Gamefish Bycatch and Mortality in Hoop Nets in the St. Johns River, Florida

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Abstract: An intensive hoop net study was conducted on the St. Johns River, Florida, to: (1) estimate commercial hoop net effort, bycatch and initial gamefish mortality; (2) determine delayed mortality of game fish caught in hoop nets; and (3) estimate riverwide gamefish mortality in hoop nets. A survey of all known hoop net fishers revealed 38 fished 2,386 hoop nets for 794,300 net-days of effort in 1993. Between July 1992 and June 1993, 1,053 commercially-fished hoop nets were observed that were fished 7,320 net-days. Catfish (Ictaluridae) comprised 95% of the 87,278 individuals captured, while game fish comprised 2.3% of the total catch. Estimated riverwide hoop net-induced mortality in 1993 was 1 black crappie (*Pomoxis nigromaculatus*)/9.7 ha and 1 *Lepomis* spp./10.5 ha. We felt these low mortality estimates did not threaten gamefish populations on the St. Johns River, and recommended allowing the continued use of hoop nets.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 49:216–223

Hoop nets have been fished commercially for catfish in many southeastern states, including Alabama (Bryan and White 1958, Spencer et al. 1965), Louisiana (Lambou 1963), and West Virginia (Leckie 1981). Currently, 11 of 16 southeastern states surveyed allow hoop nets to be fished commercially. In Florida, Dequine (1948) reported only a few hoop nets were fished prior to 1946 when all commercial fishing devices (with the exception of trotlines) were banned. Beginning in 1947, the Florida Game and Fresh Water Fish Commission (GFC) reinstated hoop net fishing on the St. Johns River and Lake Okeechobee under strict regulation. Hoop nets are currently legal in Florida only in specific locations on the St. Johns River.

The commercial fishery on the St. Johns River is well-documented (Hale et al. 1986*a*, 1991). It generated an average annual wholesale value of $2.3 mil-

lion between 1986 and 1991. Catfish landings comprised the bulk of the freshwater commercial harvest. The hoop net was the most effective commercial fishing device used on the St. Johns River (followed by trotlines and wire traps) and accounted for most of the catfish harvest. Studies by Hale et al. (1981*a*) and Hale et al. (1984) estimated 80% of the St. Johns River catfish landings were harvested by hoop nets. This estimate was supported by a catfish tagging study conducted between 1983 and 1985 where approximately 70% of all tag returns came from hoop net harvest (Hale et al. 1986*b*).

Controversy surrounding freshwater commercial fishing devices in Florida has been documented since 1946 (Dequine 1948, 1950, 1952). To address more recent concerns, hoop net studies were conducted in the 1980s to determine their catch composition and potential impact (Hale et al. 1981*a*, Hale et al. 1984, 1986*a*). While catch rates and initial mortality were estimated in previous studies, delayed mortality, total commercial effort, and total mortality were not estimated. This study was conducted with the following objectives: (1) estimate commercial hoop net effort, bycatch and initial gamefish mortality; (2) determine delayed mortality of game fish caught in hoop nets; and (3) estimate riverwide gamefish mortality in hoop nets.

Methods

The St. Johns River, located in east-central Florida, is 483 km long and has a drainage area of approximately 25,900 km^2. Tidal fluctuations average 1.5 m at the river mouth and tidal effects are evident as far upstream as Lake George (193 km). During droughts, high tides combined with northeasterly winds can cause upstream flow 257 km south to Lake Monroe (Hale 1993).

The St. Johns River was divided into 3 areas where hoop net fishing was legal to ensure the entire fishery was evaluated. Hoop nets are legal in the 78,688 ha between Jacksonville and State Road 46 near Sanford.

Effort, Bycatch and Initial Gamefish Mortality

All known commercial hoop net fishers (as determined by biologists, wildlife officers, and other fishers) were contacted by telephone and asked to participate in a short survey addressing the 1993 St. Johns River hoop net fishery. Fishers were contacted by telephone to save time and to produce more accurate results (Johnson and Timmons 1989). Fishers were asked how many hoop nets they fished, the number of days nets were fished and their location. The number of nets was multiplied by the number of days fished to yield an estimate of 1993 commercial hoop net effort.

