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Investigation of Barge-associated Mortality of Larval Fishes in the Kanawha River

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ABSTRACT

Field studies were conducted to assess barge-associated mortality of larval fish in the Winfield Pool, Kanawha River, West Virginia. Bongo nets were used to collect larval fish from the sailing line before and immediately after barge passage in June and July 1983. The percent of live larvae in samples taken before and after barge passage did not differ significantly for either sampling period. High handling mortality and variation in percent of live larvae among samples may have masked any barge effects.

INTRODUCTION

Increases in commercial navigation on the Mississippi River and its tributaries (ANSP 1980; UMBRC 1982; USACE 1983) has stimulated concern about the impacts vessel passage may have on fish communities (Nielsen et al., 1986). Due to their small size and planktonic nature, fish eggs and larvae within the sailing line may be subject to a variety of lethal forces including hull shear (Morgan et al., 1976), entrainment through the propulsion mechanism (abrupt changes in hydrostatic pressure and shear forces), and exposure to the turbulent high velocities within the propeller wash. Ichthyoplankton along the shoreline may be subject to lethal drawdowns created by approaching barges (Holland, 1987) and vessel-generated waves breaking along the shore (Bhowmik et al., 1982). Few laboratory and field investigations of effects on ichthyoplankton have been done (Morgan et al., 1976; Holland, 1986; Holland, 1987; Killgore et al., 1987); consequently, no generalizations of the severity of impacts have been documented.

Direct mortality of fish larvae caused by barge passage has not been documented. The field conditions for detecting damage to small, delicate, widely-dispersed organisms in large flowing-water systems in the presence of large vessels moving at high speeds hinders assessment efforts. In the only published field study, Holland (1986) detected direct effects, in the form of visible damage, on freshwater drum (*Aplodinotus grunniens*) eggs but not on larvae. Abundant algae in the Mississippi River filled ichthyoplankton samples, preventing Holland (1986) from separating live and dead larvae; consequently, captured larvae were preserved in formalin and examined later for signs of damage.

This research was designed to investigate barge-related direct mortality of larval fish within the sailing line of the main channel of the Kanawha River, West Virginia, utilizing the standard technique of collecting larvae in towed plankton nets.

STUDY AREA

The Kanawha River (sixth-order stream formed by the confluence of the New and Gauley Rivers in south-central West Virginia) flows northwesterly to the Ohio River at Point Pleasant, West Virginia. Most of its 188 km are made navigable by locks and dams which create four navigational pools. Average annual discharge at Charleston, West Virginia, on the Winfield Pool (area 29,985 sq km) was 424.8 m^3/s from 1939 to 1983 (Embree et al. 1984). On sampling dates the discharge was 248 m^3/s (June) and 217 m^3/s (July).

The Winfield Pool (river km 50-109) is a heterotrophic system dependent upon allochthonous energy sources (Hershfeld et al., 1986). Deciduous vegetation lines the shoreline except within industrial sections of the Charleston area. The Winfield Pool is lotic and lacking backwaters at the upstream end, grading to a more lentic nature with frequent small embayments (inundated tributaries) in the downstream end. The predominant substrate within the Winfield Pool grades from cobble and pebble in the upper end, to sand and silt in the downstream portion. Aquatic macrophytes are rare. The shoreline zone is characterized by overhanging riparian vegetation, occasional fallen trees extending out into the river, sunken and partially buried logs and woody debris, riprap, and an abundance of industrial and residential refuse. Due to reduced velocities in this zone, the shoreline substrate is primarily sand and silt mixed with organic matter. The fish assemblage contains 65 species (Hershfeld et al., 1986). Fish biomass is dominated by gizzard shad (*Dorosoma cepedianum*), common carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), and smallmouth buffalo (*Ictiobus bubalus*); numerical abundance is dominated by emerald shiner (*Notropis atherinoides*), gizzard shad, mimic shiner (*Notropis volucellus*), and spotfin shiner (*Cyprinella spiloptera*). The sport fishery is dependent upon channel catfish, *Micropterus* spp. basses, sauger (*Stizostedion canadense*), freshwater drum, and white bass (*Morone chrysops*).

A sampling site was selected in the lower portion of the Winfield Pool between river km 55 and 59.5 where traffic was heaviest. The river width at the site is approximately 225 m with a midchannel depth of approximately 9.4 m. Water depth does not change noticeably with discharge except during unusually large floods. The site has steep banks and a relatively uniform depth.

METHODS

Mortality of fish larvae in the vicinity of moving barges was evaluated by comparing mortality in samples collected before and immediately after barge passage. Sampling was conducted during 16-17 June, and 7-9 July 1983, periods when larval fish densities were high ($>15/100\ m^3$). All sampling was conducted in the sailing line. In June, 11 pre-passage and 9 post-passage samples were collected at three depths in the sailing line (near surface, mid-depth, and near bottom). In July, 21 pre-passage and 13 post-passage samples were collected near surface and at mid-depth.

