Movement and population of the mottled sculpin (Cottus bairdi Girard) in a small Montana stream
by James David McCleave

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE in Zoology
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Abstract:
Movement and population of the mottled sculpin (Cottus bairdi Girard), excluding young-of-the-year, were studied in Trout Creek, Gallatin County, Montana between 4 August 1962 and 10 March 1963, and in the laboratory between 7 August 1962 and 21 December 1962. Fin-clipped fish were recaptured at an average rate of 23.9 per cent (38.1-11.8 per cent) for the five censuses. About 50 per cent of the recaptures were within the original section (average length 46.8 feet), and about 80 per cent were in an original section or one of the two adjacent sections (average length 153.2 feet). Upstream movement of all masked sculpins was 23.4 per cent greater than downstream movement, but downstream movement of jaw-tagged sculpins was 16.6 per cent greater than upstream. No mass upstream migration occurred. Home range was estimated to be less than 150 feet. Homing was not exhibited. About one-third of the displaced sculpins homed, one-third did not move, and one-third moved away from home. The longest upstream movement noted was 590 feet, and the longest downstream was 502 feet. Spatial isolation and aggressive behavior were not observed in a laboratory experiment, which suggests a lack of territoriality during the non-breeding season. Modified Petersen population estimates ranged from 474-555 sculpins in a 234-foot section over the five inventories, and Schumacher-Eschmeyer estimates ranged from 480-492.

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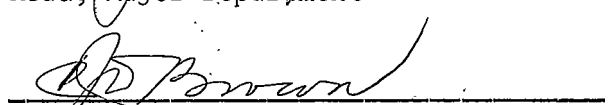
Approved:

Head, Major Department



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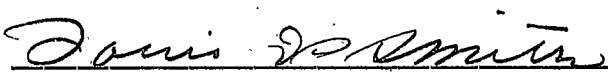

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ABSTRACT

Movement and population of the mottled sculpin (Cottus bairdi Girard), excluding young-of-the-year, were studied in Trout Creek, Gallatin County, Montana between 4 August 1962 and 10 March 1963, and in the laboratory between 7 August 1962 and 21 December 1962. Fin-clipped fish were recaptured at an average rate of 23.9 per cent (38.1-11.8 per cent) for the five censuses. About 50 per cent of the recaptures were within the original section (average length 46.8 feet), and about 80 per cent were in an original section or one of the two adjacent sections (average length 153.2 feet). Upstream movement of all marked sculpins was 23.4 per cent greater than downstream movement, but downstream movement of jaw-tagged sculpins was 16.6 per cent greater than upstream. No mass upstream migration occurred. Home range was estimated to be less than 150 feet. Homing was not exhibited. About one-third of the displaced sculpins homed, one-third did not move, and one-third moved away from home. The longest upstream movement noted was 590 feet, and the longest downstream was 502 feet. Spatial isolation and aggressive behavior were not observed in a laboratory experiment, which suggests a lack of territoriality during the non-breeding season. Modified Petersen population estimates ranged from 474-555 sculpins in a 234-foot section over the five inventories, and Schumacher-Eschmeyer estimates ranged from 480-492.

INTRODUCTION

A study of the mottled sculpin (Cottus bairdi Girard) was conducted on Trout Creek between 4 August 1962 and 10 March 1963. The objectives were: investigate the spatial stability of the population, estimate the size of the home range, determine the homing ability, and estimate the population of a segment of stream. Preliminary laboratory observations on territoriality were also made.

Bailey (1952) noted limited movement of the mottled sculpin in a Montana stream, and Williams (1957) reported restricted movement of the wooly sculpin (Clinocottus analis) in the intertidal zone off California. However Shetter and Hazzard (1939) discovered considerable instability in a population of mottled sculpins and slimy sculpins (Cottus cognatus) in a Michigan stream. Stefanich (1952) found that rainbow trout (Salmo gairdneri), brown trout (S. trutta), brook trout (Salvelinus fontinalis), mountain whitefish (Prosopium williamsoni), and white suckers (Catostomus commersoni) exhibited little movement in a Montana stream over a two year period, and Holton (1953) found the same for trout in the stream used for the present study. Miller (1957) reported similar results for the cutthroat trout (Salmo clarki), as did Shetter (1937) for brook trout and Shuck (1945) for brown trout. Some of the more important papers on limited movement of warm-water fishes in streams are those of Funk (1957) on sunfish, Gerking (1950, 1953) on suckers and sunfish, and Winn (1958) on darters.

