

ELECTRIC SHOCK DROWNING: THE INVISIBLE KILLER!

Hosted By:
PCC

Created and Presented By:
Kevin Ritz

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OBJECTIVES

1. To prevent injuries and loss of life due to Electric Shock Drowning (ESD) and water-related electrocutions.
2. To promote the understanding of the mechanisms of ESD, i.e. how this happens.
3. To recognize potential high risk areas, i.e. where this takes place.
4. To provide a basis for the investigation of all drowning's of a suspicious nature.
5. To identify prevention measures for ESD using ABYC, NFPA, and NEC Standards.
6. To enlist you, help in an effort to halt these preventable loss-of-life tragedies.

THE ISSUE ON BOATS

- ▶ Providing power to vessels in fresh-water from an external source is a unique situation that can create a hazard not found when using AC power on shore.
- ▶ Would you consider stepping into a bathtub or swimming pool with a hair dryer in the water plugged into an electrical outlet? Think of the vessel as a hair dryer. The situation can be similar if the vessel is in fresh water, connected to external power, has a fault, and is not wired to meet ABYC standards. The marina, dock, or pond may also present the same danger if simple electrical safety measures are not present.

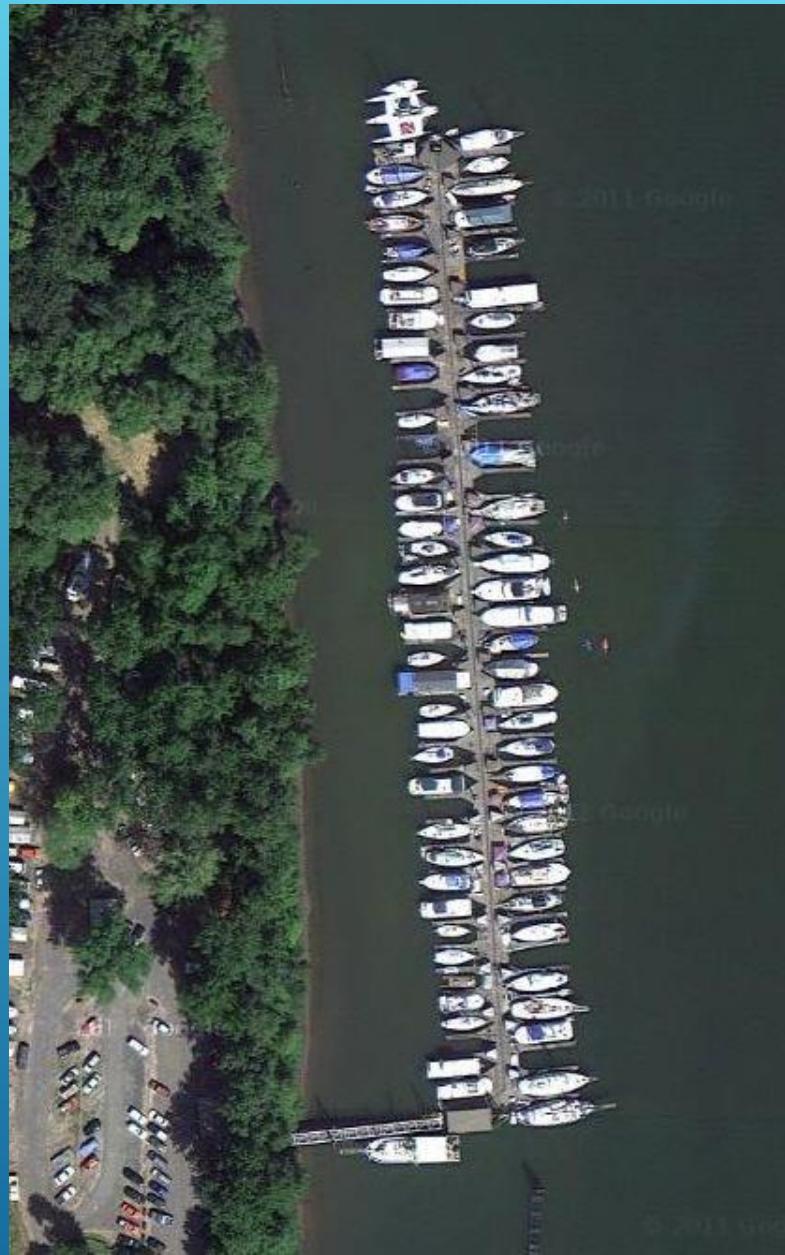
WHAT HAPPENS WHEN A VESSEL “PLUGS IN”

- ▶ You are connecting two different electrical systems together—each wired to its own code:
 - ▶ Shore based: the National Electrical Code
 - ▶ Yacht based: the ABYC Standards which include both AC and DC systems
 - ▶ Two different codes – two different levels of certification; two different perspectives guide those responsible for installation, inspection, and repair.