Project personnel accompanied commercial fishers during normal fishing operations in the 3 areas to document gamefish bycatch in hoop nets. From 1 July 1992 through 30 June 1993, at least 2 observation trips were made monthly. Observed hoop nets consisted of 4 hoops varying from 0.9 to 1.4 m in diameter with a nylon webbing funnel at each of the front 2 hoops. The front funnel and

net wall were constructed of 51- to 76-mm stretch mesh nylon netting, with the rear funnel and wall of 51-mm stretch mesh. Nets were anchored to the substrate and fished with openings facing downstream, unbaited, or baited with soybean chips or blueback herring (*Alosa aestivalis*). Fishing effort was reported in net-days (1 hoop net fished for 24 hours).

Harvestable-size game fish were arbitrarily defined as: *Lepomis* spp. ≥150 mm total length; black crappie ≥230 mm; largemouth bass (*Micropterus salmoides*) ≥356 mm; and striped bass (*Morone saxatilis*) and sunshine bass (*M. saxatilis* X *M. chrysops*) ≥250 mm. Game fish were freshwater fish designated as game fish in Florida Administrative Code 39–1.004.

Effort and harvest information including location and duration of the set, number of fish caught, whether game fish were of harvestable or subharvestable size, and initial mortality of all fish were recorded for each hoop net observed. Accurate onboard estimates of catfish were not possible because of the large number caught (up to approximately 8,500/day). Therefore, subsamples of catfish were weighed and counted at fish houses to estimate the daily catfish harvest by number. All game fish caught in observed hoop nets were immediately returned to the water in compliance with GFC regulations. Gamefish initial mortality was assigned when fish did not swim out of sight in 2–5 minutes before the fishing boat moved to another site. A less subjective method for determining initial mortality, such as opercular movement, was considered. Since the opercular movement criterion could greatly overestimate survival, we chose the more conservative criterion of requiring the fish to have the ability to swim away.

Delayed Gamefish Mortality

Twelve commercial hoop nets were purchased from a commercial fisher to determine gamefish delayed mortality. These nets were identical to nets used by commercial fishers and consisted of 51-mm nylon mesh stretched over 4 1.2-m fiberglass hoops. The unbaited nets were fished monthly in Lake George, an 18,623-ha widening of the St. Johns River, from August 1994 through July 1995. Hoop net funnels or throats were opened slightly (which would encourage gamefish entrance) to ensure enough game fish would be caught for mortality determination. After 7 days (the same amount of time commercial nets were fished), nets were inspected and fish were handled utilizing the same techniques as commercial fishers. Up to 20 game fish were randomly selected in regard to condition and placed back into the nets which were tied-off to prevent fish from entering or leaving. A mixture of harvestable-size and subharvestable-size fish was used when possible. After 2 days, nets were raised again and fish were inspected to determine survival. Dissolved oxygen and water temperature values were determined at the water surface and at the net.

Total Gamefish Mortality

Commercial fishing effort, as determined by the telephone survey, was multiplied by the gamefish catch rate in observed nets to yield the annual num-

ber of game fish captured. This annual number was then multiplied by the initial mortality percentage. After subtracting the initial mortality value from the annual gamefish bycatch, this value was multiplied by the delayed mortality percentage to yield delayed mortality. Total mortality was determined by adding initial and delayed mortalities.

Results and Discussion

Effort, Bycatch, and Initial Morality

A total of 38 hoop net fishers were contacted by telephone. They reported 794,300 net-days of commercial hoop net effort. This effort was accumulated through 1,988 hoop nets fished year-round and 398 hoop nets fished part of the year.

