The Effects of Water Turbidity and Stream Velocity On Fish Feeding Behavior

BIOS 35502: Practicum in Field Biology

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Abstract

The ecological integrity of most of the major river systems of the world has been highly degraded by human activity (Dynesius et al. 1994). Changes in flow affect streams by altering water quality and biotic distributions and interactions Turbidity plays an important role in shaping stream quality. In a national survey of fishery biologists, turbidity was considered to be the most detrimental water quality characteristic. Changes in turbidity can have direct and indirect effects on fish. At extremely high levels, turbidity can directly affect fish growth and survival, by interfering with gill function or the quality of substrata for egg laying (Bash et al. 2001) fish were starved for 24 hours to allow for gut evacuation so experiments would be run with fish with empty stomachs. On day four two replicates of four artificial streams were set up with differing turbidities (Figure 1). The turbidity of these three streams was achieved by varying amounts bentonite (fine clay) in each stream. High, medium, and low turbidity levels were achieved by adding 0.5, 1 and 1.5 tsp of bentonite to (4000 ml) of water in streams, respectively streams, with no bentonite addition served as controls when velocity was 0. In each artificial stream levels of turbidly remained constant in each alteration in stream. *Qualitative Habitat Evaluation Index* Five locations disturbed throughout Tenderfoot Creek were chosen to evaluate the physical habitat. Two sites were chosen based on there gravely substrate (sampling areas) the other three were distributed across of Tenderfoot creek to cover all aquatic habitat types (Figure 3). QHEI were filled at each of these locations and calculated for a QHEI score. The maximum score in this index is 100 utilizing six different metrics to formulate habitat quality (substrate, instream cover, channel morphology, etc.) (Table. 4).

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I. Introduction

The ecological integrity of most of the major river systems of the world has been highly degraded by human activity (Dynesius et al. 1994). The construction of dams, weirs and levees alter the natural hydrological and thermal regimes of streams and rivers. Development and habitat alteration have had severe effects on stream dynamics and flow (Gippel et al.1995). For example in many areas water withdrawals for irrigation causes water levels to drop so drastically that stream beds dry up for part of the year (Dynesius et al. 1994). Also dams constructed for electric power generation, particularly facilities designed to produce power during periods of peak need, often block the flow of a stream and later release it in a surge, which increases the velocity of the water. Changes in flow affect streams by altering water quality and biotic distributions and interactions (Dynesius et al. 1994). Stream velocity, which increases as the volume of the water in the stream increases, determines the kinds of organisms that can live in the stream, some fish species need fast-flowing run or riffles; others fish require quiet pools (Henley et al. 2000). Changes in flow may also lead to increases in sediment loads and turbidity through erosion.

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Turbidity plays an important role in shaping stream quality. In a national survey of fishery biologists, turbidity was considered to be the most detrimental water quality characteristic; and has been estimated to affect 34% of all U.S. streams (Judy et al.1984). Increases in turbidity and stream flow not only has a direct effect on the water quality of a stream, but causes adverse effects on aquatic organisms, especially those that are visually based (Bonner et al. 2002). Sources of stream sedimentation and turbidity include agriculture, forestry, mining, road construction, and urban activities.

Changes in turbidity can have direct and indirect effects on fish. At extremely high levels, turbidity can directly affect fish growth and survival, by interfering with gill function or the quality of substrata for egg laying (Bonner et al. 2002). Turbidity indirectly affects fish, by reducing the photic zone. Decreasing light penetration has shown to reduce macrophytes cover, which serves as a fish nursery. (Bonner et al. 2002). Turbidity also limits fish vision, which can interfere with behaviors such as foraging (Bonner et al. 2002). This can have varying effects on fish growth and survival, depending on a range factors such as ambient light levels and depth. For example, Reid et al. (1999) found that increased turbidity led to reduced prey detection by largemouth bass (*Micropterus salmoides*). Thus, predation rates were reduced as units of suspended particles were increased. Increases in turbidity and stream flow have negative impacts on aquatic organism behavior as well as the physical habitat used by fish species.

Assessment of the physical qualities of stream has allowed researches to determine streams characteristics that are found in unsuitable habitat (i.e. unstable stream flow, substrate, etc.) (Westenfelder et al. 2000). The qualitative habitat evaluation index (QHEI) gives scientists a quantitative assessment of physical

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characteristics of stream. This index was designed in order to provide a quantified evaluation of the habitats found within specific fish and invertebrate communities. This comprehensive assessment is critical for evaluating disturbance and habitat quality. The index utilizes six different metrics to formulate an overall score representing habitat quality needed to support a healthy biotic community (Westenfelder et al. 2000).

