Characterization of Wake-Sport Wakes and Their Potential Impact on Shorelines

by

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Executive Summary

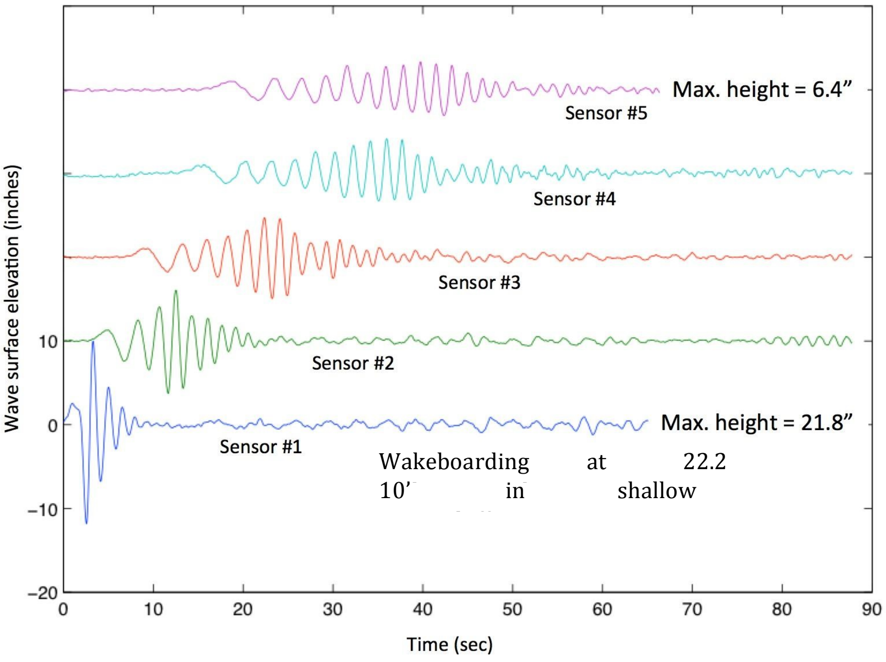
The effect of boat wakes on a shoreline varies depending on boat size, speed, water depth, and distance from shore. With the growing popularity of wake sports there has been a rise in concern over the potential effect of the associated wakes on shorelines. A study has been completed and reported here aimed at building an understanding of wake-sport wakes and how they fit into the spectrum of boat wakes in general as well as how those wakes compare to wind-driven waves.

A shallow and a deep-water test venue were used within the Conway Lake chain in Orlando, Florida. Both locations had sandy beaches and were surveyed for their depth profile to determine locations for wave-height probes within an array running perpendicular to the shore. At the four stations closest to shore, capacitance-wire wave probes were used. Due to the close passage of the boat to the outer probe, a submerged pressure probe was used. Each sensor was connected by underwater cable to a PC-based data acquisition system where the data was displayed and logged for post processing.

The vessel used for the tests was a Nautique G-23 wake-sport boat with an overall length of 23’, a maximum beam of 102”, and a light displacement of 5,900 lbs. This is considered typical of the fleet of wake-sport boats available from various manufacturers. The boat has factory installed ballast tanks that were filled to capacity with 2,850 pounds of water for the wakeboarding tests. For the wakesurfing runs, an additional 1,400 pounds of water was added, yielding a total displacement of 10,150 pounds.

