RESEARCH BRIEF | 2026

DockSafe

Electric Shock Drowning: The Hidden Crisis in America's Freshwater Marinas

Prevalence, Liability, Regulation, and the Physics of a Preventable Death

10 mA
Minimum current to paralyze a swimmer in freshwater

~26%
Of boats in a random sample leaked lethal current

100+
Documented incidents since the mid-1980s

10 mA = 1/50th the current of a 60-watt bulb. Two AA batteries (3 V) is all it takes to paralyze a swimmer.

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This brief synthesizes publicly available research and incident data. Sources: ESDPA, NFPA, ABYC, NEC, USCG, and published legal records.

The Scale of the Problem

Electric shock drowning kills an estimated 2–10 people per year in documented U.S. cases — but the true toll is almost certainly far higher. Documented cases represent only a fraction of what is actually occurring.

Since the mid-1980s, roughly 100 incidents have been confirmed and catalogued by the Electric Shock Drowning Prevention Association (ESDPA). The most authoritative dataset is maintained by Captain David Rifkin (USN, Ret.) and the late James Shafer of Quality Marine Services — last revised August 15, 2025 — tracking known fatalities and near-misses in a 16-page document.

The count has grown steadily as awareness has increased: more than 50 deaths around 2012, 74 incidents by mid-2015, approximately 90 by 2017, and an estimated 100+ as of 2025. Many single incidents killed multiple victims — two children at Lake of the Ozarks on July 4, 2012; two boys at Cherokee Lake that same week; two women at Lake Tuscaloosa in 2017.

~100+	60–90+	2–10	0
Documented incidents since the mid-1980s	Estimated U.S. fatalities since 2000	Confirmed deaths per year	Federal tracking systems for ESD

Why the Count Understates the True Toll

Captain Rifkin has estimated the actual toll could be 100 times higher than documented cases. Five structural gaps in how ESD is recorded operate independently — any one of them alone would suppress the count. Together, they make the documented list a floor, not a true measure:

- **No post-mortem evidence** — water eliminates skin resistance, preventing burn marks. Autopsies classify victims as ordinary drownings with nothing to contradict that finding
- **No federal tracking system** — no agency collects ESD data. The only comprehensive list is maintained by a retired naval officer and a marine electrician, voluntarily
- **No medical billing code** — hospital records cannot be searched for ESD cases because the diagnosis does not exist in the coding system
- **No mandatory reporting** — marinas, utilities, and first responders have no legal obligation to report incidents as ESD-related
- **Faults disappear** — intermittent electrical faults often vanish before anyone can measure them, leaving no physical evidence at the scene

> ***A random survey of 50 boats across three Portland, Oregon freshwater marinas found 13 (26%) leaking potentially lethal electrical current. ABYC Vice President Ed Sherman has stated he has never found a marina in North America where he could not find at least one boat leaking potentially lethal electrical current.***

Where Incidents Concentrate

ESD is not randomly distributed. It clusters in predictable conditions — aging electrical infrastructure, high boat density, and freshwater. Inland reservoir lakes and river impoundments — the TVA system, Lake of the Ozarks, Lake Lanier, Cherokee Lake — account for a disproportionate share of documented incidents. These water bodies combine high recreational traffic, large marina complexes with aging shore power systems, and the freshwater conductivity conditions that make the human body the preferred current path.

Documented incidents span 30+ states, but Tennessee, Missouri, Florida, Indiana, Georgia, and Texas appear repeatedly in the ESDPA dataset. The common factors are consistent: freshwater, summer swimming season, shore power within range, and an electrical fault that predated the incident with no detection system in place to identify it.

Who the Victims Are

ESD victims are disproportionately children and young adults — strong swimmers in familiar waters, at known locations, often in the company of family. The victims at Cherokee Lake were 10 and 11 years old. The Lake of the Ozarks victims were children swimming at a family dock on a holiday weekend. Wesley Seeley was 23. Gabriel Gonzalez was 21. This pattern recurs throughout the case record: the victims are not inexperienced or careless. They are swimming in places they have swum before, near boats they know. The hazard is invisible to them because it is invisible to every device on the dock.

The Seasonal Concentration

ESD incidents concentrate heavily in the Memorial Day through Labor Day window — the peak period of swimming activity at marinas and docks. Electrical faults that exist year-round go undetected in the offseason because there are no swimmers to encounter the gradient. The same conditions that have been present all winter become lethal the first weekend a child enters the water. This seasonal pattern underscores why annual or one-time electrical inspections are insufficient — a fault can develop or worsen between inspection cycles, and there is no way to know without measuring the water directly.

Why Freshwater Is Uniquely Lethal

ESD occurs almost exclusively in freshwater because of a fundamental difference in conductivity. Saltwater is 50 to 1,000 times more conductive than freshwater, and the human body's conductivity falls between the two — but much closer to saltwater. In freshwater, the body becomes the preferred path for electrical current. In saltwater, current flows around the body.

