PROTECTING MARINAS & SHORELINES FROM WAKESPORT BOATS

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presented by Marina DOCK AGE

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COURSE DESCRIPTION

Over the last two decades, the popularity of surf/wake boats has continued to rise. Large waves from these hulls can have damaging consequences to nearby marina facilities and natural shorelines if not properly protected. This presentation will review the current and future technologies of surf/wake boats, quantify the range of surf/wake boat wakes expected, and conclude with measures to protect marina facilities and manage shorelines from these wakes.

LEARNING OBJECTIVES

1. Understanding current and future technologies of surf/wake boats
2. Understanding boat wakes and range of expected wake
3. Understanding mitigation strategies to protect marinas and natural shorelines from boat wakes

MOTIVATION

“Our marina needs additional wave protection, but not from wind waves…it’s boat wakes that are the problem!”

New Hampshire adopts rules for wake surfing

Associated Press   Published: 7/25/2021 9:10:54 PM

NEWS

Waterskiing, wake surfing limited, banned on parts of Willamette River in Portland

Zach Urness Salem Statesman Journal

Published 2:02 p.m. PT Jan. 28, 2021 | Updated 8:52 a.m. PT Jan. 29, 2021 - www.statesmanjournal.com

SPORTS > OUTDOORS

Wake boats draw ire of property owners

Wed., July 27, 2016 - www.spokesman.com

News Environment

The battle over ‘wakesurfing’ has made its way to the Minnesota Legislature

- www.minnpost.com

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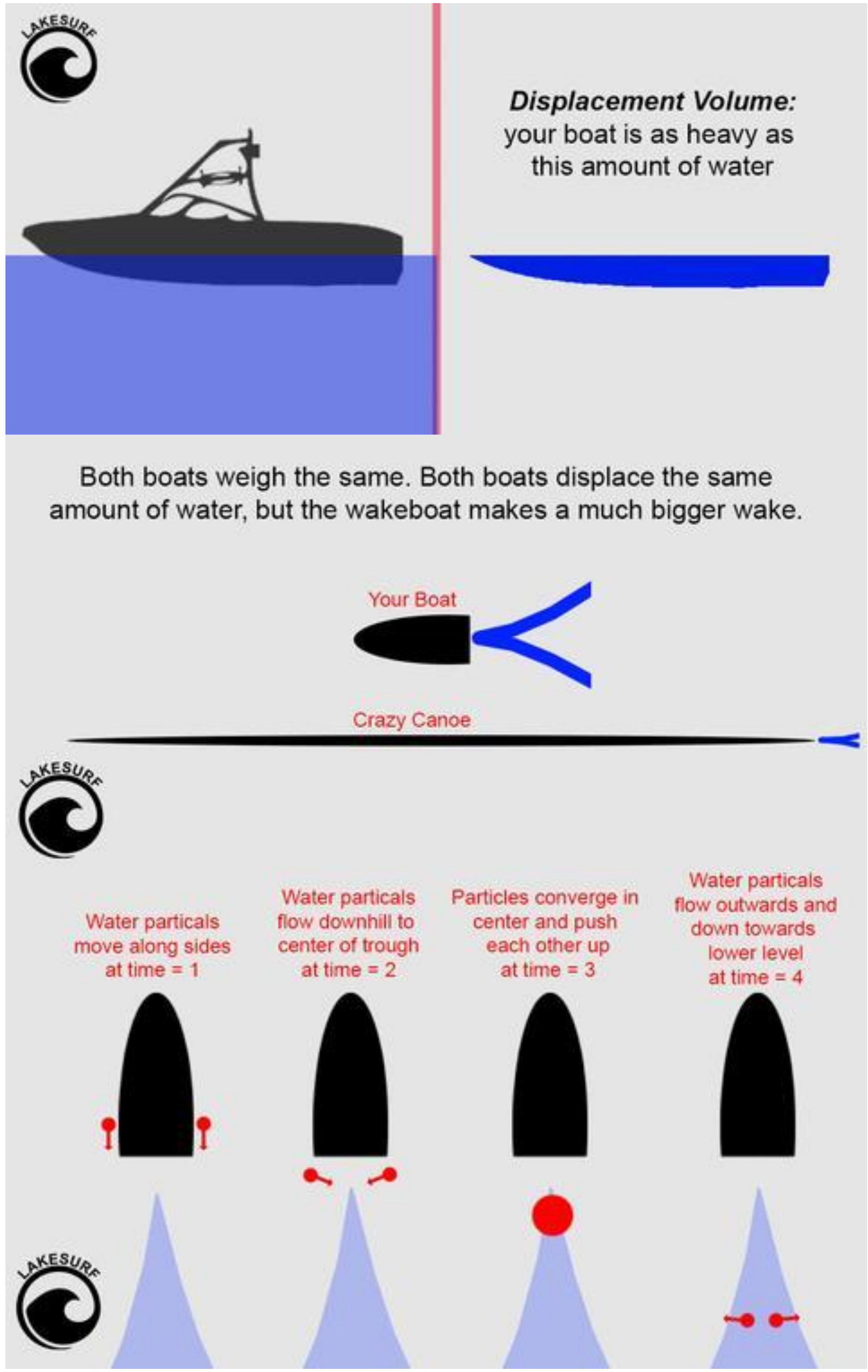
www.minutephysics.com

CREATING WAKESURFING WAKES

- Displacement – adding weight is the primary method to generate large wake; more weight, more wake but distribution of weight is also important
- Hull Design – proper hull design will maximize the wake formation and performance of the wave
- Speed – 10 to 12 mph is the normal operating speed to maximize the wakesurfing height (higher speed can plane the boat that results in less displacement)
- Delayed Convergence – the convergence at the transom creates the "rideable" portion of the wave; methods to delay the convergence will modify the wake shape and length

WAKESURF PARAMETERS

- "Push" – forward thrust on the wave; larger wakes create larger push, but generally result in shorter length of wave
- Length of Wave – provides the "rideable" section of the wave to perform tricks with time to recover



WAKE ENHANCING DEVICES (WEDs)

- Most are factory-installed features but some can also be installed after-market:
  - Power Wedge: Wedge below hull drops down to artificially simulate the effect of an additional 1500 lb of ballast
  - Gates: Help shape the wave by delaying convergence; the opposite side of the wave is engaged outside to improve the surfing side
  - Trim Tabs: Help shape the wave by delaying convergence; can increase resistance; can level the boat out lengthen wave

OPTIMAL WAKESPORT CONDITIONS

- Best wake conditions are generated in smooth, glassy surface conditions
- That typically occurs close to shore where winds cannot texture the surface as much
- Mornings where afternoon winds haven’t picked up

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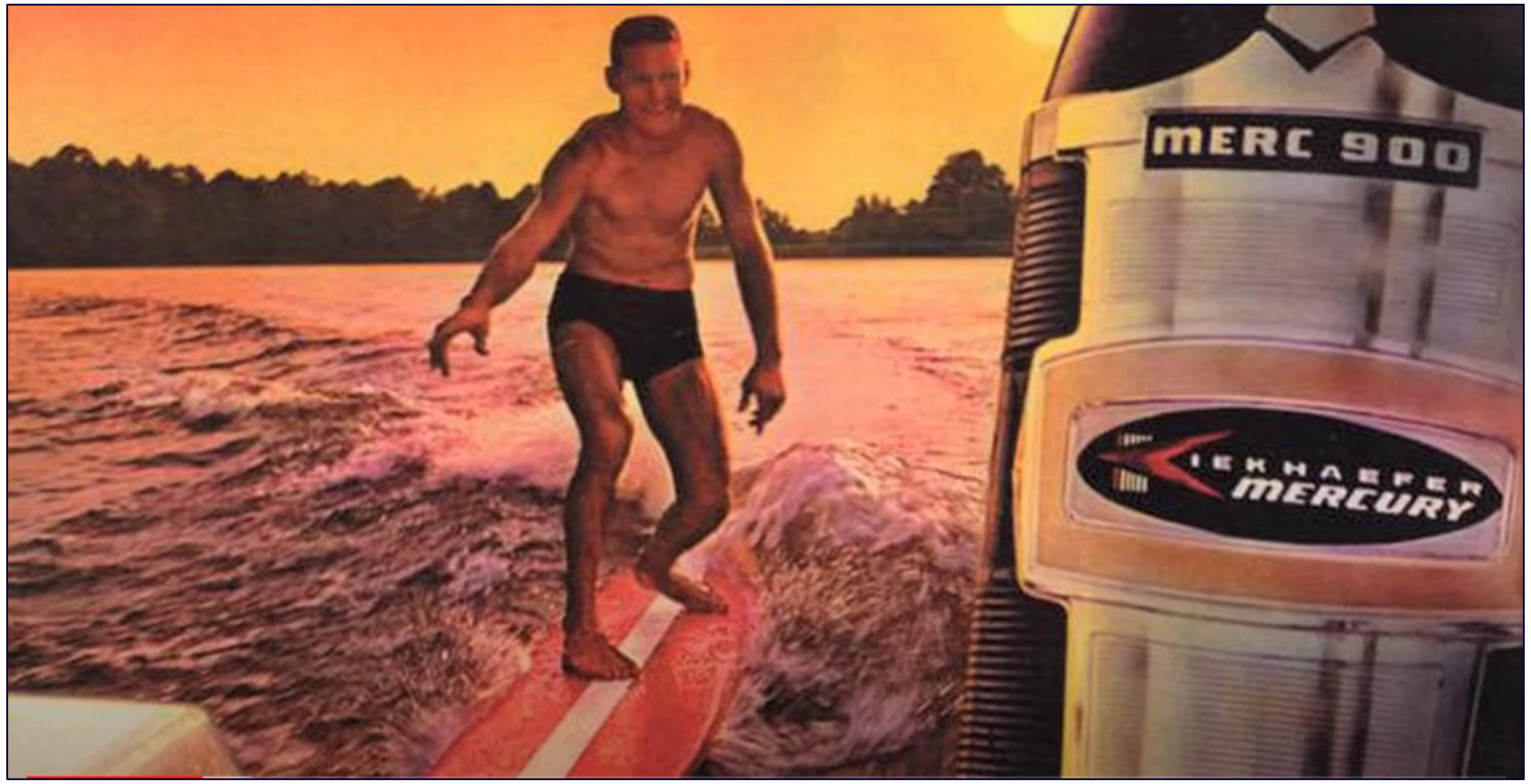
RISE OF WAKESPORTS

