A Review of Hooking Mortality, Associated Influential Factors, and Angling Gear Restrictions, with Implications for Management of the Alligator Gar

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EXECUTIVE SUMMARY

The Texas Parks and Wildlife Department (TPWD) is dedicated to the conservation and management of quality fisheries for the Alligator Gar *Atractosteus spatula*. To further inform science-based management decisions and identify knowledge gaps, we conducted a review of information concerning hooking mortality in catch-and-release fisheries, as well as gear-based regulations and best management practices (BMPs) in place to minimize its occurrence. Given the historic paucity of research on the Alligator Gar, no direct study of hooking mortality has been conducted. Thus, evaluations for species of similar form and function, as well as general information on hooking mortality in fishes, were reviewed to gain inferences on the potential significance of this mortality source within the context of Alligator Gar fisheries. Hooking mortality of other large-bodied top predators was generally less than 10%; deep hooking was the primary contributor to post-release mortality. Among 274 hooking mortality studies reviewed for various species, hooking mortality rates were positively skewed (median = 11%, mean = 18%). Anatomical hooking location was again the most significant factor influencing mortality. No states have implemented gear-based restrictions for Alligator Gar; however, restrictions on hook type for species exhibiting similar life-history or anatomical features (e.g., pikes *Esox* spp. and sturgeons *Acipenser* spp.) have been used to reduce the likelihood of deep hooking. Continued refinement of best management practices for Alligator Gar requires understanding the proportion of populations caught by anglers in a given year in order to estimate the potential impact of hooking mortality. In addition, dissemination of effective angling techniques that minimize post-release mortality should be conveyed to the angling public to promote development of BMPs.

HOOKING MORTALITY AND ASSOCIATED INFLUENTIAL FACTORS

Globally, most fishes caught by recreational anglers are released, either voluntarily or mandatorily as a byproduct of size- or creel-based harvest regulations (Policansky 2002; Cooke and Cowx 2004; Bartholomew and Bohnsack 2005; Arlinghaus 2007; Arlinghaus et al. 2007; Hühn and Arlinghaus 2007). Anglers and fishery managers largely assume that released fish survive and contribute to the future fishery, either through reproduction or subsequent recapture by another angler (Schmitt and Shoup 2013); however, not all released fish survive (Muoneke and Childress 1994). As a result, a considerable number of studies have investigated this mortality source, commonly referred to as hooking mortality (see reviews by Muoneke and Childress 1994; Bartholomew and Bohnsack 2005; and Hühn and Arlinghaus 2011). Results of these studies indicate that the rate of mortality among fishes following release is highly variable, ranging from less than 1% to as high as 95% (Bartholomew and Bohnsack 2005). The considerable differences observed among studies can largely be attributed to a number of factors, including species, body size, bait, hook, and gear types, anatomical hooking location, fish handing practices, and water depth and temperature (Bartholomew and Bohnsack 2005; Hühn and Arlinghaus 2011; Schmitt and Shoup 2013). The wide range in mortality observed among and within species, coupled with the myriad of influential factors, illustrates a need to understand sources of hooking mortality and develop best management practices (BMPs) that minimize or eliminate negative effects on fisheries.

Despite considerable research efforts to understand hooking mortality, only a fraction of fishes and fisheries have been investigated (Hühn and Arlinghaus 2011). Cooke and Suski (2005) argued that hooking mortality is reasonably understood for only five species (Largemouth Bass *Micropterus salmoides*, Walleye *Sander vitreus*, Rainbow Trout *Oncorhynchus mykiss*, Striped Bass *Morone saxatilis*, and Atlantic Salmon *Salmo salar*), whereas our understanding among other species is rudimentary or non-existent, which remains the case for many fishes today. Such is the case for the Alligator Gar *Atractosteous spatula*, which has experienced a sharp increase in popularity among recreational anglers in recent decades. Given the life history of the species, including a long life span (greater than 60 years; Daugherty et al. 2019) and periodic reproductive success (Buckmeier et al. 2016), even low rates of hooking mortality (e.g., $\leq 5\%$) may result in significant impacts in systems with high fishing effort and harvest (Coggins et al. 2007). Thus, understanding the potential impacts of hooking mortality on Alligator Gar fisheries is important. Our objective was to review the scientific literature surrounding hooking mortality within the context of its application to Alligator Gar. This was accomplished using two approaches; first, we collated and distilled information on hooking mortality for species of similar form and function. Second, we identified influential factors associated with hooking mortality derived from meta-analyses of the existing literature that are applicable to Alligator Gar fisheries. Ultimately, we used the results to provide recommendations towards identifying critical knowledge gaps and the development of BMPs for catch-and-release within Alligator Gar fisheries.