	SALTWATER	FRESHWATER
Conductivity	~5,000 mS/m (very high)	~0.5–50 mS/m (very low)
Human body by comparison	**Body conducts less than water → current bypasses body**	**Body conducts more than water → current flows through body**
ESD risk for swimmer	**Minimal — current prefers the water path**	**Severe — body is the preferred path**
Shore power fault effect	Current disperses quickly through high-conductivity medium	Voltage gradient persists over larger area and depth
Why it matters	**ESD is extremely rare in saltwater environments**	**Nearly all documented ESD fatalities occur in freshwater**

Figure. Why saltwater swimmers are largely safe while freshwater swimmers are not — the same electrical fault produces fundamentally different outcomes based on water conductivity.

What Is a Voltage Gradient?

A **voltage gradient** is the variation in electrical potential across a body of water. When a leakage source energizes the water near a dock, the voltage is highest close to the source and decreases with distance — much the way heat radiates from a fire, strongest at the center and fading outward. The gradient is the rate of that change across distance.

What matters for a swimmer is not the total voltage at any one point, but the **difference in voltage between the two ends of their body**. Current flows through the body when one part is at a higher potential than another — for example, the hands reaching toward the dock versus the feet trailing away from it. NFPA research has established 2 volts per foot as a danger threshold for this gradient. A swimmer does not need to touch any energized surface. They simply need to be in water where the gradient across their body length is sufficient to drive current through them.

The Lethality Threshold Is Shockingly Low

Ohm's Law is the governing principle: Current = Voltage ÷ Resistance ($I = V/R$). Current is what kills. Voltage is the pressure driving it. Resistance is what stands in the way. The human body's resistance is not fixed — it changes dramatically based on condition, and that is the entire problem.

Dry skin can have a resistance of 100,000 ohms or more. At that level, even 120V shore power only drives about 1.2 milliamps through the body — well below any dangerous threshold. The skin is doing its job as an insulator.

Immersion collapses that resistance to roughly 300 ohms. The math changes completely. The source voltage doesn't need to be 120V anymore — it doesn't even need to be close. At 300 ohms of body resistance, **3 volts is all it takes to drive 10 milliamps through a swimmer** (3 ÷ 300 = 0.010 amps). That is the paralysis threshold. Three volts. The kind of gradient that can exist in the water near a marina with multiple leaking boats — none of which have triggered any alarm.

> ***This is the core danger. It is not about shore power being 120 volts. It is about what happens to a human body when resistance collapses in water and even small voltage gradients become lethal. A swimmer can die from a source that would not flicker a light.***