- Pre 1980s: Waterskiing, kneeboarding, tubing, etc

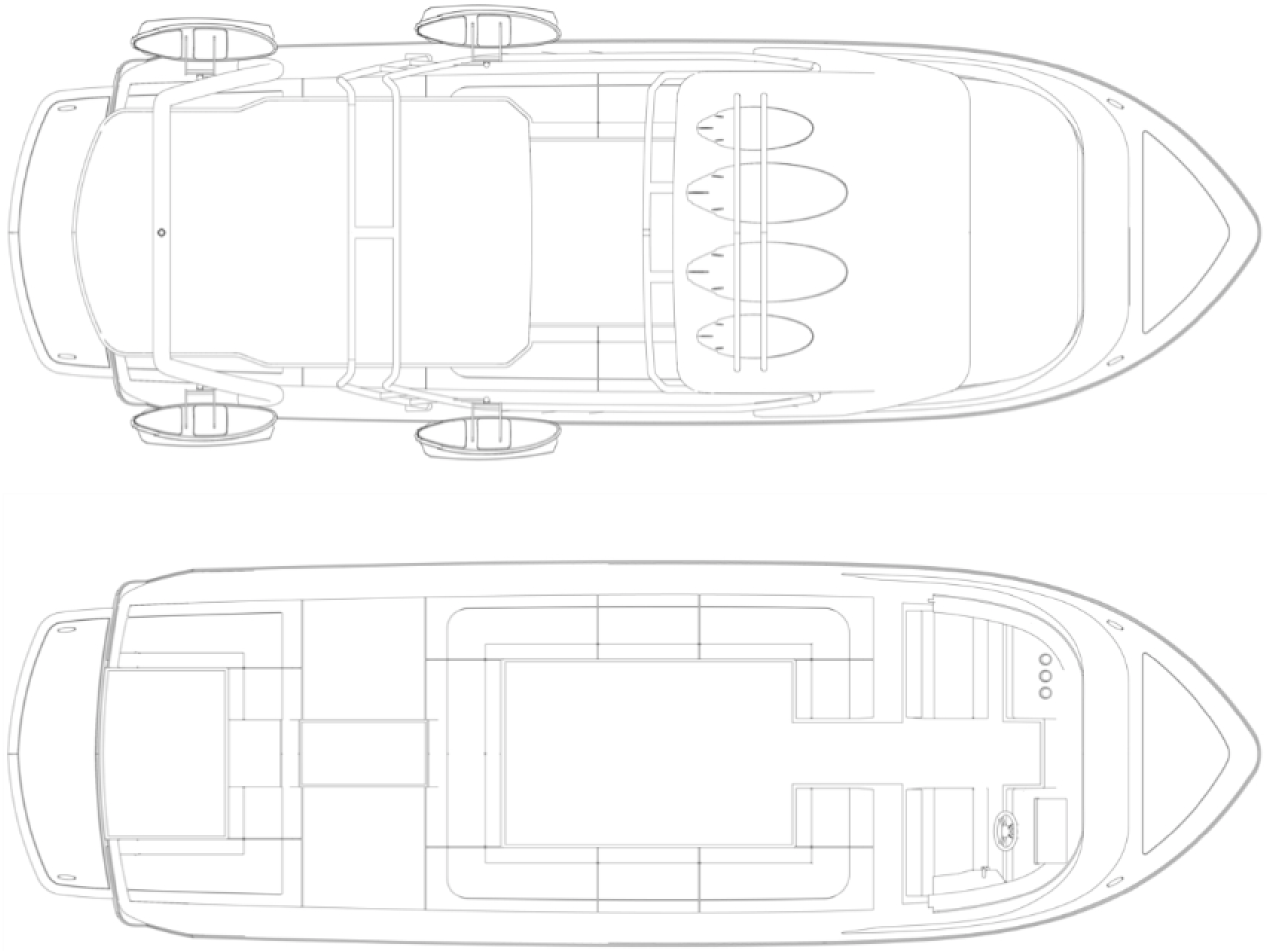
Most of today’s boating management policies were put in place around this time

- Late 1980s: Wakeboarding emerged in mainstream popularity
- Late 1990s: Wakesurfing emerged in mainstream popularity
  - Generation 0: Using old wakeboarding boats with lead weight & people on one side
  - Generation 1: Improved hull design with factory-installed ballasts to weight on one side, then transfer to the other side
  - Generation 2: Improved hull design with factory-installed ballasts on each side along with factory-installed WEDs (wedges/tabs/gates) to shape the wave



GETTING READY FOR THE GIGAWAVE!

- www.ridegigawave.com
- Attempts to reach 6 ft wake
- 35 ft boat (guessing 8,000 lb dry weight)
- 28-person capacity (assume about 4,000 lb)
- 8,000 lb factory-installed ballasts
- That’s 20,000 lb of displacement
- By comparison, current wakesurf models max out at around 12,000 lb total displacement



LOA
35′/10.66 M

Beam
10′ 6″/3.2 M

Dead Rise
12 Degrees

Draft
4′/1.21 M

Capacity
28 PEOPLE

Factory Ballast
8000 LBS/3628 KG

Engine
Twin 300 HP Electric Engines

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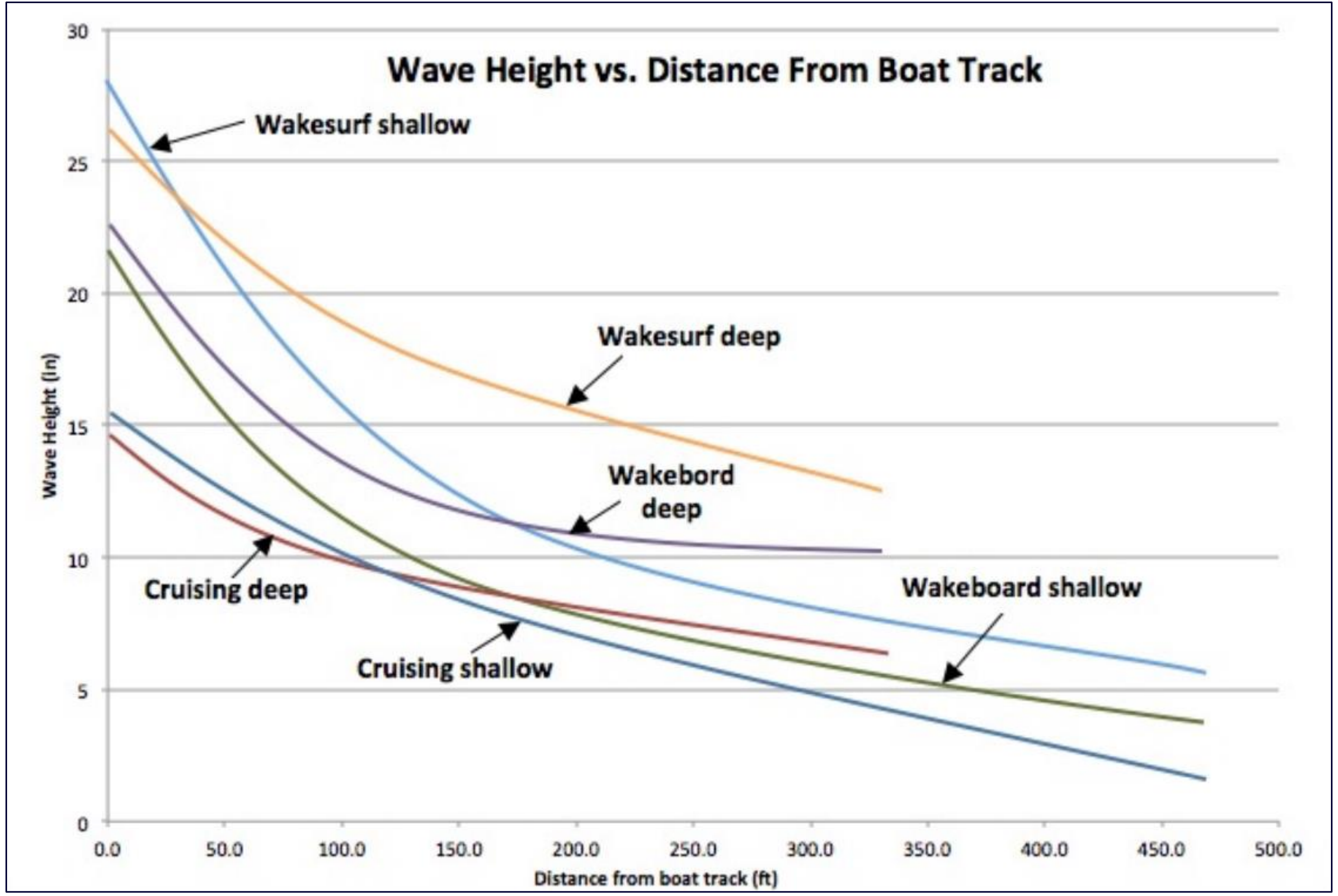
WAKESPORTS SEGMENT IS BOOMING

