# APPENDIX 12.C. POTENTIAL WITHDRAWAL EFFECTS ON ANADROMOUS HERRINGS

The three species of river shad that utilize the St. Johns River, American shad, blueback herring (*Alosa aestivalis*), and hickory shad (*Alosa mediocris*) are anadromous species that live in coastal and oceanic waters as adults and migrate into freshwater habitats to spawn. The geographic range of all three species extends from Nova Scotia to Florida, with the St. Johns River being the southernmost spawning habitat of all three (Harris and McBride 2004; Harris et al. 2007; McBride 2000; Williams et al. 1975).

American shad is the most intensively studied species in this group because of their historical importance. American shad were an important as food to many Native American tribes and once supported valuable commercial fisheries along the entire eastern seaboard. Commercial fishing for shad started during the early colonial period and had a profound influence on societal development in different regions of the continent (McPhee 2002). Commercial shad fishing in the St. Johns River began in the 1860's, relatively late compared to the rest of the continent, and by 1890, had become the most valuable commercial fishery in the state (McBride and Holder 2008). American shad was the most abundant of the anadromous species harvested. From the 1920's to the 1960's between 0.09 million and 0.4 million kg (198,400 – 881,849 lb) of shad (all species) were harvested from the river annually (McBride and Holder 2008). Thereafter catches in the St. Johns River began to decline sharply, following a trend documented along the entire east coast. Causes given for the overall population decline were overfishing, dam construction, habitat loss and pollution (Limburg et al. 2003). Overfishing (both within the river and the open ocean) was implicated as the main cause for the decline of St. Johns River stocks (Williams and Bruger 1972) although other causative factors for a decline in total harvest were shrinking markets, and increasingly restrictive netting regulations (McBride 2000). Anadromous shads are no longer commercially harvested from the St. Johns River.

All anadromous shad stocks in the United States currently are under management of the Atlantic States Marine Fishery Commission (ASMFC) and restoration efforts are now underway to rebuild populations in many rivers (ASFMC 1999; ASFMC 2009a; ASFMC 2009b). As a part of the overall ASMFC management plan, Florida is required to monitor current population and levels and recreational catch in the St. Johns River and, to submit a management plan to the ASFMC that ensures recreational fishing will not adversely affect stock recovery. Florida is also required to submit a habitat management plan by 2013 that includes a summary of current and historical nursery habitats and lists potential water resource development projects which may impact those habitats (2009a; ASFMC 2009b). States are requested by the AFMFC to carefully scrutinize water withdrawal projects and develop management plans that ensure protective flows and levels are maintained and potential entrainment/impingement impacts are minimized (ASFMC 2009a; ASFMC 2009b). Implementation of habitat management plans are not mandatory at this time pending review by the ASMFC. American shad is considered to be the most vulnerable of all the anadromous fishes in the St. Johns River to potential reductions in water level and flow that may result from water withdrawals (Harris and McBride 2004; McBride and Holder 2008). Of particular concern are the potential impacts of reduced flow on water quality, the availability of spawning habitat and the survival of eggs and larvae (Harris and McBride 2004; McBride and Holder 2008; Williams and Bruger 1972).

Of the three anadromous herrings found in the St. Johns River, the American shad has been the most intensively studied. Detailed life history information is provided in Walburg and Nichols (1967), Williams and Bruger (1972), McBride (2000), and McBride and Holder (2008). Hickory shad generally comprise less than 3% of the catch of all river herrings (Walburg 1960b; Walburg and Nichols 1960). Life history information on hickory shad in the St. Johns River is provided in Harris et. al. (2007), McBride (2000)and McBride and Holder (2008) . The blueback herring is the most rare and least studied of the three species (McBride 2000; Williams et al. 1975).

All three anadromous shad species ascend the St. Johns River to spawn in the late winter and early spring (December- March). American shad and blueback herring are semelparous, they have one reproductive cycle before they die, whereas hickory shad are iteroparous, and may enter and leave the river more once than to spawn (Harris et al. 2007; McBride 2000; Williams et al. 1975). All species are batch spawners, (i.e., all eggs within an individual female do not become ripe at once) and spawning occurs at intervals.

