U.S. Fish & Wildlife Service Susquehanna River American Shad (*Alosa sapidissima*) Restoration: Potomac and Hudson River Egg Collection, 2006

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10, August 2006

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Abstract

During April and May, 2006 we used monofilament gill nets to collect 1194 American shad from the Potomac (rkm 150) and Hudson (rkm 203) Rivers. The purpose of sampling was to supply viable eggs to the Van Dyke American Shad Hatchery in support of ongoing Susquehanna River American shad restoration efforts. Over 29 sampling days 99.3 L (44% viable) and 60.0 L (69% viable) of eggs were delivered from the Potomac and Hudson Rivers, respectively, with a potential yield of ≈ 3.2 million individuals. Ripe and green female American shad were equally represented (12% ripe, 13% green) and proportionally twice that of males (5%) in Potomac River samples, which were dominated by gizzard shad (39%) and striped bass (27%). Male (34%), ripe female (18%), and green female (12%) American shad numerically dominated Hudson River bycatch, which was most frequently brown bullhead (17%). On average, the Potomac River yielded more ripe/running male and female American shad per unit effort ($\bar{x}$ = 0.021/h/ft^2) than did the Hudson River ($\bar{x}$ = 0.007/h/ft^2), which was offset by the Hudson's increased egg viability. The U.S. Fish and Wildlife Service's first attempt to deliver Potomac and Hudson River eggs for Susquehanna River American shad restoration was a success. Results from the Potomac and Hudson Rivers nearly equaled the combined effort from the Delaware and Susquehanna Rivers, which is the basis for our recommendation to continue the project in 2007.

Introduction

American shad (*Alosa sapidissima*) are an anadromous pelagic species ranging from Labrador to Florida, along the Atlantic coast (U.S. Fish and Wildlife Service 2006). American shad are the largest of the clupeids native to North America (Stier and Crance 1985) and an important planktivore and prey for bluefish (*Pomatomus saltatrix*) and striped bass (*Morone saxatilis*) (U.S. Fish and Wildlife Service 2006). American shad return to their natal river to spawn after four to six years at sea. Spawning movements follow a latitudinal cline and although variable, spawning generally peaks from 14 to 21 C^o (Stier and Crance 1985). Generally, April is the peak spawning month for American shad in the Potomac River, followed by May in the Hudson River.

Shad have been economically important to Americans since European colonization of North America and have undergone population fluctuations as a result of anthropogenic effects. In Pennsylvania, American shad are said to have once ruled the waters of the Susquehanna River and its tributaries (The Native Fish Conservancy 2005). Initial population declines resulted from commercial harvest coinciding with increases in human population and gear efficiency. Habitat loss (damming) and degradation (pollution) followed and remain challenges to restoration. Attempts to mitigate dam effects on American shad and other Susquehanna River species began in 1866. In that year Pennsylvania drafted an Act, which directed dam owner/operators to maintain fish passage structures (The Native Fish Conservancy 2005). The Act established a commissioner's office that evolved in to the Pennsylvania Boat and Fish Commission (The Native Fish Conservancy 2005).

The U.S. Fish and Wildlife Service (Service) is partnered with state, Federal, and hydro-power companies, through the Susquehanna River Anadromous Fish Restoration Cooperative to restore American shad to the Susquehanna River and its tributaries. The Service's current Potomac and Hudson River egg harvest operation is part of this, nearly forty year, multi-agency restoration effort. The Service's Maryland Fishery Resources Office's role is to deliver viable American shad eggs to the Van Dyke American Shad Hatchery near Thompsontown, PA. Once there, American shad eggs are incubated until hatching then the young are grown out to a suitable size for stocking into the Susquehanna River drainage.

Study Area

The Potomac River is approximately 1.5 km wide at Marshall Hall, MD (rkm 150), where American shad gill netting occurs. The collection site is bounded by Dogue Creek (North) and Gunston Cove (South) and has long been linked to shad harvest and culture. Bottom habitat is characterized by an abrupt transition from the deep channel (≈ 18.3 m) area to relatively shallow depths (≤ 3.5 m). Channel substrate consists of firm sandy mud with intermittent shell. Sand increases in the shoal area forming a comparatively harder substrate.

