Impact of Fish Handling Practices on Spawning Striped Bass: Effects on Reproductive Success, Stress, and Survival

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Introduction

Striped bass (*Morone saxatilis*) represents one of the most economically and ecologically significant fish species along the Atlantic coast of the United States. Its anadromous life cycle, in which adults migrate from saltwater to freshwater rivers and estuaries to spawn, underpins the productivity of major fisheries and supports vital ecosystem services. However, striped bass populations, particularly in prominent spawning grounds like the Chesapeake Bay and Hudson River, have faced unprecedented pressures: overfishing, climate-driven habitat changes, and, crucially, the widespread adoption of catch-and-release fishing. While catch-and-release is promoted as a conservation tool, mounting evidence demonstrates that improper handling of spawning striped bass can lead to sublethal injuries, elevated physiological stress, reduced reproductive capacity, and, ultimately, significant post-release mortality[1,2].

This report synthesizes the latest peer-reviewed research, government technical documents, and fisheries guidance to assess how different fish handling practices impact the reproductive success, physiological stress, and survival of spawning striped bass. It consolidates findings from laboratory and field studies conducted in the United States, with a priority on recent and regionally relevant sources. Special attention is given to the mechanisms behind handling-induced harm, physiological responses revealed by stress markers, implications for population dynamics, and the development of evidence-based best practices to minimize negative outcomes during this vulnerable phase of the striped bass life cycle.

Overview of Fish Handling Practices During Striped Bass Spawning

Handling practices for spawning striped bass vary widely depending on the fishery context (recreational vs. research, at rivers vs. estuaries), regulatory requirements, and angler behavior. Typical handling events may involve landing the fish with nets or by hand, air exposure, hook removal or tagging, and, for larger individuals, weighing or photographing before release. Many management agencies now advocate or require the use of circle hooks for bait fishing, barbless single hooks for artificial lures, and immediate release protocols, but compliance and effectiveness still vary significantly[3,2,4].

The recurrent challenge is the trade-off between data collection, recreational enjoyment, and conservation: even with well-intentioned catch-and-release, negative outcomes arise from extended fight times, air exposure, rough netting, improper de-hooking, or thermal or hypoxic stress. Understanding the biological impacts of these practices—especially during the spawning period—is crucial for sustaining striped bass stocks.

Air Exposure Duration Effects on Spawning Success and Survival

A growing body of evidence implicates air exposure as a primary stressor that negatively affects post-release survival and reproductive performance in striped bass. Recent field and laboratory studies reveal that even short durations of air exposure (30–120 seconds) significantly increase physiological disturbance, disrupt equilibrium, and impair recovery following release[5,4,6].

For example, a 2025 field experiment in Massachusetts demonstrated that striped bass exposed to air for 120 seconds exhibited a 50% loss of equilibrium after handling, a stark contrast to those not exposed to air or exposed for only 30 seconds, who maintained reflex responses and rapid recovery. The physiological basis for this impairment involves a rapid rise in blood lactate and plasma cortisol during asphyxia, compounded by the preceding fight and handling stress[5 7].

Beyond immediate survival, air exposure can interfere with spawning behavior. Striped bass returning to spawning grounds exhaust substantial energy reserves; prolonged asphyxiation constrains their ability to resume migration, locate mates, and complete egg deposition and fertilization. Air exposure exceeding 30 seconds elevates stress hormones, impairs muscular function, and can lead to delayed mortality, often hours to days after release. Best management practices, therefore, call for limiting air exposure to under 10–30 seconds and, whenever possible, releasing fish without removing them from the water[2 6 4].

Netting Techniques Impact on Injury and Stress

Landing methods—especially the type of net used—directly affect the degree of external injury and subsequent stress response in striped bass. Traditional knotted nylon or large mesh nets tend to abrade or remove the fish's protective slime coat, disrupt scales, and increase the risk of wounds that may lead to secondary infection. Such abrasions were shown to elevate cortisol and glucose levels, indicative of acute stress[4 5 6 8].

In contrast, rubberized, knotless, or soft-mesh landing nets minimize external injury and mucus loss, substantially reducing the physiological costs of capture. A 2025 observational study recommended rubberized nets as standard equipment, noting that handling in such nets during air exposure minimizes both stress and the likelihood of delayed mortality[6 4].

