Biological Opinion

on the U.S. Army Corps of Engineers, Mobile District,

Revised Interim Operating Plan

for Jim Woodruff Dam and the Associated Releases to the Apalachicola River

Prepared by:
U.S. Fish and Wildlife Service
Panama City Field Office, Florida
June 1, 2008

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List of Acronyms

ACF	Apalachicola-Chattahoochee-Flint Basin
Act	Endangered Species Act
BHQ	Benthic Habitat Quality Index
BO	Biological Opinion
cfs	Cubic feet per second
Corps	U.S. Army Corps of Engineers
CPUE	Catch Per Unit Effort
CSU	Columbus State University
DO	Dissolved Oxygen
EDO	Exceptional Drought Operations
EV	Environmental Variation
FDEP	Florida Department of Environmental Protection
FFWCC	Florida Fish and Wildlife Conservation Commission
GDNR	Georgia Department of Natural Resources
HEC-5	Hydrologic Engineering Center – model 5
IOP	Interim Operation Procedures
ITS	Incidental Take Statement
K	Carrying Capacity
λ	Annual Population Growth
NPDES	National Pollutant Discharge Elimination System
NMFS	National Marine Fisheries Service (same as NOAA-Fisheries)
NOAA	National Oceanic and Atmospheric Administration
NWFWMD	Northwest Florida Water Management District
PCEs	Primary Constituent Elements
PVA	Population Viability Analysis
RIOP	Revised Interim Operation Plan

RM	River mile
RoR	"Run-of-River" operations
RPM	Reasonable and Prudent Measure
SAV	Submerged Aquatic Vegetation
SEPA	Southeastern Power Administration
Service	U.S. Fish and Wildlife Service
TL	Total length
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WCP	Water Control Plan
YOY	Young-of-the-year

United States Department of the Interior

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June 1, 2008

Col. Byron Jorns, District Engineer
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P.O. Box 2288
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Dear Col. Jorns:

This document is the Fish and Wildlife Service's (Service) biological opinion (BO) of the Revised Interim Operating Plan (RIOP) for Jim Woodruff Dam, per section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq*.). It also provides preliminary considerations in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq*.). The U.S. Army Corps of Engineers (Corps) requested formal consultation by letter dated April 15, 2008. The Corps has determined that the proposed RIOP may adversely affect the threatened Gulf sturgeon (*Acipenser oxyrinchus desotoi*), endangered fat threeridge mussel (*Amblema neislerii*), threatened purple bankclimber mussel (*Elliptoideus sloatianus*), and threatened Chipola slabshell (*Elliptio chipolaensis*), and areas designated as critical habitat for the Gulf sturgeon and the mussels.

The Corps has proposed modifying the Interim Operating Plan (IOP) that was adopted in 2006. The Corps adopted an Exceptional Drought Operations (EDO) plan in November, 2007, in response to ongoing severe drought conditions that were unanticipated in the development of the IOP. The Service completed a BO for the IOP on September 5, 2006. We amended that BO to address the provisions of the EDO on November 15, 2007. The proposed RIOP is based upon review of the current species information, basin stakeholder input, lessons learned from 2006-07, and continuing discussions between the Corps and USFWS. We recognize the continuity of the current proposed action with the previous actions and summarize in this BO some analyses that were included in the previous BOs. However, we have not structured this BO as an amendment to the previous BOs. This BO and the Reasonable and Prudent Measures (RPMs) included in the Incidental Take Statements (ITS) of this BO supersede previous BOs and the previous ITS.

The RIOP is intended to govern the releases from Woodruff Dam until revised or replaced with a new Water Control Plan (WCP). Drought provisions have been

incorporated in the RIOP and are effective until reservoir storage levels return to more normal levels. By notice published February 22, 2008 (FR 73(36):9780-9781), the Corps announced its intent to prepare a draft environmental impact statement for updated water control manuals for the Apalachicola-Chattahoochee-Flint (ACF) River Basin. We understand that the revision of the water control plans may take five years; therefore, we have structured this opinion to evaluate the effects of the proposed action over the next five years.

This BO is based on numerous coordination and clarifying conference calls between the Corps and the Service in recent weeks, on unpublished data in Service files, on the experience of Service biologists, and on an extensive literature search. It does not rely on the regulatory definition of destruction or adverse modification of critical habitat at 50 Code of Federal Regulations [C.F.R.] 402.02. Instead, we have relied upon the statutory provisions of the Act to complete the following analysis with respect to critical habitat. A complete administrative record is on file in the Panama City Field Office, Florida.

A total of 37 federally listed species are known to occur within the ACF Basin, but effects of the proposed action are limited to those that depend primarily on riverine habitat. Except for the temporary waiver of winter drawdown requirements at the West Point and Walter F. George projects during drought conditions, the Corps would implement the RIOP within the boundaries of the existing water control plans for the upstream reservoir projects, and will not change the top of the flood control pools, conservation pools, or the rule curves of the upstream projects. Therefore, the proposed action will have no effect or an insignificant effect (*i.e.,* any impacts should never reach the scale where take occurs) on all but the riverine- and estuarine-dependent species. Two species of sea turtles and the West Indian manatee may sometimes occur in Apalachicola Bay or the lower Apalachicola River; however, any effects of the proposed action to these species would be insignificant also, due to their low numbers and only occasional seasonal residence in the river and bay. Three of the 37 ACF listed species are freshwater mussels that do not occur in areas downstream of the Corps' ACF projects: the shiny-rayed pocketbook, Gulf moccasinshell, and oval pigtoe. The proposed action will have no effect on these. Altogether, the proposed action will have either no effect or an insignificant effect on the species listed in Table 1 and these are not further discussed in this biological opinion.

Table 1. Species and critical habitat evaluated for effects from the proposed action but not further discussed in this biological opinion.

SPECIES OR CRITICAL HABITAT
Flatwoods salamander (*Ambystoma cingulatum*)
Loggerhead turtle (*Caretta caretta caretta*)
Eastern indigo snake (*Drymarchon corais couperi*)
Atlantic ridley (*Lepidochelys kempi*)
Piping plover (*Charadrius melodus*)
Bald eagle (*Haliaeetus leucocephalus*)
Wood stork (*Mycteria Americana*)
Gray bat (*Myotis grisescens*)
Indiana bat (*Myotis sodalis*)
West Indian manatee (*Trichechus manatus*)
Shiny-rayed pocketbook (*Lampsilis subangulata*)
Gulf moccasinshell (*Medionidus penicillatus*)
Oval pigtoe (*Pleurobema pyriforme*)
Little amphianthus (*Amphianthus pusillus*)
Apalachicola rosemary (*Conradina glabra*)
Telephus spurge (*Euphorbia telephioides*)
Harper's beauty (*Harperocallis flava*)
Black-spored quillwort (*Isoetes melanospora*)
Pondberry (*Lindera melissifolia*)
White birds-in-a-nest (*Macbridea alba*)
Canby's dropwort (*Oxypolis canbyi*)
Godfrey's butterwort (*Pinguicula ionantha*)
Harperella (*Ptilimnium nodosum)*
Chapman's rhododendron (*Rhododendron chapmanii*)
Michaux's sumac (*Rhus michauxii*)
Green pitcherplant (*Sarracenia oreophila*)
American chaffseed (*Schwalbea Americana*)
Florida skullcap (*Scutellaria floridana*)
Fringed campion (*Silene polypetala*)
Gentian pinkroot (*Spigelia gentianoides*)
Cooley meadowrue (*Thalictrum cooleyi*)
Florida torreya (*Torreya taxifolia*)
Relict trillium (*Trillium reliquum*)

CONSULTATION HISTORY

Date	Description
1991-1997	Informal consultation developing information for Tri-State Comprehensive Study
1998-2003	Informal consultation on Corps operations of the reservoir system relative to ACF Compact water allocation discussions.
5-Sep-06	Biological opinion and conference report on U.S. Army corps of Engineers, Mobile District, interim operating plan for Jim Woodruff Dam and associated releases to the Apalachicola River
15-Nov-07`	Amended biological opinion and conference report on the U.S. Army Corps of Engineers, Mobile District, exceptional drought operations for the interim operating plan for Jim Woodruff Dam and associated releases to the Apalachicola River
21-Nov-07	Corps provides EDO 4,500 cfs trigger
7-Dec-07	Corps provides revised EDO 4,500 cfs trigger
10-Jan-08	Corps requests extension for RPM5 condition f, mussel depth distribution study plan
31-Jan-08	Corps provides 2007 Annual Report and mussel depth distribution study plan
28-Mar-08	Corps provides RPM5 condition h, mussel study plan
15-Apr-08	Corps requests reinitiation of formal consultation and submits proposed project description for RIOP
18-Apr-08	FWS letter regarding recent rapid drop in river flow
24-Apr-08	Corps response to FWS letter
30-Apr-08 to 30-May-08	Received letters from several agencies commenting on RIOP for consideration in consultation
2-May-08	Corps email summarizing status of system in Zone 4, however; decision not to implement EDO reduction in minimum releases since wet May is forecast.
May-08	Multiple emails between Corps and Service about RIOP model input data and results.
26-May-08	Corps email with RIOP model results using projected 2017 depletions.

BIOLOGICAL OPINION

This opinion supersedes the previous opinions dated September 5, 2006, and November 15, 2007, that also addressed water releases from Jim Woodruff Dam.

Tables and figures referenced in a section of this document are included at the end of the section.

1 DESCRIPTION OF PROPOSED ACTION

The action evaluated in this consultation is the Corps' RIOP for Jim Woodruff Dam, which describes releases from the dam to the Apalachicola River. The RIOP was formulated to address protection of endangered and threatened species and critical habitat in the Apalachicola River, manage reservoir storage for other project purposes, and meet drought related contingencies. The Corps described the RIOP in its letter dated April 15, 2008, to the Service, which requested the initiation of formal consultation. It is our understanding that the RIOP is effective until it is revised or until the ACF WCP is formally updated, at which time the Corps would reinitiate consultation.

The RIOP is not a new WCP for Woodruff Dam; it is a definition of ACF operations that is within the limits established by the existing ACF WCP except during defined drought conditions. Certain drought provisions of the proposed action require temporary waivers from the existing water control plan to provide for minimum releases less than 5,000 cubic feet per second (cfs) from Jim Woodruff Dam when specific triggers are met, described below in section 1.2. Waivers are also needed to allow temporary storage above the winter pool rule curve at the Walter F. George and West Point reservoirs to increase overall conservation storage capacity. This opinion considers the operations of Woodruff Dam under a full range of hydrologic conditions for the ACF system, both dry and wet.

The Corps operates five dams in the ACF River Basin: (in downstream order) Buford, West Point, Walter F. George, George W. Andrews, and Jim Woodruff (Figure 1.A). All are located wholly on the Chattahoochee River arm of the basin except the downstream-most dam, Woodruff, which is located at the confluence of the Chattahoochee and Flint rivers and marks the upstream extent of the Apalachicola River. Andrews is a lock and dam without any appreciable water storage behind it and Lake Seminole has very limited storage capacity. Both are essentially operated as run-of-river reservoirs. The impoundments of Buford, West Point, and Walter F. George dams, however, provide for combined conservation storage of approximately 1.6 million acre-feet, relative to the top of each reservoir's full summer pool and the bottom of the conservation pool, which is potentially available to support water management operations. For about half of its length, the Chattahoochee River forms the boundary between Georgia and Alabama. Lake Seminole straddles the boundary between Florida and the southwest corner of Georgia.

The Corps operates the ACF reservoirs as a system, and releases from Woodruff Dam reflect the downstream end-result of system-wide operations. The RIOP addresses specific parameters of the daily releases from Woodruff Dam into the Apalachicola River. The RIOP does not address operational specifics at the four federal reservoirs upstream of Woodruff or all aspects of the operations at Woodruff, other than to anticipate waivers from the winter pool rule curves at West Point and Walter F. George reservoirs during exceptional drought conditions. The RIOP specifies two parameters applicable to the daily releases from Woodruff: a minimum discharge in relation to average basin inflows (daily average in cubic feet per second [cfs]) and maximum fall rate (vertical drop in river stage [ft/day]). For purposes of this BO, we use data for both parameters that are collected by the USGS at gage number 02358000, "Apalachicola River at Chattahoochee, FL," which is located 0.6 mi downstream of Woodruff Dam. We refer to this flow measurement point throughout the BO simply as the "Chattahoochee gage".

The ACF basin (Figure 1.A) is experiencing the second year of severe drought conditions within the basin. The U.S. Drought Monitor (http://drought.unl.edu/dm/monitor.html) has classified significant portions of the basin as "D2 Drought – Severe" during much of the past year (USDM 2008). A recent (May 15, 2008) "U.S. Seasonal Drought Outlook" from the National Weather Service (http://www.cpc.ncep.noaa.gov/products/expert_assessment/seasonal_drought.html), shows the upstream half of the ACF Basin in a zone labeled as "Drought likely to improve, impacts ease" (NOAA 2008a). The calendar year 2007 was one of the driest on record for the climate divisions that encompass the ACF basin (see analysis in section 3.3.1). The drought provisions of the RIOP are intended to enhance the probability for the reservoirs in the basin to refill following a substantial drawdown as in 2007. The RIOP also specifies a set of operations that would apply when hydrologic conditions return to a wetter, more normal regime. Both normal and drought provisions of the RIOP are described below.

1.1 Action Area

Service regulations define "action area" as all areas affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR §402.02). Although the RIOP specifically addresses the releases from Woodruff Dam, the downstream-most project among the Corps' ACF reservoirs, these releases are accomplished through the collective operations of all of the Corps' ACF reservoirs. Therefore, the action area includes all aquatic habitats that are downstream of the Corps' upstream-most ACF project, Lake Lanier/Buford Dam, ending with and including Apalachicola Bay (Figure 1.A). However, the only aquatic listed species that is known to occur in this action area upstream of Woodruff Dam is a single purple bankclimber found in Goat Rock Reservoir in 2000 (Stringfellow 2000 pers. comm.). The proposed action is not anticipated to result in any physical changes to the environment of this individual animal. Therefore, while the action area includes all aquatic habitats that are downstream of the Corps' upstream-most ACF project, Lake Lanier/Buford Dam, ending with and including Apalachicola Bay, the effects of the action are limited to the aquatic habitats

downstream of Woodruff Dam ending with and including Apalachicola Bay. This portion of the action area, which we address in the remainder of this BO, is shown in Figure 1.1.A. Hereafter, our use of the term “action area” refers to this limited portion of the broader action area. We refer to locations in the action area by river mile (RM), which is distance from the mouth of the river as noted on USGS 7.5-minute topographic maps.

1.2 Minimum Discharge

The following description is adapted from the Corps’ description of the RIOP in the attachment to their April 15, 2008, letter that initiated formal consultation.

The proposed action varies minimum discharges from Jim Woodruff Dam by basin inflow and by month, and the releases are measured as a daily average flow in cfs at the Chattahoochee gage. Table 1.2.A shows minimum releases from Jim Woodruff Dam prescribed by the RIOP, and shows when and how much basin inflow is available for increasing reservoir storage. In two key respects, the RIOP minimum flow schedule is functionally similar to the current IOP: 1) minimum releases are not required to exceed basin inflow except when basin inflow is less than 5,000 cfs; and 2) a greater fraction of the basin inflow is available for storage at higher basin inflow rates than at lower rates. The current IOP defines three basin inflow threshold levels that vary by two seasons (spawning and non-spawning season). The RIOP proposes new basin inflow threshold levels that vary by three seasons: spawning season (March-May); non-spawning season (June-November); and winter (December-February).

The RIOP further modifies the current IOP by also incorporating composite storage thresholds that factor into minimum release decisions. Composite storage is calculated by combining the storage of Lake Lanier, West Point Lake, and Lake Walter F. George. Storage capacity within each reservoirs is comprised of four Zones, which are determined by the seasonal operational guide curves for each project. Composite Zone 1 represents the combined storage available in Zone 1 for each of the three storage reservoirs, Zone 2 represents the combined storage in Zone 2 for each project, etc. (Figure 1.2.A).

During the spawning season, the RIOP specifies two sets of four basin inflow thresholds and corresponding releases based on composite storage. When composite storage is in Zones 1 and 2, a less conservative operation is in place, i.e., less basin inflow is available for storage. When composite storage is in Zone 3, a more conservative operation is in place that allows for greater retention of basin inflow in storage. When composite storage falls below the bottom of Zone 3 into Zone 4, the drought contingency operations are “triggered.” Drought contingency operations are the most conservative operations because they allow for the greatest retention of basin inflow in reservoir storage. The drought contingency operations are described in section 1.4 below.

During the non-spawning season, one set of four basin inflow thresholds and corresponding releases exists based on composite storage in Zones 1-3. When composite

storage falls below the bottom of Zone 3 into Zone 4 the drought contingency operations are "triggered."

During the winter season, there is only one basin inflow threshold and one corresponding minimum release (5,000 cfs) while in composite storage Zones 1-3. Retention of basin inflow in storage is not limited provided the minimum release is not less than 5,000 cfs. When composite storage falls below the bottom of Zone 3 into Zone 4 the drought contingency operations are "triggered."

The current IOP includes a higher minimum flow provision, which was developed in response to RPM3 of the BO for the IOP, that identifies conditions for maintaining a desired minimum flow of 6,500 cfs, and a "trigger" for shifting to the WCP-required minimum flow of 5,000 cfs. The RIOP does not include this higher minimum flow provision,. The Corps states in its description of the RIOP that, by incorporating composite storage thresholds and additional basin inflow thresholds for the spawning and non-spawning seasons, they believe the RIOP fulfills the intent of "desired" flow provision of the IOP.

Like the current IOP, the flow rates listed in Table 1.2.A prescribe minimum, and not target, releases for Jim Woodruff Dam. During a given month and basin inflow rate, releases greater than the Table 1.2.A minimum releases may occur consistent with the maximum fall rate schedule, described below, or as needed to achieve other project purposes, such as hydropower or flood control.

1.3 Maximum Fall Rate

The following description is adapted from the Corps' description of the RIOP in the attachment to their April 15, 2008, letter that initiated formal consultation.

The RIOP prescribes maximum fall rates for the releases from Woodruff Dam (Table 1.3.A). Fall rate, also called down-ramping rate, is the vertical drop in river stage (water surface elevation) that occurs over a given period. RIOP fall rates are expressed in units of feet per day (ft/day), and are measured at the Chattahoochee gage as the difference between the daily average river stage of consecutive calendar days. Rise rates (*e.g.,* today's average river stage is higher than yesterday's) are not addressed. The RIOP does not change the maximum fall rate schedule (Table 1.3.A) prescribed by the current IOP other than to suspend it when composite storage is in Zone 4, at which time the drought contingency operation described below is implemented.

Unless otherwise noted, fall rates under the drought contingency operation would be managed to match the fall rate of the 1-day basin inflow (as opposed to the 7-day average basin inflow that is used for minimum release decisions). This provision of the RIOP, which is also effective under the current IOP/EDO, was clarified by letter from the Corps dated April 24, 2008, in response to an inquiry from the Service dated April 18, 2008, about unusually rapid fall rates observed in earlier in the month. Also, the RIOP does not change the use of volumetric balancing as described in the May 16, 2007, letter to the

USFWS. Volumetric balancing is intended to prevent a substantial drawdown of storage due to gradual down ramping while following declining basin inflow.

1.4 Drought Contingency Operations

The following description is adapted from the Corps' description of the RIOP in the attachment to their April 15, 2008, letter that initiated formal consultation.

The RIOP includes a drought plan that is similar to the current EDO. The RIOP drought plan is "triggered" when composite storage falls below the bottom of Zone 3 into Zone 4. At that time, all provisions applicable when composite storage is within Zones 1-3 (seasonal storage limitations, maximum fall rate schedule, minimum flow thresholds, and volumetric balancing accounting) are suspended. The drought plan includes a temporary waiver from the existing WCP to allow storage above the winter pool rule curve at the Walter F. George and West Point projects if the opportunity presents itself. This waiver would also allow the Corps to begin spring refill operations at an earlier date in order to provide additional conservation storage for future needs, including support of minimum releases from Woodruff Dam.

The minimum releases from Woodruff Dam under the drought plan are keyed to the level of composite storage within Zone 4, which is seasonally divided into an upper and a lower portion (Figure 1.2.A). The lower portion is referred to as the Drought Zone. The Drought Zone delineates a volume of water roughly equivalent to the inactive storage in lakes Lanier, West Point and Walter F. George plus the Zone 4 storage in Lake Lanier, but is adjusted to include a smaller volume of water than this at the beginning and end of the calendar year. When composite storage is within the upper portion of Zone 4 (above the Drought Zone), the minimum release from Woodruff Dam is 5,000 cfs, and the Corps may store all available basin inflow in excess of 5,000 cfs. When composite storage is within the Drought Zone, the minimum release from Woodruff Dam is 4,500 cfs, and the Corps may store all available basin inflow in excess of 4,500 cfs. When transitioning from a minimum release of 5,000 to 4,500 cfs, the Corps will limit fall rates to 0.25 ft/day. The 4,500 cfs minimum release is maintained until composite storage returns to a level above the top of the Drought Zone, at which time the 5,000 cfs minimum release is re-instated.

The drought plan is effective until composite storage returns to a level above the top of Zone 3 (i.e., within Zone 2). At that time, the temporary drought plan provisions are suspended, and all other provisions of the RIOP are re-instated.

During drought contingency operations, the Corps will assess the status of water management operations relative to the triggers on the first day of each month, also considering other relevant data and forecasts. This assessment will determine the set of operations that apply to the upcoming month.

1.5 Conservation Measures

Conservation measures are actions that benefit or promote the recovery of a listed species that a Federal agency includes as an integral part of its proposed action and that are intended to minimize or compensate for potential adverse effects of the action on the listed species. The RIOP was formulated in large part to avoid and minimize impacts to listed species while achieving other authorized project purposes. Minimum flow and maximum fall rates are set based upon the current basin inflow in a way that limits most project-induced alterations of the flow regime to higher flow rates. At lower flow rates in the months of March through November and when composite storage is in Zone 3 or higher, the Corps releases a minimum of not less than basin inflow (Table 1.2.A) and limits the rate of river stage decline (Table 1.3.A). When basin inflow is less than 5,000 cfs, which did not occur in the pre-Lanier average daily flow record of the Chattahoochee gage (1929 through 1955), the Corps augments basin inflow, which offsets to some degree the impact of the evaporative losses, non-project related consumptive water uses, and drought conditions more severe than previously observed in the Basin.

1.6 Tables and Figures for Section 1

Table 1.2.A. Proposed Action Revised IOP Releases From Jim Woodruff Dam.

Months	Composite Storage Zone	Basin Inflow (BI) (cfs)	Releases from JWLD (cfs)	Basin Inflow Available for Storage[1]
March - May	Zones 1 and 2	>= 34,000	>= 25,000	Up to 100% BI > 25,000
		>= 16,000 and < 34,000	>= 16,000 + 50% BI > 16,000	Up to 50% BI > 16,000
		>= 5,000 and < 16,000	>= BI	
		< 5,000	>= 5,000	
	Zone 3	>= 39,000	>= 25,000	Up to 100% BI > 25,000
		>= 11,000 and < 39,000	>= 11,000 + 50% BI > 11,000	Up to 50% BI > 11,000
		>= 5,000 and < 11,000	>= BI	
		< 5,000	>= 5,000	
June - November	Zones 1,2, and 3	>= 24,000	>= 16,000	Up to 100% BI > 16,000
		>= 8,000 and < 24,000	>= 8,000 + 50% BI > 8,000	Up to 50% BI > 8,000
		>= 5,000 and < 8,000	>= BI	
		< 5,000	>= 5,000	
December - February	Zones 1,2, and 3	>= 5,000	>= 5,000 (Store all BI > 5,000)	Up to 100% BI > 5,000
		< 5,000	>= 5,000	
At all times	Zone 4	NA	>= 5,000	Up to 100% BI > 5,000
At all times	Drought Zone	NA	>= 4,500[2]	Up to 100% BI > 4,500

[1] Consistent with safety requirements, flood control purposes, and equipment capabilities.
[2] Once composite storage falls below the top of the Drought Zone ramp down to 4,500 cfs will occur at a rate of 0.25 ft/day drop.

Table 1.3.A. Proposed Action Revised IOP Maximum Fall Rate Schedule Composite Storage Zones 1,2, and 3*.

Release Range (cfs)	Maximum Fall Rate (ft/day)
≥ 30,000**	Fall rate is not limited***
≥ 20,000 and < 30,000*	1.0 to 2.0
Exceeds powerhouse capacity (~16,000) and < 20,000*	0.5 to 1.0
Within powerhouse capacity and > 8,000*	0.25 to 0.5
Within powerhouse capacity and ≤ 8,000*	0.25 or less

* Maximum fall rate schedule is suspended in Composite Zone 4.

** Consistent with safety requirements, flood control purposes, and equipment capabilities.

***For flows greater than 30,000 cfs, it is not reasonable and prudent to attempt to control down ramping rate, and no ramping rate is required.

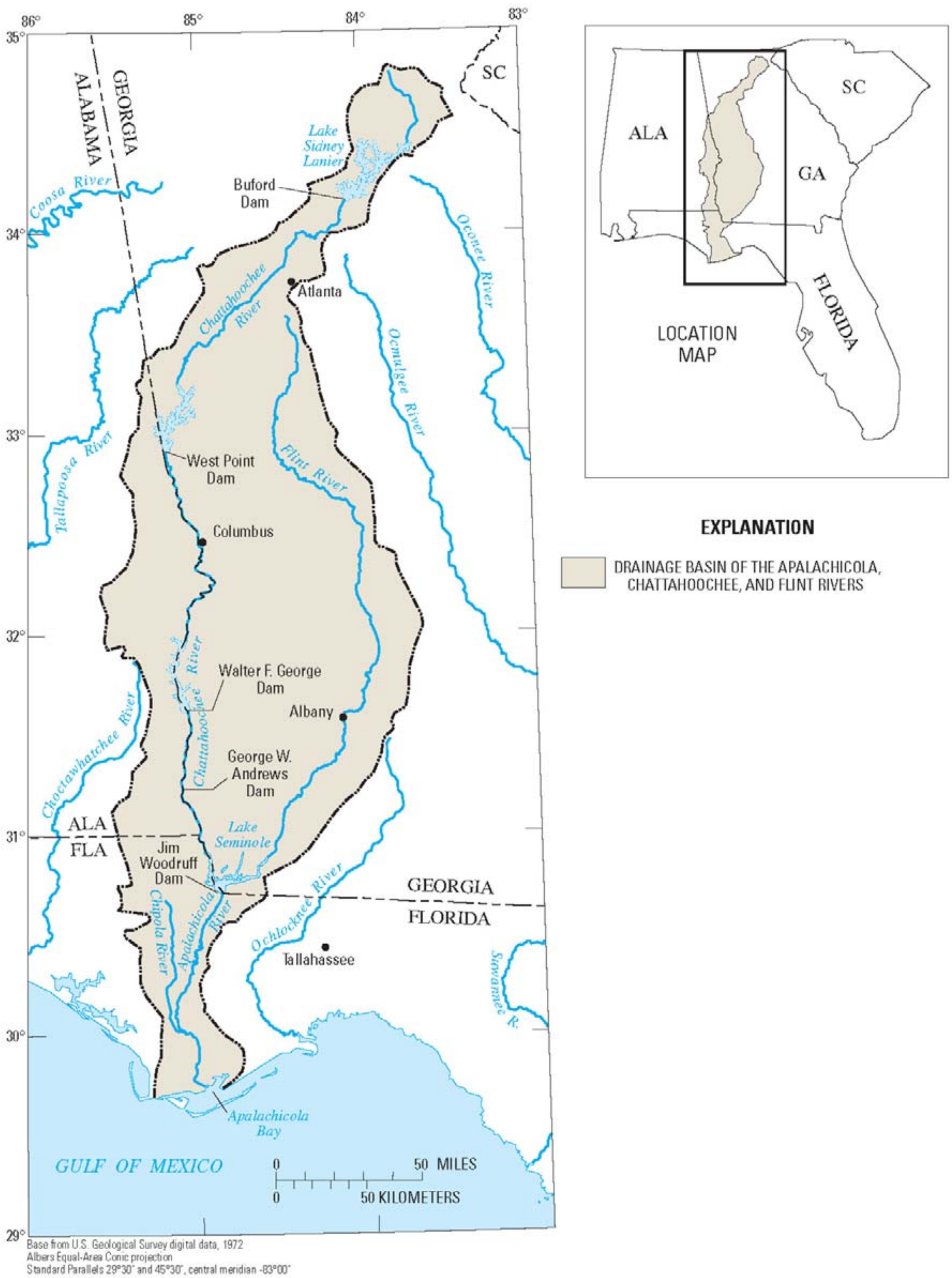

Figure 1.A. Map of the ACF Basin showing location of the Corps' dams (source: Light et al. 2006).

