EFFECTS OF HARVESTING AQUATIC BAIT SPECIES FROM A SMALL WEST VIRGINIA STREAM

(PART I)

and

CRAYFISH MARKING WITH FLUORESCENT PIGMENT

(PART II)

by

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EFFECTS OF HARVESTING AQUATIC BAIT SPECIES FROM A SMALL WEST VIRGINIA STREAM

INTRODUCTION

The use of minnows and crayfish as bait has been a long standing practice of many freshwater anglers. These bait organisms in many instances have been obtained from public lakes and streams. The exploitation of wild aquatic bait species by commercial bait dealers has generated a controversy on whether or not bait fish populations were being depleted. This study was conducted to determine if population densities of bait species can be depleted by over exploitation of wild bait stocks.

Evermann (1901), Hedges and Ball (1953), and Forney (1958) doubted that public waters would be able to satisfy the growing demand for bait minnows. Radcliffe (1931), Markus (1939), and Dobie (1947) feared more than just a bait scarcity; they foresaw damage being done to the game fish populations which utilized minnows as a forage base. Thomsen and Hasler (1944) speculated that game fish populations in minnow depleted streams were suffering not only from a forage shortage but also from the destruction of spawning nests by harvesting equipment.

The concern over shortages of aquatic bait organisms has not been restricted to minnows. Forney (1958) speculated that crayfish populations in the public waters of New York would not be sufficient to supply the demands of the growing New York fishing public. Yurane (1967) from surveying crayfish populations in Latvian SSR concluded that fishermen had in some areas completely eliminated the crayfish populations. None of the above authors cited any actual research to support their comments.

Within the last twenty years a number of reports have been published that contradict earlier views. Larimore (1954) removed 76,217 minnows from a 1.45 km (0.9 mile) section of a small Illinois stream by electro-seining methods between August, 1950 and November, 1953. He found that the removal did not reduce the minnow populations in the study sections for longer than a few months. Larimore's techniques of harvesting were more efficient than that of a typical bait dealer, but his frequency of harvesting was much less. He harvested on only nine occasions over the three year study period, whereas a bait dealer would probably have seined the same sections 20 to 35 times annually over a four to six month period.

Brynildson (1956), Brynildson and Truog (1958), and Brynildson (1959) reported similar results. Brynildson (1959) stated that a commercial bait dealer using a 30.5 m (100 ft) seine made 41 seine hauls on a Wisconsin trout stream between May 17 and November 11, 1955. Twenty-three thousand minnows and suckers were removed. The following year between April 2 and October 30 the dealer made 50 seine hauls removing 28,000 forage fish. Mark and recapture estimates (the specific type of estimator was not mentioned) were made using electro-fishing equipment during the spring and fall of both years. The results of the population estimates indicated that the seining did not lower the population densities. In 1957 and 1958 seining was prohibited and minnow traps alone were used to remove forage fish. Mark and recapture population estimates were made in the fall of 1958. The results of the estimates were interesting in that the 1958 minnow populations were double those reported in the falls of 1955 and 1956. The 1958 fall estimates also indicated that sucker populations during that year were slightly larger than the fall sucker populations of 1955 and 1956. Brynildson speculated that the increase in numbers of minnows and suckers in 1958 was due to the estimates being made later in the 1958 season than in 1955 and 1956 and thus permitting two possibilities to occur: 1) recruitment to the populations by upstream movement of fish and/or 2) recruitment of young of the year fishes to the minimum size used in the estimates. A third possibility which could account for the discrepancy is differences in the minnow and sucker spawning success during the three years. Starrett (1951) believed that minnow spawning success is greatly influenced by water level fluctuations and by the fish population densities. He believed that yearly cropping of a minnow population would produce greater yields of minnows if water levels were compatible for a successful spawn. Brynildson's harvesting in 1955 and 1956 may have reduced the populations to densities which permitted greater spawning success.

Results obtained by Summerfelt (1967) generally agreed with those obtained by Larimore and Brynildson. Summerfelt surveyed the Smokey Hill River, Kansas between May, 1965 and August, 1966. A total of 12,000 bait fishes were removed from three 91.4 m (100 yd) sections of river by electro-fishing methods. Two of the sections were harvested 17 times while a third section was harvested 16 times over the 15 month period. Summerfelt found that even after trying to remove every fish from his stations in 1965 that the corresponding collections in 1966 generally produced greater numbers of minnows. He, like Larimore, was more effective than a bait dealer but did not harvest the sections as frequently as a bait dealer would have.

My research was designed to help resolve the minnow controversy by monitoring the effects of a simulated bait operation on the bait and game fish populations of a stream. Such work should help provide for sounder management of aquatic systems.