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The objectives of this study were to 1) evaluate the effects of turbidity and stream velocity on the foraging behavior (benthic or pelagic) of creek chub, *Semotilus atromaculatus*, and 2) quantify the physical habitat quality of Tenderfoot Creek. These results will provide information on the affect of habitat alteration on a fish species, provide and stream assessment on the quality of creek chubs habitat in which they occur naturally.

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II. Methods

Creek Chub were obtained in Tenderfoot Creek on UNDERC property by seining in areas of high amounts of gravel substrate. Each week forty creek chub of f similar estimated size and mass (4-6 cm) were collected and taken to a holding tank (cattle tank) located indoor in the UNDERC wet lab. The fish were allowed to acclimate for 3 days. During the acclimation period, fish were fed fish flakes and pellets two times per day until the end of second day. On day three, the

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fish were starved for 24 hours to allow for gut evacuation so experiments would be run with fish with empty stomachs (Table 1).

Artificial Stream Systems On day four two replicates of four artificial streams were set up with differing turbidities (Figure 1). The turbidity of these three streams was achieved by varying amounts bentonite (fine clay) in each stream. High, medium, and low turbidity levels were achieved by adding 0.5 tsp (2.46 cm^3), 1 tsp (4.92 cm^3) and 1.5 tsp (7.39 cm^3) of bentonite to 4,000 ml of water in streams, respectively streams, with no bentonite addition served as controls when velocity was zero. In each artificial stream, levels of turbidly remained constant in each alteration in stream velocity, which ranged from low (3.6 m/s), medium (4.5 m/s) and high (5.2 m/s) (Fig. 1).

Observing Feeding Behavior After the 24-hour starvation period one fish was placed in each artificial stream and allowed to acclimate for 2 hours. At the end of the acclimation period each fish was fed a mixture of pellets (½ tsp, 2.46 cm^3) and flakes (½ tsp, 2.46 cm^3). Fish feeding behavior was observed for 5 minutes. During the observation period fish feeding habits were recorded as either benthic (benthic) or pelagic (flakes) by the fish's choice in food, this was repeated for all remaining streams. At the end of the 5 minute duration the fish was returned to a cattle tank for holding. After all observations were made, the fish were returned to Tenderfoot Creek to there natural habitat. At the end of observations on the eight streams set at low velocity, the streams were flushed and

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reset with same levels of bentonite and four new fish were placed in each stream for the next velocity group (medium velocity). The 2 hr. acclimation period was repeated and 5 min observations would begin on each fish. This process was repeated for each of the remaining velocities (high and zero).

Statistical Analysis We used a 3-D x^2 test to determine if there was any dependency of feeding habit on velocity of turbidity (Figure .3). The three-dimensional chi-square test compared the individual levels of velocity and turbidity, to feeding preference (benthic and pelagic). Additional test for interactions between the independent variables were to be run only if the test was significant by doing a multiple comparison test.

Qualitative Habitat Evaluation Index Five locations disturbed throughout Tenderfoot Creek were chosen to evaluate the physical habitat. Two sites were chosen based on there gravely substrate (creek chub sampling areas) the other three were distributed across of Tenderfoot Creek to represent all aquatic habitat types present (Figure 3). QHEI were filled at each of these locations and calculated for a habitat quality score. The maximum score in this index was 100 utilizing six different metrics to formulate habitat quality (substrate, instream cover, channel morphology, etc.) (Table 4).

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III. Results

In all combinations of velocity and turbidity in artificial streams containing creek chub, there were no significant differences in preference of pelagic or benthic feeding (x^2 =15.238, df =24 0.90<p<0.095, α= 0.05) Therefore, I accepted the null hypothesis; feeding habit, turbidity level, and velocity level are all mutually independent in the population sampled and do not have a interaction of statistical significance. Even thought our interactions were not statistically significant the relationship between velocity, turbidity and feeding behavior from visual observation and field notes and count data displayed a difference in the creek chubs' feeding behavior ([redacted]). Creek chub had large difference in pelagic feeding compared to benthic in zero, low, and medium turbidities. In high turbidity levels the creek chub feeding equally of both pelagic and benthic food. Even thought this relationship is not statistically significant it is biologically significant.

IV. Discussion

Across all gradients of velocity of turbidity creek chub fed in the pelagic zone by drift feeding more often then benthic feeding. However there are many biological characteristics of creek chub that may explain why no interaction was significant in feeding habits. Creek chub are found to be tolerant of turbid and unfavorable water conditions, allowing them to out compete other species (Tomelleri et al. 1990). Creek chub's tolerance to unfavorable water conditions makes noticeable behaviors in feeding preference in turbid water conditions difficult to determine.. Another biological factor affecting feeding behavior and prey selection is species' food selectivity. According to (**Miller et al. 1964**) creek

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chub demonstrate little food selectivity, consuming almost anything available, and thus is considered an opportunistic feeder. Since creek chub are opportunistic feeders, a significant relationship between velocity, turbidity and feeding habits might not be apparent in this species; further observations in different water conditions (i.e., higher turbidity levels) may be required to understand the difference in feeding behavior.