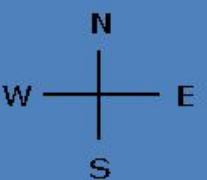
LUCAS N. RITZ, 8 YEARS OLD

11/09/1990 – 08/01/1999

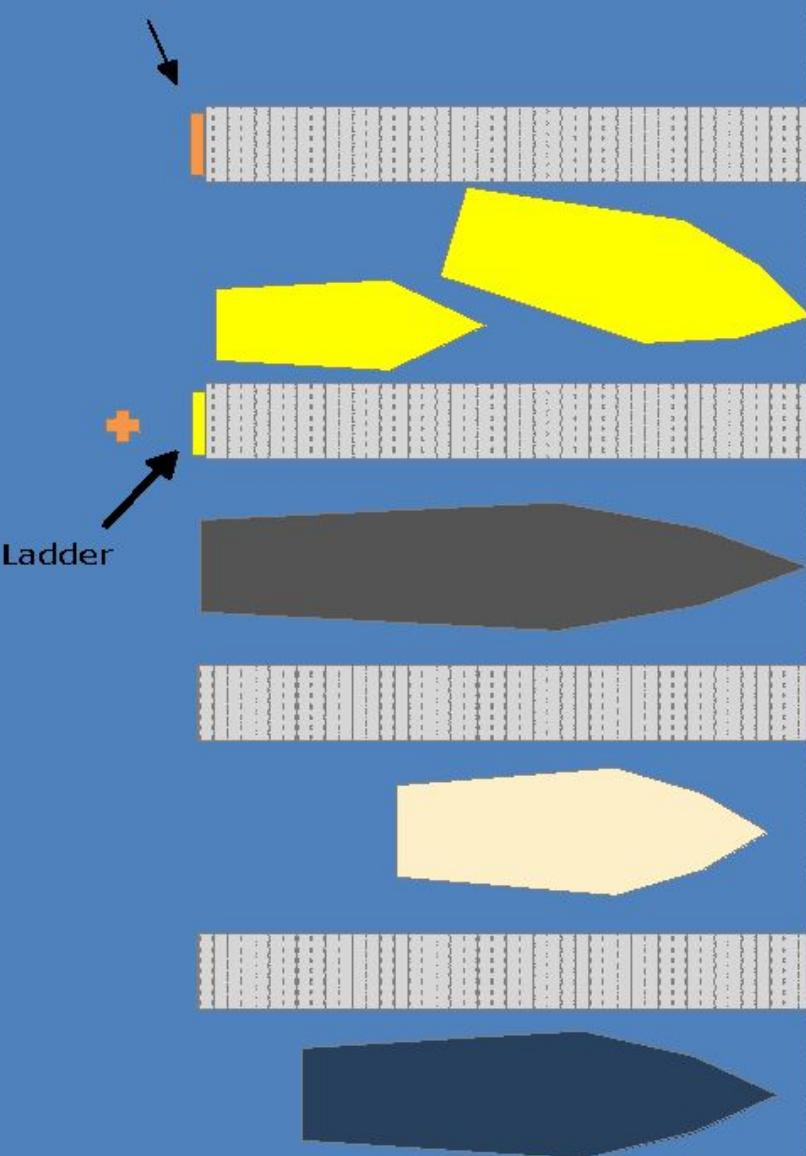


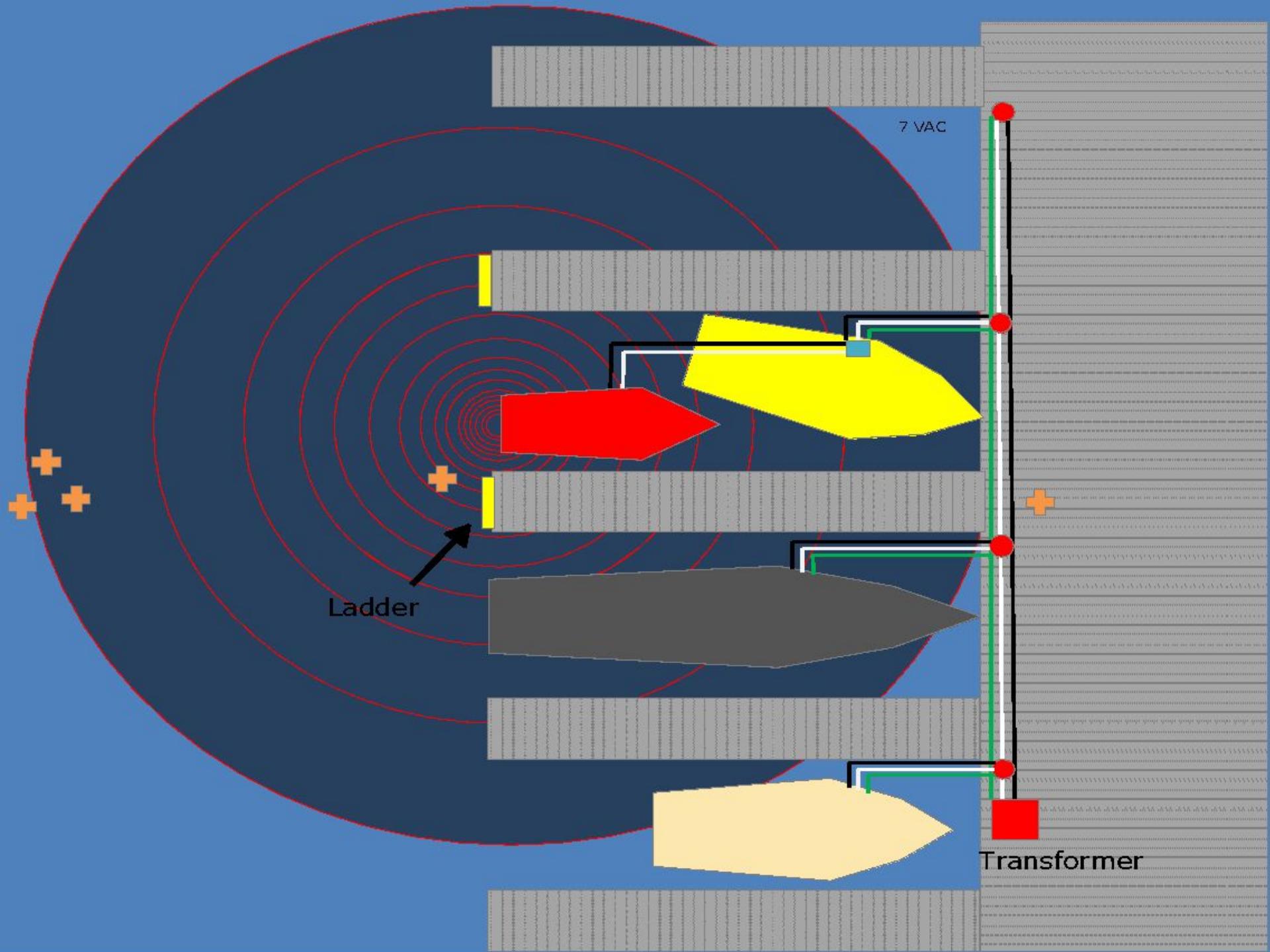
Shore/Beach

Current
↑

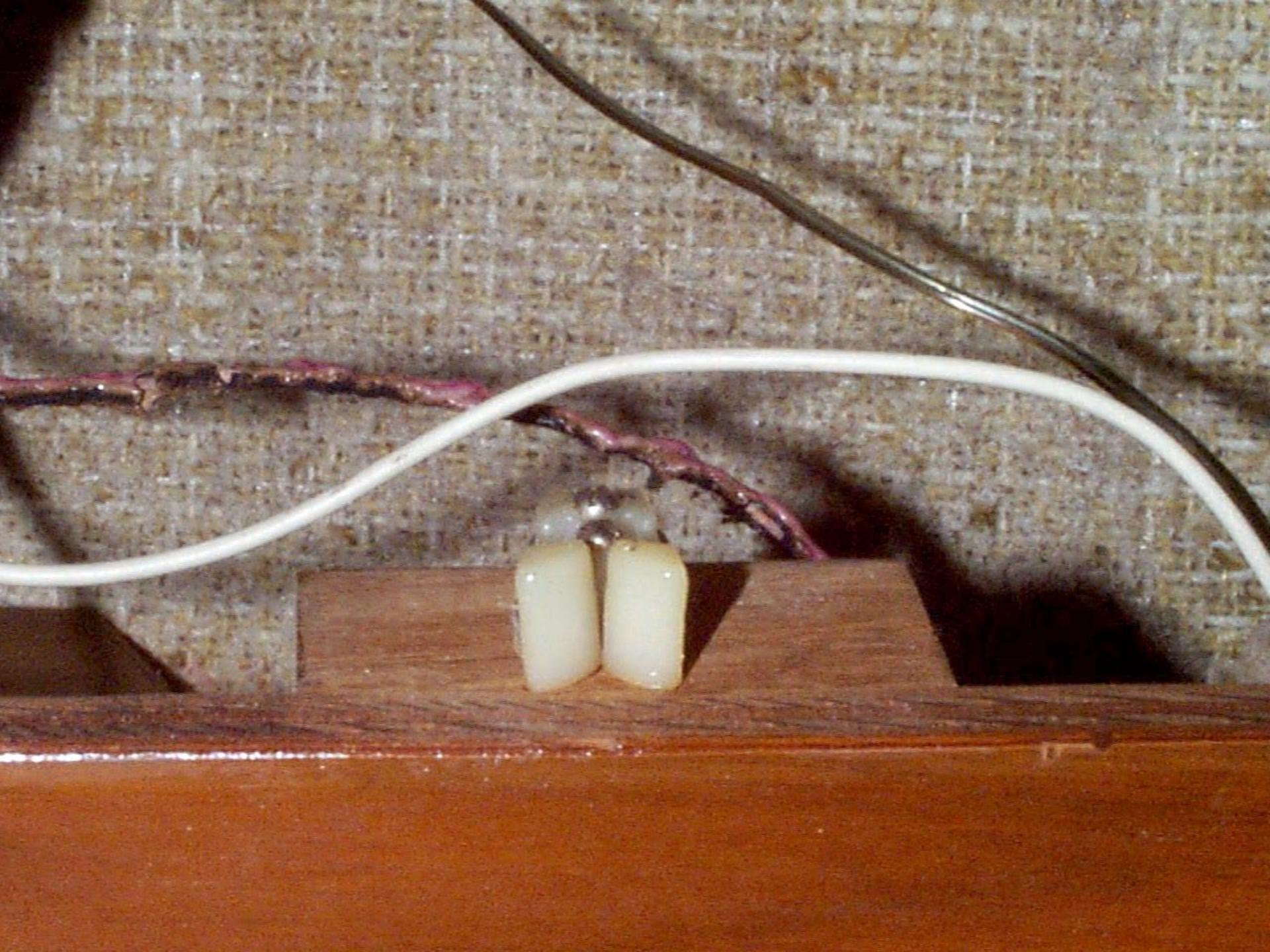


Ladder

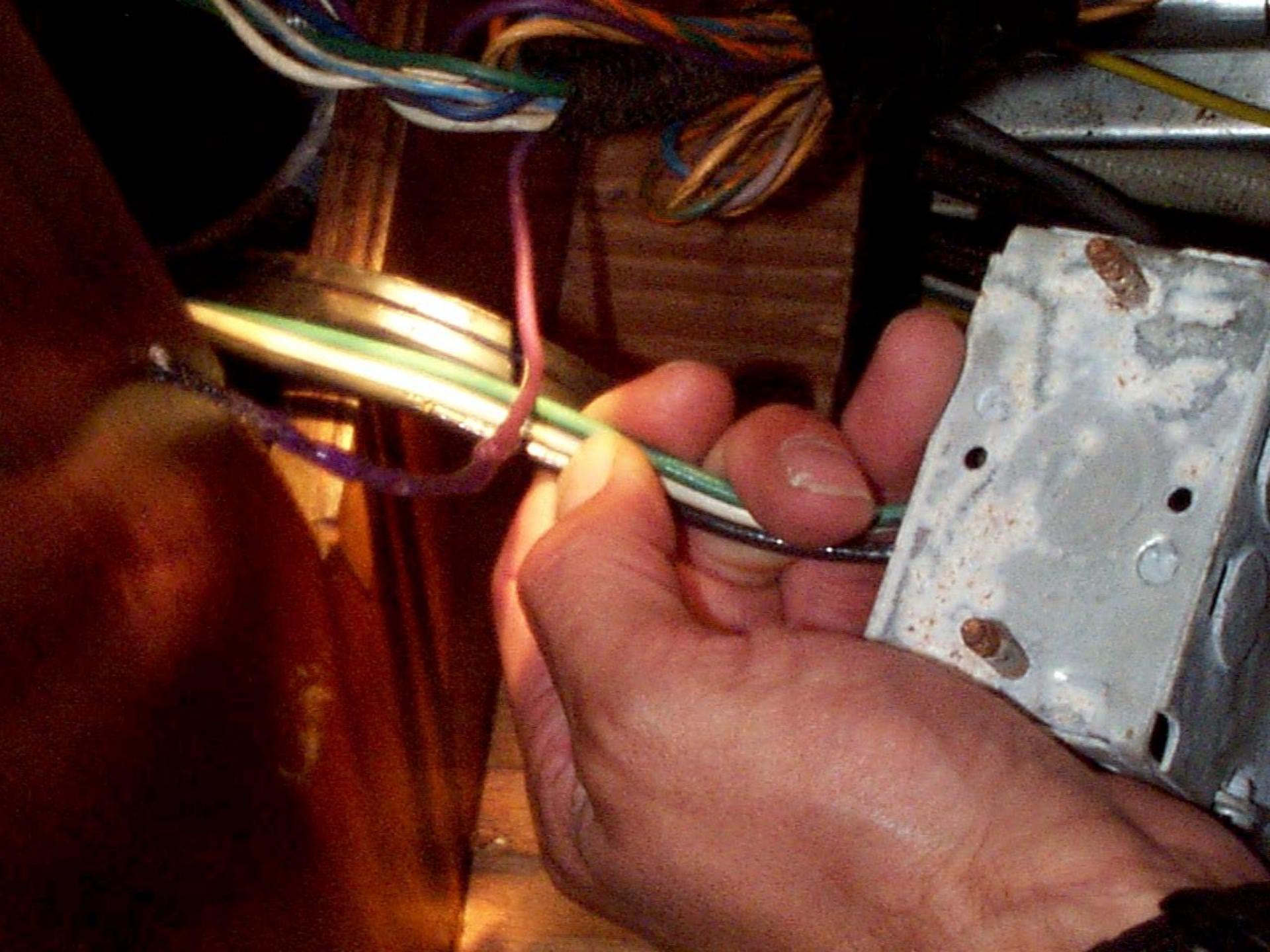


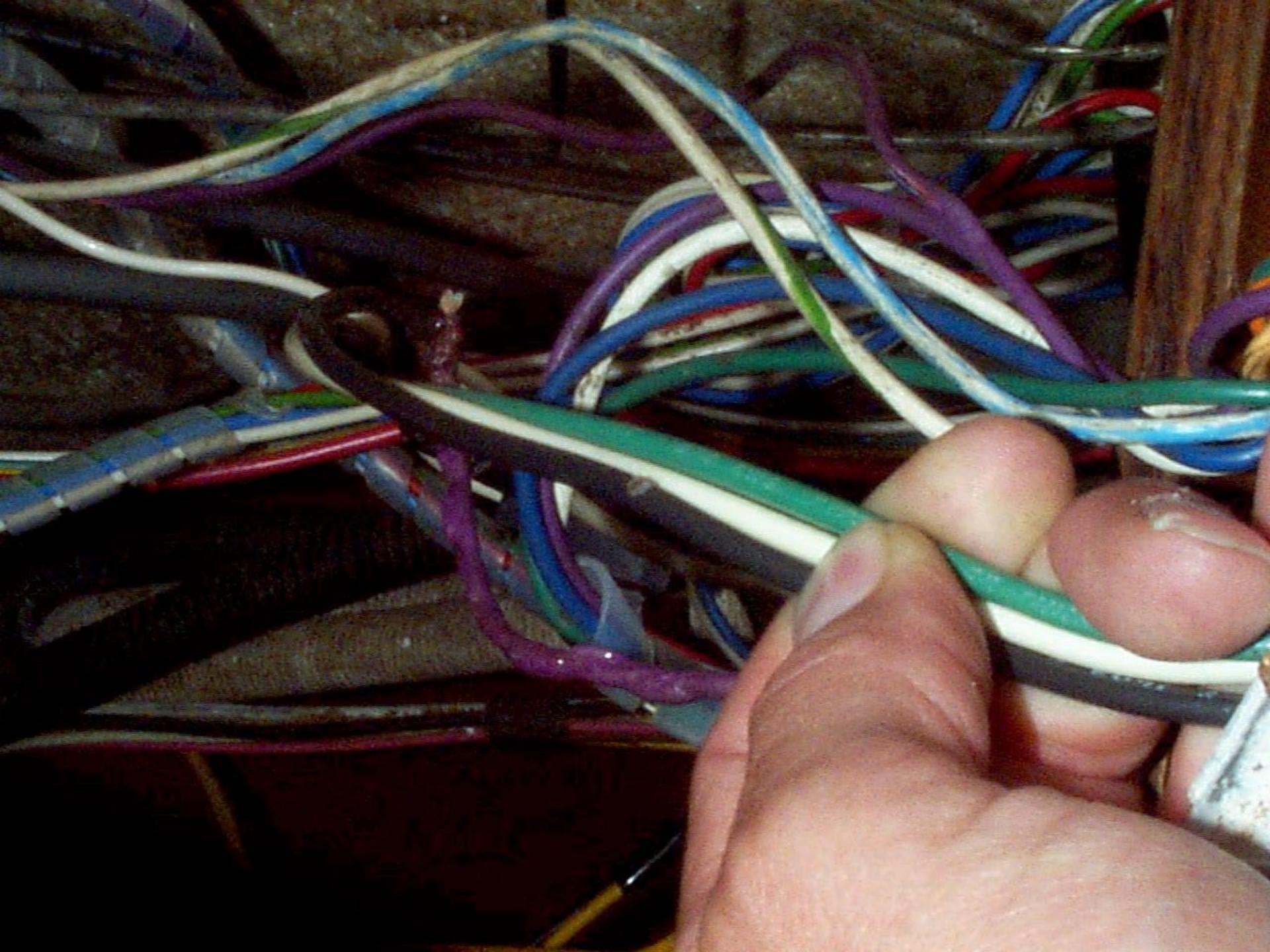












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THIS COPY NOT VALID WITHOUT INFAGLIO STATE SEAL AND BORDER



**CAUSE OF
DEATH**

6

DATE OF DEATH
INTERVIEWS
IN THESE SIDES

RESERVED FOR REGISTRAR'S USE

99-22229

37. Did tobacco use contribute to the death? 38. AUTOPSY 39. If YES were findings considered in determining cause of death?

Yes Probably
 No Unknown

Yes No Yes No N/A

41d. DESCRIBE HOW INJURY OCCURRED

Electrocuted in water while swimming

411. LOCATION (Street and Number or Rural Route Number, City or Town, State)

Multnomah Channel - 25200 N. W. St.
Helens Highway, Portland, OR

ORIGINAL-VITAL STATISTICS COPY

WHERE MIGHT THE DANGERS LURK?



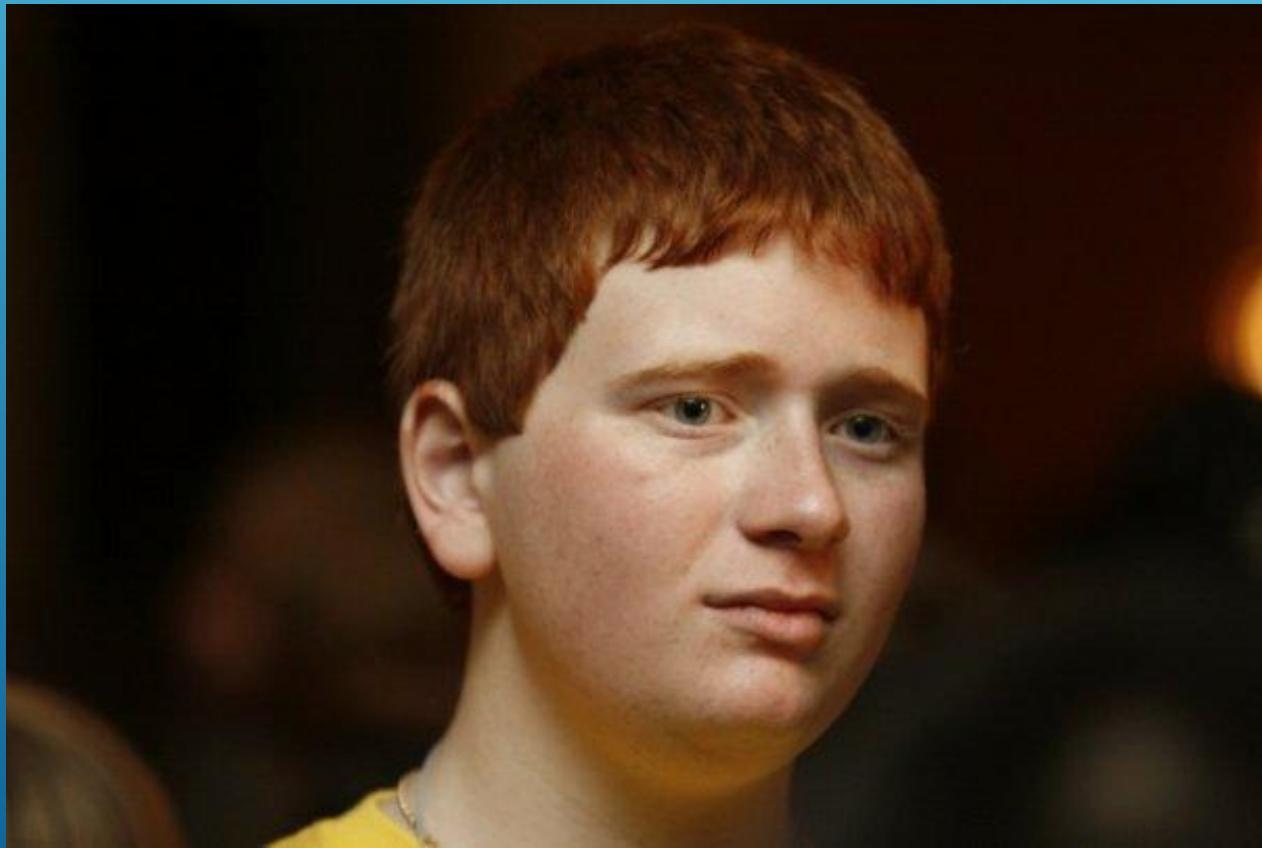
ELECTRIC SHOCK DROWNING DEFINED...

