



Colloque international sur l'étude, la restauration et la gestion de l'aloise  
International symposium on restoration and conservation of shads

## American Shad Restoration and Passage on the Susquehanna River, USA

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*Session 1 : Les actions du programme Life+ Alose / Results of the Allis shad project*

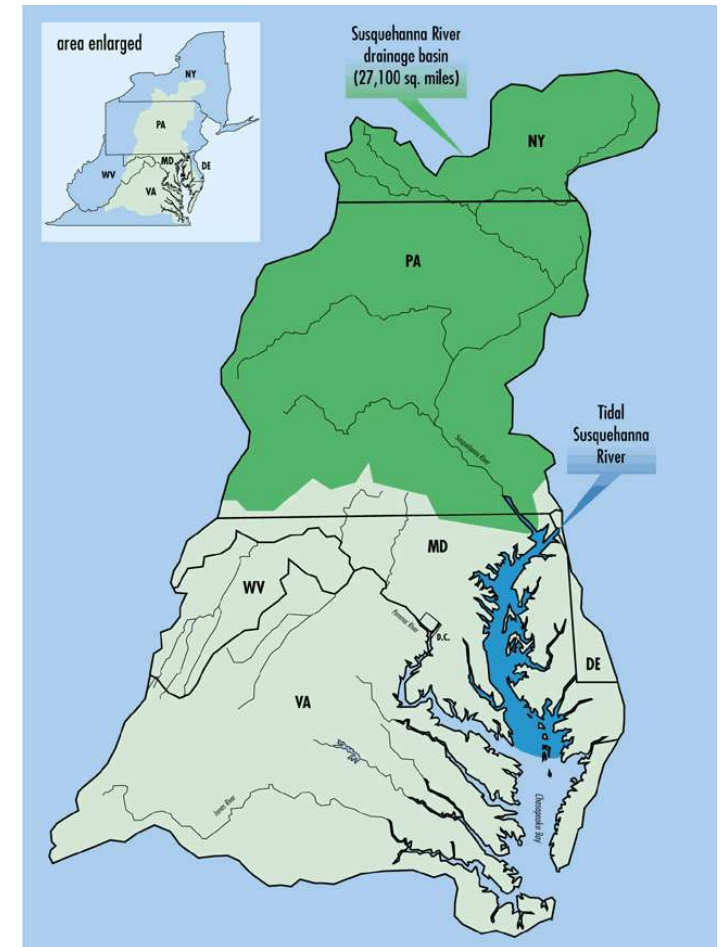
**Bergerac**

14-15 octobre 2015



## Today's Objectives

- Historic Overview of Susquehanna River American Shad
- Recent Restoration Activities
- Passage at Mainstem Hydropower Dams
- American Shad Statistics
- Near Term Improvements to Restoration
- Long Term Restoration Concerns



## American Shad - A Lost Legacy in the Susquehanna River

- American Shad were an important food source for Native Americans
- Shad reached the Susquehanna River headwaters near Cooperstown New York; a 640 mile journey
- First commercial fishing for Shad in PA established in 1750's
- Shad were abundant in the River prior to the installation of feeder dams for the PA canal system in 1830

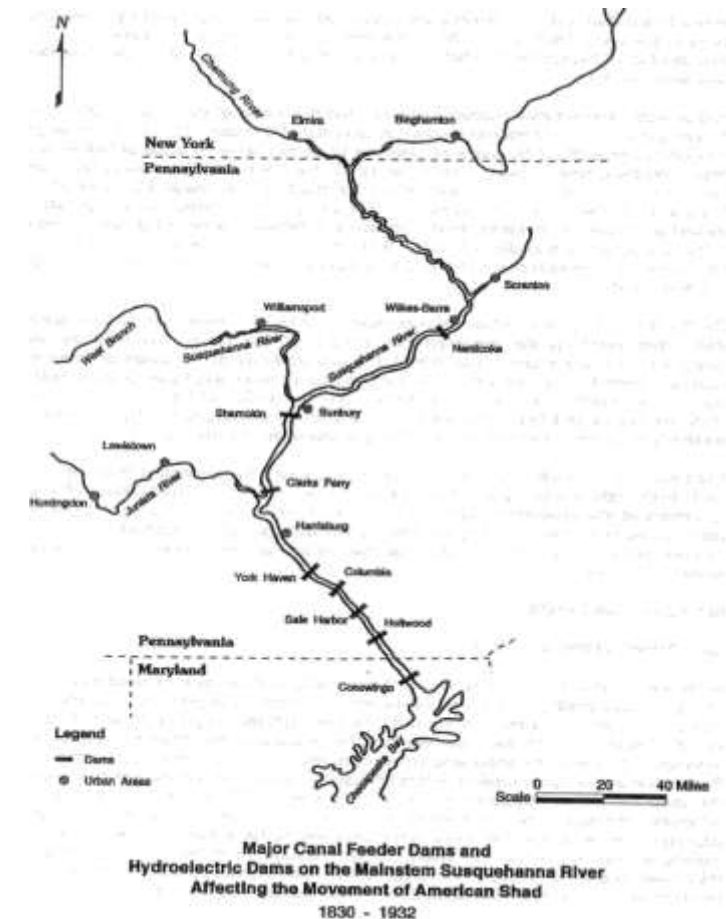






## Historic Overview - Dams, Pollution and Overfishing

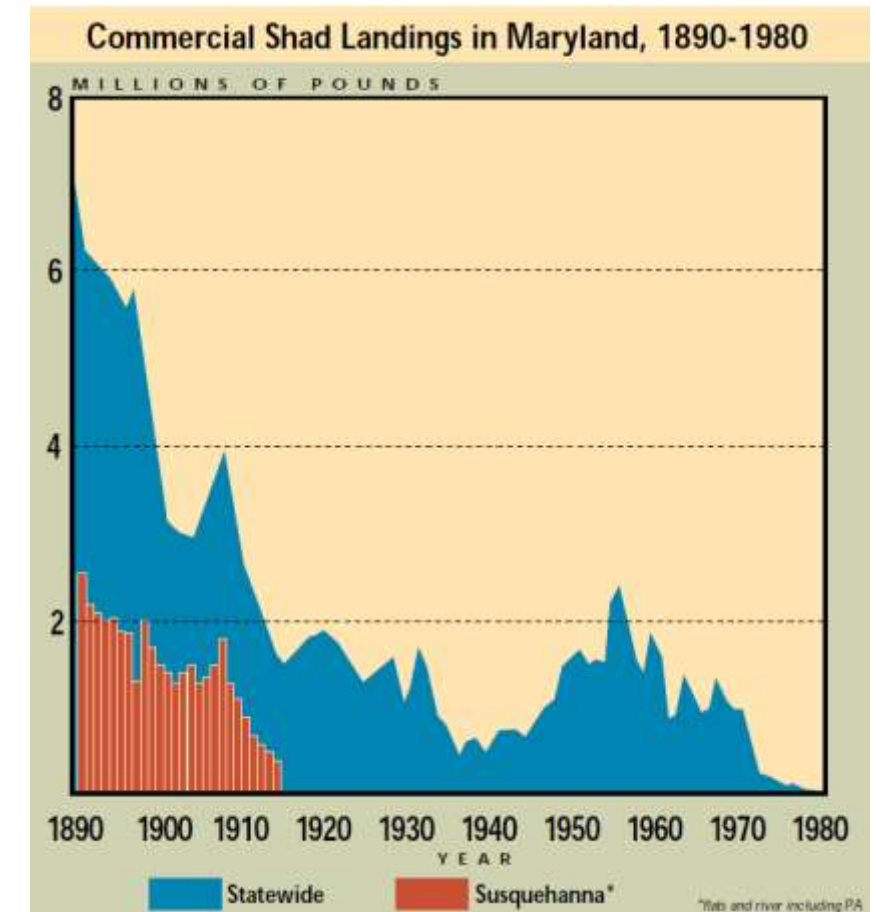
- Construction of Columbia Canal Feeder Dam in 1830's blocked hundreds of miles of spawning habitat
- Sizable shad fisheries developed in the River below Columbia Dam and at the head of Chesapeake Bay
- In 1866, Pennsylvania Legislature passed a law directing persons or companies that owned dams on the Susquehanna River and certain tributaries to "make, maintain and keep a sluice, weir or other device for the free passage of fish and spawn, up and down the stream..."
- This Act created the office of commissioner, appointed by the governor, to oversee and enforce the fish passage provision, the appointment was forerunner of the present-day PF&BC





## Historic Overview - Railroad Replaced Canal System

- By late 1800s shad runs resumed on the River once dams at Columbia and upriver were abandoned and breached
- During 1890 to 1909 Pennsylvania shad landings averaged 63,000 fish
- In 1896, the Maryland and Pennsylvania shad catch in the River was 140,000 fish
- Total Maryland shad catch that year was 1.4 million fish



## Early Fishways Failed

- Two Fishways were constructed at Holtwood Dam
  - Rock Ramp on West shore of River
  - A concrete flume on east side of River
- Passage at the two Holtwood fishways was very limited
- Federal and State fishery authorities conceded fish passage not practical at high Dams
- No Fishways constructed at the 95 ft. high Conowingo Dam
- Eliminated Susquehanna River American shad resource in PA.