The Hudson River sample site (rkm 203) is approximately 32 kilometers South of Albany and adjacent to the town of Stuyvesant, NY on the River's Eastern shore. Here the mid – Hudson is narrow (≈ 0.50 km) compared to the Potomac River. The site is a shoal area that gradually slopes to a depth of approximately 2.0 m before dropping off to a maximum depth of approximately 6.0 m. The feature is much shallower and the transition from shoal to channel is more gradual compared to the Potomac collection site.

Bottom substrate at the Hudson River sample site is softer, compared to the Potomac, consisting of mud over sandy clay.

Materials and Methods

We used 6.1 m deep by 91.4 m long floating monofilament gill nets with 14.0 cm stretch mesh panels on the Potomac River. Multiple nets were joined in series and drifted parallel to shore in depths ranging from approximately 12.2 to 18.3 m. Two small (6.7 m) boats consisting of four to five crew members set as many as five interconnected nets each. Gill nets were set shortly before the evening's slack tide and fished between 40-60 minutes. Fishing was timed so that the nets' drift stalled parallel to a sharply defined shoal area where depth abruptly decreased to less than 4.0 m.

We initially anchored 2.4 m deep by 91.4 m long sinking monofilament gill nets with 14.0 cm stretch mesh panels on the Hudson River. These nets were outfitted with float lines during the second week of sampling in order to sample the top 2.4 m of the water column. After conversion, the nets remained anchored in place while fishing. Up to four gill nets per boat were fished perpendicular to shore in less than 4.5 m of water. Stationary nets afforded consistent start times for Hudson sampling because the nets could be set and fished repeatedly in one location. As on the Potomac, set times ranged from 40 to 60 minutes. Because Hudson River nets were anchored on a shoal, we were able to set nets in advance of the evening slack tide and continue to fish well into tide reversal. Catch and effort was recorded but not regimented since the goal was to fish as many nets as possible, given sampling conditions.

Tidal condition (transitioning high or low) was noted and surface temperature (C^o), dissolved oxygen (mg/L), and salinity (ppt) were recorded (Yellow Springs

Instruments Model 85) each night gill nets were set (Figures 1and 2). We recorded the number of ripe, green, or spent female American shad, running male American shad, and bycatch (Table 1, Figures 3 and 4). Effort was recorded but not regimented, as the goal was to maximize effort during each sampling event. Catch per unit effort (CPUE) was calculated as daily combined male and ripe female catch per total hours fished per total net square footage. All CPUE values were multiplied by 1000 as a scalar for display (Figures 1 and 2). American shad catch otolith samples were taken along with total length (nearest mm) and weight (nearest 0.1 gram) from 5% (39) of American shad used for egg or sperm harvest from the Potomac River. Scale samples were also taken from 300 American shad sampled from the Hudson River. The samples were a permit requirement of the Potomac River Fisheries Commission and the New York Department of Environmental Conservation, respectively.

Results

During spring 2006 we sampled the Potomac and Hudson Rivers 16 and 13 days, respectively. Over 29 days of fishing we collected ≥ 5.0 L of eggs 16 times (55%). We shipped a total of 99.3 L (Range = 3.9 - 15.3 L, $\bar{x}$ = 9.0 L/shipment) of eggs from the Potomac River and an average of 10.0 L/shipment (Range = 5.1 – 13.3 L) of eggs from the Hudson River (Hendricks 2006). Egg viability averaged 44.0 (Range = 16.5 – 62.8%) and 68.6% (Range = 48.5 – 93.2%) respectively from the Potomac and Hudson Rivers (Hendricks 2006).

