Hudson River American Shad
An Ecosystem-Based Plan for Recovery
May 2008

Hudson River Estuary

HUDSON RIVER AMERICAN SHAD
AN ECOSYSTEM-BASED PLAN FOR RECOVERY

Prepared by
NYSDEC Hudson River Fisheries Unit
to meet the goals of the
Hudson River Estuary Action Plan

Results of a recent Atlantic States Marine Fisheries Commission analysis of coast-wide shad stocks indicated that Hudson River American shad are in serious trouble (ASMFC 2007a). Commercial landings of shad from the Hudson River Estuary are at their lowest level since 1880. Moreover, the spawning stock is experiencing excessive and unacceptably high mortality and that mortality has seriously reduced production of young in the estuary. Restoration of this signature species will require a broad based ecosystem initiative that includes management actions in the estuary and in the Atlantic Ocean and focused ecological studies to understand American shad's role within the estuary. The following summarizes current causes of decline and outlines a detailed program of response.

Causes of Decline

American shad of the Hudson River Estuary spawn in the river, but spend most of their life in the near shore Atlantic Ocean from Virginia to Maine. They are caught by recreational and commercial fishermen while in the Hudson and by various commercial fisheries in the ocean. It is not known if shad are taken by recreational fishing in ocean waters, or if they are taken in combination with, or mistaken for, hickory shad. Commercial ocean fisheries that targeted American shad (directed fisheries) were closed in all Atlantic coastal states in 2005. Incidental take of shad in other ocean commercial fisheries (called bycatch) continues and can be legally sold in some states including New York.

The principal known cause of decline of American shad of the Hudson River Estuary was over harvest by directed ocean commercial fisheries and in-river commercial and recreational fisheries (ASMFC 2007a). Directed ocean harvest of American shad has ended, but losses to in-river harvest continue. Young American shad in the river are also lost to various cooling water intake structures. Losses of young and adult shad to ocean commercial bycatch (unintended catches) may have been a factor in the decline, but the magnitude of such losses is essentially unknown.

Habitat loss and alteration probably affected historical abundance of American shad in the Hudson River Estuary. Substantial destruction of potential shad spawning and nursery habitat occurred from the late 1800s through the mid 1900s from dredge and fill in the upper third of estuary during development and maintenance of the navigation channel from New York City to Albany/Troy (Miller and Ladd 2004). This habitat alteration was probably a factor in shad decline in the late 1800s and early 1900s, but major habitat loss has essentially stopped over the last 50 years and it is unlikely that it has been a factor in the most recent stock decline. Such habitat loss however, may influence rate of stock recovery.

Interactions among biota within the estuary may have influenced shad abundance, but actual data are lacking. It has been suggested that changes in predator abundance in the river may have affected survival of young shad. Largemouth and smallmouth bass occur throughout the freshwater shad nursery area when early shad life stages are present, while bluefish, striped bass, and weakfish are present in the lower estuary in fall as young shad emigrate from the river. Diets of these species in the river have been poorly studied and so effects of these predators on shad survival remain speculative. Competition with other biota may also have influenced young shad survival. The recent introduction and explosive growth of zebra mussels in the Hudson have substantially reduced phytoplankton, along with subsequent zooplankton production (Caraco 1997). Since young shad feed on zooplankton, it is possible that feeding by mussels has reduced food available to young shad. Following the arrival of zebra mussels, the diet of blueback herring shifted from open water zooplankton and benthic drift to biota found in shallow water vegetation beds. Presumably, this shift occurred because open water prey became less available. It is not known if a similar diet shift has occurred in American shad. However, Strayer et al. (2004) did find that growth of young of year American shad decreased after zebra mussels established themselves in the river. A decrease in growth has the potential to affect survival of age zero shad over their first winter.

Two hypotheses on causes of shad decline were discounted in the recent ASMFC (2007) analyses. Predation on adult shad by adult striped bass was identified in the Connecticut River and was a cause for concern given the recent increase in striped bass abundance. However, extensive analyses of Hudson River striped bass gut contents concluded that this was not an issue in the Hudson (ASMFCa). Moreover, abundance data for adults from several east coast rivers suggested that there was no relationship between striped bass abundance and shad abundance.

Declines in water quality in shad spawning and nursery areas have been suggested as a cause of decline in some east coast estuaries. However, water quality has improved in the Hudson over the last 30 years and is likely not an issue for Hudson shad survival.

Recovery Goals

The *2005-2009 Hudson River Estuary Action Agenda* of NYSDEC calls for the restoration of the Hudson's shad by 2020. This shad recovery plan provides details of what is needed to achieve that ambitious goal.

