Electric Shock Drowning (ESD)

Original Slide Set Courtesy of:

BETH LEONARD
Boat Owners Association of the U.S.
Director of Technical Services
703-461-2878 X3153
BLEONARD@BOATUS.COM

ESD Resource Center
www.BoatUS.com/Seaworthy/ESD.asp

July 4, 2012 – Cherokee Lake, TN

- Noah Dean Winstead, 10, and Nate Parker Lynam, 11, were swimming near a houseboat with Nate's sister when she started to scream
- Nate's maternal grandparents and another bystander tried to reach the two boys while Nate's mother pulled her daughter from the water
- As soon as they hit the water, the rescuers realized the boys were being shocked
- Noah was unresponsive when pulled from the water; Nate was resuscitated but died in the hospital the next day; Nate's sister was injured but recovered

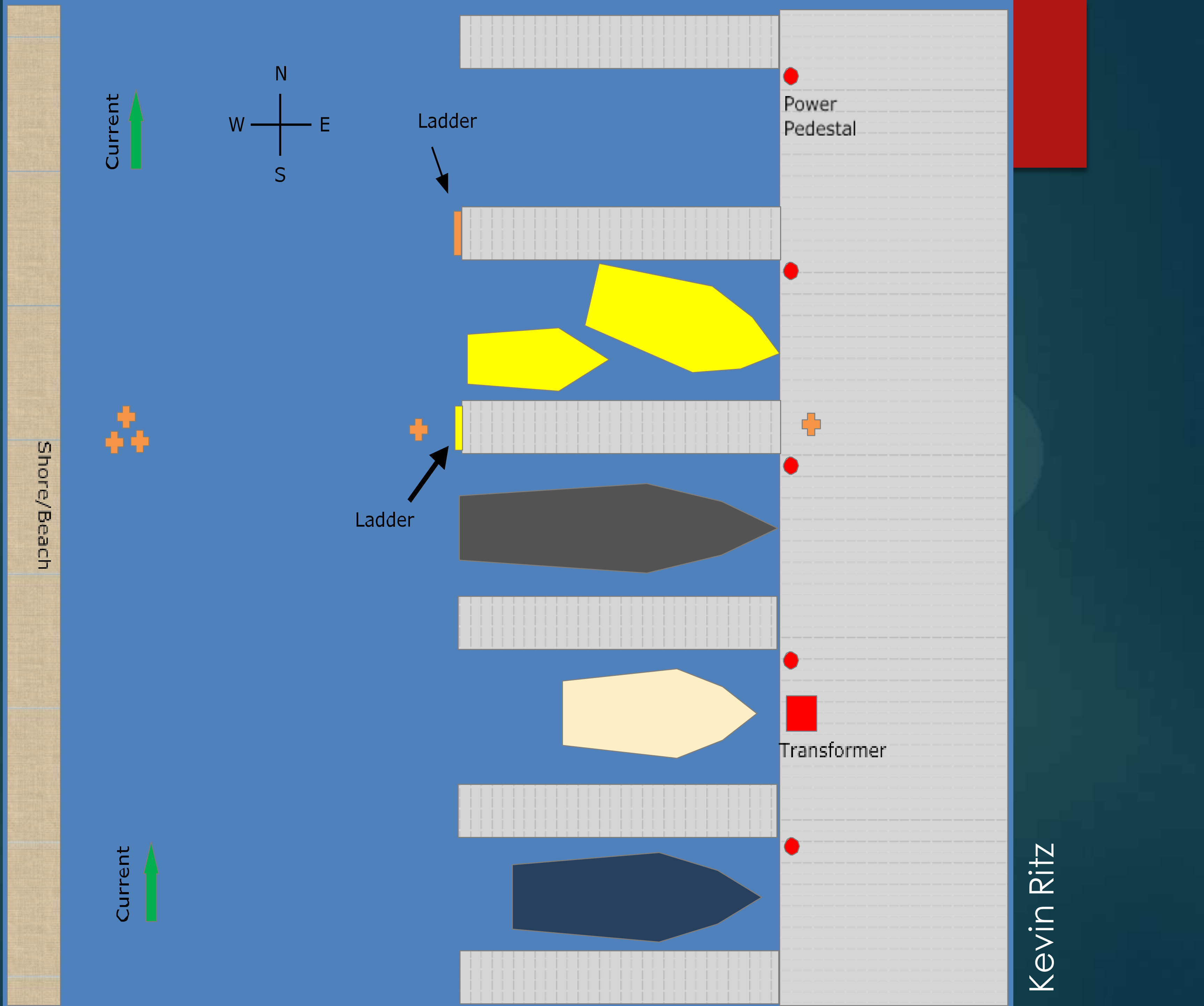
What killed Nate and Noah?