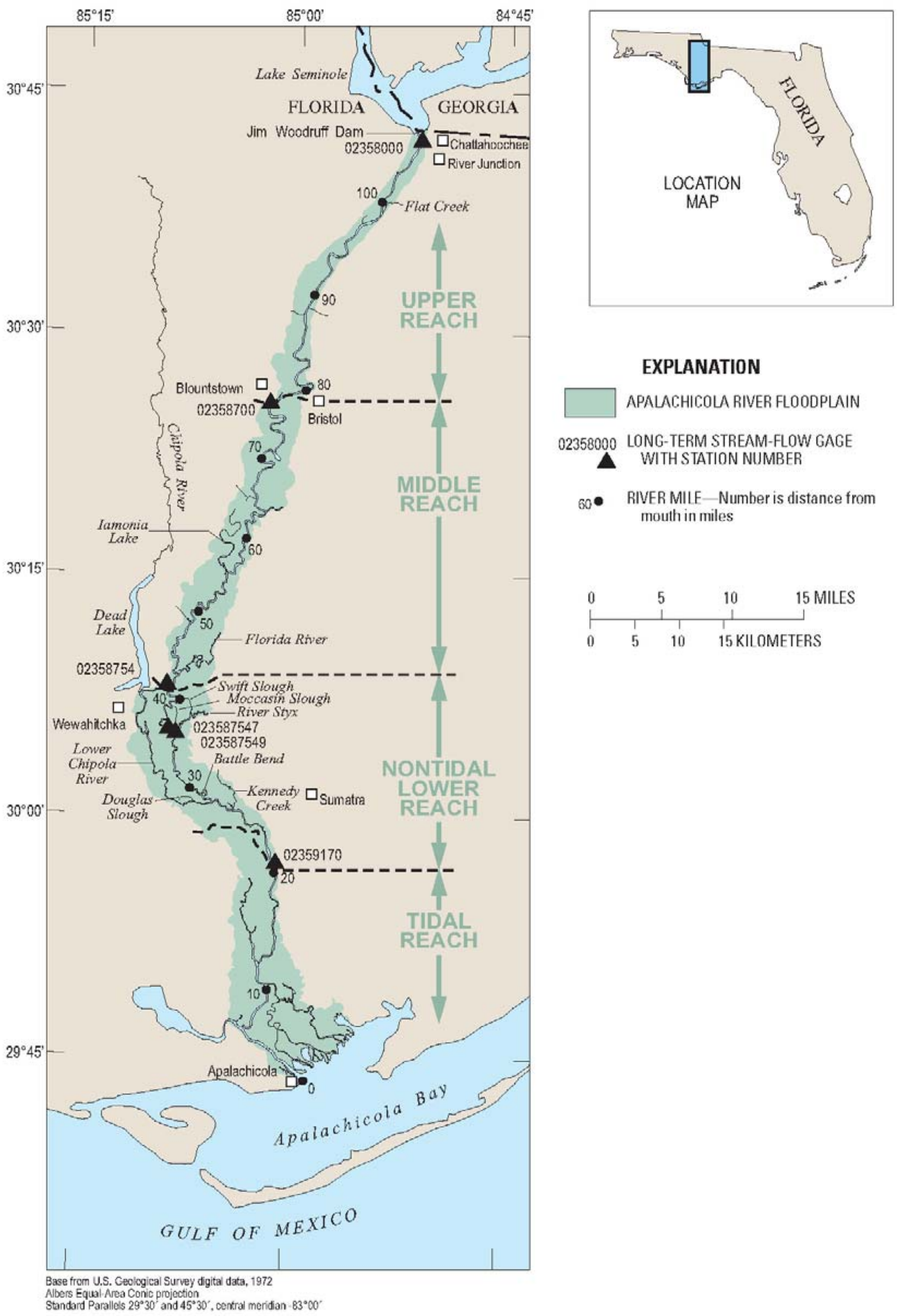

Figure 1.1.A. Map showing the Apalachicola River and Bay portion of action area (source: Light et al. 2006).

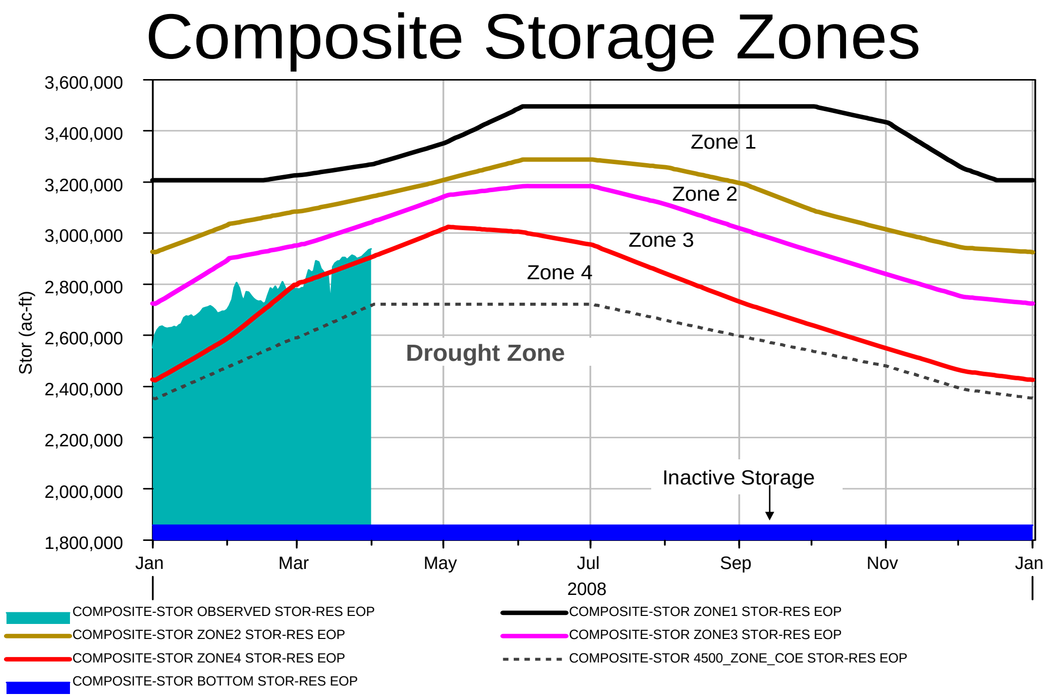

Figure 1.2.A. Composite storage zones in lakes Lanier, West Point and Walter F. George. The green shaded area depicts January 1 through March 31, 2008, observed values of composite storage, which were in Zone 3 for most of this period.

2 STATUS OF THE SPECIES/CRITICAL HABITAT

2.1 Gulf Sturgeon

2.1.1 Species Description

The Gulf sturgeon (*Acipenser oxyrinchus* (=*oxyrhynchus*) *desotoi*), also known as the Gulf of Mexico sturgeon, is an anadromous fish (breeding in freshwater after migrating up rivers from marine and estuarine environments), inhabiting coastal rivers from Louisiana to Florida during the warmer months and over wintering in estuaries, bays, and the Gulf of Mexico. It is a nearly cylindrical primitive fish embedded with bony plates or scutes. The head ends in a hard, extended snout; the mouth is inferior and protrusible and is preceded by four conspicuous barbels. The caudal fin (tail) is heterocercal (upper lobe is longer than the lower lobe). Adults range from 1.2 to 2.4 m (4 to 8 ft) in length, with adult females larger than males. The Gulf sturgeon is distinguished from the geographically disjunct Atlantic coast subspecies (*A. o. oxyrinchus*) by its longer head, pectoral fins, and spleen (Vladykov 1955; Wooley 1985). King et al. (2001) have documented substantial divergence between *A. o. oxyrinchus* and *A. o. desotoi* using microsatellite DNA testing.

2.1.2 Critical Habitat Description

The Service and NOAA Fisheries jointly designated Gulf sturgeon critical habitat on April 18, 2003 (68 FR 13370, March 19, 2003). Gulf sturgeon critical habitat includes areas within the major river systems that support the seven currently reproducing subpopulations and associated estuarine and marine habitats. Gulf sturgeon use rivers for spawning, larval and juvenile feeding, adult resting and staging, and moving between the areas that support these life history components. Gulf sturgeon use the lower riverine, estuarine, and marine environment during winter months primarily for feeding and, more rarely, for inter-river movements.

Fourteen areas (units) are designated as Gulf sturgeon critical habitat (Figure 2.1.2.A). Critical habitat units encompass approximately 2,783 km (1,729 mi) of riverine habitats and 6,042 km^2 (2,333 mi^2) of estuarine and marine habitats, and include portions of the following Gulf of Mexico rivers, tributaries, estuarine and marine areas:

Unit 1	Pearl and Bogue Chitto Rivers in Louisiana and Mississippi;
Unit 2	Pascagoula, Leaf, Bowie, Big Black Creek and Chickasawhay Rivers in Mississippi;
Unit 3	Escambia, Conecuh, and Sepulga Rivers in Alabama and Florida;
Unit 4	Yellow, Blackwater, and Shoal Rivers in Alabama and Florida;
Unit 5	Choctawhatchee and Pea Rivers in Florida and Alabama;
Unit 6	Apalachicola and Brothers Rivers in Florida;
Unit 7	Suwannee and Withlacoochee River in Florida;
Unit 8	Lake Pontchartrain (east of causeway), Lake Catherine, Little Lake, the Rigolets, Lake Borgne, Pascagoula Bay and Mississippi Sound systems in Louisiana and Mississippi, and sections of the state waters within the Gulf of Mexico;
Unit 9	Pensacola Bay system in Florida;

Unit 10 Santa Rosa Sound in Florida;
Unit 11 Nearshore Gulf of Mexico in Florida;
Unit 12 Choctawhatchee Bay system in Florida;
Unit 13 Apalachicola Bay system in Florida; and
Unit 14 Suwannee Sound in Florida.

Critical habitat determinations focus on those physical and biological features (primary constituent elements [PCEs]) that are essential to the conservation of the species (50 CFR 424.12). Federal agencies must insure that their activities are not likely to result in the destruction or adverse modification of designated critical habitats. Therefore, proposed actions that may affect designated critical habitat require an analysis of potential impacts to the PCEs. The PCEs of Gulf sturgeon critical habitat are:

- Abundant food items, such as detritus, aquatic insects, worms, and/or mollusks, within riverine habitats for larval and juvenile life stages; and abundant prey items, such as amphipods, lancelets, polychaetes, gastropods, ghost shrimp, isopods, mollusks and/or crustaceans, within estuarine and marine habitats and substrates for subadult and adult life stages;
- Riverine spawning sites with substrates suitable for egg deposition and development, such as limestone outcrops and cut limestone banks, bedrock, large gravel or cobble beds, marl, soapstone, or hard clay;
- Riverine aggregation areas, also referred to as resting, holding, and staging areas, used by adult, subadult, and/or juveniles, generally, but not always, located in holes below normal riverbed depths, believed necessary for minimizing energy expenditures during freshwater residency and possibly for osmoregulatory functions;
- A flow regime (*i.e.,* the magnitude, frequency, duration, seasonality, and rate-of-change of freshwater discharge over time) necessary for normal behavior, growth, and survival of all life stages in the riverine environment, including migration, breeding site selection, courtship, egg fertilization, resting, and staging, and for maintaining spawning sites in suitable condition for egg attachment, egg sheltering, resting, and larval staging;
- Water quality, including temperature, salinity, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;
- Sediment quality, including texture and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages; and
- Safe and unobstructed migratory pathways necessary for passage within and between riverine, estuarine, and marine habitats (*e.g.*, an unobstructed river or a dammed river that still allows for passage).

2.1.3 Life History

In a report on the early life history of the Gulf sturgeon in the Suwannee River, Sulak et al. (2004) described the evolution and life history of sturgeons generally, which we quote below as a preface to our description of the Gulf sturgeon's unique biology.

> "Sturgeons and their fossil relatives comprise a distinct lineage of fishes that originated in the late Paleozoic Era over 300 million years ago. Modern sturgeons evolved as specialized large benthic suction feeders during the age of the dinosaurs about 100 million years ago. Body form, exquisitely adapted for hydrodynamic benthic position holding and bottom feeding in large, swift rivers, has remained virtually unchanged. Advanced adaptations for bottom feeding on tiny arthropod prey include the evolutionary loss of teeth, the development of a highly protrusile tubular mouth, and the elaboration of a long sensory snout provided with multiple senses (touch, taste and electroreception). Rapid growth to large size together with an armored body confer a anti-predator advantage enabling sturgeons to exist on open sand substrate, a biotope exploited by few other fish species. The world's 25 species of sturgeons, together with two paddlefishes, are the only living representatives of the unique chondrostean lineage. All other chondrostean fishes (bony fishes with flexible, de-ossified skeletons) have become extinct. In this respect, sturgeons are sometimes considered "living fossils". However, in evolving a lifestyle that has enabled them to thrive for 100,000 millennia, they should more appropriately be viewed as one of the most progressive and successful of living fish lineages. Although they retain a primitive body plan (heterocercal tail, pelvic fins set far back, pectoral fins nearly immobile and set low, spiral valve intestine), they are perhaps the earliest group of fishes to evolve protrusile jaws, a distinguishing hallmark of all advanced groups of fishes."

Sturgeons were originally freshwater species, and some, including the Gulf sturgeon, evolved an anadromous life history, probably to exploit the richer benthic food resources of estuarine and marine habitats as adults, but still required freshwater for reproduction and early life stages. Among the world's 25 sturgeon species, the Gulf sturgeon has the southern-most distribution, and has a unique life history as the only anadromous sturgeon that displays an extended period of fresh-water residency following spawning during which it does not feed.

2.1.3.1 Feeding Habits

The Gulf sturgeon is a benthic (bottom dwelling) suction feeder. Its hydrodynamic body form is adapted for holding position on the bottom where it feeds mostly upon small invertebrates in the substrate using its highly protrusible tubular mouth. The type of invertebrates ingested vary by habitat, which ranges from riverine to estuarine to marine waters of the Gulf, but are mostly soft-bodied animals that occur in sandy substrates.

Young-of-the-year (YOY) Gulf sturgeon remain in freshwater feeding on aquatic invertebrates, mostly insect larvae, and detritus approximately 10 to 12 months after spawning occurs (Mason and Clugston 1993; Sulak and Clugston 1999). Juveniles (less than 5 kg (11 lbs), ages 1 to 6 years) are believed to forage extensively and exploit scarce food resources throughout the river, including aquatic insects (*e.g.*, mayflies and caddisflies), worms (oligochaetes), and bivalve mollusks (Huff 1975; Mason and Clugston 1993). Juvenile sturgeon collected in the Suwannee River are trophically active (foraging) near the river mouth at the estuary, but trophically dormant (not foraging) in summer holding areas upriver; however, a portion of the juvenile population reside and feed year round near the river mouth (Sulak 2002 pers. comm.). In the Choctawhatchee River, juvenile Gulf sturgeon did not remain near the estuary at the river mouth

for the entire year; instead, they were located during winter months in Choctawhatchee Bay and moved to riverine aggregation areas in the spring (Parauka 2002 pers. comm.). Subadult (age six to sexual maturity) and adult (sexually mature) Gulf sturgeon do not feed in freshwater (Wooley and Crateau 1985; Mason and Clugston 1993).

Many reports indicate that adult and subadult Gulf sturgeon lose a substantial percentage of their body weight while in freshwater (Wooley and Crateau 1985; Mason and Clugston 1993; Clugston et al. 1995) and then compensate the loss during winter-feeding in the estuarine and marine environments (Wooley and Crateau 1985; Clugston et al. 1995). Gu et al. (2001) tested the hypothesis that subadult and adult Gulf sturgeon do not feed significantly during their annual residence in freshwater by comparing stable carbon isotope ratios of tissue samples from subadult and adult Suwannee River Gulf sturgeon with their potential freshwater and marine food sources. A large difference in isotope ratios between freshwater food sources and fish muscle tissue suggests that subadult and adult Gulf sturgeon do not feed significantly in freshwater. The isotope similarity between Gulf sturgeon and marine food resources strongly indicates that this species relies almost entirely on the marine food web for its growth (Gu et al. 2001).

Having spent at least 6 months in the river fasting, we presume that adult and subadult sturgeon begin feeding immediately upon leaving the river of summer residency. If so, the lakes and bays at the mouths of the river systems where Gulf sturgeon occur are especially important because they offer the first opportunity for feeding. To regain the weight they lose while in the river system and to maintain positive growth on a yearly basis, adults and subadults need to consume sufficient quantities of prey while in estuarine and marine waters. Reproductively active Gulf sturgeon require yet additional food resources (Fox et al. 2002; Murie and Parkyn 2002 pers. comm.).

Adult and subadult Gulf sturgeon, while in marine and estuarine habitat, are thought to forage opportunistically (Huff 1975), primarily on benthic invertebrates. Gut content analyses have indicated that the Gulf sturgeon's diet is predominantly amphipods, lancelets, polychaetes, gastropod mollusks, shrimp, isopods, bivalve mollusks, and crustaceans (Huff 1975; Mason and Clugston 1993; Carr et al. 1996; Fox et al. 2000; Fox et al. 2002). Ghost shrimp (*Lepidophthalmus louisianensis*) and haustoriid amphipods (*e.g.*, *Lepidactylus* spp.) are strongly suspected to be important prey for adult Gulf sturgeon over 1 m (3.3 ft) (Heard et al. 2000; Fox et al. 2002). Harris et al. (2005) reported that the Gulf sturgeon's major prey resources in the Suwannee River, Florida consisted of brachiopods, amphipods, and brittle stars. They found that distribution of Gulf sturgeon in the spring and fall appear to be associated with sandy areas on which brachiopods settle.

2.1.3.2 Reproduction

Gulf sturgeon are long-lived, with some individuals reaching at least 42 years in age (Huff 1975). Age at sexual maturity for females ranges from eight to 17 years, and for males from seven to 21 years (Huff 1975). Adult Gulf sturgeon spawn in the upper reaches of rivers, at least 100 km (62 miles) upstream of the river mouth Sulak et al. (2004), during the spring when water temperature rises to between about 17-25 °C. Gulf sturgeon eggs are demersal (they are heavy

and sink to the bottom), adhesive, and vary in color from gray to brown to black (Vladykov and Greeley 1963; Huff 1975; Parauka et al. 1991). Chapman et al. (1993) estimated that mature female Gulf sturgeon weighing between 29 and 51 kg (64 and 112 lb) produce an average of 400,000 eggs. Eggs require at least 2 to 4 days to hatch. Hatching time for artificially spawned Gulf sturgeon eggs ranged from about 86 hours at 18.4°C to about 54 hours at about 23.0°C (Parauka et al. 1991). Chapman et al. (1993) reported that artificially spawned Gulf sturgeon eggs incubated at 20°C hatched in 3.5 days.

Habitat at egg collection sites consists of one or more of the following: limestone bluffs and outcroppings, cobble, limestone bedrock covered with gravel and small cobble, gravel, and sand (Marchant and Shutters 1996; Sulak and Clugston 1999; Heise et al. 1999a; Fox et al. 2000; Craft et al. 2001; USFWS unpub. data 2005; Pine et al. 2006). On the Suwannee River, Sulak and Clugston (1999) suggest a dense matrix of gravel or cobble is likely essential for Gulf sturgeon egg adhesion and the sheltering of the yolk sac larvae, and is a habitat spawning adults apparently select. Other substrates identified as possible spawning habitat include marl (clay with substantial calcium carbonate), soapstone, or hard clay (Slack 2002 pers. comm.; Parauka 2002 pers. comm.). Water depths at egg collection sites ranged from 1.4 to 7.9 m (4.6 to 26 ft), with temperatures ranging from 18.2 to 25.3 degrees Celsius (^{o}C) (64.8 to 75.0 degrees Fahrenheit (^{o}F)) (Fox et al. 2000; Ross et al. 2000; Craft et al. 2001; USFWS unpub. data 2005; Pine et al. 2006).

Laboratory experiments indicated optimal water temperature for survival of Gulf sturgeon larvae is between 15 and 20^{o}C (59 and 68^{o}F), with low tolerance to temperatures above 25^{o}C (77^{o}F) (Chapman and Carr 1995). Sulak and Clugston (1999) suggested that sturgeon spawning activity in the Suwannee River is related to the phase of the moon, but only after the water temperature has risen to 17^{o}C (62.6^{o}F). Other researchers however, have found little evidence of spawning associated with lunar cycles (Slack et al. 1999; Fox et al. 2000). Spawning in the Suwannee River occurs during the general period of spring high water, when ionic conductivity and calcium ion concentration are most favorable for egg development and adhesion (Sulak and Clugston 1999). Fox et al. (2002) found no clear pattern between timing of Gulf sturgeon entering the river and flow patterns on the Choctawhatchee River. Ross et al. (2001b) surmised that high flows in early March were a cue for sturgeon to begin their upstream movement in the Pascagoula River.

Atlantic sturgeon (*A. oxyrinchus oxyrinchus*) exhibit a long inter-spawning period, with females spawning at intervals ranging from every 3 to 5 years, and males every 1 to 5 years (Smith 1985). Researchers believe that Gulf sturgeon exhibit similar spawning periodicity, with male Gulf sturgeon capable of annual spawning, but females requiring more than one year between spawning events (Huff 1975; Fox et al. 2000).

The age structure evident from mark/recapture studies of the Apalachicola sturgeon population suggests variable recruitment over time (Pine and Allen 2005), but the factors influencing this variability have not yet been investigated. Randall and Sulak (2007) examined variable recruitment in the Suwannee and suggested that it may be due to flow in fall and amount of estuarine habitat of moderate salinity.

2.1.3.3 Freshwater Habitat

During early life history stages, sturgeon require bedrock and clean gravel or cobble as a substrate for egg adhesion and a shelter for developing larvae (Sulak and Clugston 1999). In the Suwannee river, YOY disperse widely downstream of spawning sites, using extensive portions of the river as nursery habitat. They are typically found in open sand-bottom habitat away from the shoreline and vegetated habitat. The wide dispersal of YOY fish in the river may be an adaptation to exploit scarce food resources in these sandy habitat types (Randall and Sulak 1999). Clugston et al. (1995) reported that young Gulf sturgeon in the Suwannee River, weighing between 0.3 and 2.4 kg (0.7 and 5.3 lb), remained in the vicinity of the river mouth and estuary during the winter and spring. Sulak et al. (2004) noted that the apparent preference of juvenile sturgeon for sandy main channel habitats enable sturgeon to exploit a unique niche with little competition.

In the Pascagoula River and Apalachicola River, some adult and subadult Gulf sturgeon remain near the spawning grounds throughout the summer months (Wooley and Crateau 1985; Ross et al. 2001b), but the majority move downstream to areas referred to as summer resting or holding areas. In these two systems, however, confirmed spawning habitats are located within a relatively short distance downstream of impediments to further upstream migration. In other rivers, most Gulf sturgeon spawn and move downstream to summer resting or holding areas. A few Gulf sturgeon have been documented remaining at or near their spawning grounds throughout the winter (Wooley and Crateau 1985; Slack et al. 1999; Heise et al. 1999a). Adults and subadults are not distributed uniformly throughout the river, but show a preference for these discrete areas usually located in lower and middle river reaches (Hightower et al. 2002). Often, these resting areas are located near natural springs throughout the warmest months of the year, but are not located within a spring or thermal plume emanating from a spring (Clugston et al. 1995; Foster and Clugston 1997; Hightower et al. 2002). These resting areas are often located in deep holes, and sometimes shallow areas, along straight-aways ranging from 2 to 19 m (6.6 to 62.3 ft) deep (Wooley and Crateau 1985; Morrow et al. 1998; Ross et al. 2001a, b; Craft et al. 2001; Hightower et al. 2002). The substrates consisted of mixtures of limestone and sand (Clugston et al. 1995), sand and gravel (Wooley and Crateau 1985; Morrow et al. 1998), or just sandy substrate (Hightower et al. 2002).

River flow may serve as an environmental cue that governs both sturgeon migration and spawning (Chapman and Carr 1995; Ross et al. 2001b). If the flow rate is too high, sturgeon in several life-history stages can be adversely affected. Data describing the sturgeon's swimming ability in the Suwannee River strongly indicates that they cannot continually swim against prevailing currents of greater than 1 to 2 m per second (3.2 to 6.6 ft per second) (K. Sulak, USGS, pers. comm. cited in Wakeford 2001). If the flow is too strong, eggs might not be able to settle on and adhere to suitable substrate (Wooley and Crateau 1985). Flows that are too low can cause clumping of eggs, which leads to increased mortality from asphyxiation and fungal infection (Wooley and Crateau 1985). Flow velocity requirements for YOY sturgeon may vary depending on substrate type. Chan et al. (1997) found that YOY Gulf sturgeon under laboratory conditions exposed to water velocities over 12 cm/s (0.4 ft/s) preferred a cobble substrate, but favored water velocities under 12 cm/s (0.4 ft/s), and then used a variety of substrates (sand, gravel, and cobble).

Gulf sturgeon require large areas of diverse habitat that have natural variations in water flow, velocity, temperature, and turbidity (USFWS and GSMFC 1995; Wakeford 2001). Laboratory experiments indicate that Gulf sturgeon eggs, embryos, and larvae have the highest survival rates when temperatures are between 15 and 20^{o}C (59 and 68^{o}F). Mortality rates of Gulf sturgeon gametes and embryos are highest when temperatures are 25^{o}C (77^{o}F) and above (Chapman and Carr 1995) (see section 2.1.3.2 for more details). Researchers have documented temperature ranges at Gulf sturgeon resting areas between 15.3 and 33.7^{o}C (59.5 and 92.7^{o}F) with dissolved oxygen levels between 5.6 and 9.1 milligrams per liter (mg/l) (Morrow et al. 1998; Hightower et al. 2002). Compared to other fish species, sturgeon have a limited behavioral and physiological capacity to respond to hypoxia (insufficient oxygen levels) (Secor and Niklitschek 2001). Basal metabolism, growth, consumption, and survival are sensitive to changes in oxygen levels (Secor and Niklitschek 2001). In laboratory experiments, young shortnose sturgeon (*A. brevirostrum*) (less than 77 days old) died at oxygen levels of 3.0 mg/l and all sturgeon died at oxygen levels of 2.0 mg/l (Jenkins et al. 1993). Data concerning the temperature, oxygen, and current velocity requirements of cultured sturgeon are being collected. Researchers plan to use information gained from these laboratory experiments on hatchery-reared sturgeon to develop detailed information on water flow requirements of wild sturgeon throughout different phases of their freshwater residence (Wakeford 2001).

2.1.3.4 Estuarine and Marine Habitat

Most subadult and adult Gulf sturgeon spend cool months (October or November through March or April) in estuarine areas, bays, or in the Gulf of Mexico (Odenkirk 1989; Foster 1993; Clugston et al. 1995; Fox et al. 2002). Studies of subadult Gulf sturgeon (ages 4 to 7) in Choctawhatchee Bay found that 78% of tagged fish remained in the bay the entire winter, while 13% ventured into a connecting bay. Possibly the remaining 9% overwintered in the Gulf of Mexico (USFWS 1998c). Adult Gulf sturgeon are more likely to overwinter in the Gulf of Mexico, with 45% of the tagged adults presumed to have left Choctawhatchee Bay and spent extended periods of time in the Gulf of Mexico (Fox and Hightower 1998; Fox et al. 2002). In contrast, Gulf sturgeon from the Suwannee River subpopulation are known to migrate into the nearshore waters, where they remain for up to two months and then depart to unknown feeding locations in the open Gulf of Mexico (Carr et al. 1996; Edwards et al. 2003).