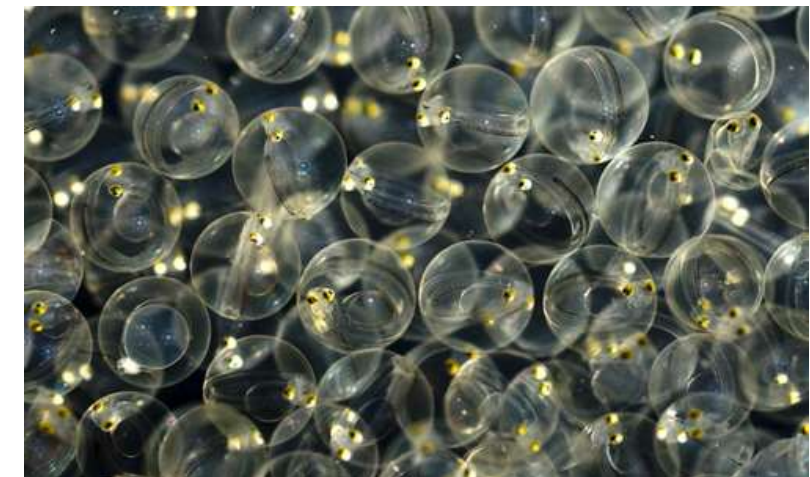


## Recent Restoration Activities

- In 1969, Susquehanna Shad Advisory Committee formed
  - U.S. Fish & Wildlife Service
  - Pennsylvania Fish Commission
  - New York Department of Environmental Conservation
  - Maryland Department of Natural Resource
- In 1970, agreement reached with dam owners to stock the River with shad eggs and build a trapping facility along the west shore at Conowingo Dam
- In 1972 West Lift at Conowingo Dam Placed in Service
- In 1976 egg stocking replaced with culture and release of shad fry; PF&BC developed Van Dyke Research Station
- Shad Advisory Committee renamed “Susquehanna River Anadromous Fish Restoration Committee” (SRAFRC)



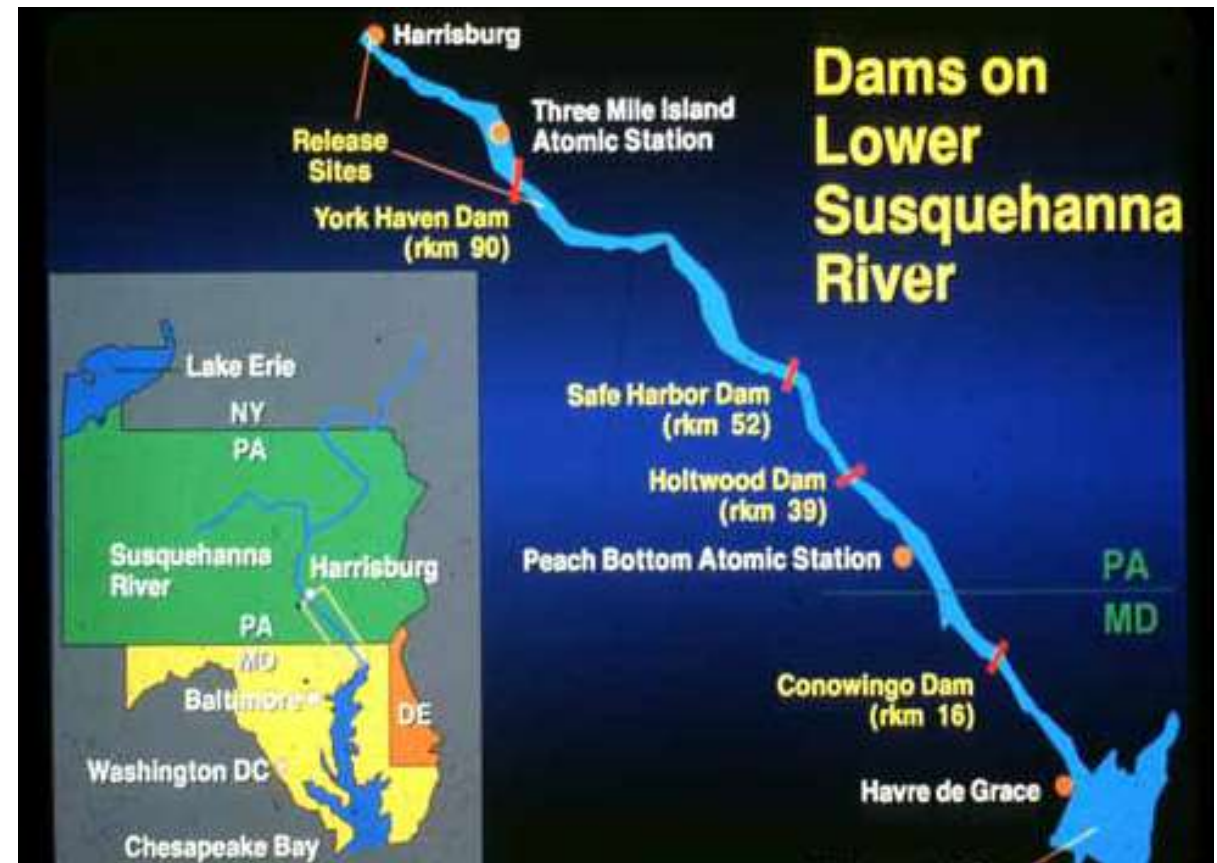
credit: USFWS





## Four Hydroelectric Dams Constructed on Lower River 1904 - 1931

- York Haven Dam – 1904, River Mile 55
- Holtwood Dam - 1910, River Mile 24
- Conowingo Dam - 1928, River Mile 10
- Safe Harbor – 1931, River Mile 31





## 1979 – Strategic Restoration Plan Adopted For River

Reopen river to natural migrations

Within 25 years restore annual spawning populations upstream of York Haven Dam:

- 2 million shad
- 10 million river herring

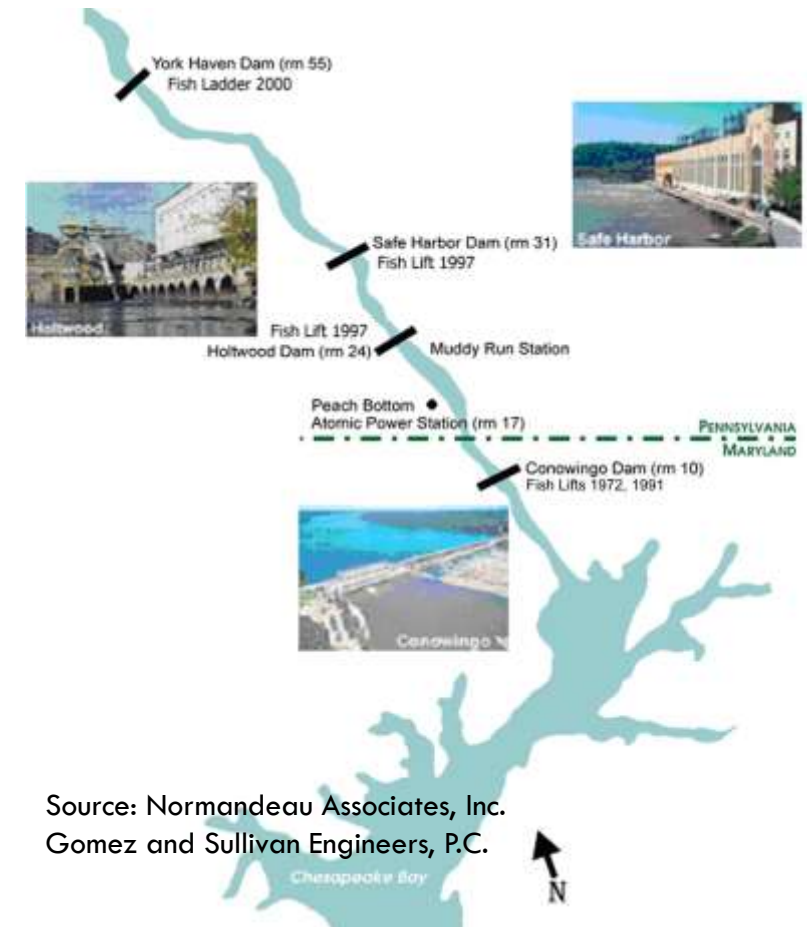
Goals adopted by Susquehanna River Basin Commission (SRBC) in its Comprehensive Plan for management of the Susquehanna River Basin





## 1980 – FERC Issues Long Term Operating Licenses

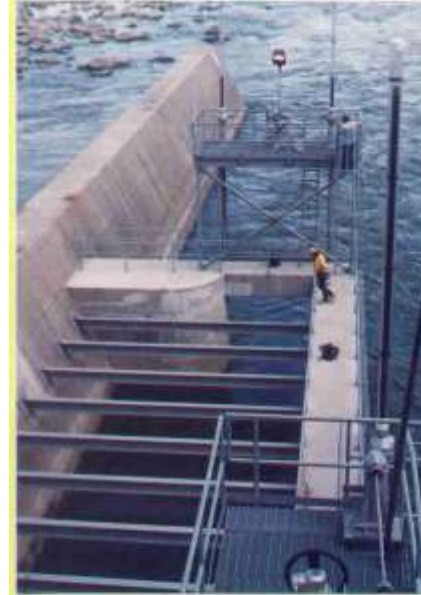
- FERC renewed licenses for the four Susquehanna River Hydroelectric projects
- Questions related to shad restoration addressed at hearings in Washington, D. C.
- Parties urged to negotiate a settlement that would result in design and implementation of cost-effective program to rebuild shad stocks



Source: Normandeau Associates, Inc.  
Gomez and Sullivan Engineers, P.C.