Researchers also caution against handling fish with dry hands, rough surfaces, or bank contact, all of which further compromise protective barriers. Avoiding excessive netting, supporting fish horizontally, and keeping them in water during unhooking are recommended to maintain fish health and increase the odds of successful spawning after release[2 9 8].

Hook Type and Hooking Location on Post-Release Mortality

Hook type and hooking location are among the strongest predictors of mortality in caught-and-released striped bass. Circle hooks—now widely mandated for bait fishing—are designed to reduce incidents of deep or gut hooking and are consistently shown to result in higher rates of jaw-hooking, which is far less injurious. Numerous studies confirm that fish jaw-hooked with circle hooks have markedly higher survival rates than those hooked in the gills, pharynx, or stomach[3 4 5 1 10].

Experimental studies by Diodati and Richards (1996) reported that striped bass deeply hooked (e.g., in the throat or gills) were six to seventeen times more likely to die post-release compared to those jaw-hooked. The odds of death for gut-hooked fish were nearly six times greater. Gut hooking is more likely when using traditional J-hooks, especially with natural bait. Use of artificial lures further reduces deep hooking incidences, and single barbless hooks are also preferable for ease of hook removal and minimal tissue damage[4 1].

It is worth noting that multiple or treble hooks, commonly used on plugs or lures, increase the risk of foul hooking sensitive body areas, compounding injury rates and stress. Regulatory trends now favor replacing treble hooks with singles to lower these risks and facilitate faster releases[4 5 2].

De-Hooking Methods and Tools Effects on Fish Injury

Expeditious and gentle de-hooking is central to reducing injury, stress, and post-release mortality. The longer a hook remains embedded—especially deeply—the greater the risk of hemorrhage, organ damage, or prolonged air exposure. Guidelines emphasize the use of long-nosed pliers, hemostats, or dehooking tools that enable rapid hook removal with minimal force. When a hook is deeply embedded or visible removal poses a risk of further damage, it is best practice to cut the leader close to the hook eye and release the fish with the hook in place, as most hooks will corrode and dislodge over time[4 11 2 8].

Research also highlights the advantage of using barbless hooks, which facilitate swift removal and further minimize tissue injury. Forceful or aggressive hook removal is discouraged, as it can tear tissue and prolong handling, leading to increased mortality[4 11].

Handling Time Out of Water and Stress Physiology

The total duration a spawning striped bass is handled, especially out of water, shows a direct correlation with physiological stress markers. Handling time encompasses the total interval from landing to release, including time spent photographing, weighing, or measuring the fish. Prolonged handling out of water leads to cumulative increases in the stress hormone cortisol, blood glucose, and lactic acid, all of which impair muscular and metabolic recovery-a prerequisite for resuming migration or spawning activity[7 5 4 6].

Laboratory tests have repeatedly shown that cortisol and glucose levels peak within minutes of intense handling, with post-exercise metabolic acidosis (lactate buildup) corrected only after several hours of recovery in optimal (preferably brackish) water. Studies confirm that restricting fighting and handling times to less than two minutes and ensuring rapid, in-water release produce the best outcomes for post-release survival and future reproductive effort[5 7].

Use of Sedatives During Handling and Reproductive Performance

The use of sedatives or anesthetics (e.g., MS-222, clove oil) in fisheries research or aquaculture settings is intended to reduce struggling and related injuries. However, results regarding their efficacy in reducing physiological stress are mixed. Peer-reviewed studies found that most commonly used sedatives, such as MS-222 and sodium chloride baths, do not consistently reduce the cortisol or glucose response in hybrid or pure-strain striped bass when exposed to handling or low-water stress[12 13].

Metomidate, a non-barbiturate anesthetic, showed some promise in briefly dampening the stress response, but its regulatory approval and field applicability are limited. In practice, sedation is rarely used in recreational fisheries due to practical and legal constraints. Thus, the focus remains on minimizing handling and employing gentle restraint rather than pharmacological intervention to reduce stress and ensure reproductive performance is maintained post-handling[12 13].

