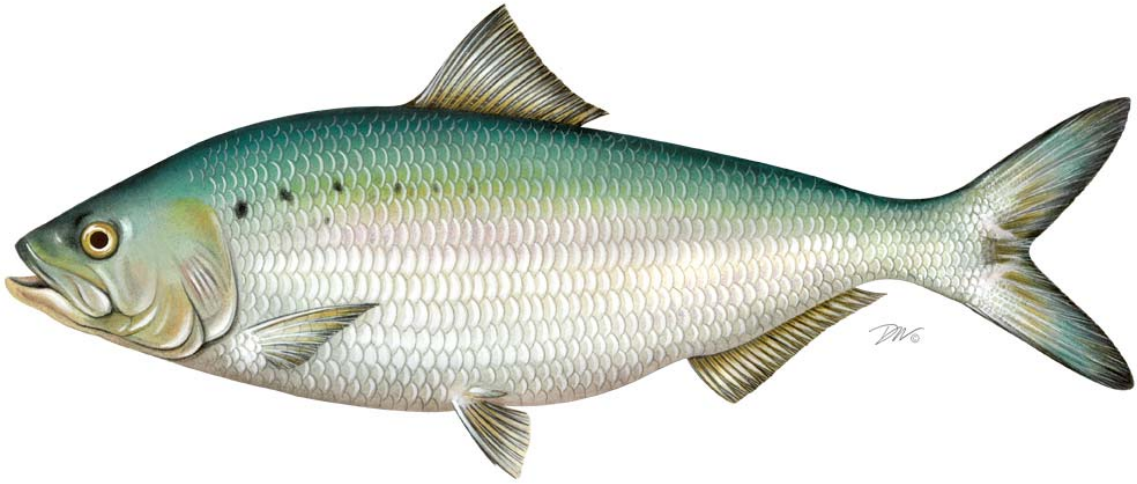
American Shad Habitat Plan for the Connecticut River



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Massachusetts Division of Marine Fisheries
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Introduction

The Atlantic States Marine Fisheries Commission's (ASMFC) Amendment 3 to the American Shad and River Herring Fishery Management Plan (FMP) requires all states to submit a Habitat Plan for shad stocks in their jurisdiction. This document is that plan for the Connecticut River basin for the states of Massachusetts and New Hampshire with input from Vermont and Connecticut. The ASMFC requested a collaborative effort on larger, multi-jurisdictional river plans and this approach among basin members was adopted for this document with input provided by the State of Connecticut, which chose to submit its own plan that addresses their portion of this river basin independently. The Connecticut River's American shad population is under active restoration through the multi-agency Connecticut River Atlantic Salmon Commission (CRASC), signed into federal law in1983 with complimentary State legislation (Gephard and McMenemy 2004). The CRASC has served as the lead in obtaining both upstream and downstream passage measures at main stem dams and in coordinating state and federal agencies, commercial river users, and other partners on management topics for this species. The CRASC Technical Committee, under the policy guidance of the Commission, maintains a Shad Studies, Fish Passage, and newly designated Habitat subcommittees that actively work on topics including shad habitat and access to habitat.

Habitat Assessment

The historic upstream extent of the species range on the main stem is Bellow Falls, Vermont, at rkm 280, with three main stem dams located within this range (Table 1 and Figure 1). Surveys for shad eggs and larvae and spawning behavior have been conducted in the main stem within the state of Connecticut (Marcy 1976) and from Holyoke Dam (rkm 139) to the Turners Falls Dam (rkm 198), Massachusetts. Marcy (1976) identified American shad spawning in the lower main stem river at river kilometer (rkm) 26 to his most upstream study site at rkm 87, Enfield, Connecticut, with major spawning areas identified as Windsor Locks (rkm 78), Wilson (rkm 74) and Rocky Hill (rkm 51). Research by the University of Massachusetts has shown a relatively wide range of documented spawning primarily from egg and fish behavior surveys between the Holyoke Dam, Massachusetts (rkm 139) and the Turners Falls Dam, Massachusetts (rkm 198)(Watson 1970; Gilmore 1975; Layzer 1974; Kuzmeskus 1977). Shad spawning habitat, as described in Greene et al. (2009), is located to varying degrees upstream of dam impoundments on both the main stem and identified tributaries and are subject to shifting with changing river discharge. The University of Massachusetts conducted studies in the late 1960s and 1970s that showed shad spawning starting at rkm 140, just upstream of Holyoke Dam, to rkm 192, at 22 sampled sites (Kuzmeskus 1977). Most of the preferred habitat in this main stem reach begins upstream of the Holyoke Dam's impoundment, beginning approximately at rkm 180 and extending upstream to the Turners Falls Dam (rkm 198). Based on available information, a summary on main stem habitat types is provided in Table 2. In the absence of habitat specific data, assessment assignments of fixed percentage of potential suitable habitat by type were used based upon known habitat features and the extent of impoundments. It is important to note that there is no understanding of the variation in habitat quality, in addition to quantity, among the identified management reaches which effects the interpretation of these habitat designations.

Table 1. Main stem dams on the Connecticut River from rkm 0 upriver to the historic upstream extent of American shad range, Bellow Falls, Vermont, at rkm 280.

River kilometer	Barrier	Designated extent of impoundment/habitat break (rkm)[A]	Purpose	Status
110	Enfield Dam (historic site), Enfield CT	0	Barge canal use	no longer present
139	Holyoke Dam, Holyoke, MA	177	Hydroelectric power	Active, with fishways
198	Turners Falls Dam, Montague, MA	223	Hydroelectric power	Active, with fishways
228	Vernon Dam, Vernon, VT	273	Hydroelectric power	Active, with fishways
280	Bellows Falls Dam, Bellows Falls, VT		Hydroelectric power	Active with fishways

[A] reported impoundment distance may vary slightly, designations attempt to take into account transition in habitat features in these dynamic area

There have been no studies on main stem spawning habitat upstream of the Turners Falls Dam. However, annual monitoring of juvenile shad has occurred upstream of Vernon Dam, in the lower impoundment and immediately below Vernon Dam (several km) by the owners of Vermont Yankee Nuclear Power Station for over 15 years. In addition several special studies on juvenile shad have been conducted by the owners of the Northfield Mountain Pumped Storage Facility (NMPS), focused on entrainment and near field studies, and the University of Massachusetts/Conte Anadromous Fish Research Center, focused on age structure, size, and movement. As part of the Federal Energy Regulatory Commission's (FERC) ongoing relicensing process of the Turners Falls Dam, Northfield Mountain Pumped Storage Facility (NMPS), Vernon Dam, and Bellows Falls Dam, study requests by both state and federal resource agencies have been submitted for FERC's review to determine shad spawning locations and habitat use relative to these hydro-electric projects and their operations, which are expected to be conducted beginning in 2015.

Table 2. Connecticut River main stem river distance by state, to Bellows Falls, Vermont (rkm 280) and American shad habitat types by distance.

State	Main stem distance (rkm)	River kilometers of main stem habitat type			
		Spawning		Rearing	
		Historic	Current	Historic	Current
Connecticut	113.9	34.2	34.2	79.7[A]	79.7[A]
Massachusetts	105.5	n. a.	39.2[B]	n. a.	66.3[B]
New Hampshire[C]	60.6	n. a.	16.9[B]	n. a.	43.7[B]
Total	280.0		90.3		189.7

[A] Includes estuarine habitat

[B] Designated unimpounded habitat was assigned as 60% spawning habitat and designated impounded areas was assigned as 20% spawning habitat with balances designated as rearing; refer to Table 1 for designation point of dam impoundment break

[C] State of New Hampshire boundary extends to historic (un-impounded) western shoreline of State of Vermont

Historic and, in some cases, current American shad distribution include three tributaries in the State of Connecticut, five in the State of Massachusetts, one in the State of New Hampshire, and one in the State of Vermont (Table 3). Habitat information is based on the best information available which often is based

on a limited qualitative assessment. It is important to note that it is difficult to categorize what type of habitats may have existed under current dam impoundments and no effort has been made on that topic.