Using Hayne's (1949) definition, Gerking (1953) estimated the home

range of suckers and sunfish and defined homing as returning to the home range rather than going to other equally suitable locations when displaced by natural migratory habits, accident, or experimental manipulation (1959). The wooly sculpin has been shown to return to a home tidepool after displacement (Williams, 1957). Shetter (1937), Shuck (1945), and Miller (1954) reported that stream-dwelling trout have the ability to home as do numerous warm-water stream species including longear sunfish (Lepomis megalotis) (Gerking, 1953; Gunning, 1959), smallmouth bass (Micropterus dolomieu) (Larimore, 1952), and walleye (Stizostedion vitreum) (Stoudt, 1939; Eschmeyer and Crowe, 1955). The homing ability of the salmon and eel is well known. Territoriality as defined by Noble (1939) has been demonstrated for many species including kamloops trout (Salmo gairdneri kamloops) (Stringer and Hoar, 1955) and green sunfish (Greenberg, 1947).

The mottled sculpin has been reported common in the study stream (Holton, 1953; Boussu, 1954; and Wipperman, 1963). Most population estimates on small streams have been conducted by direct enumeration. Shetter and Leonard (1943) used this method on the mottled sculpin and brook trout in a Michigan stream. However Crossman (1956) and McFadden (1961) employed mark-and-recapture procedures in estimating stream populations of muskellunge (Esox masquinongy) and brook trout, respectively.

The portion of Trout Creek studied is located about 3.5 air miles northeast of Belgrade, Montana. This creek originates mostly from springs and flows about 4 miles through a fertile agricultural area before its confluence with the East Gallatin River. The stream bottom in the study

area was composed of mud and fine sand in the pools and gravel in the riffles. Both overhanging and aquatic vegetation were scanty. Some physical and chemical characteristics are given in Table 1. The mottled

Table 1. Physical and chemical characteristics of Trout Creek. Flow, temperature, and chemical data are from Wipperman (1963).

Width (feet)	5-20
Depth (inches)	2-30
Normal flow (c.f.s.)	12-14
Temperature range (^{o}F.)	32-62
pH	7.9-8.2
Dissolved oxygen (per cent saturation)	88-100
Total hardness ($CaCO_3$)	180-198
Total alkalinity (methyl orange)	168-224

sculpin was the most abundant species in the study area, and is common in all major Montana drainages east of the Continental Divide. Other species of fish found in order of decreasing abundance were rainbow trout, brown trout, and brook trout. Holton (1953) reported a few mountain whitefish, suckers (Catostomus sp.), and longnose dace (Rhinichthys cataractae) in addition, and Wipperman (1963) also captured a few mountain whitefish.

Methods

Sampling sections were partitioned with block nets to prevent intersectional movement during fish collection. Fish were captured by the direct electrical current method with power provided from a portable 900-watt maximum output (300 volt, 3 ampere) D.C. generator. Repeated shocking passes were made through each section until most sculpins were captured. Sculpins did not react to electrical current by actively swimming toward the positive electrode as did trout, but lay paralyzed on the stream

bottom in still water areas or tumbled along the bottom in swift water. Captured fish were retained in live cars in quiet water away from the shocking area until sampling of the section was completed.

Sculpins were anesthetized a few at a time with tricaine methanesulfonate (M.S. 222) before marking. A solution strong enough to produce anesthesia in 30-45 seconds (approximately 1:10,000) was used. Fish were marked by removing combinations of pelvic and dorsal fins. Some fin-clipped fish were later tagged with strap tags (0.75-inch long) on the dentary bone. After marking, sculpins were replaced in live cars until completely recovered from the anesthetic, at which time they were released near the middle of an experimental section. A 1.1 per cent (19 fish) immediate mortality of the 1674 sculpins handled during the study occurred presumably due to shocking, anesthetizing, and marking. Nine of these died on one occasion, probably from overexposure to the anesthetic.

Acknowledgements

Thanks are due especially Dr. C. J. D. Brown, who directed the study and assisted with the preparation of the manuscript, and the writer's wife, Barbara, who gave continual assistance with the field work. The major portion of the study was conducted while the writer was a fellow of the National Institutes of Health. Some funds were given by the Montana Agricultural Experiment Station, and fish collection equipment was provided by the Montana Fish and Game Department.