Hooking mortality in similar species

Whereas no studies in the literature have investigated hooking mortality among gars (Lepisosteidae), a considerable amount of research has been conducted on hooking mortality in the pike family (Esocidae) which includes the Northern Pike *Esox lucius* and Muskellunge *E. masquinongy*. Similar to the Alligator Gar in both anatomical form (e.g., large terminal mouth, elongate body, large body sizes [to 1,800-mm; Page and Burr 1991]) and function (piscivorous, top predators), evaluations of hooking mortality in these species provide the most applicable inferences to the Alligator Gar (Wydoski 1977). Tomcko (1997) reviewed 11 studies and reported mean estimates of hooking mortality (weighted by sample size) ranging from 4.5% for Northern Pike to 15.6% for Muskellunge (Table 1); however, the author noted that Muskellunge hooking mortality may have been overestimated due to unusual handling techniques employed in one study (Beggs et al. 1980). Among the studies examined, the author further noted that fishing tackle typically inflicted greater damage and subsequently higher mortality when fish were deeply hooked in critical areas (e.g., in the gills, gullet, stomach). Grimm (1981; *sensu* Tomcko 1997) reported that irrespective of hook type (i.e., single versus treble), the most important determinant of mortality in angled Northern Pike was whether the hook was swallowed. In that study, fish were angled, lines were cut (i.e., hooks were not removed), and fish were released into ponds for up to 10 months. Mortality was 13.5% when hooks were swallowed, versus 4.2% for mouth-hooked fish. Burkholder (1992) reported that mortality of Northern Pike angled with treble hooks ranged from 3.3 to 4.8%, whereas no mortality was observed among those caught on single hooks. In addition, the likelihood of both deep hooking and bleeding was significantly greater for fish caught on treble hooks.

Subsequent studies of Esocid hooking mortality have reported similar results to those reviewed by Tomcko (1997). Arlinghaus et al. (2008) reported hooking mortality for Northern Pike of 2.4% (95% confidence interval = 0.9 to 3.9%), with mortality significantly related to the incidence of bleeding. The authors noted that the use of natural baits may be associated with a higher incidence of deep hooking, which in turn increased the likelihood of bleeding. Collectively, these studies of Esocids indicated that deep hooking is the primary contributor to post-release mortality, with the use of treble hooks being associated with higher rates of deep hooking and the incidence and severity of associated bleeding.

Influential factors affecting hooking mortality

Muoneke and Childress (1994) provided the first meta-analysis of hooking mortality studies, incorporating data from 76 studies covering 32 fish taxa. Bartholomew and Bohnsack (2005) built upon those efforts, evaluating an additional 53 studies and 32 fishes. Collectively, these studies assessed 274 estimates of hooking mortality and their associated biotic and abiotic correlates. Across species and studies, the distribution of hooking mortality rates was positively skewed (median = 11%, mean = 18%, range = 0 to 95%).

Similar to the results reported for Esocids, anatomical hooking location was the most significant factor influencing mortality across studies and species. Eleven studies investigating this factor concluded or experimentally demonstrated that fish hooked in critical areas experienced higher mortality (Pauley and Thomas 1993; Murphy et al. 1995; Diodati and Richards 1996; Nelson 1998; Lukacovic 2000; Lukacovic 2001; Taylor et al. 2001; Lukacovic and Uphoff 2002; Prince et al. 2002; Skomal et al. 2002; Zimmerman and Bocheneck 2002).