Gill net sampling produced 2571 and 620 fish from the Potomac and Hudson Rivers, respectively. Together, thirteen fish species from seven families were represented (Table 1). Ripe and green female American shad were equally represented (12% ripe,

13% green) and proportionally twice that of males (5%) in the Potomac River catch, which was dominated by gizzard shad (39%) and striped bass (27%) (Figure 3). By contrast, the target species dominated the Hudson River catch. Male (34%), ripe female (18%), and green female (12%) American shad numerically dominated bycatch, from the Hudson River, which was most frequently brown bullhead (17%) (Figure 4).

From mid-April to early July, surface temperature increased and dissolved oxygen decreased gradually on the Potomac River. There, surface temperatures ranged from 15.5 to 20.6 C^{o} ($\bar{x}$ = 18.2 C^{o}) while dissolved oxygen behaved inversely (Range 6.2 – 8.6, $\bar{x}$ = 7.4 mg/L) (Figure 1). Weather on the Hudson River, from early May to June, was erratic by comparison. There the lowest recorded surface temperature (12.9 C^{o}) occurred midway (5/23) through sampling and gradually increased to a high of 20.6 C^{o}, when sampling ceased (Figure 2). Fluctuation in, Hudson River, surface temperature was reflected in dissolved oxygen values (7.64 – 10.0, $\bar{x}$ = 8.0 mg/L) (Figure 2). As time progressed CPUE was variable and apparently unrelated to tide on both rivers. CPUE was highest on the first day of sampling (0.118/h/ft^2, 0.033/h/ft^2) for the Potomac and Hudson rivers, respectively (Figure 1). The lowest CPUE values were recorded on the final day of sampling on the Potomac (0.001/h/ft^2) and Hudson (< 0.001/h/ft^2) Rivers (Figures 1 and 2), which is expected given ambient surface temperatures (Figures 1 and 2). On average, the Potomac River yielded more ripe/running male and female American shad per unit effort ($\bar{x}$ = 0.021/h/ft^2) than did the Hudson River ($\bar{x}$ = 0.007/h/ft^2) (Figures 1 and 2). Total egg shipments and liters were also higher for the Potomac (N = 11, 99.30 L) compared to the Hudson (N = 6, 60.00 L) (Table 2). However, egg viability was higher from the Hudson River (68.65%) than from the Potomac River (44.40%).

Discussion

The amount of nightly effort (gill net linear feet) increased on both rivers as American shad sampling progressed. Net design and the method of fishing were different than anticipated for the Hudson River and provided unique challenges, initially. Crew members with local knowledge eased the transition to Hudson River sampling.

Wet weather in the Northeast curtailed Hudson River sampling during May, 2006. Cool cloudy weather and heavy rainfall combined to reduce surface water temperatures and increase flows, which led to some localized flooding. Of the six egg shipments made from the Hudson River, two were collected when surface water temperatures were ≤ 15 C^o. Also, New York permitting requires that gill netting be suspended from Friday 6:00 pm to Saturday 6:00 pm (local) to allow recreational anglers unfettered access to the river. The mandatory stand down and inclement weather combined to reduce sampling effort below that which may be expected during a typical Hudson River American shad spawning season. For instance, the net lift and a three day foul weather allowance would leave 24 days for shad egg harvest/season on the Hudson River. Actual conditions permitted 13 fishing days. Of 13 attempts, 6 yielded an egg volume ≥ 5 L. We supplied an estimated 1.3 million viable American shad eggs from the Hudson River during spring, 2006 (Table 2). Given our average viability (≈ 69%) and harvest volume (10.0 L), 5.1 million viable American shad eggs were possible, given 24 days of effort. Therefore, the 3.8 million viable egg difference (expected – observed) may be considered the cost of spring, 2006 weather. Fortunately, weather - induced losses on the Hudson were offset by Potomac River gill netting during June, 2006 (Table 2). However, lower

egg viability in the Potomac River (≈ 44%) compared to the Hudson River (≈ 69%) reduced the 4.5 million potential eggs to 2.0 million viable eggs (Table 2).