Table 3. Tributaries of the Connecticut River identified as having historic and or currently accessible American shad habitat.

Distance from main stem river mouth (rkm)	Tributary name and location	Historic total habitat (rkm)	River kilometers of habitat type			
			Spawning		Rearing	
			Historic	Current	Historic	Current
52	Mattabesset River, Middletown, CT	36.3	15.7	15.7	20.7	20.7
92	Farmington River, Windsor, CT	60.3	59.7	29.8	33.4	29.0
	Pequabuck River, Bristol, CT – tributary to Farmington River	12.4	4.9	3.1	11.0	9.3
96	Scantic River, South Windsor, CT	22.4	14.8	11.2	22.0	11.2
121	Westfield River, West Springfield, MA	29.4	29.4	29.4	29.4	29.4
130	Chicopee River, Chicopee, MA	unknown	n. a.	1.6	n. a.	1.6
150	Manhan River, Easthampton, MA	unknown	n. a.	n. a.	n. a.	n. a.
192	Deerfield River, Deerfield, MA	21.5	21.5	21.5	21.5	21.5
203	Millers River, Erving, MA	unknown	n. a.	n. a.	n. a.	n. a.
225	Ashuelot River, Hinsdale, NH	60.0	n. a.	n. a.	n. a.	n. a.
240	West River, VT	31.0	n. a.	n. a.	n. a.	2.0

Habitat accessibility

Adult shad have access to main stem habitat to the historic extent of their range up to Bellow Falls Dam (VT) through the use of a fish lift system at the Holyoke Dam (MA), the fish ladders at Turners Falls Dam (MA), and the Vernon Dam fish ladder (VT). However, fish passage efficiency remains a major concern and has been demonstrated to vary widely among these main stem facilities, with the Turners Falls fishway complex determined to be problematic for upstream shad passage (Appendix 1). The U. S. Geological Survey's Conte Anadromous Fish Research Center (USGS Conte), in cooperation with the dam owner, has conducted numerous studies to understand the issues and implement modifications for passage improvements in advance of the current relicensing process, with limited success. The Connecticut River Atlantic Salmon Commission's (CRASC) Management Plan for Connecticut River American Shad (1992) identifies a management objective of 40-60% passage, based on a five year running average, at each successive upstream barrier on the main stem. Shad passage upstream of Turners Falls Dam has averaged 3.8% annually, since its fishways became operational in 1980 through 2013, based on counts of shad passed upstream of Holyoke Dam, thus restricting access to upstream habitat (Appendix 1). Alternatively, the Vernon Dam fish ladder, following the recent identification and repairs of ladder issues, has achieved passage rates of 39% and 53% for 2012 and 2013 respectively, from the number of shad passed upstream of Turners Falls Dam (Appendix 1).

Access to tributary habitat is often limited due to the presence of dam(s) that often are located a short distance from the confluence with the main stem river (Table 4).

Table 4. Identified American shad tributaries of the Connecticut River basin with first and second dam locations and status of passage.

Tributary	Distance to first upstream dam (rkm)	First Dam	Passage provided by	Second Dam (rkm)	Status
Mattabesset River	11	StanChem	Denil Ladder	Kensington (36)	unladdered, but beyond historic range
Farmington River	13	Rainbow	Vertical slot	Lower Collinsville (60)	None, pending FERC action
Pequabuck - tributary of Farmington River	12	Bristol Brass	None, planned for removal	Polkville Brook (17)	Beyond historic range
Scantic	32	Springborn	Planned removal	Somersville (37)	unladdered
Westfield River	7	West Springfield	Denil Ladder	Woronoco (30)	None, not planned
Chicopee River	2	Dwight	None, not planned	Chicopee (5)	None, not planned
Manhan River	5	Manhan	Ladder to be completed 2013	Unnamed (18)	None, not planned
Deerfield River	21	TransCanada Dam #2	None, not planned		
Millers River	14	Erving Paper	Partial breach	New Home (22)	unladdered
Ashuelot River	3	Fiske Mill	Fish lift	Ashuelot Paper (5)	unladdered
West River	31	Townshend	None, not planned		

Distances of unobstructed access to the first barrier and type of available passage are noted with status of the next barrier, in Table 4. However, as is the case on the main stem, fish passage efficiency is poorly documented on tributary dam fishways. The first dam on the Farmington River has the Rainbow Fishway, in operation since 1976, which is known to not effectively pass shad upstream. This State-owned facility is planned for replacement with a fish lift. The Westfield River (MA) is the next major tributary with substantial access provided by a Denil fishway at the West Springfield Dam. This fishway has not been evaluated, but shad passage efficiency is believed to be fairly good as shad passage counts have increased to over 10,000 adults in 2012. Other substantial, but not studied tributaries that may provide shad spawning and nursery habitat include the lower Deerfield River (MA) up to its first dam, a distance of 21 rkm and the Millers River (MA), which like the Deerfield quickly transitions into higher gradient reaches and larger substrate types, but also includes more reaches of run habitat between riffles than the Deerfield River.