Samples were collected by towing behind a twin bridleless 0.5-m diameter bongo nets (0.5-mm mesh) for 5 min at 85 cm/s. Pre-passage samples were collected before barge passage and no less than 1 h after the passage of a barge. When a barge entered the sampling area, a tow was made beginning approximately 100 m behind the barge, and proceeding in the same direction of travel. Upon completion of the tow, the sample was rushed to the sorting crew for immediate processing. The sampling boat then caught up to the barge and collected another sample. Two or three samples could be collected in this way before the barge left the mortality sampling area.

The sorting crew sorted fish into live and dead larvae within 20 min of tow completion. Larvae were examined and classified as live or dead based on mobility. They were counted and fixed in 5-10% buffered formalin.

Each period's samples were pooled across depths and a Wilcoxon rank sum test (Hollander and Wolfe, 1973) was employed to determine if mortality differed between collections taken before and after barge passage. An alpha level of 0.05 was used for statistical significance in these tests.

RESULTS

Percentages of live larvae were low in pre-passage and post-passage samples, and did not differ significantly at the 0.05 level for either June or July (Table 1). In June, when samples were dominated by small gizzard shad larvae (81% of catch), mean percentages of live larvae decreased from 32% before to 18% after barge passage, but the difference was not significant ($P = 0.074$). In July, gizzard shad comprised 23% of the catch, being replaced by freshwater drum and minnows (Cyprinidae) as the dominant components (45% and 28% of catch, respectively). The mean percentage of live larvae following barge passage at this time appeared higher than in pre-passage samples, but the difference was not significant ($P = 0.123$). The mean sizes of larvae were similar in the June and July sampling periods.

DISCUSSION

The results of this study illustrate the difficulty of larval fish impact assessment. Conservative risk assessments may assume as much as 100% mortality of larvae entrained through barge propulsion mechanisms. However, vessel-related mortality has been surprisingly difficult to detect in the field. Our inability to document barge-related direct mortality of larval fish is similar to the findings of Holland (1986), despite our separation of live and dead larvae immediately after collection.

Four explanations for our inability to document vessel-related mortality may be plausible. First, barges may not kill or damage significant numbers of larvae in the Kanawha River. Holland (1986) observed that for a significant increase in damaged eggs of freshwater drum, followed barge passage, but a similar trend for larvae was not evident. Morgan et al. (1976) reported striped bass (*Morone saxatilis*) larvae survived experimental shear forces better than eggs. Therefore, for some species, larvae may be more tolerant than eggs to vessel-related perturbations. Similar information for eggs and larvae of other species common to the Mississippi River drainage is not available.

Second, Holland (1986) suggested that mixing of non-impacted larvae with impacted larvae within the barge wake may dilute the damaged larvae to an imperceptible percentage. This implies that larvae have a lower barge-associated mortality than eggs; otherwise Holland (1986) would not have found a significant increase in damaged eggs following barge passage.

Third, high and variable handling mortality of larvae associated with plankton nets may have masked differences in barge-related mortality. If sampling mortality were zero, for example, then a 10% barge-induced mortality would cause a 10% difference in total mortality. With a 70% sampling mortality, however, the difference in total mortality would be only 3%. Given the variation in observed catches and mortality rates, a 3% difference is virtually undetectable.

TABLE 1. Two-sided Wilcoxon Rank Sum tests on barge-induced larval fish mortality data.

	June		July	
	Before	After	Before	After
Number of replicates:	11	9	21	13
Mean larvae/replicate:	55.4	44.0	38.7	28.5
SD (larvae/replicate):	50.7	21.6	24.9	15.9
Mean % live larvae:	31.9	18.3	21.5	31.0
SD (% live larvae):	14.9	16.2	14.3	20.4
P-value:	0.074		0.123	

Fourth, the sampling methodology used in this study (towed plankton nets), as well as that employed by Holland (1986), may have an additional shortcoming in assessing barge-associated mortality of larvae. Avoidance of nets by larvae is considered to be triggered by visual clues and pressure waves moving ahead of towed nets. The pre-passage samples were collected in relatively calm water, whereas the post-passage samples were collected in the turbulent wake of barges. Turbidity levels may increase following barge passage, reducing visibility, and turbulence within the wake may disguise the pressure waves of an oncoming net. Reduced avoidance capability could result in a higher percentage of live larvae being captured than if the water's physical conditions matched those existing when the pre-passage samples were taken.

Future investigations of direct impacts on larval fishes by barge passage should consider alternate sampling methods. Although standard plankton nets are efficient in filtering large volumes of water, mortality is relatively high in captured larvae. Large diameter plankton nets pushed at low velocities ahead of a sampling boat (e.g., Kriete and Loesch, 1980; Siler, 1983; Tinsley et al., 1989) may be an acceptable compromise between low handling mortality and the need to filter large volumes of water, but such a gear type would need to be developed especially for this purpose. Until a better sampling technique is developed and employed, it is unlikely that the controversy regarding vessel impacts to larval fish will be adequately addressed.

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