Another behavioral factor is that Creek chubs' prey preference size is a controlled by the body size of the individual creek chub (**Miller et al. 1964**). Young creek chub (20-40 mm long) feed on chironomids larvae, as well as ceratopogonids, simuliids, and cecidomyid and ephemeropteran naiads (benthic macroinvertebrates) (Dinsmore et al. 1963). At lengths between 41-60 mm, larger prey, such as tipulid larvae and dragonfly nymphs, are added to the diet. As individuals reach maturity at 61-80 mm, in length, mollusks and fish constitute the bulk of the total volume of the diet, while fish over 81 mm long are primarily piscivorous. Feeding occurs at all depths with younger fish (<175 mm) feeding in schools while fish over 175 mm feed individually (Dinsmore et al. 1963).

The feeding success of fish species that rely on visual search strategies can be greatly affected in turbid waters. In general, the abundances of visual feeders, like sunfish and trout, decline with elevations in turbidity. Gardener (1981) found that the feeding rate of bluegill *(L. macrochirus)* decreased at a turbidity of 60 NTU, and **Henley, al 2000** noted striped bass larvae consumed less *D. pulex*

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with increased turbidity levels. Species that depend on drifting insects as a major food source, including trout and salmon, have also shown depressed feeding rates in turbid waters **(Henley, W.F 2000)**

Not only can turbidity and sedimentation can have profound influences fish feeding behaviors but can have a greater effect on the local ecology of lotic systems at the individual, population, and community levels **(Henley, W.F 20000** In such an environment, reductions in food availability, environmental quality, and habitat can directly affect growth, recruitment, and mortality rates at multiple trophic levels, in turbid environments, reductions in species density, biomass, and diversity throughout a trophic level are translated into reductions in energy input to the next trophic level **(Henley, W.F 2000)**. Decreases in plant, zooplankton, and insect abundance and biomass initiate reductions in herbivore, omnivore, and, consequently, predator classes of fish (**Henley, W.F 2000**). Biotic adaptations to sediment perturbation also may lead to changes in local community composition. A further synergistic effect may occur when lotic communities are impacted by pesticides and other toxins entering the river or stream with eroded material affecting water quality and biotic habitats (**Henley, W.F 2000**).

The qualitative habitat evaluation (QHEI) conducted on Tenderfoot Creek provided an evaluation of the stream habitat found on UNDERC property. The assessment showed that there was no disturbance and habitat quality at all sites received a high score (Table.8). Due to the lack of development and canalization

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on the creek the habitat quality received high quality scores (Table. 6). The two locations used for creek chub sampling received the highest scores of 80 and 83.

The other sites there were similar in habitat on the southern end of tenderfoot creek ranged from 59 to 66 in score. The differences in score were due to lack of riffles, and deep pools. In the area of high QHEI, runs, riffles, and pools were all present along a rocky substrate, while in areas of low scores, runs with a silt and sand substrate was observed. Creek chub were caught in high abundance in areas of high QHEI score due to there reproductive dependence to gravely substrate. In reproduction creek chub fan shallow depression into the stream bottom and removes gravel and small stones in order to create a mound of stones at the head of there spawning pit (**Dinsmore et al. 1962**). This reproductive dependence makes us hypothesis that creek chub are discouraged from living in areas high in silt and sediment deposits; showing a relationship in QHEI score and fish abundance; however, further analysis would need to be conducted to distinguish this relationship. The QHEI provided us with a better understanding of the aquatic habitat with our sampling area and how it compared to them the rest of the creek's aquatic habitat.

Future research with creek chub should include feeding preference of differing in creek chub size, in order to understand preference relating to fish size. Also further research should be conducted on feeding preferences of sensitive fish species in unfavorable water conditions to see a difference in feeding behavior. If

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this experiment was repeated more replicates should be conduct to yield more data and significant results. Further analysis on the QHEI should be conducted in relation to fish abundance on Tenderfoot Creek, examining the relationship between creek chub habitat and score.

V. Acknowledgements

IV. References

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Table 1.