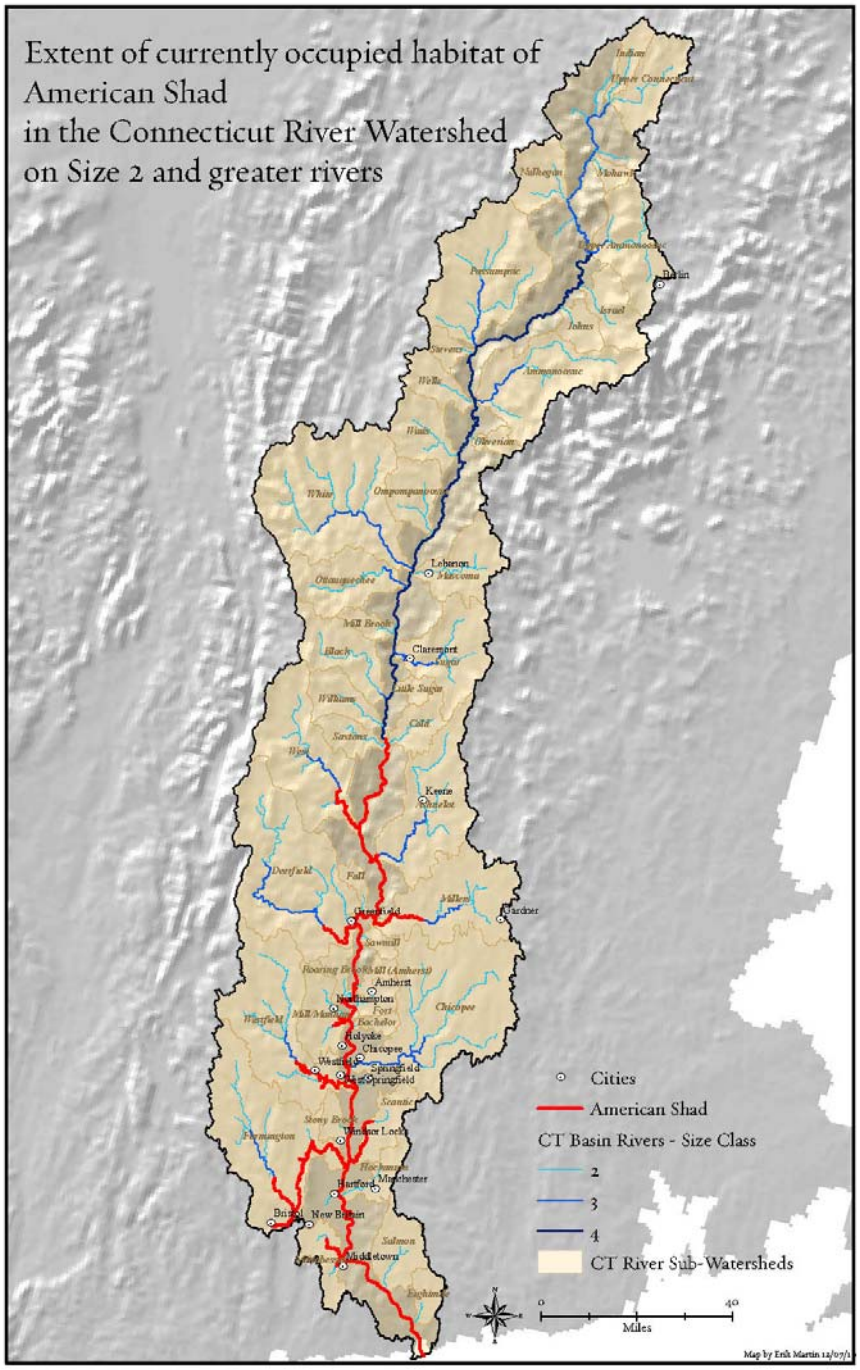

Figure 1. The current range of American shad in the Connecticut River basin (figure courtesy of The Nature Conservancy).

Threat Assessment

Threat: Barriers to Migration

Recommended Action: Continue the implementation of the CRASC's Management Plan for Connecticut River Shad (1992) which includes the following two management objectives: 1) achieve annual passage of 40 to 60%, based on a five year running average, at each successive upstream barrier on the main stem; and 2) maximize outmigrant survival for juvenile and spent adult shad.

Tributary fishways should be evaluated for upstream passage performance and enumeration of passed fish should occur annually. Downstream passage performance should be evaluated at both main stem and tributary fishways for both adults and juveniles. Recent research suggests delays in both upstream and downstream passage of adult shad are occurring and should be more closely examined and as issues are noted, measures should be implemented and/or developed to reduce delay or otherwise reduce other project impacts. FERC relicensing shad studies are to occur in 2015 and 2016 for Turners Falls Dam, NMPS, and Vernon Dam. Information obtained on movement, behavior, delay and survival in relation to dams, power plant facilities and fishways should be utilized in development of operational and structural (fishway prescriptions) recommendations by the agencies with respective legislative authorities. Completion of the analyses from the 2011 and 2012 shad migration and survival study from river mouth to Vernon Dam by USGS Conte and USFWS, must occur and should also be utilized in this process. The State and Federal agencies should coordinate in the review and development of recommendations to provide safe, effective and timely fish passage measures.

The timing, relative magnitude, and duration of the juvenile shad outmigration, and possible negative effects from barriers and or the associated power station operations and or structures of those facilities, should be understood and be the focus of further study. As part of the FERC relicensing studies scheduled for 2015 and 2016, information to assess potential project effects will be examined at Turners Falls Dam, NMPS, and Vernon Dam. Information obtained by these studies on movement, behavior, delay and survival in relation to dams, power plant facilities, and fishways should be utilized in development of operational and structural (fishway prescriptions) recommendations by the agencies. The State and Federal agencies should coordinate in the review and development of these recommendations.

Adult upstream passage main stem -
As described earlier, American shad have access in the main stem Connecticut River to the historic upstream extent of their range, Bellows Falls, Vermont, through the use of fishways of varied design and operation and efficiencies (Table 1, Figure 1, Appendix 1). Upstream passage for shad includes a fish lift system at Holyoke Dam, upgraded in 2005, as part of that dam's FERC relicensing process. Based on both historic and recent unpublished studies on shad movement, the Holyoke Dam may pass between 40 to 60% of the adult shad that enter the river mouth in the spring. A large scale shad movement and survival study using radio telemetry conducted in both 2011 and 2012 by the USGS Conte and the U. S. Fish and Wildlife Service, supports this previous finding but also provided evidence for concerns of migratory delay at this dam and others. On this topic, Castro-Santos and Letcher (2010) have developed a shad migration model study using Connecticut River American shad related variables, which highlighted the potential negative impacts to adult shad survival as outmigrants through the mechanisms of delay on both upstream and downstream migrations, in relation to limited energy reserves. The shad movement study conducted in 2011 and 2012 is still being analyzed but will provide important information on this potential issue. As described earlier, the FERC has initiated the relicensing process for the owner/operators of the Turners Falls Dam, the Northfield Mountain Pumped Storage Facility and the owner/operators of the Vernon Dam and Bellows Falls Dam (including the next upstream Wilder Dam,

outside of shad range) as their licenses are set to expire in 2018. Comprehensive telemetry studies are planned to examine movements in habitat up to the dams, at the dams, and through the various fishways in relation to other managed (generation schedule) and unmanaged (spill occurrences at dams) variables.

Upstream shad passage at Turners Falls Dam has been problematic since the opening of its three fishways in 1980. The Cabot Station (power house), at the end of a 3.4 km power canal off the Turners Falls Dam, is the primary location of shad attraction on their upstream migration and has a modified "Ice Harbor" design ladder. Fish that successfully pass that ladder must then proceed up the power canal to the Gatehouse, which contains the Gatehouse Fish Ladder (vertical slot design), that has two entrances from the canal. One entrance is a newer "extended" entrance, developed and installed for 2008 as part of the collaborative studies of the owner with the USGS Conte Lab and input with state and federal agencies. Shad may also move up the "bypass" reach (distance of 4.3 km) to the base of Turners Falls Dam where they may use the Spillway Ladder, which is also a modified Ice Harbor design. The Spillway Ladder still requires shad reaching the top of that ladder to pass along an entry flume to access the entrance to the Gatehouse ladder. Therefore, all fish must pass two of three fishways regardless of route used. Evaluations of the Cabot fish ladder were conducted by the USGS Conte Lab from 1999 through 2005, with no success in improved passage so work was shifted to address the other issue of getting shad to pass out of the power canal and through Gatehouse. This work was conducted from 2006 through 2012 and has led to eventual structural and operational changes that indicate a positive effect starting in 2008 (extended entrance flume) for improved fish passage out of the canal (Appendix 1), although overall passage for the dam remains a major concern and is well below management objectives defined in the CRASC Shad Plan.

Upstream shad movement past the Northfield Mountain Pumped Storage Facility is not well understood. The 2011 and 2012 shad movement study did obtain some data from this area, but further examination is deemed necessary and will occur with planned relicensing studies. This facility typically pumps from the river during off-peak hours (pumping capacity is up to 15,000 CFS) of the evening and is generating (generation capacity is up to 20,000 CFS) during peak load, daytime hours. Agency concern has been more focused on entrainment of juvenile life stages at this facility (to be discussed later).

Upstream passage at Vernon Dam is made possible through a fish ladder that is a modified Ice Harbor design in its lower section and serpentine vertical slot design in its upper section. This ladder became operational in 1981. Following some modifications and instances of issues with structures or operations, passage of American shad has been shown to meet CRASC Plan target rates in many years (Appendix 1). However, reduced shad passage efficiencies became noticeable in 2005 and it was not until analyses of data from the 2011 shad movement study that it was determined that approximately 90% of tagged fish were reaching the dam but not passing. A structured annual, pre-season field review for all fishways was subsequently developed by the agencies. This review located issues prior to 2012 and company fixes were made. As a result, both 2012 and 2013 shad passage numbers were viewed as dramatic improvements to rates seen in prior years (Appendix 1).