1. Long term goal:

    Restore American shad abundance to levels that occurred in the 1940s. The quantitative target will be relative abundance of age zero American shad estimated for 1940-1950 from population modeling and calibrated to relative abundance indices obtained by NYSDEC beach seine sampling. Progress toward this goal will be measured as the five year running average of age zero relative abundance from ongoing NYSDEC beach seine monitoring.

2. Short term goal:

Restore American shad abundance to levels observed in the late 1980s. The quantitative targets will be the mean age zero abundance index from NYSDEC beach seine monitoring from 1985 through 1989, measured as the five year running average of age zero relative abundance; and a total mortality rate (A) at or below 52% on the adult stock measured from the NYSDEC spawning stock survey.

Recovery Plan

Responses to problems of Hudson River American shad include continued stock monitoring, actions that we can implement relatively quickly and at relatively low cost, and longer term actions that will take planning and substantial funding. Longer term actions include those that lead to meaningful responses and those that clarify understanding of ecological processes that we cannot change. Recovery activities and estimated costs are summarized in Table 1.

1. Maintain American shad monitoring programs

We need to continue current annual stock monitoring to track current condition and progress toward recovery. Two separate, fishery independent shad monitoring efforts must be maintained.

A. NYSDEC programs.

Objective: Monitor annual status of juvenile and adult American shad in the Hudson River.
Actions:
1) Obtain annual abundance index for juvenile shad in the estuary by 30.5 m beach seine; and
2) Characterize annual age structure and survival rates of spawning American shad.
Progress: Annual sampling is on schedule. Both programs are supported by the Hudson River Estuary Program (HREP) and Wallop-Breaux Federal Aid funds. Funding for these programs is currently stable.

B. Hudson Valley Generating Companies (HVGC)

Objective: Provide data needed by NYSDEC to calculate an annual index of adult shad abundance. Index is calculated from HVGC egg abundance and NYSDEC spawning stock age data.
Action: Continue the Long River Ichthyoplankton Survey to obtain annual early shad life stage abundance.
Progress: Funding comes from Hudson Valley generating companies and is currently mandated under NYSDEC power generating plant operating permits. Maintenance of sampling will require continuation of monitoring requirements in these permits.

2. Reduce Mortality

The most important and meaningful action that we can take right now for shad recovery is to reduce mortality on all life stages as quickly as possible.

A. In River Fisheries

Objective: Minimize or eliminate losses to commercial and recreational fisheries within the Hudson River to levels that will allow the population to grow.
Action: Implement fishing restrictions for American shad fisheries in the Hudson River.
Progress: Emergency fishery regulations were implemented in March 2008. This management initiative is ongoing, requiring public input from stakeholders before regulations are finalized. Based on the results of annual evaluation, further management action will be taken as needed.

B. NY Ocean Fisheries

Objective: Eliminate legal sale of shad taken while fishing for other species in NY ocean waters.
Action: Management action is under development. Issue is complex because many fisheries are involved and data on shad take are limited.
Progress: NYSDEC identifying data needs.

C. Water Intakes

Objective: Reduce or eliminate losses of all shad life stages to Hudson River power generating plants
Action: Ensure that permits include provisions to reduce losses of shad to water intakes.
Progress: NYSDEC has issued draft operating permits for Hudson River power generating plants currently using once-through cooling water systems; the finalization process for each plant's permit is ongoing.

3. Characterize and Reduce Bycatch

American shad from the Hudson River estuary are taken in commercial fisheries from Maine to Virginia. Unintended loss of shad in fisheries targeting other species is called bycatch. Knowledge of bycatch characteristics (quantity, location and time of year) allows us to evaluate impact of bycatch and to reduce it in guilty fisheries through regulation in New York state waters and through ASMFC action in waters of other states and in federal waters. Since shad from many stocks are taken as ocean bycatch, we will also need to develop a method to identify that part of the bycatch from the Hudson. This would allow New York to focus regulatory protection on those fisheries most affecting Hudson shad.

A. Available NMFS Data

Objective. Evaluate existing National Marine Fisheries Service (NMFS) sea sampling data.