There has been one report of adult sturgeon overwintering in freshwater in the Apalachicola River; however, we believe this resulted from shed tags, not actual overwintering in freshwater. Wooley and Crateau (1985) reported that two Gulf sturgeon equipped with external radio transmitters in May 1983, overwintered at the capture site below Jim Woodruff Lock and Dam. Both fish remained in the collection area during the entire monitoring period. In a recent conversation, Wooley indicated that the external transmitters may have been shed, which would account for the fish exhibiting no movement during the monitoring period (Parauka 2008 pers. comm.). Therefore, it is likely these fish did not overwinter in freshwater. Hightower et al. (2002) reported that of 29 Gulf sturgeon equipped with 2 year external transmitters in the Choctawhatchee River, only 5 provided useful information, and 8 tags were located in the river in the same positions throughout the second field season, indicating that either the tag had been shed or that the fish had died. Furthermore, Hightower et al. (2002) suggests that tag shedding may limit the long-term effectiveness of externally-attached transmitters on Gulf sturgeon. The

FWS has equipped 103 Gulf sturgeon with telemetry tags in the Apalachicola River since 1989 and have not found any sturgeon overwintering in freshwater below Jim Woodruff Lock and Dam (Parauka 2008 pers. comm.).

Research in Choctawhatchee Bay indicates that subadult Gulf sturgeon show a preference for sandy shoreline habitats with water depths less than 3.5 m (11.5 ft) and salinity less than 6.3 parts per thousand (Parauka et al. 2001). Fox and Hightower (1998) found that adult Gulf sturgeon monitored in Choctawhatchee Bay use some of the same habitats as subadults. The majority of tagged fish have been located in areas lacking seagrass (Fox et al. 2002; Parauka et al. 2001). Gulf sturgeon in the Suwannee River estuary were associated with areas composed of mostly sand containing high abundances of known benthic prey (Harris et al. 2005). Craft et al. (2001) found that Gulf sturgeon in Pensacola Bay appear to prefer shallow shoals 1.5 to 2.1 m (5 to 7 ft) and deep holes near passes. Estuary and bay unvegetated habitats with sandy substrate support a variety of burrowing crustaceans, such as ghost shrimp and small crabs, amphipods, polychaete worms, and small bivalve mollusks (Menzel 1971; Abele and Kim 1986; Williams et al. 1989). Gulf sturgeon are often located in these areas, and because their known prey items are present, it is assumed that Gulf sturgeon are foraging.

Telemetered Gulf sturgeon tracked in Mississippi Sound were frequently located over sandy substrates at the passes between barrier islands (Ross et al. 2001a). Bottom samples at these sites all contained lancelets (*Branchiostoma*), a documented prey item of Gulf sturgeon. Nearshore areas of the Gulf of Mexico (less than 1.6 km [1 mi] from land) with unconsolidated, fine-to-medium-grain sand substrates, typically support crustaceans such as mole crabs, sand fleas, various amphipod species, and lancelets (Menzel 1971; Abele and Kim 1986; Williams et al. 1989), all of which are sturgeon prey items.

Sulak and Clugston (1999) describe two hypotheses regarding adult Gulf sturgeon winter habitat: 1) Nearshore -- adults move along the coast in waters less than 10 m (33 ft) deep; and 2) Offshore -- adults migrate far offshore to the broad sedimentary plateau in deep water (40 to 100 m [131 to 328 ft]) west of the Florida Middle Grounds, where over twenty species of bottom-feeding fish congregate in the winter (Darnell and Kleypas 1987). Telemetry data collected to date support the first hypothesis. Gulf sturgeon from the Pearl River and Pascagoula River subpopulations migrate from their natal river systems to Mississippi Sound and move along the barrier islands, where they are relocated most often at the passes between islands (Ross et al. 2001a; Rogillio et al. 2002). Gulf sturgeon from the Choctawhatchee River, Yellow River, and Apalachicola River have been documented migrating in the nearshore Gulf of Mexico waters between Pensacola and Apalachicola Bays (Fox et al. 2002; Parauka 2002 pers. comm.). Telemetered fish are usually located in areas less than 6 m (19.8 ft) deep (Ross et al. 2001a; Fox et al. 2002; Rogillio et al. 2002; Parauka 2002 pers. comm.).

2.1.3.5 Migration

In the spring (March to May), most adult and subadult Gulf sturgeon return to their natal river, where sexually mature sturgeon spawn, and then stay until October or November (6 to 8 months) in freshwater (Odenkirk 1989; Foster 1993; Clugston et al. 1995; Fox et al. 2000). Fox et al.

(2000) found that some individuals of the Choctawhatchee River subpopulation do not enter the river until the summer months.

Migratory behavior of the Gulf sturgeon seems influenced by sex, reproductive status, water temperature, and possibly river flow. Carr et al. (1996) reported that male Gulf sturgeon initiate migration to the river earlier in spring than females. Fox et al. (2000) found no significant difference in the timing of river entry due to sex, but reported that males migrate further upstream than females and that ripe (in reproductive condition) males and females enter the river earlier than nonripe fish (Fox et al. 2000). Change in temperature is thought to be an important factor in initiating sturgeon migration (Wooley and Crateau 1985; Chapman and Carr 1995; Foster and Clugston 1997). Most adults and subadults begin moving from estuarine and marine waters into the coastal rivers in early spring (*i.e.,* March through May) when river water temperatures range from 16.0 to 23.0^{o}C (60.8 to 73.4^{o}C) (Huff 1975; Wooley and Crateau 1985; Odenkirk 1989; Clugston et al. 1995; Foster and Clugston 1997; Fox and Hightower 1998; Sulak and Clugston 1999; Fox et al. 2000), while others may enter the rivers during summer months (Fox et al. 2000). Some research supports the theory that spring migration coincides with the general period of spring high water (Chapman and Carr 1995; Sulak and Clugston 1999; Ross et al. 2001b), however, observations on the Choctawhatchee River have not found a clear relationship between the timing of river entrance and flow patterns (Fox et al. 2002).

Downstream migration from fresh to saltwater begins in September (at about 23^{o}C [73^{o}F]) and continues through November (Huff 1975; Wooley and Crateau 1985; Foster and Clugston 1997) and may be related to discharge. Parauka et al. (2001) reported that telemetered sub adult Gulf sturgeon departed the Choctawhatchee River in early October 1998 as the river discharge increased. Water temperature in the river was 24.5°C. These fish migrated from the river to the marine system 2-4 weeks earlier than sub adults monitored in 1996 and 1997. Heise et al. (1999b) found that the greatest seaward movement of Gulf sturgeon in the Pascagoula River in 1998 corresponded with elevated river flows associated with Hurricane Georges. During the fall migration from fresh to saltwater, Gulf sturgeon may require a period of physiological acclimation to changing salinity levels, referred to as osmoregulation or staging (Wooley and Crateau 1985). This period may be short (Fox et al. 2002) as sturgeon develop an active mechanism for osmoregulation and ionic balance by age 1 (Altinok et al. 1998). On some river systems, timing of the fall migration appears to be associated with pulses of higher river discharge (Heise et al. 1999a, b; Ross et al. 2000 and 2001b; Parauka et al. 2001).

Sturgeon, ages 1 through 6, remain in the mouth of the Suwannee River over winter. In late January through early February, YOY Gulf sturgeon migrate down river for the first time (Sulak and Clugston 1999). Huff (1975) noted that juvenile Gulf sturgeon in the Suwannee River most likely participated in pre- and post-spawning migrations, along with the adults.

Parauka et al. (2001) noted that most telemetered sub adult Gulf sturgeon relocated while overwintering in Choctawhatchee Bay were associated with the lower salinity (6.3 ppt) found in the eastern portion of the bay. Fox et al. (2002) reported that most male Gulf sturgeons (60%) overwintered exclusively in Choctawhatchee Bay while most females (60%) were found in adjacent bays, the Gulf of Mexico, or were not located.

Findeis (1997) described sturgeon (Acipenseridae) as exhibiting evolutionary traits adapted for benthic cruising. Tracking observations by Sulak and Clugston (1999), Fox et al. (2002), and Edwards et al. (in prep.) support the idea that individual fish travel until they encounter suitable prey type and density, at which time they forage in that area for extended periods of time. Individual fish often remained in localized areas (less than 1 km^2 [0.4 mi^2]) for extended periods of time (greater than 2 weeks), and then moved rapidly to another area where localized movements occurred again (Fox et al. 2002). It is unknown precisely how much benthic area is needed to sustain Gulf sturgeon health and growth, but Gulf sturgeon are known to travel long distances (greater than 161 km [100 mi]) during the winter, which suggests that significant resources must be necessary.

When temperature drops associated with major winter cold fronts occur, researchers of the Escambia, Yellow, and Suwannee Rivers subpopulations have been unable to locate adult Gulf sturgeon within the bays (Craft et al. 2001; Edwards et al. 2003). They hypothesize that the sudden drop in water temperature disperses sturgeon to more distant foraging grounds. It is currently unknown whether Gulf sturgeon undertake extensive offshore migrations, and further study is needed to determine whether important winter-feeding habitat occurs offshore.

2.1.3.6 River-Specific Fidelity

Stabile et al. (1996) analyzed tissue from Gulf sturgeon in eight drainages along the Gulf of Mexico for genetic diversity. They noted significant differences among Gulf sturgeon stocks and suggested that they displayed region-specific affinities and may exhibit river-specific fidelity. Stabile et al. (1996) identified five regional or river-specific stocks (from west to east): (1) Lake Pontchartrain and Pearl River, (2) Pascagoula River, (3) Escambia and Yellow Rivers, (4) Choctawhatchee River, and (5) Apalachicola, Ochlockonee, and Suwannee Rivers.

Tagging studies suggest that Gulf sturgeon exhibit a high degree of river fidelity (USFWS and GSMFC 1995). From 1981 to 1993, 4,100 fish were tagged in the Apalachicola and Suwannee Rivers. Of these, 868 total fish were recaptured. Of the recaptured fish, 860 fish (99%) were recaptured in the river of their initial collection. Eight fish moved between river systems and represented less than 1% (0.009) of the 868 total fish recaptured. We have no information that would verify Gulf sturgeon spawning in non-natal rivers. Foster and Clugston (1997) noted that telemetered Gulf sturgeon in the Suwannee River returned to the same areas as the previous summer, and suggested that chemical cuing may influence distribution.

As of June 2005, biologists have documented a total of 35 Gulf sturgeon making inter-river movements. Tallman and Healey (1994) noted that observed straying rates between rivers were not the same as actual gene flow rates, *i.e.*, inter-stock movement does not equate to interstock reproduction. The gene flow is low in Gulf sturgeon stocks, with each stock exchanging less than one mature female per generation (Waldman and Wirgin 1998).

2.1.4 Status and Distribution

Historically, the Gulf sturgeon occurred from the Mississippi River east to Tampa Bay (Figure 2.1.2.A). Its present range extends from Lake Pontchartrain and the Pearl River system in

Louisiana and Mississippi east to the Suwannee River in Florida. Sporadic occurrences have been recorded as far west as the Rio Grande River between Texas and Mexico, and as far east and south as Florida Bay (Wooley and Crateau 1985; Reynolds 1993).

In the late 19th century and early 20th century, the Gulf sturgeon supported an important commercial fishery, providing eggs for caviar, flesh for smoked fish, and swim bladders for isinglass, which is a gelatin used in food products and glues (Huff 1975; Carr 1983). Gulf sturgeon numbers declined due to overfishing throughout most of the 20th century. The decline was exacerbated by habitat loss associated with the construction of dams and sills (low dams), mostly after 1950. In several rivers throughout the species' range, dams and sills have severely restricted sturgeon access to historic migration routes and spawning areas (Wooley and Crateau 1985; McDowall 1988).

On September 30, 1991, the Service and the National Marine Fisheries Service (NMFS) listed the Gulf sturgeon as a threatened species under the Act (56 FR 49653). Threats and potential threats identified in the listing rule included: construction of dams, modifications to habitat associated with dredging, dredged material disposal, de-snagging (removal of trees and their roots) and other navigation maintenance activities; incidental take by commercial fishermen; poor water quality associated with contamination by pesticides, heavy metals, and industrial contaminants; aquaculture and incidental or accidental introductions; and the Gulf sturgeon's long maturation and limited ability to recolonize areas from which it is extirpated.

These threats persist to varying degrees in different portions of the species range. In recent years, dredging for channel maintenance and beach nourishment has resulted in death and injury of a few Gulf sturgeon in the marine environment. Collisions with boats traveling at high speeds through areas where sturgeon jump out of the water have occurred on numerous occasions in the Suwannee and Choctawhatchee rivers, which support the two largest sturgeon populations. These collisions have seriously injured several people as well as the sturgeon. A sudden drop in dissolved oxygen content of the waters in the lower Escambia River of Florida following Hurricane Ivan in 2004 resulted in the death of at least 10 Gulf sturgeon.

Currently, seven rivers are known to support reproducing subpopulations of Gulf sturgeon. Table 2.1.4.A lists these rivers and most-recent estimates of subpopulation size. At this time, the Service characterizes the status of the species as stable. Identifying specific limiting factors to the species' recovery is difficult due to its long life span, large range, and utilization of diverse riverine, estuarine, and marine habitats.

2.2 Mussels

2.2.1 Species Description

2.2.1.1 Fat threeridge

The fat threeridge (*Amblema neislerii*) is a medium-sized to large, subquadrate, inflated, solid, and heavy-shelled mussel that reaches a length of 4.0 inches (in) (10.2 centimeters (cm)). Large specimens are so inflated that their width approximates their height. The umbo (bulge near the

hinge of a mussel) is in the anterior quarter of the shell. The dark brown to black shell is strongly sculptured with seven to eight prominent horizontal parallel plications (ridges). As is typical of the genus, no sexual dimorphism is displayed in shell characters. Internally, there are two subequal pseudocardinal teeth in the left valve (shell half) and typically one large and one small tooth in the right valve. The lateral teeth are heavy, long, and slightly arcuate (curved like a bow), with two in the left valve and one in the right valve. The inside surface of the shell (nacre) is bluish white to light purple and iridescent.

This taxon was originally described as *Unio neislerii* Lea, 1858, and was assigned to the genera *Quadrula* and *Crenodonta* by Simpson (1914) and Clench and Turner (1956), respectively. Subsequent investigators (*e.g.,* Mulvey et al. 1997; Turgeon et al. 1998) have placed the fat threeridge in the genus *Amblema*.

2.2.1.2 Purple bankclimber

The purple bankclimber (*Elliptoideus sloatianus*) is a large, heavy-shelled, strongly-sculptured mussel reaching lengths of 8.0 in (20.5 cm). A well-developed posterior ridge extends from the umbo to the posterior ventral margin of the shell. The posterior slope and the disk just anterior to the posterior ridge are sculptured by several irregular plications that vary greatly in development. The umbos are low, extending just above the dorsal margin of the shell. No sexual dimorphism is displayed in purple bankclimber shell characters. Internally, there is one pseudocardinal tooth in the right valve and two in the left valve. The lateral teeth are thick and slightly curved, with one in the right valve and two in the left valve. Nacre color is whitish near the center of the shell becoming deep purple towards the margin, and iridescent posteriorly. Fuller and Bereza (1973) described aspects of its soft anatomy, and characterized *Elliptoideus* as being an “extremely primitive” genus.

This taxon was originally described as *Unio sloatianus* Lea, 1840, and was included in the genus *Elliptio* until Frierson (1927) erected the subgenus *Elliptoideus*. The new subgenus designation was based on the presence of glochidia in all four gills instead of two gills, a characteristic of the genus *Elliptio* (Ortmann 1912). Clench and Turner (1956) overlooked the work of Frierson (1927), placing the species under *Elliptio*. Subsequent investigators (*e.g.,* Turgeon et al. 1998) have elevated the subgenus, creating the monotypic genus *Elliptoideus*. A genetic evaluation by Serb et al. (2003) indicated a close relationship between *E. sloatianus* and *Plectomerus dombeyanu*s, but with weak support. A more extensive study of North American unionids found the two species to be widely separated (Campbell et al. 2005). The Service currently follows Turgeon et al. (1998) and recognizes the purple bankclimber as *Elliptoideus sloatianus* with the following names considered synonyms: *Unio atromarginatus* Lea, 1840, *Unio aratus* Conrad, 1849, and *Unio plectophorus* Conrad, 1850.

2.2.1.3 Chipola slabshell

The Chipola slabshell (*Elliptio chipolaensis)* is a medium-sized species reaching a length of about 3.3 in (8.4 cm). The shell is ovate to subelliptical, somewhat inflated, with the posterior ridge starting out rounded but flattening to form a prominent biangulate margin. The periostracum is smooth and chestnut colored. Dark brown coloration may appear in the umbo

region and the remaining surface may exhibit alternating light and dark bands. The umbos are prominent, well above the hingeline. As is typical of all *Elliptio* mussels, no sexual dimorphism is displayed in shell characters. Internally, the umbo cavity is deep. The lateral teeth are long, slender, and slightly curved, with two in the left and one in the right valve. The pseudocardinal teeth are compressed and crenulate, with two in the left and one in the right valve. Nacre color is salmon, becoming more intense dorsally and somewhat iridescent posteriorly. This taxon was originally described as *Unio chipolaensis* Walker, 1905, and was subsequently moved to the genus *Elliptio* by Frierson (1927).

2.2.2 Critical Habitat Description

On November 15, 2007, the Service designated 11 stream segments (units) as critical habitat for the endangered fat threeridge, shinyrayed pocketbook, Gulf moccasinshell, Ochlockonee moccasinshell, and oval pigtoe, and the threatened Chipola slabshell and purple bankclimber (collectively referred to as the seven mussels) pursuant to the Endangered Species Act of 1973, as amended (72 FR 64286, November 15, 2007). These units comprise portions of the Econfina Creek (Florida), ACF (Alabama, Florida, and Georgia), Ochlockonee (Florida and Georgia), and Suwannee (Florida portion only) river basins. The total length of streams designated is approximately 1,185.9 river miles (1,908.5 river km). The rule became effective on December 17, 2007.

2.2.2.1 Fat threeridge

Three units are designated as fat threeridge critical habitat (Table 2.2.2.1.A). Critical habitat units encompass approximately 786.6 kilometers (488.8 miles) of river in the Lower Flint River in Georgia, Chipola River Basin in Alabama and Florida, and the Apalachicola River in Florida.

2.2.2.2 Purple bankclimber

Six units are designated as purple bankclimber critical habitat (Table 2.2.2.1.A). Critical habitat units encompass approximately 1,493.5 kilometers (928.0 miles) of river in the Flint River Basin in Georgia, Apalachicola River Basin in Florida and the Ochlockonee River Basin in Florida and Georgia.

2.2.2.3 Chipola slabshell

One unit is designated as Chipola slabshell critical habitat (Table 2.2.2.1.A). Critical habitat unit encompasses approximately 228.8 kilometers (142.2 miles) of river in the Chipola River Basin in Alabama and Florida.

2.2.2.4 Primary Constituent Elements

Each of the designated critical habitat units for these three listed mussels contains one or more of the PCEs that the Service describes as essential to the conservation of the species, and which may require special management considerations or protection. The PCEs of fat threeridge, purple bankclimber, and Chipola slabshell designated critical habitat are:

- A geomorphically stable stream channel (a channel that maintains its lateral dimensions, longitudinal profile, and spatial pattern over time without an aggrading or degrading bed elevation);
- A predominantly sand, gravel, and/or cobble stream substrate;
- Permanently flowing water;
- Water quality (including temperature, turbidity, dissolved oxygen, and chemical constituents) that meets or exceed the current aquatic life criteria established under the Clean Water Act (33 U.S.C. 1251-1387); and
- Fish hosts (such as largemouth bass, bluegill, redear sunfish, weed shiner, and blackbanded darter) that support larval life stages of the mussels.

2.2.3 Life History

The fat threeridge, purple bankclimber and Chipola slabshell- mussels are bivalve mollusks (clams) of the family Unionidae. Unionid mussels generally live embedded in the bottom of rivers, streams, and other bodies of water. They siphon water into their shells and across four gills that are specialized for respiration and food collection. Known food items include detritus (disintegrated organic debris), diatoms, phytoplankton, zooplankton, and other microorganisms (Coker et al. 1921; Churchill and Lewis 1924; Fuller 1974). Adults are filter feeders and generally orient themselves on or near the substrate surface to take food and oxygen from the water above them (Kraemer 1979). Juveniles typically burrow completely beneath the substrate surface and are pedal (foot) feeders (bringing food particles that adhere to the foot while it is extended outside the shell, inside the shell for ingestion) until the structures for filter feeding are more fully developed (Gatenby et al. 1997; Yeager et al. 1994).

Sexes in unionid mussels are usually separate. Males release sperm into the water, which females take in through their siphons during feeding and respiration. Eggs are fertilized and retained in the gills of the female until the larvae (glochidia) fully develop. The glochidia of most unionid species, including the fat threeridge, purple bankclimber and Chipola slabshell, require a parasitic stage on the fins, gills, or skin of a fish to transform into juvenile mussels. Females release glochidia either separately or in masses termed conglutinates, depending on the mussel species. The duration of the parasitic stage varies by mussel species, water temperature, and perhaps host fish species. When the transformation is complete, juvenile mussels normally detach from their fish host and sink to the stream bottom where, given suitable conditions, they grow and mature to the adult form.

2.2.3.1 Feeding Habits

Adult freshwater mussels are filter-feeders, orienting themselves in the substrate to facilitate siphoning of the water column for oxygen and food (Kraemer 1979). The diet of adult mussels consists of fine particles of primarily detritus, phytoplankton, and bacteria (Coker et al. 1921; Churchill and Lewis 1924; Fuller 1974; Neves et al. 1996). According to Baldwin and Newell (1991), bivalves feed on an array of naturally available particles (e.g., heterotrophic bacteria, phagotrophic protozoans, phytoplankton). Based on the findings of studies such as Baldwin and

Newell (1991) and Neves et al. (1996), an omnivorous opportunistic diet allows mussels to take advantage of whatever food type happens to be abundant.

Juvenile mussels employ foot (pedal) feeding and are suspension feeders (Yeager et al. 1994). Video observations of rainbow mussel (*Villosa iris* [Lea, 1829]) by Yeager et al. (1994) revealed juveniles occupy the top 0.4 in (1.0 cm) of sediment and employed two types of feeding mechanisms: 1) collecting organic and inorganic particles that adhere to the foot and conveying them to the pedal valve gape with sweeping motions; and 2) extending the foot anteriorly pulling themselves along while picking up organic and inorganic particles on the foot.

Foods of juveniles up to two weeks old include bacteria, algae, and diatoms with amounts of detrital and inorganic colloidal particles (Yeager et al. 1994). In juvenile freshwater mussel feeding experiments, Neves et al. (1996) found that algae was a suitable food and Gatenby et al. (1997) determined that a tri-algal (three algae species) diet high in lipids and mixed with fine sediment resulted in better growth. Silt provided some nutritional value, which was also observed by Hudson and Isom (1984), but bacteria in riverine sediments was not essential to growth and survival (Neves et al. 1996).

2.2.3.2 Growth and Longevity

Growth in freshwater mussels tends to be relatively rapid for the first few years (Chamberlain 1931, Negus 1966), then slows appreciably (Bruenderman and Neves 1993, Hove and Neves 1994). The abrupt slowing in growth rate occurs at sexual maturity, probably due to the diversion of energy to gamete production. Growth rates vary among species; heavy-shelled species grow slowly relative to thin-shelled species (Coon et al. 1977; Hove and Neves 1994). Under shoal habitat conditions, where high water velocities in river shallows are characterized by increased oxygen levels and food availability per unit time, growth rates are probably higher (Bruenderman and Neves 1993).

As a group, mussels are extremely long-lived, with maximum life spans of 100 to 200 years for certain species (Neves and Moyer 1988; Bauer 1992, Mutvei et al. 1994). Heavy-shelled species, which include many riverine forms, tend to reach higher maximum ages (Stansbery 1961). Some Virginia subpopulations of Cumberland moccasinshell, *Medionidus conradicus* (Lea, 1834) and Tennessee clubshell, *Pleurobema oviforme* (Conrad, 1834) were found to have individuals up to 24 and 56 years old, respectively (Moyer and Neves 1984).

Because no population demographic information was available for the fat threeridge, the Service collected fresh-dead shells for age and growth analysis in June of 2006. We collected eight shells of various sizes from a main channel site at RM 44.3 and sent them to Virginia Tech (J. Jones, USFWS) for aging via examination of internal annuli by shell thin-sectioning (Neves and Moyer 1988; McCuaig and Green 1983). Ages of the eight shells ranged from 3 years old (42 mm total length) to 32 years old (82 mm total length). The Panama City Field Office of the Service continued this work in 2007. We have currently aged 31 individuals ranging from 31-85 mm total length. Ages range from 2 years old (36 mm total length) to 27 years old (85 mm total length). A von Bertalanffy growth curve for the mean length-at-age data (Anthony et al. 2001; San Migel et al. 2004; Neves and Moyer 1988) was statistically significant ($R^2 = 0.93$; p <

0.0001; Figure 2.2.3.2.A). We used this relationship to predict ages from October 2007 quantitative sampling efforts in the Apalachicola River (RM40-50) (see section 3.5.2.2).

EnviroScience provided age and growth information for the purple bankclimber. They aged 11 individuals ranging from 80-184 mm total length. Ages range from 3 years old (80 mm total length) to 15 years old (184 mm total length). In addition, we found a dead shell of the smallest known purple bankclimber from the Apalachicola River. It was likely dead for at least one year, but the shell was still in good shape for aging. It measured 63 mm and was 4 years old. A von Bertalanffy growth curve does not fit these data. Although the sample size is very small, the relationship between age and total length appears to be exponential (Figure 2.2.3.2.B).

No age or growth information is available for the Chipola slabshell.

2.2.3.3 Reproduction

Following is a summary of freshwater mussel reproduction (see Watters [1994] for an annotated bibliography of mussel reproduction). Freshwater mussels generally have separate sexes, although hermaphroditism is known for some species (van der Schalie 1970, Downing et al. 1989). The age of sexual maturity for mussels is variable, usually requiring from 3 (Zale and Neves 1982) to 12 (McMahon and Bogan 2001) years. Males expel clouds of sperm into the water column, although some species expel spermatozeugmata (sperm balls), which are comprised of thousands of sperm (Barnhart and Roberts 1997). Females draw in sperm with the incurrent water flow. Fertilization takes place in the suprabranchial chamber of the female, and the resulting zygotes develop into specialized parasitic larvae, termed glochidia, in water tubes of the gills.

Three subfamilies are generally recognized within the family Unionidae and can be separated based on the number or portions of the gills used as marsupia (brood chambers) (Parmalee and Bogan 1998): Ambleminae (*e.g., Amblema*, *Elliptio*, *Elliptoideus*, *Pleurobema*); Anodontinae (*e.g., Alasmidonta*, *Pyganodon*); and Lampsilinae (*e.g., Lampsilis*, *Medionidus*). Depending upon the subfamily, all four gills (Ambleminae), the entire outer pair of gills (Anodontinae, some Ambleminae), or discreet portions of the outer pair of gills (Lampsilinae), are used as marsupia, although Heard and Guckert (1970) argue that amblemines (*e.g., Elliptio*, *Pleurobema*) which use only the outer gills as marsupia may warrant a fourth subfamily, the Pleurobeminae. Spawning appears to be temperature dependent (Zale and Neves 1982; Bruenderman and Neves 1983), but may also be influenced by stream discharge (Hove and Neves 1994). Fertilization rates are dependent on spatial aggregation of reproductive adults (Downing et al. 1993).