Electric Shock Drowning (ESD) is the result of the passage of a typically low level AC current through the body with sufficient force to cause skeletal muscular paralysis, rendering the victim unable to help him/herself, while immersed in fresh water, with drowning the eventual result.

Higher levels of AC current can result in electrocution.

ESD has become the catch all phrase that encompasses all in-water shock causalities and fatalities.

MICHAEL CUNNINGHAM, 15





SISP J

WV 9926S



Cardinalis





SAMANTHA CHIPLEY, 19

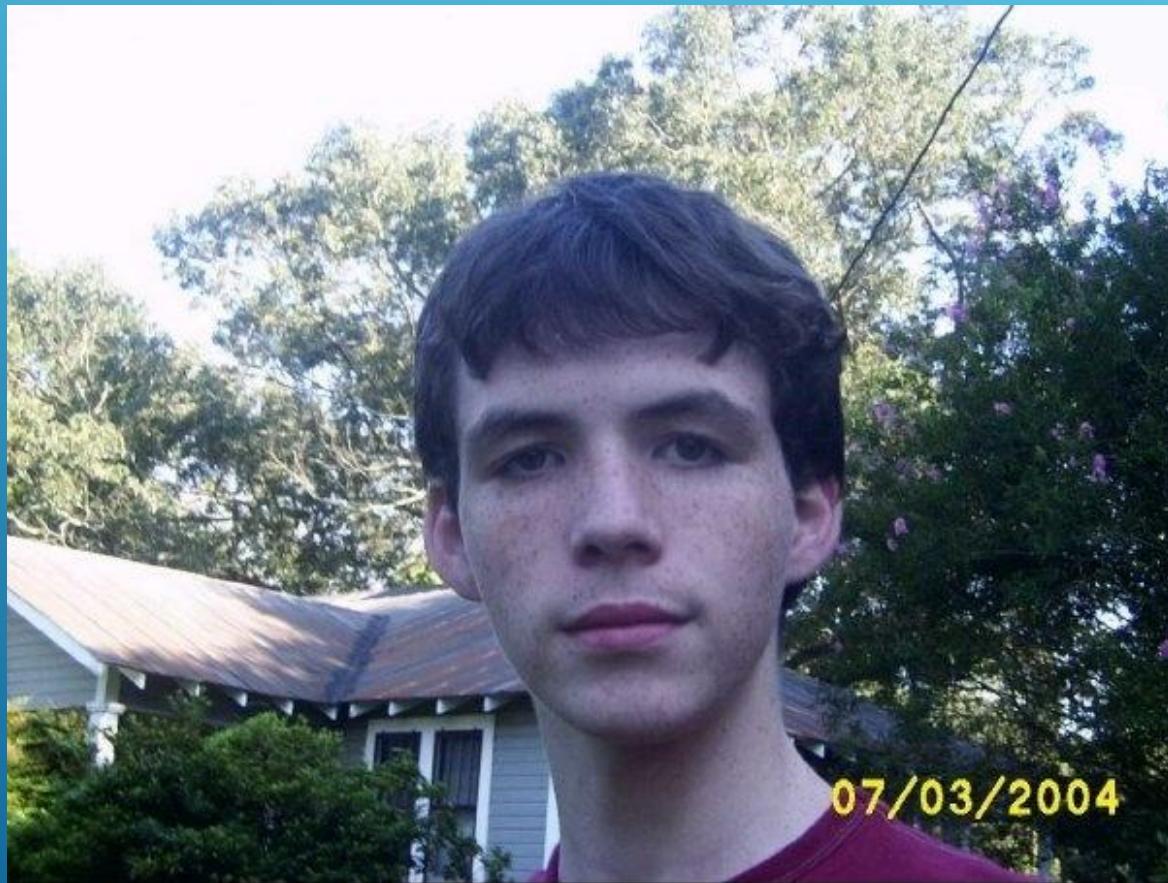


- ▶ Died Jun 27th 2005 At 19 Years of age.
- ▶ Scott Creek Marina, Cave Run Lake, Moorhead, KY
- ▶ Caused By Lack Of Grounding System And Faulty Battery Charger On Houseboat
- ▶ Would Be Rescuer Dived Into Water Only To Be Turned Back By Electrical Field

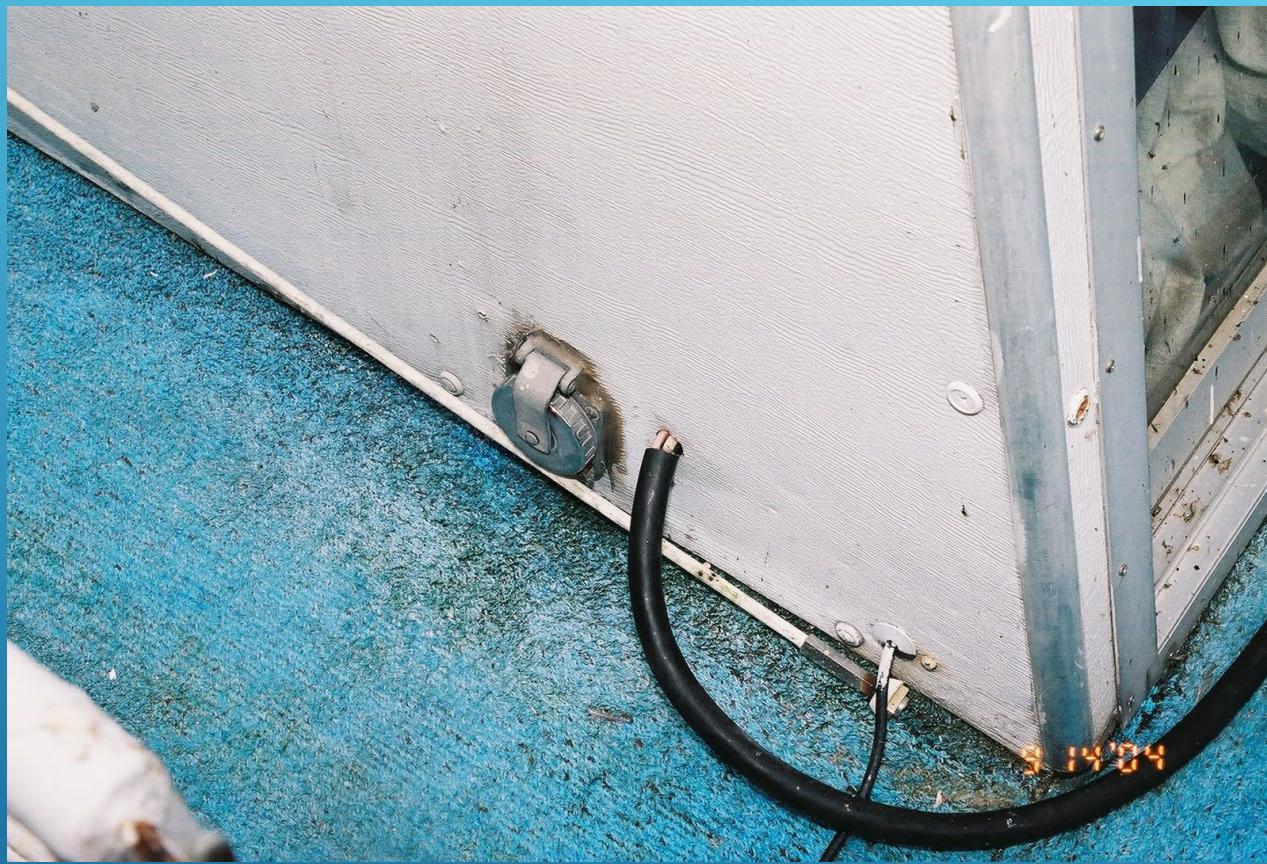
ZACHARY CRAYS, 13



KENNETH LUTRICK, 16

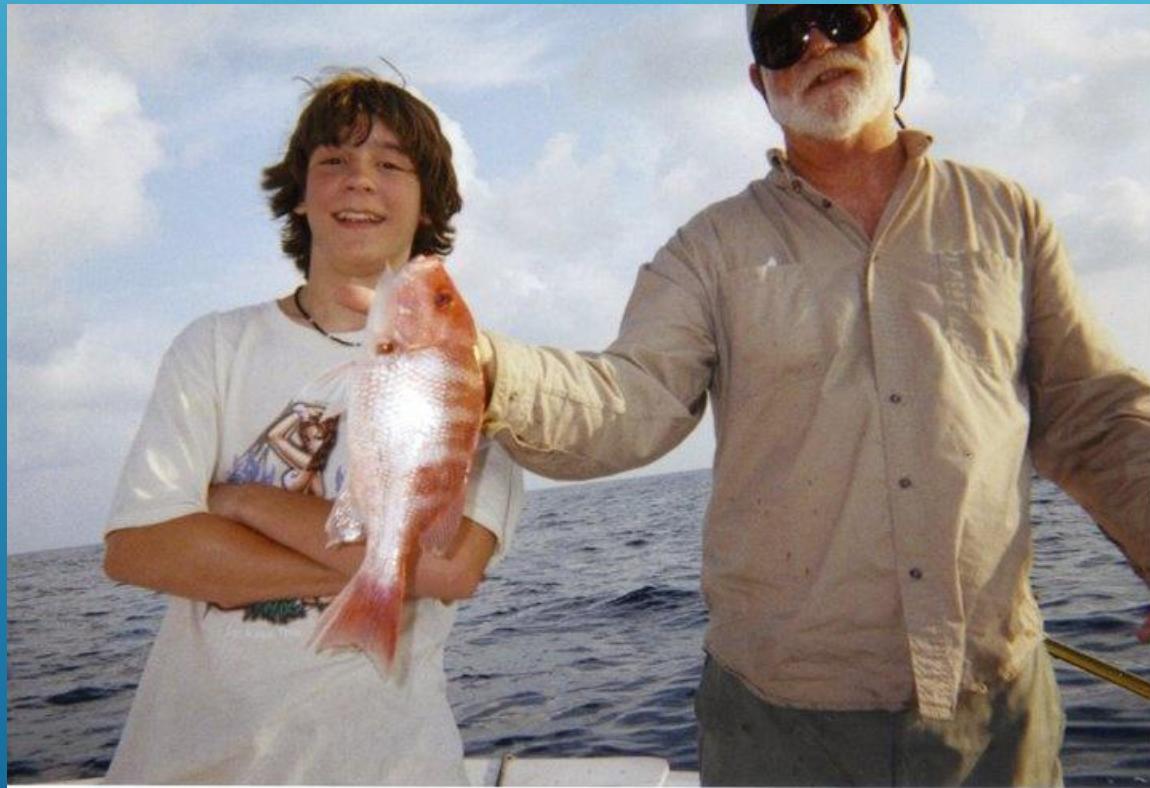








JESSIE FORTNER EISON, 14



LAKE TRAVIS, TEXAS

This particular case involves two juvenile females that jumped into the water, off of the dock. The females were seen by another juvenile as "eyes wide open, mouth wide open, very stiff and unable to talk". Then they both went limp and rolled over in the water.
(Detective) "I believe that this other juvenile witnessed the electric shock until the breaker was tripped."
Breaker most likely did not trip and never would have.





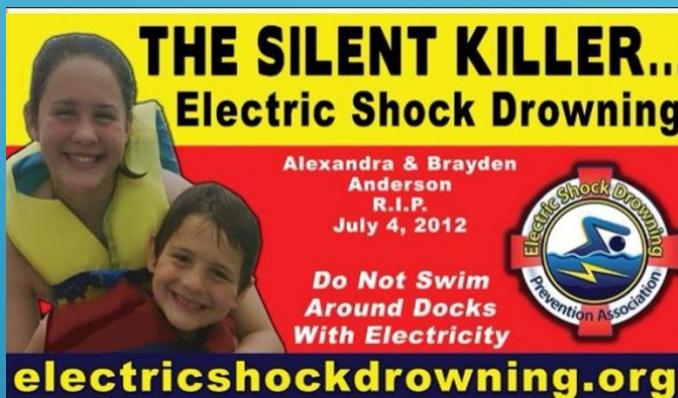












TYPICAL SCENARIO

- ▶ **Victim enters water, becomes disabled, may or may not call for help;**
- ▶ **Rescuers may be unable to assist due to feeling electrical shock themselves—would be rescuers may become additional victims;**
- ▶ **Victim's situation may worsen while seeking a “safe haven.”**

CASE HISTORY 1

- ▶ **River Street Marina, Port Huron, MI.** A 20 year old man jumped, or fell, into the water from the pier behind a 29' boat, moored stern to. He became disabled as he attempted to climb onto the swim platform. Two friends attempting to pull him on board reported being shocked. The man could not be resuscitated. The next day an inspector reported 107 VAC in the water behind the boat.
- ▶ Investigation determined that the battery charger had faulted across the AC/DC connection in combination with lack of safety ground.