DESCRIPTION OF STUDY AREA

Rich Creek, a spring fed stream primarily in Monroe County, West Virginia, runs 17.70 km (11 miles) before emptying into the New River, Virginia. Its drainage area is 84.95 km^2 (52.8 square miles), the majority of which is pasture land. A spring at its headwaters supports a small commercial trout hatchery. The stream as a whole is classified as a marginal trout stream and is stocked with trout during the colder months of the year. Self-sustaining game fish populations of smallmouth bass (*Micropterus dolomieui*), spotted bass (*Micropterus punctulatus*), rock bass (*Ambloplites rupestris*), and other centrarchids also inhabit the stream. Cyprinids, however, compose the greatest fish biomass of the drainage. The species present in the study area are listed in Table 1. The stream's substrate is primarily gravel with silt deposits in many areas. The water depth during average flow is 0.46-0.77 m (1.5-2.5 ft). Average width is 4.65 m (15 ft).

Table I. Fish and crayfish present in Rich Creek and their classification for this study

Categories	Species	Common Name
Bait fish		
Campostoma	*Campostoma anomalum*	Stoneroller
Nocomis	*Nocomis leptocephala*	Bluehead chub
Notropis	*Notropis albeolus*	White shiner
	Notropis telescopus	Telescope shiner
Others	*Catostomus commersoni*	White sucker
	Hypentelium nigricans	Northern hog sucker
	Pimephales notatus	Bluntnose minnow
	Pimephales promelas	Fathead minnow
	Semotilas atromaculatus	Creek chub
	Cottus bairdi	Mottled scuplin
	Etheostoma flabellare	Fantail darter
	Etheostoma blennioides	Greenside darter
Game fish	*Amblоplites rupestris*	Rock bass
	Lepomis sp.	
	Micropterus dolomieui	Smallmouth bass
	Micropterus punctularus	Spotted bass
	Salmo gairdneri	Rainbow trout
	Salmo trutta	Brown trout
	Salvelinus fontinalis	Brook trout
Crayfish	*Orconectes spinosus*	
	Cambarus bartoni bartoni	

METHODS AND MATERIALS

Bait dealer survey. A three county survey was conducted of local licensed bait dealers to determine the magnitude of their operations in order that exact simulation of a typical harvest operation could be undertaken. The survey consisted of a mail questionnaire (Appendix I) sent to 43 bait dealers. Only 14 of the questionnaires were returned, the majority of which were only partially completed. Personal interviews with 12 bait dealers in the Blue Stone Reservoir area of West Virginia were also made. The information thus obtained reflects a typical bait operation for this area. An average operation was headed by a dealer who, with the help of 1 or 2 children 16 years old or younger, collected bait three times every two weeks between May 15 and September 15 working 3-4 hours/day. Seining was carried on in small streams in pool areas just below riffles, average pool depth being about 0.9 m (3 ft). Gear used by the dealers conformed to the bait harvesting equipment laws of West Virginia; i.e., a 1.83 by 1.22 m (6 x 4 ft) seine with a mesh size of 0.64 cm (0.25 in) and minnow traps less than 60.9 cm (24 in) in length with an opening diameter of less than 2.54 cm (1 in). Rich Creek was characteristic of the streams harvested by the local bait dealers.

Experimental design. Nine 50 m sampling sections were established on Rich Creek. The sections reflect the type of area most often harvested by commercial dealers. The nine sections were selected on the basis of their similarity to each other in substrate and in pool and riffle areas. The sections were separated from each other by at least a 200 m buffering zone to minimize, if possible, mixing of populations between sections. A random block design, where the nine sections were divided into three groups, each group receiving three different harvesting pressures, was incorporated so that differences between individual stations would not mask possible treatment effects. The pressures included 1) control areas (station III, IV, and VIII) where no fish were removed, 2) average harvest pressure (stations II, VI and IX) in which harvesting pressure was similar to that of a typical bait dealer, and 3) a double harvest pressure (stations I, V, and VII) in which harvesting intensity was twice that of a typical bait dealer. An average harvest section was seined in an upstream direction, seining the entire length of the section and capturing as many fish and crayfish as possible. One minnow trap was also fished in the section. A double harvested section was seined through twice as above and two traps were fished. All traps were baited with bread and fished in the sections for 2-4 hours. The gear used to sample the sections was the same as used by local bait dealers. The sections were fished three times every two weeks from May 15 to September 15 except for one week in May when high water prevented sampling. All bait forms captured greater than 2.54 cm in total length (1 in) were preserved in 10% formaline, identified, and measured. Organisms less than 2.54 cm (1 in) and all game fish were measured and returned to the stream.