Spawning grounds of the American shad are located in the main river primarily between Lake Monroe and Lake Poinsett with some use of the Econlockhatchee River (Anonymous 1969; Boucher 2008; Williams and Bruger 1972). Hickory shad spawning appears to be limited in the main river, with most activity apparently occurring in the Wekiva and Econlockhatchee River tributaries. (Harris et al. 2007). Blueback herring spawning occurs in the main river and tributaries from Lake George to Lake Poinsett (Williams et al. 1975). All three species appear to require flowing water and have demersal (non-floating) eggs that are non-adhesive. Larvae become planktonic after they hatch and migrate downstream where they enter the estuary and eventually migrate to the Atlantic Ocean. Spawning habitat characteristics in the St. Johns River for blueback herring and hickory shad are unknown although current velocity is likely an important factor influencing site selection. For American shad, most spawning occurs over clean sandy substrate free of mud and silt, in depths < 4 m, and in current velocities of 30 to 45 cm $s^{-1}$ (1.0 to 1.5 ft $s^{-1}$)(Hightower and Sparks 2003; Massman 1952; Read and Hightower 2005; Weiss-Glanz et al. 1986; Williams and Bruger 1972). This type of substrate dominates the river between Lake Monroe and Poinsett, where numerous shallow sand bars are interspersed with deeper channels (Williams and Bruger 1972).

To assess potential impacts of water withdrawals on anadromous shads, the DISTRICT has provided funding for radio telemetry studies to investigate adult American shad movement and habitat use (Dutterer et al. 2010), and for studies to assess the abundance and distribution of eggs and larvae near proposed intake sites (see Appendix 12.B). The radio-telemetry study is on-going and although some preliminary analysis is available, complete results will not be available until spring 2012. Similarly, complete results for the larval fish studies will also not be complete until fall 2012. Some results of the egg and larval surveys that will be useful to investigating withdrawal effects on anadromous herrings are presented in Boucher (2008) and are be discussed in the entrainment section (See Chapter 12 Fish Section 5.1.2 Entrainment Effects on Ichthyoplankton).

To investigate how withdrawals may potentially influence the availability of American shad spawning habitat we first quantified the extent of suitable habitat available under varying flow conditions. We measured river velocities, mid-channel depths, and substrate at 158 intermittently spaced locations covering 108 km (67 miles) of river between Lake Monroe and Lake Poinsett under both low and intermediate flows. The river reach between Lake Monroe and Lake Poinsett is considered to encompass the primary spawning grounds of American shad in the St. Johns River (Williams and Bruger 1972). Low flows were defined as average daily discharges measured at the State Road (SR) 50 USGS gauging station between 2.3 and 13.5 $m^3 s^{-1}$ (81 to 477 cfs). The majority of low-flow measurements (>92%) were taken at flows < 6.4 $m^3 s^{-1}$ (225 cfs). Medium flows were defined as discharges at SR 50 that ranged from 21.7 to 24.8 $m^3 s^{-1}$ (766-876 cfs). Inspection of the historical flow duration curve indicated that low flows as defined here are exceeded 73 to 93% of the time whereas medium flows are exceeded 47 to 51% of the time.

At each location, mid-channel depth was measured using a survey rod. At approximately 60% of the measured mid-channel depth, three separate velocity measurements were taken with a Marsh McBirney Flow-Mate™ Model 2000 portable flowmeter and averaged. Bottom substrates were characterized as either sand, hard clay/sand, or mud. All locations were sampled once during low flow conditions and once during medium flows with a few exceptions around Puzzle Lake. During medium flows, a few sites near Puzzle Lake came part of the open water of the lake and flows were not measurable. All sampling locations points were recorded as GPS waypoints.