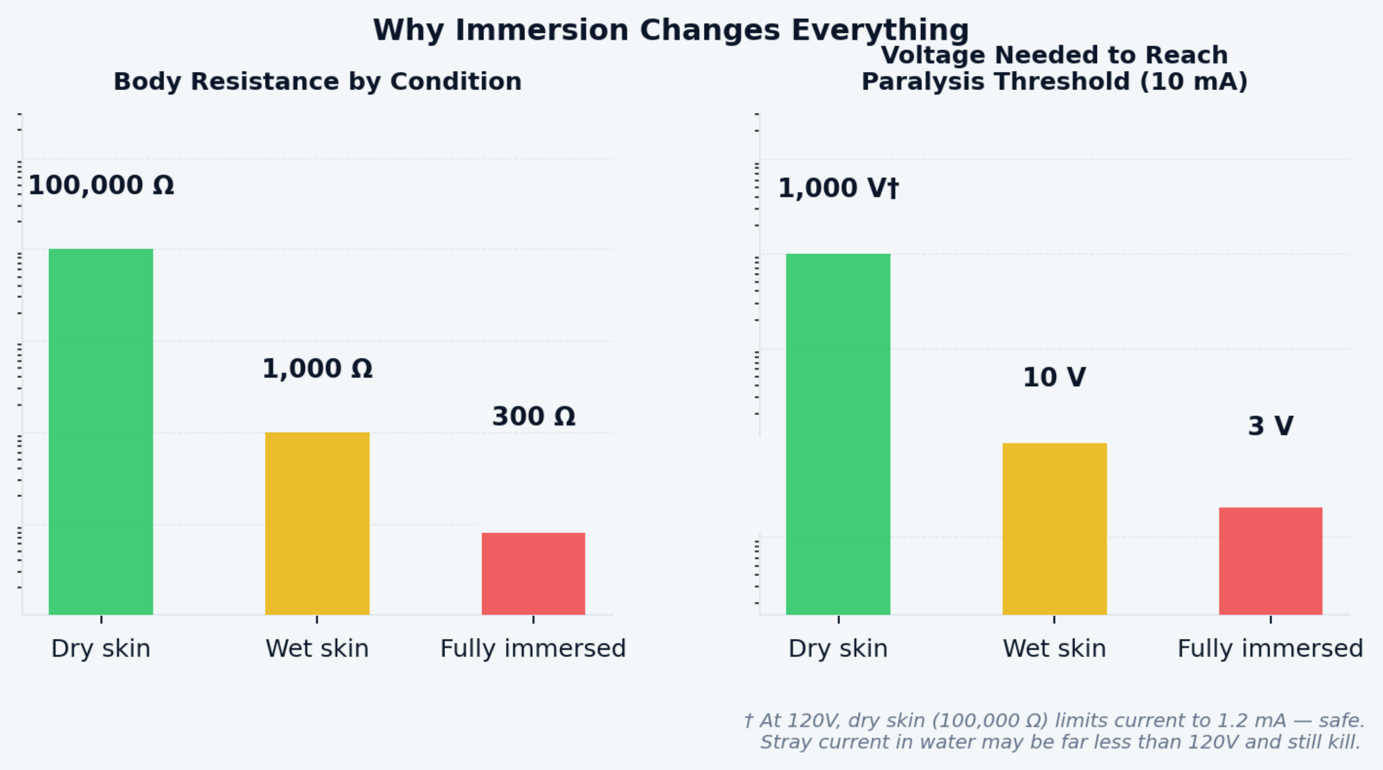

Figure 2. Left: body resistance drops dramatically from dry skin to full immersion. Right: the voltage required to drive a paralysis-level current at each condition — calculated directly from Ohm's Law ($V = I \times R$).

10 milliamps	Sufficient to cause muscular paralysis preventing swimming — one-fiftieth the current of a 60-watt light bulb.
~300 ohms	Immersed body resistance, versus 100,000 ohms for dry skin. Immersion reduces resistance 300x.
3 volts	Voltage required to drive 10 mA through an immersed body (Ohm's Law: 0.010A × 300Ω = 3V exactly). In-water body resistance varies 200–500Ω by individual, so the real-world range is roughly 2–5V — all well below any household source.
2 volts/foot	Electric field danger threshold established by NFPA field research.
30 mA	NFPA threshold established as sufficient to precipitate ESD (Fire Protection Research Foundation, 2017).
Unknown radius	The danger zone cannot be predicted without direct measurement. Field research documents incapacitation at 20+ feet; in lower-conductivity water the radius extends further. No safe assumed distance.

> ***A swimmer does not need to touch anything to be killed. Voltage gradients radiate outward from any energized underwater source. The swimmer may be far from any visible structure, in water that looks completely normal, and still be within a lethal voltage gradient.***

When Multiple Gradients Overlap

A critical scenario occurs when multiple leakage sources are present simultaneously. Voltage gradients do not cancel — they compound. In a working marina with six boats each producing a modest 5 mA leak per boat, the combined field in the water may reach 30 mA or more. Crucially, no individual circuit ever trips — each boat reads normal at the pedestal. The hazard accumulates in the water column entirely outside what any panel device monitors.

AC, DC, and the Mixed-Current Hazard

ESD is primarily associated with alternating current (AC) from shore power systems. DC current — from solar panels, battery chargers, electric outboard motors, and inverter systems — presents its own danger that is frequently overlooked. While AC protection devices cannot detect DC at any level, DC current at sufficient magnitude causes muscle tetany and loss of swimming control.

When AC and DC currents are simultaneously present in the water column, the combined effect is significantly more dangerous than either alone. As solar arrays, battery storage, and electric vessel systems become more common at marinas, mixed-current conditions will become increasingly prevalent.

Why These Physics Matter for Marina Operators

The physics described in this section are not abstract. They translate directly into operational reality at any working marina. A boat owner who plugs into shore power with a degraded battery charger is not aware their boat is leaking DC current into the water. A marina operator with fully code-compliant pedestals has no installed device that will tell them. The water itself is carrying a hazard that neither party can see, and that none of the equipment on the dock is designed to detect.

The resistance collapse that makes freshwater so dangerous is not something that can be engineered around at the swimmer level. A life jacket does not help. Swim ability does not help. Familiarity with the water does not help. The victims in the ESDPA case record are almost uniformly strong, experienced swimmers who had no warning and no ability to self-rescue once paralysis began. ESD incapacitates the very muscles needed to survive.

The gradient that kills can exist for weeks or months before a swimmer encounters it. It may intensify on a busy summer weekend when more boats are plugged in and more DC sources are running. It requires no single catastrophic failure — only the normal operating condition of a marina with aging boats and standard electrical wear. The following section catalogs the specific sources that put current in the water and why each one evades the protection systems currently in place.

Common Sources of Marina Leakage Current

Understanding what actually puts current in the water is essential context for understanding why panel-level protection alone leaves significant gaps. In the 'Detected by Panel?' column: **Only partial** = only detected above the 30 mA trip threshold; **No — DC source** = panel protection is AC-only and cannot detect this at any level.