CASE HISTORY 2

- ▶ **Bull Shoals Lake, Bull Shoals, AR.** A diver was found in shallow water 8 feet from the dock, drowned. An incorrectly wired junction box caused 117 VAC to appear on metal dock components. A rescue diver reported feeling electric shock sensations 20 feet from the dock.

CASE HISTORY 3

Summerset Lake, near Desoto, St. Louis, MO. A teenage boy was killed when he received an electric shock while swimming towards a metal ladder at a dock on the lake. Three other teens (two boys and a girl) were with him, and all received shocks in the same area. One teen was uninjured, the other two were in critical condition at a hospital (these two were unconscious at the dock when rescuers arrived). There was an electric boat lift and lighting on the dock. A utility rep found 10 amps of current running in the dock with no known loads on. There was a chain leading into the water where arcing, a dead muskrat, and ten dead minnows were observed.

CASE HISTORY 4

Brady Mountain Resort, Lake Quachita, AR. A 14 year old boy died from electric shock while swimming near a houseboat. A friend was also shocked and taken to the hospital. A man jumped in to help and was rendered unconscious (reason unknown, he was unharmed after regaining consciousness). The cause appeared to be inserting a shore power cord with a 30A/125V (L5-30) plug, with the grounding pin bent back into a 50A/125/250V receptacle in such a way so as to energize the neutral wire which was connected to the boat's bonding system, thereby energizing the hull.

CASE HISTORY 5

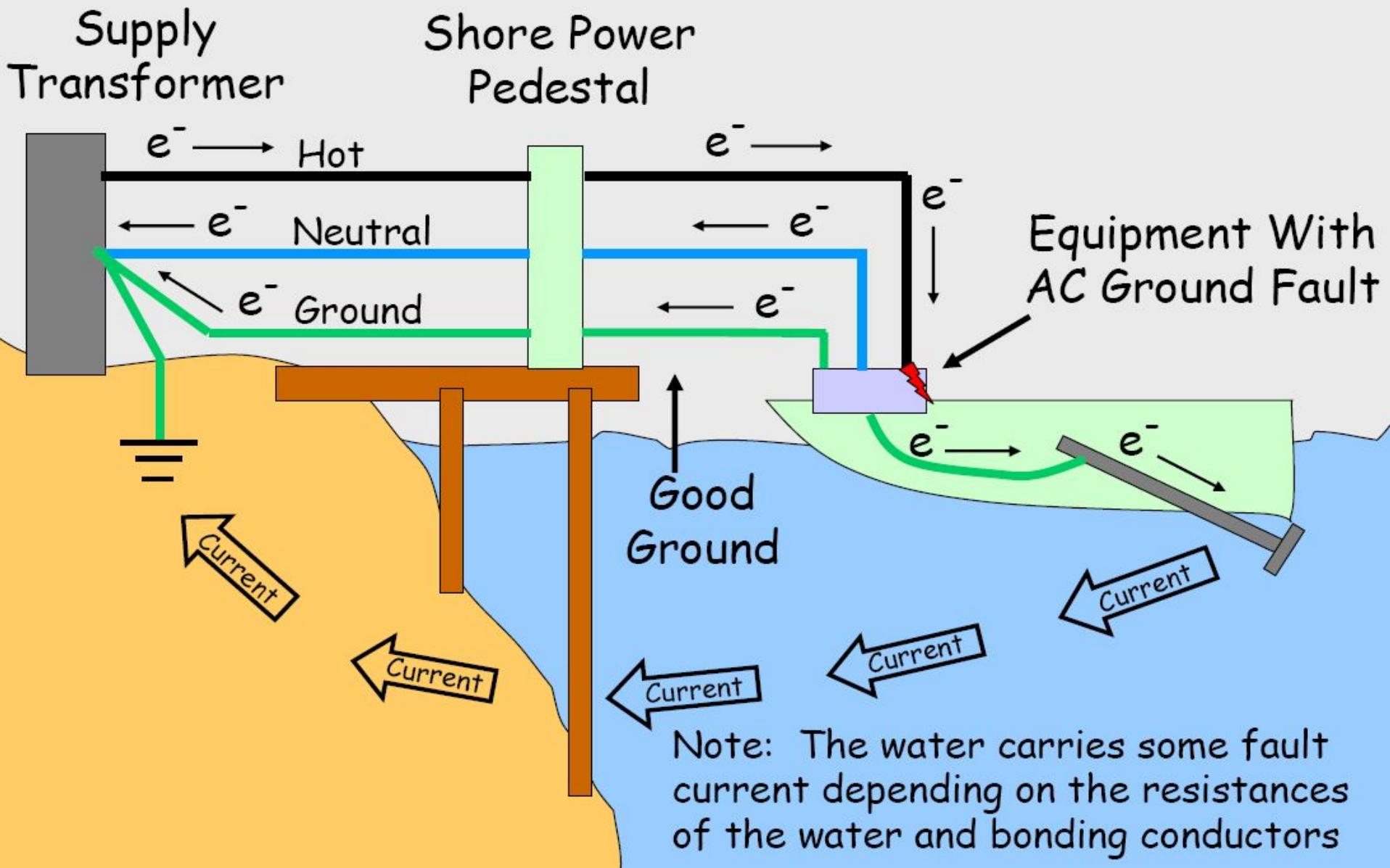
Harrods Creek, Lexington, KY—Ohio River. Two dogs jumped into the water from the owner's boat and were observed to be in great distress. The wife jumped in to help the dogs and was herself in immediate distress. The husband jumped in to save his wife—both drown. Rescuers felt strong electric shock sensations and could not approach the victims. A faulty light switch and missing ground on a nearby houseboat was determined to be the cause. Both dogs survived.

THE CAUSE

- ▶ The conditions necessary to create an in-the- water shock hazard apply to docks, boats, Irrigation pumps, fountains, and any place where you have AC and fresh water. There are two general electrical failures necessary:
- ▶ First, a lack of, or a failure in, the AC grounding/bonding system.
- ▶ Second, an electrical fault (i.e., a short circuit);

LOW CONDUCTIVITY WATER

- ▶ Due to low water conductivity, voltage gradients develop reaching out from the source. The human body salinity level is the same as ancient oceans. That means we are considerably more conductive than the fresh or brackish water. We become a conductor bridging the voltage gradients.
- ▶ 2 volts per foot is considered lethal.



