
Observations of a Vertical Foraging Behavior of Blue Catfish in Lake Ellsworth, Oklahoma

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Blue Catfish (*Ictalurus furcatus*) are the largest catfish found in Oklahoma and are native to the Red River and Lower Arkansas River (Miller and Robison 2004). Blue Catfish are now found in many areas of the state because the Oklahoma Department of Wildlife Conservation (ODWC) stocked Blue Catfish into many impoundments due to their popularity as a sport fish (Miller and Robison 2004, Snow et al. 2017). Blue Catfish are considered omnivorous due to their very diverse diet, often consuming vegetation, mollusks, insects, and crustaceans, with larger individuals shifting to piscivory (Schmitt et al 2017, Jennings et al. 2018). Their diverse foraging ecology is likely caused by seasonal habitats shifts and opportunistic feeding strategy on abundant prey species (Magoulick and Lewis 2002, Jolley and Irwin 2003, Jennings et al. 2018).

Blue Catfish are a migratory species native to large rivers, moving up-river in the spring for spawning and retreating back down-river in fall when water temperatures cool (Pflieger 1997). In reservoirs, Blue Catfish remain in the upper end of the reservoir throughout summer eventually moving to the lower portion of the reservoir in fall where they remain throughout winter (Grist 2002). As Blue Catfish move towards the lower portions of reservoirs, a dietary shift to predominately Gizzard Shad (*Dorosoma cepedianum*) and Threadfin Shad (*D. petenense*) occurs (Graham 1999, Grist 2002, Jennings et al.

2018). Overlapping habitat occupancy by both shad and Blue Catfish during fall and winter likely contributes to this diet shift.

Blue Catfish have been observed feeding on schools of Gizzard Shad in both reservoirs and in the tailwaters below reservoir dams. Blue Catfish were observed gorging on Gizzard Shad that were stressed after being discharged from a Missouri reservoir dam into a tailwater (Graham and DeiSanti 1999). Graham (1999) reported Blue Catfish suspending under a school of Gizzard Shad being preyed upon by Striped Bass (*Morone saxatilis*) and foraging on wounded and dead shad. On September 8, 2018, a potential fish kill was reported by an angler fishing at Lake Ellsworth, Oklahoma to ODWC officials. The report described Blue Catfish swimming vertically and bobbing up and down in the wave action near the Lake Ellsworth Dam in apparent distress. Attempts were made by ODWC officials to create a disturbance near the Blue Catfish, which caused individuals to flee (suggesting that the Blue Catfish were healthy) and those fish were quickly replaced with other Blue Catfish that continued to forage vertically on Gizzard Shad. On two occasions during this observation, ODWC officials also witnessed small schools of Blue Catfish swimming normally near the water surface around the outside perimeter of the group of vertically oriented Blue Catfish (also suggesting that the Blue Catfish were healthy).

Standard ODWC protocol requires an employee to investigate a reported fish kill or an ongoing fish kill on public waterways, particularly when reports describe thousands of fish in distress and potentially affected. When ODWC staff arrived at the Lake Ellsworth Dam, it was quickly recognized that the Blue Catfish were actively feeding on distressed Gizzard Shad that were pushed into the dam via wave action. ODWC staff observed several thousand Blue Catfish (Figure 1) positioned vertically in the water column foraging on Gizzard Shad (Figure 2). Blue Catfish predation on Gizzard Shad was confirmed by an angler catching these fish and ODWC staff observed age-0 Gizzard Shad (mean TL = 55 mm) being regurgitated once brought to shore (presumably due to Blue Catfish feeding until satiation). This behavior was observed for approximately one hour and no other fish species were observed.

We suggest there are two possible scenarios that triggered this vertical foraging behavior. First, in the southwest area of the dam where the observation occurred, shad were trapped between the dam face and a side wall (Figure 1).