To further evaluate the impact of the summer's harvest each of the sections, including the controls, were intensively seined two, four, and eight weeks after the last summer harvesting date on

September 29, October 13, and November 10, 1973, respectively. Stations were sampled by means of three 7.3 m (24 ft) seines, one seine used as a block seine at the head end of a section while the other two seines were used to remove as many fish and crayfish as possible. All fish and crayfish captured were identified, measured, divided into species, and total weight determined for each species. All organisms were returned to the stream.

Water chemistry analyses were conducted weekly from June 21, 1973 to February 9, 1974. A Hach Kit was used for all determinations.

RESULTS

Experimental design, which employed a random block design, hopefully eliminated bias among sampling stations. Examination of the summer harvesting data (Table 2 and 3) reveals two major conclusions: 1) wide unpredictable fluctuations in the numbers of fish and crayfish removed from the study area between the individual harvesting dates existed over the summer and, more importantly, 2) equally large numbers of fish were harvested from each of the sections throughout the summer indicating that the population sizes of the study sections were not depleted. Although year class data is limited, cursory examination reveals no correlation between the two harvesting pressures and different year class sizes for individual species. Results of the water chemistry analyses are contained in Table 4. Wide ranges for some parameters were due to seasonal weather changes and not daily fluctuations. No correlation could be made between the parameters determined and the fish density of the study area.

The two conclusions drawn from the summer's data are further supported by an analysis of the post-summer harvesting data. The populations in all nine stations during the post-summer harvests also showed the wide unpredictable fluctuations (Table 5) which were characteristic of the summer harvests. The post-summer harvest populations showed not only wide variation in the numbers of fish present but also wide unpredictable fluctuations in the total weights of the individual species collected (Table 6).

Table 2. Bait fish, crayfish, and game fish removed from 50 m sections of Rich Creek, West Virginia, between May 17 and September 11, 1973

DOUBLE HARVEST SECTIONS

Species and Harvesting Techniques	Station I			Station V			Station VII		
	Summer Total	Individual Dates $\bar{X}$	Individual Dates Range	Summer Total	Individual Dates $\bar{X}$	Individual Dates Range	Summer Total	Individual Dates $\bar{X}$	Individual Dates Range
Bait fish by seine									
Campostoma	120	5.0	0-13	103	4.3	0-24	117	4.9	0-24
Nocomis	152	6.3	0-20	111	4.7	0-17	105	4.4	0-21
Notropis	362	15.1	0-41	117	4.9	0-38	305	12.7	0-48
Others	82	3.4	0-8	18	0.7	0-5	37	1.5	0-5
Total	716	29.8	14-66	349	14.5	1-50	564	23.5	5-66
Bait fish by trap	34	1.4	0-12	26	1.1	0-8	162	6.7	0-29
Game fish by seine	235	9.8	0-32	29	1.2	0-4	8	0.3	0-1
Game fish by trap	7	0.3	1-3	43	1.8	0-6	11	0.5	0-5
Crayfish by seine	223	9.3	2-18	12	0.5	1-8	13	0.5	0-6

Table 2. continued

AVERAGE HARVEST SECTIONS

Species and Harvesting Techniques	Station II			Station VI			Station IX		
	Summer Total	Individual Dates		Summer Total	Individual Dates		Summer Total	Individual Dates	
		$\overline{X}$	Range		$\overline{X}$	Range		$\overline{X}$	Range
Bait fish by seine									
Campostoma	32	1.3	0-6	97	4.0	0-58	248	10.3	0-60
Nocomis	91	3.8	0-17	57	2.4	0.7	171	7.1	0-23
Notropis	232	9.7	2-39	163	6.8	0-36	269	11.2	0-36
Others	55	2.3	0-7	22	0-9	0-5	30	1.3	0-4
Total	410	17.1	3-29	339	14.1	1-41	718	29.9	10-88
Bait fish by trap	23	1.0	0-11	86	3.6	0-20	17	0.7	0-9
Game fish by seine	76	3.2	0-12	10	0.4	0-2	89	3.7	0-21
Game fish by trap	1	0.04	0-1	5	0.2	0-1	1	0.04	0-1
Crayfish by seine	106	4.4	0-18	12	0.5	0-3	18	0.7	0-3

Table 3. Total numbers of organisms removed for each of the different harvesting pressures exerted on Rich Creek, West Virginia, during the summer of 1973