After a variable incubation period, mature glochidia, which may number in the tens of thousands to several million (Surber 1912; Coker et al. 1921; Yeager and Neves 1986), are expelled into the water column. The temporal release of glochidia is thought to be behavioral rather than developmental (Gordon and Layzer 1989). Glochidia must come into contact with specific species of fish whose gills and fins they temporarily parasitize, although two species have been shown to possibly utilize amphibian hosts (Howard 1915; Watters 1997a). Some mussel species, such as the green floater (*Lasmigona subviridis* [Conrad, 1835]), creeper (*Strophitus undulatus* [Say, 1817]), and paper pondshell (*Utterbackia imbecillis* [Say, 1829]) may not require a host

fish to complete their life cycle (Lefevre and Curtis 1912; Howard 1914; Dickinson and Sietman 2008). Glochidia failing to come into contact with a suitable host will drift through the water column, surviving for only a few days at most (Sylvester et al. 1984; Neves and Widlak 1988; O'Brien and Williams 2002).

Glochidia are generally released individually in net-like mucoid strands that entangles fish (Haag and Warren 1997), or as discreet packets termed conglutinates (Barnhart et al. 2008), which represent all the glochidial contents (and sometimes eggs) of a single water tube packaged in a mucilaginous capsule (Ortmann 1911; Lefevre and Curtis 1912). A newly described method, termed a "superconglutinate" by Williams and Butler (1994), involves the expulsion of the sum of the conglutinates from discreet portions of both outer gills that are packaged in a single glochidial mass (Haag et al. 1995; O'Brien and Brim Box 1999; Roe and Hartfield 2005).

Each of the three basic methods of glochidial expulsion and glochidial shape facilitates attachment to specific host fish and to specific fish structures (fin vs. gill), respectively (Lefevre and Curtis 1910; 1912). Although supported by field observations (Lefevre and Curtis 1912; Neves and Widlak 1988), the fish structure parasitized may in some cases be due to fish behavior rather than morphology (Gordon and Layzer 1989).

As few as 1 to as many as 25 fish species are known to serve as suitable hosts for particular species of mussels (Fuller 1974; Trodan and Hoeh 1982; Gordon and Layzer 1989; Hoggarth 1992). Host specificity appears to be common in mussels (Neves 1993), with most species utilizing only a few host fishes (Lefevre and Curtis 1912; Zale and Neves 1982; Yeager and Saylor 1995).

The parasitic stage generally lasts a few weeks (Neves et al. 1985, O'Brien and Williams 2002) but possibly much longer (Yeager and Saylor 1995; Haag and Warren 1997), and is temperature dependent (Watters and O'Dee 2000). After dropping from fish hosts, newly metamorphosed juveniles passively drift with currents and ultimately settle in depositional areas with other suspended solids (Neves and Widlak 1987; Yeager et al. 1994). Juveniles must, however, come into contact with suitable habitat to begin their free-living existence (Howard 1922). Survival rates for a glochidium to metamorphosis ranges from 0.000001 to 0.0001%, not factoring in predation after metamorphosis (Watters and Dunn 1993-94).

Glochidial parasitism serves two purposes: nutrition for larval development and dispersal. Substances within the blood serum of the host fish are necessary for the transformation of a glochidium into a juvenile mussel (Isom and Hudson 1982). Parasitism also serves as a means of dispersal for this relatively sedentary faunal group (Neves 1993). The intimate relationship between mussels and their host fish has therefore played a major role in mussel distributions on both a landscape (Watters 1992) and community (Haag and Warren 1998) scale. Haag and Warren (1998) determined that mussel community composition was more a function of fish community pattern variability than of microhabitat variability, and that the type of strategy used by mussels for infecting host fishes was the determining factor. The distribution of host-generalist mussels without elaborate host-attracting mechanisms (*e.g.,* anodontines) and host-specialized mussels with elaborate host-attracting mechanisms (*e.g.,* lampsilines) was independent of host-fish densities. Conversely, the distribution of host-specialist mussels

without elaborate host-attractant mechanisms (*e.g.,* amblemines) was dependent on densities of host fishes. Host fish density appears to be a factor in determining where amblemines, which include the three listed mussels addressed in this BO, may persist.

Knowledge about the reproductive biology of many freshwater mussels remains incomplete (National Native Mussel Conservation Committee 1998). For example, host fish for only 25% of the 300 mussel species in North America have been identified (Watters 1994), although subsequent studies are gradually expanding that number (*e.g.,* Luo 1993; Weiss and Layzer 1995; Yeager and Saylor 1995; Haag and Warren 1997; Howells 1997; Keller and Ruessler 1997; Roe and Hartfield 1997; O'Dee and Watters 2000). Host fish information is lacking most in the Southeast where over 90% of the freshwater mussel species occur (Neves et al. 1997).

Villella et al. (2004) summarized the general unionid life history strategy:

> Unionids are unique among freshwater invertebrates both in their longevity and their high and constant adult survival. This life history strategy is instead similar to large mammals and some freshwater vertebrates such as hellbenders and some fish species. Their life history strategy can be considered a hybrid between an *r*- and *K*-strategist. Unionids share some qualities of *K*-strategists (longevity and high adult survival) and they also share some of the qualities of *r*-strategists (high output of glochidia, lower survival of young, no parental care). It is possible that continuous (though low) reproduction during a long adult life span can be beneficial for unionids and may be an evolutionary strategy in response to uncertain larval and juvenile survival.

2.2.3.3.1 Fat threeridge

O'Brien and Williams (2002) studied various aspects of the life history of the fat threeridge, determining that it is likely a short-term summer brooder of its glochidia. Females appear to be gravid in Florida when water temperatures reached 75.2°F, in late May and June, suggesting that the species expels glochidia in the summer. Fat threeridge glochidia are released in a white, sticky, web-like mass, which expands and wraps around a fish, thus facilitating attachment. The glochidia are viable for 2 days after release.

The fat threeridge lacks mantle modifications or other morphological specializations that would serve to attract host fishes and appears to be a host-fish generalist that may infect fishes of at least three different fish families. Five potential host fishes were identified: weed shiner (*Notropis texanus*), bluegill (*Lepomis macrochirus*), redear sunfish (*L. microlophus*), largemouth bass (*Micropterus salmoides*), and blackbanded darter (*Percina nigrofasciata*). Transformation of the glochidia on host fishes required 10 to 14 days at 73.4 ± 2.7°F (O'Brien and Williams 2002).

2.2.3.3.2 Purple bankclimber

Females of the purple bankclimber with viable glochidia were found in the Ochlockonee River from February through April when water temperatures ranged from 46.4 to 59.0°F (O'Brien and Williams 2002). The species may or may not brood glochidia over the winter, depending on

when fertilization occurs, but most likely expels glochidia in late winter to early spring. Females expel narrow lanceolate-shaped conglutinates (0.4 to 0.6 in (1.0 to 1.5 cm) long) that are viable for 3 days after release. The white structures, which are two-glochidia thick, are generally released singly, although some are attached to each other at one end and released in pairs (O'Brien and Williams 2002). Prematurely released conglutinates (containing only unfertilized eggs) are rigid, but conglutinates with mature glochidia easily disintegrate, presumably facilitating host infection.

The eastern mosquitofish, blackbanded darter, guppy and greater jumprock transformed glochidia of the purple bankclimber during laboratory infections (O'Brien and Williams 2002; Johnson 2007 pers. comm.). Only the eastern mosquitofish was effective at transforming glochidia (100% transformation rate), with the percentages for the blackbanded darter and guppy being under 33%. Transformation on eastern mosquitofish occurred in 17 to 21 days at temperatures of 68.9 ± 5.4°F (O'Brien and Williams 2002). Only one glochidium was successfully transformed on the greater jumprock during preliminary trials and occurred after 52 days (Johnson 2007 pers. comm.). The eastern mosquitofish occupies stream margins in slower (or slack) currents, and is considered a secondary host fish since the purple bankclimber is more of a main-channel species (Williams and Butler 1994). The primary host species for this mussel remains unknown (O'Brien and Williams 2002).

2.2.3.3.3 Chipola slabshell

Little is known about the life history of the Chipola slabshell. It is suspected that this species expels conglutinates and is a tachytictic summer releaser. Southeastern congeners of the Chipola slabshell have been documented to use centrarchids (sunfishes) as host fish (Keller and Ruessler 1997). Bluegill is likely one of the host fish species for the Chipola slabshell. Researchers from Columbus State University (CSU) recently documented the successful transformation of glochidia on bluegill (Priester 2007 unpub. data).

2.2.3.4 Habitat

Adult mussels are generally found in localized patches (beds) in streams and almost completely burrowed in the substrate with only the area around the siphons exposed (Balfour and Smock 1995). The composition and abundance of mussels are directly linked to bed sediment distributions (Neves and Widlak 1987; Leff et al. 1990). Physical qualities of the sediments (*e.g.,* texture, particle size) may be important in allowing the mussels to firmly burrow in the substrate (Lewis and Riebel 1984). These and other aspects of substrate composition, including bulk density (mass/volume), porosity (ratio of void space to volume), sediment sorting, and the percentage of fine sediments, may also influence mussel densities (Brim Box 1999, Brim Box and Mossa 1999). Water velocity may be a better predictor than substrate for determining where certain mussel species are found in streams (Huehner 1987). In general, heavy-shelled species occur in stream channels with currents, while thin-shelled species occur in more backwater areas.

Stream geomorphic and substrate stability is especially crucial for the maintenance of diverse, viable mussel beds (Vannote and Minshall 1982; Hartfield 1993; Di Maio and Corkum 1995). Where substrates are unstable, conditions are generally poor for mussel habitation. Although

several studies have related adult habitat selection with substrate composition, most species tend to be habitat generalists (Tevesz and McCall 1979; Strayer 1981; Hove and Neves 1994; Strayer and Ralley 1993).

Habitat and stream parameter preferences for juveniles are largely unknown (Neves and Widlak 1987). This is possibly due to a prevalent lack of evidence of recruitment, inadequate sampling methods, or reproductive failure (Coon et al. 1977; Strayer 1981; Moore 1995; McMurray et al. 1999). Isely (1911) stated that juveniles may prefer habitats that have sufficient oxygen, are frequented by fish, and are free of shifting sand and silt accumulation. Neves and Widlak (1987) suggested that juveniles inhabit depositional areas with low flow, where they can feed pedally (see "Food Habits") and siphon water from interstitial spaces among substrate particles (Yeager et al. 1994). Juvenile mussels of certain species stabilize themselves by attaching to rocks and other hard substrates with a byssal thread (Frierson 1905; Isely 1911; Howard 1922). Strayer (1999a) demonstrated in field trials that mussels in streams occur chiefly in flow refuges, or relatively stable areas that displayed little movement of particles during flood events. Flow refuges conceivably allow relatively immobile mussels to remain in the same general location throughout their entire lives. He thought that features commonly used in the past to explain the spatial patchiness of mussels (*e.g.,* water depth, current speed, sediment grain size) were poor predictors of where mussels actually occur in streams.

Neves and Widlak (1987) summarized juvenile mussel associations with substrate, current velocity, and presence of other bivalves. Most of the youngest juveniles they found were clumped in runs and riffles on the downstream side of boulders, and were significantly correlated with fingernail clam presence. They observed that the habitat of older juveniles (*i.e.,* ages 2 to 3 years) was similar to that of adults, but did not conclude whether juveniles of most species experience differential survival rates in different habitat types, remain in the habitat of the host fish, or exhibit any specific habitat preference (Neves and Widlak 1987).

Mussels may be particularly susceptible to exposure by low flows during the spawning season, which, for the fat threeridge, occurs in the late spring and early summer. Once the water warms and the days become longer, mature mussels move vertically to the substrate surface (Balfour and Smock 1995; Amyot & Downing 1998; Watters et. al 2001; Perles et al. 2003). Watters et al. (2001) studied eight freshwater mussel species and found that all of the species surfaced during the spring to spawn. Studies of *Elliptio complanata* showed that 80% of the population migrate vertically to the sediment surface to spawn (Balfour and Smock 1995; Perles et al. 2003). Mussels also aggregate via horizontal movement to enhance recruitment (Amyot & Downing 1998). Spawning itself requires a substantial energy expenditure for female mussels (Amyot & Downing 1998), and because of the energy cost associated with movement (Trueman 1983), females may move less than males during the reproductive season (Amyot and Downing 1998). For this reason, females may be relatively more susceptible than males to exposure-induced mortality.

Williams and Butler (1994) discussed the habitat features associated with the listed mussels addressed in this BO, including stream size, substrate, and current velocity. Brim Box and Williams (2000) and Blalock-Herod (2000) also provided habitat information, particularly substrate associations. Following is a summary of this information.

2.2.3.4.1 Fat threeridge

The fat threeridge inhabits the main channel of small to large rivers in slow to moderate current. Substrate used by this mussel varies from gravel to cobble to a mixture of sand and sandy mud (Williams and Butler 1994). Brim Box and Williams (2000) found 60% of the specimens were located in a sandy silt substrate. Main channel populations prefer moderately depositional areas, at depths of around 1 meter (Miller and Payne 2006).

2.2.3.4.2 Purple bankclimber

The purple bankclimber inhabits small to large river channels in slow to moderate current over sand or sand mixed with mud or gravel substrates (Williams and Butler 1994). Over 80% of the specimens located during the ACF Basin portion of the status survey were found at sites with a substrate of sand/limestone (Brim Box and Williams 2000). ACF Basin collections were often in waters over 10 feet in depth.

2.2.3.4.3 Chipola slabshell

The Chipola slabshell inhabits silty sand substrates of large creeks and the main channel of the Chipola River in slow to moderate current (Williams and Butler 1994). Specimens are generally found in sloping bank habitats. Nearly 70% of the specimens found during the status survey were associated with a sandy substrate (Brim Box and Williams 2000).

2.2.4 Status and Distribution

2.2.4.1 Fat threeridge

The type locality of the fat threeridge is the Flint River, Macon County, Georgia. Records for this species are limited to main channels of the Apalachicola, Flint, and Chipola rivers, and a few tributaries/distributaries of the Apalachicola, all in north Florida and southwest Georgia (Clench and Turner 1956; Williams and Butler 1994) and all below the Fall Line (Brim Box and Williams 2000). We have no records of the species in the Chattahoochee Basin. Two historical records from the Escambia River (van der Schalie 1940; Heard 1979) are considered erroneous (Williams and Butler 1994). Brim Box and Williams (2000) reported 56 historical museum collections from 21 sites in the ACF Basin.

The fat threeridge was added to a list of regionally rare mussels compiled in 1971 (Stansbery 1971). The Service (1989) made it a candidate for federal listing in 1989 and listed it as a endangered species in 1998. In two separate reports, Williams et al. (1993) assigned the fat threeridge mussel a status of endangered rangewide, while Williams and Butler (1994) assigned it a status of threatened in Florida.

Until recently, the Service believed that the fat threeridge was extirpated from the Flint River Basin; however, biologists recently re-discovered it in the Flint River. During the summer of 2006, seven live adults were found in the main channel near Georgia State Highway 37. Biologists from the Georgia Department of Natural Resources (GDNR) and USFWS revisited

the site in May 2007 and found an additional three specimens (Wisniewski 2007). These collections may represent one additional subpopulation. However, all fat threeridge sampled at this location were relatively large and likely adults. Therefore, the viability of this subpopulation is unknown. In addition, we cannot assess the extent of a range increase because they have only been sampled from one location. Additional surveys are necessary to document presence at other locations in the Flint River.

Elsewhere in its extant range, the fat threeridge is documented in recent collections from several main channel sites on the Apalachicola River and in the lower Chipola River in Florida, both upstream and downstream of Dead Lake (Figure 2.2.4.1.A). Many surveys have been conducted since 2006 in these areas, and we report this information in Sections 3.5.2.1 and 3.5.2.2.

Concerning its historical abundance, van der Schalie (1940) reported only 17 fat threeridge specimens from 2 of 25 Chipola River system sites collected from 1915 to 1918. The majority of the sampling sites he reported were in the upper half of the system where this species has never been reported. Van Hyning (1925) considered it "rare," having spent some money sent by L.S. Frierson to acquire specimens in 1918 "several times over since then in the endeavor to locate them." It took several years of effort on his part before a "nice little lot" of fat threeridge was secured from the lower Chipola River. Clench and Turner (1956) described it as being a "rather rare species [but]. . . locally abundant." They reported it common from an Apalachicola River site (56 specimens collected in 1954) now submerged in the reservoir created by Jim Woodruff Lock and Dam (Brim Box and Williams 2000).

Clench and Turner (1956) documented an exceptional subpopulation of fat threeridge, reported at densities of 0.9 to 1.4 specimens per square foot along a 600+ foot stretch of shoreline, from Dead Lake, a natural flow-through, lake-like section of the lower Chipola River. Several museum lots containing a total of 102 specimens dated September 3, 1954, probably refer to their collection from this subpopulation. Dead Lake was impounded in 1960 by a low-head dam (Brim Box and Williams 2000). Although the dam was removed in 1987, Dead Lake has aggraded with sediment, which may have contributed to the localized extirpation of the fat threeridge. Though only a few locations within the Apalachicola and Chipola rivers were examined, Heard (1975) considered this species rare throughout its range and in danger of extinction. He also noted the decline of this species in the Apalachicola River (likely at US Highway 90) (Butler 2003 pers. comm.) from abundant to rare over a seven-year period. Eight of 21 historical collections contained 10 or more fat threeridge specimens (Brim Box and Williams 2000).

A status survey (USFWS 1998a) produced an average of 6.4 live specimens of the fat threeridge from six sites of occurrence in the ACF Basin. Brim Box and Williams (2000) reported a subpopulation of approximately 100 specimens located on the Chipola River below Dead Lake in 1988. Relatively large subpopulations are currently known in the lower Apalachicola River, where scores of specimens could be found in the mid-1990s (Brim Box 1994 pers. comm.), and a distributary (a side channel whose origin is the river main stem), Swift Slough. Limited quadrat sampling at one main stem site (six 2.7-square feet samples) conducted by Richardson and Yokley (1996) determined the fat threeridge to be the second most abundant of four species encountered (25% relative abundance).

Between 1996 and 2003, the Corps conducted six mussel surveys at potential dredged material disposal sites, slough locations, and other main channel areas within the Apalachicola and Chipola rivers (Miller 1998; Miller 2000a; Miller and Payne 2006). During these surveys, approximately 100 sites were examined over 171 river kilometers. The fat threeridge was detected at 22 locations and recruitment was documented at several of these locations. These surveys revealed that fat threeridge are most abundant at moderately depositional areas, usually downriver of point bars, at an average depth of 1.2 meters. The catch per unit effort (CPUE) per hour for fat threeridge at moderately depositional sites averaged 13.6 individuals, compared to 2.2 individuals at other sites. At a moderately depositional site on the Chipola River cutoff (river mile 41.7), a "dense band" of mussels was located, with 61% being fat threeridge. At this location, total substratum quantitative samples, which better detect the presence of small mussels, found evidence of recent recruitment, with total shell lengths ranging from 12.8 to 63.7 mm (Miller and Payne 2006). Miller and Payne (2006) concluded that, in appropriate habitat, the fat threeridge is common to abundant and exhibits evidence of recruitment.

Based on the above data, we categorized the fat threeridge population as "stable" in our 2005 annual reporting. Survey results from the fall of 2005, provided to the Service in the spring of 2006 (EnviroScience 2006a), and our own surveys during the summer of 2006, demonstrated that the fat threeridge was more abundant than we previously believed. The areas of highest density were also the areas subject to high mortality as water levels dropped in the summer of 2006 and 2007. Some mussels located in the main channel appeared to move in response to declining flows, but large numbers were located in side channels and in at least one distributary, Swift Slough, from which movement to deeper areas was not possible. Because the drought-induced mortality continued in 2007, we classified the fat threeridge as declining in the short-term in our 2007 annual reporting. The long-term implications of the high mortality are unknown; therefore, pending results of further studies, we classified the long-term status as unknown. Further discussion on this drought induced mortality and additional surveys conducted in 2007 are reported in Sections 3.5.2.1 and 3.5.2.2.

2.2.4.2 Purple bankclimber

The type locality of the purple bankclimber was the Chattahoochee River, Columbus, Georgia, by Clench and Turner (1956). This large-bodied species is known from the main channels of the ACF Basin, and the Ochlockonee Basin in Florida and Georgia (Clench and Turner 1956; Williams and Butler 1994; Brim Box and Williams 2000) (Figure 2.2.4.2.A). Generally distributed in the Flint, Apalachicola, and Ochlockonee Rivers, it was also known from the lower halves of the Chattahoochee and Chipola Rivers, and from two tributaries in the Flint River system. Heard (1979) erroneously reported it from the Escambia River system (Williams and Butler 1994). Brim Box and Williams (2000) located 68 historical museum collections from 25 sites in the ACF Basin alone. Fossil material is also known from the Suwannee River main stem and the Hillsborough Bay system in peninsular Florida (Brim Box and Williams 2000; Bogan and Portell 1995). The latter site has been dated from the early Pleistocene (Bogan and Portell 1995).

The purple bankclimber was recognized in lists of rare species published in the early 1970s (Athearn 1970; Stansbery 1971). Williams et al. (1993) assigned this species a status of

threatened rangewide, while Williams and Butler (1994) assigned it a status of threatened in Florida. The Service listed the purple bankclimber as a threatened species in 1998.

Subpopulations from the Chattahoochee River have apparently been extirpated save for a single live specimen found in 2000 (Stringfellow 2000 pers. comm.). In addition, it is no longer known from Line and Ichawaynochaway Creeks, and only two live individuals have been found in the Chipola River since 1988. Within portions of the Flint and Ochlockonee Rivers, the purple bankclimber occurs more sporadically than it did historically. Most occurrences in the Ochlockonee River are upstream of Talquin Reservoir. An anomalous small stream occurrence (a single specimen from an unnamed tributary of Mill Creek, Flint River system) was discovered during our status survey in the early 1990s (USFWS 1998a). A survey of five sites in the main channel of the Flint River between Warwick Dam and Lake Worth found that the purple bankclimber was the most abundant among nine species collected, but very few small individuals were observed (McCann 2005).

van der Schalie (1940) did not record the purple bankclimber from the Chipola River, but the 1915-18 surveys upon which he based his findings searched the upper portion of the system more thoroughly than the lower main stem. The purple bankclimber was noted as being a "relatively rare species" by Clench and Turner (1956). Heard (1975) considered this species to be common in the Apalachicola River in the 1960s, but that population sizes by the mid-1970s, particularly below Jim Woodruff Lock and Dam, had been "drastically reduced." Based on museum records, however, this species was relatively common in the lower Flint, upper Apalachicola, and upper Ochlockonee Rivers (Brim Box and Williams 2000; J.D. Williams, USGS, unpub. data). The largest museum collections with the same localities and dates were from the upper Apalachicola River (36 specimens collected in 1954) and lower Flint River (17, 1954). Museum collections may under-represent its abundance at certain sites where it was common, however, due to the difficulty of processing and storing substantial numbers of this large species.

An average of 54 specimens of the purple bankclimber were recorded from 41 sites rangewide during our status survey of the early 1990s; 30 sites in the ACF Basin and 11 in the Ochlockonee Basin (USFWS 1998a; Brim Box and Williams 2000). The Corps has periodically surveyed for mussels at designated dredged material disposal sites and other sites in the Apalachicola River and the lower Chipola River (Miller 1998; Miller 2000a; Miller 2003 pers. comm.). The purple bankclimber was found at 10 of these sites, including several that represented new locations for the species.

During surveys of the Ochlockonee River conducted in 2007, the USFWS identified purple bankclimbers at 16 sites, many of which represented new locations for the species. A total of 235 individuals were found from Interstate 10 in Florida upstream to Hadley Ferry Road in Georgia. In addition, biologists from GDNR sampled an individual purple bankclimber in the Ochlockonee River upstream of Barnetts Creek (Wisniewski 2006), representing a range extension of over 15 miles. At most of these sites, purple bankclimbers were the dominant species. However, no small or medium-sized individuals were found. The lack of small and medium-sized individuals suggests either poor reproductive success or sampling methods that are not suited to detecting juveniles of this species. We do not know the extent and viability of

many subpopulations throughout the range of the species, and further surveys for juveniles are necessary in all basins.

Richardson and Yokley (1996) used sieves to quantitatively sample substrates in the Apalachicola River downstream of Woodruff Dam, measuring purple bankclimber densities of about one animal per ft^2. Bankclimber density in four hand-picked (not sieved) substrate samples taken in the Ochlockonee River in 1993 averaged 0.34 animal per ft^2 (J. Brim Box, USGS, unpub. data).

Based on the above data and additional surveys in the action area described in Section 3.5.3, we categorized the purple bankclimber as “declining” in our 2007 annual reporting. Although past studies indicated that the species range and abundance are relatively unchanged, we now believe purple bankclimbers in the Apalachicola and Ochlockonee rivers may not have been recruiting for some time. As described above, studies in the Ochlockonee River during the summer of 2007 failed to detect any small or intermediate-sized individuals, which may signal a widespread reproductive failure. All individuals found were about the same, large size; whereas, juveniles of other species were collected regularly. It is also extremely rare to find small individuals in the Apalachicola River, where data suggest it may be one of the rarest mussels (see Section 3.5.3). Studies to verify recruitment, by an age structure analysis of the adult population and by detecting juveniles in the field, are particularly necessary to adequately assess the bankclimber’s status.

2.2.4.3 Chipola slabshell

The type locality of the Chipola slabshell is the Chipola River, Marianna, Jackson County, Florida. The Chipola slabshell was thought to be endemic to the Chipola River system (van der Schalie 1940; Clench and Turner 1956; Burch 1984; Heard 1979; Williams and Butler 1994) until Brim Box and Williams (2000) located a museum lot (single specimen) from Howards Mill Creek, a Chattahoochee River tributary in southeastern Alabama. The historical range of this ACF Basin endemic is centered throughout much of the Chipola River main stem and several of its headwater tributaries (Figure 2.2.4.3.A). The Chipola slabshell is one of the most narrowly distributed species in the drainages of the northeast Gulf of Mexico. Brim Box and Williams (2000) located 37 historical museum collections from 17 sites. Williams et al. (1993) assigned the Chipola slabshell a status of threatened range wide. Williams and Butler (1994), who considered it a Florida endemic, also assigned it a status of threatened. In 1998, the Service listed it as a threatened species.

The Chipola slabshell is no longer known from Howards Mill Creek in Alabama. Likewise, this species is probably extirpated from Dead Lake on the lower main stem of the Chipola in Florida. Sites supporting the Chipola slabshell are in Marshall and Dry creeks, and in the upper two-thirds of the Chipola River main stem. EnviroScience (2006a) found a single live individual in the Chipola River downstream of Dead Lake. The largest remaining subpopulation appears to be on the Chipola River main stem upstream of (but not in) Dead Lake, where the species remains relatively common (J.D. Williams, USGS, unpub. data).

A new status survey of the mussel fauna of the Chipola River, focused on the slabshell. Researchers from CSU sampled over 300 individuals from 10 new subpopulations and 6 previously known subpopulations. The majority of these subpopulations occur upstream of Dead Lake. However, Chipola slabshells were sampled from four locations in the action area, all of which represent new locations for the species (C. Stringfellow 2006 unpub. data). Additionally, biologists from Alabama re-discovered Chipola slabshells in Cowarts and Big creeks in Houston County, Alabama in 2006 and 2007 (Garner et al. 2007). The species had not been reported from Alabama reaches of the Chipola drainage since 1916, when it was reported from Cowarts Creek (Brim Box and Williams 2000).