- 2012 – Ski and wakeboard boats are seeing healthy growth with an increase of 13.4% new boats sold in 2012
- 2018 (Pre-Pandemic) – Sales of new wakesport boats are estimated to be up 9 – 11% to 10,000 units in 2018
- 2020 – Wakesports boat sales increased by 20% with 13,000 new units sold
- 2021 – Malibu Boats outperformed elevated projections across all metrics in fiscal Q4 with net sales increasing 133.2% to $276.7 million (www.tradeonlytoday.com)

QUANTIFYING WAKESPORTS WAKES

- Water Sports Industry Association Study (Goudey & Girod, 2015)
  - Nautique G-23 wakesport boat
  - 23 ft long, 8.5 ft beam
  - Factory displacement of 5,900 lbs
  - Factory-installed ballasts up to 2,850 lbs
  - Cruising activity: 5,900 lbs
  - Wakeboarding activity: 8,750 lbs
  - Wakesurfing activity: 10,150 lbs
- Other studies generally concluded on similar results (e.g., Ruprecht et. al., 2015; WEC, 2021)
- Must consider deep and shallow water wave transformation effects (waves in this range start to really feel the bottom in around 10 ft water depth)
- In shallow water, waves can transform from shoaling, refraction, bottom friction, etc.



Activity	Maximum Wave Height – Deep (in)	Maximum Wave Height – Shallow (in)	Average Wave Period (sec)
Cruising/Waterskiing	14.5	15.4	1.8
Wakeboarding	22.5	21.8	2.0
Wakesurfing	26.1	27.8	2.2

DECAY OF BOAT WAKES

Stoker (1957) and Cox (2002), among others, have demonstrated that boat wakes in deep water decrease in proportion to the negative root of the distance from the boat waves decay with increasing distance from the boat, or:

$$H = A\,y^{n}$$

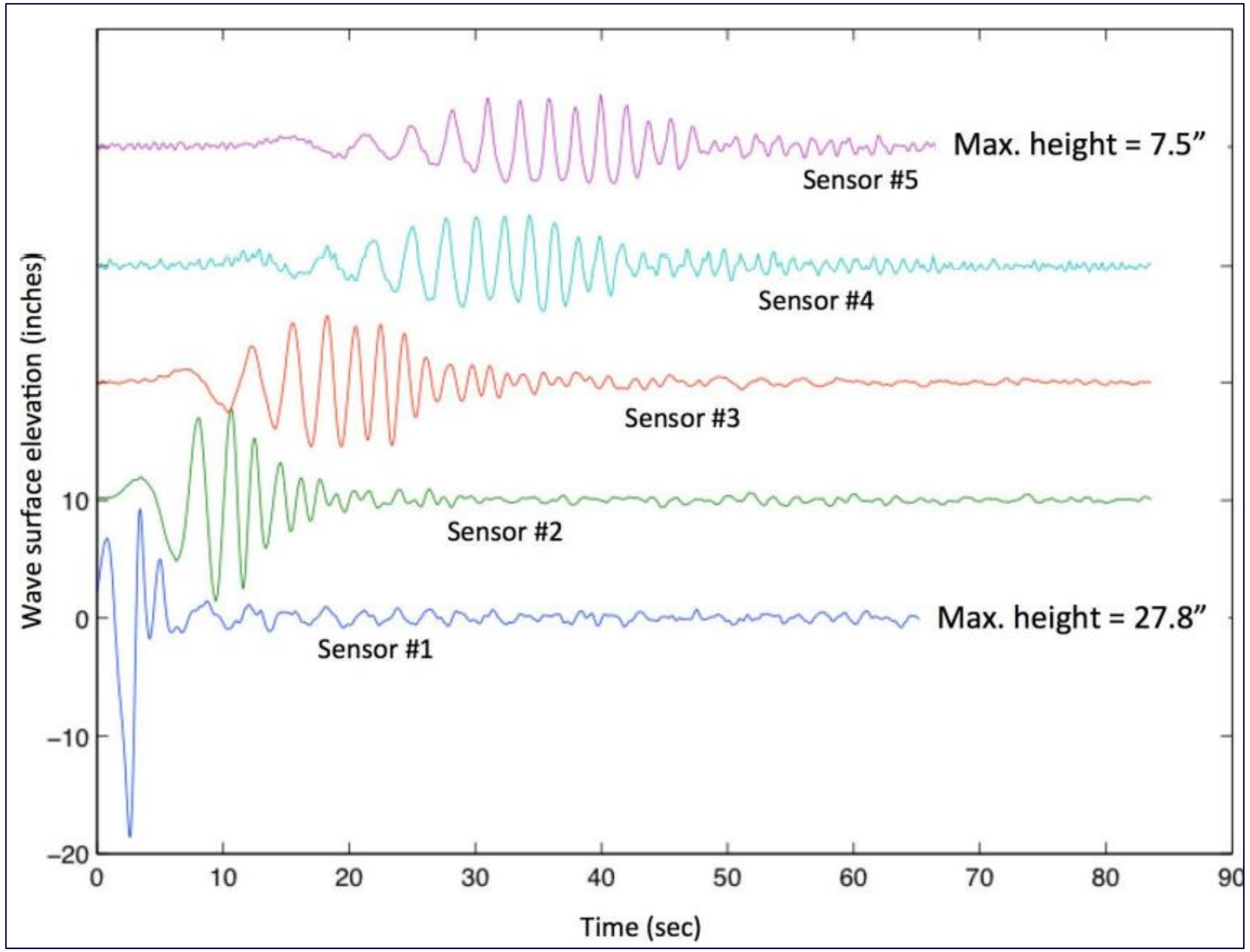
where:

H = wave height

A = boat-dependent constant

y = perpendicular distance from sailing line

n = exponent varies between -0.22 and -0.4 with - -0.33 as standard value (Macfarlane, 2002)

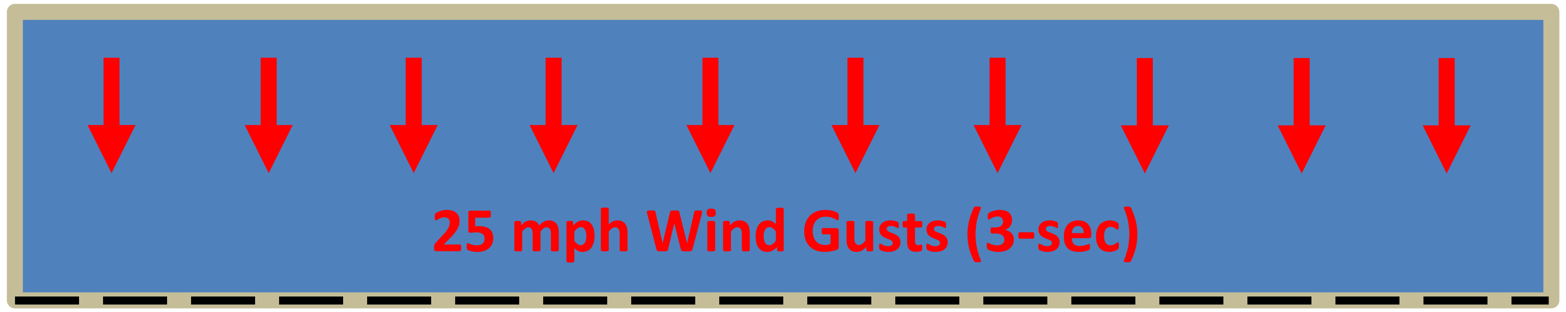


Measured Wave Heights from Wakesurfing Run @ 11mph (Source: Goudey & Girod, 2015)

HOW DO BOAT WAKES COMPARE TO WIND WAVES?