MOVEMENT

Spatial Stability

The validity of a spatial stability study rests upon the assumption stated by Gerking (1959): "... that if a marked fish is caught two or more times in a restricted area, it is very likely that the fish has occupied this area for a substantial period of time." Recapture of many marked sculpins within a restricted area would demonstrate limited movement, and would indicate home range size. The 234-foot segment of stream selected for the stability phase consisted of five adjacent sections. These were designated A through E beginning at the upstream end, and were 63, 50, 41, 41, and 39 feet in length, respectively (Figure 1). Section boundaries were chosen to correspond with natural riffle-pool division of the stream as suggested by Gerking (1953). The study sections were initially shocked on 4-5 August 1962. All sculpins greater than 1.25 inches in length were given a fin-clip code corresponding to the capture section and returned to that section. All five sections plus a 101-foot segment above A and a 65-foot segment below E were shocked on 26 August 1962 and 29-30 September 1962. On each occasion the fin-clip code, section of capture, and number of sculpins taken were recorded. Sculpins captured for the first time in the five study sections were fin-clipped. All captured fish, including those taken outside their original section, were released in the original capture section. Sculpins recaptured during the next two shockings (17 November 1962 and 8 January 1963) in areas not corresponding to their fin-clip were jaw-tagged and released in the section of capture rather than be-

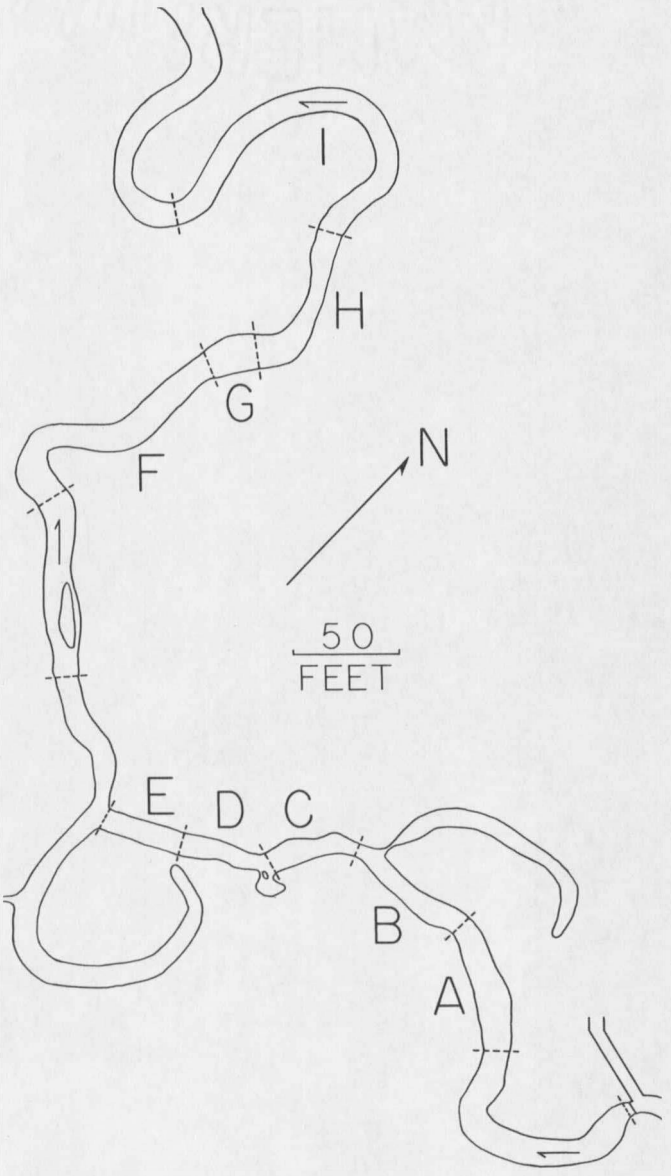

Figure 1. Trout Creek study area (T. 1N, R. 5E, S. 29, Gallatin County, Montana), showing section boundaries.

being returned to the original section. These fish were thereafter included with fish originally present in the recapture section. This was done to give a more accurate movement estimate, since the home range may have overlapped section boundaries. A final inventory was made on 9 March 1963.