Each sampling point was classified for quality of potential American shad spawning habitat based on average velocity and depth using information provided in Stier and Crance (1985), and Williams and Bruger (1972). Mean water temperature and current velocity are the most important factor influencing selection of spawning habitat (Stier and Crance 1985). American shad may spawn anywhere in rivers and over a variety of substrates but they prefer broad shallow flats with sand or gravel bottom. American shad are pelagophils (i.e., open substrate spawners) that produce demersal eggs that rely on river currents for movement and oxygenation. Hatching occurs in 3-7 days dependent upon water temperature (Marcy 1972). Spawning occurs at water velocities of 0.09-1.3 $m\ s^{-1}$; optimal velocities are 0.3 to 0.9 $m\ s^{-1}$ (1.0 to 3.0 $ft\ s^{-1}$). (Stier and Crance 1985). Spawning depths range from 0.46 to 15.24 m (1.5 to 50 ft); optimal depths are 1.2 to 6.0 m (4 to 20 ft). Water depths less than 0.46 m (1.5 ft) are not utilized (Stier and Crance 1985).

We categorized riverine habitats in the St. Johns Rivers into one of two categories; 1) good to excellent and 2) marginal to poor. Habitat was considered good to excellent if water depths were > 0.46 m (1.5 ft) and water velocities were > 0.20 $m\ s^{-1}$ (0.70 $ft\ s^{-1}$). Habitat was considered marginal to poor if depth was < 0.46 m (1.5 ft) or if water velocity was < 0.20 $m\ s^{-1}$ (0.70 $ft\ s^{-1}$). We also divided the river into two segments (Lake Monroe to Lake Harney and Lake Harney to Lake Poinsett based upon published observations (Williams and Bruger 1972). They documented that during low water years the river from Lake Poinsett to Lake Harney constituted the primary American shad spawning grounds whereas during normal water years, American shad spawning was concentrated between Lake Harney and Lake Monroe. For both low and medium flow conditions separately, sampling locations were mapped and coded according to their classification as described above. Sampling locations were connected to determine channel length of each habitat type under each flow regime. Where site classification changed between sampling points, habitat classifications were extended to halfway between the points. Habitat boundaries were further refined from field notes. Summed habitat lengths provide length of the total river that fell within each classification for each flow condition.

During low flows, approximately 30 km (19 miles) or 37% of the 76 km (47 miles) of river channel between Lake Harney and Lake Poinsett potentially provided good or excellent spawning habitat for American shad (Figure 12.C-1). During low flows, habitats between Lake Monroe and Lake Harney were poor. This is consistent with published observations that American shad spawning was concentrated upstream of Lake Harney during lower flow conditions (Williams and Bruger 1972). During medium flows, 44% of the channel between Lake Monroe and Lake Harney was rated good to excellent spawning habitat whereas 67% of the river channel between Lake Harney and Lake Poinsett fell in this category. In 2010, when monthly average spring flows were > 21.7 $m^3 s^{-1}$ (766 cfs), a majority of radio-telemetered shad stayed in an area between Lake Harney and Lake Monroe throughout the spawning season although a few fish were recorded utilizing habitat all along the river as far south as Lake Winder and up the Econlockhatchee River (Dutterer et al. 2010). Even though exact spawning locations are unknown, these data suggest that under medium flow conditions, suitable spawning habitat is widespread in the St. Johns River from Lake Monroe to Lake Poinsett. Under low flow conditions, however, suitable spawning habitat appears only widespread from Lake Harney to Lake Poinsett.

Results of our surveys suggest that under natural flows, availability of suitable habitat may not be a limiting factor to American shad spawning in the St. Johns River. However, our study only measured potential habitat, not actual spawning. Unrecognized site-specific variables may make one potential spawning location site more desirable than another may. In addition, no information is available on how spawning location influences egg and larvae survival.

Water withdrawals for the Taylor Creek Project and at SR 46 may have the greatest potential for influencing American shad spawning because withdrawals will occur just upstream, or in the middle of, documented spawning grounds. Negative impacts could occur if withdrawals cause an increase in the intensity, duration, or return frequency of more extreme low-flow events. This could reduce availability of suitable spawning grounds, reduce flows and adversely affect egg survival, or create shallow areas that block upstream migration. However, analyses of hydrologic data indicates the return-frequency of low-flow events will not increase under near-term withdrawal scenarios that include flow augmentation from the Upper Basin Project (See Chapter 12 Fish Section 4.1.1 Effects on Hydrology).

