Wake Sport Wave Energy Study

A report on methods, findings, and recommendations

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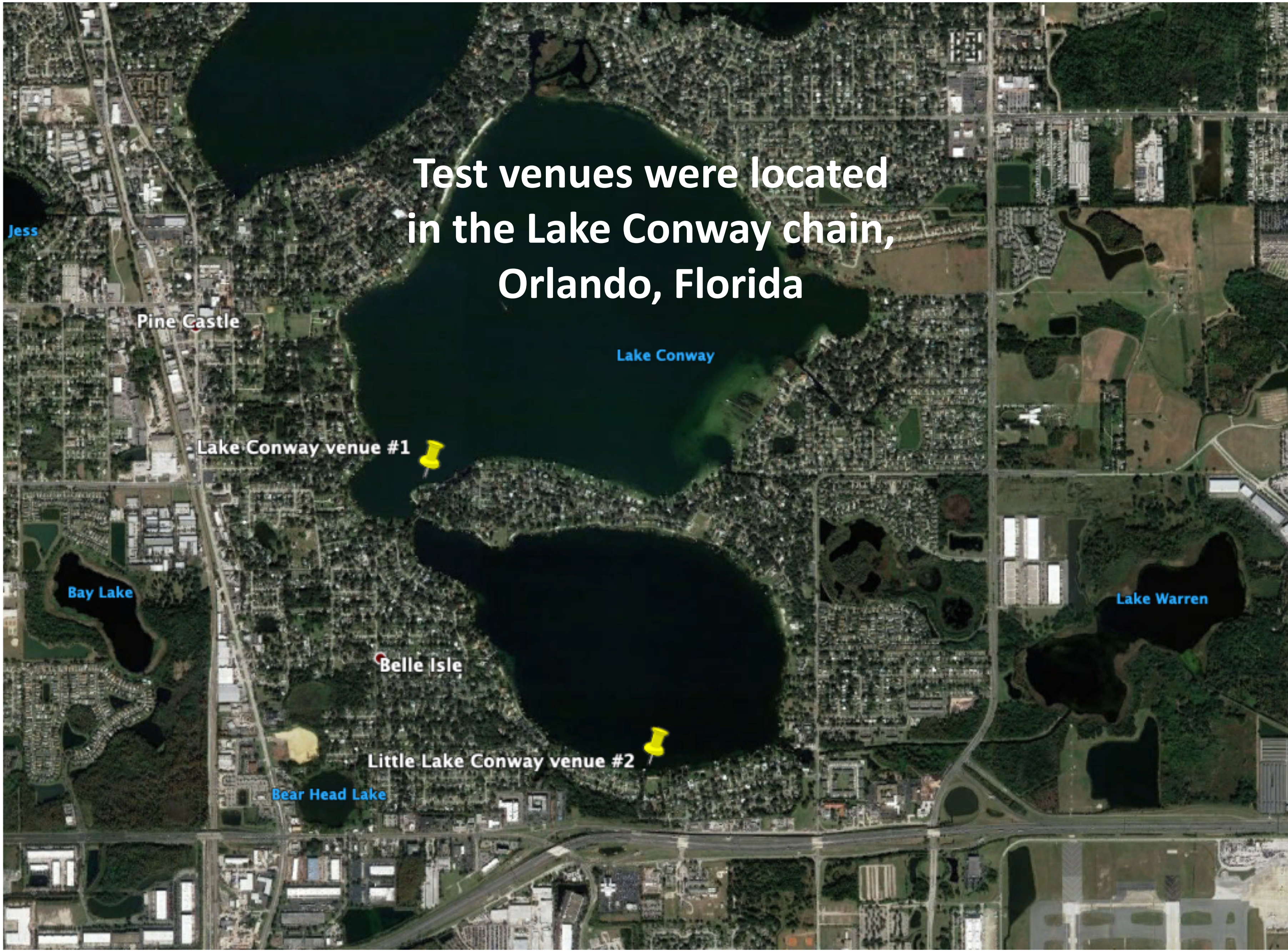
This study was commissioned by the Water Sports Industry Association (WSIA) in Spring 2015 to help bring science and empirical data to emerging boat-wake issues.

Purpose of study

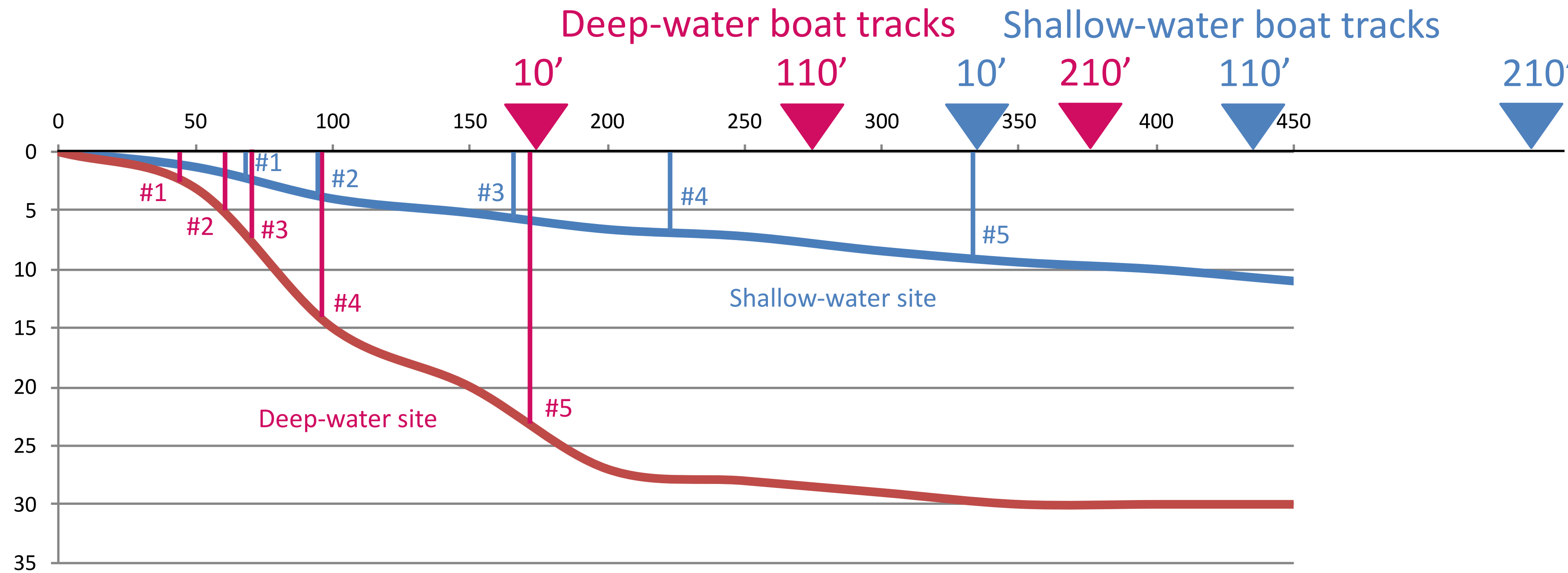
- Collect accurate data on waves generated in wake sports
- Build an understanding of how waves are influenced by boat operation
- Quantify the role of depth and distance from shore
- Compare wake-sport wakes with other wave sources
- Guide the development of responsible wake-sport practices

To be covered today

- Explain the methods used in the study
- Characterize the wakes generated by a typical wake-sport boat during cruising, wakeboarding, and wakesurfing
- Explain the role of depth and distance from shore
- Compare wake energies with wind-wave energies

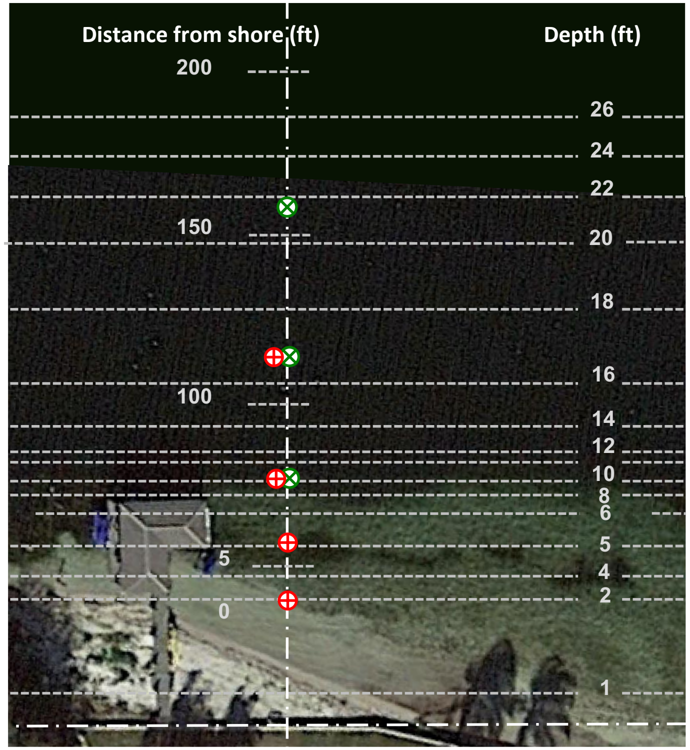

Test venues were located
in the Lake Conway chain,
Orlando, Florida
Jess
Pine Castle
Lake Conway
Lake Conway venue #1
Bay Lake
Lake Warren
Belle Isle
Little Lake Conway venue #2
Bear Head Lake