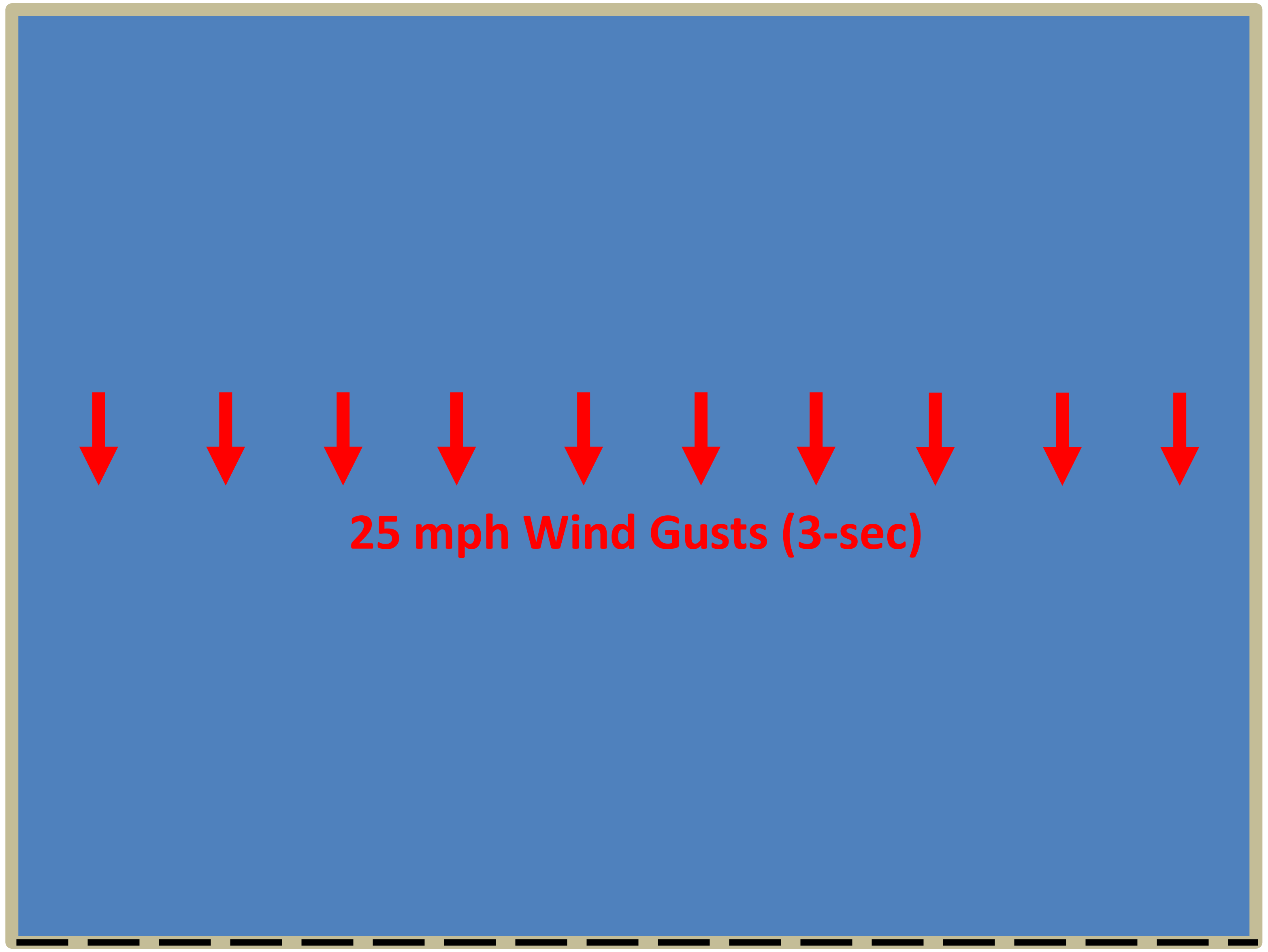
Two Fictitious Lakes
Winds Typical Of Once A Month Scenario

LAKE 1: 1500 ft x 6000 ft x 50 ft



Hs = 0.26 ft, Tp = 0.8 sec
Hmax = 0.5 ft, Tp = 0.8 sec

LAKE 2: 6000 ft x 6000 ft x 50 ft



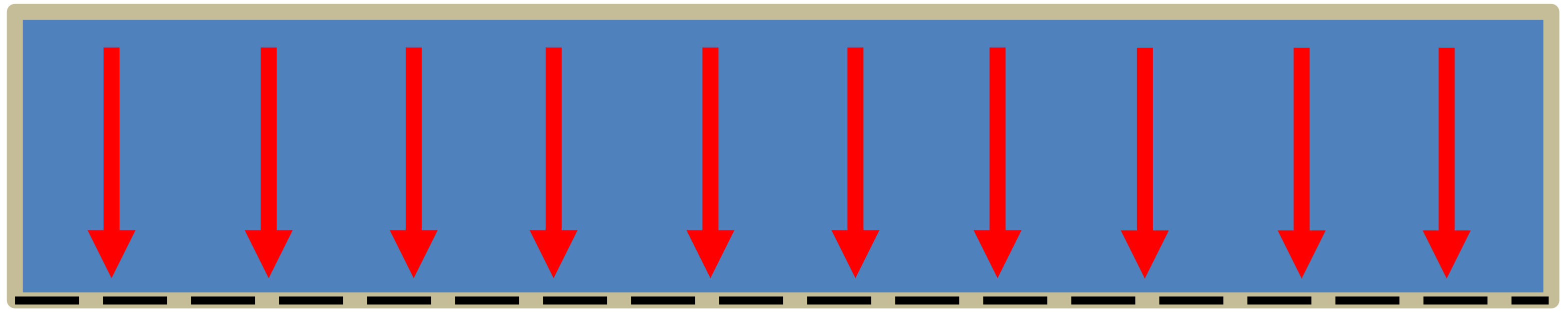
Hs = 0.51 ft, Tp = 1.3 sec
Hmax = 0.9 ft, Tp = 1.3 sec

** Hmax = 1.8 x Hs, which is nominally the maximum wave height in the wave spectrum ($H_{1/250}$)*

HOW DO BOAT WAKES COMPARE TO WIND WAVES?

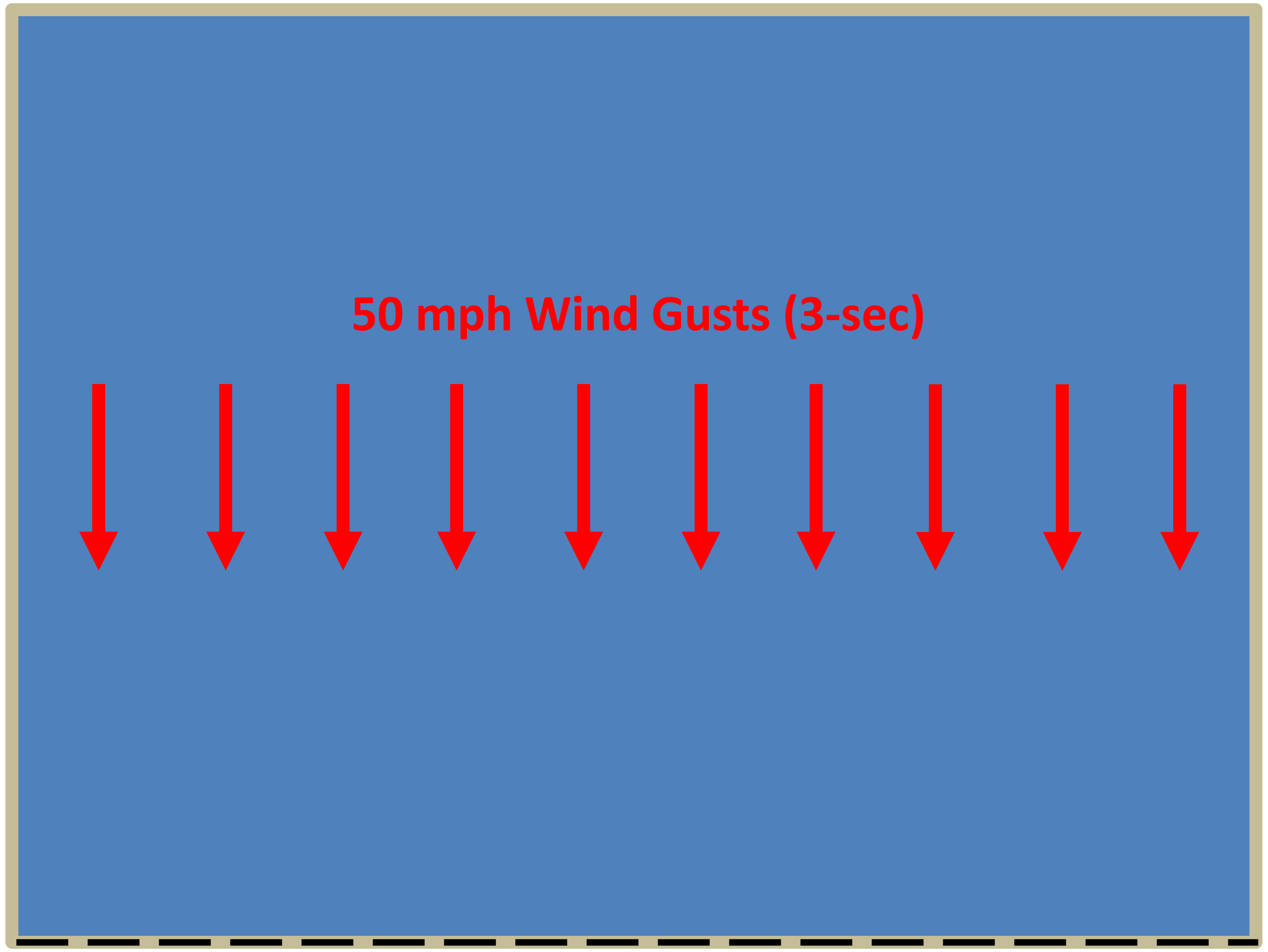
Two Fictitious Lakes
Winds Typical Of Once A Year Scenario

