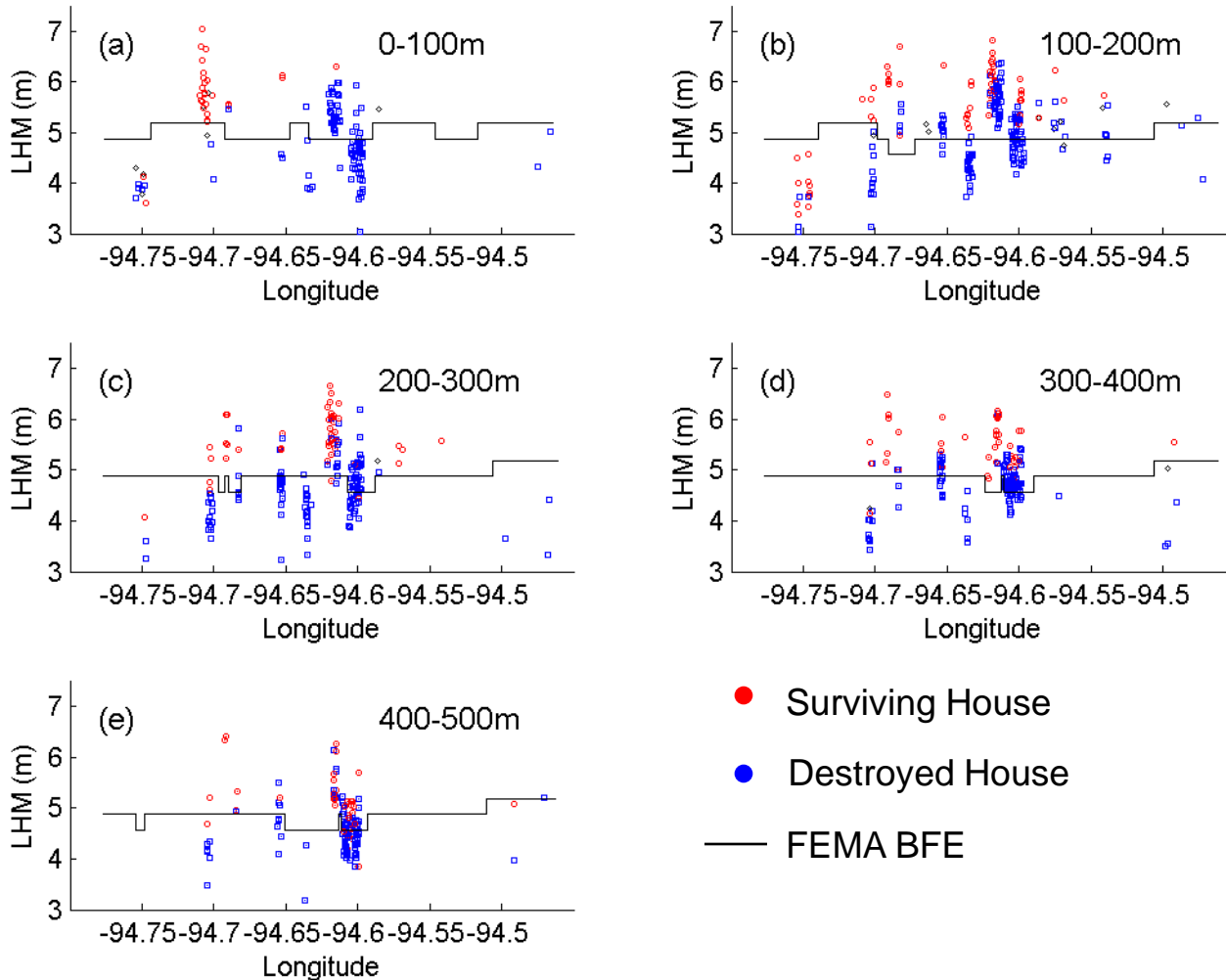
At-grade house less than 100m from gauge GAL-2 on the Intracoastal Waterway. Note the flood debris on roof and survival of a flimsy picket fence. Photo courtesy of USGS.

Overall Destruction Near Gulf Shoreline



- Very high destruction along entire shoreline – varies by location and elevation of construction

Survival vs Elevation near Gulf Shoreline



Conclusions

- Large and sustained waves and surge over parts of Peninsula during Ike
- Strong link between building survival and elevation in areas with large waves
- Weaker link in areas with small waves
- Large decay of waves traveling across peninsula – detailed dissipation not yet predictable
- Wave height where waves stop battering down houses also unclear

Acknowledgements

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- Thanks in advance to anyone who sponsors this work for next hurricane season



Last House Standing
Photo: Ray Asgar, Helicopter Pilot