Site depths, sensor locations, and boat track offsets

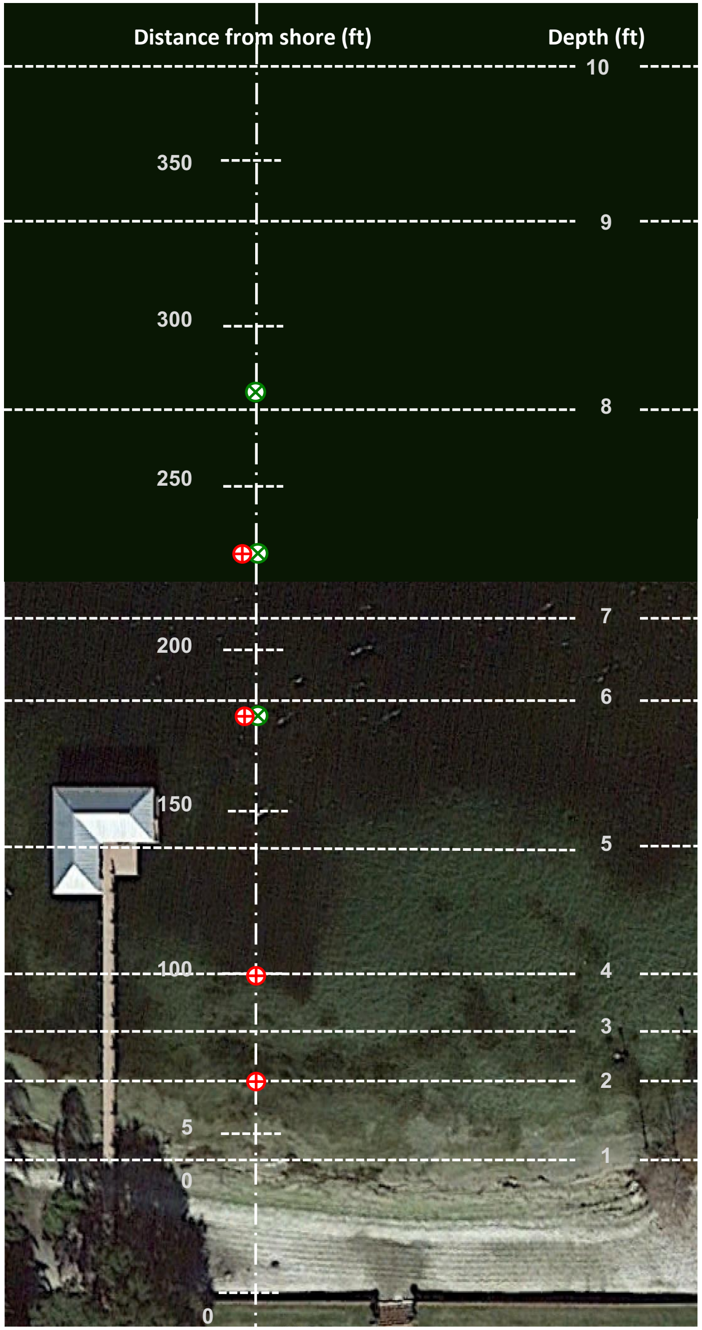


Test venues in the Lake Conway chain

Deep-water site



Shallow-water site



Installation at the shallow-water site as seen from shore

Pressure sensors and capacitance–wire probes were used to measure water surface elevation.

Boat runs were at an angle to generate waves parallel to the shore.
Three tracks were used distance 10’, 110’, and 210’ from the outer probe.

Cruising speeds	Wakeboard speeds	Wakesurf speeds
20 , 25, and 35 mph	21.2 , 22.2, and 23.2 mph	10 , 11, and 12 mph

A suitably ballasted Nautique G-23 was used for all tests

Sensor data was collected with a PC-based data acquisition system using LabView.

A bit about waves

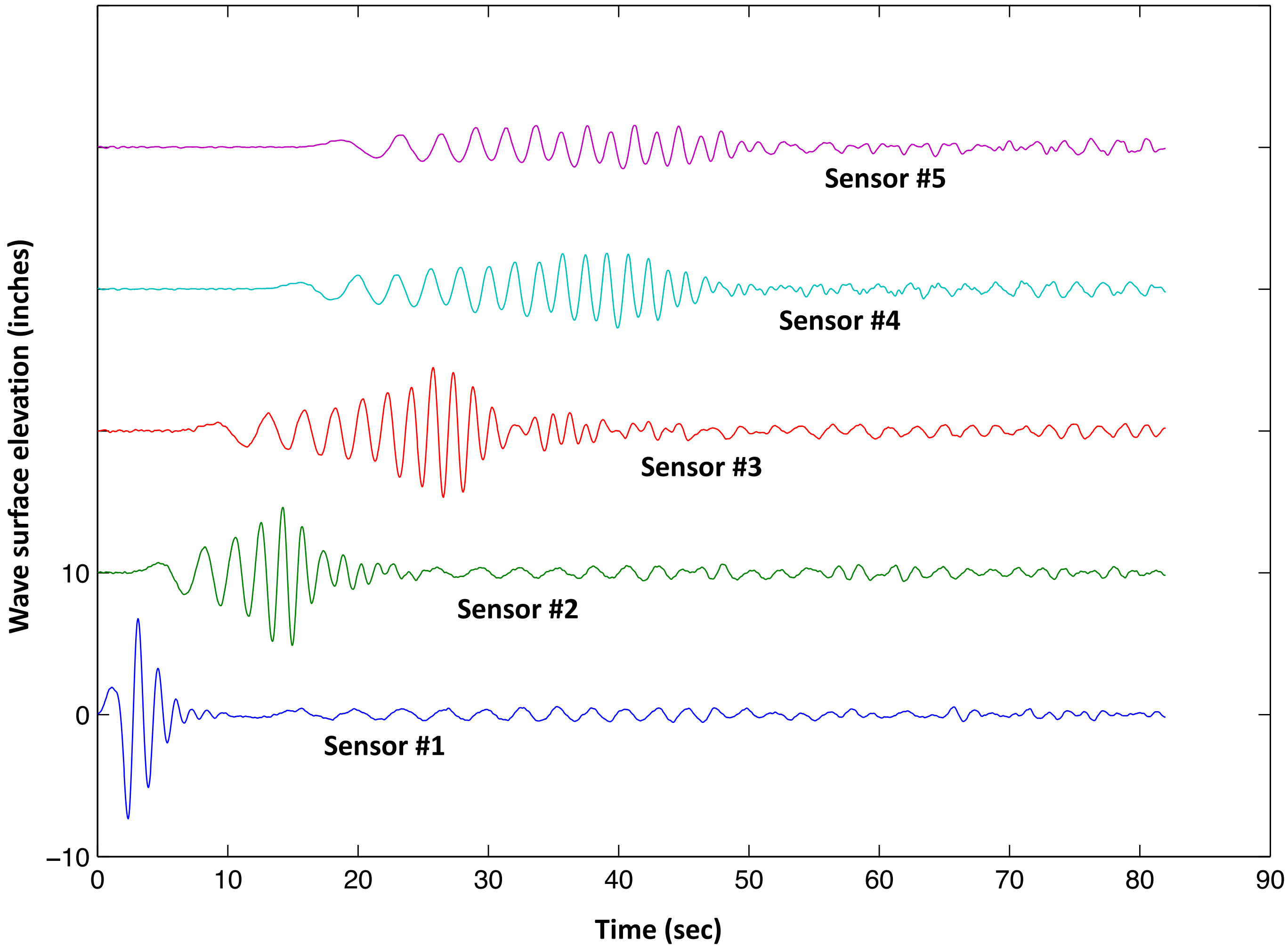
Waves have a phase velocity and a group velocity. In deep water the phase velocity is twice the group velocity. A wake is a group of waves and new waves emerge from the back of the wake and travel through the group and disappear at the front of the wake.

The implications for us is that our plots of wave elevation indicate twice the number of waves compared to a photo of that same wake.

https://en.wikipedia.org/wiki/Dispersion_%28water_waves%29

This is important to keep in mind when looking at the wake plots to follow

Shallow-water Run #6 - Cruising, 25 mph, 10’ distance



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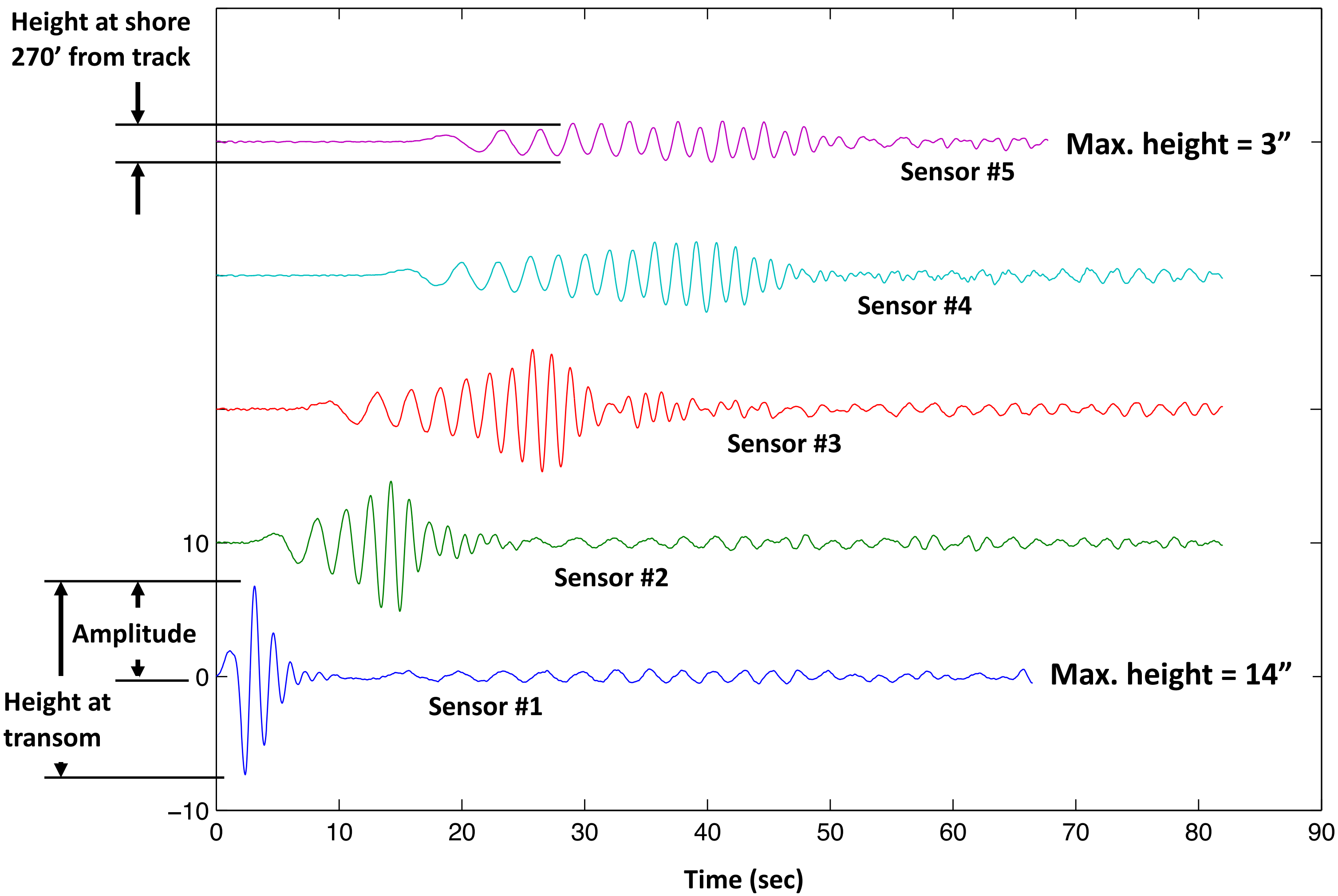