Background: Current NMFS data were obtained from onboard sampling of commercial operations to document catches of endangered marine mammals, sea birds, and reptiles. Consequently, coverage of fishing operations is patchy and is concentrated on times and locations where bycatch of endangered biota is expected. These data have not been analyzed for presence of American shad.
Action: NYSDEC staff will analyze NMFS data with the assistance NMFS staff at the Northeast Fisheries Science Center at Woods Hole, MA. Analysis will, where possible:

- Identify and characterize fisheries with shad bycatch and identify, quantify and characterize bycatch of these fisheries by time and location. Analysis is expected to follow procedures identified in ASMFC (2007b) and Wigley et al. (2007).
- Identify times and locations of inadequate fishery monitoring coverage that will require additional onboard monitoring to resolve.

Progress: NYSDEC staff has arranged a series of workgroup meetings at the Woods Hole facility. Analysis of NMFS data has been initiated. First meeting is scheduled for early May 2008.

B. NY Ocean Sea Sampling

Background: American shad are apparently rare in the existing NMFS data base. Thus existing data may be inadequate to quantify and characterize shad bycatch.
Objective. If existing data are inadequate, obtain needed data to identify, quantify, and characterize the American shad bycatch in ocean commercial fishing operations based in New York State.
Action: Many fish species managed by NY are taken as bycatch in ocean fisheries, thus monitoring will be more useful and more sellable if it covers all NY managed species and not just shad. Costs are essentially the same whether monitoring one or many fish species.

- Develop sample design needed to achieve a given level of precision; contracted through the Pew Institute of Ocean Studies.
- Develop sample design based on results of step one and execute contract for onboard sampling of commercial vessels; Obtain funding from possible sources: Hudson Estuary Program (HREP) and the Ocean and Great Lakes Ecosystem Conservation Council (OGLECC); once complete initiate step 3.
- If results of bycatch monitoring identify fisheries or specific times or locations of high shad bycatch, NYSDEC can reduce shad bycatch through regulatory actions.

Progress: Contractor has started work on sample design development.

C. Sea Sampling in Other Coastal States

Objective: Obtain information on shad bycatch in commercial fisheries of other coastal states and in Federal waters greater than three miles from shore (EEZ).
Background: Will need support of other states and the federal government for a broad based bycatch monitoring program. Sampling will also require funding from the federal government and private foundations.

Action: Best accomplished through ASMFC Inter-State Fisheries Management Plan (ISFMP) program and Shad and river herring ISFMP Amendment 3. This assures compatible sampling and data sharing and consistency with the Atlantic Coastal Cooperative Statistics Program (ACCSP). Possible funding sources include the Wildlife Conservation Society or the Pew Institute for Ocean Studies.
Progress: Amendment 3 to the ASMFC shad and river herring ISFMP has been initiated by ASMFC. Input to the amendment will include suggestions by states, including mandatory monitoring to meet the objective of reducing mortality as identified in the 2007 American shad stock assessment. New York will strongly suggest that bycatch sampling should be part of mandatory monitoring for American shad as well as for other highly valued species along the Atlantic coast.

D. Ocean Harvest Stock Identification

Objective: Identify Hudson River American shad in mixed shad stocks ocean bycatch.
Background: Bycatch of American shad in ocean fisheries include fish from many spawning stocks along the Atlantic coast. Researchers at the NMFS Laboratory at Woods Hole, MA have developed a technique to identify stock of origin of Atlantic Coast American shad using information on micro chemistry of shad otoliths (Walter and Thorrold, NMFS). The reference collection used to develop this technique was obtained from the 2004 year class of shad from major coastal rivers. Since chemical signatures appear to change among years, studies that rely on this collection must be conducted before the 2004 year class grows through the fishery.
Action: Support a proposed study using this technique to identify shad stock of origin in the mixed stock fishery of lower Delaware Bay in 2009. Hudson River shad are known to be taken in this fishery (ASMFC 2007a).
Progress: Initial discussions on the proposed study have occurred between the states of Delaware, Pennsylvania, New Jersey and New York.

4. Characterize and restore critical spawning and nursery habitat.

Approximately 3,500 acres of upriver shallow water habitat were lost through dredge and fill operations during construction of the federal navigation channel in the early and mid 1900s. Much of this area was probably shad spawning and nursery habitat. Identification, characterization, and restoration of some of this habitat is an important component of Hudson River shad restoration.

A. Spawning Habitat

Objective: Identify and characterize current spawning habitat used by adult shad.
Action: Spawning habitat can be identified by sonic or radio tracking of spawning shad in conjunction with benthic maps and GPS location information. NYSDEC Hudson River Unit currently uses this technology on juvenile Atlantic sturgeon so equipment, vessels, and expertise reside within the Department.