LAKE 1: 1500 ft x 6000 ft x 50 ft
50 mph Wind Gusts (3-sec)



Hs = 0.6 ft, Tp = 1.1 sec
Hmax = 1.0 ft, Tp = 1.1 sec

LAKE 2: 6000 ft x 6000 ft x 50 ft



Hs = 1.1 ft, Tp = 1.7 sec
Hmax = 2.0 ft, Tp = 1.7 sec

** Hmax = 1.8 x Hs, which is nominally the maximum wave height in the wave spectrum*

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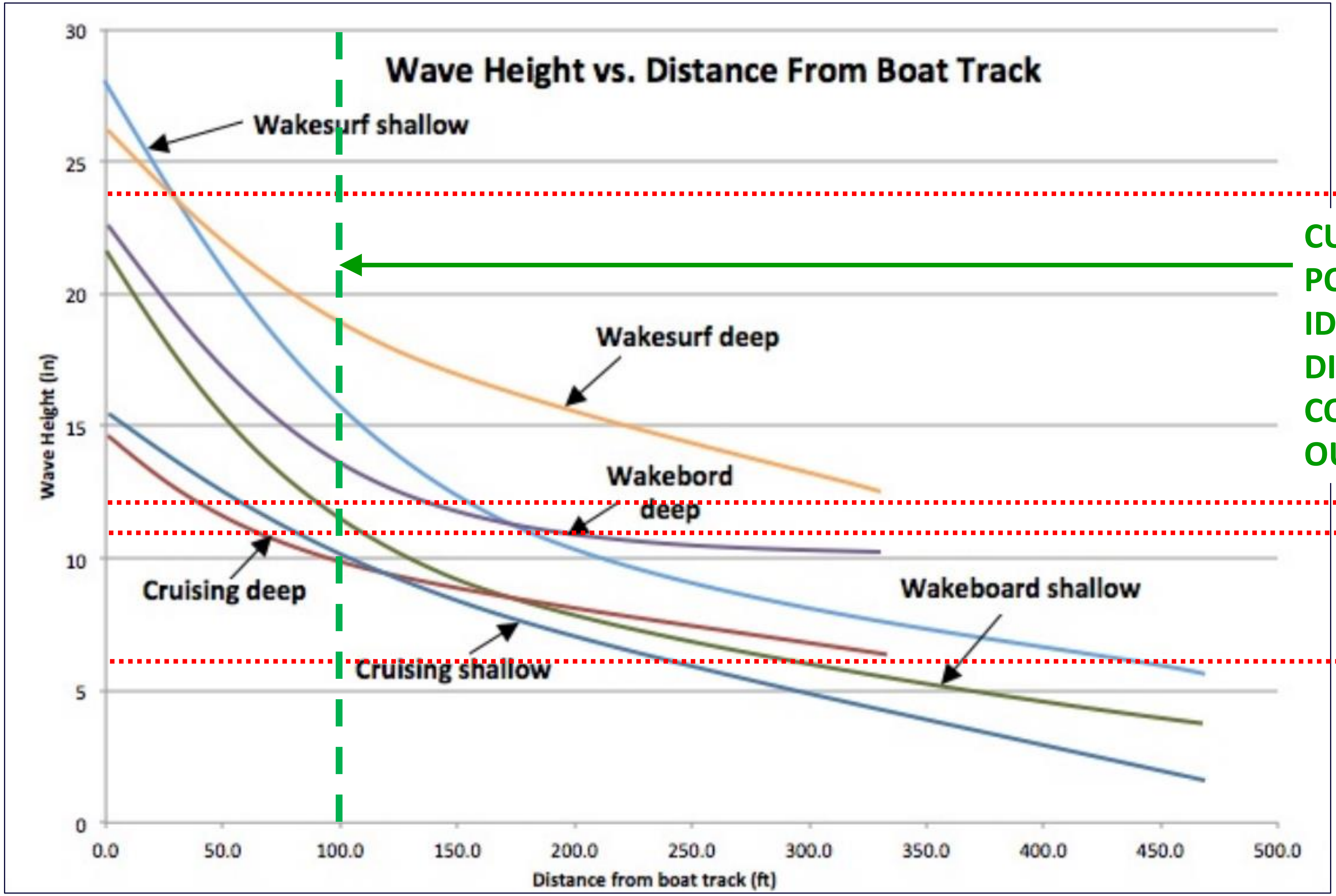
HOW DO BOAT WAKES COMPARE TO WIND WAVES?



LAKE 2 YEARLY

CURRENT LAKE MANAGEMENT POLICIES RESTRICT BOATING ABOVE IDLE SPEED TO MINIMUM 100 ft DISTANCE FROM SHORELINE; MANY COASTAL BAYS HAVE NO POLICY OUTSIDE OF “NO WAKE” ZONES

LAKE 1 YEARLY

LAKE 2 MONTHLY

LAKE 1 MONTHLY

* Remember the frequency of wakesport wakes is more like weekly

WHAT DOES THIS MEAN TO NATURAL SHORELINES?

- Increase wave heights with increase frequency increases erosive potential
- Shoreline erosion is also a function of the sediment properties, among other parameters
- Describe erosive potential in terms of wave energy, which is expressed as USACE (2002)
- Compared to monthly wind waves on a Lake 2, wakesurfing traveling close to shore clearly increases the erosive potential (in terms of wave energy) of natural shorelines by 8.5 times
- Don't forget to consider the frequency of wakesports (i.e., weekly)

Wave Scenario	Wave Energy (lb ft)	% Increase Over Monthly Lake 1	% Increase Over Monthly Lake 2
Monthly Lake 1	193	0%	
Monthly Lake 2	1830	850%	0%
Cruising/Waterskiing @ 100 ft from Shoreline	2898	1404%	58%
Wakeboarding @ 100 ft from Shoreline	7011	3539%	283%
Wakesurfing @ 100 ft from Shoreline	15626	8010%	754%

SHORELINE EROSION FROM BOAT WAKES

“I don’t think this one will make it through the winter,” said Dennis Rewinkel about a tree on the northwest corner of Newman Lake. Rewinkels and members of Newman Lake Property Owners group are working to stop the erosion of the shore due mostly to boat traffic. (Kathy Plonka / The Spokesman-Review)

Figure 6. Marsh erosion reportedly induced by boat generated waves on Lynnhaven River, Virginia. Photo by Bill Fleming.

WHAT DOES THIS MEAN TO BULKHEADS/SEAWALLS?

- Increase wave heights with increase frequency increases the cyclical forcing on bulkheads/seawalls
- For example, consider the wave force on a wall (lb/linear feet of wall) for a 6 ft deep bulkhead as outlined in USACE (2002)
- Compared to monthly wind waves on a Lake 2, wake-surfing creates about 4.5 times as much force on a 6 ft deep bulkhead
- Don't forget to consider the frequency of wakesports (i.e., weekly)
- Even if the bulkhead has been designed to accommodate much greater wave forces, its highly likely that waves are overtopping and washing out the lee of the wall:
  - Increasing pore pressure on the backside of the wall
  - Washing out backfill behind the wall
  - Both of which now make the wall more susceptible to failure

Wave Scenario	Wave Force on 6 ft Deep Bulkhead (lb/ft)	% Increase Over Monthly Lake 1	% Increase Over Monthly Lake 2
Monthly Lake 1	16	0%	
Monthly Lake 2	77	381%	0%
Cruising/Waterskiing @ 100 ft from Shoreline	135	744%	75%
Wakeboarding @ 100 ft from Shoreline	225	1306%	192%
Wakesurfing @ 100 ft from Shoreline	355	2119%	361%