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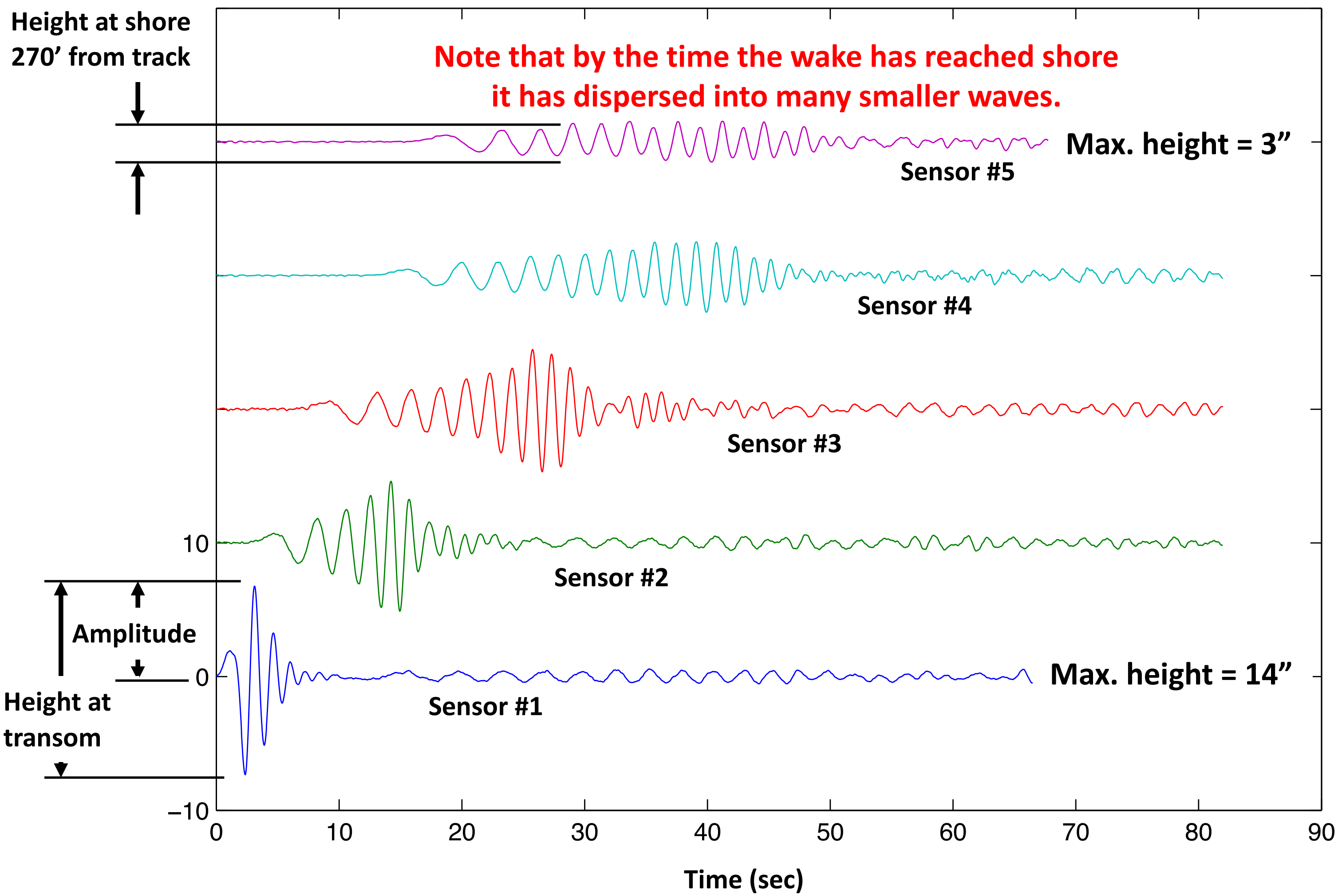
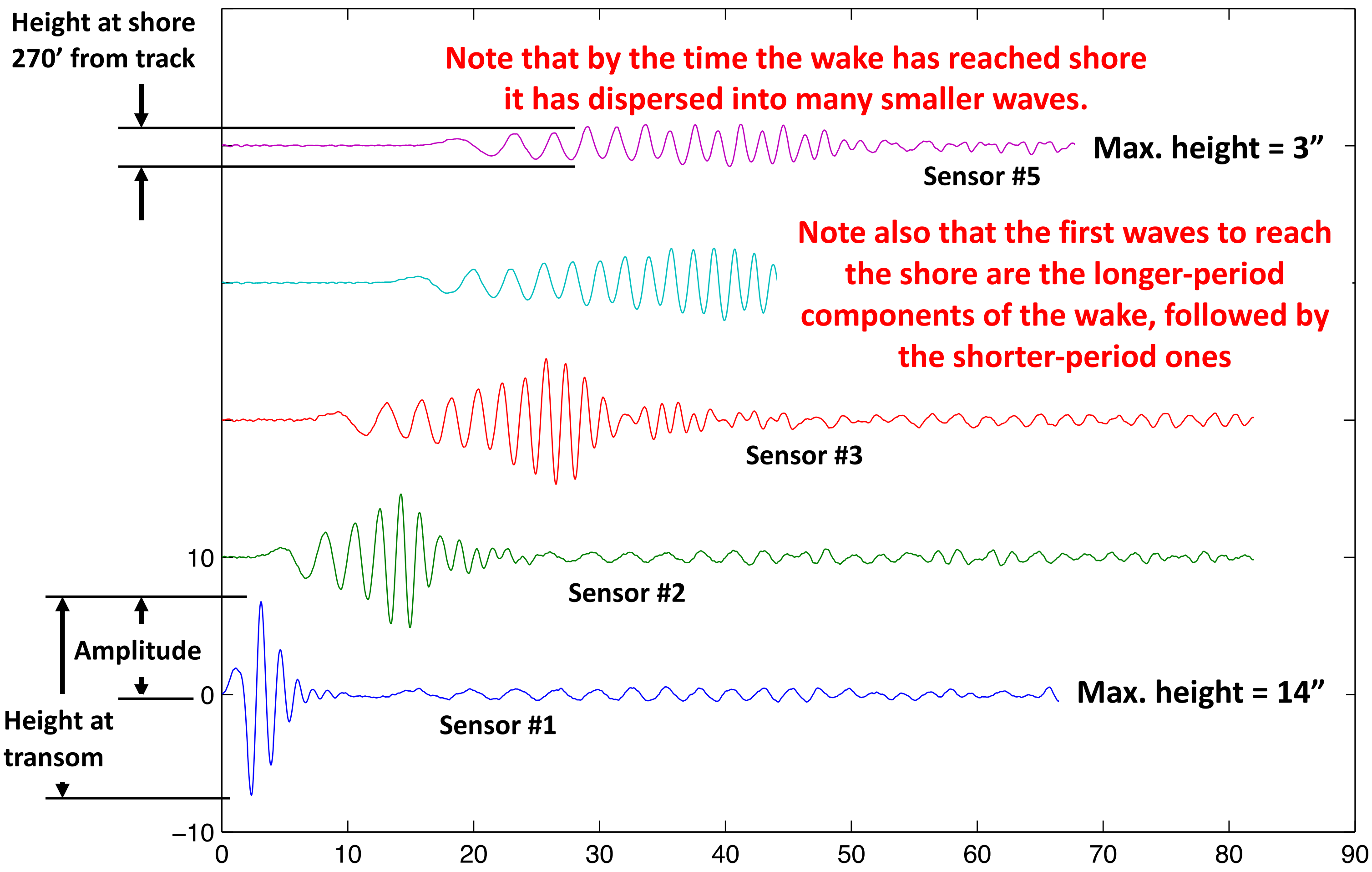
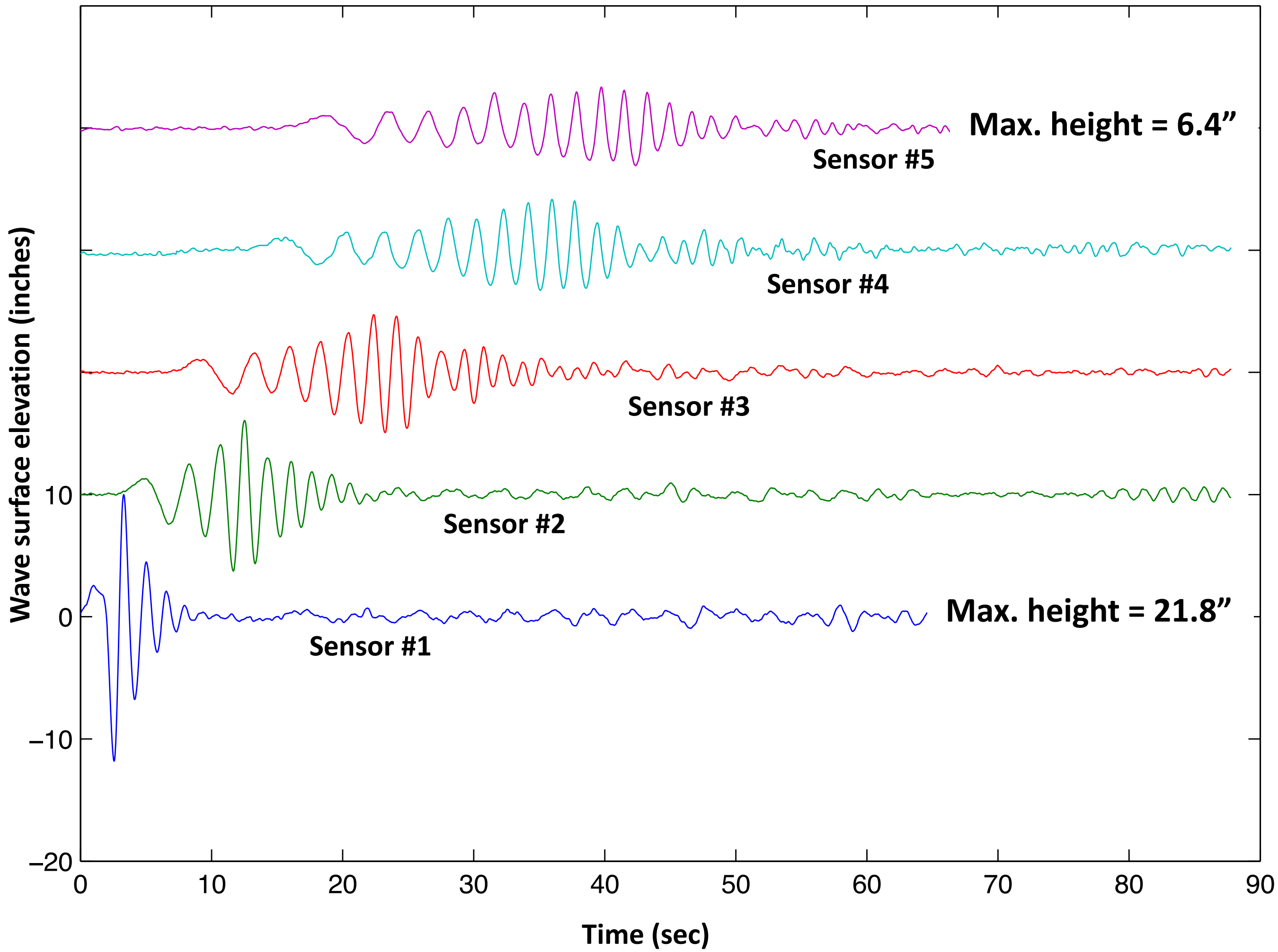