Wind and wave action may have forced Gizzard Shad into the corner of the dam, which prevented escapement and created an easy foraging opportunity for Blue Catfish. The confined, cube-like space at the corner of the Lake Ellsworth Dam where the Gizzard Shad were trapped likely improved foraging success of Blue Catfish and contributed to the observed vertical foraging behavior. Second, it is possible that Gizzard Shad were stressed by environmental events that de-stratified Lake Ellsworth, resulting in an easy foraging opportunity for Blue Catfish. This mixing of the epilimnion and hypolimnion occurs usually during the fall when the density of the water changes as a result of cooling water temperatures, which is caused by cooling air temperatures, wind action, or in-flow events, and results in oxygenated surface water mixing with anoxic water on the lakes bottom. When de-stratification occurs, the dissolved oxygen (DO) of the water usually decreases (Steichen et al. 1979, Bohrer and Schultze 2008) and trapped CO₂ (Carbon dioxide) and H₂S (Hydrogen sulfide) gases escape from the hypolimnion and can ultimately affect fish behaviors (Bohrer and Schultze 2008). Occasionally following a fall

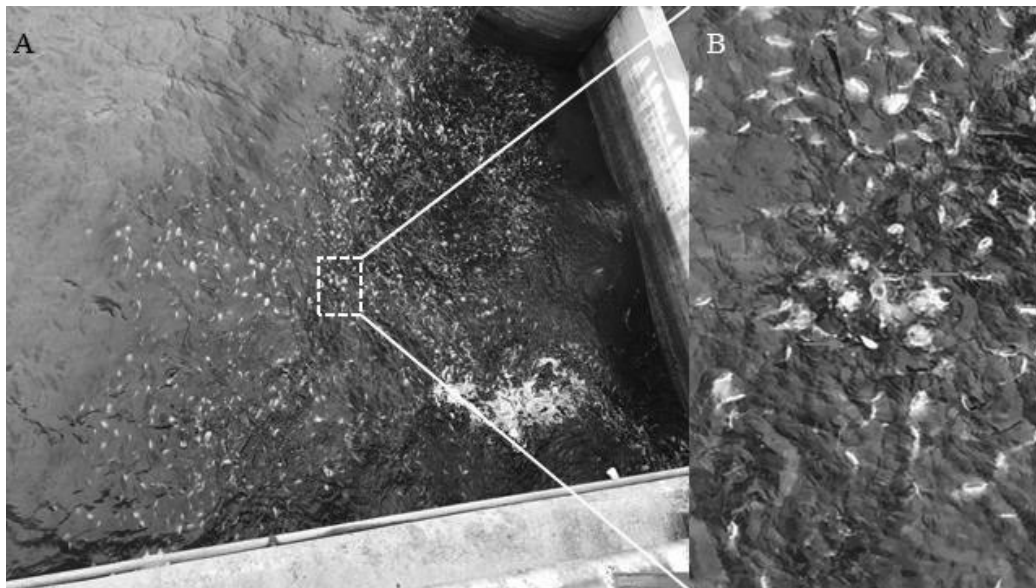


Figure 1. Photographs taken on September 8, 2018 showing Blue Catfish foraging vertically on Gizzard Shad at the southwest corner of the dam at Lake Ellsworth, Oklahoma. Photographs depict A) the entire observation area, and B) a cutaway showing a group of Blue Catfish foraging on shad. Orange arrows show Gizzard Shad being launched from the water by Blue Catfish.