Source	Typical Leakage	Detected by Panel?	Why It Matters
Electric water heater (degraded element)	10–80 mA	**Only partial**	One of the most common ESD sources. Element insulation degrades in the marine environment, often intermittently. Can leak well past the 30 mA threshold and still go undetected if faulting through a path not monitored by the panel.
2-wire battery charger (no isolation xfmr)	2–20 mA DC	**No — DC source**	Very common on older boats. Without an isolation transformer, the DC charging circuit has a path into the water through the bonding system. AC panel devices cannot detect DC at any level.
Faulty N-G bond on boat	5–60 mA	**No — bypasses circuit path**	An improper neutral-to-ground bond reroutes return current through the water. The more appliances running, the more current leaks. This bypasses the circuit path that ELCI monitors.
Shore power pedestal (corroded/loose)	2–30 mA	**Only partial**	Pedestal wiring corrosion increases over time in humid dock environments. Can leak 5–25 mA indefinitely — only trips ELCI at the 30 mA threshold.
Solar panel grounding fault	3–18 mA DC	**No — DC source**	Degraded insulation or improper grounding creates a continuous DC leakage path. Completely invisible to shore power monitoring. Increasingly common as marinas and liveaboards add solar.
Electric outboard / trolling motor	5–25 mA DC	**No — DC source**	Electric motors create leakage through the drive shaft and propeller during operation. The propeller becomes an energized surface in the water.
Liveaboard inverter / charger system	5–40 mA mixed	**No — DC source**	Generates both AC output and DC input leakage simultaneously. The AC output runs on a separate circuit from shore power and does not pass through the pedestal ELCI.
Multiple sources compounding	Each boat <30 mA	**No circuit ever trips**	The most common dangerous scenario. Each boat's individual leakage stays below every alarm threshold — no pedestal, ELCI, or GFCI trips. But voltage gradients from all sources combine in the water column. A swimmer enters a combined field that no device has registered.

Why an ELCI That Has Never Tripped Is Not Reassurance

An ELCI monitors a single AC shore power circuit and trips when leakage on that circuit exceeds 30 mA. It provides no information about: DC leakage from any source on any boat; AC leakage below 30 mA on the monitored circuit; leakage originating from other boats whose current accumulates in the water column; or the combined voltage gradient in the water — which is the actual hazard a swimmer encounters.

> ***An ELCI is a circuit breaker with a low trip threshold. It protects the circuit. It does not measure what is in the water. Those are fundamentally different things, and the gap between them is where ESD incidents occur.***

What a Complete Electrical Safety Picture Requires

A marina with fully code-compliant electrical infrastructure — ELCI on every pedestal, GFCI on every outlet, wiring inspected and up to standard — has addressed the shore power circuit. That is meaningful and necessary. It is not sufficient.

Code compliance addresses the known, single-source fault path: one boat, one circuit, one pedestal. The sources in the table above illustrate what exists alongside that path. DC faults from battery chargers and solar panels have no circuit-level detection mechanism at all. N-G bond faults bypass the circuit path that ELCI monitors entirely. And no code-compliant device on any pedestal sees the aggregate field that accumulates in the water when multiple sub-threshold sources are present simultaneously.

The practical implication is straightforward: the only way to know what is actually in the water is to measure the water. Not the circuit — the water. A marina can have every required device in place and still have a dangerous gradient between its boats that no installed equipment will ever detect or report.

> ***The sources in the table above are not edge cases or rare failure modes. They are the normal operating condition of a working marina. The ABYC finding — that no marina in North America has been found free of at least one leaking boat — means the compounding scenario is not a theoretical risk. It is the baseline.***

The Detection Gap

The single most important concept for understanding why ESD persists despite decades of code development is the detection gap — the range of current levels that are dangerous in water but invisible to every panel-level protection system currently in use.