Species	Harvesting Methods	Harvesting Pressure	Harvesting Dates 5-17	5-22	6-4	6-12	6-14	6-20	6-26	6-28	7-4	7-10	7-12	7-18	7-24
Bait fish	Seine	Average	54	86	43	68	47	19	53	39	54	43	61	46	47
		Double	56	114	58	90	38	35	83	39	66	63	66	72	45
	Trap	Average	0	0	0	0	0	0	9	8	4	4	28	17	22
		Double	0	0	17	1	1	2	4	8	17	12	5	14	18
Game fish	Seine	Average	3	5	1	0	2	3	1	3	3	3	3	0	9
		Double	5	4	2	2	1	4	3	2	3	4	4	18	12
	Trap	Average	0	0	1	0	0	0	1	1	1	1	0	0	0
		Double	0	4	0	11	1	0	2	4	6	1	3	0	2
Crayfish	Seine	Average	18	6	6	18	0	2	5	13	1	6	3	3	3
		Double	12	16	8	12	2	5	10	11	5	10	10	9	7

Table 3. continued

Species	Harvesting Methods	Harvesting Pressure	7-26	8-2	8-7	8-9	8-15	8-23	8-28	8-30	9-4	9-9	9-11	Total For Summer
Bait fish	Seine	Average	34	48	170	49	34	82	76	95	75	60	83	1466
		Double	42	49	65	36	33	154	78	139	69	69	70	1629
	Trap	Average	17	3	0	0	0	6	0	0	6	0	2	126
		Double	15	25	0	28	2	30	8	5	1	5	4	222
Game fish	Seine	Average	13	7	12	14	23	5	4	19	3	27	12	175
		Double	20	6	16	18	29	18	7	36	18	17	23	272
	Trap	Average	0	0	1	0	1	0	0	0	0	0	0	7
		Double	5	1	3	6	3	1	3	1	1	3	0	61
Crayfish	Seine	Average	2	3	3	3	6	1	7	9	1	8	9	136
		Double	13	6	18	10	16	7	12	17	12	2	18	248

Table 4. Summary of weekly water quality determinations (Hach Kit) on Rich Creek, West Virginia between June 2, 1973 and February 9, 1974

Water Quality Parameters		Average	Range	Average	Range	Average	Range
Temperature °C	Air	14.4	-2-+31	14.5	-1-+31	14.5	0-+31
	Water	12.6	4-23	13.1	4-24	13.4	4-25
pH		7.5	7.0-8.5	7.4	6.9-8.4	7.6	7.1-8.5
Dissolved Oxygen (p.p.m.)		10.2	7.6-13.0	10.1	8.0-11.4	9.6	8.0-11.0
Total Alkalinity (p.p.m.)		115.3	90-145	131.1	110-145	124.5	90-140
Hardness (p.p.m. as $CaCO_3$)	Ca	105.0	90-110	105.5	100-130	105.5	90-120
	Total	144.0	130-160	147.5	120-160	142.4	120-160
Nitrogen (p.p.m.)	$N\text{-}NO_2$	0.016	0.005-0.04	0.022	0.005-0.1	0.013	0.005-0.03
	$N\text{-}NO_3$	0.31	0.12-0.6	0.31	0.04-0.51	0.28	0.10-0.41
Ortho-phosphate (p.p.m.)		0.73	.15-3.0	1.25	0.1-6.6	2.1	0.14-18.0
Turbidity (J.T.U.)		2.2	0-15	2.0	0-10	4.1	0-32

Table 5. Total numbers of organisms per category captured in the nine study sections of Rich Creek, West Virginia, during the post-harvesting season collections of 1973

Categories	Control Sections				Sections Receiving Average Harvest Pressure				Sections Receiving Double Harvest Pressure			
	III	IV	VIII	Total No. Removed	II	VI	IX	Total No. Removed	I	V	VII	Total No. Removed
	September 28-29, 1973 Collections											
Bait fish												
Campostoma	81	0	3	84	11	1	146	158	12	0	3	15
Nocomis	4	0	3	7	2	0	8	10	1	0	1	2
Notropis	95	17	5	117	41	31	142	214	84	8	11	103
Others	6	1	2	9	2	1	1	4	14	0	1	15
Total	186	18	13	217	56	33	297	386	111	8	16	135
Game fish	19	0	2	21	27	0	25	52	59	0	0	59
Crayfish	28	0	14	42	250	10	21	281	291	0	8	299