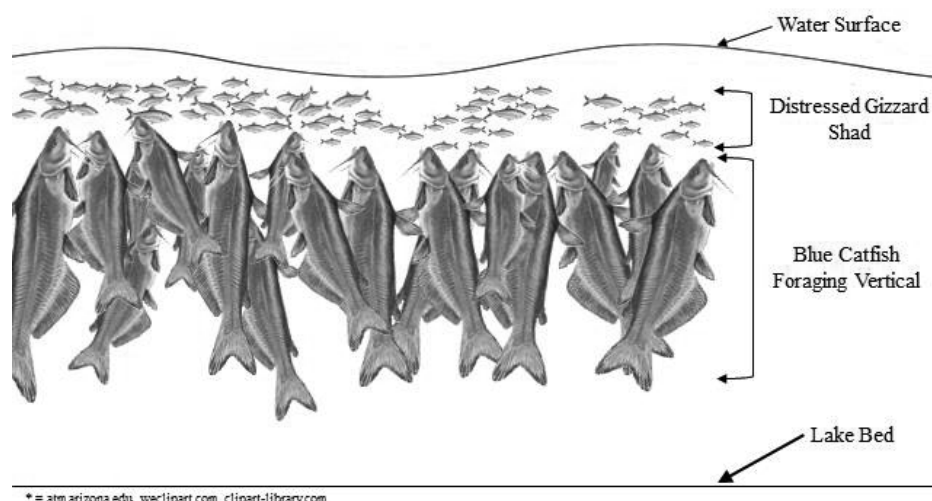


Figure 2. Depiction (in lateral view) showing observed vertical foraging behavior of Blue Catfish in Lake Ellsworth, Oklahoma on September 8, 2018. Blue Catfish were observed in the lower portion of the lake where presumably wave action had pushed distressed Gizzard Shad in to the southwest corner of the dam following a fall mixing event. *Acknowledgments for clipart illustrations.

turnover event, the reduction in DO or exposure to hydrogen sulfide gases can result in stress or death of fish (Steichen et al. 1979). A third option is a combination of the two; gizzard shad succumbed to reduced water quality conditions as a result of mixing, and when they surfaced they were transported by wind and wave action to the area at which they were observed.

Gizzard Shad are intolerant to swings in water temperature and DO, and stress associated with these environmental events can slow their movements increasing the risk of predation

(Griffith and Tomljanovich 1976, Porath 2006, VanDeHey et al. 2012). Based on environmental data captured by the Apache, Oklahoma Mesonet Station (34° 54' 51" N, 98° 17' 31" W; Table 1) we concluded that mean air temperature decreased by 7.4°C from September 1 to September 8. A cold front entered the region resulting in 2.8 cm of rain over the same time period. Wind gusts from the north/northeast were 7.21 m/s with a mean wind speed of 3.36 m/s. Solar radiation during this time decreased by 16.83 MJ/m² as a result of increased cloud cover. A DO water column profile was collected at Lake Ellsworth

Table 1. Environmental data collected by the Apache, Oklahoma Mesonet Station (34° 54' 51" N, 98° 17' 31" W) from September 1 through September 8, 2018. This station is located 13.52 km to the north-northeast of Lake Ellsworth, Oklahoma.

Date	Mean Air Temp. (°C)	Wind Direction	Mean Wind Speed (m/s)	Wind Gust (m/s)	Daily Rain (cm)	Total Solar Radiation (MJ/m ²)
9/1/2018	28.5	SSE	5.11	13.39	0.00	22.36
9/2/2018	27.5	SSE	5.70	17.00	0.00	20.00
9/3/2018	24.6	SE	4.55	12.48	0.25	13.37
9/4/2018	23.7	S	4.94	11.56	0.05	8.68
9/5/2018	23.4	S	2.31	20.38	0.66	8.08
9/6/2018	23.6	NE	2.60	6.08	1.45	9.31
9/7/2018	22.3	NNE	3.49	7.48	2.77	5.11
9/8/2018	21.1	NNE	4.00	8.07	0.00	5.53

on September 11, 2018 to verify that the lake had mixed. We determined that DO concentrations ≥ 4.06 mg/L were present from the surface to the bottom in 12.2 m of water, suggesting that a fall turnover occurred, which likely affected Gizzard Shad.

The observation of vertical foraging of Blue Catfish is a novel and unique observation, which, to our knowledge, has not been described in the literature. Although diet of Blue Catfish has been well studied, mechanisms for obtaining their food are not well known. We will continue to monitor the Lake Ellsworth Blue Catfish population into the future to determine if this was an isolated event resulting from environmental conditions and a unique dam configuration or if this foraging behavior occurs in other reservoirs following a lake mixing event.

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