Additional factors resulting in significantly elevated hooking mortality were the use of natural baits, the removal of hooks from deeply hooked fish (as opposed to cutting the line and leaving the hook in place), the use of "J" style hooks versus circle hooks, water temperature and depth, and extended fight and handling times. In contrast, the use of barbed over barbless hooks was found to have limited impacts on the mortality of hooked fish, as was the size of fish hooked, hook size, and the use of treble versus single hooks.

Natural baits increase the risk of deep hooking because fish are more likely to voluntarily ingest them as compared to artificial lures (May 1973; Warner and Johnson 1978; Diggles and Ernst 1997; Bartholomew and Bohnsack 2005). Cutting the line on deeply hooked fish is known to significantly increase survivorship because attempts to retrieve these hooks can result in further internal injury. For example, removal of ingested hooks from Yellowfin Bream *Acanthopagrus australis* and Mulloway *Argyrosomus japonicus* resulted in 88 and 73% mortality, respectively, whereas mortality of fish released without removing ingested hooks was 2 and 16% (Butcher et al. 2007). Deeply hooked fish commonly shed the hooks over time (Bartholomew and Bohnsack 2005); some have reported shedding of retained hooks within six months (Mason and Hunt 1967; Schill 1996, Tsuboi et al. 2006; Broadhurst et al. 2007; Weltersbach et al. 2016). However, most of the fish in these studies were hooked in the gills or gullet and, barring serious injury, likely regurgitated the hooks rather than passing them through the digestive tract (Lamansky et al. 2018). Lamansky et al. (2018) documented the passing of hooks ingested by White Sturgeon *Acipenser transmontanus* averaged about 16 months. Because passing hooks through digestive processes often requires the hook to degrade via oxidation, anticorrosive coatings or the use of stainless steel delays or prevents such processes. In turn, this lengthens the time the hook point and barb remain sharp, increasing the potential for further internal damage (McGrath et al. 2011). As a result, many agencies advocate against the use of stainless steel (McGrath et al. 2011).

The use of circle hooks can effectively reduce deep hooking (and therefore hooking mortality) when compared to "J"-style hooks for many species. Cooke and Suski (2004) advocated for the use of circle hooks in a specialized fishery for Muskellunge, in which live bait rigs, designed to be swallowed by trophy-sized fish prior to hook setting, were used. They suggested that circle hooks may minimize injury and mortality in this situation, which was supported by angler-supplied, informal evidence. Margenau and Petchenik (2004) reported that 93% of Muskellunge anglers surveyed had no experience with circle hooks (as of 1999), but 51% said they would support their use. Another 40% expressed uncertainty about their use until they used them. Some species can suffer greater injury with circle hooks, and their design may be incompatible with the feeding behavior or mouth morphology of others, rendering them ineffective (Cooke and Suski 2004). Thus, Cooke and Suski (2004) encouraged management agencies to conduct appropriate studies to assess their conservation benefits and provide anglers with credible information.

The significance of water temperature in relation to hooking mortality is related to its relationships with dissolved oxygen and fish metabolism. Dissolved oxygen concentrations decline with increasing temperatures, while fish metabolic activity increases (Bartholomew and Bohnsack 2005). Combined with the physiological stresses associated with capture and air exposure during hook removal, low dissolved oxygen can lead to prolonged or failed recovery, which can be exacerbated by lengthy fight durations and handling times (Wood et al 1983;

Ferguson and Tufts 1992; Muoneke and Childress 1994; Tomasso et al. 1996; Wilkie et al. 1996; Lee and Bergersen 1996; Cooke et al. 2001). In addition, injuries associated with hooking may be more susceptible to infection at higher water temperatures (Muoneke 1992). Water depth effects on hooking mortality were generally associated with the physical and physiological impacts of barotrauma (i.e., physiological regulation of dissolved gases; Bartholomew and Bohnsack 2005).