Agencies with regulatory authority: The CRASC has signed agreements with main stem hydropower operators that led to the installation and or operation of facilities to facilitate upstream passage on the main stem dams identified. The individual States have their independent authorities and the U. S. Fish and Wildlife Service and National Marine Fisheries Service have authority through the Federal Power Act, used in connection with FERC. The CRASC operates a Fish Passage Subcommittee, under its Technical Committee, which has been a forum to coordinate inter-agency staff, researcher, and activities with the various power companies in both official and unofficial capacities, in a regular and ongoing process. The CRASC issues a

schedule of Upstream Passage Operation Dates through the Connecticut River Coordinator, annually in March that specifies species, lifestage, dates and hours of operations.

Goal/Target: CRASC's Management Plan for Connecticut River Shad (1992) includes the objective: achieve annual passage of 40 to 60%, based on a five year running average, at each successive upstream barrier on the main stem. Through the FERC relicensing process, more information to better define known upstream passage issues and those that may not yet be identified with planned studies in 2015 and 2016 will be obtained. Based on results and findings of these studies, agency staff will develop recommendations that may include fishway prescriptions, modifications and possible operational or other structural measures to address existing project impacts and upstream fish passage. Agency staff may recommend additional work required to identify measures to address issues of other management concern.

Progress: FERC relicensing is ongoing for Turners Falls Dam, Northfield Mountain Pumped Storage, Vernon Dam and Bellows Falls Dam, where licenses will expire in 2018. Field studies to obtain more information on shad upstream movement and passage at from downstream of Turners Falls Dam to Bellows Falls will begin in 2015 as part of FERC process; as of this date, Revised Study Plans have been filed with FERC. The 2011 and 2012 shad migration and survival study data is still under analyses; preliminary results have been produced including a draft report using 2011 data at Vernon Dam, which facilitated the successful measures to restore passage efficiency at that facility.

Cost: Dam operators will cover costs of FERC requested agency studies as part of relicensing, including fish movement (telemetry based) studies that will be used to inform fish passage evaluations and recommendations. Agency staffs have invested substantial time in the review, development, interaction, and planning of activities associated with the identified main stem hydropower projects that are covered by the agencies that will continue up to and after licensing. Additional costs will be incurred by the USGS Conte and USFWS in analyses and report writing of the 2011 and 2012 shad migration and survival study. Upstream fish passage operation costs and fish counting at Holyoke Dam are covered by the owner as part of the FERC 2003 relicensing. Fish count evaluations at Turners Falls fishways are the responsibility of State of Massachusetts, but the owners have covered that cost and operation for the last 15 years. Fish count evaluations at Vernon Dam are the responsibility of the State of Vermont.

Timeline: Studies required as part of FERC relicensing are scheduled to occur in 2015 and 2016. Subsequent data analyses and report preparation will occur in following years. The agencies will use information from these studies as well as the results from the 2011 and 2012 USGS/USFWS shad migration and survival study and other data remaining to be analyzed to develop appropriate recommendations for license requirements by FERC in 2018.

Adult upstream passage tributaries -

Farmington River (CT) - Currently upstream passage at the Rainbow Dam on this largest tributary in the State of Connecticut is a management issue (Table 3). The Rainbow Fish Ladder became operational in 1976 and is a vertical slot design that has been targeted for replacement by the State of Connecticut. The Winchell Smith Dam, next upstream structure, is a possible barrier to upstream movement of shad at some flow levels. The Lower and Upper Collinsville Dams are at the upstream extent of shad habitat on the Farmington River and will be considered for ladder installation should FERC grant licenses for proposed hydro-power development. The Pequabuck River is a tributary of the Farmington River with historic habitat blocked by the Bristol Brass Dam.

Agencies with regulatory authority: The Rainbow Dam is not a FERC licensed jurisdictional dam and the fish ladder was installed by the State of Connecticut using its own funds through an agreement with the owners. The State of Connecticut continues to work through an agreement process with the owners but also has legal authorities regarding dams and fish passage at noted dams. The Lower and Upper Collinsville dams are being considered for hydro-power development and are expected to require FERC involvement and as result will involve the federal resource agencies. If this development proceeds, fish passage installations are expected.

Goal/Target: Install a state-of-the-art fish lift system at the Rainbow Dam and discontinue the use of the ladder for shad passage. Explore the possibility of either the removal or installation of a ladder at The Winchell Smith Dam. Provide input and recommendations on fish passage needs at the Lower and Upper Collinsville dams as hydropower development continues to be explored. Remove the Bristol Brass Dam and open access to historic habitat in this tributary.

Progress: Design plans for the Rainbow Dam fish lift are in process. Removal of the Bristol Brass Dam is pending. The Winchell Smith Dam project is under development. Both lower and Upper Collinsville fish passage will proceed as part of any planned hydropower development.

Cost: The construction cost for the Rainbow Dam fish lift is expected to be approximately $5 – 6 million. The Bristol Brass and Winchell Smith dam removal project costs remain to be determined. If warranted, fish passage at Lower and Upper Collinsville also remains to be determined.

Timeline: Once design plans have been completed, a search for sources of funding will be initiated, possibly in 2014, for the Rainbow Dam fish lift. The Bristol Brass Dam should be removed in 2014. The Winchell Smith Project is in development. The Lower and Upper Collinsville dams' future use remain uncertain at this time.

Scantic River (CT) – Currently, accessible shad habitat extends upstream to the Springborn Dam, which is planned for removal (Table 3).

Agencies with regulatory authority: The State of Connecticut has legal authorities regarding dams and fish passage at this small non-hydropower dam.

Goal/Target: To remove this dam which would open another 5 km of river habitat to the next upstream dam (Somersville), which is planned for a fish ladder following the successful removal of the downstream barrier.

Progress: The dam removal is in design.

Cost: The removal cost is estimated at $2-4 million due to contaminate issues.

Timeline: To be determined.

Chicopee River (MA) – Accessible habitat in this tributary is restricted to approximately 2 km to its confluence with the Connecticut River. There is a high density of closely placed hydropower dams that proceed upstream from that point.

Agencies with regulatory authority: The Commonwealth of Massachusetts has legal authorities regarding dams and fish passage and the U. S. Fish and Wildlife Service and National Marine Fisheries Service have authority through the Federal Power Act and through FERC for these lower dams.

Goal/Target: There have been unexecuted plans to stock pre-spawn shad, transferred from Holyoke Fish Lift, into the impoundments of the upstream dams with follow up sampling to determine if there is juvenile production.

Progress: No pre-spawn stocking of shad or herring has occurred to date. It is possible that these stockings, with evaluation for production, may occur in the near future.

Cost: Should stocking produce juveniles, an assessment and development of a plan for shad would need to be developed to consider the types and extent of upstream passage.

Timeline: Unknown relative to passage needs.

Ashuelot River (NH) – In 2012, the Fiske Mill Dam, the first barrier 3 km from confluence with the Connecticut River, had its fish lift become operational. The owner operator conducted visual inspections of lifts and never observed any shad. The McGoldrick Dam, which had been the next upstream dam, was completely removed in 2001. As shad passage at Fisk Mill Dam becomes documented, upstream passage options to pass fish upstream of both Ashuelot Paper and Lower Robertson hydropower dams will be developed. Once fish are able to pass these additional two dams, the vast majority of targeted spawning and nursery habitat will be completely accessible as two additional unmaintained dams have been completely removed from identified shad habitat in recent years.

Agencies with regulatory authority: The State of New Hampshire has legal authorities regarding dams and fish passage and the U. S. Fish and Wildlife Service and National Marine Fisheries Service have authority through the Federal Power Act and through FERC for the identified dams.

Goal/Target: A Plan to Restore Migratory Fishes to the Ashuelot River Basin (1998) by New Hampshire Fish and Game (NHFG) outlines clupeid stocking, dam removals, and fish passage targets. A NHFG habitat survey estimated approximately 140 ha of shad habitat that at a production rate of 124 adults/ha, translates to a run potential of approximately 17,000 adults.