Overall, American shad from the Hudson River seemed larger than those observed from the Potomac River. Greater fecundity and higher fitness is expected from larger individuals. Although anecdotal, the Hudson's larger spawning female American shad may explain the higher observed mean egg viability (Table 2). This assumption is supported, albeit circumstantially, by the nearly two - fold increase (0.32 : 0.54 L/ripe female) in observed egg yield from Hudson vs. Potomac River females.

American shad and bycatch recruited to the gear variably and in pulses during spring, 2006. This was especially evident on the Potomac River during the evening of April, 28. During this sampling event 328 striped bass were caught in 1.48 hours with a combined 549 m of net. Net length was equally divided between two Service boats fishing in a North/South line parallel and in close proximity to the steep drop, from shoal to channel. Service nets were joined directly to the south by identical nets of similar length, belonging to MDDNR. Fishing in this manner resulted in an almost uninterrupted blockade of the underwater feature. The large aggregation of striped bass encountered a small area of net over a relatively short time period. Most (n = 287) of the school was caught in 275 m of Northernmost boat's net. The remaining striped bass were caught by the boat to the South. Further South, MDDNR nets captured approximately 75 striped bass in approximately the same amount of time. Short staggered gill net set/retrieval times and assistance from MDDNR combined to prevent large – scale loss of striped bass.

American shad harvest in numbers sufficient to yield egg shipments was also variable on the Potomac River. Often, most of the shad were encountered by one boat. Males were rare from the Potomac (5%) compared to the Hudson River (34%) and were outnumbered by ripe females by nearly 2 to 1 (Figures 3 and 4). Restoration efforts would have benefited from this ratio, had it been maintained throughout sampling. On the Potomac River, male American shad were often shared between Service boats and MDDNR and occasionally re-used. By contrast male American shad dominated the Hudson River catch (Figure 4) and were never a limiting factor, as on the Potomac River.

Conclusion

The Service's first attempt to harvest eggs from the Potomac and Hudson Rivers for delivery to the Van Dyke American shad hatchery, in support of Susquehanna River restoration, was a success. Taken together, harvest, from Service gill netting, equaled results from the Delaware and Susquehanna Rivers, with respect to viable eggs, which is the basis for our recommendation to continue the project. A key to success was the decision to gill net the Potomac River for American shad prior to the Hudson River season. Spreading effort over two months at locations separated by nearly 640 km circumvented the unforeseen effects of inclement weather in the Northeast.

Acknowledgements

The Maryland Fishery Resources Office thanks those who volunteered time and energy to further Susquehanna River American shad restoration efforts. They are Art Coppola, Dr. Fred Pinkney, and Dan Murphy from the U.S. Fish and Wildlife Service; Matthew Baldwin from the Maryland Department of Natural Resources; Kathy Hattala, Kris McShane and Jen Temple from the New York Department of Environmental

Conservation; Kale Kaposhilin from Kingston, New York. We also appreciate Richard St. Pierre's expertise and guidance during the early stages of this project.