Implications for the catch-and-release of Alligator Gar

A considerable amount of research has been conducted in recent years on the Alligator Gar, providing critical information for the sustainable management of fisheries (see Smith et al. 2019). However, no studies to date have directly addressed hooking mortality, and best management practices have yet to be developed. As a result, reasonable expectations must be determined from what has been estimated for similar species and from associated factors applicable to Alligator Gar fisheries. Given that current harvest in Texas' Alligator Gar fisheries is estimated to be about 3% annually (Binion et al 2015; Buckmeier et al. 2016; Smith et al. 2018), and the desire of the Texas Parks and Wildlife Department (TPWD) to maintain total harvest of stocks at or below 5% (Buckmeier et al. 2016), added losses from catch-and-release mortality could be a concern if significant. It should be noted that while harvest rates are a direct proportion of the population (e.g., 3% harvest equates to 3% of the population removed), hooking mortality is limited to the portion of the population caught and released by anglers annually. For example, if anglers catch 10% of a given population each year, a hooking mortality rate of 20% would result in a 2% increase in fishing mortality at the population level.

Traditional angling techniques for Alligator Gar centered on the use of large treble hooks and natural bait, allowing fish to consume it prior to setting the hook much like that described by Cooke and Suski (2004) for Muskellunge. This technique increases the likelihood of a successful hookset. However, it also can increase the number of fish that are deeply hooked, increasing the probability of hooking mortality. While the technique is still used today, some anglers have taken the initiative to reduce the likelihood of hooks penetrating vital organs through the use of smaller treble hooks (see https://www.in-fisherman.com/editorial/alligator-gar-greatest-sportfish/359146; accessed 15 May 2019). Alternatively, some anglers have abandoned the practice of allowing fish to swallow the bait, employing larger "J"-style or circle hooks that are set before baits are swallowed. Artificial lures and flies are also becoming more popular, further promoting the hooking of fish in the mouth. In addition to promoting these alternatives as BMPs, managers should inform anglers of the risks associated with the use of large hooks, hooks made of stainless steel or other corrosion-resistant materials, and removal of hooks from deeply-hooked fish (i.e., line should be cut). Finally, managers should inform anglers that bleeding increases the likelihood of mortality to allow informed decisions regarding harvest where permitted.

Water temperature and depth are less likely to impact Alligator Gar hooking mortality, as compared to other species, given that gars are adapted to high water temperatures and low dissolved oxygen concentrations. This is largely due to their relatively unique ability to utilize atmospheric oxygen, swallowed at the water surface and transferred to their highly vascularized swim bladder through a duct in the esophagus (Schmidt-Nielsen 1997). However, gars receive 70 to 80% of their oxygen from the atmosphere at temperatures > 22° C (71° F; Rahn et al. 1971). Summertime water temperatures in Texas rivers routinely exceed 30° C (86° F), and thus, access to atmospheric oxygen is critical during this time. Deep hooking, particularly in the esophagus, may negatively impact atmospheric air exchange, delaying or preventing recovery following hooking.

Although hooking mortality studies have largely been limited to active gear types, recent consideration of the effects of hooking mortality via passive gears, including jug lines and trot lines, have increased (e.g., Schmitt and Shoup 2013). When employed, these gears are used to target Alligator Gar almost exclusively using natural baits. Given their passive presentation, it is reasonable to assume that most baits are swallowed prior to angler retrieval, resulting in a high incidence of deep hooking. In addition, these gears are commonly set for catfishes, and incidental catch of Alligator Gar is also known to occur. Because current regulations allow these gears to be set for up to 10 days, Alligator Gar incidentally caught by these gear types, particularly at high water temperatures during summer, may experience significant mortality. Discouraging the use of passively-set gears for Alligator Gar, or promoting the use of light-duty tackle could reduce potential impacts.