Relative abundance of the Chipola slabshell has always been low. Clench and Turner (1956) considered it to be "rather rare, though it does occur throughout most of the length of the river proper and its smaller tributaries." van der Schalie (1940) reported 31 specimens of this species from 6 of 25 sites (average of 5.2 per site of occurrence). The largest museum collections with the same localities and dates were from Cowarts Creek, Houston County, Alabama (28 specimens collected in 1916) and Chipola River (22 specimens collected in 1954). The former record represents the only occurrence of the Chipola slabshell from the Alabama portion of the Chipola River system (Brim Box and Williams 2000), and was apparently overlooked by van der Schalie (1940). Heard (1975) reported this species as being relatively uncommon but that it could be locally abundant. We found an average of 3.7 Chipola slabshell specimens per site of occurrence (3 sites) during our status survey of the early 1990s (USFWS 1998a).

Based on the new status survey and data provided by Garner et al. (2007), we categorized the Chipola slabshell population as "improving" in our 2007 annual reporting. Results of these efforts demonstrated that the Chipola slabshell was more abundant than we previously believed. Twelve new subpopulations were discovered that included range extensions in the Chipola River and Cowarts Creek and Big Creek.

2.3 Analysis of the Species/Critical Habitat Likely to be Affected

This BO addresses effects of the Corps' water management operations under the Woodruff Dam RIOP and the associated releases to the Apalachicola River on the Gulf sturgeon, fat threeridge, purple bankclimber, and Chipola slabshell and their designated critical habitats. These listed species are found in the Apalachicola River and distributaries downstream of Woodruff Dam, which is the downstream-most federal reservoir within the ACF system.

The Apalachicola River is one of seven rivers currently known to support a reproducing subpopulation of Gulf sturgeon. The critical habitat in the Apalachicola system is included in Unit 6 (the Apalachicola River mainstem, downstream to its discharge at Apalachicola Bay, and all Apalachicola River distributaries [channels flowing out of the mainstem]). Critical habitat for Gulf sturgeon is also found in Apalachicola Bay included in Unit 13 (the main body of Apalachicola Bay and its adjacent sounds, bays, and the nearshore waters of the Gulf of Mexico). Unit 13 provides winter feeding migration habitat for the Apalachicola River Gulf sturgeon subpopulation. Corps operations affect freshwater flow into the bay, which affects salinity regimes and habitat conditions for Gulf sturgeon and their estuarine feeding habitats. Therefore,

we limit our analysis of effects to Gulf sturgeon in this BO to the Apalachicola River subpopulation of the species in critical habitat Units 6 and 13.

The Apalachicola River is designated as critical habitat for the fat threeridge and purple bankclimber. It is included as Unit 8 of 11 critical habitat units (72 FR 64286). Unit 8 includes the main stem of the Apalachicola River, two distributaries: the Chipola Cutoff downstream to its confluence with the Chipola River and Swift Slough downstream to its confluence with the River Styx, and one tributary: the downstream-most portion of River Styx. Kennedy Creek and Kennedy Slough do not receive flow from the Apalachicola River, but could receive backwater inundation from the river. The Chipola River and several of its tributaries are critical habitat for the fat threeridge and Chipola slabshell, including the portion of the Chipola River that is within the action area: the Chipola River downstream of its confluence with the Chipola Cutoff. The Chipola slabshell was recently found in this reach (EnviroScience 2006a), where the fat threeridge was already known to occur. Therefore, we limit our analysis of effects to the fat threeridge and purple bankclimber in Unit 8 and to the fat threeridge and Chipola slabshell in Unit 2.

2.4 Tables and Figures for Section 2

Table 2.1.4.A. Estimated size of known reproducing subpopulations of Gulf sturgeon.

River	States	Estimated Gulf Sturgeon Subpopulation Size[1]	Source
Pearl	LA, MS	300	Rogillio et al. 2002
Pascagoula	MS	162-216	Heise et al. 1999a; Ross et al. 2001b
Escambia	AL, FL	388-656	USFWS 2007
Yellow	AL, FL	500-911	Berg et al. 2007
Choctawhatchee	AL, FL	2000-3000	USFWS 2002
Apalachicola	FL	270-321	USFWS 1998; USFWS 1999
Suwannee	FL	5500-7650	Sulak and Clugston 1999; Pine et al 2001

[1] All estimates listed apply to the portion of the subpopulation exceeding a minimum size, which varies between researchers according to the sampling methods used.

Table 2.2.2.1.A. Critical habitat for the fat threeridge, purple bankclimber, and Chipola slabshell.

Species, Critical Habitat Unit, and State(s)	Miles
fat threeridge	
2. Chipola River, AL, FL	142.1
7. Lower Flint River, GA	246.5
8. Apalachicola River, FL	100.2
Total	488.8
purple bankclimber	
5. Upper Flint River, GA	236.4
6. Middle Flint River, GA	187.8
7. Lower Flint River, GA	246.5
8. Apalachicola River, FL	100.2
9. Upper Ochlockonee River, FL, GA	110.2
10. Lower Ochlockonee River, FL	46.9
Total	928.0
Chipola slabshell	
2. Chipola River, AL, FL	142.2
Total	142.2

Figure 2.1.2.A. Designated critical habitat and historic range of Gulf sturgeon.

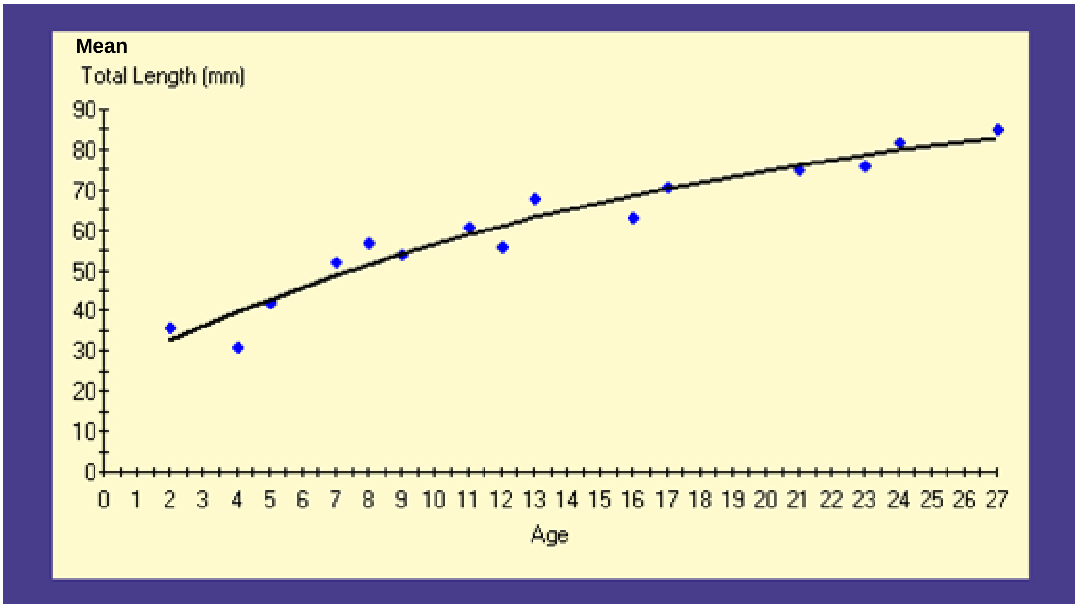

Figure 2.2.3.2.A. The von Bertalanffy growth relationship for the fat threeridge sampled in the main channel of the Apalachicola River.

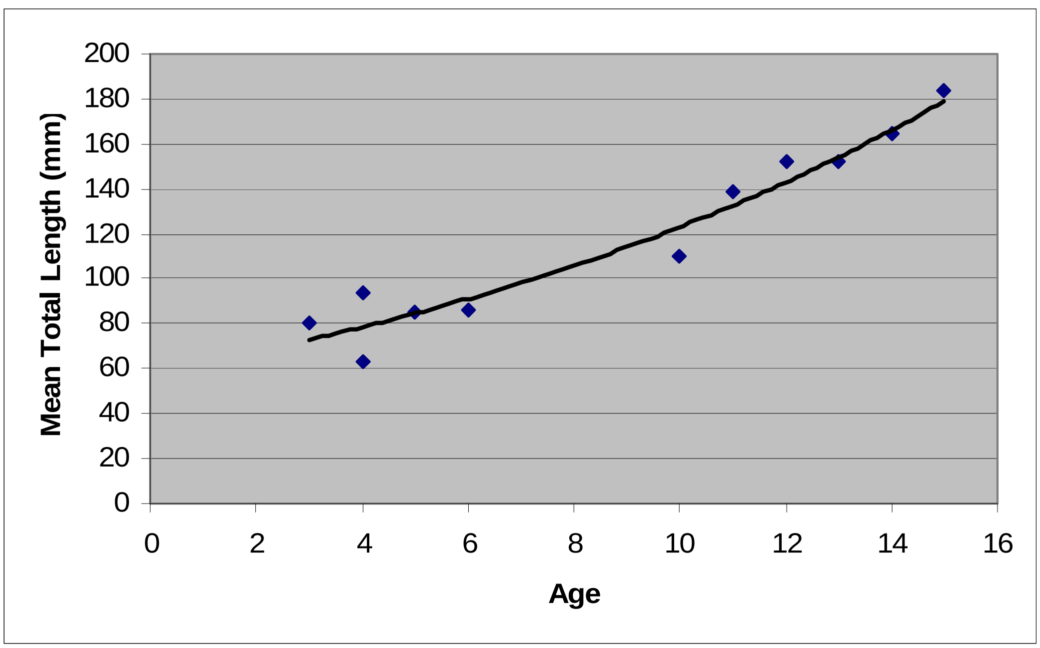

Figure 2.2.3.2.B. The exponential growth relationship for the purple bankclimber sampled in the main channel of the Apalachicola River.

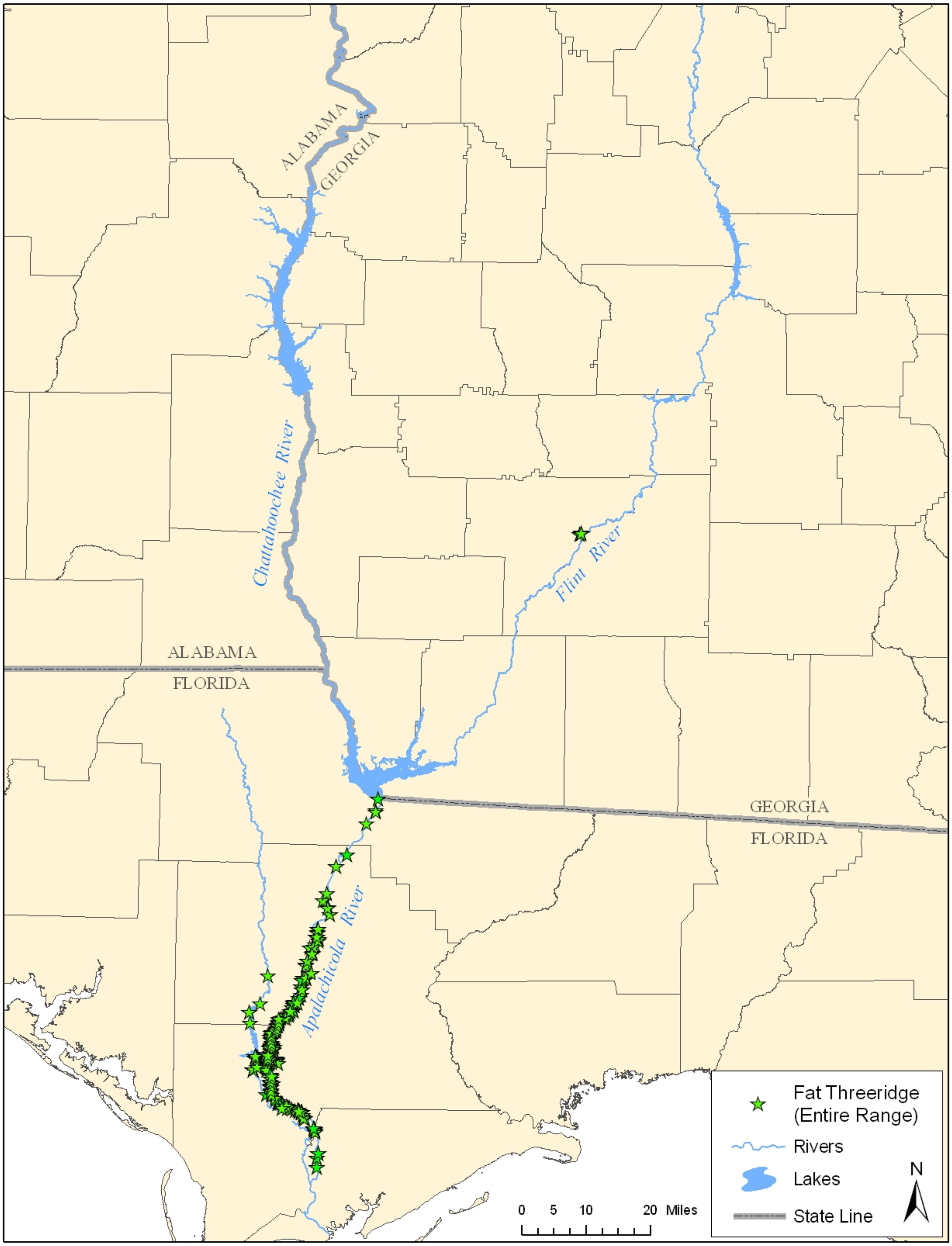

Figure 2.2.4.1.A. Known occurrences (post 1990) of the fat threeridge throughout its current range.

Figure 2.2.4.2.A. Known occurrences (post 1990) of the purple bankclimber throughout its current range.

Figure 2.2.4.3.A. Known occurrences (post 1990) of the Chipola slabshell throughout its current range.

3 ENVIRONMENTAL BASELINE

This section is an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem, within the action area. The environmental baseline is a "snapshot" of a species' health at a specified point in time. It does not include the effects of the action under review in the consultation. The action under review is the Corps' RIOP for the releases from Woodruff Dam. In the case of an ongoing water project, such as Woodruff Dam, the total effects of all past activities, including the effects of its construction and past operation, current non-federal activities, and federal projects with completed section 7 consultations, form the environmental baseline (USFWS 1998b).

Within the action area, various Federal, State, and private actions affect the Apalachicola River ecosystem and the listed species considered in this opinion, which we discuss in this section. Not all Federal actions in the ACF basin have undergone consultation with the Service regarding potential effects to listed species. In particular, the construction of the Corps' dams, which preceded the Act and the listing actions for the sturgeon and mussels, continue to affect the Apalachicola River by trapping sediment in reservoirs that would otherwise move as bed load through the system. The interruption of this bed load movement is a major factor contributing to altered channel morphology, which we address in this section. However, no present discretionary Federal action, *per se*, perpetuates sediment trapping that would prompt a consultation, and as stated above, we include the effects of project construction in the baseline. Consultations regarding water supply storage contracts, hydropower contracts, and the water control master operations manual are expected in the future.

3.1 General Description of the Action Area

See Section 1.1 for a definition of the action area. The Apalachicola River has the highest annual discharge of any river in Florida. It is the fifth-largest river in the continental United States, as measured by annual discharge to the sea (Leopold 1994). Together with the Chattahoochee and Flint rivers, its two largest tributaries, the Apalachicola drains an area of 19,800 square miles in parts of southeastern Alabama (15%), northwestern Florida (11%), and central and western Georgia (74%). The basin extends approximately 385 miles from the Blue Ridge Mountains to the Gulf of Mexico, and has an average width of 50 miles. The ACF Basin spans 50 counties in Georgia, 8 in Florida, and 10 in Alabama.

The Apalachicola River is entirely within the State of Florida and flows from Woodruff Dam about 107 miles to the Apalachicola Bay. Tidal influences on the river extend about 25 miles upstream from the bay. Within Florida, it receives flow from several tributaries, the largest of which is the spring-fed Chipola River. Lidstone and Anderson, Inc., (1989) described general morphological features of the Apalachicola River, which we summarize here. Almost the entire floodplain is forested and averages 1-2 miles in width in the upper river, 2-3 miles in the middle river, and 2.5 to 4.5 miles in the lower river. Limestone outcrops are found within the channel from river mile RM 86 to RM 105, where slope averages 0.424 ft per mile, and channel width averages 670 ft. The middle river has a slope of 0.495 ft per mile, is about 600 ft wide, and

includes several abandoned river channels and oxbow lakes. In the lower river, both tidal and nontidal portions, slope is 0.334 ft per mile with an average width of 533 ft.

As a sand-bed alluvial river, the Apalachicola is a dynamic system constantly changing by ongoing processes of erosion and sedimentation. Historically, the river included large meanders and tree-lined banks. The river banks were dominated by cohesive sediments that include large quantities of silt and clay (Lidstone and Anderson, Inc., 1989). Winter floods deposited tons of tree limbs, trunks, and stumps in the main channel. It was noted that the extensive tree growth in the subtropical environment required constant trimming to reduce hazards to steamboats that plied the river in the 1800s (Jeanne 2002).

The flow of the Apalachicola is carried by a complex of channels that includes the main channel and various distributaries. The upstream-most distributary is a "loop stream" called The Bayou, which departs the main channel at RM 86 and returns to the main channel at RM 78. Loop streams like this become increasingly more common downstream, particularly downstream of the river gage near Wewahitchka, FL (~RM 42). These loop streams carry a substantial portion of the total flow of the river at medium and high flows (Light et al. 2006). Distributaries that do not loop back to the main channel and instead carry water directly to Apalachicola Bay begin at RM 14.

3.2 Channel Morphology Alterations

The Apalachicola River is a large, meandering, alluvial river that migrates across the floodplain (Hupp 2000). However, the Apalachicola has not followed the normal pattern of lateral migration in which erosion and deposition are balanced so that the channel maintains a relatively constant width and bed elevation (Light et al. 2006). In the past 50 years, many portions of the Apalachicola have substantially declined in elevation (incised) and/or become substantially wider. The navigational channel was previously maintained by dredging; however, the Corps did not dredge the navigation channel in 2000, conducted limited dredging in 2001, and none since then. Although the federal navigation project is still authorized, the State of Florida has denied project certification under its delegated authority in section 401 of the Clean Water Act. At this time, channel maintenance are deferred indefinitely. Unless otherwise noted, the source for our summary of these changes in this section is Light et al. (2006) and Price et al. (2006), and our use of the terms upper, middle, and lower river refer to the delineation provided in Figure 1.1.A.

Mean bed elevation declined to some degree from 1960 to 2001 at 42 of 51 cross sections measured by the Corps throughout the nontidal portion of the Apalachicola River (Price et al. 2006). This decline is greatest in the upper river. During the period 1954 to 2004, the stage equivalent to 10,000 cfs declined 4.8 ft. During the period 1960 to 2001, in the upper 41 miles of the river, mean bed elevation declined an average of 2.2 ft at 26 cross sections measured in this reach. The probable cause of the bed degradation is sediment sequestration in Lake Seminole following construction of Woodruff Dam.

Channel width, measured as the distance between the treeline of opposite banks on aerial photography, has significantly increased since 1941. The mean increase in width of the nontidal

river has been 77 ft, using 2004 aerial photography as the most recent measure. Relative increases were greater going downstream. Most of the widening occurred between 1959 and 1979, and appears to have stabilized between 1979 and 1999, with the exception of some minor widening in the middle and non-tidal lower reaches that continued between 1999 and 2004, which warrants continued monitoring. Channel widening is in part responsible for the declining elevation associated with a given discharge over time, as the same amount of water spreads over a larger area. The current widening in the middle and lower nontidal reaches may slow or even reverse itself somewhat in the future as riparian vegetation stabilizes point bars and other depositional areas on the channel margins.

Channel incising (declining mean bed elevation) and channel widening both contributed to reduced connectivity between the main channel and its distributaries and its floodplain. We examine the effects of reduced connectivity on the baseline specifically in section 3.3.2, and again when considering the effects of the proposed action in section 4.2.6.

In order to better understand active channel morphology relative to the habitats of the listed species, the Corps conducted an evaluation of the sediment dynamics and channel morphology trends on the Apalachicola River in accordance with RPM4 of the 2006 BO. Such an analysis was needed in order to improve our understanding of dynamic river conditions, to monitor the zone at which take may occur, and to identify possible alternatives to minimize effects to listed mussels in vulnerable locations. The Corps consulted with experts, jointly identified by both agencies, to identify the current status of sediment transport and channel stability in the Apalachicola River as it relates to the distribution of listed mussels and their vulnerability to low-flow conditions. The goals of the evaluation were to identify: 1) feasible water and/or habitat management actions that would minimize listed mussel mortality; 2) current patterns and trends in morphological changes; and 3) additional information needed, if any, to predict morphological changes that may affect the listed mussels. Due to time constraints, the evaluation was based on available information and tools, and on best professional judgment.

Based on the experts' review of existing information, the reconnaissance field trip, presentations and discussions at the technical workshop, and the summary of individual findings prepared by each, the Corps determined that the river appears to be in a relatively stable dynamic equilibrium. The morphology of the river has been impacted over time by land use changes, upstream impoundments and consumptive use of water, and tectonic movement, as well as channel alterations, meander cutoffs, and channel dredging and snagging operations. Obvious channel degradation impacts were noted below Jim Woodruff Lock and Dam immediately after construction. However, these impacts appear to be reduced through time. Data from the Blountstown and Wewahitchka gages downstream of the dam indicate that there was a small change in low flow water surface elevations at those sites in response to Jim Woodruff construction, but the changes appear to have stabilized.

Field observations and data analysis by the river specialists suggest that the river is not continuing to degrade and that it may have attained a state of relative equilibrium. This is consistent with the findings of Light et al. (2006). Although a large portion of the middle river (RM 78 to RM 35) is very sinuous and actively meandering, maximum erosion rates on the outside of the bends in this reach are extremely low compared to other large alluvial rivers.

Furthermore, the erosion appears to be part of the natural down-valley meander migration which is common to most meandering streams. This does not appear to be the result of continuing post-dam system-wide adjustment such as degradation, aggradation, or channel widening. It appears unlikely that erosion rates will increase over time.

3.3 Flow Regime Alterations

Because the proposed action is an operational plan that prescribes the flow of the river, the habitat characteristic of greatest relevance to this consultation is the flow of the river, which is highly variable over time. A river's flow varies in its magnitude, seasonality, duration, frequency, and rate of change, and collectively, this variability is called its flow regime. The environmental baseline is a "snapshot" of a species health and habitat within the action area (USFWS 1998b), but to capture intra- and interannual variability, the flow regime of the environmental baseline is necessarily a "video" of river flow that begins at an appropriate date in the past and concludes at the present. Determining effects to the species and their habitat in the baseline flow regime is an evaluation of the degree to which the natural flow regime in the action area has been altered to date by all anthropogenic factors, including past operations of the Corps' ACF projects. Determining effects of the proposed action is an evaluation of the degree to which the baseline flow regime may be further altered by operations under the RIOP.

As noted in the "Description of Proposed Action" section, USGS stream gage number 02358000 at Chattahoochee, FL, which is located 0.6 mi downstream of Woodruff Dam, is the point at which Woodruff releases and ramping rates under the RIOP are measured. We use this gage also as the source of data for describing the baseline flow regime and for estimating characteristics of the natural flow regime of the river. The continuous discharge record of this gage begins in 1928, with 1929 as the first complete calendar year of record. The flow of the Apalachicola River has been altered over time to some degree by land use changes, reservoirs, and various consumptive water uses, and these alterations contribute to the environmental baseline.

The first dam/reservoir completed among the Corps' ACF projects was Buford Dam/Lake Lanier, which began operations in 1956. Although several other ACF mainstem dams were built before Buford, only Bartlett's Ferry Reservoir on the Chattahoochee River has appreciable storage capacity. The capacity of Bartlett's Ferry is less than 10% of Lanier's capacity, and less than 5% of the total capacity of the Corps' ACF projects. We therefore use the 27-year pre-Lanier flow record of the Apalachicola River's Chattahoochee gage from 1929 to 1955 to characterize the pre-impoundment flow regime. The Corps' full complement of ACF projects was not completed until October 1974, when operations of West Point Reservoir began. Although we could use all 50 post-Lanier years as the flow baseline, we use only the post-West Point years, 1975 to 2007 (33 years), because this period is the full history of the present configuration of the Corps' ACF projects.

The Corps' operations have changed incrementally over the post-West Point period. These changes were documented in a draft water control plan in 1989. Additional incremental changes in water control operations have occurred since 1989, and are reflected in the current operations and the RIOP. Except in very general terms, it is not possible to describe a single set of reservoir operations that apply to the entire post-West Point period.

3.3.1 Annual Flow

To compare the flow regimes of the pre-Lanier period and the post-West Point periods, we use several of the measures identified in the Service's instream flow guidelines for the ACF Basin (USFWS and USEPA 1999), as well as other measures appropriate to this consultation. We begin with a general comparison of the two periods. Figure 3.3.1.A shows the distribution of annual average discharge for the Apalachicola River in the 1929-1955 pre-Lanier period and the 1975-2007 post-West Point period. Although the median annual discharge is slightly higher in the post-West Point period, the three lowest-flow years (2000, 2002, and 2007) and six of the 10 lowest-flow years belong to the baseline period. The occurrence of these lowest-flow years in the baseline period may be due to differences in precipitation patterns.

An obvious climatic basis for annual discharge differences between these two periods; however, is not apparent in an examination of readily available historical precipitation data (NOAA 2008b) for the Chattahoochee and Flint Basins. Figure 3.3.1.B shows annual precipitation during the two periods compiled for Alabama climate zones 5, 6, and 7, and Georgia climate zones 1, 2, 3, 4, 5, 7, and 8. The climate zone boundaries do not coincide with the ACF Basin boundaries; therefore, we computed annual precipitation data as an average of the annual inches reported for these ten climate zones weighted by the area of each zone within the ACF Basin. These data suggest that, despite the occurrence of the lowest-flow years in the post-West Point period, it was generally wetter than the pre-Lanier period (median 52.00 inches vs. 49.30 inches). The driest 10 years are divided equally between the pre-Lanier and post-West Point periods. The last two years, 2006 and 2007, are among these.

Figure 3.3.1.C shows the relationship between annual precipitation in the ACF basin upstream of Woodruff Dam, estimated as described above, and annual discharge of Apalachicola River at the Chattahoochee gage for the two periods. The addition of 3.7 million acre ft of reservoir storage (including inactive storage) during the post-West Point period does not appear to have altered the overall relationship between precipitation in the Chattahoochee and Flint Basins and discharge into the Apalachicola Basin. The trend lines (linear model best fit) for the two periods are similar.

Figure 3.3.1.D is a flow frequency chart for the two periods taken from an analysis that combines all daily discharge values in each period, sorts the data in ascending order, and computes the percentage of the period containing values that exceed each unique value in the sorted list. This kind of flow frequency analysis shows the distribution of discharge magnitude in a period of record as a whole and is useful in characterizing overall differences between two periods of record. The frequency plots of the two periods are close to each other for flows greater than about 25,000 cfs, but the curves separate by about 4 to 5% for flows less than about 15,000 cfs. Flows less than 25,000 cfs occur more often in the post-West Point Period than the pre-Lanier Period. Differences in flow frequency in the range greater than 25,000 cfs are less than 2%, therefore, Figure 3.3.1.D is truncated at 35,000 cfs to allow for greater clarity in the range less than 35,000 cfs.

Climate change has potential negative implications for the current and future status of ESA-listed species in the Apalachicola River. The four key climate drivers in the region (Burkett 2008) –

rising temperatures, changing precipitation patterns, rising relative sea levels, and increasing storm intensity – all have water management implications. Alterations to the hydrograph, water temperature increases, and habitat alterations are a few possible effects of climatic variation. The Intergovernmental Panel on Climate Change (IPCC 2007) concluded that it is very likely that heat waves, heat extremes, and heavy precipitation events over land will increase during this century. Even in mid-latitude regions where mean precipitation is expected to decrease, precipitation intensity is expected to increase (IPCC 2007).