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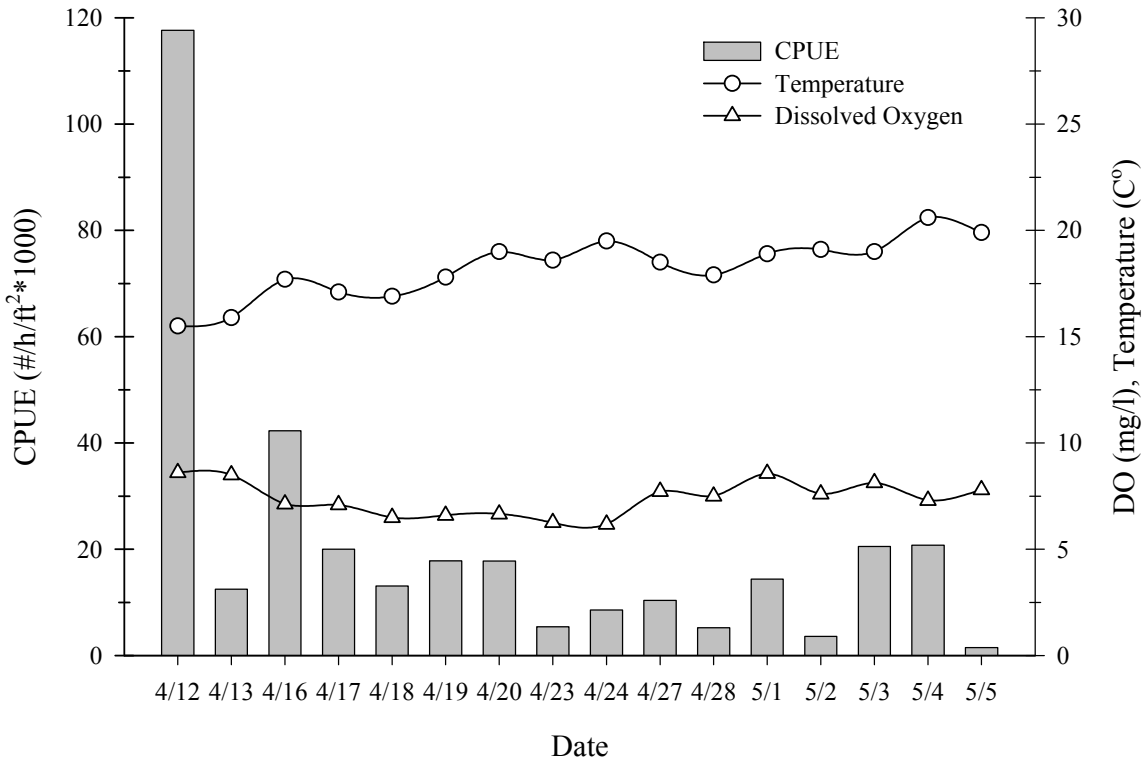

Figure 1. Spring 2006 American shad catch per unit effort, surface dissolved oxygen, and surface temperature, by sample date, for the Potomac River at Marshall Hall, MD. Surface salinity (not depicted) was always ≤ 0.20 ppt.