Two proposed intake locations for the Taylor Creek Project withdrawals are 1) at SR 520 where the river leaves Lake Poinsett, and 2) downstream at SR 50. Modeled withdrawal schedules for the Taylor Creek Project stipulate that withdrawals will not occur when the river discharge at SR 50 falls below 8.4 $m^3 s\text{-}^1$ (300 cfs). A discharge of 8.4 $m^3 s\text{-}^1$ (81-477 cfs) at SR 50 generally equates to a discharge of 6.8 $m^3 s\text{-}^1$ (240 cfs) upstream at SR 520. At a discharges > 8.4 $m^3 s\text{-}^1$ (300 cfs) at SR 50, greater than 37% of the river between Lake Harney and Lake Poinsett will provide good or excellent habitat for American shad spawning (Figure 12.C-1). At higher flow, the percentage of good or excellent habitat will likely increase.

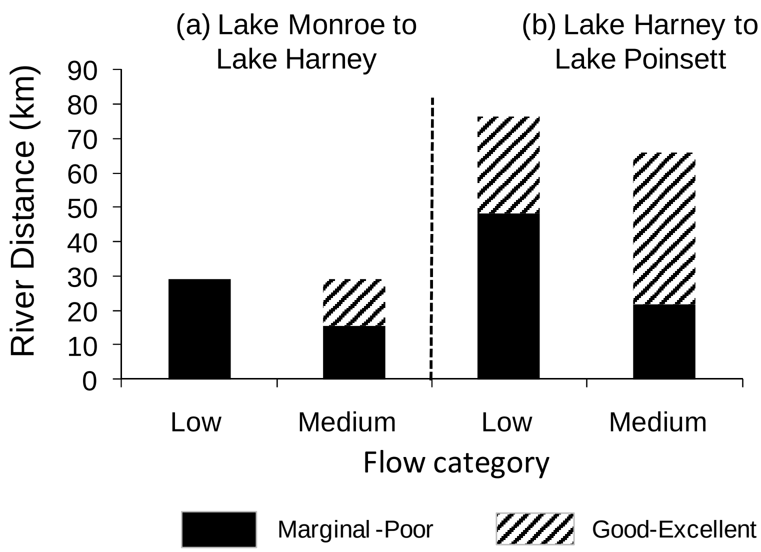


Figure 12.C-1. American shad spawning habiat habitat classification for riverine sections of the St,. Johns River from (a) Lake Monroe to Lake Harney and (b) Lake Harney to Lake Poinsett during low flow (2.3 to 13.5 $m^3\ s^{-1}$ ( 81 to 477 cfs)) and medium flow ((21.7 to 24.8 $m^3\ s^{-1}$ (766-876 cfs)) conditions. Flows were reported discharges at the USGS gauging station at Christmas FL on the date that depths and velocities were measured. Marginal – poor habitat had either depths < 0.46 m, or flow velocities < 0.20 m $s^{-1}$ (0.7 ft $s^{-1}$). Good – excellent habitat had depths >0.46 m and flow velocities > 0.20 m $s^{-1}$ (0.7 ft $s^{-1}$). Habitat classifications derived from Stier and Crance (1985).

To further investigate potential water withdrawal effects we looked at the percent of time water levels were < 6.4 $m^3$ $s\text{-}^1$ (225 cfs) at SR 50 for each of the withdrawal scenarios. The Full1995NN Scenario was the only scenario that had a decline in the percentage of time flow exceeded 6.4 $m^3$ $s\text{-}^1$ (225 cfs) compared to the Base1995NN Scenario (Figure C.12-2). Addition of the Upper Basin Project to the full flow withdrawal scenario (Full1995PN) increased the percentage of time flow exceeded 6.4 $m^3$ $s\text{-}^1$ by 2% (Figure C.12-2). Under the long-term Full2030PS Scenario, the percentage of time flow exceeded 6.4 $m^3$ $s\text{-}^1$ (225 cfs) increased by 6% (Figure C.12-2). Annual return frequencies of flow events (< 6.4 $m^3$ $s\text{-}^1$ (225 cfs)) also decreased under the Full1995PN and Full2030PN Scenarios. Under all scenarios a 1-day low event <6.4 $m^3$ $s\text{-}^1$ (225 cfs) occurred on average once every 1.1 years. The occurrence of a 30-day continuous low-flow event however was once every 1.2 years under the Base1995NN Scenario but decreased to once every 1.3 and 1.5 years under the Full1995PN and Full2030PS Scenarios, respectively. The occurrence of a 120-day continuous flow <6.4 $m^3$ $s\text{-}^1$ (225 cfs)s decreased further from once every 2.2 years under the Basse1995NN Scenario to once every 3.7 years under the Full1995PN Scenario and once every 5.5 years under the Full203PS Scenario.