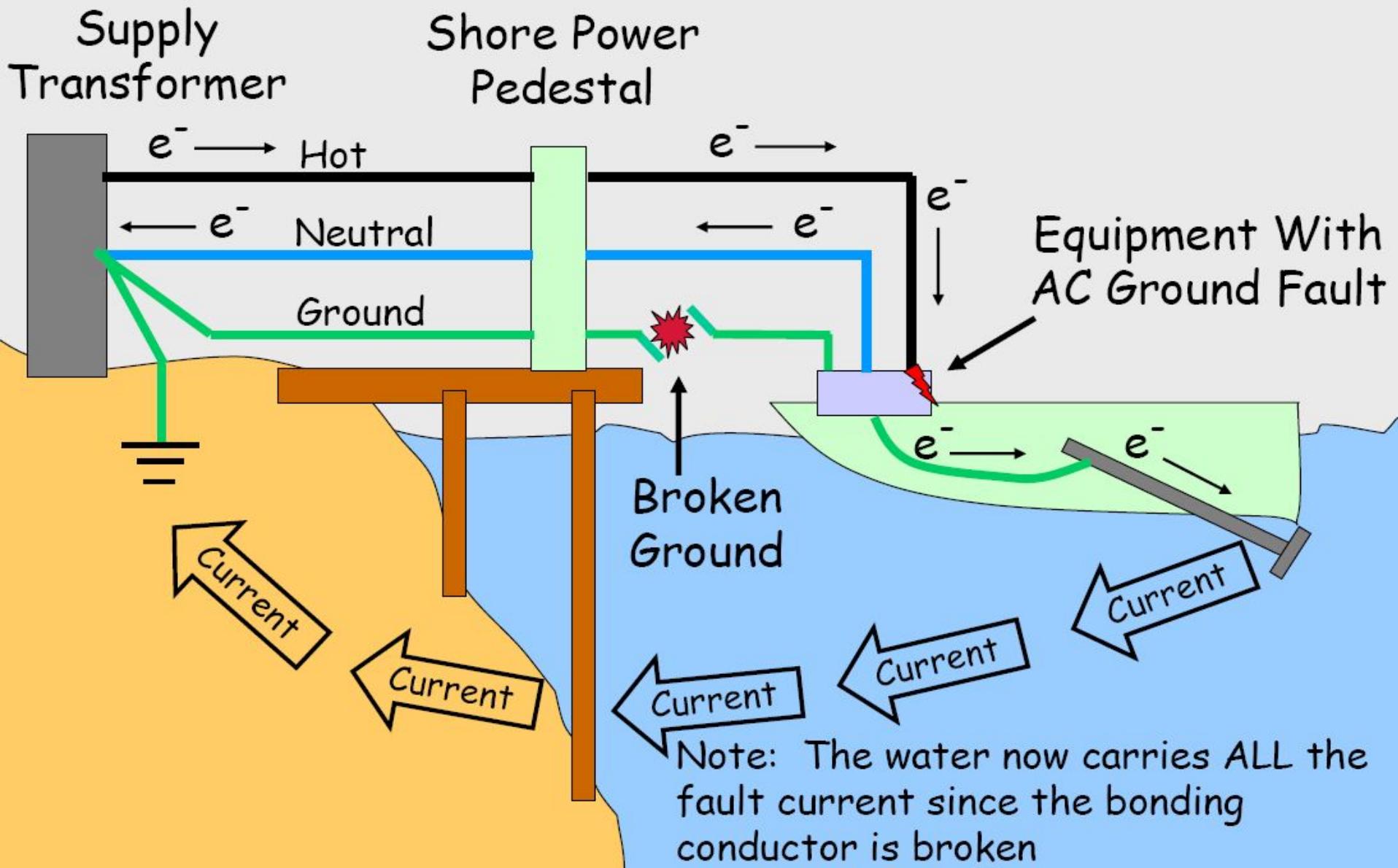


FIGURE 10 –TYPICAL INBOARD DC SYSTEM

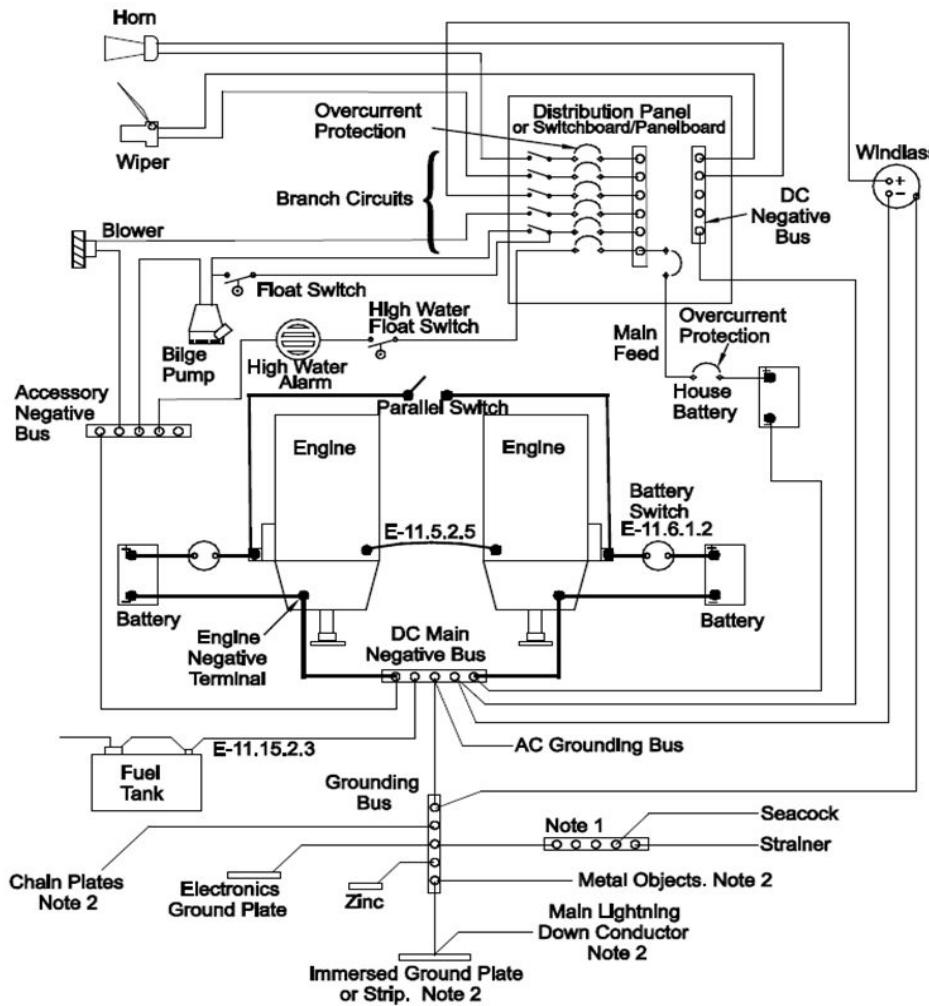
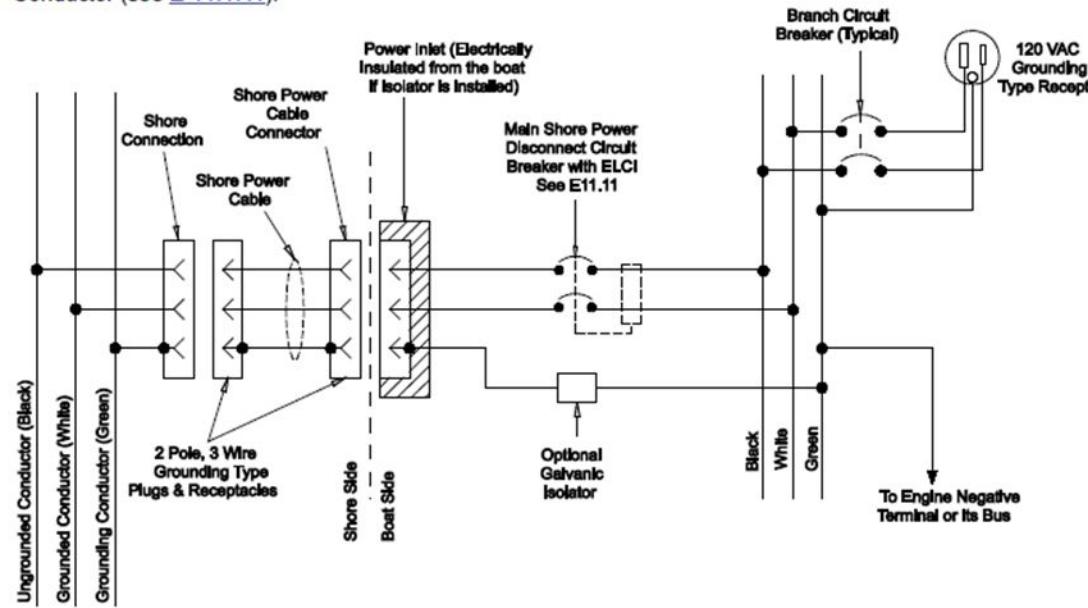
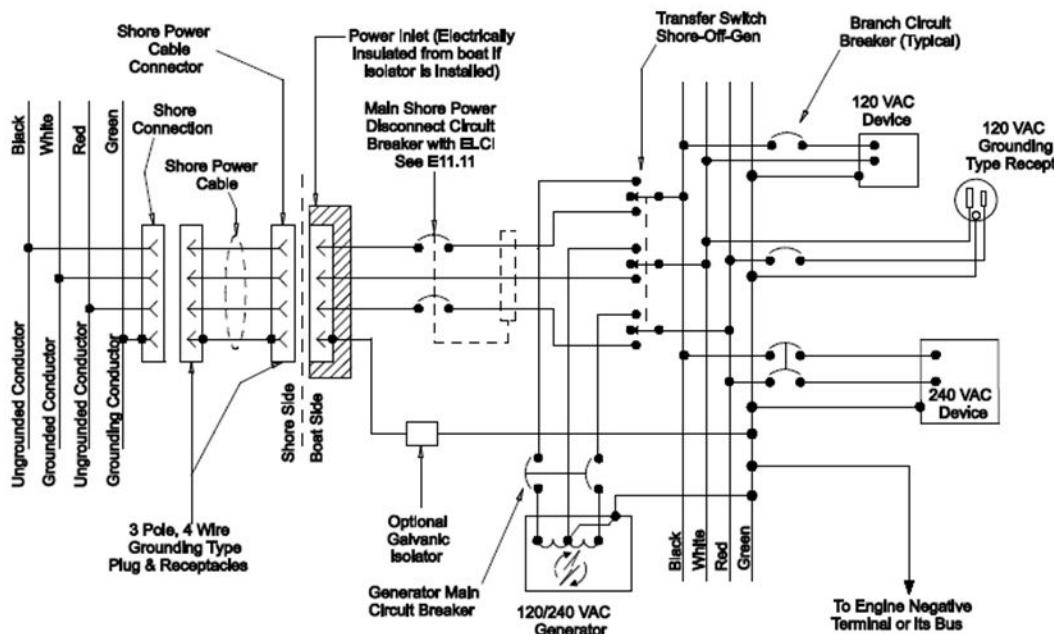


DIAGRAM 1 - Single Phase 120-Volt Systems with Shore-Grounded (White) Neutral Conductor and Grounding (Green) Conductor (see [E-11.17.1](#)).



NOTE: This diagram does not illustrate a complete system. Refer to appropriate text.

DIAGRAM 4 - Single Phase 120/240 Volt System with Shore Grounded (White) Neutral Conductor and Grounding (Green) Conductor (see [E-11.17.2](#)).

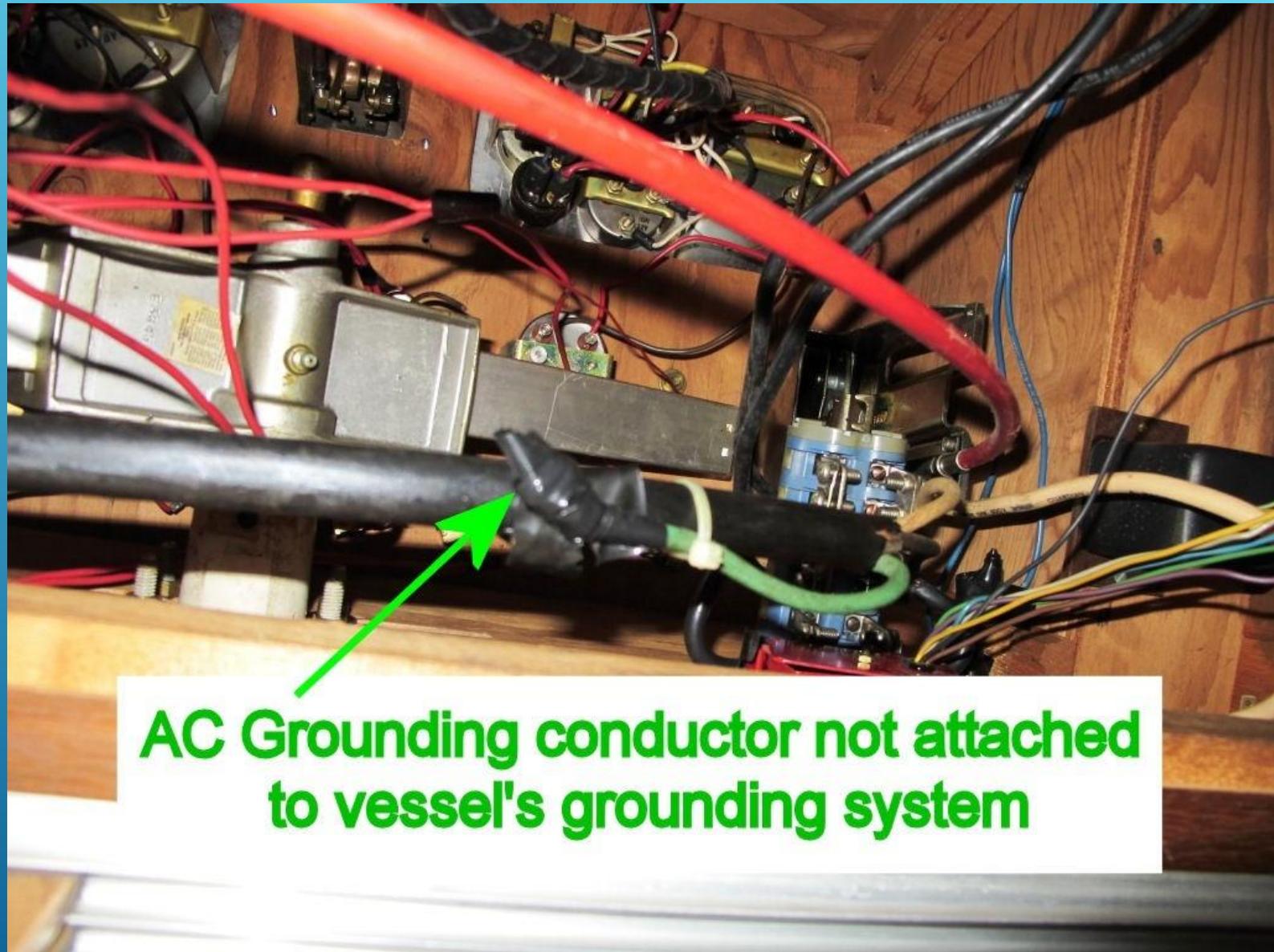


NOTE: This diagram does not illustrate a complete system. Refer to appropriate text.