Electric Shock Drowning (ESD):

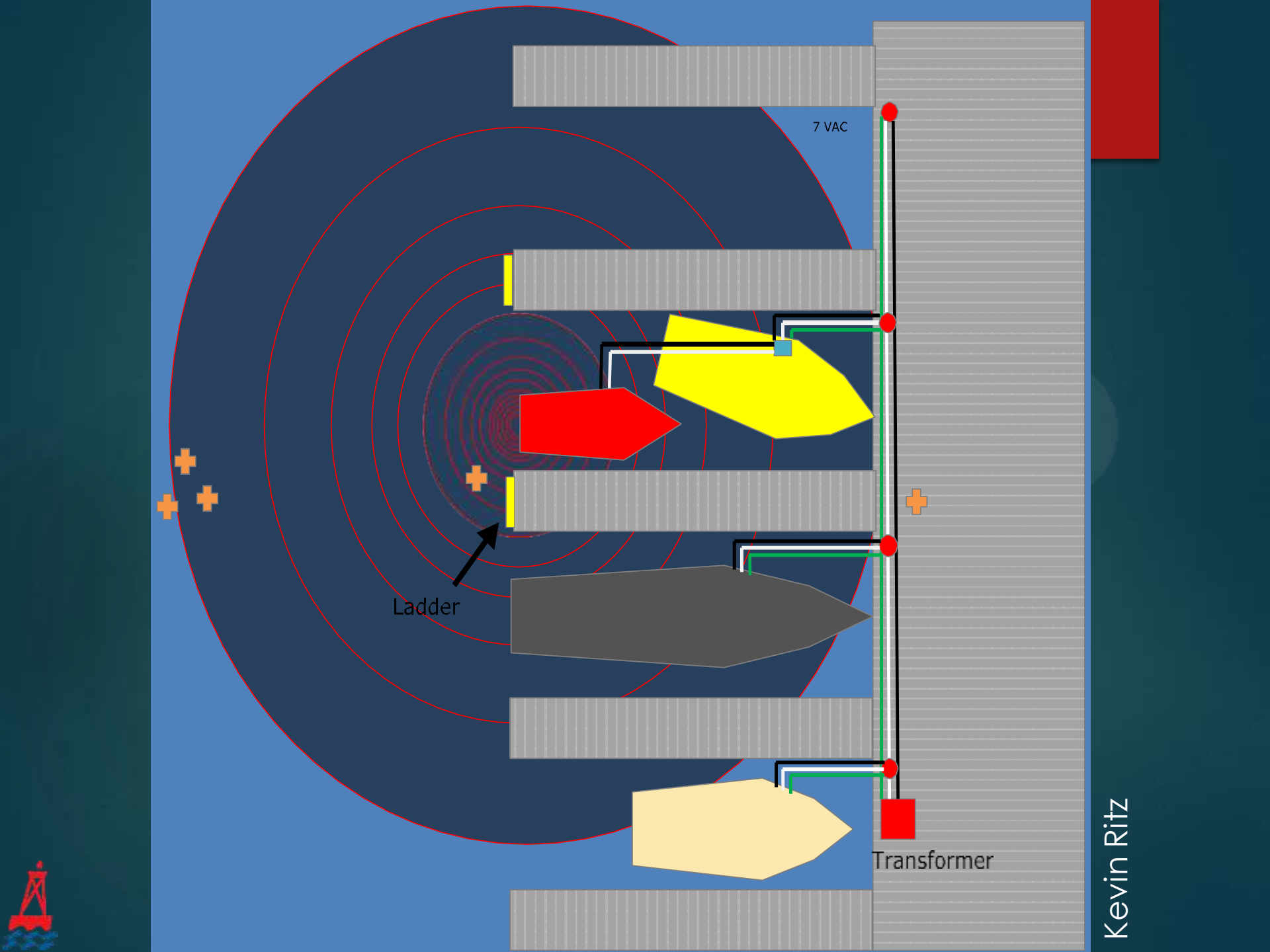
"ESD happens in fresh water where minute amounts of alternating current are present."

