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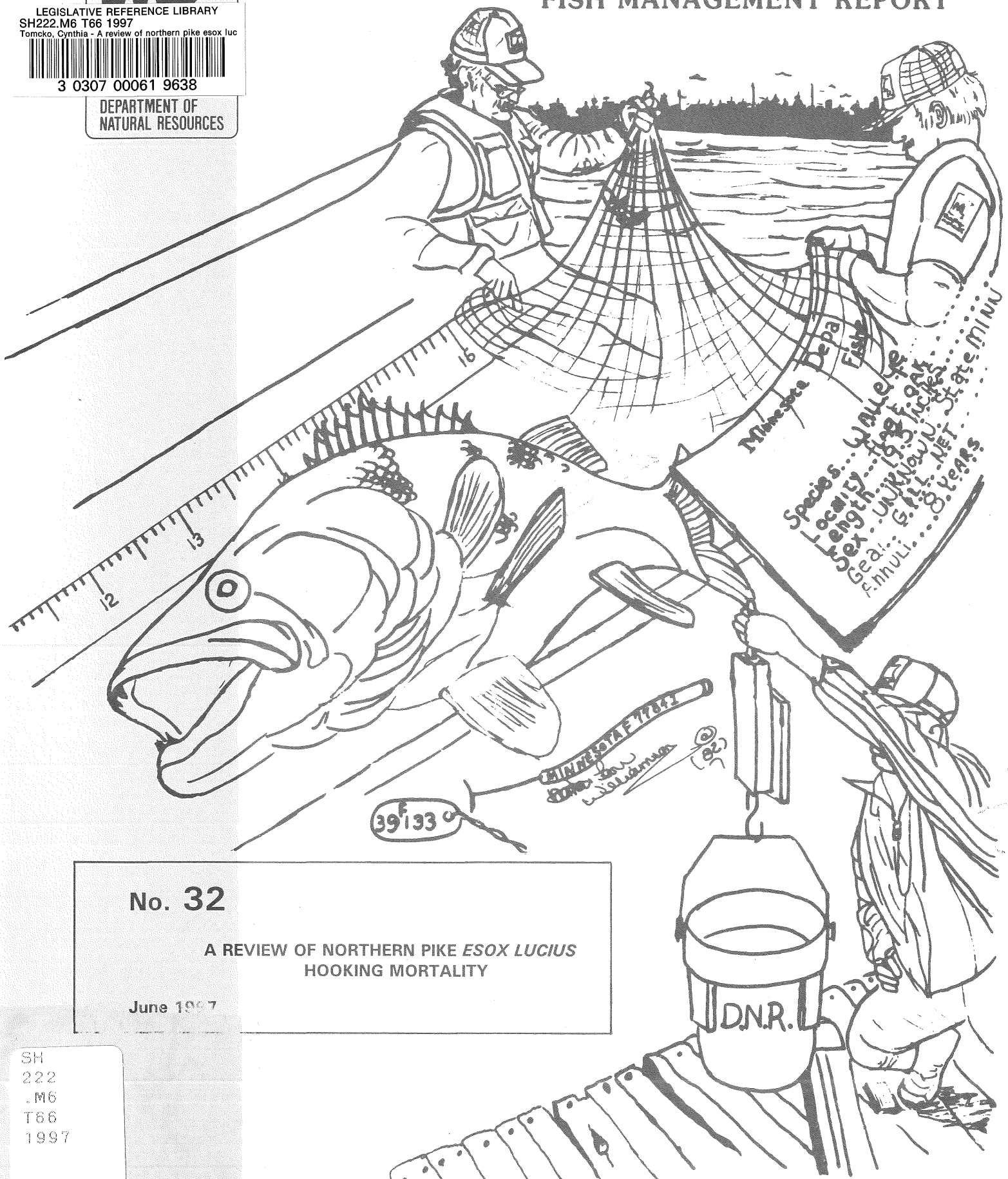

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A REVIEW OF NORTHERN PIKE *ESOX LUCIUS* HOOKING MORTALITY

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A REVIEW OF NORTHERN PIKE *ESOX LUCIUS* HOOKING MORTALITY[1]

by

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Abstract.-- Low northern pike *Esox lucius* hooking mortality is important for justifying catch and release fishing and encouraging angler acceptance of length regulations for northern pike. A literature review on esocid hooking mortality indicated that the average hooking mortality for northern pike is less than 5%. This low hooking mortality estimate suggests that additional research to increase the accuracy of the estimate is not a high priority.