We observed 1,053 hoop nets that had been fished 7,320 net-days on 34 trips. Approximately 87,278 individuals of 37 fish species were captured. Commercial species (those kept by fishers and used commercially) contributed 97.1% of the entire catch by number (Table 1). Catfish (predominantly white catfish, *Ameiurus catus*) contributed 95.2% of the total catch at a rate of 11.35 fish/net-day, higher than rates previously reported in St. Johns River lake habitats (2.51 fish/net-day, Hale et al. 1984) and in riverine habitats (6.83 fish/net-day, Hale et al. 1981*a*).

Table 1. Catch composition of 1,053 commercial hoop nets fished in the St. Johns River, Florida, July 1992 through June 1993.

Species	*N* caught	% composition	*N*/net-day
	Commercial species		
Catfish	83,080	95.2	11.350
Blue crab	1,409	1.6	0.192
Striped mullet	220	0.2	0.030
Miscellaneous[a]	49	0.1	0.007
Total	84,758	97.1	
	Nongame species		
Gizzard shad	169	0.2	0.023
Atlantic croaker	168	0.2	0.023
Hogchoker	83	0.1	0.011
Miscellaneous[b]	102	0.1	0.014
Total	522	0.6	
	Freshwater game fish		
Lepomis spp.[c]	1,276	1.5	0.174
Black crappie	704	0.8	0.096
Morone spp.[d]	11	<0.1	0.002
Largemouth bass	7	<0.1	0.001
Total	1,998	2.3	0.273

[a]Four commercial species that each made up <0.1% of the total by number.
[b]Twelve nongame species that each made up <0.1% of the total by number.
[c]Four species, but predominantly composed of bluegill.
[d]Combination of striped bass and sunshine bass.

A total of 1,998 freshwater game fish (2.3% of the total) were captured in observed nets at a rate of 0.27/net-day. *Lepomis* spp. (almost entirely bluegills, *L. macrochirus*) made up 64% of all the game fish; black crappies made up 35%. When combined, *Morone* spp. and largemouth bass contributed <1% of all the game fish.

The gamefish catch rate was much lower than that in earlier studies. Hale et al. (1981*a*) reported a gamefish catch rate of 1.06 fish/net-day in the St. Johns River in 1980–1981 and 1.39 fish/net-day in St. Johns River lake habitats in 1980–1983 (Hale et al. 1984). The lower gamefish catch rate in this study may be attributed primarily to a change in the type of funnel design used in hoop nets after 1983. Most commercial fishers used a "finger throat" design in their hoop net funnel in the early 1980s, but later switched to a "webbing throat" design. Finger throat funnels offer less obstruction to fish entering the net than webbing throat funnels. The webbing throat design is more restrictive and, when fished properly, requires a fish to force its way into the catch area of the net.

Hale et al. (1981*b*) determined significantly fewer game fish ($P < 0.01$) were caught in webbing throat nets than in finger throat nets. That study reported a catch rate of 1.36 game fish/net-day in finger throat nets and was similar to the 1.06 fish/net-day (Hale et al. 1981*a*) and 1.39 fish/net-day (Hale et al. 1984) catch rates in commercially fished nets. The 1981 gamefish catch rate of 0.21/net-day in webbing throats (Hale et al. 1981*b*) was similar to our gamefish catch rate (0.27 fish/net-day). Approximately 95% of hoop nets observed in our study were webbing throat nets. A voluntary switch from finger throats to webbing throats has apparently reduced gamefish bycatch in the St. Johns River.

The proportion of baited hoop nets may also have affected gamefish catch rates. Pierce et al. (1981) reported unbaited hoop nets caught 3 times more black crappie than baited nets in the upper Mississippi River. In lake habitats of the St. Johns River, Hale et al. (1984) reported unbaited hoop nets caught 15 times more black crappie than baited hoop nets. Conversely, bluegill exhibited higher catch rates in baited hoop nets than in unbaited nets (Pierce et al. 1981, Hale et al. 1984). Less than 25% of observed St. Johns River hoop nets in the early 1980s were baited (Hale et al. 1984), while 48% of the nets observed in our study were baited.