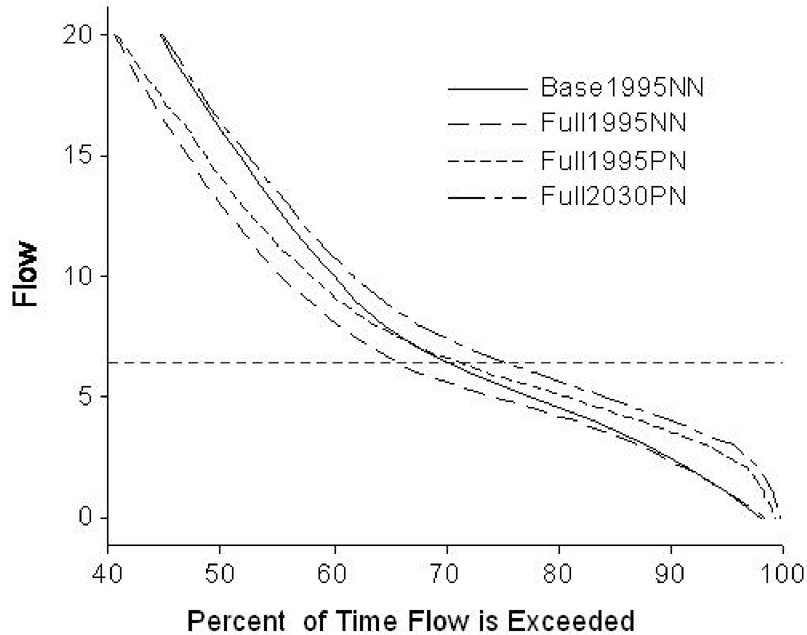


Figure 12.C-2. Flow duration curves at State Road 50 comparing the base model run (Base1995NN) to the worse case test Scenario (Full1995NN), a potential near-term Scenario (Full1995PN) and a potential long-term Scenario Full2030PN. Horizontal dotted line represents the flow level of 6.4 $m^3$ $s^{-1}$ (225 cfs), a flow at which 37% of the river between Lake Poinsett and Lake Harney is considered to be good to excellent potential spawning habitat for American shad.

These results indicate that full withdrawals will likely not adversely affect the availability of good to excellent spawning habitat for American shad, nor movement to the spawning grounds, due to the increased base flows that will result from operation of the Upper Basin Project and predicted 2030 land use changes. Potential withdrawal impacts to hickory shad and blueback herring spawning habitat are less clear, but will likely be similar to those for American shad due to increased base flow conditions and their preference for similar spawning habitats. Future research should focus on more specifically delineating spawning habitats utilized by all three species and investigating potential spatial variability in survival of eggs and newly hatched larvae. In addition, future research should investigate use of the tributaries for spawning, especially by hickory shad and blueback herring.

Literature Cited


Anonymous. 1969. A preliminary survey of the distribution of American shad in the Econlockhatchee River, a tributary of the St. Johns River. Unpublished Mimeo Florida Game and Fresh Water Fish Commission.

ASMFC (Atlantic States Marine Fisheries Commission). 1999. Amendment 1 to the interstate fishery management plan for shad and river herring. Fishery Management Report No. 35. Atlantic States Marine Fisheries Commission.

ASMFC (Atlantic States Marine Fisheries Commission). 2009a. Amendment 3 to the interstate fishery management plan for shad and river herring (American shad management). Fishery Management Report. Atlantic States Marine Fisheries Commission.

ASMFC (Atlantic States Marine Fisheries Commission). 2009b. Amendment 2 to the interstate fishery management plan for shad and river herring (river herring management). Fishery Management Report. Atlantic States Marine Fisheries Commission.