Table 5. continued

Categories	III	IV	VIII	Control Sections Total No. Removed	II	VI	IX	Sections Receiving Average Harvest Pressure Total No. Removed	I	V	VII	Sections Receiving Double Harvest Pressure Total No. Removed
October 12-13, 1973 Collections												
Bait fish												
Campostoma	26	1	1	28	2	2	6	10	7	4	0	11
Nocomis	9	3	1	13	1	1	3	5	3	4	0	7
Notropis	55	6	10	71	26	63	57	146	74	35	0	109
Others	8	1	3	12	1	1	2	4	12	0	0	12
Total	98	11	15	124	30	67	68	165	96	43	0	139
Game fish	31	1	0	32	36	2	8	46	15	4	0	19
Crayfish	161	10	22	193	186	2	20	208	119	7	22	148

Table 5. continued

Categories	Control Sections				Sections Receiving Average Harvest Pressure				Sections Receiving Double Harvest Pressure			
	III	IV	VIII	Total No. Removed	II	VI	IX	Total No. Removed	I	V	VII	Total No. Removed
November 8-9, 1973 Collections												
Bait fish												
Campostoma	28	2	0	30	14	2	34	50	9	4	1	14
Nocomis	0	2	2	3	2	8	0	10	1	3	3	7
Notropis	0	11	10	21	15	55	9	79	55	54	38	147
Others	7	1	1	9	7	3	4	14	3	5	2	10
Total	35	15	13	63	38	68	47	153	68	66	44	178
Game fish	11	0	0	11	10	0	6	16	7	4	0	11
Crayfish	50	7	3	60	29	2	4	35	9	4	3	16

Table 6. Total weight in grams of organisms per category captured in the nine study sections of Rich Creek, West Virginia, during the post-summer harvesting season collections of 1973

Categories	Control Sections				Sections Receiving Average Harvest Pressure				Sections Receiving Double Harvest Pressure			
	III	IV	VIII	Total No. Removed	II	VI	IX	Total No. Removed	I	V	VII	Total No. Removed
					September 28-29, 1973 Collection							
Bait fish												
Campostoma	328	0	7	335	40	1	149	189	13	0	4	17
Nocomis	37	0	8	45	28	0	112	140	1	0	9	9
Notropis	361	76	21	458	162	74	246	481	254	17	17	287
Others	9	2	6	17	5	0	4	9	15	0	4	18
Total	735	78	42	855	235	75	511	819	283	17	34	331
Game fish	158	0	16	174	20	63	49	132	191	0	0	191
Crayfish	237	0	76	313	998	120	5	1123	1082	0	54	1136

Table 6. continued

Categories	Control Sections III	IV	VIII	Total No. Removed	Sections Receiving Average Harvest Pressure II	VI	IX	Total No. Removed	Sections Receiving Double Harvest Pressure I	V	VII	Total No. Removed
						October 12-13, 1973 Collection						
Bait fish												
Campostoma	45	4	3	52	1	5	14	20	7	24	0	31
Nocomis	14	31	1	46	13	3	14	30	37	32	0	69
Notropis	251	43	18	312	38	112	170	320	152	184	0	336
Others	14	4	7	25	2	6	2	10	0	0	0	0
Total	324	82	29	435	54	126	200	380	196	240	0	436
Game fish	89	13	0	102	45	2	10	57	21	6	0	7
Crayfish	890	88	144	1122	554	24	37	615	386	79	299	764

Table 6. continued

Categories	Control Sections III	IV	VIII	Total No. Removed	Sections Receiving Average Harvest Pressure II	VI	IX	Total No. Removed	Sections Receiving Double Harvest Pressure I	V	VII	Total No. Removed
					November 8-9, 1973 Collection							
Bait fish												
Campostoma	57	19	0	76	22	8	101	131	10	18	1	29
Nocomis	0	2	5	7	4	26	0	30	4	20	5	29
Notropis	0	58	16	74	26	104	6	136	66	174	39	279
Others	10	2	1	13	219	221	8	448	4	604	4	612
Total	67	81	22	170	271	359	115	745	84	816	49	949
Game fish	36	0	0	36	10	0	6	16	6	229	0	335
Crayfish	268	105	10	383	70	18	12	100	62	33	4	99

Statistical analysis of the post-summer harvest data supports the above findings. No significant difference was found at $\alpha = 0.05$ (F test) in total numbers or total weights of each of the four bait fish categories, game fish category, or the crayfish category between stations receiving different harvesting pressures for each of the three post-season harvesting dates (Table I contains definitions of the categories). One exception to this was the total number of *Notropis* collected on the third post-summer harvest date. Because wide fluctuations did occur within the stations' populations during both the summer and fall harvest, it is believed that this exception was due to population fluctuations and not due to the different harvesting pressures. There was also no significant difference (F test, $\alpha = 0.05$) between the simple linear regression lines determined over the elapsed time of the post-harvest season for the total weight and total number of organisms removed from all sections.