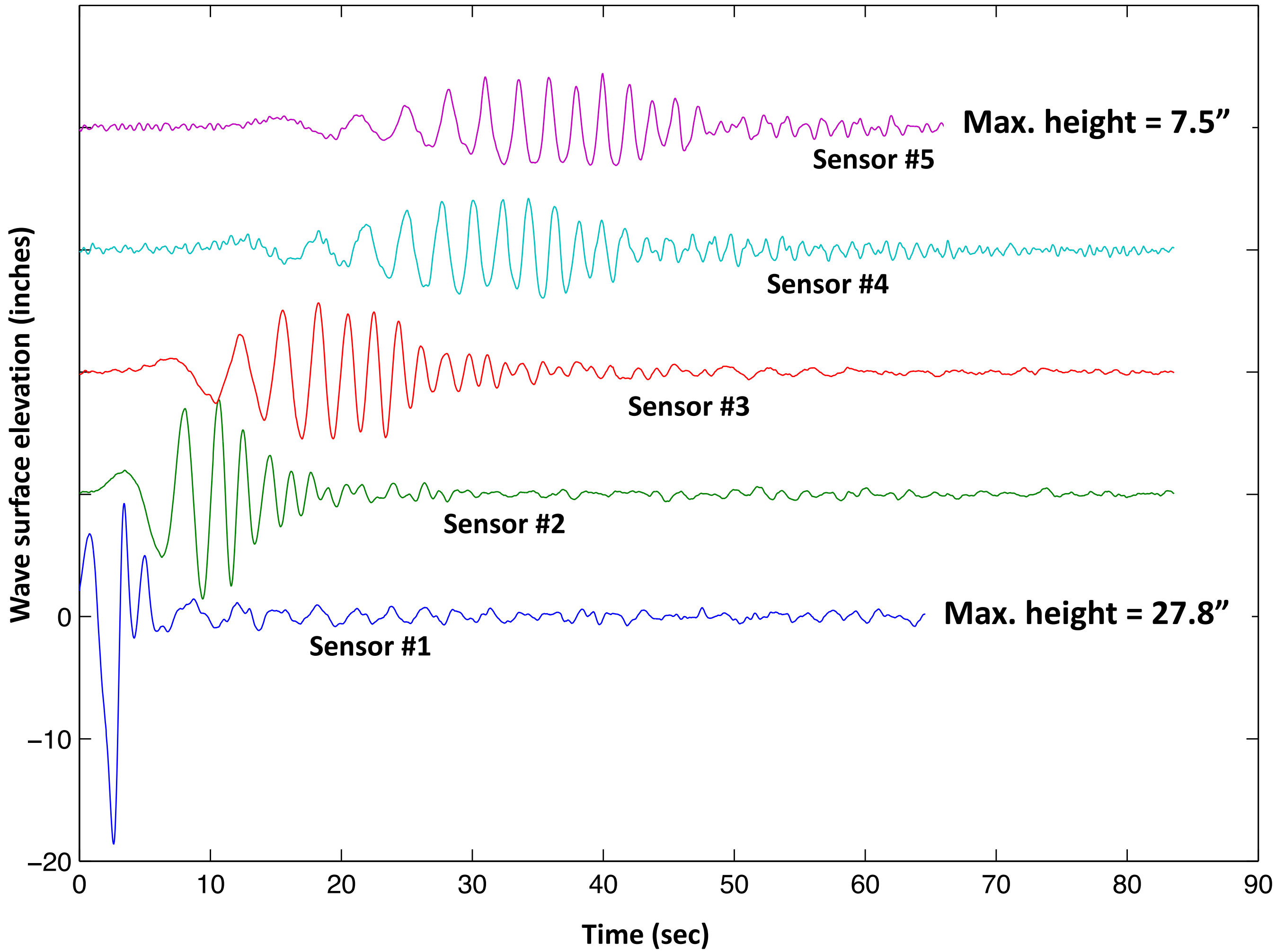
Shallow-water Run #6 - Cruising, 25 mph, 10' distance



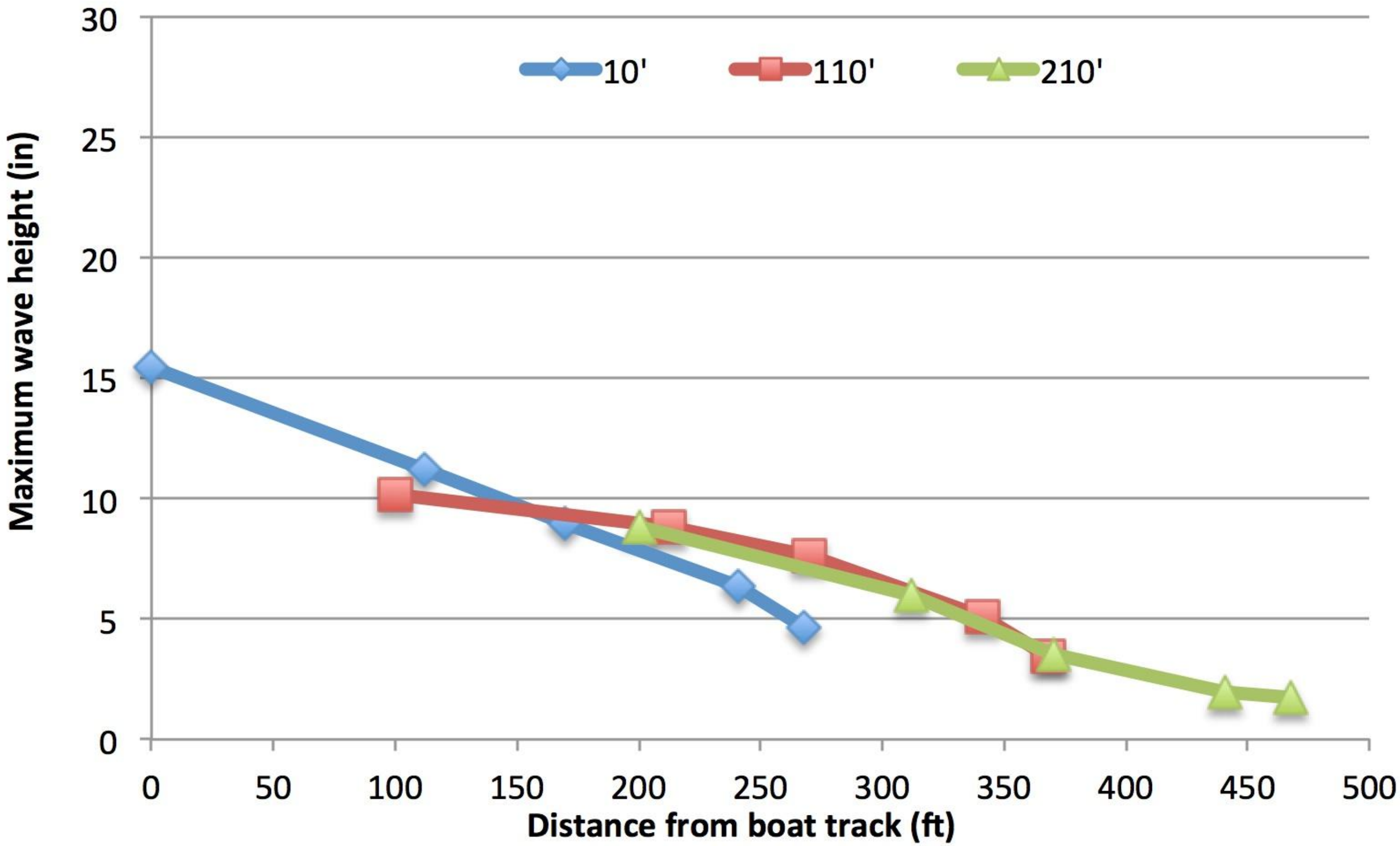
Shallow-water Run #15 - Wakeboarding, 22.2 mph, 10' distance