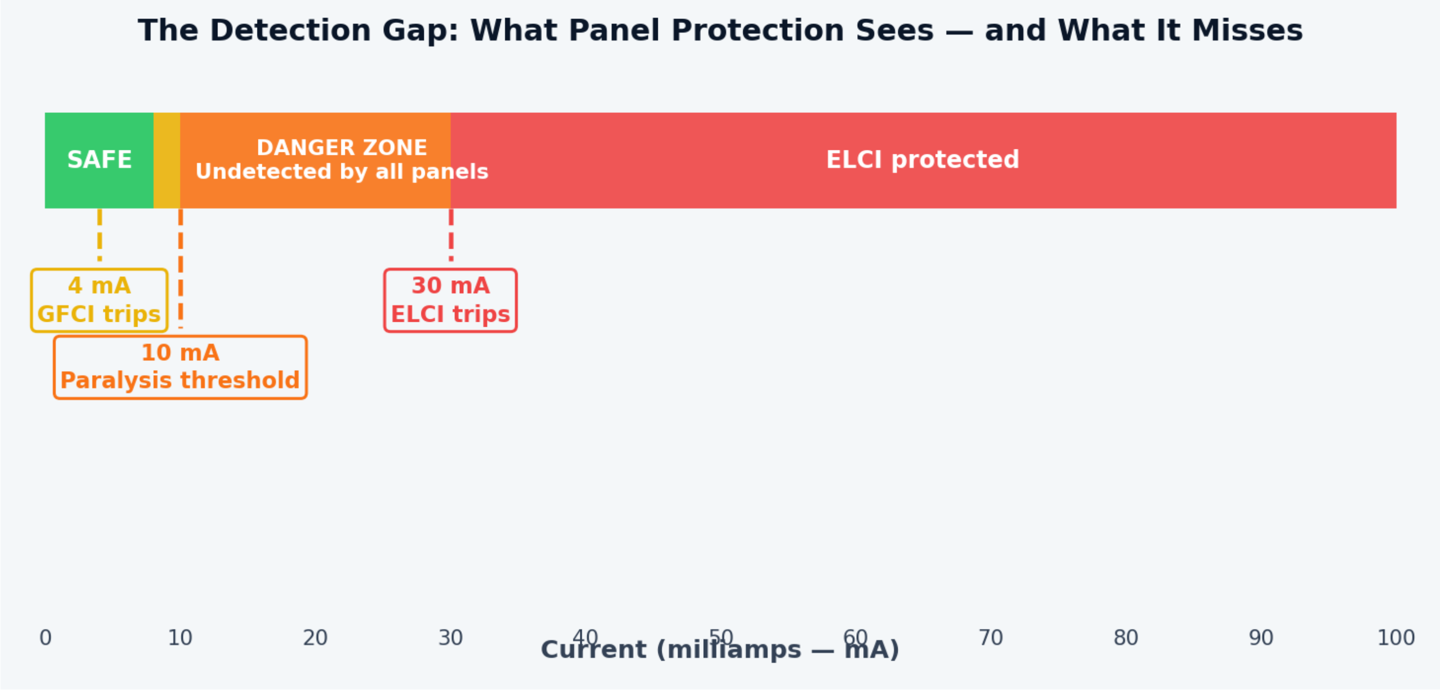

Figure 3. The current spectrum from safe to lethal. The orange danger zone — between 10 mA and 30 mA — is where most chronic marina leakage lives. No panel device detects anything in this zone. DC sources are not on this scale at all.

How Compounding Works — and Why It's Invisible

Picture a marina with four boats plugged into shore power on a summer weekend. Boat A has a degraded battery charger leaking 8 mA. Boat B has a corroded pedestal connection leaking 7 mA. Boat C has a solar panel with a grounding fault leaking 6 mA of DC current. Boat D has an aging water heater leaking 5 mA. Every single one of those boats is below every alarm threshold. No GFCI trips. No ELCI trips. No warning light. Nothing.

But voltage gradients in water do not stay contained to one boat's slip. They radiate outward and overlap. A swimmer between those four boats is not encountering 8 mA. They are encountering a combined field that may total 26 mA or more — well past the paralysis threshold — and not a single panel on the entire dock has registered anything unusual.

What If the Combined Field Exceeds 30 mA?

This is the critical question — and the answer reveals exactly why panel protection fails as a safety system for swimmers. An ELCI trips when the current on **its own circuit** exceeds 30 mA. It has no awareness of any other circuit, any other boat, or anything happening in the water.

If the combined field in the water reaches 50 mA, 80 mA, or 100 mA because eight boats are each contributing 8–12 mA, every single ELCI on every single pedestal still reads normal. Each one only sees its own boat's 8–12 mA contribution — well below its 30 mA trip point. The compounded hazard in the water is completely invisible to all of them simultaneously. There is no device on the dock that adds those numbers together. Only a sensor measuring the water column itself can see the aggregate field.

> ***This is not a gap in the rules. It is a fundamental limitation of the technology. Circuit protection was designed to protect circuits. It was never designed to measure what accumulates between boats in open water — and no amount of ELCI compliance closes that gap.***

The DC source on Boat C compounds this further. Because it is DC, the shore power panel cannot detect it at any level — it is contributing to the water column hazard from a completely separate blind spot that AC panel protection was never designed to address.

> ***The water is the accumulator. Individual circuits each read normal. The hazard exists only in the aggregate field between the boats — and the only instrument that can reveal it is a sensor in the water itself.***

The Liability Landscape

ESD litigation has produced outcomes ranging from $0 — dismissed under governmental immunity — to multi-million dollar verdicts. The case record reveals the interplay between negligence, immunity, the duty to warn, and the consequences of prior knowledge.

Seeley/Gann v. Libra Electric (Oklahoma, 2021)	$8.5M jury verdict — the largest publicly reported ESD award. Wesley Seeley, 23, died and Brandon Gann was left with catastrophic injuries at the Bricktown Canal. Oklahoma City settled separately for $344,650. A jury found electrical contractor Libra Electric had acted with reckless disregard and was 75% responsible — having failed to alert the city to dangerous conditions including the complete absence of GFCI protection.
Anderson v. Ameren Missouri (Missouri Supreme Court, 2015)	Two children died at Lake of the Ozarks on July 4, 2012. The Missouri Supreme Court ruled 5–2 that Ameren Missouri was immune under the Recreational Use Act, holding that dock permit fees were not primarily commercial in purpose. This precedent effectively shields the utility from liability for dock electrocutions despite its regulatory authority over dock construction.
Winstead/Lynam v. German Creek Marina (Tennessee, 2013)	Two $3 million lawsuits filed following the deaths of Noah Dean Winstead and Nate Lynam at Cherokee Lake on July 4, 2012. Settled confidentially. These deaths directly prompted Tennessee's Public Chapter 923 — the only comprehensive state ESD law in the country.
Gonzalez v. Marina Shores (Indiana, 2025 — pending)	Punitive damages sought because the marina allegedly failed to act on a prior electrocution incident four days before Gabriel Gonzalez, 21, was killed. Once a marina operator has documented exposure to knowledge about ESD risk, failure to act removes the defense of ignorance and opens the door to punitive damages beyond compensatory awards.