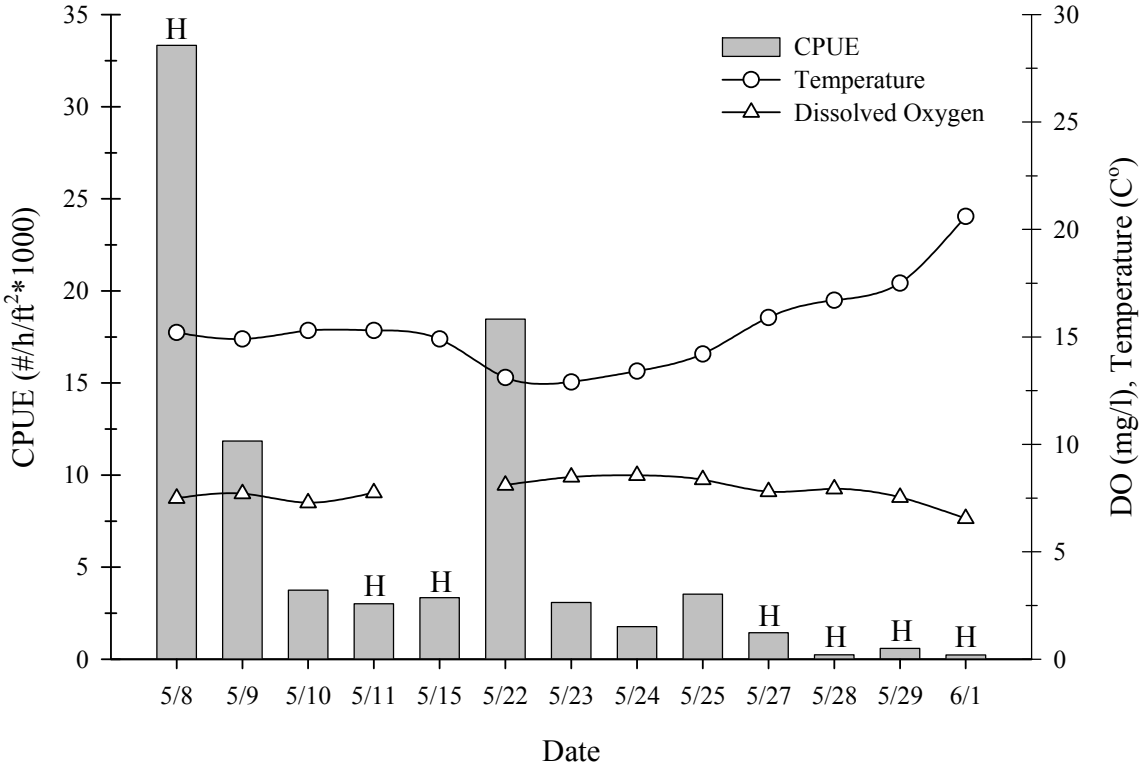

Figure 2. Spring 2006 American shad catch per unit effort, surface dissolved oxygen, and surface temperature, by sample date, for the Hudson River at Stuyvesant, NY. Surface salinity (not depicted) was always ≤ 0.20 ppt.

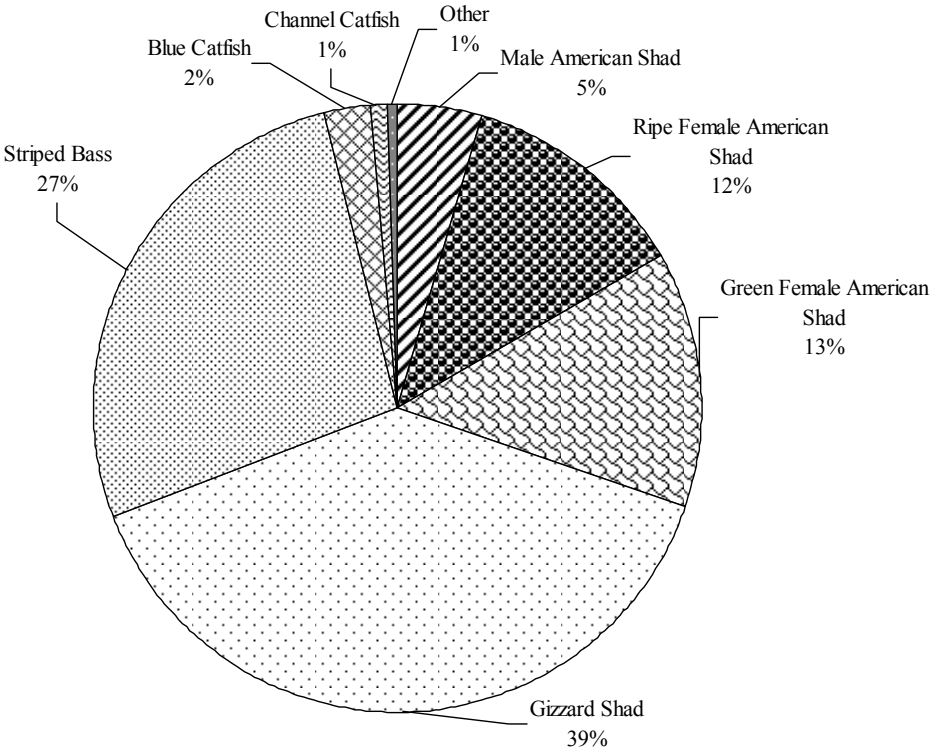

Figure 3. Spring 2006 species composition from Potomac River gill net sampling at Marshall Hall, MD. Other species were long nose gar, Alosids, and common carp.