- NYSDEC will develop project to collect and tag adult American shad below the spawning grounds and track fish during the spring over the upper half of the river.
- Project will require purchase of tags and perhaps improved receiving equipment and contracting of field technicians.
- Possible funding sources include HREP, State Wildlife Grants Program (SWG), Hudson River Foundation (HRF), OGLECC, DEC Natural Resources Damages Unit (NRD), or perhaps the NY Environmental Protection Fund (EPF).

Progress: NYSDEC is currently developing a work plan and seeking funding to begin work in spring 2009.

B. Spawning and Nursery Habitat

Background: Early life stages of American shad are too small to tag and track and shallow vegetated areas are not sampled by existing sample programs in the Hudson River Estuary.
Objective: Identify and characterize shallow water habitat used by eggs, larvae, and juvenile American shad in the Hudson River Estuary.
Action: Sample existing vegetated shallow water habitat by larval push net mounted on the bow of a work boat. This apparatus has proven to be very effective at collecting larval fish from vegetated shallows in the Kissimmee River in Florida and Chesapeake tributaries in Virginia. Potential funding sources include HREP, SWG, HRF, or NRD.
Progress: NYSDEC Hudson River National Estuarine Research Reserve (HRNERR) is developing a pilot study to focus on two shallow water sites to be initiated in 2009 or 2010.

C. Demonstration Restoration Project

Objective: Create a demonstration Shad habitat restoration project.
Action: Craft experimental projects to increase the amount of spawning and nursery habitat similar to habitats identified in Objective A and B above. Experimental projects would cover a range of possible restoration approaches, include measurable goals, and specify monitoring to verify results. Promising methodology could then be applied in conjunction with resource agencies such as the Army Corps of Engineers. Logistical challenges to this type of restoration have been identified and still need to be addressed. They include restoration dredge spoil disposal and regulatory and permitting issues (habitat trading).
Progress: Will commence once objective A and B are met.

5. Ecosystem Studies

During their first year of life, American shad could be prey for a variety of predators and could compete with other species for critical food. Either interaction could be a factor in the recent decline in shad abundance. Studies of predation and interaction would clarify these interactions, but most likely would not lead to effective restoration activities.

A. Predation.

Objective. Identify estuarine predators of young of the year American shad that are abundant enough to affect the shad population.
Background: The most logical marine predator to evaluate is striped bass. This species has increased in abundance in the last 20 years and appears to congregate in the lower river in the fall when young shad emigrate. The most logical freshwater predators are largemouth and smallmouth bass. These fish are present in the middle and upper estuary in spring and summer when young shad are in shallow water nursery areas
Action: Conduct diet studies of striped bass, largemouth bass, and smallmouth bass. Striped bass should be collected from the lower river in late summer and early fall. The others should be collected in summer from shallow water nursery habitat in the mid and upper estuary. Sample size should be 200 to 300 stomachs for each species annually.

- Diet studies should continue for three consecutive years.
- Suggest that work would best by contract. NYSDEC will develop necessary requests for proposal. The contractor should work cooperatively with ongoing NYSDEC sampling programs to obtain a portion of the fish to be sampled. Sample collection may require additional sampling by contractor. Identification of stomach contents will be the responsibility of the contractor.
- Potential researchers include Institute of Ecosystem Studies and SUNY Stonybrook. The USGS-Columbia River Research Laboratory at Cook, WA is also exploring potential American shad predators and may partner with NYSDEC to conduct this work.
- Potential funding sources include the HREP and the Hudson River Foundation.

Progress: NYSDEC is seeking partners to develop project proposal.

B. Competition

Background: The recent introduction and explosive growth of zebra mussels in the Hudson has substantially reduced phytoplankton, along with subsequent zooplankton production. Since young shad feed on zooplankton, it is possible that feeding by mussels has reduced food available to young shad. Following the arrival of zebra mussels, the diet of blueback herring shifted from open water zooplankton and benthic drift to biota found in shallow water vegetation beds (personal communication, Dr. D. Strayer, IES, Millbrook, NY). Presumably, this shift occurred because open water prey became less available. It is not known if a similar diet shift has occurred in American shad.
Objective: Describe potential interactions between age zero American shad within the estuary and other organisms that may be competing for the same food source.
Action: Conduct diet analyses of early life stages of young of the year American shad that occur within the estuary.

- Will involve annual collection of 300 shad larvae and 300 young for three years. Early life stage samples may be obtained from existing sampling programs. Larval stages can be potentially obtained from the Long River ichthyoplankton survey,

or the nursery habitat study described above. NYSDEC can supply later stage juveniles from the annual beach seine survey.