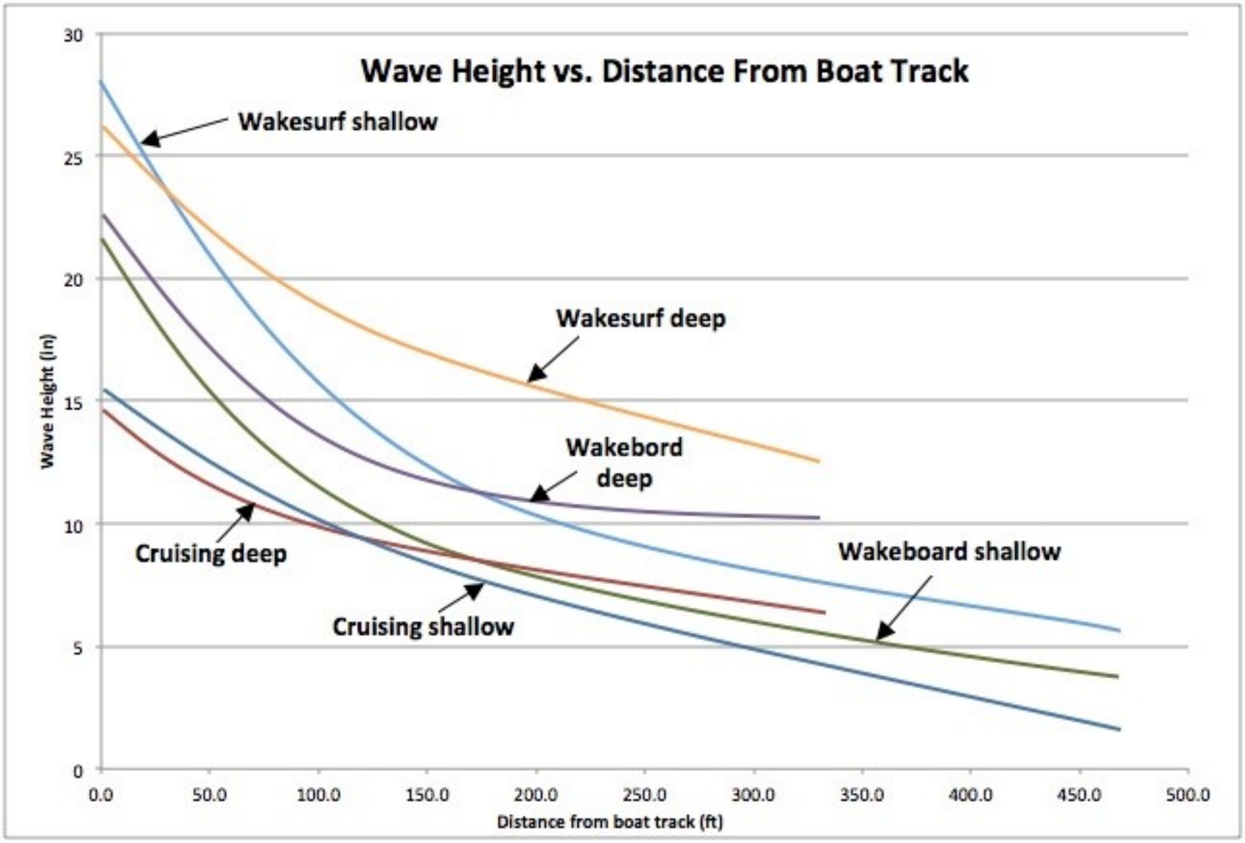
Test runs were conducted at cruising speeds (20, 25, 30 mph), wakeboarding speeds (21.2, 22.2, 23.2 mph), and wakesurfing speeds (10, 11, 11.5, 12 mph). These runs were done at three distances from the outer wave probe (10’, 110’, 210’) with the closest track resulting in a wave measurement being taken very close to the boat. A total of 94 tests runs were made at the shallow and deep sites. Logged data from each run were then processed to yield plots of wave profiles vs. time and to determine wave heights and wave counts at each sensor station. Wave profiles from all five probes were plotted for each run to enable quality control as shown below.

Note that the wave heights are given in terms of the total height of the wave from its trough to its crest. It is worth noting that very close to the boat the trough is deeper than the height of the crest. Specifically, at sensor #1 a trough 11.8” deep precedes a 10” crest for a total wave height of 21.8”.