Hoop net catch rates of black crappie and bluegill in the St. Johns River in the 1980s (Hale et al. 1984) were much higher than and about half, respectively, those in our study. Possible contributing factors to this trend include: (1) change in funnel type (finger throat vs. webbing throat) and (2) a higher proportion of baited nets. Another possible explanation for the lower black crappie catch rate and higher bluegill catch rate in our study might be a shift in relative population densities. Unfortunately, no long-term population data were available to address this hypothesis.

In observed hoop nets, initial mortality was 5.4% (13 of 240) for harvestable-size black crappie and 6.5% (30 of 464) for subharvestable-size black crappie. *Lepomis* spp. exhibited lower mortality (1.9% or 12 of 643 for harvestable-

size and 1.6% or 10 of 633 for subharvestable-size fish) than black crappie. No initial mortality was observed for the 6 harvestable-size or 5 subharvestable-size *Morone* spp. captured. Of the 7 largemouth bass captured, all were subharvestable-size and 1 suffered initial mortality. Gamefish initial mortality values were too small to yield accurate estimates by area. Therefore, initial mortality values by area were combined to yield 1 riverwide value for harvestable-size and subharvestable-size black crappie and *Lepomis* spp.

Delayed Gamefish Mortality

From August 1994 through July 1995, 124 hoop nets were fished in Lake George for 878 net-days of effort. A total of 2,919 fish were caught, of which 1,829 (62.7%) were black crappies, 171 (5.7%) were *Lepomis* spp., and 821 (28.1%) were catfish.

Of the 1,031 black crappies kept for observation, harvestable-size fish exhibited 1.1% delayed mortality (6 of 546). Subharvestable-size black crappies exhibited 7.6% delayed mortality (37 of 485). No delayed mortality was observed in 91 harvestable-size *Lepomis* spp. while 7.4% (4 of 54) of subharvestable-size *Lepomis* spp. exhibited delayed mortality. Five largemouth bass (all subharvestable size) exhibited 20% delayed mortality. None of 5 *Morone* spp. (all harvestable size) exhibited delayed mortality.

Subharvestable-size black crappies were the only species and size group captured with enough frequency to allow monthly dissolved oxygen and temperature evaluation. Monthly average dissolved oxygen levels near each net ranged from 4.3 ppm in November to 8.4 ppm in April. Dissolved oxygen levels had no apparent effect on mortality since the month with the highest subharvestable-size black crappie mortality (20% in June) also had a high dissolved oxygen level (8.2 ppm). No black crappie mortality was observed in November, the month with the lowest dissolved oxygen level (4.3 ppm). However, mortality did appear to be related to temperature. The highest mortalities for subharvestable-size black crappie were observed in the 5 hottest months (23.8 - 31.2 C), while no mortality was observed in the 4 coldest months (16.6 - 22.0 C). Since hoop nets were used to hold fish and controls were not used, our delayed mortality estimates represented a worst-case scenario.

Annual Gamefish Mortality

An estimated 19,858 harvestable-size and 50,041 subharvestable-size black crappies were caught in the 1993 riverwide commercial hoop net fishery (Table 2). Total mortality figures were 1,279 harvestable-size (1 fish/60.7 ha) and 6,809 subharvestable-size (1 fish/11.6 ha) black crappies. When both size groups were combined, the annual riverwide black crappie mortality was 1 fish/9.7 ha.

Annual *Lepomis* spp. bycatch was much higher than black crappie bycatch. An estimated 75,458 harvestable-size and 68,310 subharvestable-size *Lepomis* spp. were captured in 1993 hoop nets. Although *Lepomis* spp. bycatch was much higher than black crappie bycatch, total mortality estimates were similar be-

Table 2. Annual estimates for the 1993 St. Johns River, Florida, commerical hoop net fishery.