Boucher, J. M. 2008. Spawning patterns and larval growth and mortality of American shad (*Alosa sapidissima*) in the St. Johns River, FL. Mastes Thesis Submitted to the Florida Institute of Technology, Melbourne, Florida.

Dutterer, A. C., M. S. Allen, and W. E. Pine III. 2010. Spawning Microhabitats for American Shad at the St. Johns River, Florida: Potential for Use in Establishing MFLs Year 2 of 3. Annual Progress Report to the Florida Fish and Wildlife Conservation Commission and St. Johns River Water Management District. Program for Fisheries and Aquatic Sciences, School of Forest and Resources and Conservation. University of Florida, Gainesville,FL.

Harris, J. E., and R. S. McBride. 2004. A review of the potential effects of water level fluctuation on diadromous fish populations for MFL determinations. St. Johns River Water Management District Special Publication SJ2004-SP40.

Harris, J. E., R. S. McBride, and R. O. Williams. 2007. Life History of Hickory Shad in the St. Johns River, Florida. Transactions of the American Fisheries Society 136(6):1463-1471.

Hightower, J. E., and K. L. Sparks. 2003. Migration and spawning habitat of American shad in the Roanoke River, North Carolina. American Fisheries Society Symposium 35:193-199.

Limburg, K. E., K. A. Hattala, and A. Kahnle. 2003. American shad in its native range. Pages 125-140 *in* K. E. Limburg, and J. R. Waldman, editors. Biodiversity, status, and conservation of the world's shads. American Fisheries Society Symposium 35, Bethesda, Maryland.

Marcy, B. C. J. 1972. Spawning of the American shad, *Alsoa sapidissima* in the lower Connecticut River. Chesapeake Science 13(2):116-119.

Massman, W. H. 1952. Characteristics of spawning areas of shad, *Alosa sapidissima*, (Wilson) in some Virginia streams. Transactions of the American Fisheries Society 81:78-93.

McBride, R. S. 2000. Florida shad and river herrings (*Alosa* species): a review of population and fishery characteristics. Florida Marine Research Institute Technical Report TR-5.

McBride, R. S., and J. Holder. 2008. A review and updated assessment of Florida's anadromous shads: American shad and hickory shad. North American Journal of Fisheries Management 28:1668-1686.

McPhee, J. 2002. The Founding Fish. Farrar, Straus,and Giroux, New York, New York.

Read, A. N., and J. Hightower, E. 2005. Characterizing American shad spawning habitat in the upper Roanoke River Basin, Virginia. Final Report to North Carolina Wildlife Resources Commmission.

Stier, D. J., and J. H. Crance. 1985. Habitat suitability index models and instream flow suitability curves: American shad. U. S. Fish and Wildlife Service Biological Report 82(10.88):34 pp.

Walburg, C. H. 1960b. Abundance of St. Johns River shad. Proceedings of the 25th North American Wildlide Conference:327-333.

Walburg, C. H., and P. R. Nichols. 1960. Biology and management of American shad and status of the fisheries, Atlantic coast of the United States, 1960. U. S. Fish and Wildlife Service Special Scientific Report Fisheries 550:105p.

Walburg, C. H., and P. R. Nichols. 1967. Biology and management of American shad and status of the fisheries, Atlantic coast of the United States, 1960. U. S. Fish and Wildlife Service Special Scientific Report-- Fisheries 550:105p.

Weiss-Glanz, L. S., J. G. Stanley, and J. R. Moring. 1986. Species profile:life histories and environmental requirements of coastal fishes and invertebrates (North Atlantic)-- American Shad. U. S. Fish and Wildlife Service Biological Report 82(11.59):13pp.

Williams, R. O., and G. Bruger, E. 1972. Investigations on American shad in the St. Johns River. Florida Board of Conservation Marine Research Laboratory Series No. 66:1-49.

Williams, R. O., W. F. Grey, and J. A. Huff. 1975. Anadromous fish studies in the St. Johns River. Completion Report for the study of anadromous fishes of Florida (Project AFCS-5). U. S. National marine Fisheries Service, St. Petersburg, Florida.