Progress: Annual stockings of approximately 750 pre-spawn shad have occurred beginning in 1998. Upstream passage options for the remaining dams will be explored as adult fish are documented passing the Fiske Mill Dam.

Cost: Stocking of transferred pre-spawn fish is conducted by NHFG, USFWS, and state partners. Upstream passage installation and operation costs are the responsibility of the dam owner operators. The noted three dam removals were completed with grant funding support from many sources and state funds.

Timeline: Upstream passage measures for shad around the second and third dams on the lower Ashuelot will be implemented as returning adult shad are documented at the Fiske Mill Dam fish lift.

Adult downstream passage main stem -

The CRASC shad plan's objective to maximize outmigrant survival for juvenile and spent adult shad is based on the iteroparous nature of the Connecticut River stock. The State of Connecticut Marine Fisheries Division has documented the long-term decline in the proportion of repeat spawners of this stock. Theories on the mechanisms for these declines have included reduced survival of spent shad with increased access to upstream habitat from fishways (Leggett et al. 2004). Other research has suggested that the decline in repeat spawners occurred prior to increased upstream access (Castro-Santos and

Letcher 2010). In either case, there is an interest by fishery managers to provide effective and timely downstream passage past the main stem hydropower facilities and address impacts from delays on the outmigration. However, each dam presents its own unique structure, operations, facility design, surrounding landscape and other unique features which often restrict available options more frequently resulting in the development of novel approaches for passage improvements.

Numerous and varied downstream measures have been explored and implemented at the Holyoke Dam. Currently, the Holyoke Dam operates a Bascule Gate with a specially designed "Alden Weir" to facilitate downstream passage of spent fish moving towards the power stations intake/forebay to the proximally located gate. This gate is operated for downstream passage of fish from April through July, with dates or operation specified in a CRASC Downstream Passage Notification Letter, issued by the Connecticut River Coordinator. There are concerns with the survival of passed shad at this gate as the water spills onto the dam's cement apron and also partially hits a cement retaining wall off this apron. A current Settlement Agreement among the state and federal resource agencies and several non-profit groups is designed to address downstream passage for shortnose sturgeon and American eel, but also includes improvements with the discharge area of the bascule gate for down running shad. Design work is in process.

A second route for downstream shad passage at Holyoke includes the power canal, which has a gatehouse located at its upstream end, adjacent to the dam structure. Shad that are directed or move into the canal will swim and/or drift to a full depth angled weir that covers the entire canal. The weir bar spacing is designed for juvenile fish field based guidance as well. At the downstream corner of this acutely angled weir is the entrance to the downstream fish passage pipe. The pipe conveys fish into the tailrace of the Holyoke power station, where the pipe discharges directly into deep water from a height of several meters.

> **Agencies with regulatory authority:** The Commonwealth of Massachusetts has legal authorities regarding dams and fish passage and the U. S. Fish and Wildlife Service and National Marine Fisheries Service have authority through the Federal Power Act and through FERC for the identified dams. The CRASC issues a schedule of Downstream Passage Operation Dates through the Connecticut River Coordinator, annually in March that specifies species, lifestage, dates and hours of operations.
>
> **Goal/Target:** There are no current numeric targets or values for downstream passage of adult shad in the CRASC shad plan or anywhere else. The existing Settlement Agreement with the dam's owner includes provisions that will seek to improve situation with the spill of the Bascule Gate described earlier.
>
> **Progress:** There have been several submitted plans that have been pulled back due to a variety of issues. The Settlement Agreement will require resolution in the near term on this matter.
>
> **Cost:** Planned modifications to enhance downstream passage water discharge, via the Bascule Gate, will be covered by the owner operator.
>
> **Timeline:** Existing Settlement Agreement is in place. Resolution of downstream plans should occur in 2014, with possible construction in 2015.

Downstream passage of shad at the Turners Falls Dam is complicated by the design of the dam, gatehouse, and power canal described earlier. Downstream passage of adult shad occurs either by spill at the dam through a bascule gate required to spill for upstream passage flow in the bypass reach (400

cfs or when flows exceed canal capacity) or the primary designed emigration route via the Gatehouse, into the power canal and then to the downstream bypass structure at the Cabot Power Station. The modified log sluice bypass at the Cabot Station utilizes an Alden Weir, which fish reach after passing across the trash racks (partial depth reduced bar spacing) of the intakes to the powerhouse. Only juvenile shad and herring downstream passage has been examined at this facility. As part of the FERC relicensing process currently underway, studies will occur in 2015 to track radio tagged adult fish, assess downstream passage routes, timing, conditions (operational and natural), and survival as fish approach Turners Falls Dam from upstream. The 2011 and 2012 shad movement and migration study, as well as previous years' data from USGS Conte studies with radio tagged shad in this canal, suggest substantial delays of tagged down running fish in the canal.

Downstream shad movement past the Northfield Mountain Pumped Storage Facility is not well understood. The 2011 and 2012 shad movement and migration study remains to be fully examined for effects in this area. Further examination for possible delays, directional or other behavior modifications and possible entrainment will be examined as part of the FERC relicensing study on downstream shad movement in 2015.

Downstream passage for adults at Vernon Dam is made possible by a partial depth (15 feet) and partial length louver in the forebay that directs fish into the primary fish bypass pipe (350 CFS) with a secondary, smaller bypass pipe (40 CFS) on the Vermont near-shore side. No studies on adult shad use of the bypass systems have been successfully conducted. As part of the FERC relicensing process underway, studies tracking radio tagged adult fish in 2015 will assess downstream passage routes, timing, conditions (operational and natural), and survival.

Agencies with regulatory authority: The CRASC has signed agreements with main stem hydropower operators that led to the installation and/or operation of facilities for downstream fish passage at Turners Falls Dam, Northfield Mountain Pumped Storage (juvenile Atlantic salmon only) and Vernon Dam with the CRASC 1990 MOA for downstream passage development. The individual States have their legislative authorities and the U. S. Fish and Wildlife Service and National Marine Fisheries Service have authority through the Federal Power Act in connection with FERC. The CRASC operates a Fish Passage Subcommittee, under its Technical Committee, which has been a forum to coordinate inter-agency staff, researchers and work with the various power companies in both official and unofficial capacities, in a regular and ongoing process. The CRASC issues a schedule of Downstream Passage Operation Dates through the Connecticut River Coordinator, annually in March that specifies species, lifestage, dates and hours of operations.

Goal/Target: No current numeric targets or other values exist for downstream passage of adult shad in the CRASC shad plan or elsewhere. Through the noted FERC relicensing process, more information to better define known and yet to be identified issues through planned studies in 2015 and 2016 will be obtained. Based on results and findings of these studies, agency staff will develop recommendations that may include fishway prescriptions, modifications and possible operational or other structural measures to address existing project impacts and upstream fish passage. Agency staff may recommend additional work required to identify measures to address issues of other management concern.

Progress: FERC relicensing is ongoing for Turners Falls Dam, Northfield Mountain Pumped Storage and Vernon Dam (licenses expire in 2018). Field studies to obtain information on shad downstream movement and passage will begin in 2015 as part of the FERC process; as of this

date, Revised Study Plans have been filed with FERC. The 2011 and 2012 shad migration and survival study data from USGS/USFWS is still under analyses.

Cost: Dam operators will cover costs of FERC requested agency studies as part of relicensing, including fish movement (telemetry based) studies that will be used to inform fish passage evaluations and recommendations. Agency staffs have invested substantial time in the review, development, interaction, and planning of activities associated with the identified main stem hydropower projects that are covered by the agencies that will continue up to and after licensing. Additional costs will be incurred by the USGS Conte and USFWS in analyses and report writing of the 2011 and 2012 shad migration and survival study.