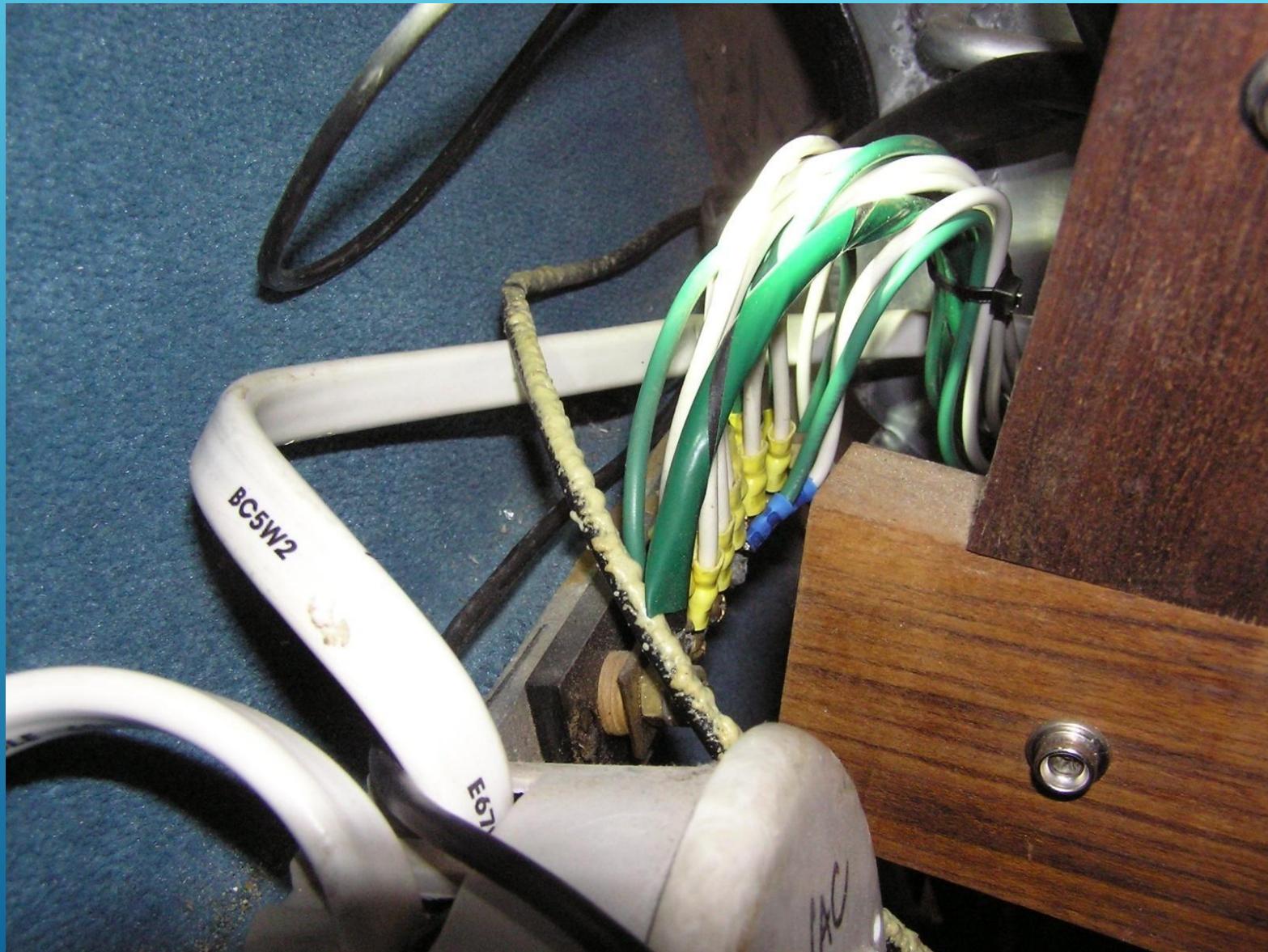
ONE CONSISTENT FAULT

- ▶ Lack of Safety Ground

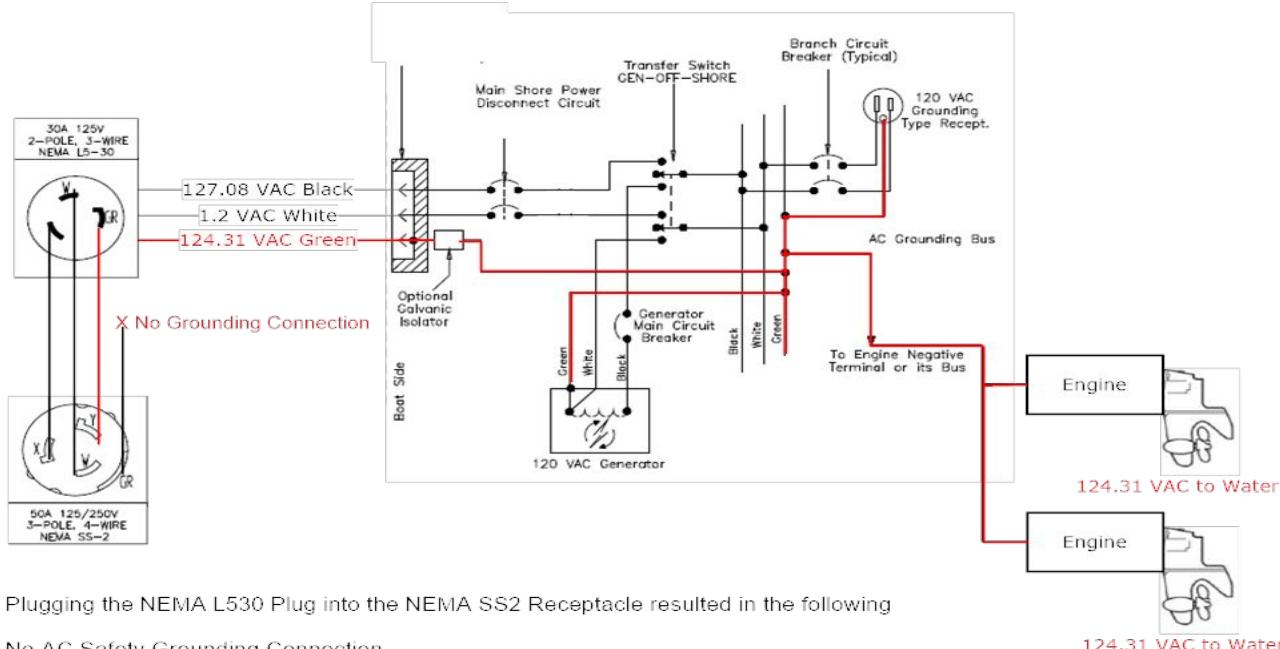




**AC Grounding conductor not attached
to vessel's grounding system**



Lake Powell Bullfrog Marina
2000 Rinker Fiesta Vee 340
Diagram 1



Plugging the NEMA L530 Plug into the NEMA SS2 Receptacle resulted in the following

No AC Safety Grounding Connection

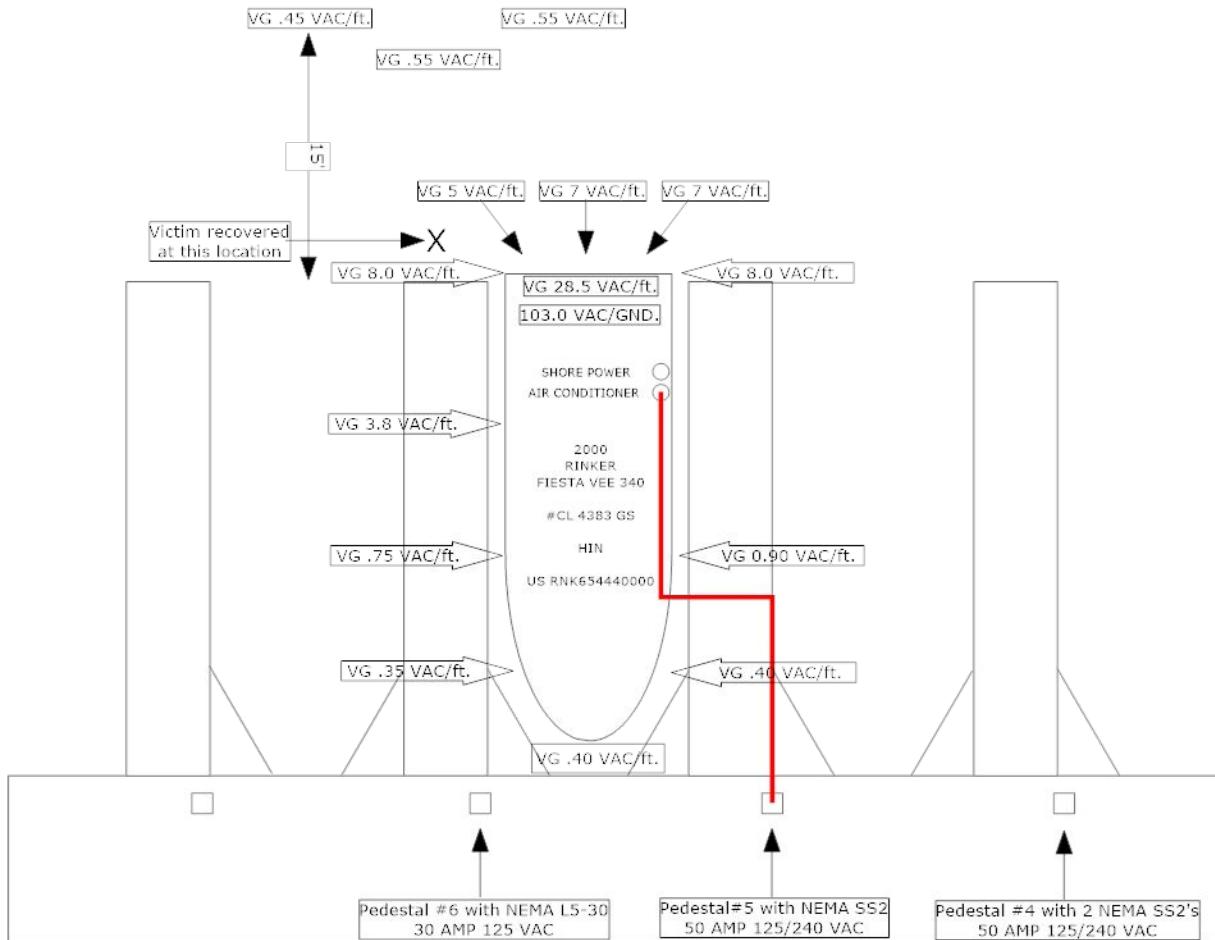
Marina X Connected to Ungrounded connection on L530

Marina Y Connected to Grounding connection on L530 Putting 124.31 VAC into Water

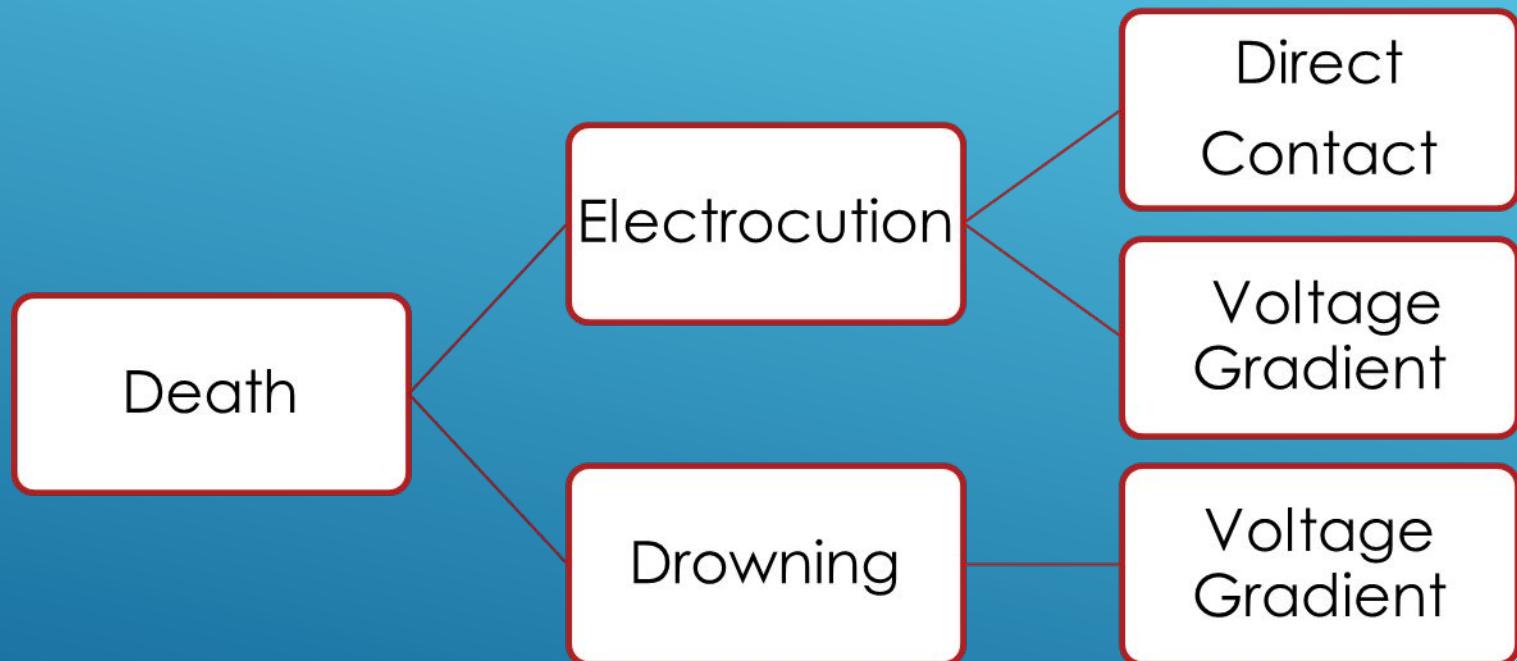
Marina Grounding Connected to Grounding on L530

124.31 VAC to Water

Lake Powell Bullfrog Marina
Voltage Gradient and Location Diagram



MECHANISMS OF MORTALITY FOR ESD



HOW FREQUENTLY DOES THIS OCCUR?

- ▶ How many unexplained drownings of healthy, vibrant people around boats and marinas have there been? The answer—many.
- ▶ How many of these unexplainable drownings might be attributable to something other than extreme fatigue, cramping, excessive alcohol use, etc.? The answer—probably many.
- ▶ The number of verifiable, in-water deaths, due to Electric Shock Drowning is, in all likelihood, just the tip of the iceberg.

RANDOM SAMPLING

- ▶ Random clamping of shore power cords in several fresh water marinas, in Portland area, found that approximately 13% of the boats clamped were leaking potentially lethal amounts of AC current into the water.

CASUALTIES & FATALITIES 2010-2014

- ▶ 2010
 - ▶ 3 Fatalities
 - ▶ 20 Casualties
- ▶ 2011
 - ▶ 2 Fatalities
 - ▶ 2 Casualties
- ▶ 2012
 - ▶ 12 Fatalities
 - ▶ 15 Casualties
- ▶ 2013
 - ▶ 9 Fatalities
 - ▶ 11 Casualties
- ▶ 2014
 - ▶ 3 Fatalities
 - ▶ 9 Casualties

FACTORS THAT DETERMINE SHOCK VALUE IN THE HUMAN BODY

- ▶ The Body's Average Resistance
(1500 Ohms Dry, 300 Ohms Wet) (OSHA Values)
- ▶ Voltage And Current
- ▶ Current Path
- ▶ Duration Of Current Flow
- ▶ Body Mass And Chemistry
- ▶ Male Or Female
- ▶ Body Orientation-- Important
- ▶ Cuts And Abrasions
- ▶ Water Conductivity

EFFECTS OF CURRENT ON HUMAN BODY

| Milliamps (mA) | Physical Result |
|----------------|--|
| 1-3 | <u>Perception</u> Tingling Sensations |
| 10-20 | <u>Can't Let Go</u> Loss Of Voluntary Muscle Control |
| 18-22 | <u>Can't Breathe</u> Paralysis Of Diaphragm And Chest Muscles |
| 50-65 | <u>Heart Fibrillation</u> Could Become Fatal Time Is A Critical Factor |
| 100+ | <u>Deadly</u> Death Can Occur Within A Very Few Seconds |
| 200+ | <u>Cardiac Immobilization</u> The Heart Muscle Is Instantly Immobilized |

TESTING FOR AC CURRENT

- ▶ Clamping shore power cords for current in the water.
- ▶ Readings of 1 amps or greater present a dangerous condition and immediate action should be taken.
- ▶ Readings less than 1 amps are still serious, should be considered a threat to someone in the water, and should be checked by an ABYC certified marine electrician.
- ▶ Remember: AC current must return to its source and it will take all paths to get there.

WHAT GOES IN MUST COME OUT

Clamp Meter Use:

- ▶ Current in the shore power cord goes into the boat on the cord's "hot" conductor, and comes out on either the cord's return "neutral", its "safety" return green wire, or both.
- ▶ Clamping the entire shore power cord tells whether or not the boat's AC system is putting current into the water.
- ▶ Here's Why: The in-bound magnetic field created on the AC "hot" conductor must equal the out-bound magnetic fields created on either, or both of the returning conductors. If the fields are equal, then there is no lost current and the clamp meter reading is zero.
- ▶ Any reading other than zero identifies the amount of current that is using the water as a return path.

HIOKI
3280-20
(RMS)

CLAMP ON METER

1038.