Thermal Stress During Handling and Its Effects

Thermal regime at the time of handling is a critical determinant of post-release survival and spawning success. When water temperatures exceed 21°C (70°F), the physiological burden associated with handling spikes sharply; mortality rates for caught-and-released striped bass surge in both freshwater and marine environments as temperature rises, especially when compounded by low dissolved oxygen[14 4 2 15 5].

Field and laboratory studies in the southern U.S. show that during peak summer, suitable thermal refugia contract, leading to greater vulnerability during handling-induced stress. Fish subjected to handling at 28°C (82°F) exhibited decreased condition factor, reduced growth, and increased genetic markers of stress, such as telomere degradation (potentially affecting longevity and future fecundity). Studies further demonstrate that post-release recovery from acute acidosis is delayed at higher temperatures, increasing the window for predation, secondary mortality, and sub-optimal reproductive output[14 5 7].

Best practices recommend avoiding all non-essential targeting and handling of striped bass during periods of elevated water temperatures-typically late spring through summer, with regional variability[2 6].

Reproductive Outcomes: Egg Viability and Fertilization Rates

Proper handling is foundational to successful spawning and recruitment. Physical and physiological stress during and after handling is known to reduce gamete quality, suppress ovulation, delay or prevent spawning, and lower the viability of eggs released. Elevated stress hormones interfere with reproductive hormone cascades, leading to reduced fertilization and hatching success[16 17 4 6].

Controlled experiments revealed that eggs stripped and exposed to air before ovulation failed to hatch, while eggs suspended immediately in water and handled with minimal disturbance yielded hatch rates as high as 91%. Thermal fluctuation, excess air exposure, and rough handling drastically reduce fertilization rates and egg survival. Additionally, larger, older females—key to population sustainability due to their exponentially greater egg output—are particularly susceptible to handling stress, emphasizing the need for exceptional care with trophy-sized spawning individuals[17 16].

Physiological Stress Markers After Handling

Physiological measures routinely used to quantify stress in handled striped bass include plasma cortisol, glucose, and lactate levels, assessed immediately after handling and during subsequent recovery intervals. These markers provide insights into the metabolic and endocrine cascades triggered by catch-and-release, netting, or confinement. Elevated post-handling cortisol signals acute stress, with observed values rising from a baseline of 45–50 ng/mL to 500–800 ng/mL after strenuous exercise or extended confinement[18 7 5].

Metabolic acidosis, characterized by decreased blood pH and sharply increased lactate (from anaerobic exercise), impairs muscle function and recovery. Prolonged acidosis delays the fish's ability to resume migration, spawning, or escape from predators after release. These findings validate practical recommendations for minimizing fight and handling times, limiting air exposure, and releasing fish in optimal (well-oxygenated, cool) water whenever possible[18 5 7].

Behavioral Changes Post-Handling on Spawning Sites

Behavioral consequences of sublethal handling stress extend beyond immediate physiological impairment. Angled and stressed striped bass have demonstrated disrupted feeding behavior, altered migratory patterns, and compromised site fidelity upon release. In acute cases, equilibrium loss and suppressed post-release activity were documented, especially after air exposure or at warm temperatures[5 4 6].

Suppressed post-release movement may increase predation risk or delay return to spawning grounds. Studies using acoustic telemetry revealed that larger, exhausted striped bass that remained disoriented or hypoactive for even 20–40 minutes post-release could more easily succumb to predation or fail to recover reproductive function in time for effective spawning. Collectively, these sublethal effects reduce individual reproductive fitness and, in aggregate, can lead to lower year-class strength during periods of high angling pressure[19 5].

Delayed Mortality and Sublethal Effects After Tagging

Tagging studies, both with external and internal transmitters, play a vital role in stock assessment but also introduce unique handling challenges. The process of capturing, confining, anesthetizing (in some studies), and surgically implanting tags is associated with short-term increases in stress markers and, occasionally, delayed mortality that occurs beyond the direct observation period. Studies have reported survival rates typically exceeding 90% under best practices, but with clear evidence that excessive air exposure, prolonged handling, and warm water elevate the risk of both mortality and sublethal effects, such as stunted growth and diminished subsequent spawning behavior[5 20 21].

In population-level studies, sublethal impacts can include reduced migratory capacity and disruption of spawning aggregations, effects that may not be apparent without long-term tracking and robust survey designs.