Timeline: Studies required as part of FERC relicensing are scheduled to occur in 2015 and 2016. Subsequent data analyses and report preparation will occur in following years. The agencies will use information from these studies as well as the results from the 2011 and 2012 USGS/USFWS shad migration and survival study and other data remaining to be analyzed to develop appropriate recommendations for license requirements by FERC in 2018.

Adult downstream passage tributaries -
Dams with fishways that do not operate hydropower facilities were not included in the following list of tributaries due to their perceived lack of known threat(s) at this time. Evaluation of downstream passage survival, delay, or other deleterious effects and uses of any alternate routes that may be presented should be examined at dams that have active hydropower facilities, including those listed below.

Farmington River (CT) – The first dam, Rainbow, has a reduced bar trash rack spacing and a surface orientated bypass to guide fish to a bypass pipe that discharges to the tailwater.

Westfield River (MA) – The first dam, West Springfield, has reduced bar trash rack spacing and a surface orientated bypass to guide fish away from the gate house/intake for the power canal. In addition, spill is provided at the dam to ensure adequate flow for fish either still migrating upstream in this period and or for downstream migration.

Ashuelot River (NH) - The first dam, Fiske Mill, has reduced bar trash rack spacing and a surface orientated downstream bypass pipe that discharges to the tailwater.

Juvenile downstream passage main stem -
The Holyoke Dam has had ongoing development with downstream fish passage measures since the 1980s, involving FERC (added license Articles) and then relicensing, CRASC with the 1990 MOA signed with the main stem dam operators on downstream fish passage development, and most recently the still open Settlement Agreement. Over time, the current existing downstream passage measures were developed consisting of a partial depth reduced bar spacing trash rack in front of the turbine intakes, spill at the Bascule Gate, and lastly in the canal, the full depth, full span, angled louver array with fish bypass pipe.

At Turners Falls Dam, downstream passage of juvenile shad principally occurs via the Gatehouse at the dam and then, through the power canal, leading to the Cabot Station. However, the timing, magnitude and frequency of spill at the dam once the canal capacity is exceeded, also provides a downstream passage route. In addition, for a one week period typically scheduled for mid to late September, the power canal's water is shut off at the Gatehouse for maintenance purposes of the canal. This situation results in all river flow directed through gate structures at the dam and the eventual draining of the canal

principally through the Cabot Station turbines. The downstream fish bypass installed as part of the 1990 MOA with CRASC was evaluated for juvenile shad and blueback herring passage in the mid-1990s. The company study demonstrated that of those juveniles that utilized the bypass, relatively high survival was demonstrated (~90%). However, the evaluations did not determine timing, magnitude, or duration of the wild juvenile fish run and their route selection or other management concerns such as conditions that direct fish to use the dam's spill gates and survival of those fish; these are scheduled to be addressed by planned FERC relicensing studies. The relicensing studies will also include an examination of potential juvenile shad migrational impacts in relation to the operation of the NMPS facility. As noted earlier, concerns on NMPS also include entrainment, which will be discussed later.

Downstream passage for juvenile shad at Vernon Dam is made possible by a partial depth and partial length louver which directs fish into the primary fish bypass pipe with a secondary, smaller bypass pipe on the Vermont near-shore side. No studies on juvenile shad use of the bypass systems have been successfully conducted. As part of the FERC relicensing process, 2015 studies will assess downstream passage routes, timing, conditions (operational and natural), and survival as fish approach this project from upstream.

Agencies with regulatory authority: The CRASC has signed agreements with main stem hydropower operators that led to the installation and or operation of facilities for downstream fish passage at Turners Falls Dam, Northfield Mountain Pumped Storage (juvenile Atlantic salmon only) and Vernon Dam with the CRASC 1990 MOA for downstream passage development. The individual States have their legislative authorities and the U. S. Fish and Wildlife Service and National Marine Fisheries Service have authority through the Federal Power Act and through FERC. The CRASC operates a Fish Passage Subcommittee, under its Technical Committee, which has been a forum to coordinate inter-agency staff, researchers and work with the various power companies in both official and unofficial capacities, in a regular and ongoing process. The CRASC issues a schedule of Downstream Passage Operation Dates through the Connecticut River Coordinator, annually in March that specifies species, lifestage, dates and hours of operations.

Goal/Target: No current numeric targets or other values exist for downstream passage of juvenile shad in the CRASC shad plan or elsewhere. Through the noted FERC relicensing process, more information to better define known and yet to be identified issues through planned studies in 2015 and 2016 will be obtained. Based on results and findings of these studies, agency staff will develop recommendations that may include fishway prescriptions, modifications and possible operational or other structural measures to address existing project impacts and downstream fish passage. Agency staff may recommend additional work to identify measures to address issues of other management concern.

Progress: FERC relicensing is ongoing for Turners Falls Dam, Northfield Mountain Pumped Storage and Vernon Dam, whose licenses will expire in 2018. Field studies to obtain information on juvenile shad downstream movement and passage will begin in 2015 as part of FERC process. Revised Study Plans have been filed with FERC as of this date.

Cost: Dam operators will cover costs of FERC requested agency studies as part of relicensing, including fish movement (telemetry based) studies that will be used to inform fish passage evaluations and recommendations. Agency staff has invested substantial time in the review, development, interaction, and planning of activities associated with the identified main stem hydropower projects that are covered by the agencies and that will continue up to and after licensing.

Timeline: Studies required as part of FERC relicensing are scheduled to occur in 2015 and 2016. Subsequent data analyses and report preparation will occur in following years. The agencies will use information from these studies as well as the results from the 2011 and 2012 USGS/USFWS shad migration and survival study and other data remaining to be analyzed to develop appropriate recommendations for license requirements by FERC in 2018.

Juvenile downstream passage tributaries

Dams with fishways that do not operate hydropower facilities were not included in the following list of tributaries due to their perceived lack of known threat(s) at this time. Evaluation of downstream passage survival, delay, or other deleterious effects and uses of any alternate routes that may be presented should be examined at dams that have active hydropower facilities, including those listed below.

Farmington River (CT) – The first dam, Rainbow, has a reduced bar trash rack spacing and a surface orientated bypass to guide fish to a bypass pipe that discharges to the tailwater.

Westfield River (MA) - The first dam, West Springfield, has reduced bar trash rack spacing and a surface orientated bypass to guide fish away from the gate house/intake for the power canal. In addition, spill is provided at the dam to ensure adequate flow for fish either still migrating upstream in this period and or for downstream migration.

Ashuelot River (NH) – The first dam, Fiske Mill, has reduced bar trash rack spacing and a surface orientated downstream bypass pipe that discharges to the tailwater.

Threat: Hydropower Dam and Hydropower Facility Discharge Fluctuations and Operations

Recommended Action: The operation of hydropower facilities includes peaking operations, which can result in substantial alterations to river discharge (timing, magnitude, duration) downstream of the facilities as well as upstream (e.g., impounding periods and the operation of NMPS), and may alter shad habitat types, quantity, and quality at a sub-hourly time scale and on a daily basis. An inventory and assessment of all hydropower facilities that are not required to operate as “run-of-the-river” should be identified and evaluated. This should occur on both the main stem river and identified tributaries. The FERC relicensing process for the five identified main stem hydropower projects will include studies to determine shad spawning locations, habitat features, success, and any operational effects on these measures. Relicensing of FERC projects in recent years, such as Holyoke Dam, have stipulated run-of-river operations.

Agencies with regulatory authority: The States have legal authorities regarding dams and hydropower operation through FERC, Water Quality Certification (401) and Coastal Zone Management Act, as applies. The U. S. Fish and Wildlife Service and National Marine Fisheries Service have authority through the Federal Power Act. Fish and Wildlife Coordination Act. And Endangered Species Act.