## Philadelphia Electric Agreement

- Resulted in construction of a permanent fish passage facility at the east side of the Conowingo powerhouse
- Fish passage facility designed to pass 1.5 million shad and 10 million river herring

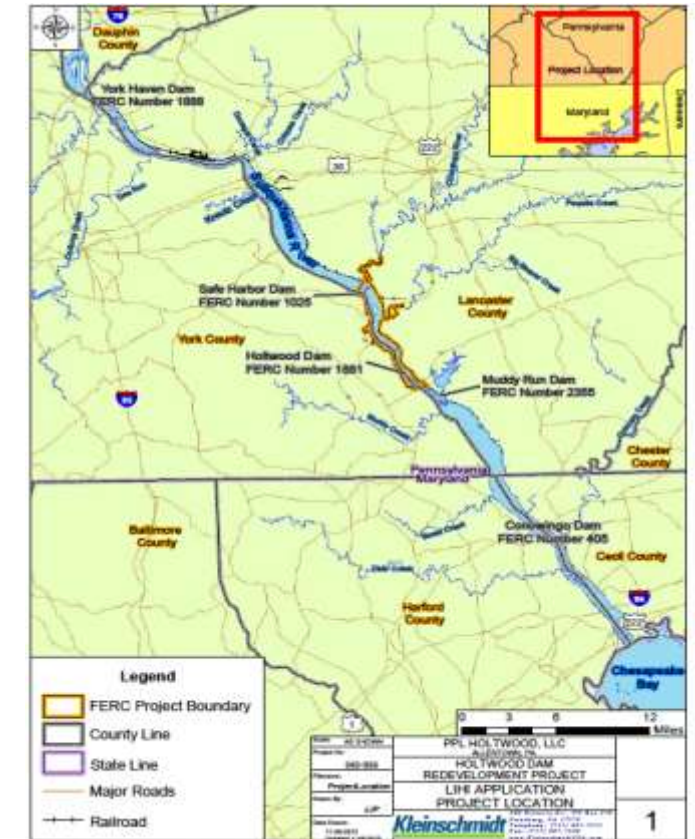






## Important Aspects of Upstream Agreement

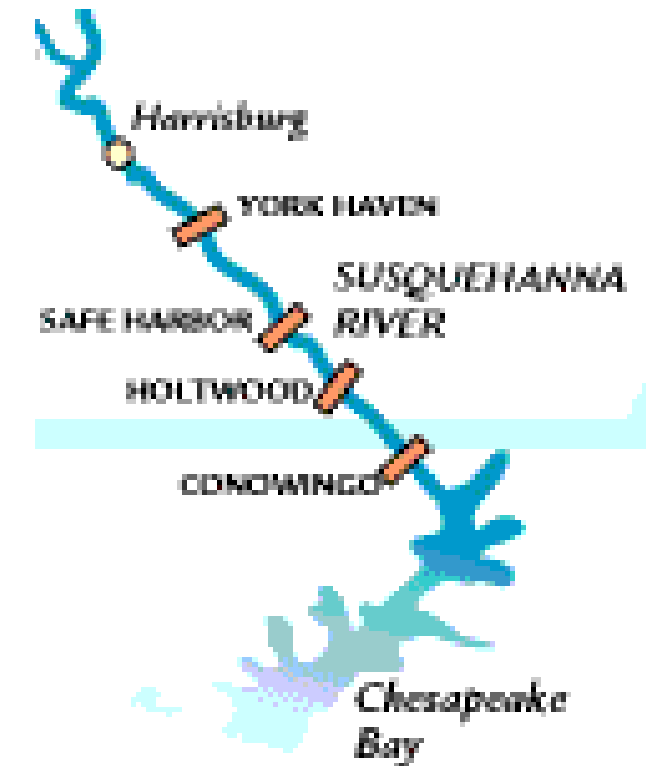
- Upstream Utilities provided PFBC \$3.7 million dollars over 10 year period (1985 -1994)
- Funds used for trap and transfer of adult shad and expand hatchery operations
- Conduct other studies related to shad restoration
- Parties agreed to resolve outstanding issues related to design and construction of fish passage facilities at Holtwood, Safe Harbor and York Haven





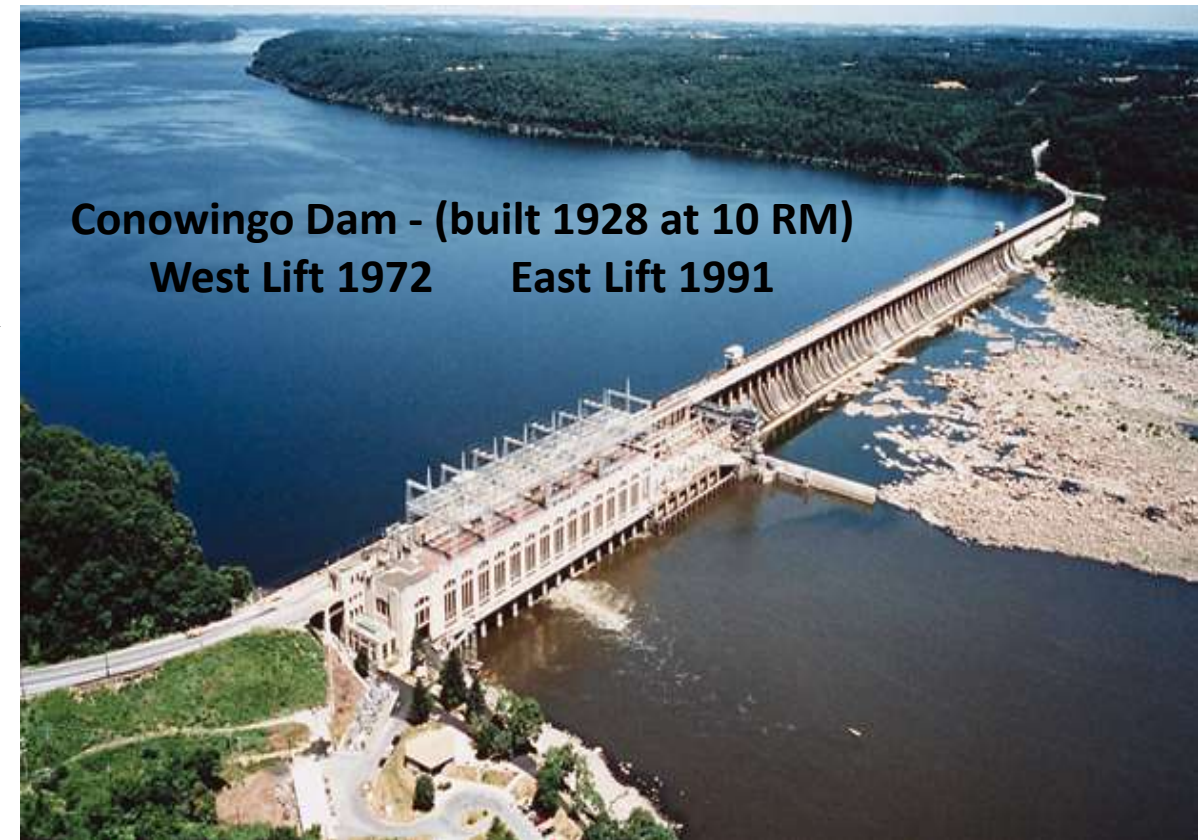
## Susquehanna River Restoration Methods

- Restoration Methods
  - Hatchery stocking, trap/transport
  - Fishways, fishing moratorium
- Fishways at lower 4 Mainstem dams
- Goal: 3 million shad to the mouth of the river
- 18 year shad passage average
  - ~ 62,300 shad - 1<sup>st</sup> Dam (Conowingo)
  - ~ 10,425 Shad passed at Conowingo in 2014



## Conowingo Hydroelectric Project (FERC No 405)

- Completed in 1928
- Consists of a concrete gravity overflow dam 4,869 ft. long by 95 ft. high and a powerhouse
- Power house contains 11 turbines, 7 Francis units & 4 Kaplan Turbines that were replaced (1992 -1996)
- Excess flows spilled through 50 crest gates & 1 reg. gate
- Powerhouse has a hydraulic capacity of 85,0000 cfs
- Powerhouse has a generating capacity of 549.5 MW
- Project forms Conowingo Pond (14 mile long impoundment)