– Kevin Ritz

Lucas Ritz
1991-1999



N
W
E
S
Current
Ladder
Power
Pedestal
Shore/Beach
Ladder
Transformer
Current
Kevin Ritz



Kevin Ritz

How Big a Problem is This?

- These are CONFIRMED incidents where the source of the electricity was identified
- Cannot tell from the body that electricity was involved
- Many more unexplained drownings go uninvestigated every year
- As awareness increases, the numbers will likely increase as well

YEAR	FATALITIES	NEAR MISSES
2010	3	20
2011	2	2
2012	14	13
2013	6	6

More than 1,000 children (19 and under) die each year from drowning; only automobile accidents kill more.

- Michigan Public Health Institute

Today, a Lot More AC + Water…

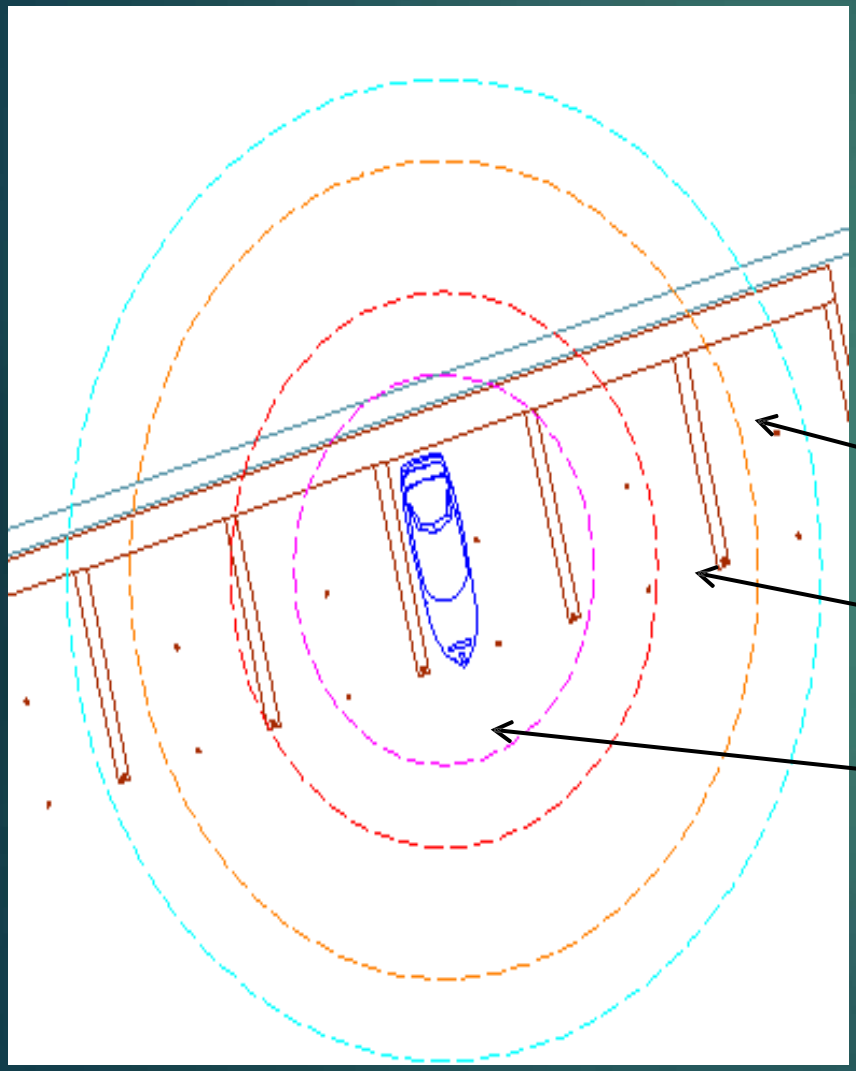
It's Not Just Marinas and Boats
It's Any Electrified Dock or Lift

ESD Basics

- Fresh water + AC = Danger
- How electricity gets into the water
- How to test for electrical leakage from boats and docks
- How to keep electricity from getting into the water

Current (mA)	Probable effect on human body
1	Perception level. Slight tingling sensation. Still dangerous under certain conditions.
5	Slight shock felt; not painful but disturbing. Average individual can let go. However, strong involuntary reactions to shocks in this range may lead to injuries.
6-16	Painful shock, begin to lose muscular control. Commonly referred to as the freezing current or let-go range.
17-99	Extreme pain, respiratory arrest, severe muscular contractions. Individual cannot let go of an electrified object. Death is possible.
100-2,000	Ventricular fibrillation (uneven, uncoordinated pumping of heart). Muscular contraction and nerve damage begin to occur. Death is likely.
2,000+	Cardiac arrest, internal organ damage, and severe burns. Death is probable.