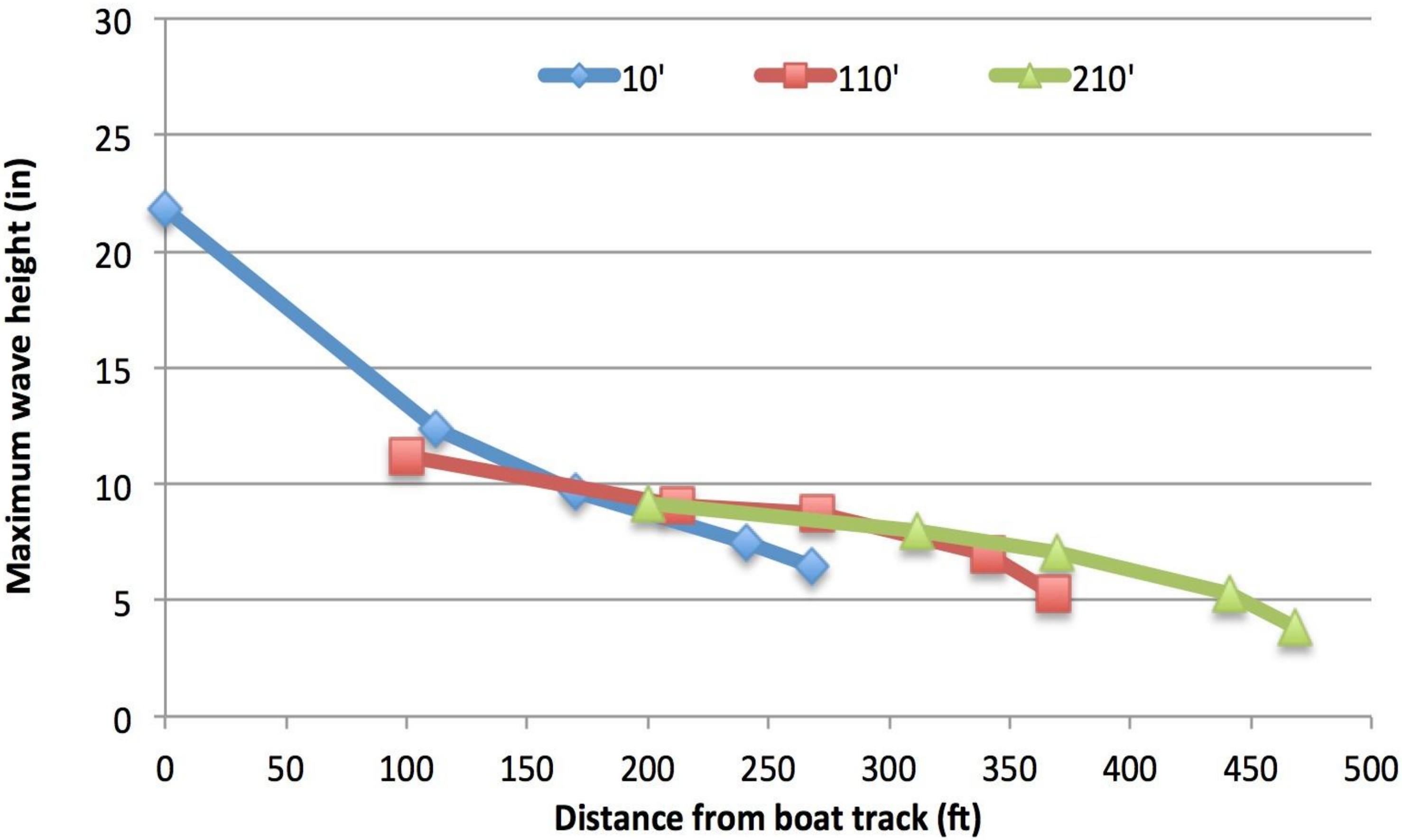
Shallow-water Run #24 - Wakesurfing, 11 mph, 10' distance



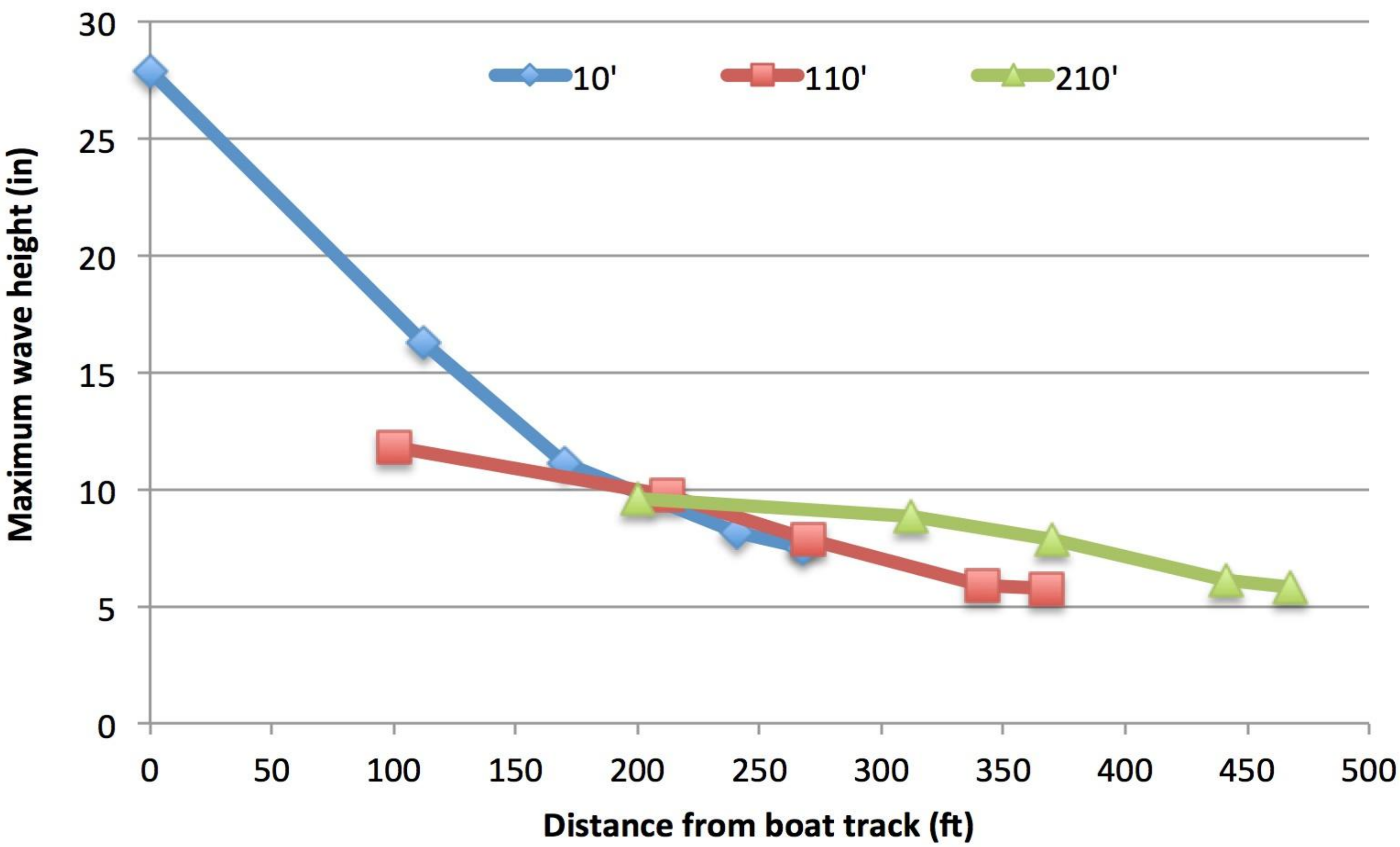
Wave height vs. distance in shallow-water cruising at 25 mph