## Conowingo West Fish Lift

- Trapping device constructed on the west side of the Conowingo tailrace
- Placed in service in 1972
- Since 1985 most shad were transported upriver
- Since 1997 used to collect shad for hatchery needs and special studies





## Conowingo East Fish Lift

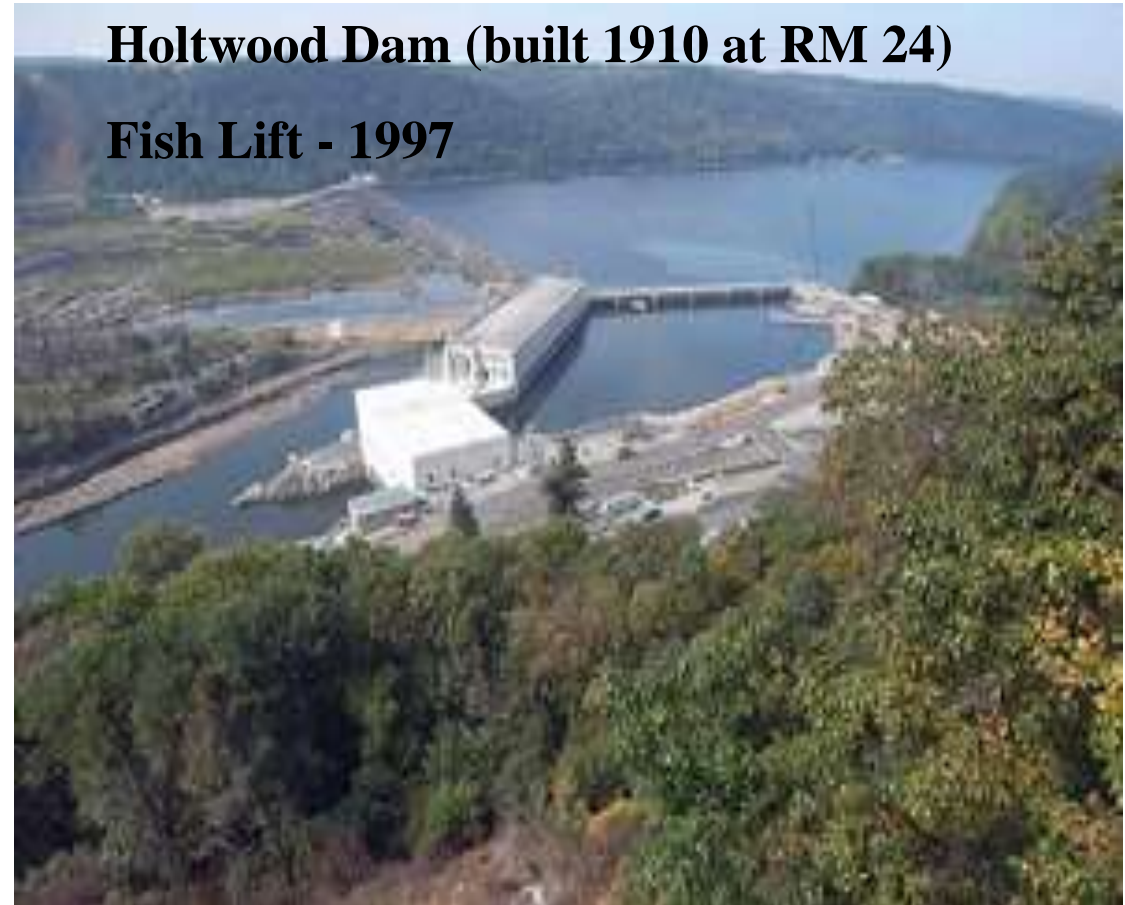
- Trap and transport facility placed in service in 1991
- Operated as trap & transport facility between 1991 and 1996
- Volitional passage commenced in 1997
- Designed to pass 1.5 million shad and 10 million river herring
- Three entrances (A, B, & C)
- Fish are hoisted and sluiced into to a trough and are counted as they swim into Conowingo Pond





## Holtwood Hydroelectric Project (FERC No. 1881)

- Completed in 1910
- Consists of a concrete gravity overflow dam 2,392 ft. long by 55 ft. high and a powerhouse
- Legacy Powerhouse contains 10 turbines; 3 single runner Francis & 7 double runner Francis turbines, each capable of passing 3,000 cfs with a total hydraulic capacity of 32,000 cfs
- New Powerhouse contains 2 Kaplan turbines, each capable of passing 15,000 cfs with a total hydraulic capacity of 30,000 cfs
- Project has a hydraulic capacity of 61,500 cfs and a generating capacity of 195.5 MW
- Project structures form Lake Aldred (7 mile long impoundment)





## Holtwood Fish Lift

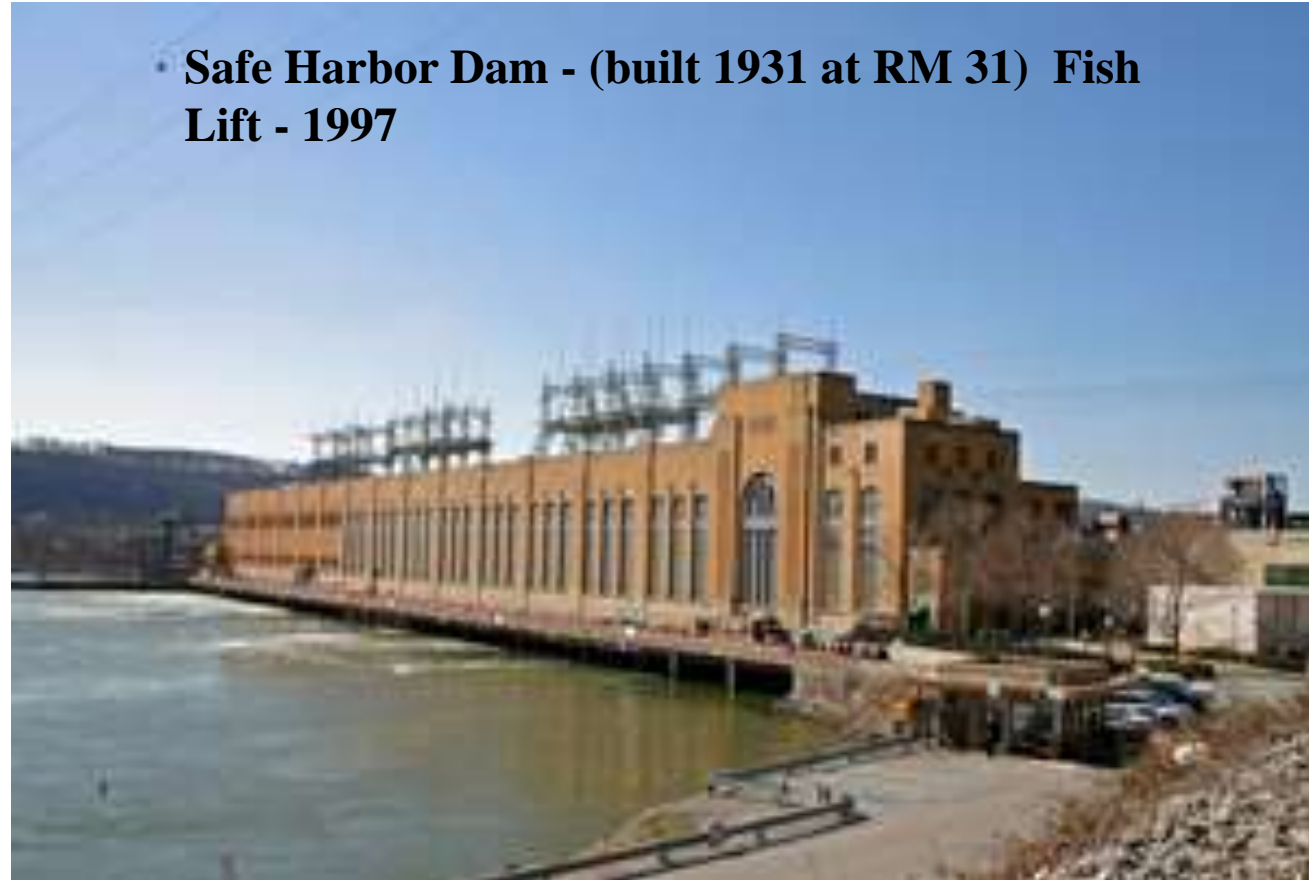
- Placed in service in 1997
- Designed to pass 2.7 million shad equivalents (where 10 river herring equal 1 shad)
- Comprised of a spillway lift and tailrace lift
- Tailrace lift has two entrances (A & B)
- Spillway lift has one entrance (C)
- Fish are hoisted and sluiced into to a trough and are counted as they swim into Lake Aldred



## Safe Harbor Hydroelectric Project (FERC No 1025)

- Completed in 1931
- Consists of a concrete gravity overflow dam 4,869 ft. long by 75 ft. high and a powerhouse
- Power house contains 12 turbines, 7 original units (Kaplan turbines) and five mixed flow units added in 1986
- Each Unit is capable of passing approximately 8,500 cfs
- Powerhouse has a hydraulic capacity of 110,000 cfs
- Powerhouse has a generating capacity of 417.5 MW
- Project forms Lake Clarke (10 mile long impoundment)