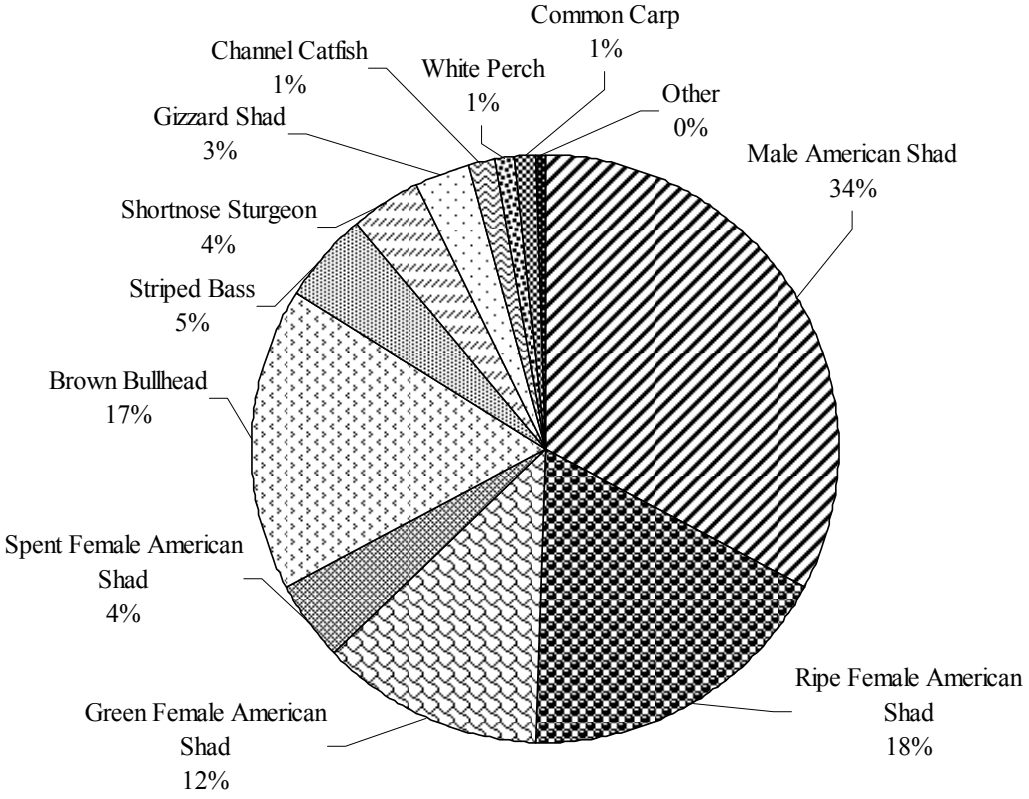

Figure 4. Spring 2006 species composition from Hudson River gill net sampling at Stuyvesant, NY. Other species were walleye and goldfish.

			Number	
Family	**Scientific Name**	**Common Name**	**Potomac R.**	**Hudson R.**
Acipenseridae	*Acipenser brevirostrum*	shortnose sturgeon		25
Clupeidae	*Alosa sapidissima*	American shad	777	417
	Alosa sp.	river herring	3	
	Dorosoma cepedianum	gizzard shad	1002	18
Cyprinidae	*Carassius auratus ssp.*	goldfish		1
	Cyprinus carpio	common carp	2	8
Lepisosteidae	*Lepisosteus osseus*	longnose gar	12	
Moronidae	*Morone Americana*	white perch		7
	Morone saxatilis	striped bass	693	31
Ictaluridae	*Ameiurus nebulosus*	brown bullhead		103
	Ictalurus furcatus	blue catfish	63	
	Ictalurus punctatus	channel catfish	19	8
Percidae	*Stizostedion vitreum*	walleye		2

Table 1. List of species and number collected in gill nets from the Potomac and Hudson Rivers during spring, 2006.

Site	Shipments (N)	Volume (L)	Eggs (N)	Viable Eggs (N)	Viability (%)
Potomac R.	11	99.3	4,511,426	2,003,222	44.40
Hudson R.	6	60.0	1,859,518	1,276,500	68.65
Delaware R.	12	64.9	2,328,165	1,164,868	50.03
Susquehanna R.	17	169.25	10,281,444	2,232,459	21.71
Total	46	393.45	18,980,553	6,677,049	35.18

Table 2. 2006 American shad egg shipment and viability summary from sites delivering to the Van Dyke American Shad Hatchery near Thompsontown, PA (Hendricks 2006, unpublished).