Collectively, the scientific literature on hooking mortality provides a foundation for the development of best management practices within catch-and-release fisheries for Alligator Gar. Understanding the proportion of Alligator Gar populations caught by anglers in a given year, along with the dissemination of current scientific information to the angling public, is an important first step in encouraging the use of angling techniques that minimize post-release mortality. This, along with continued refinement of BMPs for catch-and-release angling of Alligator Gar based on new scientific information, will be beneficial to the conservation of both the Alligator Gar and the quality of its fisheries in Texas and beyond.

ANGLING GEAR RESTRICTIONS

Most U.S. state agencies allow the harvest of Alligator Gar by a variety of means and methods, including rod and reel, bowfishing, and spearfishing. Most current regulations concerning harvest pertain only to restrictive daily or annual bag and length-based limits (e.g., one per day in Texas, one per year greater than 36 inches in Arkansas). However, no U.S. state or federal agency currently places restrictions on the equipment used when rod and reel angling for Alligator Gar. Regulations on hook type, bait type, and bait size have been used for other sport species, primarily to reduce hooking mortality caused by deep hooking, to limit harvest, to prevent illegal snagging, or reduce the spread of non-native species. Herein, we synthesize existing gear-based regulations, with the intent of informing the development of best management practices for catch-and-release angling of Alligator Gar.

Gear restrictions for similar species

Some states have placed restrictions on hook type for species exhibiting life-history or anatomical features similar to the Alligator Gar, including the Muskellunge *Esox masquinongy,* Tiger Muskie *E. masquinongy* × *E. lucius or E. lucius* × *masquinongy,* and sturgeons *Acipenser* spp. Historically, Muskellunge anglers utilized a single hook, placed in the mouth of a bait when trolling, and allowed the fish to swallow the bait before initiating the hookset. Wisconsin now mandates the use of "quick-strike rigs" or a non-offset circle hook when fishing with a minnow eight inches or longer. A "quick-strike rig" is tackle that has one or more treble hooks attached to the body of a bait fish, behind the head. Along with the quick-strike rig, anglers are also required to immediately attempt to set the hook upon indication of a bite. The regulation is intended to increase the odds of hooking a Muskellunge in the mouth when using natural bait, thereby reducing the likelihood of a deeply hooked fish.

In select locations, Utah prohibits the harvest of Tiger Muskie because the fish are primarily utilized as a management tool to control the abundance of other species such as yellow perch. Utah also restricts bait size and quantity to an individual piece per hook, not larger than one inch in any dimension; using whole fish for bait is unlawful. The intent of this regulation is to reduce the incidence of invasive species introductions through bait transfers. Multiple agencies, including the National Park Service, Canadian Ministry of Natural Resources, and Inland Fisheries Ireland, also prohibit the use of natural baits to prevent the introduction of invasive species that might be used as bait.

Multiple agencies regulate the hook type used for sturgeon species to aid hook removal by the angler and increase the likelihood a fish will quickly shed an unremoved hook following capture. Most states and Canadian agencies with fishable sturgeon populations require the use of a single, barbless hook (e.g. California, Idaho, Washington, British Columbia) when fishing for sturgeon. Idaho also requires the use of sliding sinkers for sturgeon, attached by swivel and leader to the mainline, to reduce the amount of fishing gear left in rivers if the sinker is caught in rocks.

Gear restrictions for other fishes

The most common restrictions on hook type include regulations mandating the use of a single or barbless hook for recreational trout and salmon fisheries along with highly restrictive size or creel limits (e.g., Arizona, Arkansas, California, Colorado, Indiana, and Oklahoma). Alaska, Wisconsin, Michigan, and Indiana also regulate the size of hook used and the use of weighted hooks or placement of weights in a specified proximity to a hook to prevent illegal snagging of salmonids during spawning migrations.