Wave height vs. distance in shallow-water wake boarding at 22.2 mph



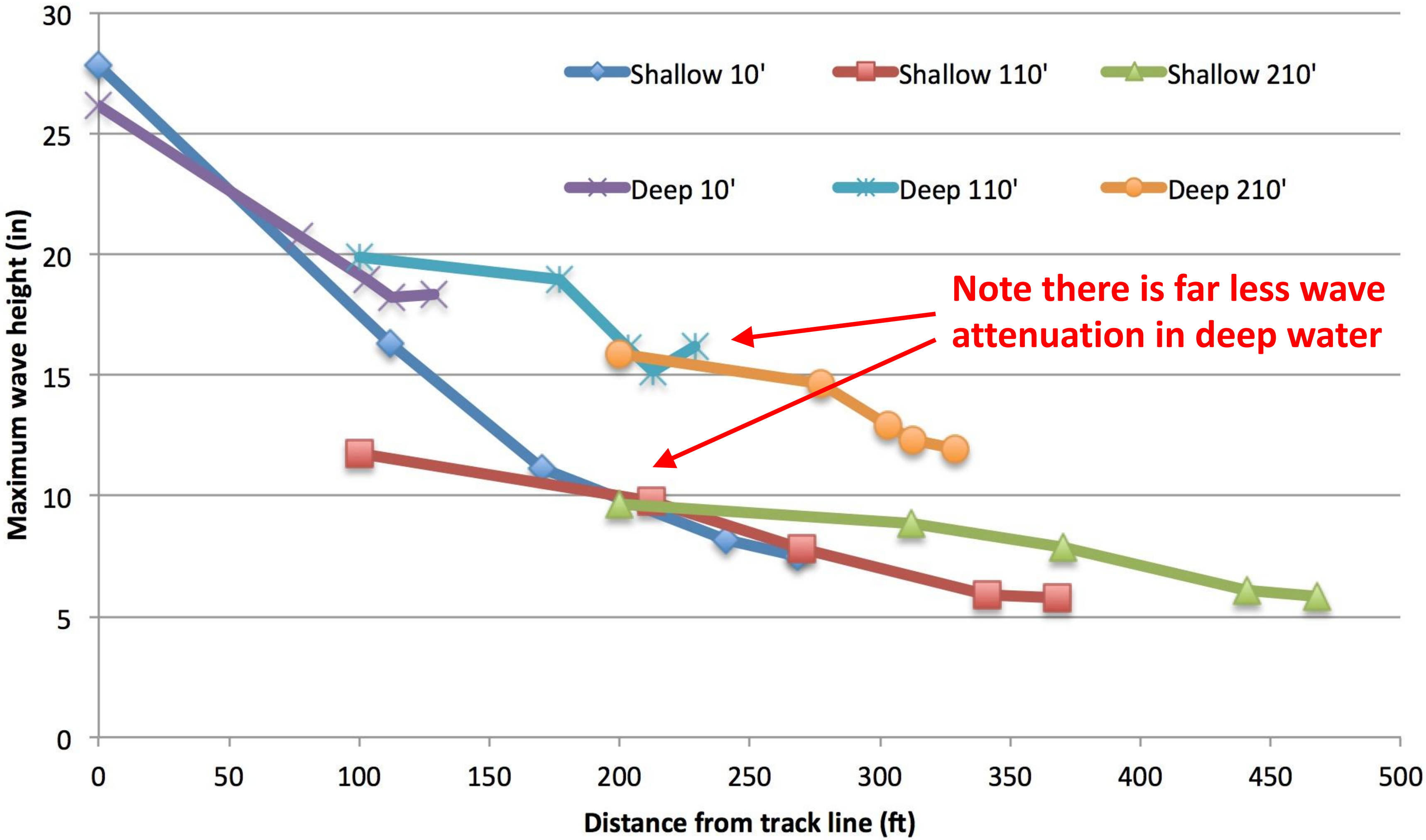
Wave height vs. distance in shallow-water wake surfing at 11 mph



At the boat, there are significant differences in maximum wave height between the three operating conditions, less so at 200’.

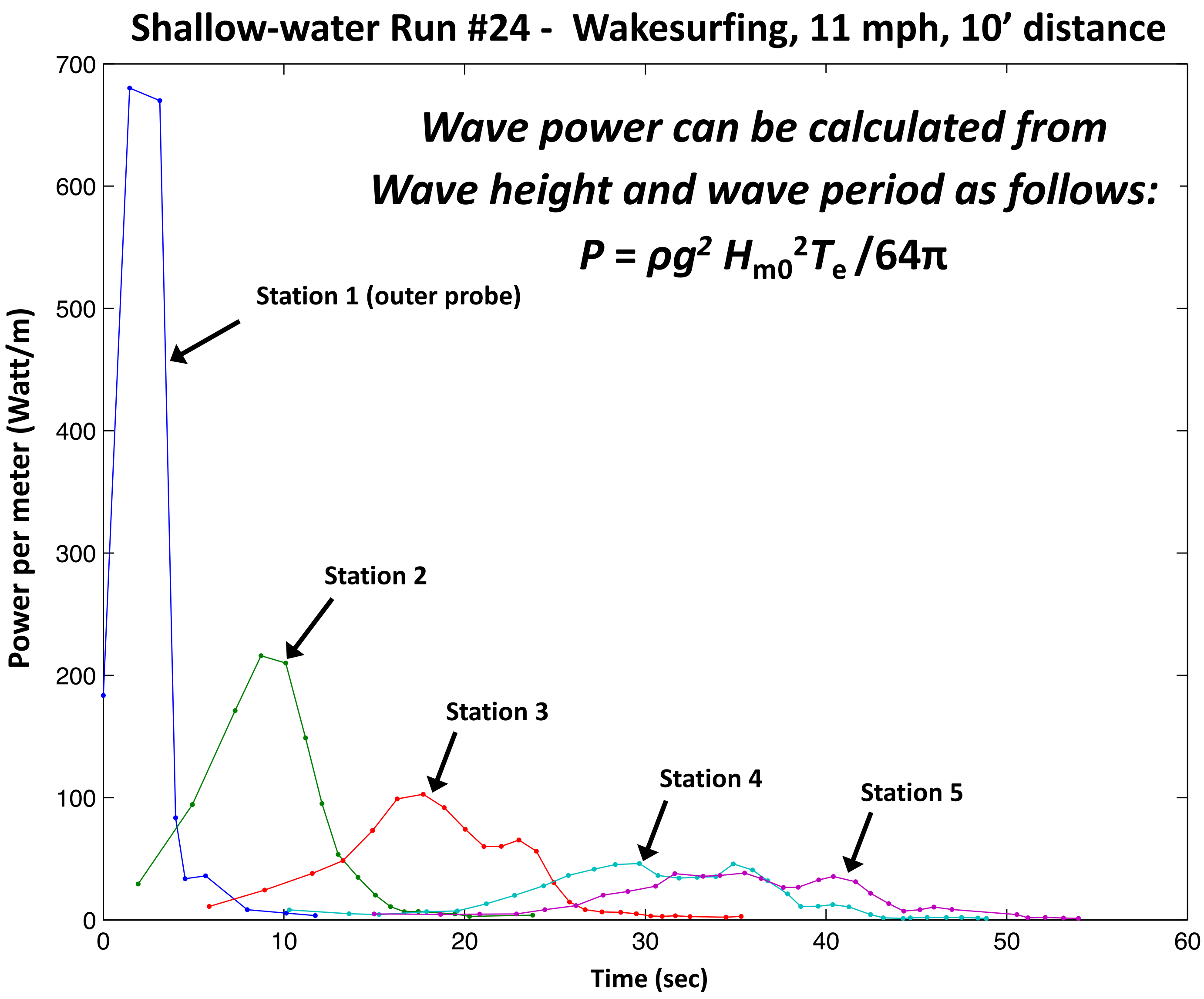
	Distance from track	
Condition	**10’**	**200’**
Cruising	**15.4”**	**8.5”**
Wake boarding	**22”**	**9.0”**
Wake surfing	**27”**	**9.5”**