Do not have
on when
shore power
is on

Circuit



DANGER - Never turn off power to the load center when shore power is on

WARNING - Turn off power to the load center before performing maintenance or repair work. Failure to do so could result in serious injury or death.

F SINGLE R SINGLE F 2

Hunter SIDE LITE

BERKANE DI COMPANY



IS THIS A LETHAL BOAT?



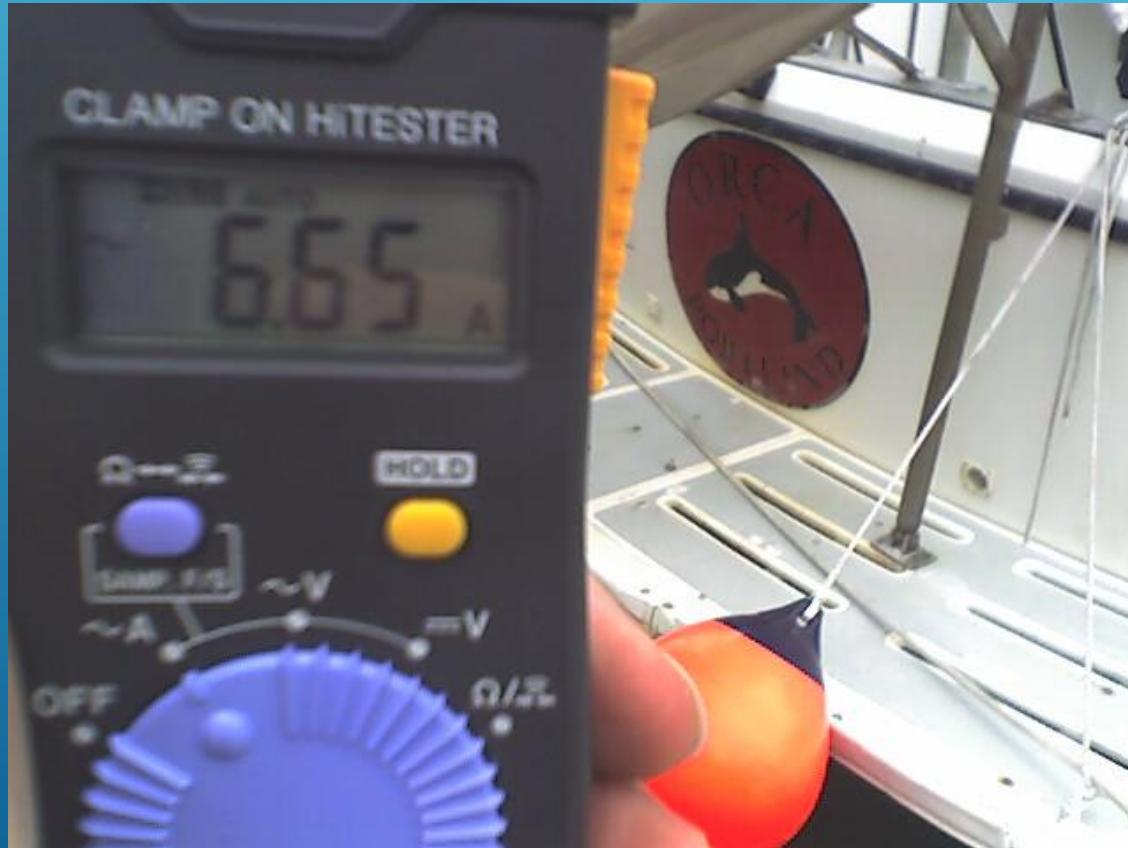
WHAT ABOUT THIS ONE?



EXTREMELY LETHAL IN FRESH WATER



THIS IS IN SALT WATER... IS THIS LETHAL?



- Clamp one, and then the other
- If you get a reading, clamp both together
- If you then still get a reading, you have a leak of that magnitude
- If you are unable to clamp both for some reason, record the two readings and subtract them; the result should be zero. If it is not, you have a leak of that magnitude

MULTIPLE SHORE CORDS?

- Possibility of two separate systems

TESTING FOR AC VOLTAGE

- ▶ The AC voltage can be easily tested and documented using a probe.
- ▶ This is accomplished by placing a meter, in line, between the water probe and the dock ground.
- ▶ Always test ground integrity.
- ▶ As the probe approaches the source, voltage will increase.
- ▶ Be sure that each AC component on-board, or on the dock, that cycles (i.e., sump pumps, battery chargers, water heaters, space heaters, etc.) cycles while the water is being probed.

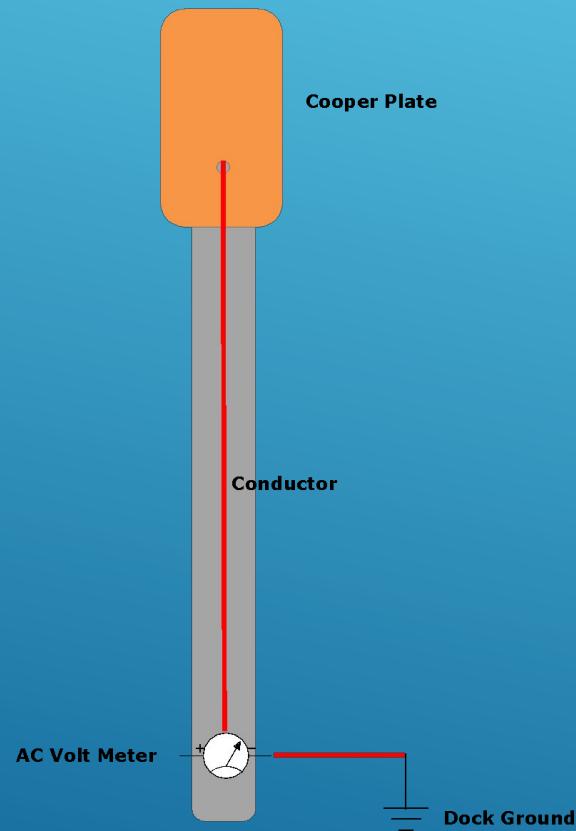
VERIFY YOUR GROUND



AC VOLTAGE PROBE



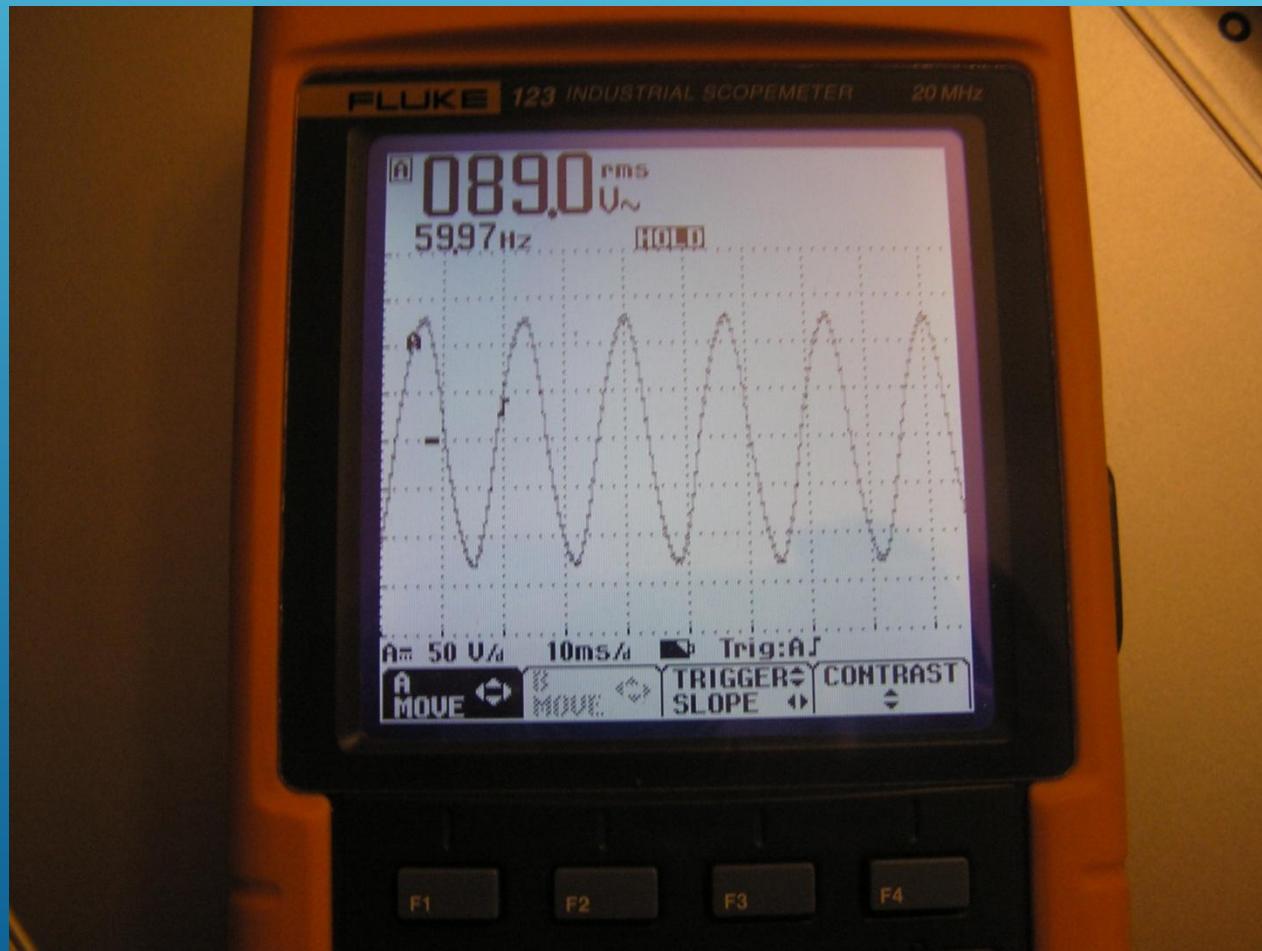
AC VOLTAGE PROBE



PROBING FOR VOLTAGE 89 VAC 1 FOOT FROM PROPELLER



OSCILLOSCOPE READING



EVERYTHING IS HOT! 24 VOLTS AC ON STANCHIONS



VOLTAGE GRADIENT DEFINED

The amount of voltage measured across two given points at a set distance apart.

For In-water Use:

- ▶ Measurement with a multi-meter set to AC volts;
- ▶ The closer and more parallel the probe is to the direction of the AC source, the greater the voltage gradient;
- ▶ Voltage gradients diminish as the probe moves away from the source.

Potentially lethal voltage gradient—two volts AC per foot. This voltage (2VAC/Ft.) will push 12 millamps of AC current through the body potentially inducing muscular paralysis.