The seining mortality for all fish removed on individual post-summer harvest dates varied from 19% during the warm, September harvest to 0% during the November harvest when water temperatures were near freezing. Actual numbers removed from the populations during post-season harvests were small compared to summer levels and thus were believed to have had little effect on the results.

DISCUSSION

The unpredictable fluctuations in the numbers of bait fishes removed from Rich Creek during the summer harvest period suggests wide spread movement of the fish populations within the stream. Funk (1955) found that each population of the 14 species of warmwater fish inhabiting a stream could be divided into two components, a sedentary group and a mobile group. Individuals of the sedentary segment had a definite home range and remained within a limited area. Individuals of the mobile segment did not exhibit a home range and wandered unpredictably within the stream. Gunning and Shoop (1964) studied a stream population of sharpfin chubsuckers (*Erimyzon tenuis*) and found evidence that members of this species occupied home ranges. Gunning and Berra (1968) reported that the sharpfin chubsucker also had a mobile segment of its population which exhibited a spring and/or summer type of movement which was not associated with the spring spawning movement. The movement of the stream's fish population into and out of the sample sections might explain the fluctuations in captures observed during this study.

The main reasons why it is unlikely that minnow populations, such as exist in Rich Creek, could be seriously depleted over a summer by a bait dealer, have been stated by Larimore (1954): 1) minnows have a short life cycle, 2) they have a great reproductive potential, 3) they exhibit a rapid growth rate, and 4) they cannot be efficiently harvested from most streams. Even if under the most extreme conditions a bait dealer did deplete a stream's minnow population, the depletion would most likely only be temporary. The following spring the known migrations of most stream dwelling minnows would occur (Trautman 1957) and would repopulate the stream. Larimore et al. (1959) have reported on the effectiveness of a spring migration in restoring a stream's fish fauna. Their study dealt with an Illinois stream in which the fish population had been completely eliminated by the combination of a severe drought and by the retenoning of the remaining fish containing pools. Two weeks after the spring rains restored full water flow, the stream was repopulated by 21 of the 29 regularly occurring fishes. Similar results of the repopulation of streams where drought conditions and fish kills have reduced or completely eliminated minnow fauna have been observed by Paloumpis (1958), Harrel, et al. (1967), and Olmsted and Cloutman (1974).

Crayfish populations, like minnow populations, fluctuated unpredictably over the summer harvesting period. Unlike fish, no mobile and sedentary segment for a crayfish population has been proposed. There is evidence of crayfish movement within a stream (Momot 1966), but crayfish most likely exhibit home range tendencies (Black 1963; Merkle 1969).

From the data obtained during the post-summer harvest it is evident that the 1.22 m (6 x 4 ft) seine was not an effective method of harvesting crayfish. Even if a larger seine had been used, it is doubtful that the stream would have been depleted for two reasons: crayfish are usually located under rocks, in burrows, or in thick vegetation and thus are not readily available to capture and crayfish are known to populate areas in extremely high densities. Penn (1960), for example, reported that crayfish populaions were as high as 135,000 crayfish/acre of stream.

The game fish populations were not apparently affected by the removal of the bait species as can be seen from the post-summer harvest data. Both the bait fish populations, which are utilized as a forage base by the game fish, and the game fish populations did not appear to be adversely affected by the different harvesting pressures. The suspicions of Thomsen and Hasler (1944) concerning destruction of spawning nests by harvesting gear is apparently not an important factor. The majority of the game fish removed during the post-summer harvest were young of the year, and thus it can be assumed that the seine did not measurably affect survival of the game fish eggs. As long as bait dealers are required to return all game fish to the stream or lake, it is very unlikely that the game fish populations could be harmed by commercial bait operations.

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Appendix I.

Survey of Local Bait Dealers

1. How long is your minnow harvesting season: (approximately)
   Beginning date . . . ________________________
   Ending date . . . . ________________________

2. Type of gear you use: (check all types of gear you use)
   a) seines . . . . ( )
   b) minnow traps . . . ( )
   c) hooks and lines. . ( )
   d) others . . . . ( ) Please describe. _______________

   ____

3. Of the above which type of gear do you use the most often?

   ____

4. Type of area which you take most of your minnows from. (check one)
   a) Lake or pond . . . . ( )
   b) River . . . . ( )
   c) Stream or creek . . . . ( )