The Climate Change Scientific Committee noted in their 2008 report on the Central Gulf Coast (Burkett 2008) that the models to predict future precipitation rates are complex, but tend to indicate a slight decrease in annual rainfall across the Gulf Coast. The Committee found that average runoff is likely to remain the same or decrease when changing seasonal precipitation is considered with increasing temperatures. However, droughts are more likely to become more severe. The actual effects of changes in climate are likely to be variable across the 19,800 square miles of the Apalachicola basin, but the potential for an unprecedented duration or recurrence frequency of drought cannot be discounted.

3.3.2 High Flow

High flows perform many functions that are vital to the maintenance of riverine and estuarine ecological integrity, including (USFWS and USEPA 1999):

- the maintenance of channel and floodplain features by transporting sediment;
- the export of organic matter, nutrients, and organisms from the floodplain to the main channel and the estuary;
- removing and transporting fine sediments, clearing interstitial spaces in gravel bars used for fish spawning;
- importing woody debris into the channel, creating new high-quality habitat for fish and invertebrates;
- scouring floodplain soils, which rejuvenates habitat for early-successional plant species;
- reducing estuarine salinity, which provides nursery habitat for many marine species with early life stages that are intolerant of high salinity, and prevents the permanent intrusion of marine predators, such as oyster drills, that are intolerant of low salinity;
- connecting the main channel to the floodplain, providing access to spawning habitats, nursery areas, and food sources; and
- maintaining flood-resistant, disturbance-adapted communities.

Higher-flow events move more sediment per unit time than lower-flow events and, therefore, exert the greatest influence on channel morphology (Leopold and Wolman 1957). Although the analysis referenced in the previous section did not show appreciable differences in the overall frequency of the highest flow rates between the pre-Lanier and post West Point, this kind of analysis does not necessarily detect a change in the inter-annual recurrence of flow events, which could affect channel-forming processes. The discharge generally associated with the greatest volume of sediment movement over time is the bankfull discharge, which is typically the annual peak flow event that occurs an average of two out of three years (1.5-year recurrence interval) (Dunne and Leopold 1978). Bankfull discharge tends to occur almost annually in the coastal plain portions of Alabama, north Florida, and Georgia (Metcalf 2004). Although higher flow

rates than the 1.0- to 1.5-year recurrence peaks move more sediment per unit time, these more frequent events move the greatest sediment volume over time. Using 85 years of annual instantaneous peak flow data from the Chattahoochee gage, the 1.0- and 1.5-year recurrence peak flows for the Apalachicola River are 23,400 cfs and 72,100 cfs.

Figure 3.3.2.A shows a comparison of the annual duration of high flow in the pre-Lanier and post-West Point periods using a threshold of 50,000 cfs, which is about mid-way between the 1.0-to 1.5-year peak flow values. Flow did not exceed 50,000 cfs in about 10% of the years in both periods, however, the median number of days greater than 50,000 cfs is almost doubled in the post-West Point period (27 days vs. 15 days). This shift in the inter-annual duration of high flows suggests a relatively greater potential for sediment transport in the baseline period, which may have exacerbated the process of bed degradation and channel widening set in motion following the construction of Woodruff Dam (see section 3.2).

One effect of bed degradation and channel widening has been to reduce the amount of floodplain inundation associated with a given discharge (Figure 3.3.2.B) (pre and post total acres v. flow chart) (Light et al. 1998; Light et al. 2006). For example, the amount of floodplain habitat inundated by a flow of 30,000 cfs was about 46,500 acres in the pre-Lanier period and about 35,000 acres in the post-West Point period, a 25% reduction. Floodplain inundation during the growing season (generally April through October) is critical to the reproduction of many fish species, including some identified host species for the listed mussels. Figure 3.3.2.C shows the frequency and area extent of growing-season (April through October) floodplain inundation in the pre-Lanier and post-West Point periods, which is computed by transforming the daily flow records to daily acres inundated in each period using the applicable area versus discharge relationship shown in Figure 3.3.2.B. Despite an increase during the post-West Point period in the annual duration of flows greater than 50,000 cfs, discussed in the previous paragraph, the frequency and extent of floodplain inundation during the post-West Point period is decreased relative to the pre-Lanier period, largely due to altered channel morphology. For example, 20,000 floodplain acres were inundated for 32% of the growing-season days in the pre-Lanier period, but for only 18% of the growing-season days in the post-West Point period.

Figure 3.3.2.C is an analysis of the pre-Lanier and post-West Point periods as a whole, and does not assess the inter-annual frequency or magnitude of floodplain inundation. Inter-annual patterns are important in interpreting effects to riverine and estuarine biota, because the year-to-year variability in habitat conditions influences reproductive success and other population characteristics. In the case of fish spawning in floodplain habitats, it is further important to consider continuous days of inundation within a year, because utilization of these floodplain habitats requires time for movement from the main channel into the floodplain, courtship and spawning behaviors, egg incubation, and juvenile growth to a size capable of moving to and surviving in the main channel when water levels recede. We analyzed the growing-season floodplain inundation during the pre-Lanier and post-West Point periods using a 30-day moving minimum to represent this aspect of habitat availability, identifying the maximum acreage inundated for at least 30 days each year in both periods. Figure 3.3.2.D shows the results of this analysis, and again, habitat availability during the post-West Point period is substantially less than the pre-Lanier period. In 50% of the pre-Lanier years, more than about 23,500 floodplain

acres were inundated for at least 30 continuous growing-season days. The median for the post-West Point period is less than half this amount, about 11,000 acres.

3.3.3 Seasonality

Many riverine organisms have life history features that are adapted to seasonal patterns of river flow (Poff et al. 1997). As noted in sections 3.1.3.3 and 2.1.3.5, Gulf sturgeon migratory movements are likely prompted by a combination of temperature and flow cues. Freshwater flow into Apalachicola Bay regulates its salinity and likely influences the amount of feeding habitat available to young sturgeon, which move towards the bay in the fall and winter and have not yet developed a tolerance for high salinity (Altinok et al. 1998). Seasonal flow adaptations of the mussels have not been investigated, but due to their limited mobility, it is likely that any such adaptations would serve to enhance fertilization of gametes and infection of fish hosts with glochidia. The habits of many fish species, some of which may serve as hosts for the listed species, are seasonal and flow dependent (Angermeir 1987; Schlosser 1985). We discussed the importance of floodplain inundation as spawning and rearing habitat for fishes in the previous section. Although many riparian plant species thrive under frequently inundated conditions, most require exposed substrate at some time of year for seed germination. In estuaries, plants and animals also are adapted to seasonally dynamic flows delivered by rivers. High spring flows deliver nutrients and extend the area of freshwater out toward the sea. Low flows in late summer and autumn permit salt water to move inland, sustaining marshland vegetation and allowing saltwater fishes and invertebrates opportunities to feed in the productive estuarine habitats. A seasonally variable flow regime is for many reasons vital to the health of the riverine and estuarine ecosystem. In this section, we examine the possibility of seasonal shifts in the baseline flow regime.

Figures 3.3.3.A and 3.3.3.B compare the distribution of monthly average flow in the pre-Lanier and post-West Point periods. The distributions of monthly flow for January, June, September, October, and December, are similar. In February and March, the median monthly flow is appreciably higher in the post-West Point period, which is probably not the result of reservoir project operations. The ACF federal reservoirs' are generally drawn down in the fall from summer to winter pool levels, and this drawdown is completed before February. The fall drawdown is a likely explanation for a higher distribution of monthly flow for November in the post-West Point period. The Corps generally begins refilling West Point reservoir to its summer pool level sometime in February, which reduces, not increases, flow to the Apalachicola River. Higher flow during February and March, therefore, suggests possible climatic differences between the two periods, but since the average annual flow of the two periods is comparable (Figure 3.3.3.A), the post-West Point period must necessarily also contain months with lower flow than the pre-Lanier period. These months appear to be April, May, July, and August, which show a generally lower distribution of monthly flow. The Corps' project operations may explain to some degree lower flow in April and May, since the system is generally operated to fill the reservoirs to summer pool levels by the end of May, and this necessarily reduces flow to the Apalachicola. Lower flow in July and August is likely a combination of climatic differences in the two periods, higher consumptive uses, as well as reservoir operations.

3.3.4 Low Flow

Extreme low flows are likely among the most stressful natural events faced by riverine biota. Cushman (1985) and Kingsolving and Bain (1993) described the some of the effects of low flows. Low flow constricts available habitat and portions of the channel become dry. Aquatic animals perish that are unable to move to remaining pools or burrow into the moisture of the streambed itself. Others become concentrated in pools, where small-bodied species are more vulnerable to aquatic predators and large-bodied species are more vulnerable to terrestrial predators, particularly birds and raccoons. During warm months, extreme low water levels are accompanied by higher-than-normal water temperatures and low dissolved oxygen levels, further stressing river biota. Because of the physical and biological harshness of extreme low-flow conditions, decreasing the magnitude, increasing the duration, or increasing the inter-annual frequency of low-flow events is likely to have detrimental effects on native riverine biota, including the listed species.

Figures 3.3.4.A and 3.3.4.B show the distribution of monthly 1-day minimum flow in the pre-Lanier and post-West Point periods. The medians of the two periods are about the same in the months of January, February, July, September, and October. The distribution of monthly 1-day minimum flow is shifted to generally higher levels in the post-West Point period in the months of November and December, and to lower levels during the months of March through August. In the month of May, for example, flows less than 10,000 cfs occur in three times the number of years in the post-West Point period. The shift in the seasonal occurrence of low-flow rates into the March through June time frame is significant to the listed species and to many other riverine species, as these are the months of concentrated reproductive activity and early life stage development.

The duration of low-flow events in the two periods is shown in Figures 3.3.4.D and 3.3.4.E, which shows the maximum number of days per year and the maximum number of consecutive days per year that flow rates were less than 5,000 to 10,000 cfs. It is appropriate to focus on the maximum duration, because the mortality or reproductive failure associated with a severe episode of extended low flow may adversely affect a population for many years. For all rates between 5,000 and 10,000 cfs, the post-West Point period has a greater maximum event duration, expressed as both total days per year and consecutive days.

3.3.5 Rate of Change

Riverine rate of change is the rise and fall of river stage over time. Rapid changes in river stage may wash out or strand aquatic species (Cushman 1985; Petts 1984). By capturing high flows in storage, reservoirs typically accelerate the drop in stage compared to pre-reservoir conditions by closing spillway gates during flood recession, which may reduce germination and survival of riparian tree seedlings that colonize banks and sandbars by drying these areas out too fast (Rood et al. 1995). Successful regeneration of riparian vegetation is essential in the balance of erosion and deposition to maintain channel stability.

The RIOP prescribes daily minimum releases and daily maximum fall rates from Woodruff Dam; therefore, we address rate of change in this BO in an average daily context; *i.e.,* change in

river stage from one day to the next. We further focus on fall rates, and not rise rates, in this analysis due to the possible effect of stranding listed species and host fishes for the mussels in higher portions of the stream channel or floodplain when river stages decline too rapidly. Figure 3.3.5.A shows fall rates in the pre-Lanier and post-West Point periods, using the same intervals of fall rates that define this measure under the proposed action, which range from less than 0.25 ft/day to greater than 2.00 ft/day. The most extreme fall rates, 1.00 to 2.00 ft/day and > 2.00 ft/day, are the least common in both periods, but the frequency of these events is more than doubled in the post-West Point period (9.9% vs. 4.4%). This increase represents a substantial increase in the risk of stranding aquatic organisms due primarily to how the system of reservoirs was operated in this period.

3.4 Water Quality

Although the State standards adopted consistent with the U.S. Environmental Protection Agency (USEPA) criteria generally represent levels that are safe for sturgeon and mussels, these standards are sometimes violated. The 2001 Impaired Surface Waters Rule analysis identified potential impairments in the action area for biology, coliforms, DO, and unionized ammonia (FDEP 2002). Several segments of the Apalachicola and Chipola rivers that are within the action area are included on the 2004 Verified List of Impaired Waters that fail to fully meet their designated uses (FDEP 2004). The impairments included turbidity, coliform bacteria, mercury, and dissolved oxygen. Mercury-based fish advisories apply to one or more segments of both watersheds, and organochlorine pesticides were found at levels in ACF Basin streams that often exceeded chronic exposure criteria for the protection of aquatic life (FDEP 2002; Frick et al. 1998). The 2001 Impaired Surface Waters Rule analysis identified potential impairments in the action area same segments for biology, coliforms, DO, and unionized ammonia (FDEP 2002). Point and non-point source pollution have contributed to impaired water quality in the Apalachicola and Chipola rivers.

The Apalachicola River receives effluent from 15 surface water discharge facilities, including 6 domestic and 8 industrial waste facilities and 1 concrete batch plant. The major domestic waste facilities are the city of Blountstown (discharge (Q) = 1.5 million gallons per day (mgd)), the city of Chattahoochee (Q = 0.5 mgd), Florida State Hospital (Q = 1.3 mgd), and the town of Sneads (Q = 0.495 mgd). The only major industrial waste facility is the Gulf Power Scholz Steam Plant (Q = 129.6 mgd). Of these facilities, bioassays were completed for Blountstown, Chattahoochee, and the Florida State Hospital (adjacent to the town of Chattahoochee). The bioassay for Blountstown (3 September 1997) noted that the discharge to Sutton Creek had unionized ammonia (0.079 mg/L) and silver (0.27 µg/L) greatly exceeding the freshwater criterion of 0.07 µg/L (FDEP 2002). The bioassay for Chattahoochee (October 1998) noted no toxicity, no organic pollutants or metals, and no algal growth impacts to Mosquito Creek (FDEP 2002). The bioassay for the hospital (May 2000) noted no effluent toxicity and little impact on taxa richness to a tributary to North Mosquito Creek (FDEP 2002).

Predominant land uses in the drainage area of the Apalachicola River in Florida include upland forests (53.5%), wetlands (30.5%), agriculture (8.4%), and urban/built-up (2.1%); however, most of the drainage area of the basin as a whole is upstream of Florida in Alabama and Georgia. The Northwest Florida Water Management District (NWFWMD) recently completed a study of 12

watersheds in the Apalachicola drainage basin to determine relationships between land use and water quality (Thorpe et al. 1998). Very few water quality differences were noted between silviculture-dominated and naturally forested watersheds. Agriculture-dominated watersheds showed higher loading than natural and silviculture rates for a number of nutrients, such as unionized ammonia, nitrate-nitrogen, total nitrogen, and total phosphorus (Thorpe et al. 1998). The USGS has estimated nonpoint loadings for the Apalachicola River (Frick et al. 1996). The total nitrogen loads (tons/yr) are point sources (11), animal manure (210), fertilizer (1500), and atmospheric deposition (1300). For total phosphorus, the loads are point sources (5), animal manure (64), and fertilizer (680). The USGS has also estimated loadings for the Chipola River (Frick et al. 1996). The total nitrogen loads (in tons/yr) are point sources (28), animal manure (1700), fertilizer (6100), and atmospheric deposition (1500). For total phosphorus, the loads are point sources (6), animal manure (480), and fertilizer (1700).

The sources of these nutrient loadings are likely related to the violations of the water quality standards observed for coliforms, dissolved oxygen (DO), and unionized ammonia (FDEP 2002). Elevated coliform bacteria counts are not known to harm Gulf sturgeon or freshwater mussels; however, elevated unionized ammonia and low DO are associated with adverse effects to fish and mussels (Secor and Niklitschek 2001; Fuller 1974; Sparks and Strayer 1998; Johnson 2001; Augspurger et al. 2003).

USGS has recorded water temperature intermittently at the USGS Apalachicola River gage near Chattahoochee, FL. Records were available from 1974-1978 and 1996-1997; however, water temperatures were not available for all of the days in each year. We calculated the mean daily temperature from the available data for each calendar date to plot a seasonal average water temperature profile for the river (Figure 3.4.A).

3.5 Status of the Species within the Action Area

This portion of the environmental baseline section focuses on each listed species, describing what we know about its spatial distribution, population status, and trends within the action area.

3.5.1 Gulf sturgeon

Gulf sturgeon catch in the Apalachicola River in the early 1900s ranged from about 9,000 to 27,000 kg/year (U.S. Commission of Fish and Fisheries 1902; Huff 1975). The fishery declined to minimal levels by 1970 (Barkuloo 1987), and in 1984, the State of Florida prohibited all Gulf sturgeon fishing (Rule 46-15.01, Florida Marine Fisheries Commission). The Services (USFWS and NOAA) listed the species as threatened in 1991.

Gulf sturgeon radio tagged in 2004 were located below the dam during the spring of 2005 and 2006 during studies to locate spawning sites. However, most of these fish did not remain near the dam for the summer period. For reasons unknown at this time, sturgeon are selecting alternate summer habitats elsewhere in the system, such as the Brothers River. A number of telemetered sturgeon did not migrate upstream to Woodruff Dam in the spring of 2005, and instead entered the Brothers River, remaining there until the fall downstream migration.

In spring 2007, Gulf sturgeon migration data was assessed in conjunction with a Florida Fish and Wildlife Conservation Commission (FFWCC) funded research project on fish movement and spawning patterns in the Battle Bend region of the Apalachicola River. The study included monitoring an array of several passive receivers located at strategic positions along the river to document movement patterns of 13 sturgeon with known viable acoustic tags. Preliminary data from the study indicate that several of the tagged sturgeon migrated up to the documented spawning habitat near RM 105, and at least one of the tagged sturgeon migrated up to the documented spawning habitat near Torreya State Park (Pine 2007 pers. comm.). A full analysis of the data has not been completed. Average flows in March, April, and May of 2007 were about 19,000, 14,000, and 7, 000 cfs, respectively. Spawning habitat availability at these flows varies between about 13 and 15 acres at the two sites known to support spawning (Figure 3.6.1.4.C of the 2006 BO). However, there are no data available indicating whether spawning occurred.

Two studies documenting Gulf sturgeon spawning and habitat in the Apalachicola River were conducted in 2005 and 2006 by the Service and University of Florida, respectively (Pine et al. 2006). Results of these studies are described in Section 3.6.1.4. We are currently conducting an additional study of Gulf sturgeon spawning to supplement these existing surveys. To date, we have documented spawning at the two known locations (RM 105 and RM 99), and one additional location at RM 100.3. This study is ongoing; therefore, complete results are not available.

The U.S. Geological Survey (USGS) conducted a study during October 2006-May 2007 to track the movement of juvenile sturgeon within the East Bay-Apalachicola Bay area (Sulak 2007 pers. comm.). USGS deployed an array of 14 passive receivers and tracked the movement of 4 juvenile sturgeon (age 1-2 fish) in the size range of 350-750 mm total length (TL). Of the tagged sturgeon, three (429-680 mm TL) reported back numerous times to individual receivers; though no reports were obtained for the fourth fish. The receivers also sampled data on larger adult Gulf sturgeon with viable tags from separate studies. A detailed report on these data has not been completed. However, preliminary information indicates that juvenile sturgeon remained very close to shore (within 1-3 km), and mostly in the East Bay area. After October 2006, no data were sampled from receivers within the Apalachicola River proper or East River proper until late March 2007, when the fish were moving in. Over the whole monitoring period, no data were obtained from the three receivers deployed further offshore in the bay. This suggests that early juveniles appear to be primarily using very shallow, nearshore areas as winter feeding grounds. Based on National Oceanic and Atmospheric Administration (NOAA) benthos data, these same areas have higher densities of polychaetes and amphipods (important prey items) than deeper areas of the bay. Based on the juvenile and adult sturgeon tracking data, it appears that small juveniles stay close to shore and are heavily using the East Bay area, while the larger sturgeon are using the same areas, as well as additional areas farther out into the bay proper (Sulak 2007 pers. comm.).

Studies to estimate the size of the adult Gulf sturgeon population below Woodruff Dam have been conducted periodically since 1982. Researchers noted that Gulf sturgeon congregated in the area immediately downstream of Woodruff Dam during the summer months, with little movement out of area during their residency, which provided an opportunity for relatively unbiased population estimates using capture/recapture methods. Population sizes from these

studies have ranged from a low of 62 fish in 1989 to 350 fish in 2004 (Wooley and Crateau 1985; Zehfuss et al 1999; USFWS Annual Report 1983-2005). Our attempts to repeat these estimates in 2005 and 2006 were not successful due to low capture rates.

The Gulf sturgeon population in the Apalachicola River appears to be slowly increasing relative to levels observed in the 1980's and early 1990's (Pine and Allen 2005). The majority of sampling in the Apalachicola River has occurred below Woodruff Dam which is one of several known population aggregation areas within the Apalachicola River system (Wooley and Crateau 1985, Zehfuss 2000). Since 2001, we have captured and tagged 440 sturgeon in the Brothers River (USFWS Annual Reports 2001 through 2005; Parauka 2006 pers. comm.). Pine and Allen (2005) suggest that a monitoring program for the Apalachicola Gulf sturgeon population should rely upon a sampling scheme that includes sites, such as the Brothers River, as well as the established site at Woodruff Dam.

3.5.2 Fat threeridge

3.5.2.1 Current Distribution in the Action Area

Eighty-four percent of the currently occupied range of the fat threeridge (111.2 out of 132.5 river miles) falls within the action area of this consultation. Two sites of the species range are outside the action area: a site at the upstream end of Dead Lake on the Chipola River, and a site on the lower Flint River. These latter two sites are literally on the upstream fringe of the species' extant range and probably support less than 1% of the species' total abundance. Known locations of fat threeridge in the action area are displayed in Figure 3.5.2.1.A, and many were discussed in Section 2.2.4.1. Recent surveys in the Apalachicola River and its tributaries and distributaries include Brim Box and Williams (2000), Miller and Payne (2005, 2006, 2007), EnviroScience (2006a), FFWCC (unpub. data 2007), and our recent surveys in 2006 and 2007. In addition, CSU conducted surveys in 2006 and 2007 in the Chipola River and found five additional sites with fat threeridge in the action area.

The fat threeridge has been recently collected near the tailrace of Woodruff Dam (RM 106) and at various locations downstream to RM 15.3 on the south end of Bloody Bluff Island. However, the bulk of the population (46%) is located between RM 40-50, and we estimate a significant portion resides in the Chipola River downstream of Dead Lake (see Section 3.5.2.2). Results of extensive sampling in the Apalachicola system from 2005-2007 confirm that the fat threeridge is locally abundant in the appropriate habitat (see description below) of the Apalachicola River from RM 40 to 50 and the Chipola River and Chipola Cutoff (EnviroScience 2006a; Miller and Payne 2006; and our recent surveys in 2006 and 2007). In these surveys, it was fourth-most to most common species collected, representing anywhere from 10-36% of the total mussels collected (EnviroScience 2006a; Miller and Payne 2005, 2006). The fat threeridge has also been detected in the Florida River, Kennedy Creek and in the inflow of Brushy Creek Feeder B (Miller unpub. data 2001; EnviroScience 2006a; FFWCC 2006). Of note, it was previously abundant in the upstream-most portions of Swift Slough, but most of the population in Swift Slough perished in 2006 and 2007 at flows between 5,000 to 10,000 cfs (see Section 3.5.2.2.). It was also once abundant at the shoal located near RM 105; however, live specimens have not been collected there since 1981.

In May of 2007, the Service began to formulate a hypothesis for identifying suitable fat threeridge habitat. The hypothesis is based on characterizing sites in the RM40-50 reach where mussels were found at high densities in the summer of 2006. Our observations indicated that sites with fat threeridge had banks that were not eroding, a gentle slope of less than 15 degrees, and firm silty-sand substrate. These were aggrading portions of the channel that often had young willows present. We surveyed the entire reach between RM40-50 and found fat threeridge at all of the 26 sites that fit these criteria. We also quantified the habitat at 10 of these sites using standard survey equipment to describe channel bathymetry from the water surface to a depth of 3 ft (extent of mussel beds) relative to Wewa gage height of 11.2 ft. Results of the habitat surveys indicated that the average width of the 10 sites was 34.3 ft, and the average length was 433.3 ft. At this time, it appears that the main channel habitats favored by the fat threeridge are moderately depositional areas associated with eddies.

Using this information, we surveyed the entire Apalachicola River from Woodruff Dam to RM 24, identified all potential fat threeridge habitats matching this description, and delineated the length of each site. Where possible, we performed a quick presence-absence survey to verify the presence of fat threeridge in these habitats. Because the site length varied by river mile, we tallied the number of sites by 10-mile segment and averaged the site length by 10-mile segment. To calculate the area of each site, we applied a mean site width from the RM40-50 reach to the total number of sites in each segment. Several of these locations came from survey data provided by FFWCC during their sampling efforts in the fall of 2007. Because we have not yet delineated the lengths of these five sites, we describe them using the average site length in the reach.

We have not yet had the opportunity to perform these habitat surveys in the Chipola River, although we know that high density sites of fat threeridge occur in the action area (see Table 3.5.2.2.B). We have observed that the type and amount of habitat available in RM40-50 and the Chipola River is similar. Therefore, to account for the potentially large amount of habitat available in the Chipola River, we estimated the amount of available habitat using RM40-50 as a reference. The length of the Chipola Cutoff and Chipola River downstream of the Cutoff was calculated in GIS to be 17 miles. Assuming the amount of habitat in RM40-50 is similar (26 sites/10 miles), then we expect about 43 sites to occur in the action area. We also assumed the average width and length of each site in the Chipola River is similar to the average site width and length measured in RM40-50 reach (34.3 x 433.3 ft), which results in an estimated 14.6 acres of fat threeridge habitat in the Chipola River.

During habitat surveys, we located 115 sites in the Apalachicola River that fit the fat threeridge habitat description, and fat threeridge presence was documented at 93 of these sites (81%). The remaining 22 locations need to be sampled to verify fat threeridge presence/absence. Data provided to us by the FFWCC lend credence to our habitat search image. FFWCC searched an additional 14 sites that were not identified as fat threeridge habitat; however, no individuals were detected during these qualitative searches. In total, all the sites in the Apalachicola River represent about 59 acres of fat threeridge habitat in the main channel. The Chipola River may have an additional 15 acres for a grand total of 74 acres of fat threeridge habitat available in the entire action area. There is relatively less habitat available in the upper river, and the amount of habitat increases from RM 40-20. In RM40-50, where 46% of the population resides, there are

about 9 acres of habitat, which is only about 12% of the available habitat. Results of the fat threeridge habitat survey are summarized in Table 3.5.2.2.B.

The fat threeridge is generally found at water depths less than 5 ft in the Apalachicola River (Miller and Payne 2005; EnviroScience 2006a; EnviroScience unpub. data 2006). Miller and Payne (2005) found that it was most abundant at depths ranging from 3 to 5 ft (highest abundance at 4 ft). It was much less common in waters deeper than 5 ft and shallower than 3 ft. EnviroScience (2006a) found most fat threeridge within 5 m of the shoreline at depths less than 5 ft. Both of these surveys (Miller and Payne 2005; EnviroScience 2006a) were conducted at discharges generally greater than 9,000 cfs; however, similar patterns of fat threeridge distribution depths are also observed when flows are much lower (about 5800-6000 cfs). EnviroScience sampled a main channel location (RM 46.8) on 7 August 2006, finding a majority of the fat threeridge at about 3 ft deep and 99% at depths of less than 4 ft (EnviroScience unpub. data 2006). Because the fat threeridge was found at similar depths at various flows, it likely prefers depths of less than 4-5 ft, and under prolonged stable flow conditions, it moves to maintain these depths.

In October 2007 during flows around 5,130 cfs, we sampled locations in RM40-50 across a large variety of depths to verify the observation that fat threeridge are most abundant at depths less than 4-5 ft. Quantitative depth distribution studies at depths up to 3 ft indicated that about 20% of the animals were located at depths less than 1 ft, 50% were located between 1-2 ft, and 30% were located at depths of 2-3 ft. Quantitative diving surveys were conducted at RM 44.3 and RM 43 on the same transects where animals were found in high densities at depths less than 3 ft. No fat threeridge were detected in any of the 27 deeper quadrat samples sampled (water depths ranged from 4 to 13 ft) at RM 44.3. An 84 minute search along a transect (4-20 ft deep) at RM 43.0 yielded only one fat threeridge at about 7 ft deep. The substrate at all but one depth consisted of coarse sand only. The divers noted that in areas of strongest current, the bottom was shifty, and sand was forming small dunes as it moved downstream.