### Safe Harbor Dam - (built 1931 at RM 31) Fish Lift - 1997





## Safe Harbor Fish Lift

- Placed in service in 1997
- Designed to pass 2.5 million shad and 5 million river herring
- The lift has three entrances (A, B & C)
- Operation of entrances dependent on station generation
- Fish are hoisted and sluiced into to a trough and are counted as they swim into Lake Clarke





## York Haven Hydroelectric Project (FERC No. 1888)

- Completed in 1904
- Project includes a powerhouse and two dams; a 5,000 ft. long Main Dam and a 970 ft. long East Channel Dam
- Powerhouse contains 20 turbines; 6 Propeller & 14 Francis turbines
- Powerhouse has hydraulic capacity of 17,000 cfs
- Units are capable of passing between 800 and 1,100 cfs  
Powerhouse has a generating capacity of 19 MW
- Project structures form Lake Frederic (5 mile long impoundment)

**York Haven Dam - (built 1910 at RM 56)**

**Serpentine Vertical Notch Fishway - 2000**



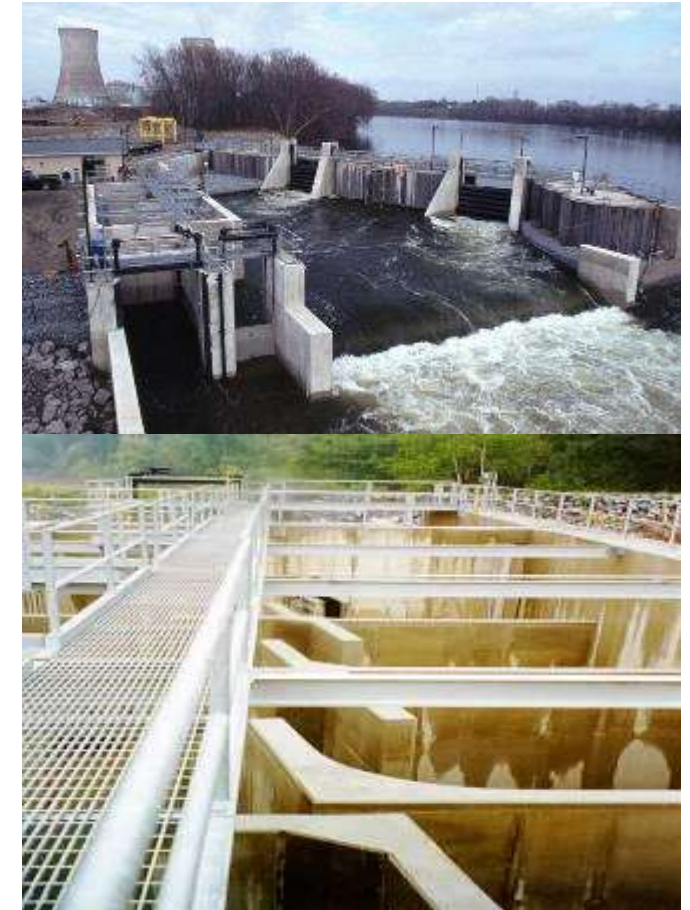
## York Haven Project Layout





## York Haven Fishway

- Placed in service in 2000
- Fishway includes a “Weir Cut” and vertical notch fish ladder
- Designed to pass 500,000 shad equivalents (where 10 river herring equal 1 shad)
- When river flows are less than 23,000 cfs York Haven spills 4,000 cfs over the Main Dam and 2,000 cfs through the East Channel Dam in order to improve fish passage





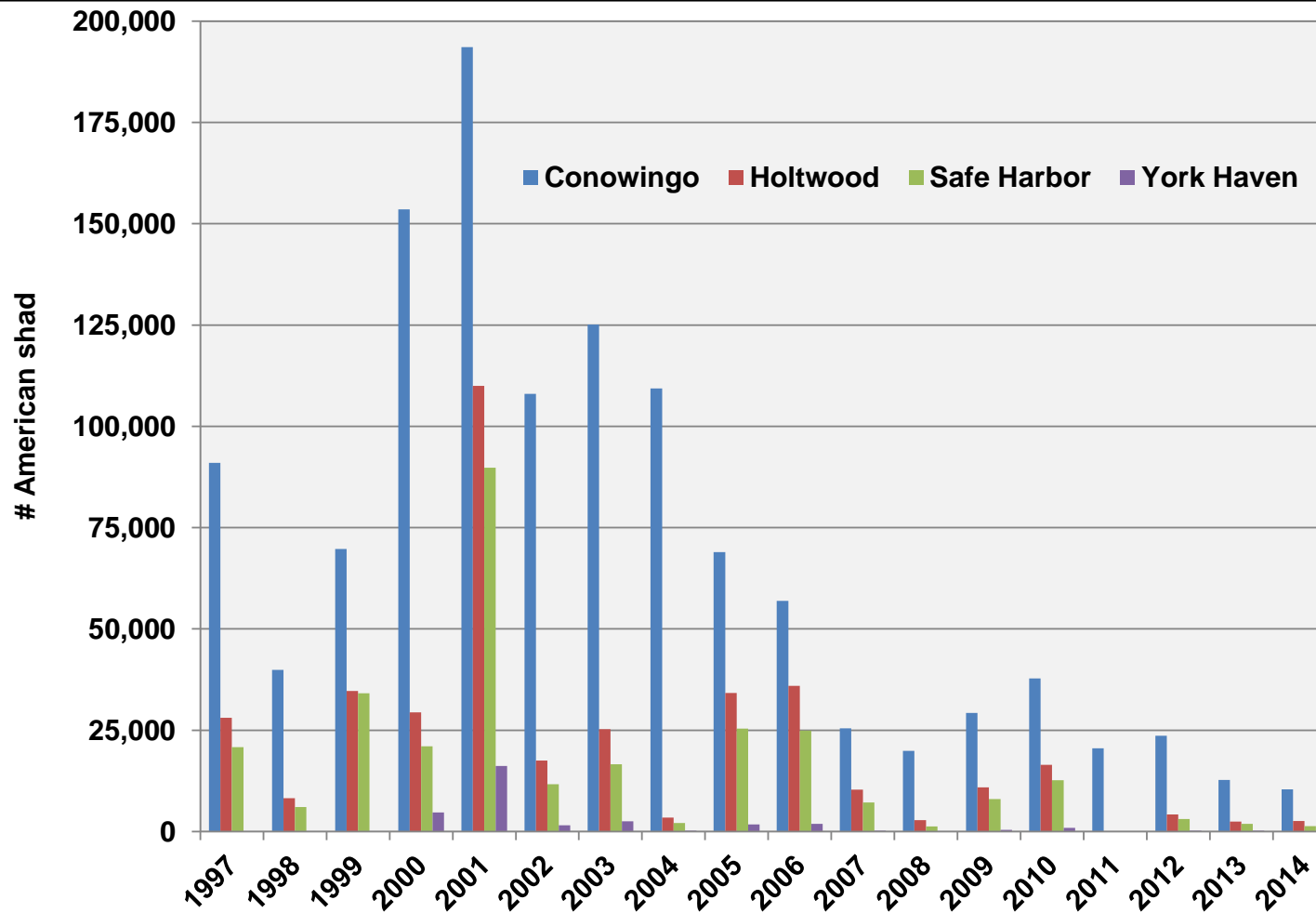


## Susquehanna River Passage 1997 - 2014

Year	Conowingo (rm 10.0)	Holtwood ( rm 24.6)	Safe Harbor (rm 32.2)	York Haven (rm 56.1)	Holtwood %	Safe Harbor %	York Haven %	Overall %
1997	90,971	28,063	20,828	-	31%	74%	-	-
1998	39,904	8,235	6,054	-	21%	74%	-	-
1999	69,712	34,702	34,150	-	50%	98%	-	-
2000	153,546	29,421	21,079	4,687	19%	72%	22%	3%
2001	193,574	109,976	89,816	16,200	57%	82%	18%	8%
2002	108,001	17,522	11,705	1,555	16%	67%	13%	1%
2003	125,135	25,254	16,646	2,536	20%	66%	15%	2%
2004	109,360	3,428	2,109	219	3%	62%	10%	0%
2005	68,926	34,189	25,425	1,772	50%	74%	7%	3%
2006	56,899	35,968	24,929	1,913	63%	69%	8%	3%
2007	25,464	10,338	7,215	192	41%	70%	3%	1%
2008	19,914	2,795	1,252	21	14%	45%	2%	0%
2009	29,272	10,896	7,994	402	37%	73%	5%	1%
2010	37,757	16,472	12,706	907	44%	77%	7%	2%
2011	20,571	21	8	0	0%	38%	0%	0%
2012	23,629	4,238	3,089	224	18%	73%	7%	1%
2013	12,733	2,503	1,927	202	20%	77%	10%	2%
2014	10,425	2,625	1,336	8	25%	51%	1%	0%
Total	1,195,793	376,646	288,268	30,838	29%	69%	9%	2%