Goal/Target: The State and Federal agencies will seek to develop and implement measures to reduce any documented impacts of water use (e.g., generation) on shad spawning habitat based upon available information. A natural flow regime, to the extent possible, is preferred.

Progress: The FERC relicensing process has resulted in planned studies to examine any project operation discharge effects on identified shad spawning habitat and behavior below Turners Falls

Dam, in the Turners Falls impoundment, below the Vernon Dam, in the Vernon Dam impoundment, and below the Bellows Falls Dam.

Cost: FERC relicensing study costs will be covered by the power company. However, agency staff planning, review, discussions, input and evaluation will be ongoing over coming years.

Timeline: The noted FERC relicensing studies are expected to occur in 2015 and possible 2016.

Threat: Water Withdrawal

Recommended Action: An inventory and assessment of all permitted water withdrawals from the main stem and targeted tributary shad habitat should be conducted using state agency permit data. At this time, there are water withdrawals for cooling water intake structures permitted by appropriate state and or federal agencies from the main stem river. The list of water users includes from upstream to downstream: Vermont Yankee Nuclear Power Station, Vernon, VT; Mount Tom Power Station, Holyoke, MA (coal); West Springfield Generation Station, MA (fossil fuels); Algonquin Power, Windsor, CT (natural gas); South Meadow Plant, Hartford, CT (fossil), GenConn, Middletown, CT (natural gas/fossil), and possibly others that remain to be identified. In addition the NMPS facility in Northfield, MA has a pumping capacity, to its storage reservoir, of up to 15,000 cubic feet per second, and is regulated by the FERC. Details of the type and extent of water withdrawal and subsequent discharge for these plants and others that remain to be collectively examined should be reviewed for potential impacts to American shad habitat and population impacts. The NMPS facility did conducted an entrainment study of shad eggs, larvae and juveniles in 1992 that reported an estimated 13.2 million yolk sac and post yolk larvae, and 37,260 juvenile/out migrants entrained. Fish entrained at this facility are considered lost to the Connecticut River population. As part of the FERC relicensing study, a hydroacoustic study at the intakes and radio tagged juvenile shad will be used to evaluate potential project impacts at NMPS. Vermont Yankee's cooling water intake structures are monitored for juvenile shad entrainment and reported to the State and Federal agencies on an annual basis. Vermont Yankee is scheduled for shut down in December 2014, when it has been reported that water discharge (intake) will be reduced by 98% from current maximum level of approximately 800 CFS.

Agencies with regulatory authority: Regulatory authority for the withdrawal of water is under State authorities and/or legislation. In the case of the NMPS facility, licensed through FERC, both the Massachusetts and the federal resources agencies have specific authorities.

Goal/Target: The State and Federal agencies will seek to develop and implement measures to reduce documented impacts of water withdrawals on early life stages and outmigrants (e.g., entrainment and/or impingement) through available regulatory or other mechanisms.

Progress: An inventory of water withdrawals remains to be considered as a management task by the fishery agencies relative to American shad and river herring habitat. However, increased workloads for both State and Federal agency staff will likely delay this activity in order to address other higher priorities. Through the ongoing FERC relicensing process, study plans are still being considered for NMPS evaluation of entrainment impacts to shad life stages (juveniles through adults) with implementation in 2015 and or 2016. Fish entrainment monitoring of the Vermont Yankee intake structure is an ongoing State of Vermont permit requirement.

Cost: Permitting and monitoring of water withdrawal permits are typically handled by State agencies. FERC relicensing study costs will be covered by the power company. However, agency staff planning, review, discussions, input and evaluation will be ongoing over coming years.

Timeline: Review and permitting by the states is ongoing. The examination of this information by the fisheries agencies remains to be identified

Threat: Thermal Discharge

Recommended Action: An inventory and assessment of all permitted thermal discharges from the main stem and targeted tributary shad habitat should be conducted using state agency permit data as well as data from the Environmental Protection Agency (EPA) which has responsibility for the National Pollution Discharge Elimination System (NPDES) and/or its delegation to approved State agencies, to varying levels. Permitted water withdrawals and discharge for cooling water intake structures occur on the main stem river, from upstream to downstream, at: the Vermont Yankee Nuclear Power Station, Vernon, VT; Mount Tom Power Station, Holyoke, MA (coal); West Springfield Generation Station, MA (fossil); Algonquin Power, Windsor, CT (natural gas); South Meadow Plant, Hartford, CT (fossil); GenConn, Middletown, CT (natural gas/fossil); and possibly others.

Agencies with regulatory authority: NPDES authority has been delegated by the EPA to the states of Connecticut and Vermont. Whereas, the Commonwealth of Massachusetts and the State of New Hampshire have not been delegated authority and work with the EPA to issue NPDES permits.

Goal/Target: Varies by authorizing agency. A NPDES permit will generally specify an acceptable level of a pollutant or pollutant parameter in a discharge (e.g., water temperature). The permittee may choose which technologies to use to achieve that level. Some permits, however, do contain certain generic 'best management practices'. NPDES permits make sure that a state's mandatory standards for clean water and the federal minimums are being met.

Progress: Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters since passage of this law in 1972. An inventory of NPDES permitted thermal discharges, remains to be considered as a management task by the fishery agencies relative to American shad and river herring habitat in this basin. However, increased workloads for both State and Federal agency staff will likely delay this activity.
Cost: Permitting and review of monitoring data review are covered by both State and Federal agencies, depending on the location of the discharge. Costs of technologies or other measures to reduce impacts and to monitor discharge levels are covered by the permittee.

Timeline: The Clean Water Act limits the length of NPDES permits to five years. NPDES permits can be renewed (reissued) at any time after the permit holder applies. In addition, NPDES permits can be administratively extended if the facility reapplies more than 180 days before the permit expires, and EPA or the state regulatory agency, which ever issued the original permit, agrees to extend the permit.

Threat: Water Quality

Recommended Action: State and Federal agencies should regularly assess water quality monitoring data to ensure water quality does not become impaired and to support recommendations on proposed activities that may affect water quality. Physical, chemical, and biological monitoring of water quality should be adequately supported, primarily through existing State agency authorities, by designated agencies, to ensure sufficient temporal and spatial coverage, sampling design, and sampling intensity. Classification standards and data among the four basin states should be coordinated and shared along

with necessary monitoring measures. Communication between professional fishery agency staff and water quality staff should continue to be strengthened.

Agencies with regulatory authority: The Clean Water Act of 1972 is the foundation for surface water quality protection in the United States. Sections of this Act provide direction on standards to the states. The states of Vermont, New Hampshire, Massachusetts, and Connecticut all maintain surface water monitoring programs.

Goal/Target: Varies by authorizing agency and standards cannot be weaker than federal identified designations. The State of New Hampshire designates the main stem as Class B. The State of Vermont classifies the main stem as Class B and also as coldwater fish habitat. The Commonwealth of Massachusetts designates the main stem as Class B and also as warmwater fishery habitat. The State of Connecticut also classifies the main stem and tributaries as Class B. Standards associated with these designations are available on respective state agency web sites.

Progress: Water quality on the main stem and tributaries are monitored directly by respective state agencies, federal agencies (e.g., U. S. Geological Survey) non-profit watershed groups, power companies and others. With the previously mentioned FERC relicensing process, more intensive and diverse water quality studies are scheduled to occur in 2015.

Cost: State and Federal agencies conduct ongoing monitoring and review of other data sources. Power companies cover monitoring costs for existing permits (NPDES) and or new licenses such as through FERC.