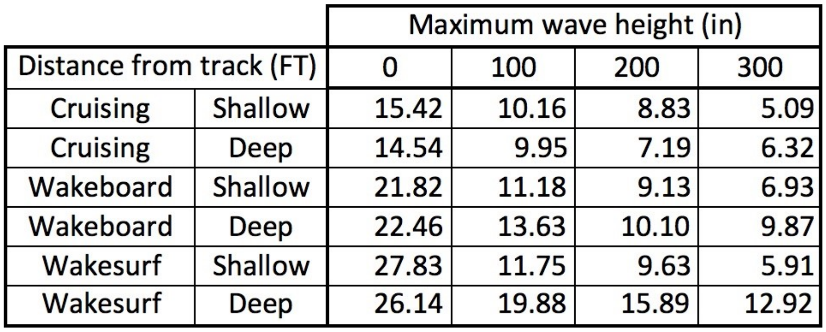
Wakes dissipate in three ways. First, and as can be seen in the above figure, the small number of waves seen at sensor #1 grows to more numerous waves as the wake progresses away from the boat's track. The three initial waves become 14 distinct but much smaller waves by the time the wake has reached sensor #5, which is 270 feet away. A second cause of wake dissipation is the friction of the wave's motion on the lake bottom and is much more significant in shallow water. A third cause of wake dissipation is through breaking. This form of energy loss happens quickly behind a wake-sport boat that is generating a large wave.

Comparisons among runs are shown in the figure below and are based on the speed of each operational mode that produced the highest waves. For those "optimal" speeds the maximum wave height at each station is shown.



The higher waves associated with wakeboarding and wakesurfing dissipate more rapidly than those generated under the cruising condition, more typical of a conventional craft on a full plane. We can also see in this figure that the maximum wave heights associated with wakeboarding and wakesurfing dropped precipitously in the first 100 to 150' of their travel from the boat's track. By contrast, the waves heights associated with cruising speeds dissipate more slowly and lack the initial drop seen with the other two modes of operation. This difference is because these smaller waves tend not to break and therefore propagate with less energy loss.

These results demonstrate the importance of standoff distance from the shoreline and from the data wave height can be predicted for various standoff distances. As shown in the table below, with the exception of wake surfing in deep water, the wake sport waves from a track 200' from shore fall below heights that could be viewed as exceptional.



		Maximum wave height (in)			
Distance from track (FT)		0	100	200	300
Cruising	Shallow	15.42	10.16	8.83	5.09
Cruising	Deep	14.54	9.95	7.19	6.32
Wakeboard	Shallow	21.82	11.18	9.13	6.93
Wakeboard	Deep	22.46	13.63	10.10	9.87
Wakesurf	Shallow	27.83	11.75	9.63	5.91
Wakesurf	Deep	26.14	19.88	15.89	12.92

Wake surfing in deep water is the exception and it takes 300 feet for the wave height to drop by half of its original 26” height.

In understanding the significance of boat-wake effects on shorelines, it is necessary to compare them to naturally occurring processes. Wind waves are particularly important due to their persistent nature. Waves resulting from wind over a stretch of water are well studied and predictable based on wind speed and fetch. Predictions were made of the significant wave height and dominant wave period of typical combinations of wind speed and fetch distance. These values were turned into energy levels to allow comparison with boat-wake energy levels derived from our tests. Through this comparison we were able to determine how often a boat wake would need to occur in order to equal the energy associated with wind waves.

Our analysis shows that a cruising boat would need to pass 110 feet from a shoreline every 101 seconds in order to equal the energy coming from waves associated with 10 mph winds and one mile of fetch. A wakesurfing boat would only need to pass every 270 seconds to equal the same wind-wave effects. At higher wind speeds and longer fetch distances, wind waves become more energetic. For example, a 20 mph wind blowing over 4 miles of fetch yields wave conditions equivalent to a cruising boat passing 110 feet offshore every 9 seconds. Those same wind waves are equivalent to a wakesurfing passing every 23 seconds 110 feet from a shoreline. These sorts of repetition rates are not representative of the sport.

A 10 mph wind blowing over a mile of open water is a common occurrence and our results suggest boat wakes are not likely to be the most significant source of energy along the shores of all but the smallest bodies of water. The persistence of wind waves can belie their importance. While a boat wake coming ashore can seem like a significant event, in the larger scheme of things it can be of little consequence if that shore also experiences wind-driven waves. In all but the most protected of shorelines, it would be difficult for boating to match the role of wind waves and natural currents on shaping shorelines.