Population-Level Impacts of Handling-Induced Mortality

Even when release mortality rates per fish appear low (the regulatory standard is a 9% coastwide estimate for striped bass released by recreational anglers[1 22]), the sheer magnitude of catch-and-release in major spawning areas translates to significant cumulative loss. For example, in a single year, an estimated 2.7 million striped bass may die following capture and release out of more than 30 million released coastwide[1].

In spawning rivers experiencing multiple consecutive years of below-average recruitment—such as the Chesapeake Bay region from 2018–2024—handling-induced mortality can sharply curtail the reproductive potential of the stock, undermining rebuilding efforts and leading to population contractions. Delayed or sublethal effects compound these losses: fish that survive but do not spawn effectively or succumb to predation are effectively lost from the gene pool, further reducing future class strength[23 24 25].

Regulatory bodies, including the Atlantic States Marine Fisheries Commission (ASMFC), have increasingly emphasized seasonal closures, gear restrictions, education, and slot limits to address the additive mortality from both harvest and release during the critical spawning window[3 26].

Existing Guidelines and Best Practices for Handling Spawning Striped Bass

Best practice guidelines—developed and disseminated by government agencies, fisheries scientists, and angler education organizations—now incorporate an integrated view of handling, taking into account hook selection, tackle, landing, de-hooking, air exposure, and release technique. Key recommendations include:

- **Use of circle hooks** (non-offset) when fishing with bait, which dramatically decreases gut hooking and internal injuries.
- **Switch to single, barbless hooks** on lures to facilitate quick removal and reduce tissue injury.

- **Minimize fight time**: Use adequately heavy tackle to bring fish to hand quickly, especially during the spawning run or in high temperatures.
- **Rubberized, knotless nets** for landing, reducing physical abrasion and mucus loss.
- **Limit air exposure** to under 10–30 seconds and, ideally, release fish in the water.
- **Support fish horizontally** when handling for measurement or photographs; never suspend by the jaw or gill plate.
- **Wet hands or gloves** before touching fish to preserve the protective slime layer.
- **Avoid fishing during thermal extremes**; cease catch-and-release when water temperature exceeds 70°F.
- **Revive exhausted fish** by gently holding them upright, head first into a current, until they swim away on their own[4 2 22 9 8 6 5].

Educational initiatives now emphasize these approaches (e.g., ASMFC's Best Practice Outreach, Virginia DWR's guidance), and technological innovations, such as specially designed dehookers and regulatory changes mandating gear modifications, are increasingly adopted[11 3].

Gear Modifications to Minimize Handling Harm

Recent management actions underscore the effectiveness of gear restrictions as a conservation measure—chief among them, the required use of circle hooks, which has shown quantifiable reductions in deep-hooking mortality and, by extension, overall release mortality. Replacement of treble hooks with single barbless hooks further enhances fish survival by simplifying de-hooking and reducing tissue trauma. Field studies support that gear modifications, in tandem with angler education, enable consistent improvements in post-release survival rates across various water bodies and fishing contexts[3 4 5].

Laboratory vs. Field Experimental Methods in Handling Studies

Empirical evidence on handling stress derives from both laboratory and field experiments, each bringing complementary strengths and limitations. Laboratory studies allow precise manipulation of variables (e.g., holding time, temperature, recovery salinity) and fine-scale monitoring of physiological markers, but may not fully replicate environmental complexity or predation pressures. Field studies using tagging or telemetry capture real-world consequences at scale but may confound variables, especially under differing angler skill, gear use, or ambient conditions[7 5 27 18 14].

The best available knowledge now integrates both approaches: for example, tagging studies paired with behavioral acceleration loggers provide granular data on recovery and survival, while laboratory trials elucidate dose-response relationships for temperature and stress hormone kinetics.

Physiological Recovery Times After Handling

Recovery from handling-induced stress in striped bass is neither instantaneous nor uniform. In laboratory and tagging studies, metabolic (lactate, glucose) and endocrine (cortisol) markers typically return to baseline within 2–24 hours, provided the fish are released into cool, well-oxygenated water. However, elevated handling stress at high temperatures delays this recovery, sometimes prolonging physiological disturbance for more than a day, and increasing vulnerability to both predation and reproductive failure[7 5 14].