BULKHEAD ISSUES FROM BOAT WAKES

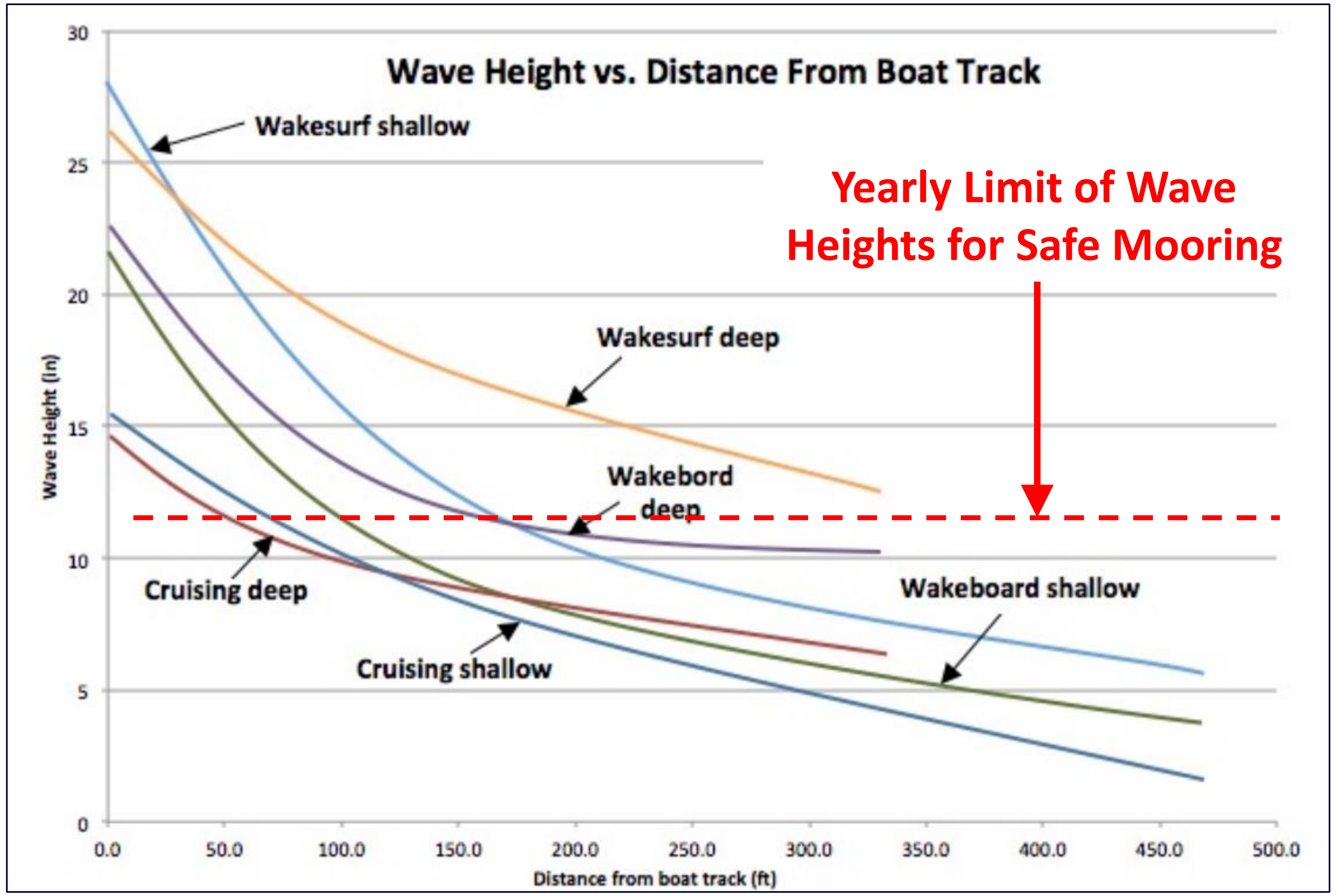
Example of Boat Wakes Overtopping Bulkhead (WEC, 2021)

Example of Backfill Washed Out Behind Bulkhead (WEC, 2021)

WHAT DOES THIS MEAN TO MARINAS & MOORED BOATS?

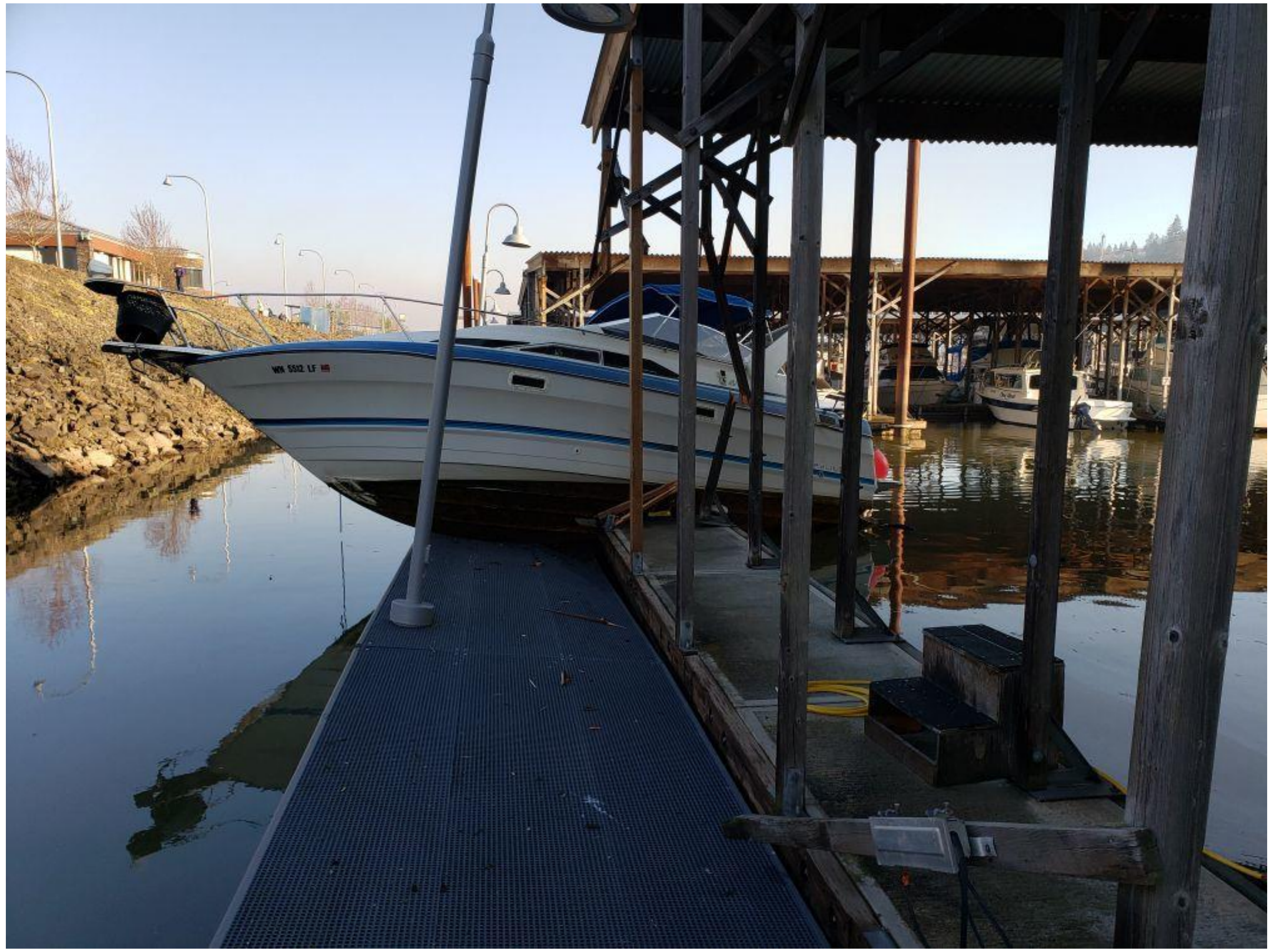
- In marinas, increase wave heights with increase frequency increases:
  - Risk of damage to docks and dock connections
  - Risk of boat damaging dock and/or dock damaging boat
  - Risk to bodily injury (trapped, overboard, etc)
  - Risk of navigation accidents
  - Risk of capsizing boats
- Standards/guidelines that outline wave height limits for berthing quiescence:
  - Australian Standards (2001)
  - ASCE (2012)
- Yearly (or 1-year return period) condition is generally not to exceed 1 ft wave heights
- Wakesports wave heights clearly exceed a 1 ft wave height within a 100 ft buffer from a marina

Direction and peak period of design harbor wave	Significant wave height (H_s)	
	Wave event exceeded once in 50 years	Wave event exceeded once a year
Head seas less than 2 s	Conditions not likely to occur during this event	Less than 0.3 m wave height
Head seas greater than 2 s	Less than 0.6 m wave height	Less than 0.3 m wave height
Oblique seas greater than 2 s	Less than 0.4 m	Less than 0.3 m wave height
Beam seas less than 2 s	Conditions not likely to occur during this event	Less than 0.3 m wave height
Beam seas greater than 2 s	Less than 0.25 m wave height	Less than 0.15 m wave height



MOORING ISSUES FROM BOAT WAKES

Capsized Boat From Passing Boat Wake (www.wect.com)



Ship Wake Causes $1million Damage at Port of Kalama Marina (www.tdn.com)

“PROTECTING MARINAS & SHORELINES FROM WAKESPORT BOATS”