Introduction

Estimates of northern pike *Esox lucius* hooking mortality are necessary when developing appropriate regulations on angler harvest. Regulations may be required because increased angling pressure has resulted in truncated size structures and few trophy-sized pike. Analysis of entries in a northwestern Minnesota sport fishing contest showed that increased angling pressure on northern pike populations resulted in declines in mean weight and fewer trophy-sized pike entered (Olson and Cunningham 1989). Fisheries managers need hooking mortality estimates to model different size regulations, such as minimum and slot length limits, and to determine whether size regulations will work. Accurate hooking mortality estimates allow managers to choose the best regulation to correct specific size structure problems.

There is much information available on hooking mortality. In one comprehensive review of hooking mortality dealing mainly

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with salmonids, there were significant differences in hooking mortality due to the species of fish, type of terminal fishing tackle, water temperature, and anatomical site of hooking (Wydoski 1977). Taylor and White (1992), in a meta-analysis of 18 other studies, found that salmonid hooking mortality varied with average fish size, presence or absence of hook barbs, hook size, number of hooks, handling time, hatchery or wild rearing, and hook extraction methods. These variables are likely to affect northern pike hooking mortality. However, salmonid hooking mortality cannot be directly related to northern pike hooking mortality due to differences in feeding behavior, which is an important factor governing hooking mortality (Wydoski 1977). It would be more appropriate to compare northern pike hooking mortality with the hooking mortality of other esocids, because esocids have similar feeding behaviors.

In this literature review, I have synthesized previous studies of esocid hooking mortality as they relate to northern pike.

Literature Review

Eleven references were found on esocid hooking mortality - six on northern pike, three on muskellunge *Esox masquinongy*, and two on tiger muskellunge (hybrid of female muskellunge X male northern pike). In North America, studies were conducted as far south as Missouri and as far north as Great Slave Lake in the Northwest Territories, with other studies in Illinois, Minnesota, Wisconsin, Ontario, and Alberta. Two studies were conducted in the Netherlands.

Esocid hooking mortality estimates ranged from 0-33% in the 10 studies (Table 1). Weighted mean estimates of hooking mortality were less than 16% for the three esocid species: northern pike = 4.5% (95% CI: 3.0-5.9%) without mortality due to pike hooks; northern pike = 5.3% (95% CI: 3.8-6.9%) including mortality due to pike hooks; muskellunge = 15.6% (95% CI: 5.4-25.9%); and tiger muskellunge = 11.3% (95% CI: 8.2-14.5%, Table 1). Muskellunge hooking mortality may have been overestimated because the muskies were subjected to unusual handling methods in one study (Beggs et al. 1980). Tiger muskellunge hooking mortality may have been underestimated because Storck and Newman (1992) expected that some tiger muskellunge in their study escaped from anglers after hooking, and their status could not be evaluated.

The reviewed research evaluated factors which affect esocid hooking mortality, such as type of terminal tackle, handling techniques, fish length, and water temperature.

Terminal tackle usually inflicted greater damage and caused greater hooking mortality if it was swallowed and the fish deeply hooked. Damage could be caused as the tackle was swallowed or when the angler removed the tackle. However, DuBois et al.'s study (1994) illustrated that treble hooks could be taken deeply, removed by the angler, and the fish suffered little damage. Research on the effects of terminal tackle concentrated on live bait, artificial lures, and barbed or barbless hooks.

Live bait did not necessarily cause high hooking mortality. Live bait prompted hooked fish to engulf and swallow the hook in one study. Beukema (1970) found that hooks baited with roach penetrated beyond the gill arches in 29% of the northern pike, whereas artificial lures (hooks attached to spinners) were infrequently swallowed. However, Beukema recorded a low hooking mortality of 5.2%. In DuBois et al.'s (1994) study, northern pike hooking mortality varied greatly due to two types of baited tackle, pike hooks and treble hooks. The pike hooks were V-shaped hooks, one side of which is impaled with a bait fish, and which are about three times larger than the treble hooks. Pike hooks baited with dead rainbow smelt caused more mortality (33%) than treble hooks baited with minnows or suckers (<1%), presumably because pike hooks caused more extensive damage to the pike. Both types of hooks were removed before pike were put in holding pens. Autopsies were not done on dead fish to determine the damage due to the hooks. Of the nine pike that died (eight on pike hooks), seven were hooked in critical areas (esophagus, stomach, gills; six on pike hooks) and two were hooked superficially (mouth, jaw). In another study,

Table 1. Study design and hooking mortality estimates for esocid species, 1967-1992. Mean fish size or a range of fish sizes in total length is listed. Species codes are: NOP = northern pike; MUE = muskellunge; TIG = tiger muskellunge.