The National Oceanic and Atmospheric Administration (NOAA) and many coastal states have restrictions on hook type, hook removal equipment, and techniques for release to prevent bycatch or hooking mortality of many saltwater species. NOAA requires pelagic longline anglers to use "weak hooks" in the Gulf of Mexico during the months of April and May to prevent the bycatch and mortality of Bluefin *Tuna Thunnus thynnus*. Weak hooks are designed to bend when large tuna are hooked, allowing the fish to escape.

Federal regulations require the use of non-offset, non-stainless circle hooks when fishing for sharks, which Texas has proposed to mandate in state waters beginning on 01 September 2019. Commercial anglers using pelagic longline gear in the Atlantic are also required to use circle hooks, primarily to reduce bycatch mortality of sharks. In addition, anglers fishing in Atlantic billfish tournaments are required to use circle hooks when fishing with natural baits. Many state and federal agencies (e.g., NOAA, Alabama, Florida) also mandate the use of non-offset circle hooks or non-stainless circle hooks for reef fishes, including snappers (Lutjanidae) or anadromous species like Striped Bass (e.g. Maryland, New Jersey) to increase the likelihood of mouth hooking and ultimately the survival of released fish.

Federal regulations are highly restrictive for the critically endangered Smalltooth Sawfish *Pristis pectinate.* If hooked, Smalltooth Sawfish must be left in the water and the angler is required to cut the fishing line as close to the hook as possible. Hooks are not permitted to be removed, except using a long-handled dehooker. A dehooking device is also required equipment to have onboard a fishing vessel in federal and most state coastal waters while fishing for any species.

The Florida Fish and Wildlife Conservation Commission prohibits the harvest of more than a dozen saltwater species using any multi-point hook (a hook with two or more points and a common shaft; e.g., treble hook) in conjunction with live or dead natural bait. These species include Spotted Seatrout *Cynoscion nebulosus*, Black Drum *Pogonias cromis*, flounders *Platichthys* spp., Red Drum *Sciaenops ocellatus*, and sharks (Selachimorpha). The intent of the regulation is to reduce mortality of deeply hooked fish, of which many are required to be released due to restrictive length limits or protected seasons.

Regulations prohibiting certain hook and bait types are predominately employed to provide added protection for threatened fish species or where both angling effort and associated hooking mortality is known to be high relative to population size. As an alternative or in addition to regulations specifying hook type or bait type, some agencies also incorporate BMPs for fish handling and release within regulatory guides or agency hosted websites (Figure 1). These BMPs can be useful in disseminating information and promoting angling practices known to reduce injury and mortality of released fish without the need for additional, complex regulations.