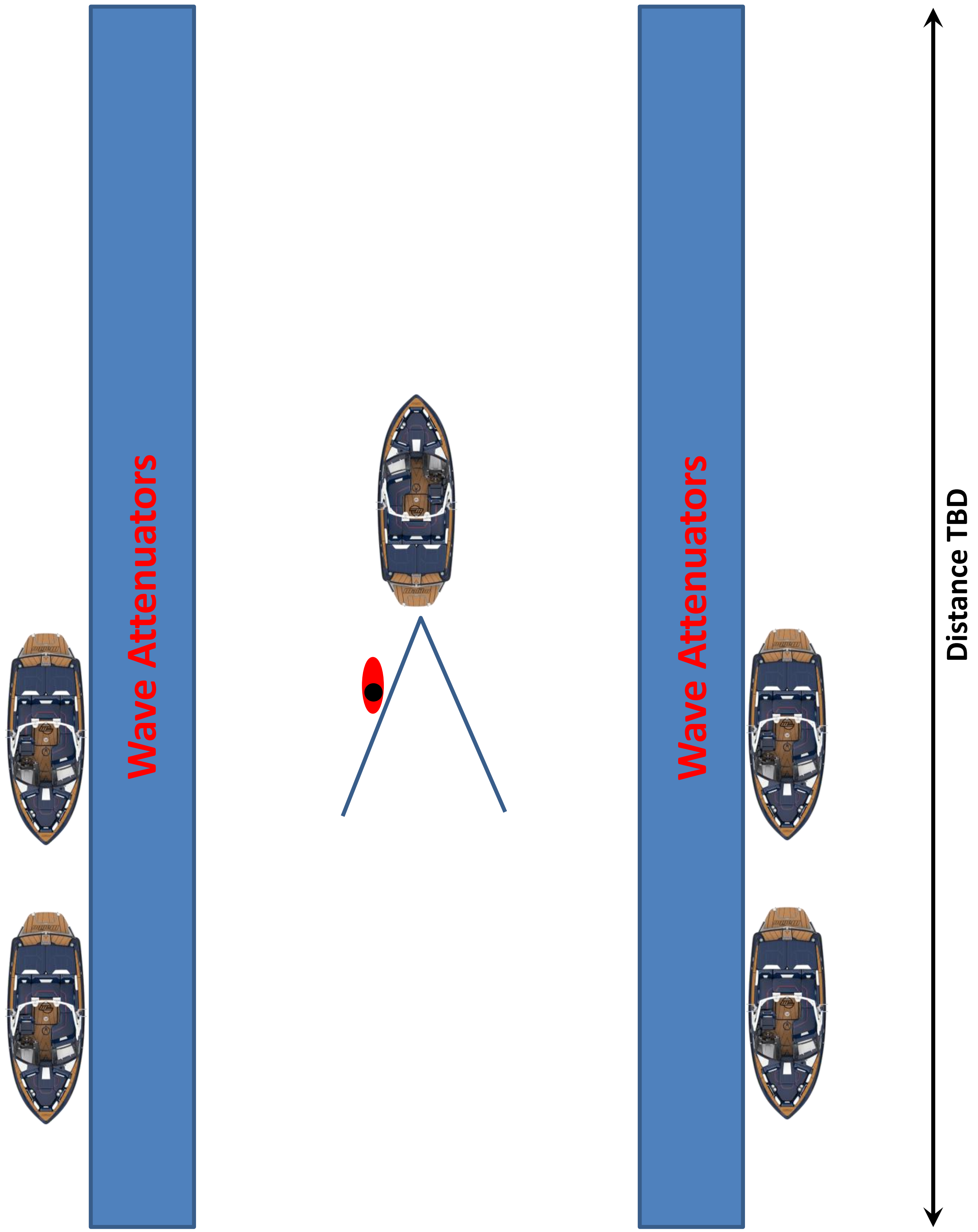
MANAGEMENT POLICIES FOR WAKESPORT BOATERS

- Require wakesport boats to maintain minimum 300 ft buffer from any shoreline or marina/dock
- Where possible, limit wakesport to the middle sections in the widest sections of waterbodies
- Avoid ballasting boats in “slow speed/no wake” zones and until reaching area to wakesurf, and unballast boats before leaving wakesurf areas
- When running parallel to shore with asymmetrical wake, require the non-surfing side to face the closest shoreline (waves will be smaller in height than the surfing side)
- Where possible, request wakesport boats to minimize repetitive passes in one area
- Prohibit wakesports during low light periods (early morning/late night)
- Avoid turns towards the shoreline
- Post signage at marinas and boat ramps to educate wakesports boaters and engage in meaningful dialogue

“REMEMBER, YOU ARE RESPONSIBLE FOR YOUR OWN WAKE”

LARGER WATERBODY WIDE POLICY PLANNING

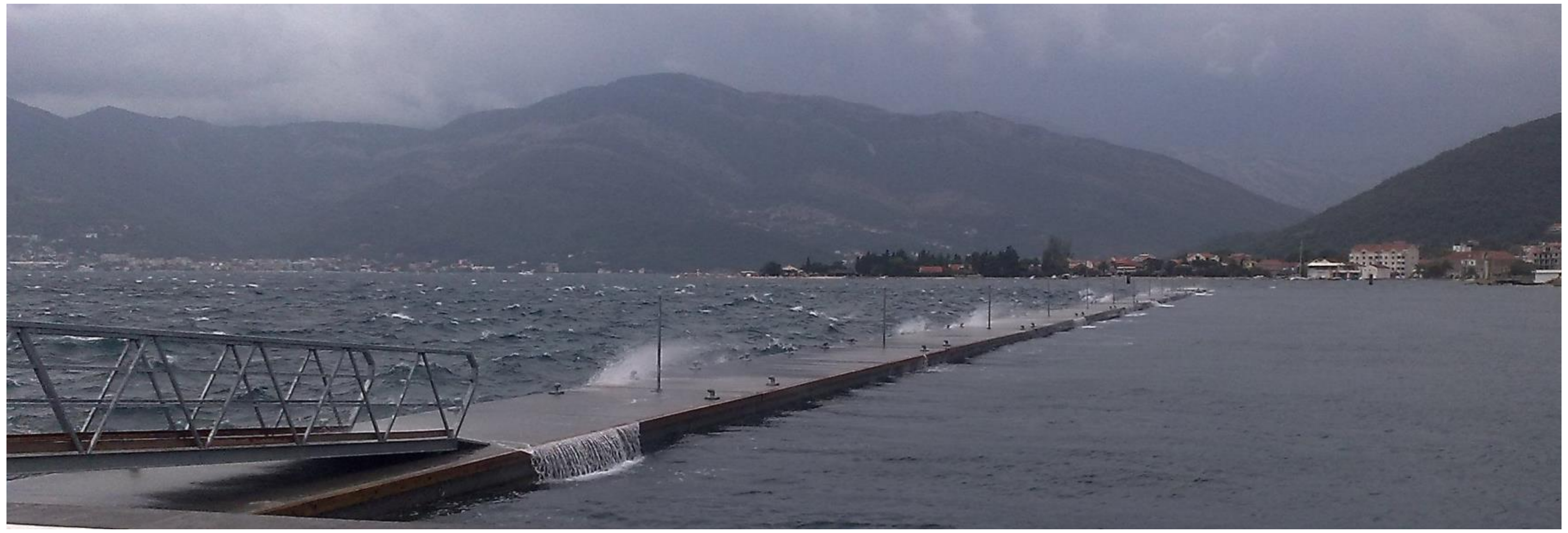
- Form a waterbody management group including all affected stakeholders
- Review the larger water body of concern and prepare a water use plan, considering:
  - Shoreline typologies (muddy shoreline, sandy shoreline, rock revetment shoreline)
  - Sensitive environmental areas
  - Waterfront land uses
  - Water body typology (fetch, water depth, etc)
- Work to identify if any obvious “zones” appear through the engagement process
- Create a “wake park” on the water with mooring tie-ups (30 years ago you probably would have brushed off skate parks!)
- Develop policies to improve management of waterbody for all
- Exchange ideas with neighboring lake management groups