Movement by mottled sculpins was infrequent and the distance traveled was small for both fin-clipped and jaw-tagged fish (Table 2). The marked fish were recaptured at an average rate of 23.9 per cent for the five inventories, however the percentage fell steadily from the first to the last shocking (38.1-11.8 per cent) even though the number available increased. This decrease was probably due to mortality from shocking and handling. Stefanich (1952) and Holton (1953) reported similar decreases in rate of marked trout recapture from one census to the next. The movement results obtained from the censuses showed remarkable uniformity. About one-half of the recaptures were within the original section (average length 46.8 feet), and about 80 per cent were either in the original section or one of the two adjacent sections (average length 153.2 feet). Average movement of individually tagged fish was nearly identical with that of all marked fish.

Bailey (1952) reported that 15 of 21 recaptured mottled sculpins were within 150 feet of the original capture point, which is in agreement with the present study, and Williams (1957) reported that the wooly sculpin moved only short distances in and out on incoming and outgoing tides, respectively. In contrast Shetter and Hazzard (1939) found that 86.4-100

Table 2. Movement of sculpins in Trout Creek (Percentages in parentheses).

Recapture date	Days since last shocking	Total number marked fish	Number recaptured	Number recaptured in original section	Number recaptured in original or adjacent section	Number moving upstream	Number moving downstream
8/26/62	21-22	239	91(38.1)	52(57.1)	78(85.7)[1/]	26(28.6)	13(14.3)
9/29/62 9/30/62	34-35	335	126(37.6)	65(51.6)	95(75.4)[1/]	40(31.7)	21(16.7)
11/17/62	48-49	396	93(23.5)	42(45.2)	74(79.6)[2/]	30(32.2)	21(22.6)
1/8/63	53	429	78(18.2)	40(51.3)	66(84.6)[2/]	23(29.5)	15(19.2)
3/9/63	60	448	53(11.8)	27(50.9)	41(77.4)	13(24.5)	12(22.6)
Totals & averages	-----	1847	441(23.9)	226(51.2)	354(80.3)	132(29.9)	82(18.6)

1/ Recaptures in other than original section returned to original section.

2/ Recaptures in other than original section jaw-tagged, left in section of recapture, and included with fish originally present in section.

per cent of the mottled and slimy sculpins moved from 100-foot sections of a Michigan stream in one month. Stefanich (1952) took 444 of 816 (54.4 per cent) recaptured brown trout, 211 of 390 (54.1 per cent) rainbow trout, all (15) brook trout, all (7) mountain whitefish, and 33 of 35 (94.2 per cent) white suckers in the original 150-foot sections of stream over a two year period. Miller (1957) reported that 67 per cent of recaptured cutthroat trout were less than 200 yards from the home pool during a three year period. Gerking (1953) recaptured about 80 per cent of the suckers and sunfish in the same pool from one year to the next, and some in the same pool four years in succession. Gerking (1950) took 75 per cent of recaptured fish in their original locations following a flash flood.

Upstream movement of all marked sculpins was 23.4 per cent greater than downstream movement. Records of individually tagged fish showed 16.6 per cent greater downstream movement, however the small sample may account for this discrepancy. No important variation in the movement of sculpins was observed among the census periods, but there was slightly increased downstream movement in successive censuses. No extensive upstream movement occurred. This would have been detected as a concentration of marked fish in the segment above Section A where movement was blocked by an irrigation diversion dam. Any migration associated with reproduction would not have been discovered, since the study was conducted during the non-breeding season.

Home Range

Since about 80 per cent of the sculpins recaptured were in the origi-

nal section or one of the two adjacent sections, the best estimate under the conditions of the experiment is that the mottled sculpin has a home range of less than 150 feet. However the home range is probably considerably less because the remaining 20 per cent of the recaptures was composed of fish whose home range overlapped section boundaries as well as those that moved. This estimate is crude, since home range size may be influenced by many factors including stream width, riffle-pool development, and food abundance. Gerking (1959) stated: "...any quantitative expression about the size of the home range and the degree of straying describes the techniques of the investigator as much as the behavior of the fish."

Miller (1957) after three years study concluded that the home range of cutthroat trout was only about 20 yards in length. Gerking (1953) divided suckers and sunfish into: those with a 100-200-foot home range — green sunfish (Lepomis cyanellus), longear sunfish, and rock bass (Ambloplites rupestris); those with a 200-400-foot home range — smallmouth bass, spotted bass (Micropterus punctulatus), northern hog sucker (Hypentelium nigricans), and golden redhorse (Moxostoma erythrurum).