Day	**Activity**
Day One	▪ Capture fish sample ▪ Determine natural stream velocity ▪ Introduces fish to the artificial stream holding tank
Day Two – Three	▪ Feed fish and let them acclimated to the article systems and fish
Day Four	▪ Feed and starve fish for 24 hours
Day Five	▪ Place staved four staved fish in each system ▪ Feed and record observations for 5 minutes

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Table 2

	Benthic				Pelagic			
	Velocity →				Velocity →			
Turbidity	None	Low	Medium	High	None	Low	Medium	High
None	3	3	2	4	7	8	8	4
Low	2	4	2	1	7	9	8	8
Medium	3	1	2	2	3	6	6	8
High	3	4	3	1	3	2	2	3

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Table 3

Qualitative Habitat Evaluation Components

Metric	Metric Component	Best Possible Score
Substrate	• Type • Quality	20
Instream Cover	• Type • Amount	20
Channel Morphology	• Sinuosity • Development • Channelization • Stability	20
Riparian Zone	• Width • Quality • Bank Erosion	10
Pool Quality	• Max Depth • Current • Morphology	12
Riffle Quality	• Depth • Substrate stability • Substrate embeddedness	8
Map Gradient		10
TOTAL		**100**

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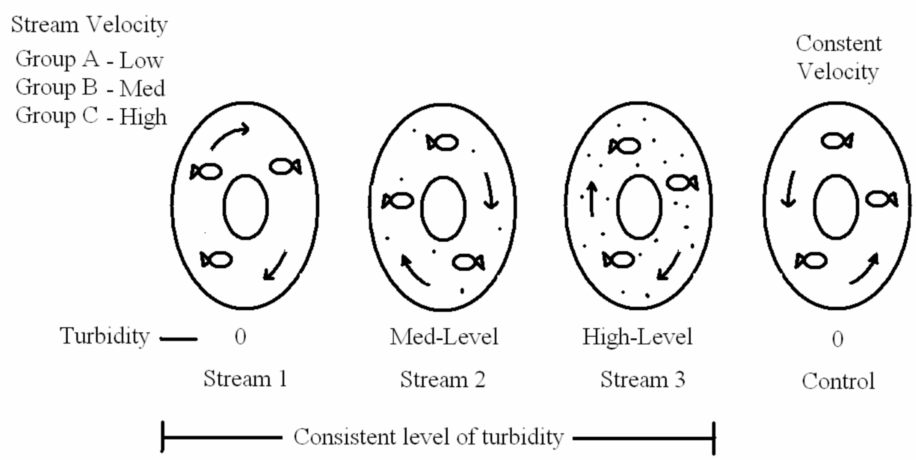

Figure 1. Artificial streams systems setup

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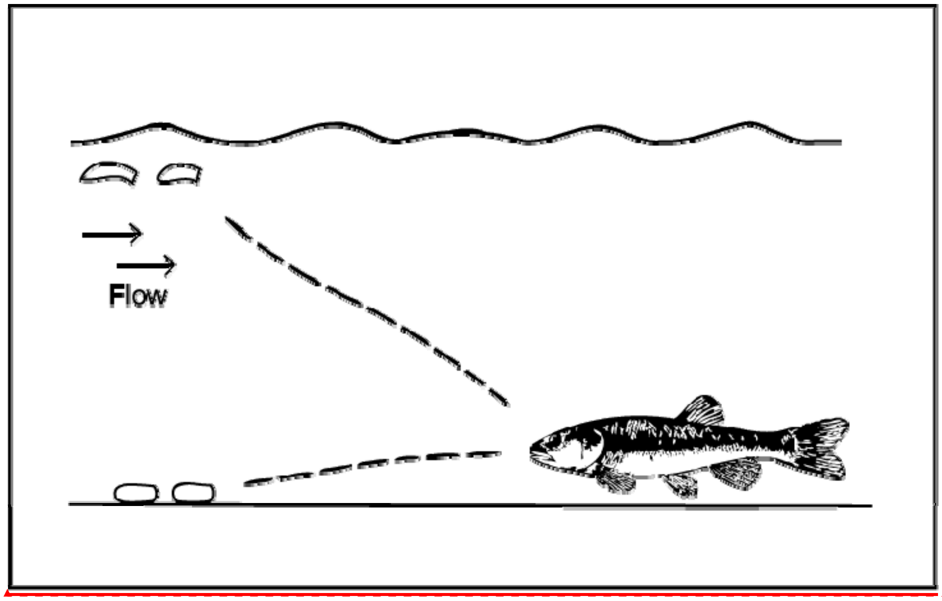

Creek chub had large difference in pelagic feeding compared to benthic in zero, low, and medium turbidities. In high turbidity levels the creek chub feeding equally of both pelagic and benthic food. Even thought this relationship is not statistically significant it is biologically significant.

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