In addition, timed qualitative searches were conducted at depths ranging from 3-12ft along steep banks of outside bend areas near these two sites. The CPUE (per hr) for fat threeridge was 15 (RM 44.3) and 60 (RM 43). At RM 44.3, the diver described that at about 8 ft deep, the steep bank flattened out, and most fat threeridge were collected from that depth in the flat area with lower shear stress. At RM 43, divers collected mussels at all depths, however the majority of fat threeridge collected, came from shallower depths (approximately 3-5 ft). It should also be noted that the RM 43 site was directly adjacent to the downstream-most transect at a high density fat threeridge site, and this is likely the reason for the higher CPUE of fat threeridge. In all, our data also support the claim that the majority of fat threeridge are present at depths less than 4-5 ft.

3.5.2.2 Population Status and Trends in the Action Area

Apalachicola and Chipola River Population Estimate

Several additional studies were conducted recently in order to better assess the population of fat threeridge on the Apalachicola River. Miller and Payne (2007) is the result of work conducted for the Corps to determine the number of fat threeridge that would be affected by a water level

decline. This survey was conducted in shallow water (up to 3 feet deep) on July 7-11, 2007, at 25 locations between RM 40 and RM 50. Miller and Payne speculated that the number of fat threeridge at these sites could be 19,000 individuals, assuming a 1 m-wide band of occupied habitat and using a relationship between CPUE and density. However, this estimate is in error. The Service later learned that an incorrect regression equation formed the population estimate (A. Miller 2007 pers. comm.), and that the band of occupied habitat is much wider than 1-m (USFWS data, described below). The correct regression equation showing the relationship between CPUE and mean density (m^2) is presented in Figure 3.5.2.2.A.

The Miller and Payne (2007) quantitative data were sampled at discrete depth intervals. They described mussel density only at particular elevation contours (i.e., 1 ft, 2 ft, and 3 ft). Their study also did not measure the relative amount of habitat available at these elevation contours, thereby precluding estimation of mussel numbers (density by area) that would be affected by a water level decline. Due to the limitations of this study, the Service re-sampled the 10 quantitative sites plus one additional site with quadrats placed on transects at all depths from the water's edge to 2-3 ft deep. These were the same sites where we measured habitat and found the average site width and length was 34.3 ft and 433.3 ft, respectively (Section 3.5.2.1). We use these data to estimate the abundance of fat threeridge in RM 40-50 and to assess the effects of water level declines on the fat threeridge population. Results of the mussel survey are summarized in Table 3.5.2.2.A. This survey took place at flows around 5,000 cfs, and no mussels were surveyed above 5,000 cfs because mussels in these areas died during low flows in 2006 and 2007. Based on the density estimates and habitat surveys, we developed a relationship between the numbers of fat threeridge and depth (see Chapter 4). This relationship allowed us to calculate a population estimate of about 107,700 individuals for these 10 river miles, which is about 10% of the range and 12% of the available habitat for the species.

To better understand the population in the entire action area, we relied upon additional data. In addition to the quantitative sampling, the Service, FFWCC, and biologists from CSU also qualitatively sampled mussels using timed searches at several additional sites that met the habitat criteria described in Section 3.5.2.1 (e.g., moderately depositional habitat). We then used the corrected relationship between qualitative and quantitative sampling conducted by Dr. Miller to predict density of fat threeridge. Since habitat and density at sites outside the RM 40-50 reach varies, we averaged the predicted densities from the timed searches within 10-mile segments of the river. Estimating numbers from mean density predicted for each 10-mile segment of the river requires a measure of habitat area for each 10-mile segment, which is discussed in Section 3.5.2.1 and provided in Table 3.5.2.2.B. We tallied the number of sites and averaged the site length by 10-mile segment and applied a mean site width from the RM40-50 reach to the total number of sites in each segment. Average density per segment multiplied by total habitat area per segment produced the abundance estimates given in Table 3.5.2.2.B. Note that the densities in Table 3.5.2.2.B are substantially less than the mean density of 0.30 animals/ft^2 measured in the RM40-50 reach. We estimate that there are about 62,400 individuals in the Chipola River and Cutoff, and about 63,400 individuals in the RM106-50 and RM40-20 reach. Combined with the separate estimate of about 107,700 individuals in the RM40-50 reach based on our quantitative samples, our total population is currently about 233,500 fat threeridge in the action area.

Swift Slough Population Estimate

EnviroScience (2006b) provided the Service a population estimate for the fat threeridge in Swift Slough in 2006 based on data collected August 3 to August 7, 2006. The estimate applied to the upstream-most mile of the stream and not to the next half mile in which EnviroScience (2006a) found much lower numbers of fat threeridge during their previous survey in 2005. The population estimate methods followed Strayer and Smith (2003). The upper portion of Swift Slough was divided into 35 stream reaches of equal length (50m), from which four randomly selected sites were sampled using quantitative systematic sampling with three random starts. The four quantitative sample sites were each 50m by 9m = 450 m^2. The full channel area beneath bankfull elevation was not sampled, because most mussels occurred at elevations beneath the toe of the banks, which they estimate is inundated by flows of approximately 6000-6300 cfs (EnviroScience 2006b).

The density estimates for the fat threeridge at 4 sites on Swift Slough are presented in Table 3.5.2.2.C. The estimated abundance per sampled reach was used to calculate an average abundance estimate of 787 (462-1473 90% CI) fat threeridge per 50m reach. This abundance estimate was then multiplied by the 23 50-m reaches representing the upstream-most segment of Swift Slough for a population estimate of 18,101 (10,626 – 33,879 90% CI) in August of 2006. This estimate excluded pool habitats, areas occupied outside of the upstream segment, and bed elevations above the stage associated with 6,300 cfs at the Chattahoochee gage. All of these excluded areas contain some fat threeridge; therefore, the total number of fat threeridge in Swift Slough in August of 2006 was likely greater than 18,101. Swift Slough is also in the action area, but most of the population in Swift Slough perished in 2006 and 2007 at flows between 5,000 to 10,000 cfs (see below).

2006 and 2007 Mortality

An extended drought from 1999 to 2002 resulted in reduced flow, lower surface water elevation, and many disconnected loop streams, backwaters, tributaries, and distributaries in the Apalachicola River. Concern over the possibility of insufficient storage for flow augmentation prompted the Corps to initiate a study in November 2003 to determine the depth distribution of the fat threeridge in order to evaluate the effects of low water on its survival (Miller 2005). Estimates of water level elevations at discharges in 1,000 cfs intervals from 3,000 to 10,000 cfs were made and used to estimate the percentage of the fat threeridge population that would be exposed at each discharge. Sites were grouped by location in the river. Group A included RM 30.0, group B included RM 41.5, 46.8, 48.4, and 49.0, and group C included RM 73.3. The percentage of fat threeridge that would be exposed at these locations (provided they did not move with receding water levels) can be found in Table 3.5.2.2.D. Results varied by location in the river, but a large percentage of the fat threeridge populations in groups B and C would be exposed at discharges less than 6,000 cfs. At location B, 77% and 60% of the population would be exposed at flows of 5,000 and 6,000 cfs, respectively. Location C would fare better with about 46% and 34% of the population exposed at 5,000 and 6,000 cfs, respectively (Miller 2005). The locations in groups B include some of the most abundant populations of fat threeridge in the main channel (i.e., RM 40-50). These results should be interpreted with care

because the mussels likely move as the water level recedes; however, this study can be used to predict the consequences of the 2006 drought.

During the summer of 2006, thousands of fat threeridge were exposed in portions of the Apalachicola River during low flows, which resulted in a die-off on a scale never before observed. To investigate this mortality, the Service conducted a limited survey of listed mussels in the main channel of the Apalachicola River (RM 40-50), the Chipola Cutoff, Swift Slough, and the large rock shoal near RM 105 during June 2006. There were seven sites in RM 40-50 and Chipola Cutoff and several sites within Swift Slough where mussels experienced extensive stranding and mortality. Several thousand fat threeridge were found exposed and/or dead, and results of the survey are summarized in Table 3.5.2.2.E.

With the exception of the rock shoal, we measured the elevation of all mussels found relative to the current water surface elevation, noted the daily average gage height on the nearest gage to each site, and estimated the Chattahoochee gage flow equivalent to these elevations using stage/discharge relationships in Light et al. (2006). We found mussels at stages equivalent to less than 4,500 cfs (the lowest flow given in these relationships) to as high as about 10,000 cfs. At several sites in RM 40-50, Chipola Cutoff, and Swift Slough, we observed fat threeridge mussels expelling glochidia onto the substrate, which is a clear sign of stress (Lefevre and Curtis 1912). We also relocated 841 fat threeridge in 50 minutes of direct effort from a site where they were in very hot (over 40°C) and shallow water with no flow. No other areas of listed mussel strandings in the Apalachicola River were reported to us.

During the summer and fall of 2007, we continued to observe additional mortality of fat threeridge at the sites in RM 40-50 and Swift Slough at flows greater than 5,000 cfs. High numbers of fat threeridge died at several vulnerable sites in RM 40-50. About 98% of the total 18,101 fat threeridge in Swift Slough died in 2007 (Hoehn 2007 pers. comm.). We further discuss the estimated amount of mortality in the Apalachicola River later in this section.

Most of the mussel mortality we observed was in the RM 40-50 reach of the river, and it was either in elevated side channels along the main channel of the river and Chipola Cutoff, or in Swift Slough. We considered several possibilities to explain why we observed so many fat threeridge (and other species) exposed or stranded in these areas during 2006 and 2007. First, we considered whether these particular areas were sites of extraordinary recruitment during the past few years. Flows during the summer of 2006 and 2007 were no lower than occurred only a few years ago from 1998 through 2002, at which time we did not observe a mussel die-off. The length-at-age data, however, demonstrated that these side channel areas and Swift Slough were populated by a full range of ages, and that most would have been spawned before 2002.

Second, we considered the possibility of substantial mussel movement into these side channels and Swift Slough. The depth distribution data discussed in Section 3.5.2.1 strongly suggest that the fat threeridge moves in response to changing river stage, as it is found generally at depths of less than 4-5 ft regardless of the stage at the time of the survey. Prior to 2006, river flows were not less than 8,000 cfs except for very brief periods since the fall of 2002. Sustained higher flows for several years could account for a net movement of mussels from deeper portions of the main river into the elevated side channel areas along the main river and Chipola Cutoff, but

would probably not account for the large numbers of mussels in the upstream-most mile of Swift Slough.

The third, and we believe the most plausible explanation for the unprecedented mussel exposure in 2006 and 2007 is the movement of a large amount of sediment in the main channel and into distributaries during either of two extended periods of very high flow during 2005. This sediment movement either carried mussels with it into new areas or aggraded areas in which mussels were already present. The first flood event, in late March through early May, 2005, exceeded 50,000 cfs for 18 days, reaching a daily average discharge peak of 158,000 cfs. The second event, in July, 2005, exceeded 50,000 cfs for 15 days, reaching a daily average discharge peak of 112,000 cfs. It is our observation that fat threeridge are consistently found in moderately depositional hydraulic eddies of the channel, and these areas would have received sediment following these high flow events. Depositional areas are, by definition, aggrading over time, and without lateral movement, mussels remaining in these areas will necessarily rise with the substrate to higher stages that are more vulnerable to low flows. Although the first flood event in 2005 peaked higher than the second did, it may be more likely that large numbers of fat threeridge were moved onto higher portions of the streambed during the second event in July. The fat threeridge is reproductively active in the late spring and early summer (see section 2.2.3.3.1). Sexually mature animals necessarily come to the streambed surface to reproduce in late May and June, and we observed many at the surface in July 2006. di Maio and Corkum (1995) suggested that freshwater mussels withstand the scouring action of floods by burrowing deeper into the substrate. It is relatively more likely that the July 2005 flood moved the fat threeridge, as they would have already been near or at the surface for reproduction.

Our hypothesis is consistent with several observations:

1) In August of 2000 during low flow (< 6,000 cfs), the Service actively searched the RM 40-50 reach of the river for evidence of listed mussel exposure and stranding. We found none on the main channel and only a few dead fat threeridge and purple bankclimber in various tributaries and distributaries (USFWS letter to the Corps dated August 10, 2000).
2) In the same time frame, two experienced USGS mussel surveyors, assisted by personnel from the Service, Corps, and FFWCC, thoroughly searched the upstream-most 100 m of Swift Slough finding a total of 17 live fat threeridge.
3) Several thousand fat threeridge were found exposed in the same areas searched under 1) and 2) above in the summer of 2006 and 2007 during comparable low flow conditions. These animals were readily apparent to anyone venturing into Swift Slough or along the stream margins of the main channel between RM 50 and RM 40. Estimated age of animals in these areas ranged from <2 to >27, ruling out an alternative hypothesis that fat threeridge in the exposed areas represented recruitment following the last extended period of low flow during 2002.
4) According to our 2006 survey, the upper portion of Swift Slough had higher CPUE than the locations further downstream (CPUE = 144.0 vs. 18.7 and 13.3, respectively; Table 3.5.2.2.A). EnviroScience (2006b) also reported that densities decrease downstream. This supports the theory that the mussels were deposited by high water, since most were deposited in the upstream-most areas and become less dense as you get deeper into the slough.

5) Swift Slough and nearly all of the other locations on the margins of the main channel where mussels were exposed in this reach appear to have substantially aggraded (filled) with sediment in the period since flows were last as low as 6,000 cfs (2002). Swift Slough was connected to main channel at a flow of about 5,000 cfs during 2000, and in 2006 it was disconnected from the main channel at a flow of about 5,600 cfs. We do not know the current flow at which Swift Slough is disconnected because the area at the mouth of the slough continues to aggrade.

We found listed mussels exposed in 2006 at elevations associated with a Chattahoochee gage flow of as high as about 10,000 cfs. Some of these animals have survived in these areas by burrowing and by movement into local thermal refugia. Estimates of mortality varied by site and date of survey (range: 8 to 98%, EnviroScience unpublished data and Table 3.5.2.2.D). We may expect further mortality among the survivors in the foreseeable future when flows are less than 10,000 cfs, especially if these flows occur during the warmer months of reproductive activity. If our hypothesis is correct about how these mussels came to be in areas that are so regularly vulnerable to exposure (flows less than 10,000 cfs occur in almost all years of the Chattahoochee gage record and flows less than 8,000 occur about 1 out of every 2 years), future high flow events could move yet more animals from the unstable main channel into shallow water habitats vulnerable to being exposed at low flows.

To quantify the mortality that occurred in 2006 and 2007 at flows greater than 5,000 cfs, we used information from the population estimate described above. There were seven sites in the main channel of the Apalachicola River (RM40-50) and Chipola Cutoff where mussels experienced extensive stranding and mortality during the summer of 2006. Because we do not have animal density or area information for those sites, we applied our estimate of the mean dimensions of the sites in RM40-50 to our mean density of fat threeridge in those same sites to get a number of individuals per site. We multiplied the number of individuals per site by 7 for an estimate of about 31,200 individuals that died in those seven sites at flows between 6,500 and 5,000 cfs.

In addition to mortality at main channel sites, we know that significant mortality also occurred in Swift Slough in 2006 and 2007 at flows greater than 5,000 cfs. The total population estimate of fat threeridge in Swift Slough was about 18,100 individuals at the end of the summer 2006. This number did not include dead individuals at elevations corresponding to a Chattahoochee gage discharge of greater than 6,300 cfs. However, EnviroScience Division Manager Greg Zimmerman (2007 pers. comm.) estimated that about 5% of the total population was already dead at these higher elevations. Therefore, about 900 fat threeridge were already dead at the time they were surveyed in August 2006. FFWCC biologist Ted Hoehn (2007 pers. comm.) reported that estimated mortality from tagged individuals in Swift Slough during 2007 was about 98%. If tagged individuals died at the same rate as the rest of the population, about 17,700 fat threeridge in Swift Slough died during 2007, and less than 400 individuals remain alive in Swift Slough today. Overall, we estimate that a total of about 18,600 (i.e., 900 + 17,700) fat threeridge have died in Swift Slough at flows less than 10,000 cfs. This number may be even higher based on further decreased flows that occurred in November and December of 2007.

Combined mortality estimates from Swift Slough and the 7 main channel sites suggest that about 50,000 fat threeridge died at flows greater than 5,000 cfs in 2006 and 2007. To calculate the

total percent mortality from 2006 and 2007, we considered the total number of fat threeridge alive today (233,500) and added the total mortality for these 2 years (50,000) for a total population estimate of about 283,500 fat threeridge in 2006 before the drought-induced mortality began. If these estimates are accurate, this mortality represents about an 18% reduction of the population size in less than 2 years.

Additional mortality occurred in November and December of 2007 as a result of flows less than 5,000 cfs. Incidental take of fat threeridge was authorized in the EDO when releases from Woodruff Dam are less than 5,000 cfs (or less than the current operational release of 5,130 cfs). The Corps developed criteria and triggers, and conditions warranted the reduction of flows to no less than 4,750 cfs from November 16 to December 17, 2007. For incremental flow reductions to 4,750 cfs, a maximum of 5,600 fat threeridge were authorized to be exposed in the Apalachicola River, Chipola Cutoff, and Chipola River downstream of the Chipola Cutoff.

The Corps implemented surveys to estimate listed mussel mortality associated with the incremental flow reductions. By letter dated December 7, 2007, the Corps provided the findings of this evaluation to the Service. In summary, the Corps randomly selected 31 of 100 known fat threeridge sites for take monitoring, of which 42% were within the RM 40-50 reach. At each site, they recorded the CPUE of exposed mussels along a standard length of shoreline at each site. The actual take estimation includes a composite of three separate take estimations within the action area: 1) 108 individuals in “nonvulnerable” sites sampled along the river channel shoreline; 2) 62 individuals in Chipola slabshell sites; and 3) 1,299 individuals in “vulnerable” sites located in depositional areas of lateral channel migration. The Corps estimated that a total of 1,469 individual fat threeridge were taken as a result of the flow reduction to 4,750 cfs. This take resulted in the mortality of an additional 0.5% of the total population and did not exceed the authorized incidental take of up to 5,600 fat threeridge mussels.

The impact of the loss of about 18.5% of the population in less than 2 years is substantial. At this time, therefore, we believe the current population trend for the fat threeridge in the action area is declining.

Status of Recruitment

To get an idea of the status recruitment and relative year class strength over time, we examined the quantitative data sampled by the Service in October 2007. The life history of many freshwater mussels, including the genus *Amblema*, is characterized by a relatively long lifespan, delayed age of maturity, high fecundity, extremely low juvenile and high adult survivorship (McMahon and Bogan 2001; Haag and Staton 2003). This type of life history ordinarily displays an exponential decline in numbers at age over time known as the Type III survivorship curve (Gotelli 2001). Although all recent surveys have reported evidence of recruitment in the main channel of the Apalachicola River, Swift Slough, and the Chipola River and Cut, our quantitative data of numbers of individuals by age show few individuals in the youngest age classes (Figure 3.5.2.2.B). Because the collection method for these data included substrate sieving to target young individuals, we would expect an exponential decline of year class numbers, but this pattern is not displayed. The year classes from 2005 to 1998 appear to be under-represented in this sample. It is also possible that 1993 to 1997 was a period of exceptionally high recruitment; however, the form of the curve and the other data described below seem to suggest the former. It

is interesting to note that 1993 to 1997 were relatively "normal" flow years; whereas, 1998 to 2005 included wet and dry years. More information about recruitment strength of fat threeridge is necessary, but we now believe the most likely explanation is either poor recruitment from 1998 to 2005 and/or sampling bias towards larger, older individuals.

The potentially under-represented younger age classes concerned us, so we examined other quantitative data sampled by EnviroScience (2006), which used the same methods as we did in our October 2007 survey. We predicted ages from total length data provided by EnviroScience using the age-length relationship, and plotted the number of individuals by year class (Figure 3.5.2.2.C). The EnviroScience data show the same pattern as our data, namely that all year classes since 1997 are under-represented. In both data sets from two different years, the 1997 year class is the peak, providing further evidence of poor year class formation in the last nine years.

In the 2006 BO, we presented similar information from qualitative data (Figure 3.5.2.2.D) where the year classes post 1999 were under-represented. The peak began with the 1999 year class, and the difference here is the use of the old length-age relationship from the 2006 IOP BO, which has since been updated with more known-age individuals. Because smaller animals are less detectable in timed searches than larger animals, we interpreted this lower-than-expected frequency of younger animals as an artifact of our qualitative sampling methods. Since this pattern is also evident in the quantitative samples described above, which are not subject to the same size-detectability bias, we now believe that poor recruitment and/or survival of the last nine year classes is occurring.

We can also use these number-at-age data to calculate annual fat threeridge survival using catch curve regression analysis. Catch curves are computed by regressing the natural log of the number of individuals at each age against age or year class. This method is appropriate for populations with relatively stable age-structure, as illustrated by an exponential decline between year classes (van den Ayvle and Hayward 1999; Slipke and Maceina 2001). As described above, many mussels (including the genus Amblema) display a Type III survivorship curve (Gotelli 2001). We acknowledge above that the exponential decline in numbers is not observed in the current fat threeridge data until the 1997 year class, which may indicate poor recruitment in the last decade; however, catch curves can still be applied to these data (Miranda and Bettoli 2007). For example, reasonable estimates of mortality can be calculated from species that usually exhibit erratic recruitment, such as crappies (Allen 1997). If this population of fat threeridge is experiencing steadily declining recruitment, then annual survival will be overestimated (Miranda and Bettoli 2007).

We performed catch curve analysis of number-at-predicted age data from our October 2007 quantitative sampling efforts in the Apalachicola River (RM40-50). Results from weighted catch curves for adult fat threeridge (age 3+) indicate that the overall annual adult annual survival rate is about 89% (0.89 ± 0.05; $p < 0.001$; $R^2 = 0.46$; Figure 3.5.2.2.E). This catch curve analysis is different from results presented in the 2006 IOP BO, which indicated that the annual survival rate was about 82%. As described above, the sampling method of the available data did not target smaller individuals. We believed the younger year classes were not fully susceptible to the sampling methodology and excluded ages less than 8 from further analysis. Data from 2007

used in the current catch curve analysis was quantitative quadrat sampling that included sieving the substrate to target younger year classes; therefore, adult fat threeridge are fully recruited to the gear. The inclusion of these younger year classes results in a "flattening" of the curve, such that the overall annual survival rate is higher than observed using qualitative data in 2006.

Population Viability Analysis

Given the significant drought-induced mortality in 2006 and 2007 and possible poor recruitment of the last ten years, we needed a tool to investigate current and future risk of fat threeridge population decline. We contracted Dr. Phillip Miller of the Conservation Breeding Specialist Group to develop a population viability analysis (PVA) to evaluate the current status of the population and explore which demographic parameters may be the most sensitive to alternative management practices. The information that follows is a summary from the report; refer to Miller (2008) for more detailed description of the methods. It is important to note that PVAs are sensitive to various assumptions made during model development, all of which can affect the accuracy of the output and conclusions. Rather than place importance on the exact quantitative values, we used these models to provide a more qualitative assessment of the species status.

A stage-structured population matrix model of fat threeridge demography was developed with input data on stage-specific fecundity and survival rates. The model included only females (i.e., number of female offspring produced by a given adult female and survival rates of females in each stage class), which is commonly used when there are few if any measurable differences in demographic behavior between males and females. Importantly, this reduces the number of required variables and their measurement uncertainty. The model assumed that fat threeridge life history could be described by assigning individuals to one of five different stages based on size or age. Stage classes and associated survival and fecundity estimates were derived either from available fat threeridge or by using a closely related congener, *Amblema plicata* and include the following assumptions:

1. Fat threeridge females reach sexual maturity at three years of age (37 mm total length using von Bertalanffy analysis in Section 2.2.3.2) based on information derived from a closely related congener, *Amblema plicata* (Haag and Staton 2003; Haag 2008 pers. comm.).
2. Individuals ≤ 29 mm are young of the year, as calculated using the von Bertalanffy relationship between length and age discussed in Section 2.2.3.2.
3. Because fecundity in *A. plicata* increases exponentially with age, multiple adult stages were used to best describe the length-fecundity relationship (Haag and Staton 2003).
4. Stage-specific fecundity rates were calculated using sex ratios, gravidity, and length-maternity relationships derived by Haag and Staton (2003) in *A. plicata* in the Sipsey and Little Tallahatchie rivers (Alabama and Mississippi).
5. Survival of glochidia to one year was estimated used fat threeridge data available from quantitative sampling by the Service in October 2007.
6. Lacking data to suggest otherwise, mean annual survival in adults (age 3+) was assumed to be constant throughout their adult lifespan.
7. The best available method to calculate adult fat threeridge survival in the Apalachicola River was to use catch curve analysis from our October 2007 quantitative sampling

efforts in the Apalachicola River (RM40-50). Results from weighted catch curves for adult fat threeridge (age 3+) indicate that the overall adult annual survival rate is about 89% (0.89 ± 0.05), or p_{Ad}=0.89. There is uncertainty about this estimate especially because it is based one year of data; therefore, it was used as a lower bound on adult survival.

8. As an upper bound, the annual survival rate of p_{Ad} = 0.98 (± 0.05) reported by Hart et al. (2004) for *A. plicata* in the Mississippi and Otter Tail Rivers in Minnesota was used because it was derived from multi-year data. There is also uncertainty about this estimate especially because it is from a congener in a different climate and geographic region.
9. Because of the uncertainty in both survival estimates, a third estimate was derived by assuming a long-term stable stochastic growth rate and then back-calculating a value of p_{Ad} that would result in a stable population. This analysis produced an estimate of p_{Ad} = 0.9125.
10. The model included a total population size estimate of 234,000 fat threeridge mussels in the Apalachicola River as described in the EDO. Because it is a female-only model, the initial population size is reduced by 50% to 117,000 individuals.
11. The total average habitat carrying capacity was calculated to be approximately 1 million female mussels, based on multiplying the total amount of available habitat in the Apalachicola River by the maximum fat threeridge mussel density observed in the river.

The description of the five stages used in the PVA models is given in Table 3.5.2.2.F. The model also included annual environmental variation (EV) in demographic rates and demographic stochasticity. Based on observations of mussel demographics within the Apalachicola River, it was assumed that complex forms of density dependence do not operate in the population under study. Current mussel densities are relatively low in the Apalachicola River compared to other systems (Holland-Bartels 1990; Miller 2000b; Miller and Payne 2007), and there is no evidence of limited resources. Based on Haag and Staton (2003), Allee effects were also assumed not to be an issue. Density dependence under high densities was included in the form of carrying capacity (K) with an annual variability in K. All stochastic population projections were simulated 1000 times. Each projection extended 50 years, and demographic information was obtained at annual intervals. All simulations were conducted using RAMAS METAPOP version 5.02 (2007). Confidence intervals on population growth and quasi-extinction rates were not calculated. Instead, uncertainty was evaluated using the worst and best case scenarios of adult survival, and therefore, estimates of extinction risk.

To better understand the status of the population, the annual population growth (λ) was estimated using deterministic (assumes no random variability in demographic rates or density dependence) and stochastic (includes environmental and demographic stochasticity) analyses of the population projection matrices. λ values less than 1 indicate a population decline, and values greater than 1 indicate an increasing population. The lower bound on the estimated adult survival rate (p_{Ad} = 0.89) leads to a deterministic population growth rate that is approximately 0.98, indicating a population that is in a long-term, relatively slow decline. In contrast, the upper-bound on adult survival estimate (p_{Ad} = 0.98) leads to a population that shows a fairly vigorous 8% rate of increase in the long-term. The back-calculated adult survival rate required for a stable mussel population is confirmed through this analysis (λ = 1.0056 at p_{Ad} = 0.9125).

As expected, the stochastic population growth rates are slightly lower than their deterministic counterparts (Miller 2008) (Figure 3.5.2.2.F).