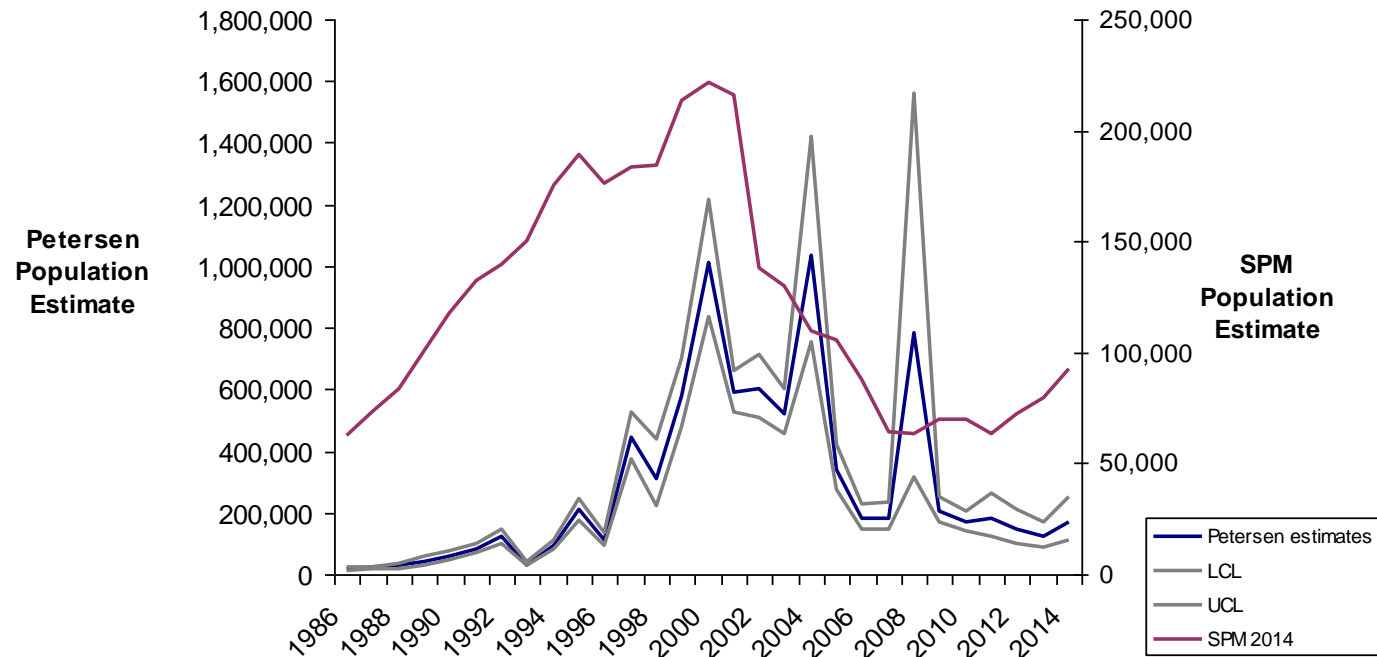


## Susquehanna River American Shad Passage





## MD DNR Shad Population Estimates 1986 -2014

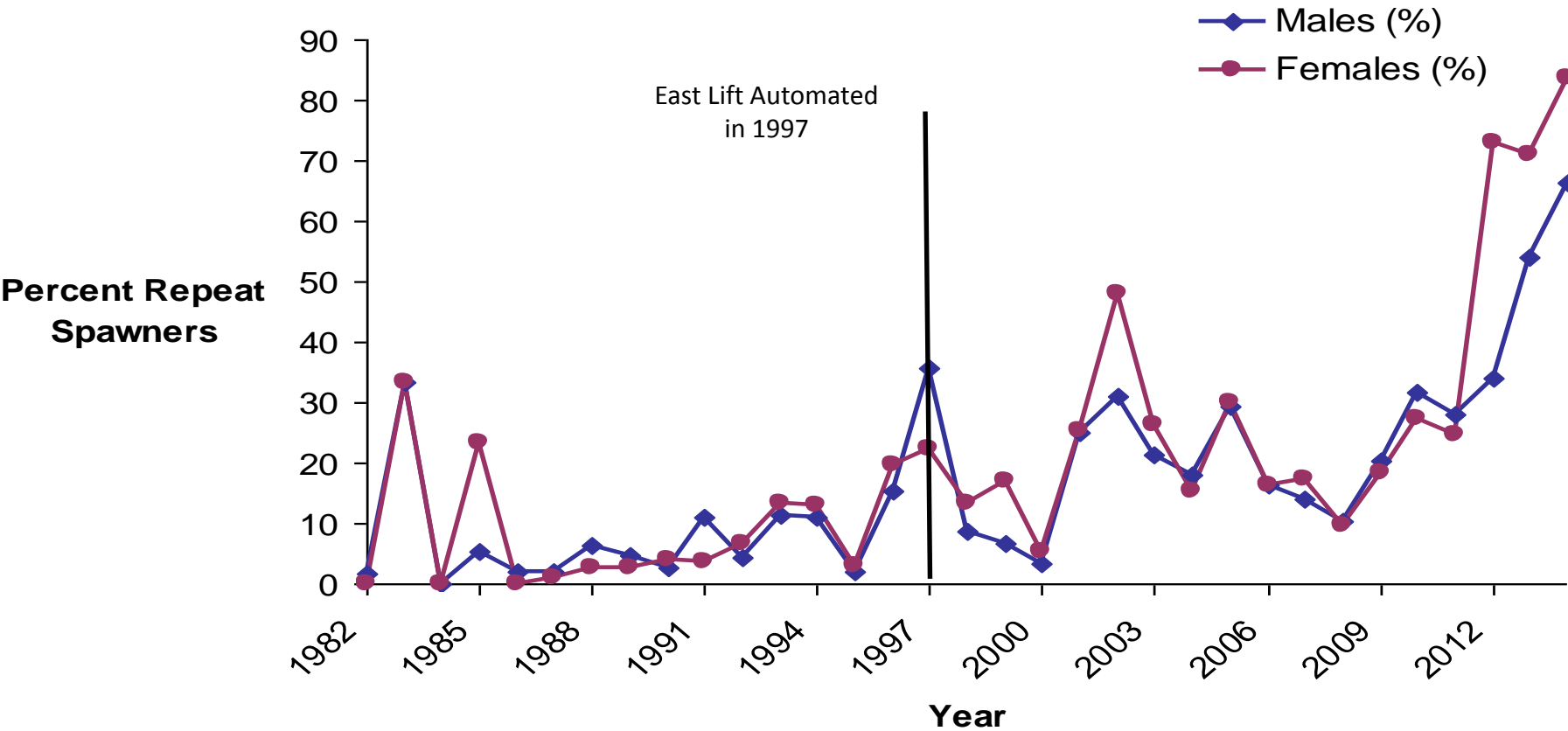


- Petersen estimate: 167,877 fish  
2004, 2008 & 2014 estimates suspect because low recapture rates ( $<0.1$ )
- Surplus Production Model Estimate: 92,685 fish
- Trends are more important than point estimates