Conceptual Plan View of Wake Park in the Middle of a Lake

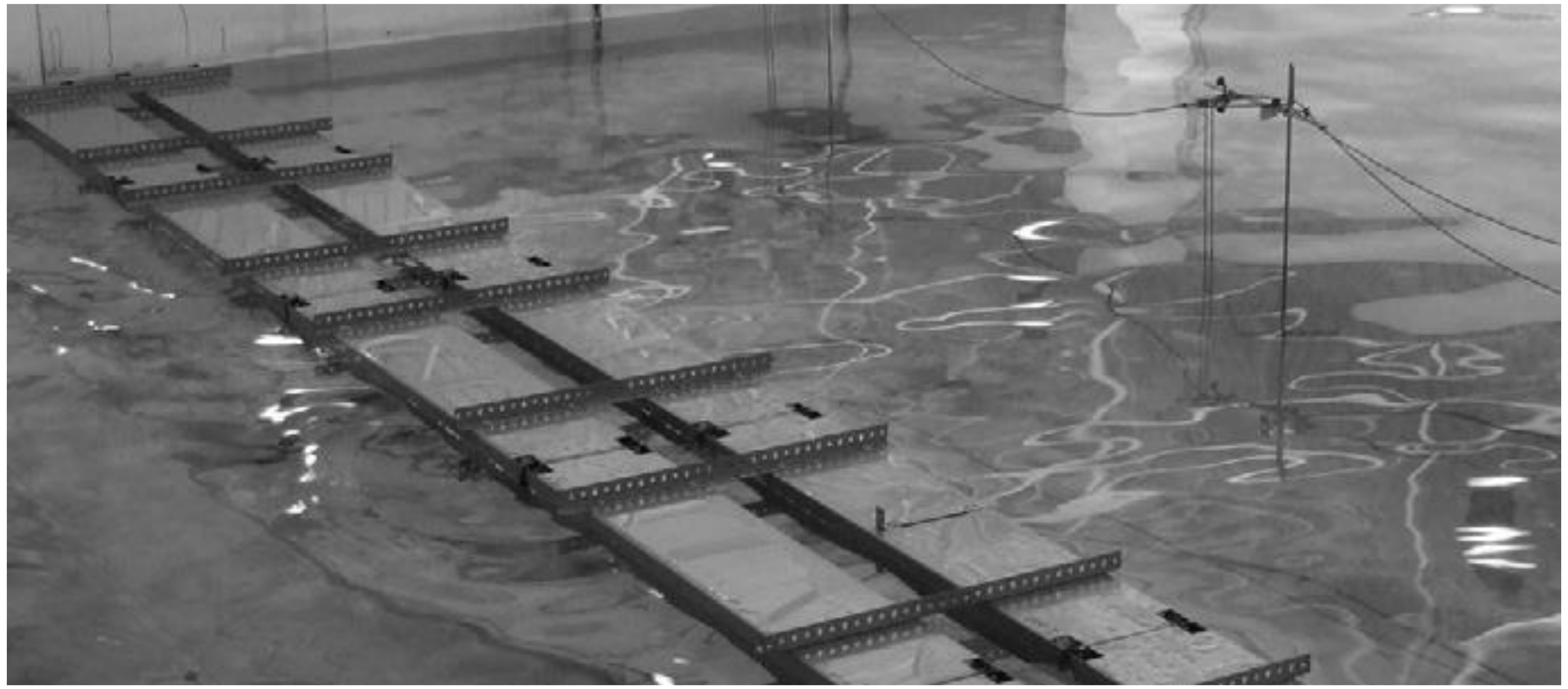
PROTECTION OPTIONS FOR MARINA OWNERS

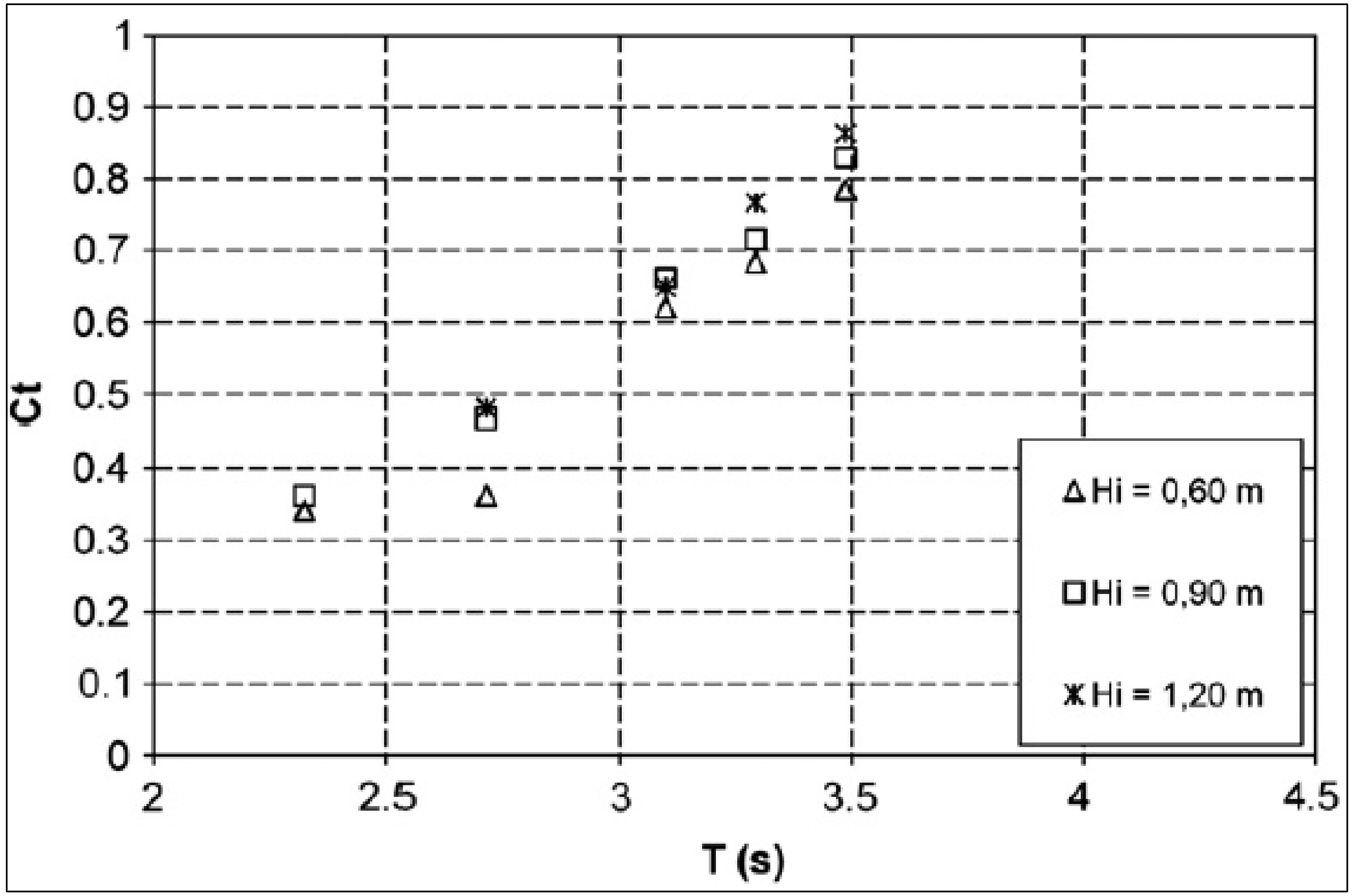
- Protect marina with wave protection infrastructure:
  - Floating wave attenuators
  - Wave screen/wall
  - Rubble mound breakwater
  - Others (e.g., rock-filled gabions)
- Incident boat wake conditions on the order of Hmax = 1 – 1.5 ft and T = 1.8 – 2.2 sec
- Floating attenuators are ideally suited for these incident conditions
- However, remember to check wind wave climate – could be the governing design condition!



MARINA PROTECTION – FLOATING WAVE ATTENUATORS

- Floating wave attenuators are complex engineered structures
- There are many factors that affect the performance of wave attenuators (width, draft, mass, anchoring, etc)
- A “one-size-fits-all” floating wave attenuator does not work
- Floating wave attenuators require proper design specific to the site’s conditions
- Information on floating wave attenuators performance from commercial dock suppliers is generally inadequate
- Frequently technical data is unavailable or any such technical data is often oversimplified without proper supporting documentation
- Documented physical model (wave flume studies) should be performed (or provided) prior to construction and installation
- As alternative, field studies should be performed after installation as part of the construction contract / performance guarantees





PROTECTION OPTIONS FOR WATERFRONT DOCK OWNERS

- Use boat lifts to raise boat above wave crest height
- Various options available:
  - Cantilever lift
  - Vertical lift
  - Elevator lift
- Avoid floating lifts – doesn’t solve the issue of getting above the wave crest elevation

PROTECTION OPTIONS FOR WATERFRONT LANDOWNERS – SLOPED SOLUTIONS

- Rock revetment is more "economical" means to stabilize shoreline
- Terraced shorelines utilize rock revetment and granular (beach sands)
- Important to make sure the crest is either:
  - Sufficiently high to counter the largest wake
  - Sufficiently wide (if lower) to dissipate traveling wake
  - Appropriate backfill to avoid washing out in lee
- Create flatter slope (if possible) to dissipate incident wake
- Import more granular fill material along shoreline (e.g., beach sands)
- Granular fill material (coarse sands) are more stable than fine material or natural clays/muds along the shoreline – faster fall velocity when mobilized in suspension by waves
- Vegetative shoreline can help naturally stabilize the shoreline

PROTECTION OPTIONS FOR WATERFRONT LANDOWNERS – VERTICAL SOLUTIONS

- Bulkhead/vertical wall maximizes waterfront property
- Important to make sure the bulkhead:
  - Has crest sufficiently high to counter the largest wake
  - Appropriate backfill to ensure correct drainage and to avoid washing out in lee if overtopped from low crest
  - Rock at toe of wall to eliminate scour
- Terrace with bulkheads is great way to improve architectural view

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** Images presented were obtained from Google (unless noted otherwise) **

THIS CONCLUDES THE COURSE PRESENTATION TITLED:

PROTECTING MARINAS & SHORELINES FROM WAKESPORT BOATS

THANK YOU

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