5. If you take minnows from a river or creek:
   a) How wide is the river or creek in the area you harvest (check one)
      1) less than five feet wide . . . . ( )
      2) from six to ten feet wide . . . . . . ( )
      3) from 11 to 15 feet wide . . . . ( )
      4) from 16 to 20 feet wide . . . . ( )
      5) greater than 21 feet wide . . . . . . ( )

   b) how long of an area of the river or stream do you harvest? (approximately)

      ____

   c) do you catch most of your minnow in: (check one)
      1) pools . . . . ( )
      2) riffles . . . . . . ( )

6. How many days a week do you harvest? (average)
   a) one day . . . . ( )   e) five days . . . . ( )
   b) two days . . . . ( )   f) six days . . . . ( )
   c) three days . . ( )   g) seven days . . . ( )
   d) four days . . . ( )

7. How many hours a week do you spend harvesting? (check one)
   a) less than three hours . . . . ( )
   b) more than three hours but less than six hours . . . . ( )
   c) more than six hours but less than nine hours . . . . ( )
   d) more than nine hours but less than 12 hours . . . . . ( )
   e) more than 12 hours . . . . ( )

8. How many people work with you when you harvest? (check one)
   a) work alone . . . . ( )
   b) one other person . . . . ( )
   c) two other people . . . . ( )
   d) three other people . . . . ( )
   e) four or more other people . . . . ( )

9. Do you also catch: (check all of the types you take)
   a) crayfish . . . . ( )
   b) hellgrammites. . . . . ( )
   c) salamanders . . . . ( )
   d) frogs . . . . ( )

10. Comments about your operation that you think may be helpful for me to know.

____

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Thank you for your time and information.

PART II

CRAYFISH MARKING WITH FLUORESCENT PIGMENT

INTRODUCTION

Crayfish, because of their importance as a natural fish food and their use as bait, have been studied in their natural environment. An assortment of crayfish marking techniques have been employed. Within the last twenty years these methods have undergone several improvements. Certain crayfish appendages are now known which when clipped will produce a recognizable scar through three molts (Momot 1966). Soldering irons are presently used to brand between one to twelve dots on the carapace to individually mark up to 999 crayfish (Abrahamsson 1965). Numbering-machine inks are also successfully being employed to mark crayfish with a visible stain that will persist even after a crayfish has undergone a molt (Slack 1955; and Black 1963). Recently, radioactive materials have been used for marking crayfish (Merle 1969). The above methods each have their own advantages but all require individual handling of each crayfish.

Fluorescent granular pigment imbedded in the dermis with compressed air is now used as a rapid, inexpensive method for marking large numbers of fish. The pigment is invisible in visible light, thus protecting the organism from predators, but readily visible under ultraviolet light. This method of marking was first described by Jackson (1959) and its use has been further refined by Scidmore (1961), Phinney *et al.* (1967), Phinney and Mathews (1969), Mattson and Bailey (1969), Andrews (1972), and Phinney (1974). A study by Benton and Lightner (1972) has been the only attempt to use fluorescent pigments to mark crustaceans. They sprayed juvenile shrimp with granular fluorescent pigment at varying pressures and found that the pigment was retained even through a molt. My study attempted to determine if crayfish could be mass-marked with fluorescent pigment and if the pigment will be retained through a molt. This method should provide a fast, inexpensive means of marking large numbers of crayfish in the field for population and movement studies.

METHODS AND MATERIALS

Crayfish (*Orconectes spinosus*, *Cambarus sciotensis*, and *Cambarus brachydactylus*) used in this study were obtained from the wild and acclimated in the laboratory one week before treatment. Males and females averaged 4.75 cm (2.6-7.0 cm) from the tip of the rostrum to the end of the tail. Fifty-five percent of the crayfish used were females.

The crayfish were randomly divided into 12 groups of 10 crayfish each. Three of the groups were used as controls and were not sprayed. The remaining nine groups were divided into three treatments of three groups each. Each treatment was sprayed at 738 g/cm^2 (105 p.s.i.) pressure for either 5, 10, or 20 seconds in a shallow hand net with the spray-gun (the spray-gun is a modified sand blast gun available from Scientific Marking Materials, Seattle, Washington) held 25.4 cm (10 in) from the net. In a preliminary survey this pressure was found to allow the pigment to be retained by the crayfish even after vigorous washing under a stream of water. The air pressure from the nozzle rolled the crayfish in the net, allowing the whole crayfish to be sprayed with pigment. The yellow Day-Glo^R (Day-Glo Corp., Cleveland, Ohio) pigment used had a granular size of 175-246 microns. Following spraying, the crayfish were rinsed with tap water to remove excess pigment. Each crayfish was then placed in an individual plastic half-gallon container to prevent canabalism. The containers were set in rows of 10 with a common water supply. The 10 containers in a row were connected in series by 7.5 cm sections of Tygon^R tubing, (Norton, Plastics and Synthetics Division, Akron, Ohio) which permitted a flow through system providing aerated water and removing metabolic wastes. The first container in each row received aerated water from one of three 20 gallon aquaria. Dead crayfish were removed daily and checked for pigment retention under a long wavelength ultraviolet light. All crayfish were checked for pigment retention 2, 7, 14, 21, 35, and 56 days after treatment.