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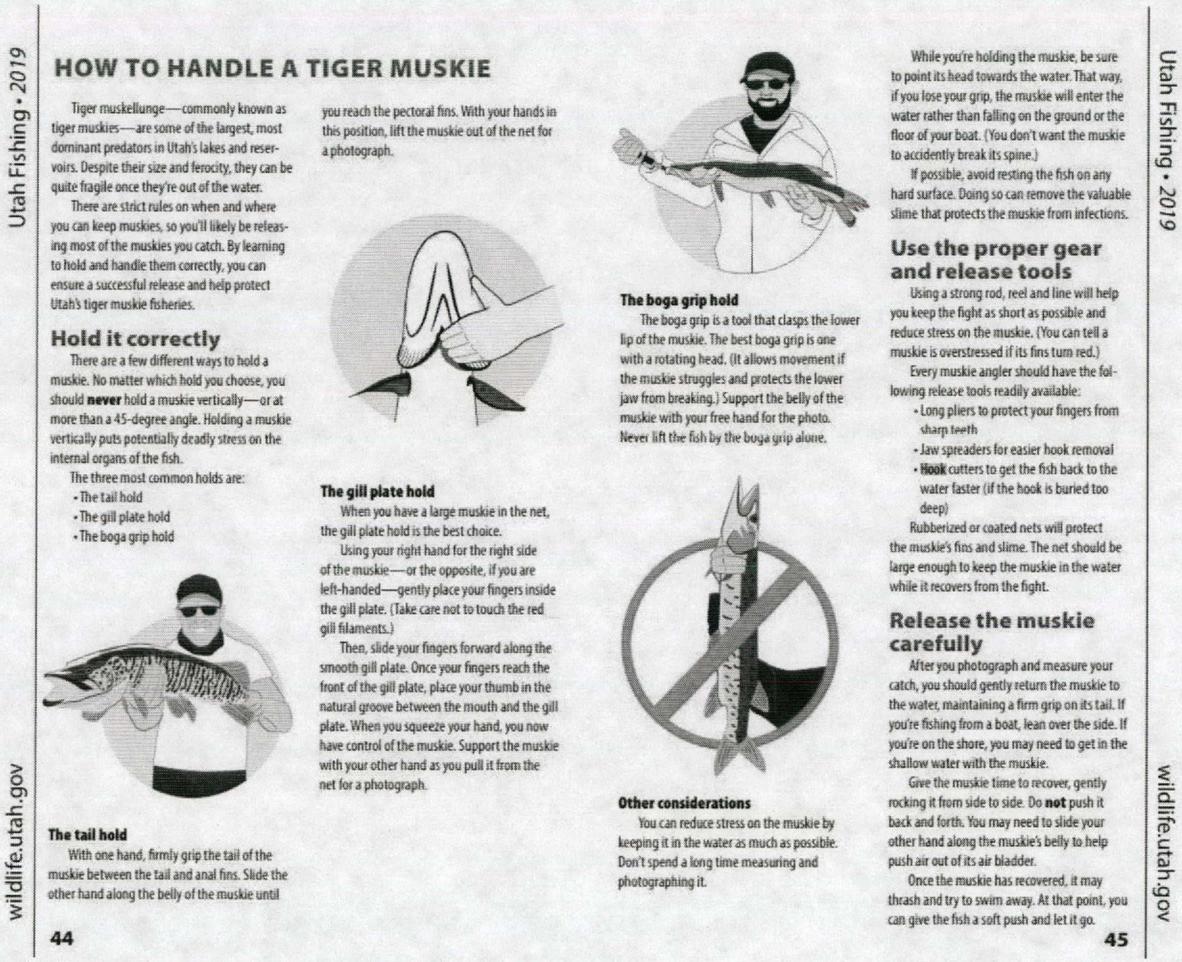
Table 1. Esocid hooking mortality data reproduced from Tomcko (1997). Species abbreviations correspond to: Northem Pike (NOP), Muskellunge (MUE), and their hybrid, Tiger Muskellunge (TIG). The terminal gear type "pike" refers to a specially designed type of hook (described in DuBois et al. 1994).

Species	Fish size TL(mm)	*N*	Hook barb	Terminal gear	Temp (oC)	Days held	Hooking mortality (%)	Study timinll	Reference
NOP	480	77	yes	lure		3	5.2	Oct	Beukema 1970
NOP	365-880	75	yes	hook	19	4	5.3	Jun-Aug.	Falk and Gillman 1975
		19	no				10.5		
NOP	245-280	38	yes	lure	15-23	>7	3	Apr-Sep	Weithman and Anderson 1976
NOP	356-610			hooked shallow					
		19		spinner,single		180	0		Grimm 1981
		41		spinner,treble		180	2.4		
		79		livebait,single		180	6.3		
		50		livebait,treble		180	6		
	559-813			hooked shallow					
		26		livebait,single		300	3.8		
		23		livebait,treble		300	0		
				hooked deep					
		24		livebait,single		300	12.5		
		50		livebait,treble		300	14		
NOP	489"	105	no	hook	19.:!;2(SD)	0.1-2	3	Jui-Aug.	Schwatme and Mackay 1985
NOP	457	24	yes	pike	37(air)	2	33.3	Dec.	DuBois et at. 1994
		161		treble			0.6		
MJE	245-.280	9	yes	lure	15-23	>7	0	Apr-Sep.	Weithman and Anderson 1976
MJE	619-918	25	yes	lure	19.7	3.5	30	May-Sep.	Beggs et al1980
MJE	850-1220	14	yes	lure	21.4	!:469	0	,:::1 yr	Strand 1986
TtG	245-280	12	yes	lure	15-23	>7	0	Apr-Sep.	Weithman and Anderson 1976
TtG	549	384				<1	11.7	Apr-Oct	Storck and Newman 1992