Legal Barriers and the Shifting Landscape

Two structural defenses have shielded defendants in the most significant ESD cases. Governmental immunity bars recovery against public marina operators in most states regardless of the degree of negligence. Recreational use statutes have protected utilities even when they hold direct regulatory authority over the conditions that caused the death.

The Gonzalez case signals a shift. As awareness of ESD grows throughout the marina industry, the defense that an operator had no prior knowledge of the risk becomes harder to sustain. The practical defense is a documented record of monitoring, inspection, and corrective action.

The Insurance Industry Response

No aggregate industry-wide data on total ESD insurance payouts exists in the public domain. However, the pattern from individual cases is clear, and major marine insurers have responded accordingly.

Chubb, Great American Insurance Group, Merrimac Marine, Cincinnati Insurance, and Global Marine Insurance have all issued formal advisories on ESD prevention. Global Marine stated plainly in 2014 that a multi-million dollar judgment could financially ruin a city or company. ABYC compliance has become effectively mandatory for coverage, and GFCI/ELCI installation is now commonly required following insurance surveys.

> ***Merrimac Marine Insurance has warned in published guidance that even marina insurance protection may not be enough in the face of an injury or wrongful death caused by electricity. Having insurance is not the same as being protected.***

Property Damage: Stray Current Corrosion

Beyond human safety, stray voltage causes severe property damage that creates additional liability exposure — and this damage affects both vessels and the marina's own infrastructure.

DC stray current corrosion can occur at 100 times the rate of galvanic corrosion, destroying hulls, propellers, propeller shafts, and through-hull fittings in what Professional BoatBuilder describes as a matter of days or even hours. Individual vessels can suffer thousands of dollars in damage, and marina conditions affect multiple vessels simultaneously when boats share shore power ground connections.

The marina's own infrastructure is equally at risk. Wire braid dock cables, metal spuds and pile guides, steel dock frames, underwater hardware, and submerged structural components are all subject to accelerated electrolytic corrosion when stray current is present in the water column. This corrosion is the marina's own property loss — not a boat owner's problem — and in a marina with persistent leakage it can silently degrade dock structural integrity over months and years. The same conditions that put swimmers at risk are actively consuming the dock itself.

This property damage dimension matters because it creates a visible, measurable consequence of the same electrical conditions that create ESD risk. Accelerated corrosion on dock hardware and boats in affected slips often appears before any human safety incident — making recurring water column measurement an early warning system for both property damage and swimmer safety.

Protection Device Reference: What Each Device Does — and Doesn't Do

Marina operators and insurance reviewers frequently cite GFCI or ELCI compliance as evidence of due diligence. The table below clarifies what each device actually monitors, where it is installed, and — critically — what hazard category it cannot address. The 'Cannot Detect' column (highlighted) is where ESD incidents occur.

Device	Trips At	Protects Against	Cannot Detect
GFCI (Ground Fault Circuit Interrupter)	4–6 mA	Ground faults on a single 15A or 20A AC outlet or branch circuit. Trips fast enough to prevent electrocution on dry land. Standard in bathrooms, kitchens, outdoor outlets.	**Any current below ~4 mA. Any DC source at any level. Any fault on a different circuit. Voltage gradients in the water — it only monitors the circuit, not the water.**
ELCI (Equipment Leakage Circuit Interrupter)	30 mA	Ground fault leakage on a single shore power circuit — one pedestal, one boat. Required by NEC 555 on shore power receptacles. Trips at 30 mA on its own circuit only.	**Any leakage below 30 mA on its circuit. Any DC current at any level. Any leakage from other boats on other circuits. The combined field in the water from multiple sources — it has no awareness of any other circuit.**
GFPE (Ground Fault Protection of Equipment)	Typically 30–100 mA	Equipment protection on large commercial circuits (feeder-level). Designed to limit equipment damage from ground faults, not personnel protection. Used on large shore power feeders at the service panel level.	**Personnel-level hazards — its trip threshold is far above the 10 mA paralysis threshold. DC current. Any leakage below its trip threshold. Water column conditions.**
ELCI + Isolation Transformer	30 mA (AC only)	Reduces galvanic corrosion and breaks the direct AC fault path from the boat's AC system to the water via the bonding system. Better protection than ELCI alone for AC shore power faults.	**DC leakage from solar, battery chargers, or electric motors — an isolation transformer only addresses AC shore power faults. Compounded fields from neighboring boats. Voltage gradients in the water itself.**
Water Column Monitor (DockSafe)	Scheduled scanning	Directly measures voltage gradient in the water column — the actual field a swimmer would encounter. Detects AC and DC contributions simultaneously. Captures aggregate field data regardless of how many sources are present or which circuits they originate from.	**Nothing measured in the water column is outside its detection range. Scheduled water column scanning is the only method that addresses the gap left by all panel-level protection systems above.**

The Regulatory Landscape

The regulatory environment for ESD in the United States consists of voluntary standards, adopted-but-unenforced codes, and isolated state requirements — with one significant exception.