The eyestalks of crayfish contain a molt-inhibiting hormone. Removal of the eyestalks and the hormone is known to induce the molting process (Hoar 1966). To evaluate pigment retention through a molt the eyestalks of 80 of the originally treated crayfish, 20 individuals for each treatment, were surgically removed 7 days after spraying to initiate molting. Vaseline was applied to the open wounds to prevent infection.

During this study all crayfish were fed Purina Developer Trout Feed daily. Individual containers were cleaned daily to remove uneaten food and wastes. Water temperature varied between 13-17°C. All dead crayfish and molted exoskeletons were removed daily and checked for pigment retention.

RESULTS AND DISCUSSION

The yellow fluorescent pigment was visible under long-wave length ultraviolet light on all non-molted crayfish 35 days after treatment (Table I). Fifty-six days after treatment the pigment was retained by 65% of the non-molted crayfish. The pigment was typically lost by crayfish after a molt. Only 16% of the molted crayfish retained pigment after 35 days and 13% after 56 days. The pigment retained by the molted crayfish usually consisted of one or two pigment granules located in body and appendage joints. Before molting, the crayfish were fairly evenly covered with large numbers of pigment granules. Even though the molted crayfish only retained one or two granules, the pigment was still readily visible under ultraviolet light.

Mortality during the first 35 days of this study was low. Spraying mortality was less than 2%. Eyestalk removal and molting mortality was less than 5%. Overall mortality during the first 35 days of the study was less than 6%.

The methods presently used for marking crayfish all require the time consuming handling of individuals (Abrahansson 1965; Black 1963; Merle 1969; Momot 1966; and Slack 1955). This study has demonstrated that fluorescent pigment can be used to rapidly mark large numbers of crayfish with a mark readily visible under ultraviolet light that will last for more than 30 days. This marking procedure is applicable in short term movement studies where large numbers of crayfish need to

Table 1. Retention of pigment by molted and non-molted crayfish

Treatment	No. Marked	No. of Days After Treatment	No. Non-molted	No. Retaining Pigment	No. Molted	No. Retaining Pigment
105 p.s.i./	30	35	11	11	18	4
5 sec		56	6	5	22	4
105 p.s.i./	30	35	10	10	20	4
10 sec		56	7	4	23	5
105 p.s.i./	30	35	8	8	18	1
20 sec		56	5	4	21	0

be marked. Higher spraying pressures could possibly yield longer retention by non-molting crayfish and greater retention by crayfish through molts, although varying duration of spraying had no affect on retention time.

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EFFECTS OF HARVESTING AQUATIC BAIT SPECIES FROM A SMALL WEST VIRGINIA STREAM

by

Thomas M. Brandt

(ABSTRACT)

The potential impact of commercial bait harvest from small streams was studied in Rich Creek, West Virginia. A mail survey and personal interviews of bait dealers in the mountain areas of this state established typical harvest pressures exerted by commercial operations. Bait fish and crayfish in fifty m sections of Rich Creek were harvested three times every two weeks from May 15 until September 15, 1973, via seine and minnow traps. Treatments consisted of nonharvested control sections, harvest simulating a typical bait dealer, and pressure twice that of a commercial dealer; all treatments were in triplicate. The effects of the harvests were determined by comparisons over time within treatments, comparisons between treatments and comparisons with final population indices. No significant differences in these comparisons were found to occur for the bait species or for the game fish species inhabiting the study sections. The different harvesting pressures did not appear to affect the densities of the bait and game fish populations.

CRAYFISH MARKING WITH FLUORESCENT PIGMENT

by

Thomas M. Brandt

(ABSTRACT)

Fluorescent granular pigment sprayed with 738 g/cm^2 (105 p.s.i.) for 5, 10, 20 second intervals was used to mark crayfish in a laboratory study. The pigment was retained by 100% of the unmolted crayfish 35 days after treatment and by 65% of the crayfish 56 days after treatment. Crayfish which were induced to molt after being sprayed generally lost the fluorescent pigment during the molt. Mortality, (2%), due to the marking procedures was minimal.