Species	Fish size TL(mm)	*N*	Hook barb	Terminal gear	Temp (°C)	Days held	Hooking mortality (%)	Study timing	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[a]	105	no	hook	19±2(SD)	0.1-2	3	Jul-Aug.	Schwalme and Mackay 1985
NOP	457	24	yes	pike	37(air)	2	33.3	Dec.	DuBois et al. 1994
		161		treble			0.6		
MUE	245-280	9	yes	lure	15-23	>7	0	Apr-Sep.	Weithman and Anderson 1976
MUE	619-918	25	yes	lure	19.7	3.5	30	May-Sep.	Beggs et al 1980
MUE	850-1220	14	yes	lure	21.4	≤469	0	≥1 yr	Strand 1986
TIG	245-280	12	yes	lure	15-23	>7	0	Apr-Sep.	Weithman and Anderson 1976
TIG	549	384				<1	11.7	Apr-Oct	Storck and Newman 1992

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

live bait caused little morality if anglers conscientiously did not allow pike to swallow the bait. In a study conducted by the Organization for the Improvement of Freshwater Fisheries, a sportfishing organization in the Netherlands, Grimm (1981) found that live bait on single or treble hooks and spinners with single hooks or treble hooks caused little hooking mortality. In that study, hooking mortality was evaluated by retaining angled pike in holding ponds that were later drained. Hooks were not removed, rather lines were cut. Large numbers of pike were evaluated, and the pike were held for long periods; 6 months in one part of the study and 10 months in another part of the same study. The authors concluded that the factor that affected mortality most strongly was whether the hook was swallowed deeply by the pike. Mortality averaged 13.5% when baited hooks were swallowed deeply compared to 4.2% when baited hooks were not swallowed deeply, regardless of whether the hook was single or treble. The study was conducted by anglers. Water temperature and the time of year when the study was conducted were not reported. Storck and Newman (1992) reported that hooking mortality was lower for tiger muskellunge taken on live bait (principally minnows) compared to artificial lures, but not significantly so (chi-square test, $p>0.05$; specific numbers and rates not reported). The tiger muskellunge did not tend to swallow either live bait or artificials.

Hooking mortality was low for esocids caught on artificial lures. Though Beukema (1970) did not specifically evaluate mortality of northern pike caught on artificial lures, he did find a low overall mortality rate of 5.3% for northern pike caught on either a spinner or live roach. Weithman and Anderson (1976) also did not specifically evaluate hooking mortality on artificial lures. They fished solely with artificial lures and found only 1 northern pike died in their study of 38 northern pike, 9 muskellunge, and 12 tiger muskellunge. That fish was deeply hooked, though they documented three other deeply hooked fish that survived. Most esocids in Weithman and Anderson's study were hooked in the maxillary and premaxillary, which caused little damage. Storck and Newman (1992) reported an overall hooking mortality rate of 11.7% for tiger muskellunge taken on artificial lures or live bait but did not divide the rate by terminal tackle type. Grimm (1981) found a mortality rate of 0% for 19 northern pike taken on spinners with single hooks and 2.4% for 41 northern pike taken on spinners with treble hooks.

It is not clear if barbless hooks increase hooking mortality compared to barbed hooks. Falk and Gillman (1975) found a hooking mortality of 10.5% for barbless hooks compared to 5.3% for barbed hooks. The sample size for barbless hooks was only 19 fish (Table 1) and the difference in mortality rates was not significant.

Pike hooks caused unusually high hooking mortality. They caused the highest hooking mortality for any of the studies reviewed, 33.3% for northern pike taken on baited size 4 and 10 pike hooks (DuBois et al. 1994). DuBois et al. postulated that either the large gauge metal of the hook caused large, deep wounds, or the unique configuration of the tackle resulted in more tissue damage during hook-set or playing of the fish. Damage may have also occurred during hook removal of this relatively large tackle. The next highest estimate of hooking mortality, 30%, was for muskellunge in a physiology study (Beggs et al. 1980) where the fish were more extensively handled than they would be by the typical angler (i.e., they were anaesthetized, cannulated, and retained in a respirometer for up to 84 hours).