Parameter	Black crappie		*Lepomis* spp.	
	Harvest[a]	Subharvest[b]	Harvest[a]	Subharvest[b]
Catch rate (*N*/net-day)	0.025	0.063	0.095	0.086
Total caught (*N*)	19,858	50,041	75,458	68,310
Initial mortality (*N*)	1,072	3,253	1,434	1,093
Delayed mortality (*N*)	207	3,556	0	4,974
Total mortality (*N*)	1,279	6,809	1,434	6,067
N ha/mortality	60.7	11.6	54.9	13.0
N ha/mortality, both sizes combined	9.7		10.5	

[a]Harvestable size (black crappie ≥230 mm total length, *Lepomis* spp. ≥150 mm total length).
[b]Subharvestable size.

cause of lower *Lepomis* spp. initial and delayed mortality rates. Total mortality figures were 1,434 harvestable-size (1 fish/54.9 ha) and 6,067 subharvestable-size (1 fish/13.0 ha) *Lepomis* spp. Both size groups of *Lepomis* spp. combined yielded an annual riverwide mortality of 1 fish/10.5 ha.

Part of our role as biologists is to determine whether the use of these commercial devices significantly affects gamefish populations. To assess this possibility, we observed 1,053 commercial hoop nets, interviewed all known commercial hoop net fishers and estimated delayed mortality with GFC hoop nets. The absence of standing stock or creel data on a riverwide or area-wide basis made it difficult to determine the magnitude of impact commercial hoop nets had on gamefish populations. However, based on our findings, low mortality rates did not appear to represent a substantial effect on gamefish populations in the St. Johns River. Therefore, we do not recommend a change in current use and regulation of commercial hoop net fishing on the St. Johns River.

Literature Cited

Bryan, P. and C. E. White, Jr. 1958. An economic evaluation of the commercial fishing industry in the TVA lakes of Alabama during 1956. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 12:128–132.

Dequine, J. F. 1948. Management of Florida's fresh-water fisheries. Trans. Am. Fish. Soc. 78:38–41.

———. 1950. Biennial report 1949–50. Fla. Game and Fresh Water Fish Comm., Tallahassee. 145pp.

———. 1952. Florida's controlled seining program. Fish Manage. Bull. No. 1, Fla. Game and Fresh Water Fish Comm., Tallahassee. 39pp.

Hale, M. M. 1993. The commercial fishery of the St. Johns River, Florida. Current 12(2):20–22.

———, J. E. Crumpton, and W. F. Godwin. 1981*a*. Game fish bycatch in commercially fished hoop nets in the St. Johns River, Florida. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 35:408–415.

———, ———, and D. J. Renfro. 1981*b*. Commercial fisheries investigations annual report, 1980–81. Fla. Game and Fresh Water Fish Comm., Tallahassee. 128pp.

———, ———, and ———. 1984. Catch composition and potential impact of baited and unbaited commercially fished hoop nets in three central Florida lakes. EPA, Rep. 440/5/84-001, Washington, D.C. 604pp.

———, ———, and ———. 1986*a*. Commercial fisheries investigations completion report, 1980–86. Fla. Game and Fresh Water Fish Comm., Tallahassee. 204pp.

———, ———, and ———. 1986*b*. Catfish movement and distribution in the St. Johns River, Florida. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 40:297–306.

———, ———, and R. J. Schuler, Jr. 1991. Commercial fisheries investigations completion report 1986–91. Fla. Game and Fresh Water Fish Comm., Tallahassee. 154pp.

Johnson, R. J. and T. J. Timmons. 1989. Multiple survey evaluation of a Kentucky commercial trotline fishery. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 43:56–65.

Lambou, V. W. 1963. The commercial and sport fisheries of the Atchafalaya Basin floodway. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 17:256–281.

Leckie, F. D., Jr. 1981. Commercial fishery investigations. W. Va. Dep. Nat. Resour., U.S. Dep. Comm., Proj. No. 3–273-R-5, Charleston, 8pp.

Pierce, R. B., D. W. Coble, and S. Corley. 1981. Fish catches in baited and unbaited hoop nets in the upper Mississippi River. North Am. J. Fish. Manage. 1:204–206.

Spencer, S. L., W. E. Swingle, and T. M. Scott, Jr. 1965. Commercial fishing in the Mobile Delta, Alabama, during the period of July 1, 1963 to June 30, 1964. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 19:432–438.