Maximum wave height results wake surfing at both shallow and deep sites

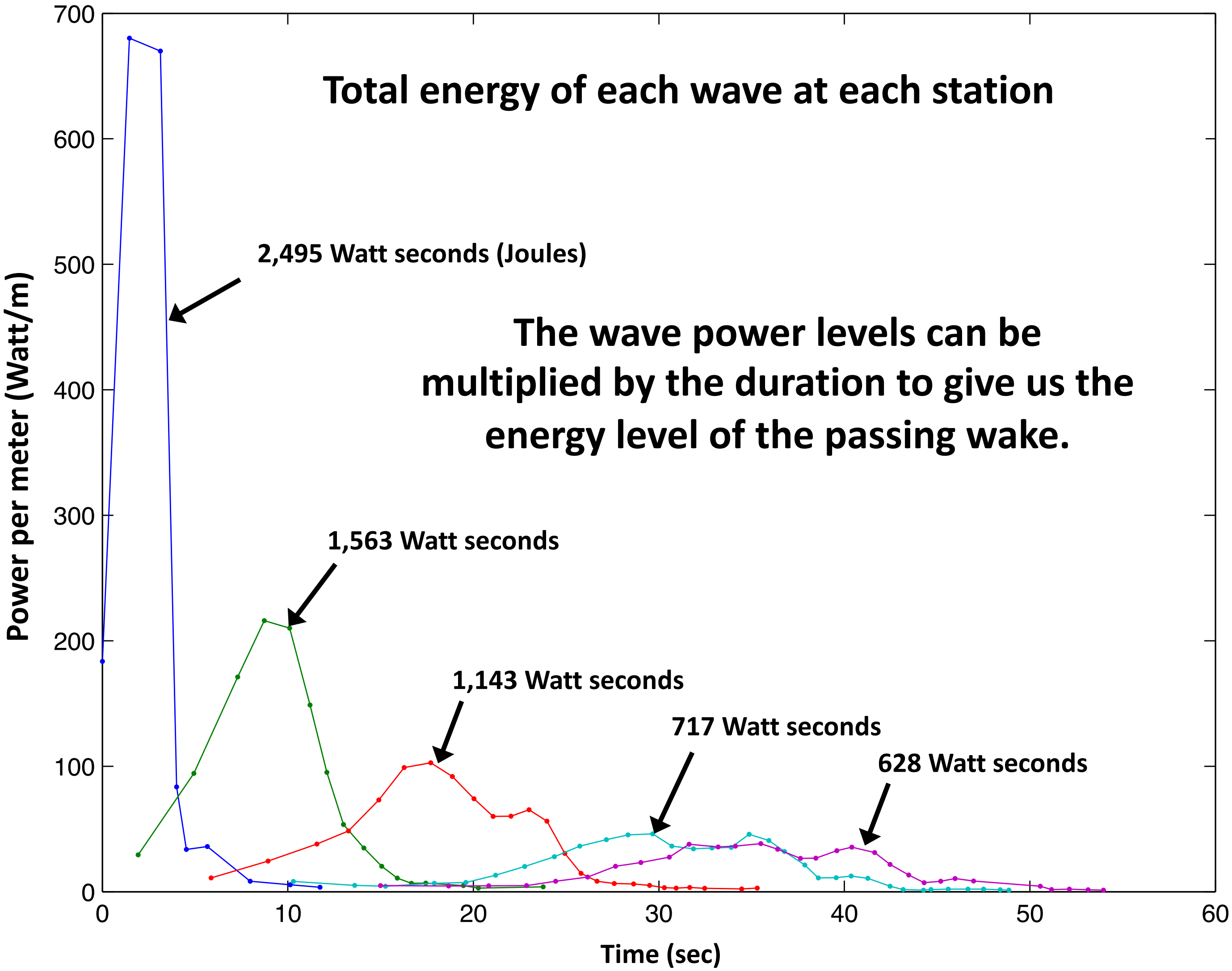


However, recall this is for the largest single wave recorded at each location

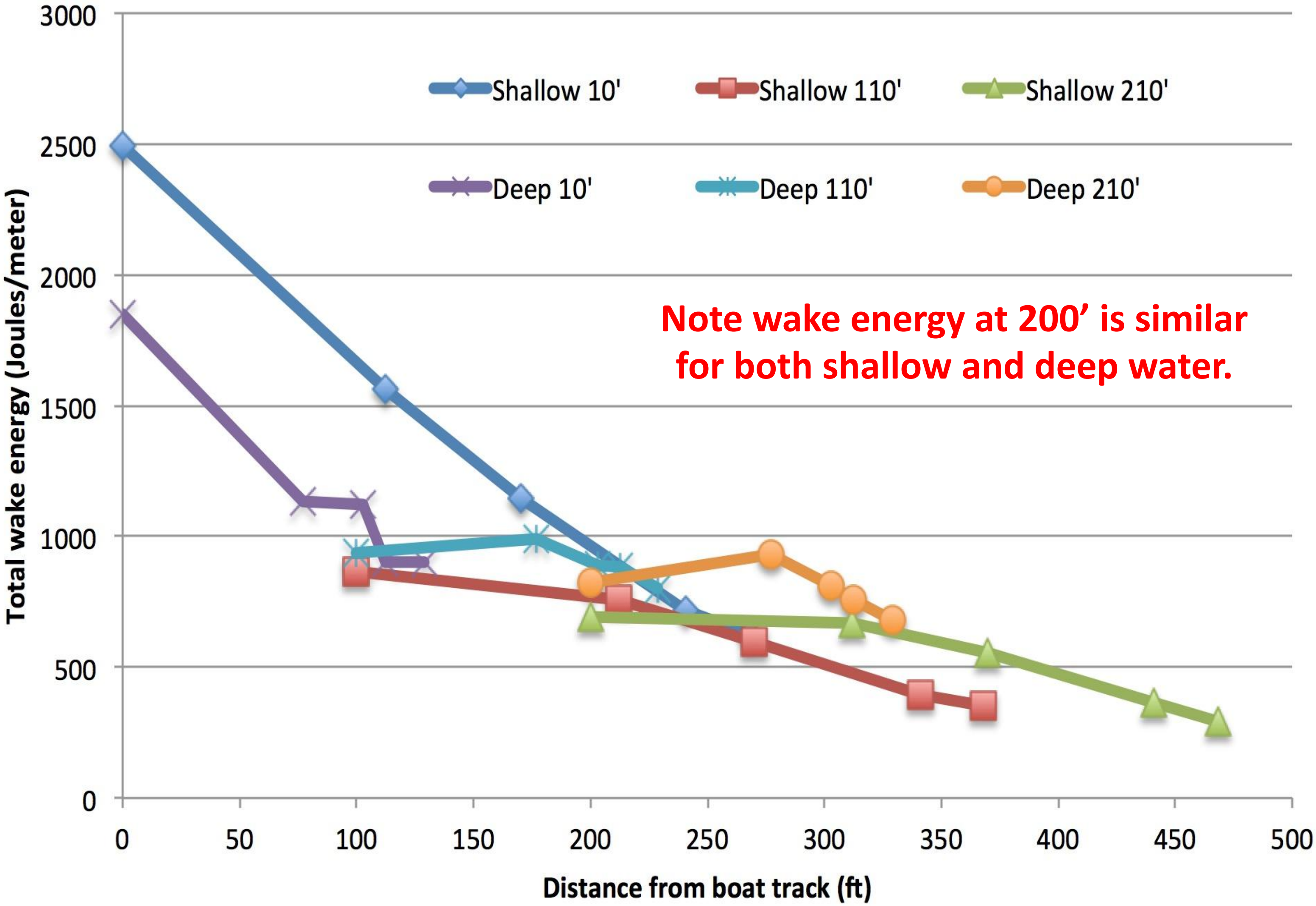
Now, let's look at wave power, as that has more bearing on shoreline impacts.



Shallow-water Run #24 - Wakesurfing, 11 mph, 10’ distance



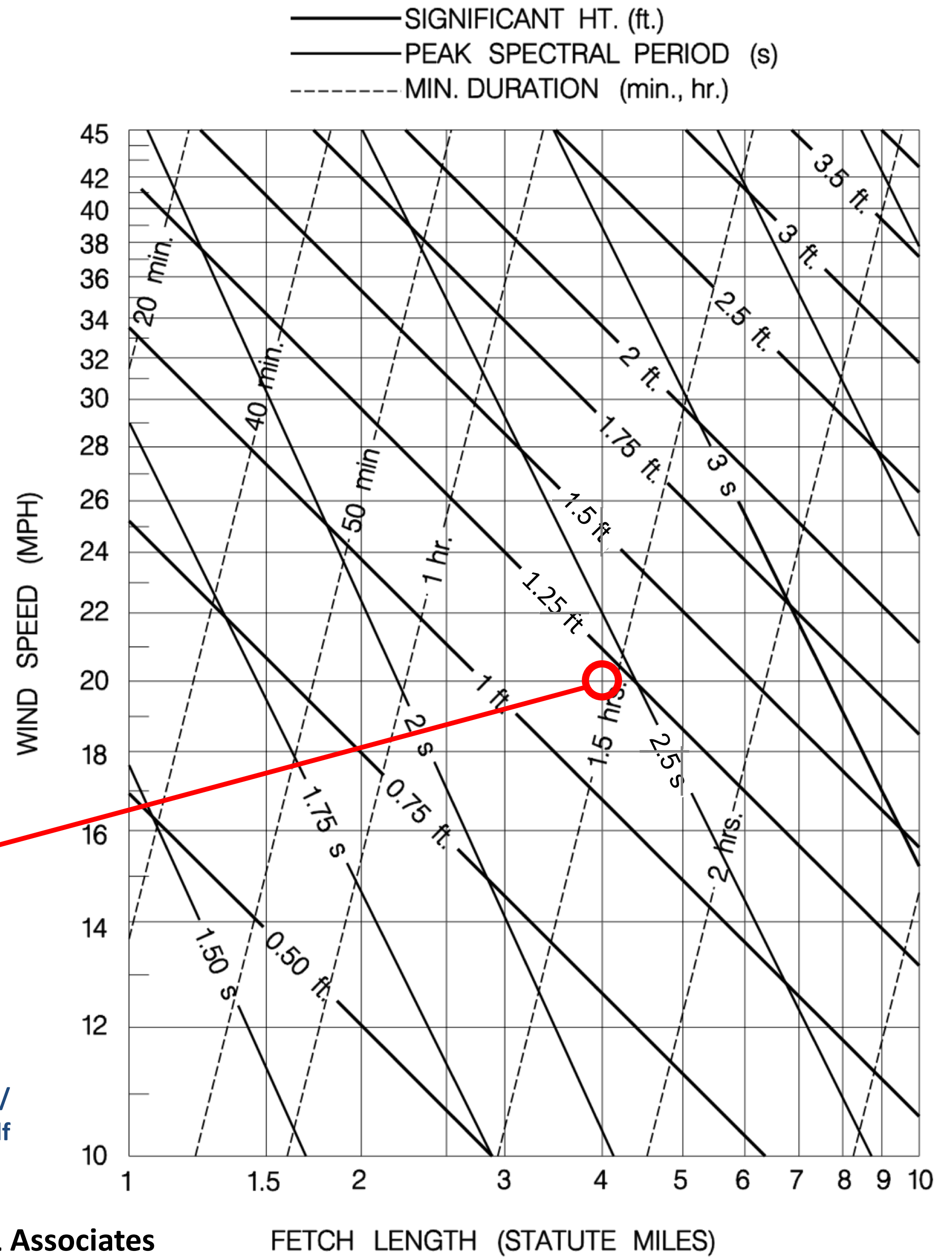
Wake energy results wake surfing at both shallow and deep sites



How does all this compare to naturally occurring waves?