Timeline: State agency monitoring for standard assessments is ongoing as are other programs including USGS gauge stations with water quality instrumentation. New, shorter duration assessments include the FERC relicensing studies associated with operation of the Turners Falls Hydroelectric Project upstream to the Bellows Falls Dam. Other special studies in recent years have included an EPA Study in 2005 done in collaboration with state agencies.

Threat: Land Use

Recommended Action: State, Federal, and local governments should continue to support existing protective measures to address poor land use practices that may affect shad habitat either directly or indirectly. These measures may occur at multiple levels of government as noted. Riparian zone vegetation protection and bank protection are examples of concerns that poor land use (e.g., agriculture, residential, commercial uses) regulation or enforcement may result in degraded habitat. States should work in collaboration to develop and support consistent regulations and enforcement measures.

Agencies with regulatory authority: Land use regulatory authority may reside at the local, state and/or federal government level.

Goal/Target: The codification of rules and adequate enforcement to provide riparian vegetation protection and bank protection/stability and address other potential negatively impacting land use activities will help protect aquatic habitats.

Progress: Status of existing state and local government rules are not summarized. Examples of measures that have improved protections for land use include the Rivers Protection Act, under the Wetlands Protection Act of the Commonwealth of Massachusetts.

Cost: Unknown.

Timeline: Ongoing.

Threat: Climate Change

Recommended Action: State and Federal agencies should identify data of value in the detection and monitoring for climate change effects on shad habitat and associated shad population dynamics or other responses (e.g., run timing) and whether those changes can successfully be adapted to by those populations. Sources of important data should be evaluated for ongoing value and whether any modifications may be necessary. Data that would be of value in this effort and are not being collected should be identified with measures to develop appropriate data collection programs explored collaboratively by the State and Federal agencies. In freshwater, the timing, frequency, and magnitude of river discharge should be evaluated at regular intervals (spring run-off, droughts, pulse events) and related to fishery data including, but not limited to, fishway operational schedules, fish movement and behavior data, spawning success, habitats, and juvenile recruitment and outmigration. In the near-shore and marine environment, monitoring and studies to assess shifts in conditions and habitats (e.g., water temperatures, currents, food sources, predators) should occur at regular intervals

Agencies with regulatory authority: Regulatory authorities for climate change are not clearly in place at this time. However, both State and Federal resources agencies have recognized the need to incorporate the reality of climate change as physical scientists work to develop future scenarios on effects (e.g., temperature regimes, river discharge, rainfall, snowpack) that may to varying degrees, affect species occurrence, population viability, and habitat quantity and quality.

Goal/Target: It will be desirable to understand any trends in population metrics or other parameters, and any linked climate change drivers that may affect population structure, distribution, abundance, and viability. The resource agencies will seek to mitigate negative climate change impacts and other related exacerbating human impacts that may accelerate these impacts. Ultimately the agencies will seek to ensure the full restoration and long-term sustainability of this population given it is not at the extreme end of its distribution range.

Progress: New or updated federal resource plans are required to include climate change.

Cost: Unknown.

Timeline: Ongoing.

References Cites

Castro-Santos, T. and B. H. Letcher. 2010. Modeling migratory energetics of Connecticut River American shad (Alosa sapidissima): implications for the conservation of an iteroparous anadromous fish. Canadian Journal of Fisheries and Aquatic Science 67: 806-830

CRASC (Connecticut River Atlantic Salmon Commission). 1992. A management plan for American shad in the Connecticut River basin. Sunderland, MA.

Gephard, S. and J. McMenemy. 2004. An overview of the program to restore Atlantic salmon and other diadromous fishes to the Connecticut River with notes on the current status of these species in the river. In P. M. Jacobson, D. A. Dixon, W. C. Leggett, B. C. Marcy, Jr., and R. R. Massengill, editors. The Connecticut River Ecological Study (1965-1973) revisited: ecology of the lower Connecticut River 1973-2003. American Fisheries Society, Monograph 9, Bethesda, MD.

Gilmore, K.S. 1975. Spawning areas and egg distribution of American shad (Alosa sapidissima) in the Connecticut River between Holyoke and Turners Falls, Massachusetts. Master's thesis. University of Massachusetts, Amherst, MA.

Greene, K. E., J. L. Zimmerman, and J. C. Thomas-Blate. 2009. Atlantic Coast diadromous fish habitat: A review of utilization, threats, recommendations for conservation, and research needs. Atlantic States Marine Fisheries Commission, Washington, DC

Kuzmeskus, D. M. 1977. Egg production and spawning site distribution of Americans had, *Alosa sapidissima*, in the Holyoke Pool, Connecticut River, Massachusetts. Master's thesis. University of Massachusetts, Amherst, MA.

Layzer, J.B. 1974. Spawning Sites and Behavior of American Shad, *Alosa sapidissima* (Wilson), in the Connecticut River Between Holyoke and Turners Falls, Massachusetts, 1972. Master of Science Thesis. University of Massachusetts, Amherst, Massachusetts.

Leggett, W. C., T. F. Savoy, and C. A. Tomichek. 2004. The impact of enhancement initiatives on the structure and dynamics of the Connecticut River population of American shad. American Fisheries Society Monograph # 9: The Connecticut River Ecological Study (1965-1973) Revisited: Ecology of the Lower Connecticut River 1973-2003.

Marcy, B. C. Jr. 1976. Planktonic fish eggs and larvae of the lower Connecticut River and effects of the Connecticut Yankee plant including entrainment. American Fisheries Society Monograph # 1: The Connecticut River Ecological Study.

Watson, J.F. 1970. Distribution and population dynamics of American shad (Alosa sapidissima), in the Connecticut River above Holyoke Dam, Massachusetts. Doctor of Philosophy Dissertation. University of Massachusetts, Amherst, Massachusetts.

Appendix 1. American shad fish passage counts from 1980 through 2013 for the Holyoke Dam (MA), Turners Falls Dam (MA), and Vernon Dam (VT).

Year	Holyoke Dam Fish Lift	Turners Falls Dam Gatehouse	% Gate vs. HFL #	Vernon Dam Fish Ladder	% Vern vs. Gate #
1980	380,000	298	0.1		
1981	380,000	200	0.1	97	48.5
1982	290,000	11	0.0	9	81.8
1983	530,000	12705	2.4	2597	20.4
1984	500,000	4333	0.9	335	7.7
1985	480,000	3855	0.8	833	21.6
1986	350,000	17858	5.1	982	5.5
1987	270,000	18959	7.0	3459	18.2
1988	290,000	15787	5.4	1370	8.7
1989	350,000	9511	2.7	2953	31.0
1990	360,000	27908	7.8	10894	39.0
1991	520,000	54656	10.5	37197	68.1
1992	720,000	60089	8.3	31155	51.8
1993	340,000	10221	3.0	3652	35.7
1994	170,000	3729	2.2	2681	71.9
1995	190,000	18369	9.7	15771	85.9
1996	280,000	16192	5.8	18844	116.4
1997	300,000	9216	3.1	7384	80.1
1998	320,000	10527	3.3	7289	69.2
1999	190,000	6751	3.6	5097	75.5
2000	225,000	2590	1.2	1548	59.8
2001	270,000	1540	0.6	1744	113.2
2002	370,000	2870	0.8	356	12.4
2003	280,000			268	
2004	192,000	2192	1.1	653	29.8
2005	116,511	1581	1.4	167	10.6
2006	155,000	1810	1.2	133	7.3
2007	158,807	2248	1.4	65	2.9
2008	156,492	4000	2.6	271	6.8
2009	160,649	3813	2.4	16	0.4
2010	164,439	16422	10.0	290	1.8
2011	244,177	16798	6.9	46	0.3
2012	490,431	26727	5.4	10386	38.9
2013	392,967	35494	9.0	18220	51.3
Mean			**3.8**		**39.8**
SD			3.2		33.9
Low			0.0		0.4
High			10.5		116.4