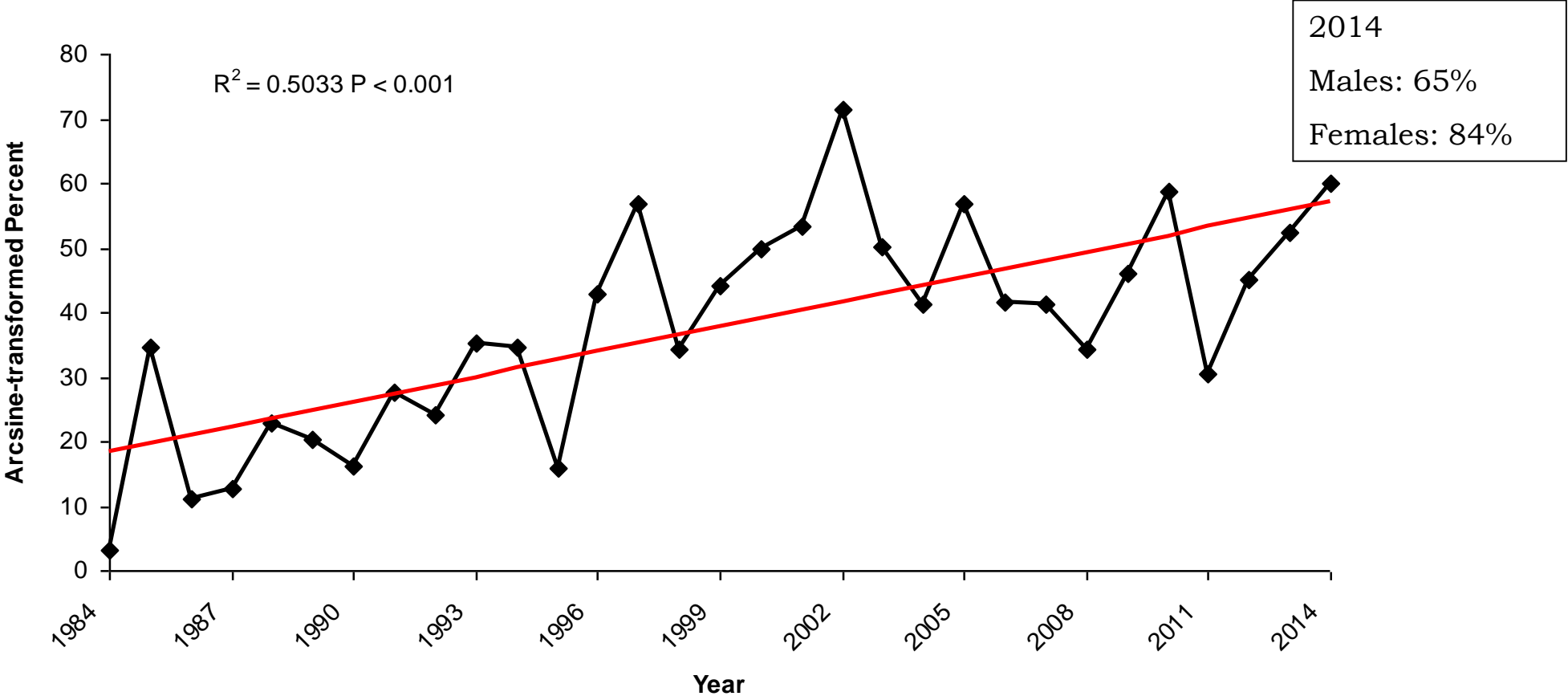


# Trend for Repeat Spawners 1982-2014



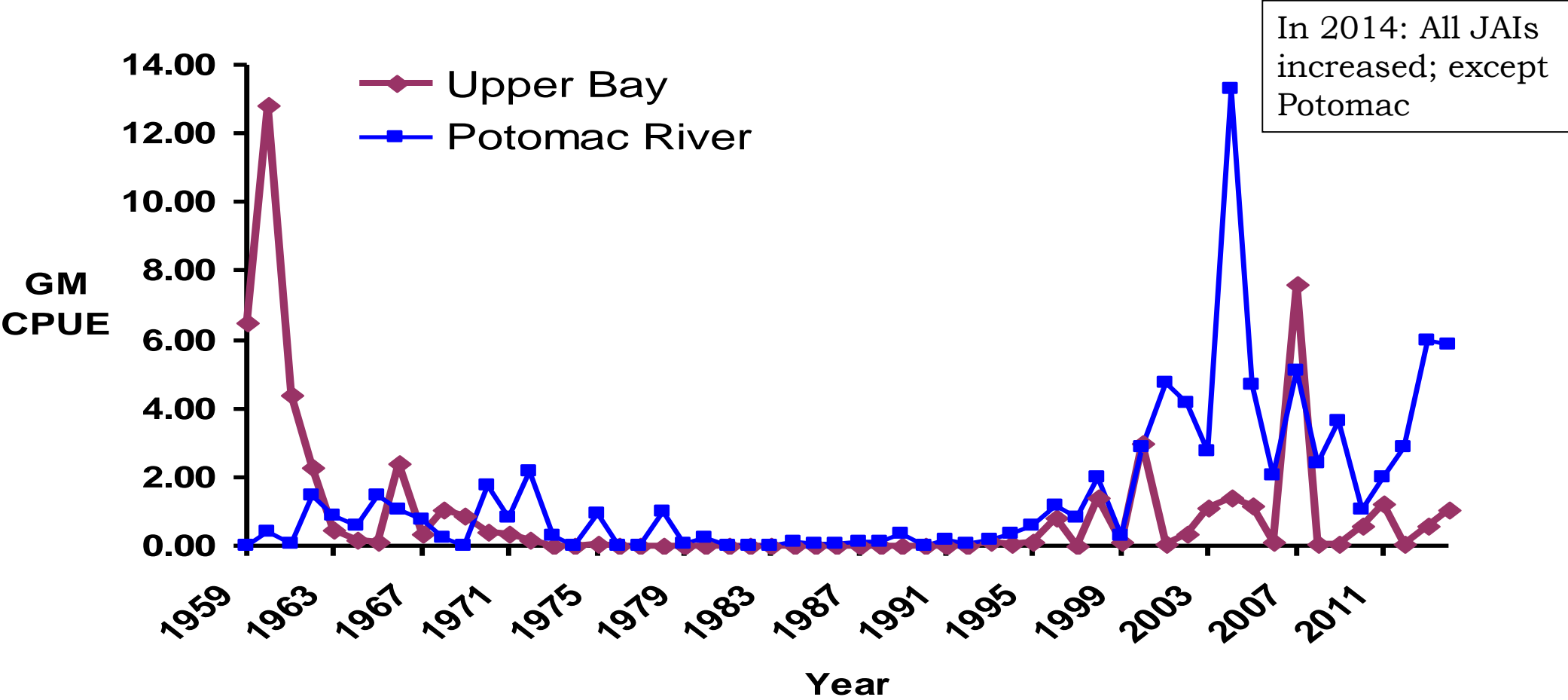


# Repeat Spawners in the Tailrace





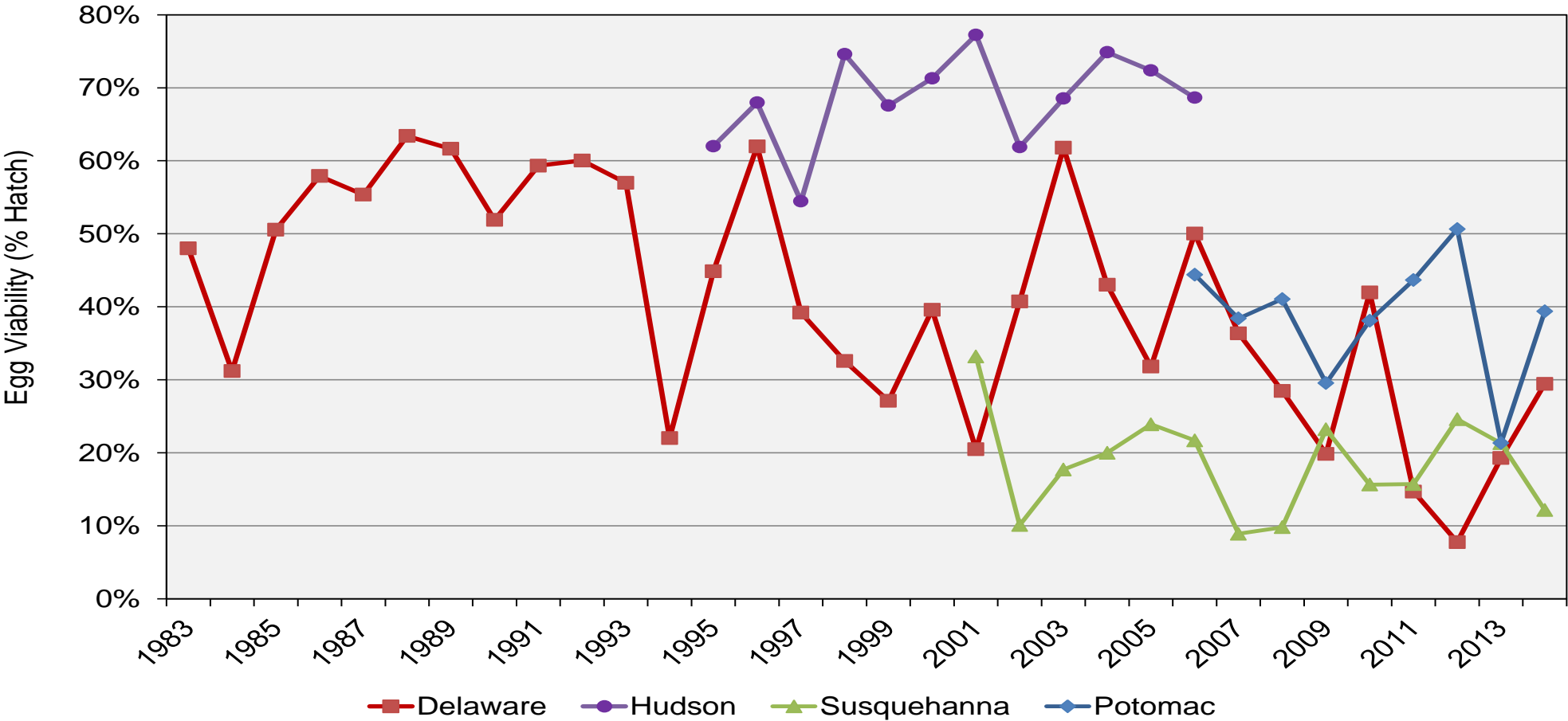
# Juvenile American Shad Relative Abundance