Wind waves are determined by the wind speed, the distance over water that it blows (fetch) and the wind's duration

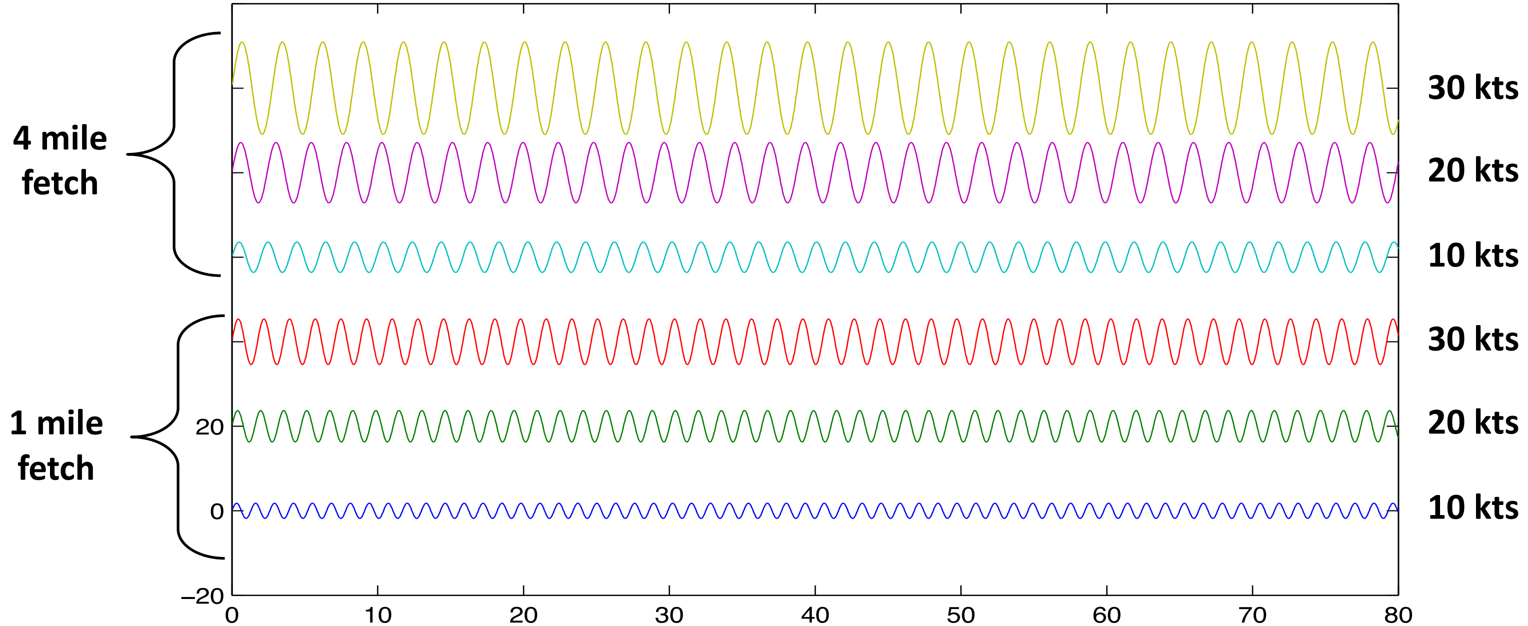
For example, 20 knots over 4 miles of fetch results in a 1.19' wave with a dominant period of 2.4 seconds.



http://www.virginiadot.org/business/resources/LocDes/DrainageManual/chapter13.pdf

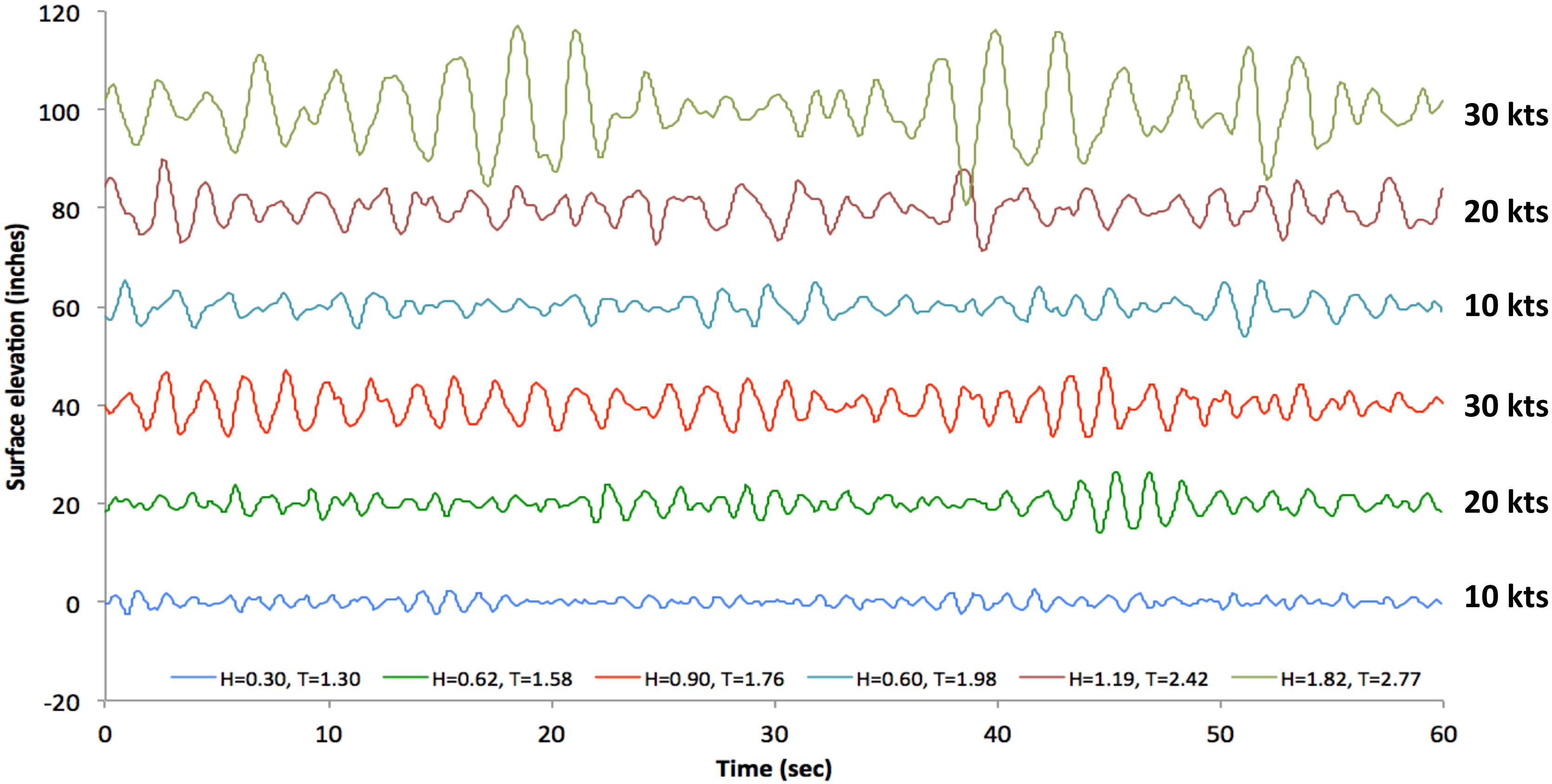
This shows the Significant wave height and dominant wave period for six different conditions.

Wind (kts)	Fetch			
	1 mile		4 miles	
	Hmo	Te	Hmo	Te
10	0.30	1.30	0.60	1.98
20	0.62	1.58	1.19	2.42
30	0.90	1.76	1.82	2.77



But we know real world waves don't look quite so neat

For a more realist look at wind generated waves we used simulation tools to generate random waves to the same specifications while better representing real wind waves.



Using the same methods we used to analyze our wakes, we can determine the energy levels associated with each of these wind wave conditions.

Wind (mph)	Fetch (miles)	Wave height (feet)	Period (sec)	Power W/m	Wind wave energy Watt sec/m
10	1	0.3	1.3	5.43	208
20	1	0.62	1.58	28.19	790
30	1	0.9	1.76	66.23	3,148
10	4	0.6	1.98	33.10	1,046
20	4	1.19	2.42	159.21	6,418
30	4	1.82	2.77	426.20	17,572

Relating this to our wake energy findings

- **Our average wake surfing energy at the transom is 2,099 Watt sec/m. This is equivalent to 3 minutes of waves from a 20 mph wind over 1 mile fetch or 20 seconds of waves from a 20 mph wind over 4 miles of fetch.**
- **That same wake after 200’ of travel 731 Watt sec/m. This is less than one minute of waves from a 20 mph wind over 1 mile fetch or 7 seconds of waves from a 20 mph wind over 4 miles of fetch.**

Similar relationships can be made for any offset distance vs. any wind and fetch condition

The take-home message is that compared to modest waves over modest distances, boat wakes are a minor source of energy.

General findings:

- **Wake-surfing waves start out very high but dissipate rapidly compared to other wakes.**
- **The wake on the surfing side is 10% higher and conveys 23% more energy. It's best to set up and to surf on the offshore side.**
- **Wave energy dissipates rapidly upon breaking, such as just behind the boat and as water becomes shallow causing friction and more breaking.**
- **If a shoreline does not experience wind or if it is narrow in the prevailing wind direction, then it may not experience much energy from wind waves and might benefit from being designated a no-wake zone.**
- **Our methodology has established a high standard for the conduct of such field studies.**

Thank you

Any questions