Voltage Gradient Probe

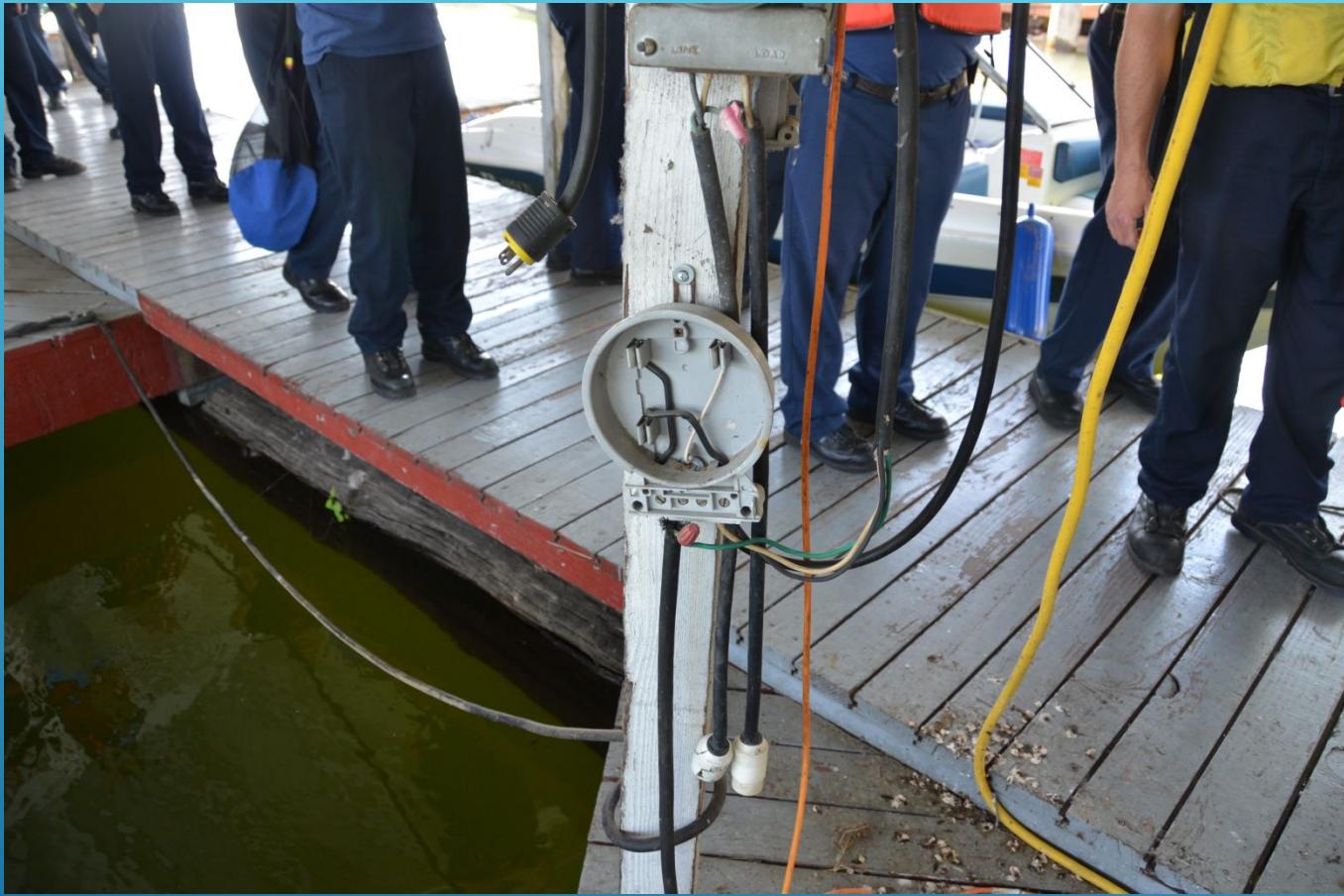


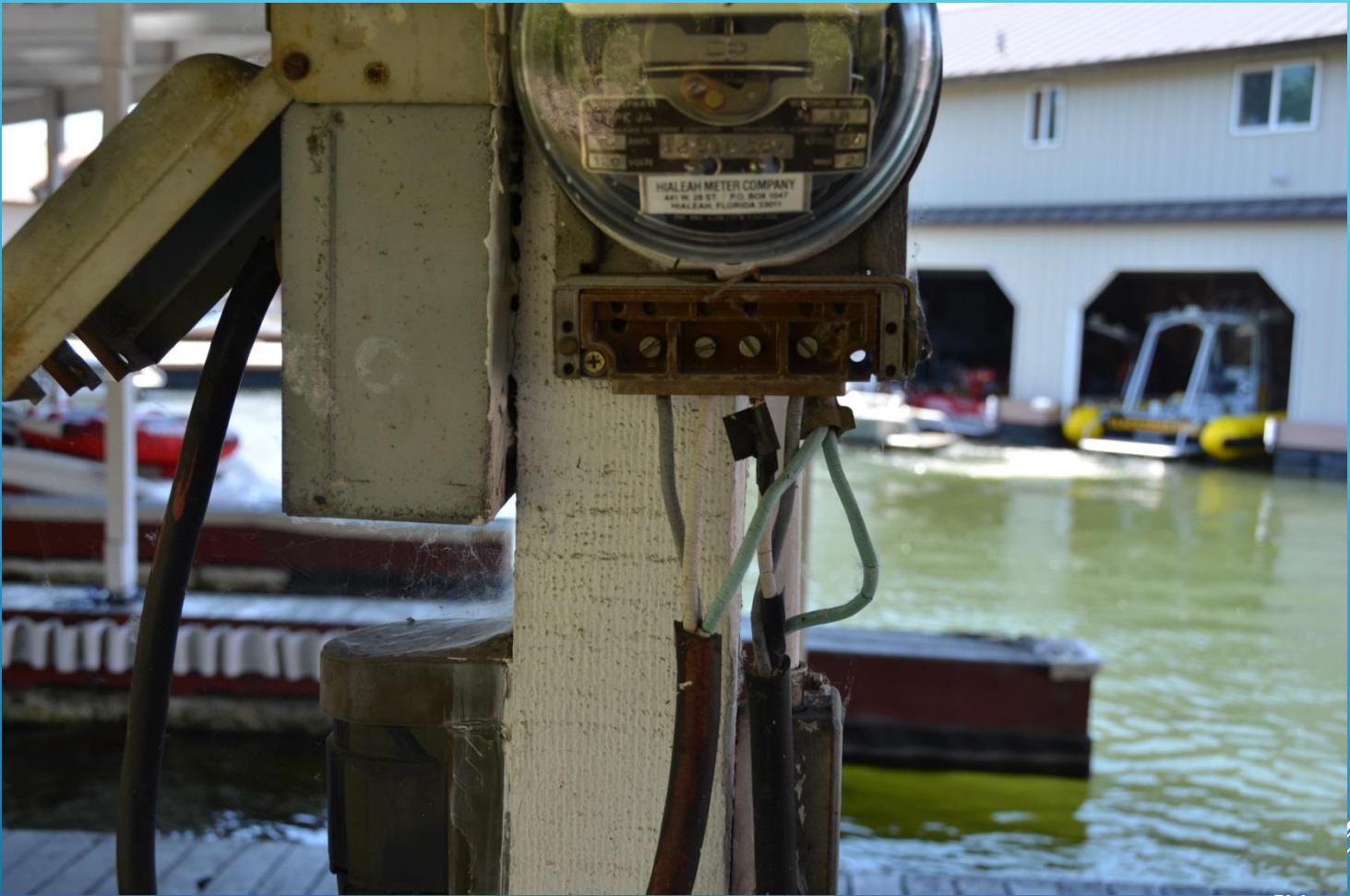
PREVENTION; DOCK SIDE

- NFPA 303
- NEC 555
 - NEC 555.3
- Correct Polarity
- Resistance on Grounding .25 ohms or Less
- Wire Integrity
- Testing and Inspections
- Ground Fault Protection on All Outlets









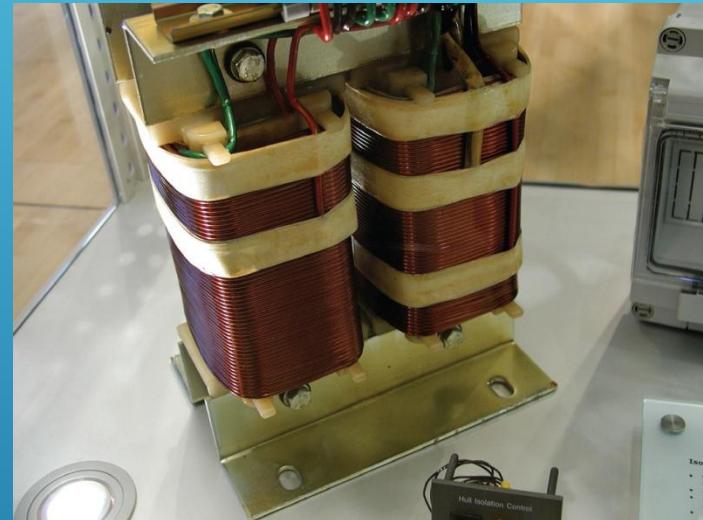




PREVENTION; BOAT SIDE

- ABYC Standards
- Polarity
- Resistance Bonding / Grounding less than 1 ohm
- Wire Integrity
- Separation of AC-DC Conductors
- AC safety ground/DC bonding connection
- Isolation Transformer
- ELCI

ISOLATION TRANSFORMER



30 AMP ELCI BREAKER



ELCI



POINTS TO REMEMBER

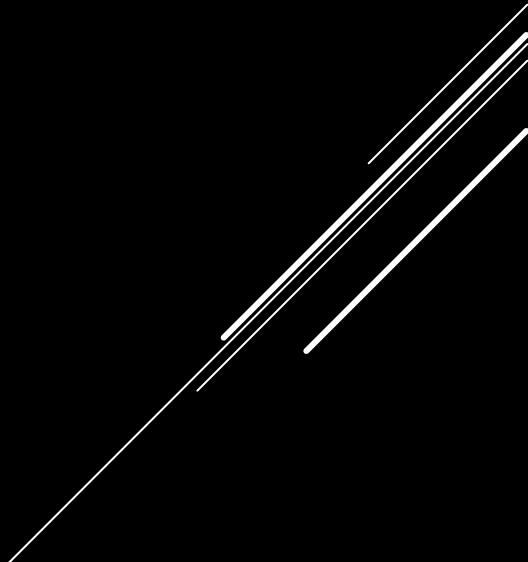
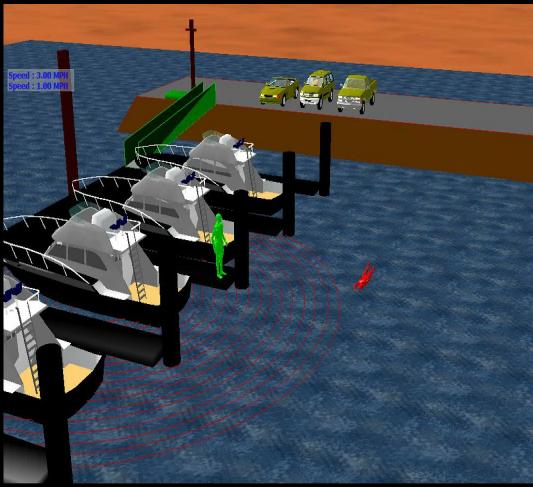
- ▶ For electrical safety in the marine environment both the on-board bonding system and the boats AC grounding system must be of low impedance (1.0 ohms or less).
- ▶ AC current will take all paths in returning to its source.
- ▶ Voltage gradients vary inversely to the surface area of the energized underwater metals.
- ▶ Lower water conductivity results in higher voltage gradients.
- ▶ It takes two faults to create a dangerous situation; an electrical fault to ground , and the lack of, or a break, in the AC grounding system.
- ▶ Seawater is electrically 100 times plus more conductive than fresh water.
- ▶ No post mortem evidence of AC involvement.



CHI 01

FIRST RESPONDER & DIVE TEAM CONSIDERATIONS

- ▶ Consider Your Own Safety First
- ▶ Turn Off ALL POWER to the Area and VERIFY
- ▶ Lock Out Power
- ▶ Listen To Any And All First Hand Accounts
- ▶ Pay Attention To Environmental Clues; Not Necessarily Present (Floating Fish, Birds, etc.)
- ▶ Secure Area, Including All Vessels, Within 100 ft. Of the Incident
- ▶ Follow All Protocols
- ▶ Back Out if Experiencing Tingling or Shock



TOOLS WE USE.

- ▶ AC clamp meter with large jaws that is accurate in the milliamp range. HIOKI 3280-20
- ▶ IDEAL® Suretest Circuit Analyzer 61-165
- ▶ Split Cords
- ▶ Voltage Probe
- ▶ Fluke 123 Portable Oscilloscope.

Electric Shock Drowning Prevention Association

Our Mission:

The electric shock drowning prevention association works diligently to prevent further loss of life and injury due to electric shock drowning and other water related electrocutions.

Prevention

- Public & Industry Awareness
- Legislation
- Standards
 - NFPA
 - NEC
 - ABYC

Education

- Presentations
- Hands-On training
- Articles
- Studies

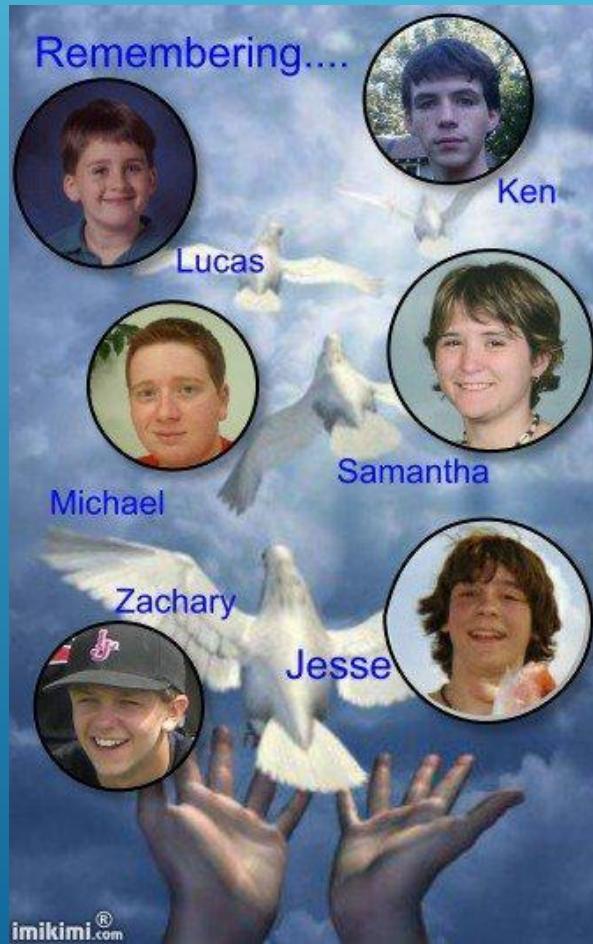
Technical Support

- Working with
 - Law enforcement
 - First Responders
 - Investigators
 - Boating public
 - Water-front owners
 - Marina Operators
 - Insurance Companies

Grief Support

- Join us on Facebook
- Get into contact with other families who have lost loved ones to ESD

ESD ON FACEBOOK



JOB SECURITY FOR FIRST RESPONDERS





Produced under a grant from the Sport Fish Restoration and
Boating Trust Fund, administered by the U.S. Coast Guard.

USCG FY2006 Grant
*In-Water Shock Hazard Mitigation
Strategies*
Final Report October 1, 2008



ABYC
Setting Standards for Safer Boating



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- ▶ Mitigation Study conducted by and additional research and documentation provided by:
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 - James Shafer, Harbor Marine Consultants kp2r@bellsouth.net
 - Kevin Ritz, Cruising Essentials, LLC kevin@cruisingessentials.com

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Thank You

Questions?

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