> ***Tennessee is the only state to have enacted comprehensive ESD-specific legislation. Every other state relies on voluntary adoption of NEC standards and NFPA 303, neither of which is self-enforcing.***

Tennessee: The Noah Dean and Nate Act (2014)

Public Chapter 923, signed by Governor Bill Haslam on June 4, 2014, was named for 10-year-old Noah Dean Winstead and 11-year-old Nate Lynam, who died swimming at Cherokee Lake on July 4, 2012. The law requires GFCI installation at all public docks and marinas, mandatory inspections by the State Fire Marshal's Office every five years, and warning signage within 100 yards of docks. Pennsylvania has had bipartisan legislation pending since June 2024 with 16+ co-sponsors that has not yet been enacted.

NFPA 303 and ABYC E-11

The 2021 edition of NFPA 303 requires vessel testing for AC ground faults at initial connection and prohibits vessels exceeding 30 mA ground-fault leakage from connecting. ABYC standard E-11 has required 30 mA ELCIs on new boats with shore power since 2012, though older boats remain grandfathered — meaning the majority of the current marina fleet was built before this requirement existed.

The Compliance Gap

Code requirements and actual conditions in the water are two different things. At Lake of the Ozarks — where multiple ESD fatalities have occurred — local fire districts found approximately 75% of docks failed to meet basic electrical safety standards when inspections were conducted. Of an estimated 20,000–25,000 docks on the lake, only about 20% met safety requirements at that time.

NEC Article 555: Fifteen Years of Tightening Standards

The National Electrical Code has progressively tightened marina electrical requirements since 2011. Each revision has moved toward more sensitive circuit-level protection, reflecting a recognition that the earlier 100 mA threshold was wholly insufficient. The 2023 edition adds two significant requirements taking effect January 1, 2026: Section 555.35(D) requires that any marina with four or more shore power receptacles must have a listed leakage current measurement device available and must use it to test each boat's leakage before allowing it to connect. Section 555.36 goes further — vessels that fail the test may be denied shore power entirely.

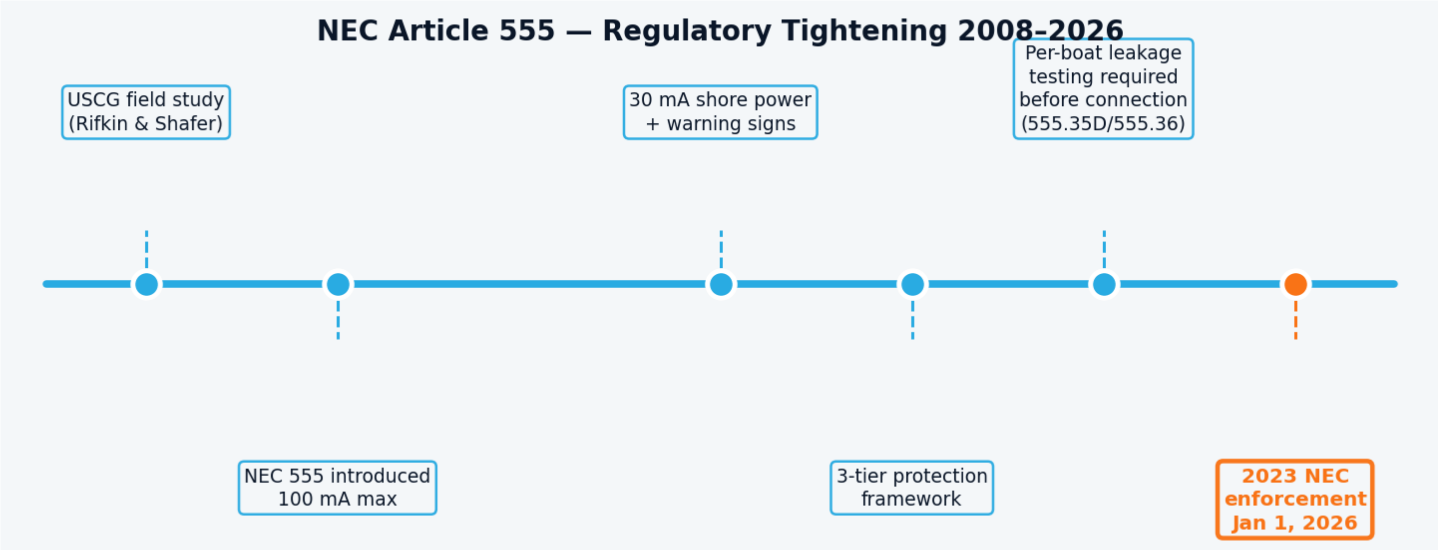

Figure 5. NEC Article 555 evolution from foundational field research in 2008 to the 2023 per-boat leakage testing requirement, effective January 1, 2026.