* Total length converted from fork length using formula from Carlander (1969); FL=0.937 TL



Utah Fishing • 2019

HOW TO HANDLE A TIGER MUSKIE

Tiger muskellunge—commonly known as tiger muskies—are some of the largest, most dominant predators in Utah's lakes and reservoirs. Despite their size and ferocity, they can be quite fragile once they're out of the water.

There are strict rules on when and where you can keep muskies, so you'll likely be releasing most of the muskies you catch. By learning to hold and handle them correctly, you can ensure a successful release and help protect Utah's tiger muskie fisheries.

Hold it correctly

There are a few different ways to hold a muskie. No matter which hold you choose, you should **never** hold a muskie vertically—or at more than a 45-degree angle. Holding a muskie vertically puts potentially deadly stress on the internal organs of the fish.

The three most common holds are:

- The tail hold
- The gill plate hold
- The boga grip hold

The tail hold

With one hand, firmly grip the tail of the muskie between the tail and anal fins. Slide the other hand along the belly of the muskie until you reach the pectoral fins. With your hands in this position, lift the muskie out of the net for a photograph.

The gill plate hold

When you have a large muskie in the net, the gill plate hold is the best choice.

Using your right hand for the right side of the muskie—or the opposite, if you are left-handed—gently place your fingers inside the gill plate. (Take care not to touch the red gill filaments.)

Then, slide your fingers forward along the smooth gill plate. Once your fingers reach the front of the gill plate, place your thumb in the natural groove between the mouth and the gill plate. When you squeeze your hand, you now have control of the muskie. Support the muskie with your other hand as you pull it from the net for a photograph.

The boga grip hold

The boga grip is a tool that clasps the lower lip of the muskie. The best boga grip is one with a rotating head. (It allows movement if the muskie struggles and protects the lower jaw from breaking.) Support the belly of the muskie with your free hand for the photo. Never lift the fish by the boga grip alone.

Other considerations

You can reduce stress on the muskie by keeping it in the water as much as possible. Don't spend a long time measuring and photographing it.

While you're holding the muskie, be sure to point its head towards the water. That way, if you lose your grip, the muskie will enter the water rather than falling on the ground or the floor of your boat. (You don't want the muskie to accidently break its spine.)

If possible, avoid resting the fish on any hard surface. Doing so can remove the valuable slime that protects the muskie from infections.

Use the proper gear and release tools

Using a strong rod, reel and line will help you keep the fight as short as possible and reduce stress on the muskie. (You can tell a muskie is overstressed if its fins turn red.)

Every muskie angler should have the following release tools readily available:

- Long pliers to protect your fingers from sharp teeth
- Jaw spreaders for easier hook removal
- Hook cutters to get the fish back to the water faster (if the hook is buried too deep)

Rubberized or coated nets will protect the muskie's fins and slime. The net should be large enough to keep the muskie in the water while it recovers from the fight.

Release the muskie carefully

After you photograph and measure your catch, you should gently return the muskie to the water, maintaining a firm grip on its tail. If you're fishing from a boat, lean over the side. If you're on the shore, you may need to get in the shallow water with the muskie.

Give the muskie time to recover, gently rocking it from side to side. Do **not** push it back and forth. You may need to slide your other hand along the muskie's belly to help push air out of its air bladder.

Once the muskie has recovered, it may thrash and try to swim away. At that point, you can give the fish a soft push and let it go.

wildlife.utah.gov 44

Utah Fishing • 2019 wildlife.utah.gov 45

Figure 1. Best management practices for handling Tiger Muskellunge, published in the 2019 Utah Fishing Guidebook.

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