Fault Current Creates an Electrical Gradient



ILLUSTRATIVE

50mA ~0.5 VAC/ft.
200mA ~1-2 VAC/ft.
500mA ~2+ VAC/ft.

Actual electrical current passing through a swimmer at any point depends upon a variety of factors including:

- Distance from source
- Salinity
- Temperature
- Depth
- Swimmer's body mass and composition
- Swimmer's orientation
- Swimmer's sex
- Cuts and abrasions

Courtesy Ed Sherman and Chris Dolan

ESD Exposure Example

200mA of fault current entering the water

Voltage Gradient = 2 volts /ft

A 4 foot child could be exposed to 8 volts head to feet

The resistance of a child in water would likely be less than 300 ohms

Using a conservative estimate of 500 ohms

V/R = I

8 Volts/500 Ohms = 0.016 Amps = 16 mA

6-16 mA	**Painful shock, begin to lose muscular control. Commonly referred to as the freezing current or let-go range.**

Difficulty Identifying an ESD Victim

What you won't see:

- Often no bodily clues to suggest anything but "simple drowning" due to alcohol intoxication or heart attack
- No signs of burning because victim in water – no signs of electrocution
- Even if there is water in the lungs, electricity could still have been a factor

Clues that it could be ESD:

- Tingling sensation reported by anyone swimming in the area
- Reports of great distress, agitation, screaming
- No water in lungs

Intuitive Reactions Can Make the Situation Worse

- Distressed swimmer's first reaction is to swim toward the dock, which almost always means swimming toward the source of the electricity
- Diving in from the dock to assist someone may put rescuer in most dangerous part of the electrical field
- If swimmer experiences mild discomfort and reaches the dock/boat, touching a metal fitting may result in electrocution

Reach, Throw, Row……..But Do Not Go!