2011 NEC	First introduced ground-fault protection at marinas — 100 mA maximum on main overcurrent devices.
2017 NEC	Reduced to 30 mA for shore power receptacles. Added mandatory warning signage.
2020 NEC	Three-tier framework: 30 mA shore power, GFCI (4–6 mA) standard receptacles, 100 mA feeders.
2023 NEC	Requires a listed leakage measurement device be available and used to test each boat before connection (555.35D). Vessels failing the test may be denied shore power (555.36). Still circuit-level and per-boat only — not water column measurement. Effective January 1, 2026.

An Important Distinction

Per-boat leakage testing before connection is a meaningful improvement — it creates a mechanism to identify and exclude a vessel contributing excess leakage before it plugs in. However, it remains a point-in-time, per-boat, circuit-level test. It does not measure what is in the water column. A boat that passes its individual test at 28 mA, plugged in alongside five others each contributing similar amounts, can still produce a combined field in the water well past the paralysis threshold — and no test will flag it. DC sources, sub-threshold compounding, and voltage gradients in the water remain outside what this requirement addresses.

What the 2023 NEC Does Not Address

Per-boat testing at connection answers one question: is this specific vessel, right now, contributing more than 30 mA on its own circuit? That is a useful question. It is not the only question that matters. It does not answer what happens when six vessels each contributing 8 mA are plugged in simultaneously — each well below the test threshold, but collectively producing a combined field in the water that exceeds the paralysis threshold. It does not answer what happens if a fault develops after a boat passes its initial test. And it does not account for DC leakage at any level, since the test device and the ELCI both operate on AC current only.

The NEC is a construction and installation standard. It governs how equipment is installed and what protection devices must be present. It does not require — and was not designed to require — direct measurement of what is actually in the water column at any given time. That gap is not a failure of the code; it is simply outside what the code was built to address. Marinas that want to know what is in the water have to measure the water.

> ***The 2023 NEC per-boat testing requirement takes effect January 1, 2026. It is a step forward. It does not address the water column — DC leakage, compounding gradients from multiple boats, and sub-threshold AC sources remain undetected by any circuit-level or per-boat test, regardless of how carefully each individual vessel is screened.***

Conclusion

The research on electric shock drowning is consistent across more than three decades of incident documentation, field investigation, and study. The physics are well established. The hazard is real, recurring, and measurable. Marinas with no documented monitoring history have no baseline to point to when an incident occurs.

~26%	75%	1	2026
Boats in a random sample leaking lethal current	Docks at Lake of the Ozarks failing safety inspections	State with enacted ESD-specific legislation	Year NEC per-boat leakage testing takes effect

Three data points summarize where the industry stands. First, a random survey found one in four boats leaking potentially lethal current in marinas with no obvious signs of a problem. Second, 75% of docks at one of the highest-incident bodies of water in the country failed basic electrical inspections when someone finally checked. Third, the code trajectory — from 100 mA protection in 2011 to mandatory per-boat leakage testing in 2026 — reflects a recognition that trip-based protection alone is insufficient.

The 2023 NEC's addition of per-boat leakage testing is significant because it creates a mechanism to identify and bar a single bad actor before it plugs in. But per-boat testing and water column measurement are not the same thing. A boat test tells you what that vessel is contributing on its own circuit. Water column measurement tells you what is actually in the water — including DC leakage, compounding gradients from multiple vessels, and any source not captured by a single-vessel circuit test. Marinas that add direct water column measurement to their electrical safety practice will have a complete picture. Those that rely on per-boat testing alone will still have the same fundamental gaps.

> ***The fundamental gap in ESD prevention is not the absence of electrical protection devices. ELCI, GFCI, and per-boat leakage testing all exist and are increasingly required. The gap is the absence of direct, recurring measurement of what is in the water column itself — across all current sources, from all vessels, at all times. Circuit protection measures circuits. The hazard lives in the water. Those two things are not the same, and the difference between them is what the data in this brief documents.***

Sources & Further Reading

ESDPA Incident List — Capt. David Rifkin (USN, Ret.) & James Shafer, Quality Marine Services. electricshockdrowning.org (rev. Aug. 15, 2025).

NFPA Fire Protection Research Foundation — "Marina Risk Reduction" (2017).

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Great American Insurance Group — "Get Familiar with Electric Shock Drowning."

Cincinnati Insurance — 2016 advisory on low-voltage shock hazards at marinas.

Global Marine Insurance — 2014 ESD liability advisory.

Merrimac Marine Insurance — published ESD prevention guidance.

Professional BoatBuilder — DC stray current corrosion reporting.

CDC WISQARS — Unintentional drowning statistics.

DockSafe — Intelligent Stray Voltage Detection for Marina Operators

DockSafe is a sensor and software platform that enables marina operators and their maintenance staff to conduct recurring, GPS-tagged voltage scans of the full marina basin — detecting AC and DC leakage current from all sources simultaneously, including sources that circuit-level protection cannot see. Every scan builds a permanent documented record. Reports are generated automatically in PDF, CSV, Excel, and JSON formats. No permanent hardware installation. Operational from day one.

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