Homing

If sculpins experimentally displaced upstream and downstream are subsequently recaptured at their original capture site, it can be concluded that they homed. Three adjacent sections (F, G, and H) were chosen beginning 130 feet below Section E (Figure 1). These were 100, 25, and 100 feet long, respectively. On 14 October 1962, 33 sculpins from Section F, nine from G, and 64 from H were captured, marked, and released in the

middle section (G). The sections were reshocked on 3 November 1962 and 10 March 1963 to determine the number showing homing, no movement, and movement away from home. Each fish was replaced in its capture section.

Homing ability was not exhibited by the mottled sculpin in this experiment (Table 3). Averages show about one-third of the recaptures re-

Table 3. Homing of sculpins in Trout Creek (Percentages in parentheses).

Recapture date	Days since last shocking	Total number marked fish	Number re-captured	Number showing no movement	Number homing	Number showing movement away from home
11/ 3/62	20	106	35(33.0)	15(42.9)	14(40.0)	8(22.9)
3/10/63	127	106	13(12.3)	4(30.8)	3(23.1)	6(46.2)
Totals and averages	---	212	48(22.6)	19(39.6)	17(35.4)	14(29.2)

mained in the middle section, one-third returned to the original section, and one-third moved away from home. Sculpins displaced downstream homed no better than those displaced upstream. However it is not safe to conclude from this experiment that they do not home, since the sections chosen were too small. Thus sculpins transported from parts of Sections F and H to G may have been within their home range. Nevertheless if homing had been exhibited, a larger percentage of recaptures in the homing category would have been expected, since sculpins from the extremes of the study area were displaced from their home range.

Williams (1957) stated that wooly sculpins as small as 11 mm returned at low tide to a home tidepool from distances up to 40 m. Gerking (1953)

found 26 of 35 recaptured longear sunfish in their home pool after a 100-yard upstream displacement, and Larimore (1952) reported that 17 of 32 smallmouth bass transported between 0.1 and 0.8 mile returned home. Miller (1954) and Gunning (1959) observed that cutthroat trout and longear sunfish, respectively, homed better when displaced downstream than upstream.

Interarea Movements

On 12 August 1962, 101 sculpins were captured, marked, and released in a 175-foot section immediately below the homing study area (Section I, Figure 1). This section plus the two study areas immediately upstream gave 865 feet of stream into which variously marked sculpins were placed and recaptured during an eight month period. Records of 13 interarea movements were obtained (Table 4). Longer upstream than downstream move-

Table 4. Interarea movements of sculpins in Trout Creek. (Distances measured from middle of origin section to middle of destination section.)

Time interval in days	Number fish	Distance moved upstream in feet	Distance moved downstream in feet
70	1		325
113	1		325
70	2		326
90	2		326
90	1		365
149	1	410	
49	1	462	
7	1		502
34	1	508	
146	1	508	
97	1	590	

ments were noted, but this is probably not significant due to greater collecting effort in the upper 400 feet (stability study area). The longest

downstream movement that could have been detected was 644 feet and the longest upstream 726 feet. The longest movements actually noted were 502 feet downstream and 590 feet upstream. Bailey (1952) stated that the greatest distance any recovered mottled sculpin moved was 470 feet.

Territoriality

Since observation of aggressive behavior of individual sculpins was not possible in the field, laboratory experiments were performed to determine if the sculpin exhibits territoriality. The assumption was that if territories were established, sculpins provided with adequate cover throughout a laboratory trough would become spatially isolated from one another and would be found repeatedly in the same location.

The laboratory apparatus consisted of an 11.3-foot long, 1.1-foot wide fiberglass fish trough fitted with vertically movable, gang operated screens at one foot intervals. Rocks were arranged in the trough in various ways providing complete cover for several sculpins in each unit. Cold, dechlorinated water was kept about 3-4 inches deep and a flow of 1.3-2.0 gallons per minute maintained. Lights in the room were kept dim, except for short periods. Sculpins used were collected with a shocker from portions of Trout Creek not involved in the field studies, and were held in laboratory troughs for 2-24 days before use. The fish were anesthetized and fin-clipped or injected dorsally with 0.1-0.2 cc of colored liquid latex for individual identification. During the experiments screens were held in the raised position to allow sculpins free access to the entire trough. At observation time the screens were suddenly lowered