- Suggest that coordination of sample collection and identification of gut contents should be done by a contractor. NYSDEC will develop necessary requests for proposal. Potential researchers include Institute of Ecosystem Studies, SUNY Environmental Science and Forestry, SUNY Stonybrook, and the USGS-Columbia River Research Laboratory.

- Possible sources of funding include the HREP and the Hudson River Foundation

Progress: NYSDEC is seeking partners to develop project proposal.

C. Bioenergetic Modeling

Background: A description of predation or potential competitive interactions does not signify that such interactions are significant. For example, the knowledge that striped bass prey on juvenile shad does not in itself prove that such predation has affected shad abundance. Potential impacts of predation can be evaluated by energetics-based population models. These models require substantial information about fish growth, consumption rates, diet, metabolism, survival, and abundance. However, enough of these data are available for Hudson River fishes to warrant some exploratory model runs. Even if results are inconclusive, attempts at modeling will identify data needed to improve modeling and thus guide future research.

Objective. Develop a bio-energetic model or models to assess the potential impacts of identified predators and competitors for food resources on Hudson River American shad.

Action: Develop a proposal for gathering necessary data to build a bio-energetic model. Potential researchers include Institute of Ecosystem Studies, SUNY Environmental Science and Forestry, SUNY Stonybrook, and the USGS-Columbia River Research Laboratory.

- Funding possible from HREP and the Hudson River Foundation.

Progress: NYSDEC is seeking partners to develop project proposal.

References

ASMFCa. Atlantic States Marine Fisheries Commission. 2007. Stock assessment of American shad, Stock Assessment Report Number 07-01. Washington, DC, USA.

ASMFCb. 2007. Estimation of Atlantic sturgeon bycatch in coastal Atlantic Commercial Fisheries of New England and the Mid-Atlantic. Report to the ASMFC Atlantic Sturgeon Management Board, Washington, DC, USA.

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Table 1. Summary of existing and proposed studies and costs for restoration of American shad in the Hudson River Estuary, NY.

Current Work

		Existing Funding	
1. Maintain American Shad Monitoring Programs	Time Period	NYSDEC	Power Generating Companies
a. NYSDEC Juvenile survey	annual	$210,000	
b. NYSDEC Adult survey	annual	$230,000	
c. HVGC Estuary Monitoring Program	annual		$2,000,000
Total Existing Annual Funding		**$440,000**	**$2,000,000**

Proposed Work

		Funding Needed		Starting
	Duration	Annual	Total	Date
2. Characterize and Reduce Bycatch				
a. NMFS Data	1 year	$1,500	$1,500	2008
b. NY Ocean Sea Sampling	3 years	$1,000,000	$3,000,000	2009
c. Sea Sampling in Other Coastal States	*	*	*	2008
d. Ocean Harvest Stock Identification	2 yrs	$100,000	$200,000	2009
3. Characterize and Restore Critical Spawning and Nursery Habitat				
a. Spawning Habitat	Year 1	$60,000	$60,000	2009
	Years 2&3	$55,000	$110,000	
b. Spawning and Nursery Habitat	Year 1	$60,000	$60,000	2009
	Years 2&3	$25,000	$50,000	
c. Demonstration Restoration Project	To be determined	**	**	2011
4. Ecosystem Studies				
a. Predation				
in-river predators	3 years	$70,000	$210,000	2009
marine predators	3 years	$70,000	$210,000	2009
b. Competition	3 years	$40,000	$120,000	2009
c. Bioenergetic modeling	To be determined	**	**	2012
Needed Funding (2 through 4)				
Year 1		$1,401,500		
Year 2		$1,360,000		
Year 3		$1,260,000		
Total			$4,021,500	

* Cost to be determined; responsibility of other coastal states

** Cost to be determined

Potential Partners
ACOE - Army Corps of Engineers
ESF - SUNY College of Environmental Science and Forestry
HREP - Hudson River Estuary Program
HRF - Hudson River Foundation
HVGC - Hudson Valley Generating Companies
IES - Institute of Ecosystem Studies
NMFS - National Marine Fisheries Service
NOAA - National Oceanic and Atmospheric Administration
NRD - NYSDEC Natural Resource Damages Unit
OGLECC - Ocean and Great Lakes Ecosystem Conservation Council
PEW - PEW Institute of Ocean Studies
SB - SUNY Stony Brook
USFWS – United States Fish and Wildlife Service
USGS - USGS Columbia River Research Laboratory at Cook, WA
WCS - Wildlife Conservation Society

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