Handling, transport, and release environments are expected to affect angler induced hooking mortality. Richards and Ramsell (1986) estimated a 17% recapture rate of captured, tagged, and released muskellunge by average anglers in a typical angling setting. This rate equaled or exceeded most muskellunge exploitation estimates reported by state and federal fisheries agencies, and indicated excellent survival and tag retention of fish handled by average muskie anglers.

Few studies specifically examined handling, transport, and release methods thus these factors could not be compared between studies. The following are some observations on the

methods used in various studies. The length of time to land a fish ranged from about 1-4 min (Falk and Gillman 1975; Beggs et al. 1980; Schwalme and Mackay 1985; Strand 1986; Dubois et al. 1994). Some researchers landed fish by grasping the leader (Falk and Gillman 1975), using a net (Falk and Gillman 1975; Beggs et al 1980), or using a landing cradle (Strand 1986). Pliers or forceps were used for hook removal in some studies (Weithman and Anderson 1976; Dubois et al. 1994) while jaw spreaders were used in another study (Dubois et al. 1994). Fish were transported in coolers (Dubois et al. 1994) or live wells (Falk and Gillman 1975; Schwalme and Mackay 1985; Storck and Newman 1992) and released to tanks (Schwalme and Mackay 1985), holding nets (Dubois et al. 1994) or cages (Falk and Gillman 1975; Storck and Newman 1992), ponds (Weithman and Anderson 1976), or lakes (Strand 1986). Falk and Gillman (1975) noted that northern pike were very active after release to holding cages, resulting in damage that promoted nonlethal fungal infections. Stork and Newman (1992) found anglers spent more time handling tiger muskies caught on artificial lures with multiple hooks than on live bait.

Little information was available on the effect the fish's size had on hooking mortality. Weithman and Anderson (1976) suggested that larger esocids would be more difficult to handle, which would slow time to unhook, and result in higher mortality. However, Storck and Newman (1992) found no difference in hooking mortality of small (<600 mm) and large ($\geq$ 600 mm) tiger muskellunge.

The relationship of esocid hooking mortality and temperature was not evaluated specifically in any individual study, but some observations suggest that esocid mortality was less at cooler temperatures. Storck and Newman (1992) found hooking mortality of tiger muskellunge was lower for April-June and September-October (mean water temperature = 21.5°C) than in July or August (mean water temperature = 27.5°C). Fifty to 85% of hooking related mortalities occurred during July and August even though 22-33% of the catch was taken during those months. Strand (1986) found 0% hooking mortality for radio-tagged muskellunge released in cool water temperatures (mean surface water temperature at time of surgery 21.4°C). Survival can also be good for esocids released in cold water during the winter. Hooking mortality was less than 1% for northern pike caught by angling through the ice with treble hooks (DuBois et al. 1994). The greater vulnerability of esocids to angling in spring and fall and lower catch in summer (Weithman and Anderson 1976; Storck and Newman 1992) may coincidentally serve to reduce hooking mortality.

Summary

Sufficient information was available to estimate that the average hooking mortality of northern pike was below 5%. If pike hooks were not included, hooking mortality was estimated as 4.5%. This estimate should allow fisheries managers to effectively model different size regulations and predict whether size regulations will work and which size regulations will work best.

Low hooking mortalities should make catch and release fishing acceptable to anglers and policy makers. However, if further reductions in hooking mortality were required, they might be accomplished with angler education on handling and releasing techniques (Weithman and Anderson 1976; Grimm 1981; Taylor and White 1992), or limiting the use of live bait and pike hooks.

The low hooking mortality estimates found in this literature review reduces the need for further study on factors expected to influence northern pike hooking mortality - type of terminal gear, hooking site, size and number of hooks, the presence or absence of hook barbs on hooks, handling techniques (method of hook extraction, length of handling and effects of barbs on handling time), fish length (the entire possible size range), and water temperature. Results of further work would likely produce only small reductions in hooking mortality estimates, with one exception. Fish caught with pike hooks suffered high mortality rates. Given the relatively small sample size used to determine mortality of northern pike caught

with pike hooks (24 fish), additional studies may be useful for ensuring an accurate estimate of hooking mortality with pike hooks.

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