Observational telemetry work confirms that fish handled quickly, with minimal or no air exposure, regain normal activity within 5–20 minutes. In contrast, air exposure beyond 60 seconds, extended handling, or handling at water temperatures above 16.6°C sharply reduces the pace and completeness of recovery, leading to greater sublethal and lethal outcomes[5].

Key Handling Practices and Documented Effects: Summary Table

Handling Practice	Documented Effect on Spawning Success	Effect on Stress Levels	Effect on Mortality	Supporting Citations
Use of circle hooks	Reduces deep hooking, improves spawning survival	Lowers injury/stress	Decreases post-release	[14†L14][36†L36][34†L34][7†L7]
Single/barbless hooks	Facilitates faster/safer removal, lower tissue trauma	Reduces stress	Improves survival	[14†L14][10†L10]
Air exposure <30 sec (prefer 10 sec)	Preserves spawning behavior, reduces sublethal harm	Minimal cortisol/lactate rise	Low mortality	[43†L43][14†L14][42†L42]
Use of rubber/knotless nets	Protects slime, scales, less injury/infection	Reduces physiological stress	Reduces delayed mortality	[14†L14][10†L10][42†L42]
Avoiding high temperatures (>70°F)	Avoids thermal reproductive suppression	Prevents additive stress	Minimizes temperature-induced death	[24†L24][14†L14][10†L10]
Gentle de-hooking/cut leader	Reduces tissue/organ damage	Shorter handling, less pain	Increases survival	[19†L19][14†L14][10†L10]
In-water release and revival	Supports oxygenation, recovery before release	Accelerates physiological reset	Reduces sublethal/latent mortality	[10†L10][39†L39]
Avoiding gill/eye contact	Maintains vital function, reduces infection risk	Lower stress response	Increases reproductive opportunity	[10†L10][15†L15]
Limiting fight and handling duration	Preserves muscular reserves for spawning	Reduces lactic acid/cortisol	Decreases mortality	[14†L14][43†L43]

Table Explanation: This table synthesizes the multitude of handling interventions into a clear compendium of “what works, why, and under which circumstances,” drawing on the most recent and rigorous evidence available. For example, a move toward universal adoption of circle hooks addresses both the immediate stress of physical injury and longer-term mortality, as does limiting air exposure and adopting proper netting and release techniques. Handling practices are ranked here by their direct impact on fish well-being and documented contributions to population-level spawning success.

Discussion: Integrating Handling Practices for Effective Management

Striped bass stocks are at a crossroads: without improved stewardship at the point of angler contact—especially during the sensitive spawning window—efforts to manage fishing mortality, rebuild stocks, and sustain the fishery into the future are at risk of failure[23][24][3]. Scientific consensus, reflected in peer-reviewed research and regulatory action, emphasizes that proper handling is an essential conservation tool, not merely a matter of angling etiquette.

Current population trends highlight the need to go beyond simple regulatory compliance; instead, targeted angler education, gear modification, seasonal closures, and proactive stewardship must become hallmarks of effective striped bass management. Small improvements in handling at the level of individual fish can, when widely adopted, yield population-scale benefits.

Conclusion

The impacts of fish handling practices on spawning striped bass are profound, encompassing acute physiological stress, sublethal impairment, reproductive failure, and significant mortality—effects that ripple through the entire population structure. Best available science demonstrates that careful attention to gear selection, air exposure duration, handling technique, and environmental context dramatically improves the odds of survival and reproductive success in released striped bass.

In summary, to maximize the conservation potential of catch-and-release—and to give the iconic striped bass the best chance at persistence and recovery—anglers, researchers, and managers alike must integrate the best practices detailed here: limit air exposure and handling time, use circle or barbless hooks, handle fish gently and in water, and minimize all contact during periods of high temperature or low dissolved oxygen. These individual actions, scaled up across the vast recreational and research fisheries, are critical for reversing declining trends, supporting strong year classes, and ensuring that future generations can enjoy the thrill and ecological benefits of healthy striped bass runs.

Web and Literature Citations Embedded

This report incorporated data and recommendations from government technical reports (e.g., ASMFC, NOAA, MD DNR), state and federal fisheries research, and recent peer-reviewed articles. Key supporting sources are referenced throughout in the required bracketed format, ensuring transparency and traceability to the underlying scientific evidence.

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