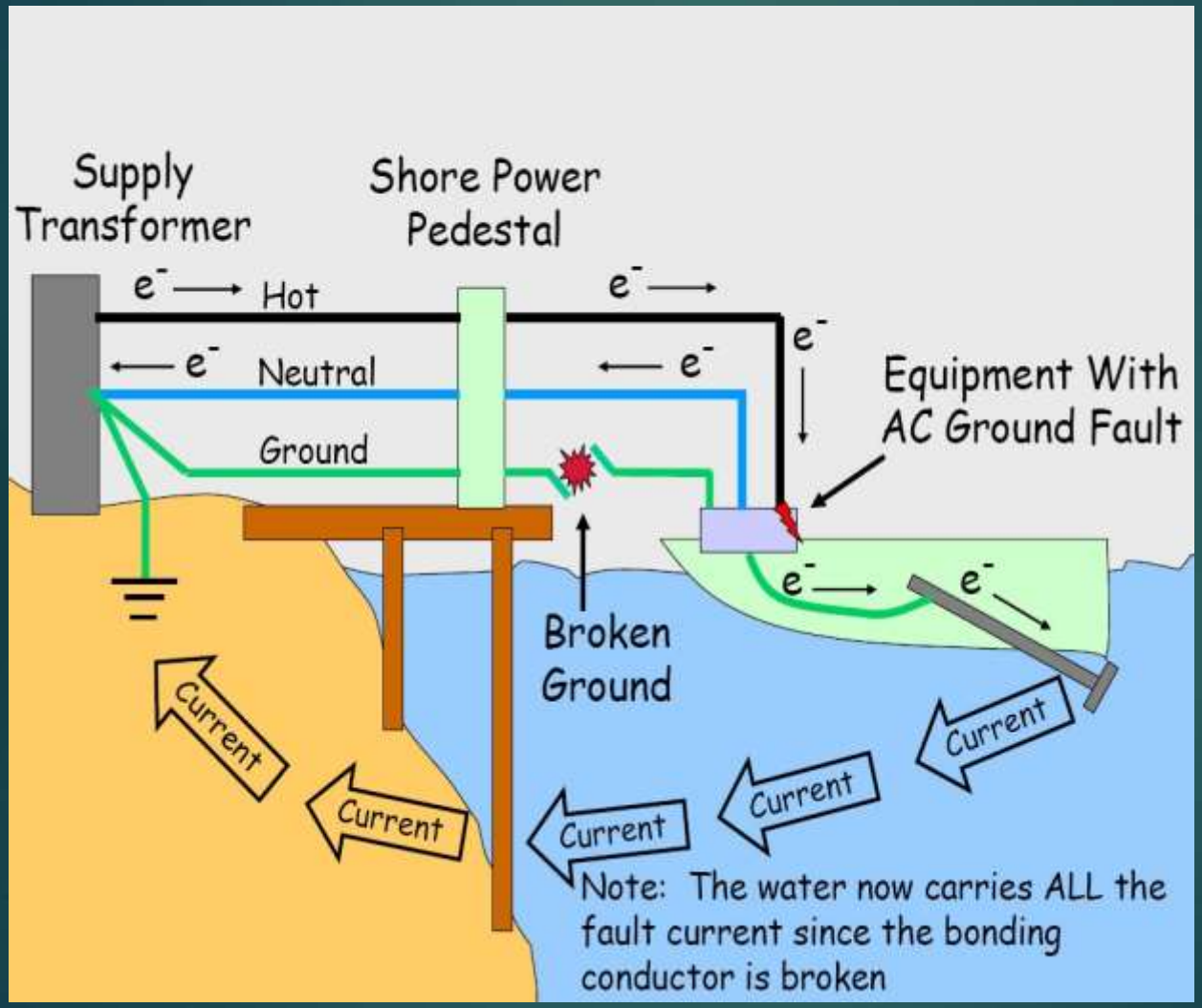
ESD Basics

- Fresh water + AC = Danger
- How electricity gets into the water
- How to test for electrical leakage from boats and docks
- How to keep electricity from getting into the water

Three Requirements

1. An AC electrical fault on a boat or a dock: Electricity must be escaping from a circuit somewhere and trying to find its way back to its source
2. AC safety ground fault: The AC grounding system must be compromised so that stray current cannot easily return to ground through the ground safety wire. Any stray electricity then has only one path back to its source — through the water.
3. No ground fault protection

AC Electrical Fault Plus Ground Fault



Safety ground fault could be on the boat or on the dock

Courtesy David Rifkin

ESD Basics

- Fresh water + AC = Danger
- How electricity gets into the water
- How to test for electrical leakage from boats and docks
- How to keep electricity from getting into the water

Check Dock Wiring

- Like a simple circuit tester, lights on the front indicate where there is continuity and where there is not
- Decoder on the back will help you to figure out what you see means
- Certain things can be misleading, particularly neutral-ground connections
- If a problem is found, a qualified electrician should evaluate the dock wiring and diagnose the problem

Ed Sherman and Chris Dolan

Check Boat Wiring

- If what goes in the "hot" conductor returns on the neutral or the safety, the meter will read zero
- A reading other than zero means one of two things:
  - Current is leaking from the boat into the water
  - Current from another boat is coming through the electrical fittings on the boat you are testing
- To determine which, turn off the pedestal and re-check the cord – if now reads zero, the boat you are checking has the fault
- If two cords, clamp them together

Ed Sherman and Chris Dolan

Check Boat Wiring

Even if you get a zero reading, you can't be sure until you've tested all AC equipment aboard, especially cycling appliances. So, to be sure:

1. Start with all AC equipment on including refrigeration, water heater, air conditioning, microwave, etc.
2. If the clamp meter reads anything except zero, turn off equipment one at a time watching to see if the reading changes
3. When it changes, you've identified a problem
4. There may well be more than one problem on a boat
5. If you turn everything off and it still doesn't read zero, try turning off the pedestal
6. If it still doesn't read zero, the electricity is coming from another boat – assuming the dock wiring is sound

Boat Wiring ≠ House Wiring

- Boats have AC and DC wiring – confusing them can electrify the entire boat (on some boats AC hot and DC negative are black)
- The AC system is tied into the DC system (AC grounding bus tied into DC negative bus) and underwater metals are bonded together to reduce electrocution risk; leakage in the AC system can electrify the underwater fittings on a boat
- If neutral and ground are tied together, as is common ashore, electricity can go into the water through the ground
- If neutral-ground connection on some appliances is not severed, electricity can go into the water through the ground
- If neutral-ground connection is severed on inverters, generators, and onboard transformers, an electrical fault may not trip the breaker