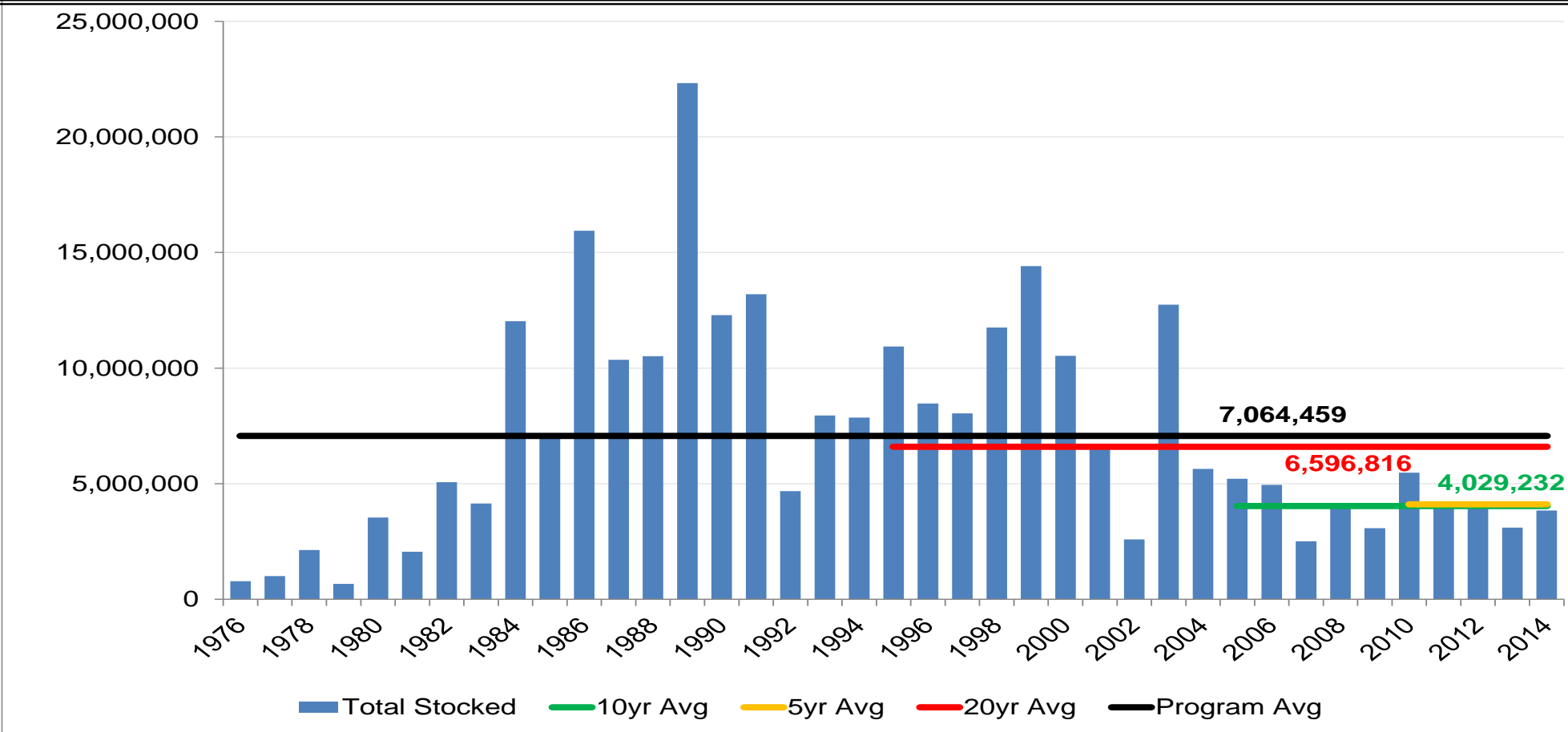


# American Shad Egg Collections Egg Viabilities (%)





# American Shad Fry Production & Stocking





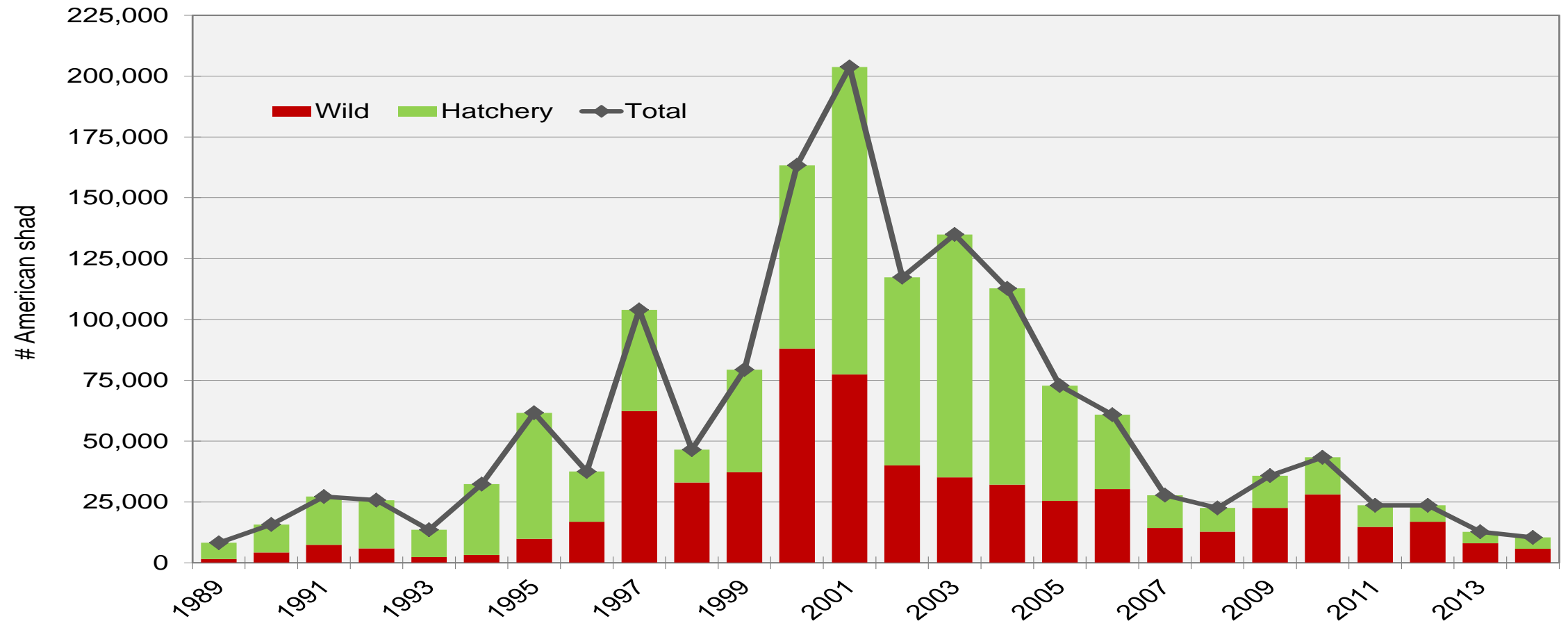
# Susquehanna River Juvenile American Shad Collections

Year	Lift Catch	Seine Catch	
	Holtwood	Columbia	City Island
1985	3626		
1986	2926		
1987	832		
1988	929		
1989	556		
1990	3988	285	
1991	208	170	
1992	39	269	
1993	1095	218	
1994	206	390	
1995	1048	409	
1996		283	
1997	1372	879	
1998	180	230	
1999	490	322	
2000	406	31	
2001	1245	377	
2002	68	0	
2003	61	17	
2004	0	25	
2005	200	23	
2006	8	1	
2007	0	2	
2008	1	0	
2009	0	0	
2010		3	2
2011		3	2
2012		1	0
2013		1	0
2014		9	24





## Adult American Shad Otolith Analysis Results





# PFBC Cohort Analysis - Hatchery Larvae, Juveniles & Transported Adult Shad

- Recruitment by year class determined for hatchery and wild origin fish, stocked above dams, to Conowingo Lifts

Lift catch for each year portioned into its component year classes based upon age composition and otolith marking

Total Recruitment by year class was determined for hatchery and wild fish by summing data for each year class over its recruitment history

- Mean Number of larvae required to return 1 adult (1986-2000) : 314
- Mean Number of hatchery fingerlings required to return 1 (1986-1994) : 196
- Mean number of adults transported upriver to return 1 adult (1986-2000) : 2.10

## Recruitment of Hatchery Larvae to Conowingo Lifts

[illegible]



## Near Term Improvements to Shad Restoration

- Upgrade Active Program Elements (Hatchery & Trap & Transport)
- Recent Licensing & Relicensing Activities to Result in Upstream Fish Passage Improvements at:
  - East & West Lifts at Conowingo Dam
  - Holtwood Dam
  - Installation of Nature Like Fishway at York Haven Dam
- Improved Downstream Passage survival of Downstream Adults and Juvenile Shad at Dams (Goal: Adults 85% & Juveniles 95%)





## Long Term Restoration Concerns

- Majority of East Coast Shad Stocks are declining limiting Egg and Brood stock for Active Restoration Program
- Susquehanna River
  - Water Quality (D.O., nutrient loading, Loss of spawning habitat due to siltation in Conowingo Pond, Lake Aldred and Lake Clarke and Upper Chesapeake Bay, etc.)
  - Invasive Species (Gizzard Shad, Zebra Mussels, etc.)
- Global Warming
  - 50 to 75 Year Projections indicate Possible 3° to 5°C H<sub>2</sub>O Temperature Increase
  - Change to East Coast Ocean Currents

# Questions?

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