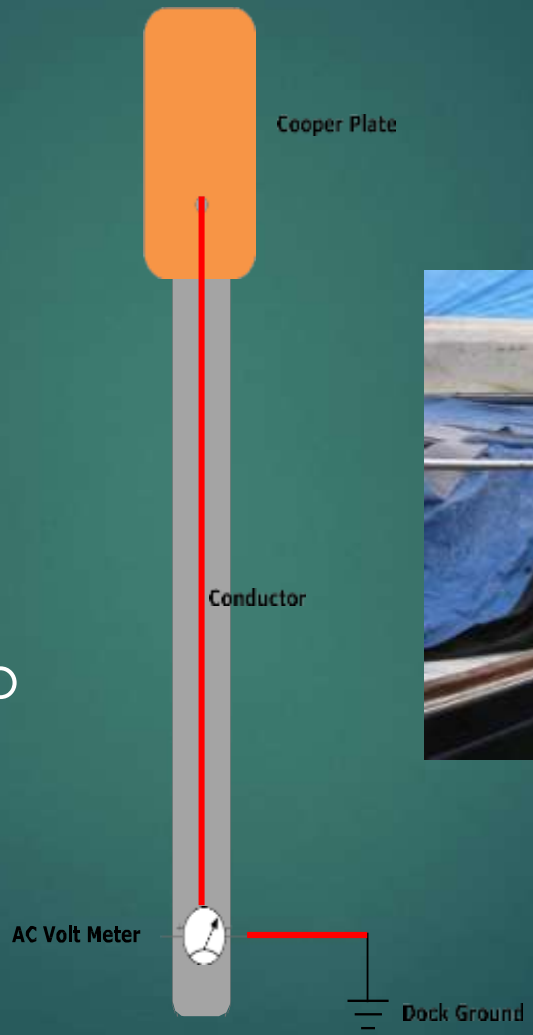
How Much Current is Dangerous?

- Clamping shore power cords for current in the water
- Readings of 100 milliamps or greater in fresh water present a dangerous condition and immediate action should be taken
- Readings less than 100 milliamps should still be checked by an ABYC certified marine electrician

Kevin Ritz

One More Tool - AC Voltage Probe

- Once you have located likely boat, use this probe to sweep the water
- Looking for voltage in the water – not current
- May also be able to find voltage on above water metal fittings



Kevin Ritz

ESD Basics

- Fresh water + AC = Danger
- How electricity gets into the water
- How to test for electrical leakage from boats and docks
- How to keep electricity from getting into the water

Three Requirements

1. An AC electrical fault on a boat or a dock: Electricity must be escaping from a circuit somewhere and trying to find its way back to its source
2. AC safety ground fault: The AC grounding system must be compromised so that stray current cannot easily return to ground through the ground safety wire. Any stray electricity then has only one path back to its source — through the water.
3. No ground fault protection

Preventing ESD Injuries/Deaths

1. Prevent electrical faults on all boats
2. Prevent faults in the safety ground wire on the dock
3. Install ground fault protection on the AC system on the docks

So what's the difference between this…

And this:

"No sane person would consider plugging a hair dryer into an AC outlet, turning it on, and stepping into the water with it. But **that's essentially what we're doing with our boats**."
- Kevin Ritz

One Big Difference is This…

Wtshymanski via Wikimedia Commons

Ground Fault Protection (GFP) facts:

- GFPs trip, shutting off the electricity, if the current in the hot wire and neutral wire differ by a certain amount of mA
- GFCIs, like those in your bathroom, trip a tenth of a second or less at 6 mA difference
- The GFCI *will* trip if there is current returning along the safety ground wire even if no current is returning through the water

Justin Baeder

States are Starting to Regulate Marinas

- West Virginia
  - Michael Cunningham Act
  - Enacted last year
- Tennessee
  - Noah Dean and Nate Act
  - Passed last summer
- Kentucky
  - Chipley Act
  - Did not pass last summer but may be reintroduced

All of these require:

- Regular dock inspections
- Ground fault protection on docks
- Posting of signs

Additional Acknowledgements

- David Rifkin
  - In-Water Shock Mitigation Strategies
- Kevin Ritz
  - Electric Shock Drowning: The Invisible Killer
- Ed Sherman and Chris Dolan
  - Marina Dock Safety

These resources and others can be found at:
www.boatus.com/seaworthy/ESD.asp