Population dynamics were also evaluated from the perspective of risk (i.e., how likely is it that a given population will grow or decline to a certain size). This was evaluated by plotting the quasi-extinction probability for a given simulation. Terminal quasi-extinction gives a probability that a population will be at or below a given threshold at the end of a simulation (50 years). As expected, under conditions of lower adult survival (p_{Ad} = 0.89) there is a very high probability (approximately 99%) that the final population size will be below the initial size of 117,000 individuals (Figure 3.5.2.2.G). In addition, there is about an 85% chance that the population will be reduced by about 50% of the initial size in 50 years, and a 50% chance that the population will be reduced by 70% in 50 years. However, when survival is high (p_{Ad}=0.98) the quasi-extinction curve is shifted significantly upwards.

The sensitivity of the models to measurement uncertainty of the different demographic parameters was also evaluated. The ability to generate precise predictions of population dynamics with any degree of confidence is impaired because these parameters were estimated with varying levels of uncertainty. However, an analysis of the sensitivity of the models to this measurement uncertainty can be used to decide which parameters are most important to the model output. The elasticity of the population growth rate (i.e., the proportional change in λ that results from a proportional change in one or another matrix element) was calculated to directly compare the sensitivity of population growth to changes in any one component. The results of the elasticity analysis indicate the dominance of survival within adult stages (P_i) in determining the final value of population growth rate, with increasing elasticity in larger (i.e., older) adults Figure 3.5.2.2.H. Therefore, female adult survival has the greatest impact on long-term population dynamics in this species (Miller 2008). This is consistent with results presented in Haag and Staton (2003) and Hart et al. (2004).

The interaction between population dynamics and the extent of environmental variability was also examined under the intermediate level of adult survival (p_{Ad}=0.9125) (Figure 3.5.2.2.I). Higher levels of demographic variability lead to a slightly lower population growth rate, a larger dispersion in final population size among independent iterations in the model and, consequently, higher quasi-extinction risks. However, the extent of the reduction in λ is rather small when compared to other species with similar levels of EV and subject to the same analysis. This is most likely due to the relative stability in long-term growth dynamics brought about by the long reproductive lifespan of fat threeridge (Miller 2008).

If we exclude the high adult survival model from consideration, the results from this simple analysis of the baseline models appear to be in accord with general observations of fat threeridge population dynamics in the field. Adult mortality estimates derived from catch-curve analysis of fat threeridge collected in the Apalachicola River yield a long-term deterministic population growth rate in our model of 0.9814. This is consistent with our belief that the fat threeridge population in the action area is declining or stable at best, especially given the loss of almost 19% of the population in 2006 and 2007 and the potentially poor recruitment of the last decade, although the long-term effects of the drought-induced mortality are unknown. Our data from the Apalachicola River suggest that adult survival is lower than observed in *A. plicata* in the upper

Midwest. Although it is lower, it is consistent with observations of *A. plicata* and many other species in the Sipsey and Little Tallahatchie rivers (Alabama and Mississippi) (Haag 2008 pers. comm.). Therefore, at this time we believe the most appropriate estimate of adult survival is the lower bound estimated from the catch curves, and the fat threeridge population in the Apalachicola River is in a long-term, relatively slow decline for the foreseeable future. As discussed in Sections 2 and 3, a number of factors may be contributing to its decline. However, results of the elasticity analysis stress the importance of more reliable estimates of adult female survival and its variability over time, in order to improve our understanding of the growth dynamics of the fat threeridge population in the Apalachicola River.

3.5.3 Purple bankclimber

3.5.3.1 Current Distribution in the Action Area

About 23% of the currently occupied range of the purple bankclimber (104.6 river miles) falls within the action area of this consultation. The purple bankclimber is only known from about 35 locations (Figure 3.5.3.1.A). It has been recently collected in the main channel of the Apalachicola River from the Woodruff Dam (RM 106) downstream to about RM 17.7. It has also been collected in Swift Slough, River Styx, a distributary that flows into Brushy Creek, and the Chipola Cutoff (EnviroScience 2006a; FFWCC 2006). It was also collected in the Chipola River upstream of Dead Lake but not within the action area (C. Stringfellow, unpub. data).

In 2007, various surveys were conducted separately by Dr. Andrew Miller, the FFWCC, and the Service on the Apalachicola River main channel. Survey type varied by location and included both dive and wadeable mussel surveys using qualitative, semi-quantitative, and quantitative methods. Combined, the surveys yielded only 105 bankclimbers at 11 sites between RM 22.3 and RM 105.5. In these surveys, as in previous surveys of the main channel (Brim Box and Williams 2000), bankclimbers were found to be locally abundant at the limestone shoals below Woodruff Dam near RM 105 (the FFWCC collected 84 individuals), but rare and sporadic from RM 22.3 to 103.2. Collection depths ranged from 0 to 13 feet, and most specimens were sampled at depths of 2 feet or less relative to the water surface (FFWCC 2007 unpub. data). No purple bankclimbers were collected during quantitative surveys conducted by Dr. Miller and the Service in RM 40-50.

The purple bankclimber is characterized as a species preferring the deeper portions of main channels (often at depths greater than 3 m) in the larger rivers within its range (Brim Box and Williams 2000; EnviroScience 2006a), which are more difficult to sample. Although our 2007 data suggest that most of the purple bankclimbers sampled were located at depths of less than 2 feet, we have not sampled many deeper areas of the river because it requires scuba diving. EnviroScience (2006a) expressed the view that deep-water habitat with stable substrate is rare in the Apalachicola River. We analyzed records provided by the Corps that list dredged volumes by navigation mile each year from 1957 to 2001 as a possible means to substantiate this view. Areas that do not require maintenance have at least a 9- to 11-ft by 100-ft wide central channel (the dimensions of the authorized navigation channel) relative to the reference flow used for dredging purposes. The Corps' records show that since 1992, 84.1 miles of the 105.4 miles between Woodruff Dam and RM 1.0 received no dredging. It is our view that portions of the

river contain deep-water habitat in relatively stable condition, but that these areas have been inadequately sampled for listed mussels.

3.5.3.2 Population Status and Trends in the Action Area

We do not have population estimates for the purple bankclimber in the action area or a length-at-age relationship from which to infer population structure, annual survival rates, or year class strength. This is mainly because purple bankclimbers are more difficult to locate on the Apalachicola River than fat threeridge (see above). Most of the sampling has been qualitative and only CPUE data is available. Recent survey data suggest it is perhaps the rarest member of the Apalachicola River mussel fauna. It represented less than 2% of the Corps' survey findings from 1996 to 2002 (Miller 2005), and 1% of the EnviroScience (2006a) survey findings in 2005, half of which were detected at a single location. The species represented much less than 1% of our surveys in 2006 and 2007. In addition, the species suffered mortality at several sites in the Apalachicola River and Swift Slough in 2006 and 2007, although the extent of mortality cannot be assessed.

While recent surveys have documented fat threeridge recruitment, we are aware of only three reports of relatively small purple bankclimbers collected recently in the action area: two at the shoal near RM 105 (70 and 75 mm), one in the Chipola Cutoff (75 mm), and one in Swift Slough (93 mm) (EnviroScience 2006a; Ted Hoehn 2008 pers. comm.). Based on known-age individuals (discussed in Section 2.2.3.2), all of these individuals are probably at least three years old. Bankclimbers sampled in the 2007 surveys ranged from 99-202 mm TL, and these individuals are probably all over six years old. The lack of young individuals suggests either poor reproductive success or sampling methods that are not suited to detecting juveniles of this species. However, in 556 quadrats sampled by the Service in October 2007 (RM40-50) at depths of less than 3 ft, no purple bankclimber recruitment was detected, and the substrate was sieved.

Although we lack the data to assess the status of purple bankclimbers in the action area, we do have some information about the effect of the recent reduction of flows to 4,750 cfs. Incidental take of purple bankclimber was authorized in the EDO when releases from Woodruff Dam are less than 5,000 cfs (or less than the current operational release of 5,130 cfs). The Corps developed criteria and triggers and conditions warranted the reduction of flows to no less than 4,750 cfs from November 16 to December 17, 2007. A maximum of 100 purple bankclimbers were authorized to be exposed on the rock shoal at RM 105 and at a few locations elsewhere in the Action Area. The Corps implemented surveys to estimate listed mussel mortality associated with the incremental flow reductions. By letter dated December 7, 2007, the Corps provided the findings of this evaluation to the Service. In summary, the Corps randomly selected 14 of 28 (50%) known purple bankclimber sites for take monitoring. The rock shoal area near RM 105 was divided into two sample sites due to its large size. At each site, they recorded the CPUE of exposed mussels along a standard length of shoreline at each site. No purple bankclimbers were observed to be fully exposed in habitat areas surveyed during the monitoring effort; therefore, the Corps estimated that no purple bankclimber take resulted from the reduction in flow. However, FFWCC reported that at least three purple bankclimbers were found dead at the shoal as a result these reduced flows. Purple bankclimbers were visible due to the reduced flows and may have been subjected to additional predation.

While flows were less than 5,000 cfs in November and December of 2007, the Service and the FFWCC monitored purple bankclimbers at the shoal at RM 105. The intent was to document movement and exposure of purple bankclimber at the highest density location. The Service collected and tagged a total of 46 bankclimbers at the upstream portion of the shoal while flows were near 4,750 cfs. Water depths searched ranged from 0 to less than 3 ft. Over 90% of the bankclimbers were at depths of less than 2 ft, 58% occurred in less than 1 ft, and 21% were found in water less than 6 inches deep. At least 4 individuals were partially exposed, but the Corps did not count these animals in the take estimate because they were not completely exposed. FFWCC monitoring took place in approximately the same location and at flows of about 5,000 cfs. They collected and tagged 93 additional purple bankclimbers in less than 3 ft of water. Over 99% were found in depths of less than 2 ft, 43% occurred in less than 1 ft, and one individual was found partially exposed in water less than 3 inches deep. The difference in numbers at depth between the FFWCC and Service data is due to differences in flow. Both the Service and FFWCC returned to this location to assess movement of tagged individuals. There was no evidence of movement for almost all of the recaptured tagged bankclimbers. A few individuals were relocated less than a foot from their original tagging location, but we later learned that FFWCC likely inadvertently moved these during some of their sampling.

Based on the rarity of the species, potential recruitment problems, and mortality experienced in 2006 and 2007, we classify the purple bankclimber in the action area as declining. However, more surveys are necessary in stable, deep water habitats throughout the river to better understand the population status in the river.

3.5.4 Chipola slabshell

3.5.4.1 Current Distribution in the Action Area

Researchers have only recently documented this species in the action area (Figure 3.5.4.1.A). In 2005, one individual was collected in the Chipola River about 2.3 river miles downstream of its junction with the Chipola Cutoff (EnviroScience 2006a). As described in Section 2.2.4.3, a 2006 status survey detected the species at four additional sites (79 total animals found), all in the Chipola River downstream of Dead Lake. If we assume that its range may include the full length of the Chipola River that is downstream of Dead Lake, the portion within the action area (13.8 river miles) would represent 14% of the total range of the Chipola slabshell.

3.5.4.2 Population Status and Trends in the Action Area

We do not yet have a population estimate for the slabshell. The recent survey conducted by CSU is a mix of timed searches, density quadrats, and untimed searches that were intended primarily to find sites that support the species, establish its current range, and gather life history information. We also lack evidence of reproduction in the action area. The available data cannot be used to assess the population status in the action area; however, it appears that the species did not suffer mortality similar to the fat threeridge during low-flow conditions in 2006 and 2007. We found no evidence of Chipola slabshell mortality during surveys of the Cutoff during 2006, and no mortality was reported in the Chipola River in 2006 or 2007.

Incidental take of Chipola slabshell was authorized in the EDO when releases from Woodruff Dam are less than 5,000 cfs (or less than the current operational release of 5,130 cfs). The Corps developed criteria and triggers and conditions warranted the reduction of flows to no less than 4,750 cfs from November 16 to December 17, 2007. A maximum of 100 Chipola slabshells were authorized to be exposed in the Chipola River downstream of the Chipola Cutoff during this time. The Corps implemented surveys to estimate listed mussel mortality associated with the incremental flow reductions. By letter dated December 7, 2007, the Corps provided the findings of this evaluation to the Service. In summary, the Corps surveyed four of five[1] known Chipola slabshell sites for take monitoring. At each site, they recorded the CPUE of exposed mussels along a standard length of shoreline at each site. No Chipola slabshell were observed in the exposed habitat areas surveyed during the monitoring effort. Therefore, the Corps estimated that no Chipola slabshell take resulted from the reduction in flow.

3.6 Status of the Critical Habitat within the Action Area

This portion of the environmental baseline section focuses on the designated critical habitats for the listed species, describing what we know about the physical and biological features that are essential to the species' conservation within the action area.

3.6.1 Gulf sturgeon

The Apalachicola is one of seven rivers known to support a reproducing subpopulation of the Gulf sturgeon (see "Status of the Species/Critical Habitat" section). The species has been reported in several other rivers that are not known to support reproduction, such as the Mobile River in Alabama and the Ochlockonee River in Florida, but among the seven spawning rivers, the Apalachicola is the largest, as measured by average annual discharge and by basin drainage area. The seven spawning rivers have been designated critical habitat for the Gulf sturgeon. The Apalachicola River critical habitat unit encompasses 173.65 river miles entirely within the action area of this consultation, which accounts for 10% of the river miles included in all seven riverine critical habitat units.

Most Gulf sturgeon of the Apalachicola subpopulation age 1 and older likely feed during some part of the year in Apalachicola Bay, which is also designated critical habitat for the species. The Apalachicola Bay estuarine unit encompasses 168,708 acres. Because the ecology of the bay is strongly influenced by freshwater inflow from the river, we include all portions of the estuarine unit in the action area. The Apalachicola Bay unit represents 12% of the estuarine acres designated as critical habitat for the species.

Because the action area includes both riverine and estuarine critical habitat, it may contain all of the PCEs that we determined are features essential to the species' conservation. The following is a summary of what is known about the status of these PCEs in the action area.

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[1] The Corps' letter states that they surveyed all four known sites of Chipola slabshell; however, they overlooked one site in the data we provided them.

3.6.1.1 Food items

Abundant food items, such as detritus, aquatic insects, worms, and/or mollusks, within riverine habitats for larval and juvenile life stages; and abundant prey items, such as amphipods, lancelets, polychaetes, gastropods, ghost shrimp, isopods, mollusks and/or crustaceans, within estuarine and marine habitats and substrates for subadult and adult life stages.

The status of food items for the Gulf sturgeon in both the river and bay is important. The Gulf sturgeon is a benthic (bottom dwelling) suction feeder. The type of invertebrates ingested vary by age and by habitat, which ranges from riverine to estuarine to marine waters of the Gulf. As described in Section 2.1.3.1, the following food resources are important to the Gulf sturgeon in the Apalachicola River and Bay: a) riverine freshwater insect larvae and detritus by YOY, b) aquatic insects (*e.g.*, mayflies and caddisflies), worms (oligochaetes), and bivalve mollusks by juveniles at the mouth of the estuary and suitable areas of the Bay, c) amphipods, lancelets, polychaetes, gastropod mollusks, shrimp, isopods, bivalve mollusks, and crustaceans by adult sturgeon when in marine and estuarine waters.

Age 1 fish and older most likely feed primarily near the mouth of the river and in the bay. Apalachicola Bay is shallow, averaging 1.8 to 2.7 m in depth. Soft muddy substrates comprise about 78% of the open water zone with the remainder divided between oyster reefs and sandy sediments with submerged aquatic vegetation (Livingston 1984). Livingston (1983) reported that the polychaete worm was the most abundant infaunal species found in the sediments of the Apalachicola Bay estuary during the winter months.

The Florida Department of Environmental Protection (FDEP) et al. (2000) conducted a benthic mapping study of Apalachicola Bay in 1999, finding that that polychaetes, bivalves, gastropods and amphipods dominated the total abundance. All of these organisms may serve as food items for Gulf sturgeon. This study noted that salinity was negatively correlated with average abundance and biomass of infaunal organisms, but positively correlated with average richness of infaunal organisms. Silty bottom areas had the lowest species richness, diversity, biomass and abundance. The study developed a benthic habitat quality (BHQ) index based on infaunal successional stages, with values greater than or equal to 5 indicating high-quality habitat. The BHQ for silt and sand (infauna subclass) were calculated at 6.0 and 6.9, respectively (FDEP et al. 2000).

The food resources for Gulf sturgeon in Apalachicola River (Unit 6) and Bay (Unit 13) appear to be adequate to support the population at this time. An investigation of juvenile sturgeon of the Apalachicola system is underway that will provide some additional information about prey for this life stage. There have been no studies to determine if the diversity, abundance, or distribution of benthos is affected by changes in salinity regime due to changes in the riverine flow characteristics.

3.6.1.2 Riverine spawning sites

Riverine spawning sites with substrates suitable for egg deposition and development, such as limestone outcrops and cut limestone banks, bedrock, large gravel or cobble beds, marl, soapstone, or hard clay;

Three sites are known to support Gulf sturgeon spawning in the action area in the upstream-most 7 miles of the Apalachicola River; a rough limestone outcrop at RM 105 and two smooth consolidated clay outcrops at RM 100.3 and RM 99. The Service cooperated with the Corps to characterize habitat conditions at these two sites and eight others that contain substrate potentially suitable for spawning, which we collectively refer to as "hard bottom". Figure 3.6.1.2.A is a map of the river showing the locations of the ten "hard bottom" sites, which all occur between Woodruff Dam and the State Highway 20 Bridge near Blountstown and Bristol, FL. Collectively, these ten sites contain about 117 acres of potentially suitable sturgeon spawning substrate, including an area of about 30 acres within which Gulf sturgeon eggs have been collected (Pine et al. 2006; USFWS unpub. data 2005). Depending on the site, the hard-bottom substrate spans a range of channel elevations from near the thalweg (deepest point on the cross section) to near the crest of the bank, and is generally located on one side of the channel only. The availability, and likely the suitability, of hard-bottom areas for spawning varies with flow, *i.e.,* more of the hard-bottom habitat is inundated at higher flow and less at lower flow. We discuss the role of flow in providing spawning habitat in greater detail below under "Flow Regime".

The status of this constituent element is stable. A portion of the historic hard bottom habitat was removed to improve the navigation channel. No additional removal is planned. The limestone habitat is affected by sedimentation at medium to low flows, but is generally swept clean again following high flows. At this time, we are unaware of specific spawning habitat alterations in Unit 6 that may limit the ability of the designated critical habitat to function for the conservation of the species.

3.6.1.3 Riverine aggregation areas

Riverine aggregation areas, also referred to as resting, holding, and staging areas, used by adult, subadult, and/or juveniles, generally, but not always, located in holes below normal riverbed depths, believed necessary for minimizing energy expenditures during freshwater residency and possibly for osmoregulatory functions.

Wooley and Crateau (1985) reported that Gulf sturgeon occupied the area immediately downstream of Woodruff Dam during the summer months. This area was the deepest available in the upstream-most 15.5 mi of the river, with a mean depth of 27.6 ft. They monitored movements of 15 radio-tagged Gulf sturgeon in this reach from May through September, 1983, finding that all remained within 0.5 mi of the dam. Whether this site, at the confluence of the Flint and Chattahoochee Rivers, was a summer aggregation area before dam construction in the 1950s is unknown. Odenkirk (1989) also found that radio-tagged sturgeon showed a strong tendency to remain immediately downstream of the dam during the summer. Zehfuss et al.

(1999) reported temporary emigration from the area near the dam of about 25% of the radio-tagged sturgeon.

Recently, use of the summer aggregation site near the dam has decreased and use of a site about 10 km upstream on the Brothers River has increased (Parauka 2008 pers. comm., Pine et al. 2006). The substrate at this site consists of sand, mud, clay, and detritus with depth ranging from seven to 14 m.

The Brothers River is also an important fall pre-migration Gulf sturgeon “staging area”. Gulf sturgeon captured at the dam and fitted with radio tags were tracked to the Brothers River during the fall downstream migration, where they remained for up to 24 days before moving further downstream (Wooley and Crateau 1985; Odenkirk 1989). Congregation areas in the Brothers River had a sand and clay substrate and average depth of 36 ft. (Wooley and Crateau 1985).

It is unknown if some factor has caused the reduced use of the summer aggregation area at the dam. Habitat in this area changes significantly following significant flood events such as occurred in May and July 2005. A shallow bar downstream of the dam is formed and degraded regularly. These changes in channel morphology could affect the extent of use of the site as summer habitat for the sturgeon. Little is known about the historic conditions of the Brothers River sites, but these sites are thought to be relatively stable. At this time, we are unaware of specific alterations to riverine aggregation areas in Unit 6 that may limit the ability of the designated critical habitat to function for the conservation of the species.

3.6.1.4 Flow regime

> *A flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of freshwater discharge over time) necessary for normal behavior, growth, and survival of all life stages in the riverine environment, including migration, breeding site selection, courtship, egg fertilization, resting, and staging, and for maintaining spawning sites in suitable condition for egg attachment, egg sheltering, resting, and larval staging;*

At this time, our ability to quantify the relationship between flow and these life history requirements in the Apalachicola River is limited to spawning habitat availability. We rely upon information from other systems and qualitative information about the role of the flow regime to infer possible effects of flow regime changes to other sturgeon life history requirements.

To review the status of the flow regime relative to Gulf sturgeon spawning habitat, we evaluated depths at the known spawning locations at various discharges. The range of depths at which eggs have been collected on the Apalachicola River was 7.5 to 20.1 ft (median 11.4 ft) in 2005 (USFWS unpub. data); and 5.9 to 21.3 ft in 2006 (median 11.8 ft) (Pine et al. 2006) (Figure 3.6.1.4.A). Data from the 2008 spawning study is not included here because the study is ongoing. The similarity in these two years of Apalachicola depth data is remarkable, considering that the median daily river stage during the 2005 egg collection period was 6.5 ft higher than during the 2006 egg collection period. River flow from the date of first to the date of last egg collection in these two studies barely overlapped (range: 20,400 to 37,400 cfs in 2005, and 12,700 to 22,400 cfs in 2006).

Most of the Apalachicola River sturgeon spawning data (110 out of 117 egg collection events) come from one site, a large limestone outcrop located within sight of Woodruff Dam at RM 105. A second site at RM 99, downstream and within sight of the Highway I-10 bridge, was sampled in both 2005 and 2006, but eggs were collected only in 2006 (Pine et al. 2006). Because sturgeon spawned at the same site at comparable depths during 2005 and 2006 under very different flow conditions, they were necessarily using different portions of the river cross section at that site. Figure 3.6.1.4.B shows one of the Corps/USFWS cross sections at the RM 105 spawning site (transect 7 of 10). This cross section is one of three that is within 250 ft of multiple egg collection locations in both 2005 and 2006 (Pine et al. 2006). This cross section is fully inundated at a flow of approximately 15,000 cfs. Figure 3.6.1.4.B notes the range of bed elevations at which eggs were collected within 250 ft of this cross section in the two years. The location and depth of these egg collections indicates that sturgeon used higher portions of the rock shoal in 2005 when flow was higher, and lower portions in 2006 when flow was lower. No eggs were collected in areas that were less than 7.5 ft deep in 2005 and less than 5.9 ft deep in 2006. Egg sampling pads deployed to capture eggs spawned in areas shallower than these depths captured fine sediments instead. No eggs were collected in 2005 in the lowest/deepest portions of the two areas sampled (RM 105 and RM 99), where egg sampling pads were repeatedly carried away by the strong mid-channel current, despite the use of large grapnel-type anchors.

Water velocity was not systematically measured at egg collection locations during 2005, but was during 2006. The range of velocities reported was 0.8 ft/sec to 3.5 ft/sec (median 2.5 ft/sec) (Pine et al. 2006). Water velocity is likely an important variable that influences substrate suitability for spawning, and higher flows preceding spawning may remove accumulated fine sediments on hard-bottom substrates that could smother eggs. A hydraulic simulation capability for the sturgeon spawning sites is not available to the Service at present to describe spawning habitat availability over a range of flows as a function of velocity, depth, and substrate. At this time, we must use depth and substrate only for that purpose.

The range of depths at which Gulf sturgeon eggs were collected in the Apalachicola River was relatively broad (5.9 ft to 21.3 ft, Figure 3.6.1.4.A). The fish used higher elevations on the river bed for spawning under higher flows in 2005, and lower elevation areas under lower flows in 2006, but the median depth used in both years was about 11 ft. Excluding the deepest 10% and shallowest 10% of the egg collection depths as outliers, the range of spawning depths observed at the site used in both 2005 and 2006 (RM 105) combined (n = 110) is 8.5 to 18.0 ft (median = 11.8 ft).

We applied this depth range to bathymetric and substrate surveys of the ten potential spawning habitat sites shown in Figure 3.6.1.2.A in order to describe the relationship between flow and spawning habitat availability. In 2003 and 2004, the Service and the Corps cooperatively surveyed 3 to 12 cross sections at each of these sites, which included the sites at RM 105 and RM 99 that were later confirmed as spawning sites in 2005 and 2006. These cross sections, a total of 72 altogether, were placed about 300 ft apart so as to span the full longitudinal extent of the hard substrate at each site. We measured the bottom elevation every 3 to 10 ft and collected 3 to 6 bottom samples on each cross section to map the approximate depth and extent of the hard substrate on the cross section. We classified the substrate as potentially suitable for spawning if

the sample contained only trace amounts of sand or finer material. Suitable substrates included clean limestone bedrock, cobble, gravel, and a consolidated hard clay-like material.

By attributing the depth and substrate characteristics on each cross section to half the distance upstream and downstream to the adjacent cross sections, we estimated the area of hard bottom at each of the three known spawning sites (includes 2008 data). We used the elevation vs. discharge relationships contained in Light et al. (2006) to estimate the area inundated at each site at flow rates of 4,500 to 50,000 cfs, in 500-cfs increments, and at higher flow rates in broader increments. Figure 3.6.1.4.C shows the acreage of hard-bottom habitat at the RM 105, RM 100.3, and RM 99 spawning sites that is inundated by this depth range at flows from 4500 to 50,000 cfs. Figure 3.6.1.4.D shows the same relationships for the other eight sites surveyed. The documented spawning sites have a greater amount of hard bottom available at a larger range of flows than the other eight sites.

Gulf sturgeon migratory movements within and into/out of the Apalachicola River may be influenced by flow; however, we have no direct evidence that either extreme high-flow events or extreme low-flow events preclude migration. Flow may affect habitat availability or suitability for YOY fish in the river; however, we have no data that would describe the relationship or a threshold flow below or above which adverse effects may occur. High flow could conceivably wash away eggs, larvae, and YOY of limited mobility; however, the extreme roughness of the limestone outcrop at the site (RM 105) that has been twice documented as a spawning site likely provides a refuge from high velocity within its many crevices and voids. For example, at one location where sturgeon eggs were collected from a depth of 14.1 ft on May 2, 2005, the water velocity 1 ft below the water surface was 3.8 ft/sec and was 0.4 ft/sec 1 ft above the river bed. Hoover et al. (2005) observed that small pallid sturgeon could maintain position for prolonged periods in flume experiments against velocities of 0.98 to 1.87 ft/sec.

For hard-bottom sites to remain suitable as spawning habitat, especially the rough limestone-bed site at RM 105, periodic high-flow events are likely necessary to remove sediments that settle on the substrate during lower flow. Such high flows may or may not exceed the flows that sturgeon find suitable for spawning behavior. We have observed substantial vegetation growth on the limestone shoal at RM 105, for example, rooted in accumulated sediments on the exposed rocks in the summer time, and then observed the same areas devoid of vegetation the following spring, presumably scoured away during intervening high flows.

Changes in the flow regime are discussed in Section 3.3. As discussed above this variability is important to some aspects of the life history of the sturgeon. The documented spawning habitat is available to the species at a wide range of discharges that are common in the spring. At this time, we are unaware of specific flow regime alterations to Unit 6 or Unit 13 that may limit the ability of the designated critical habitat to function for the conservation of the species.

3.6.1.5 Water quality

> *Temperature, salinity, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages*

We summarized under section 3.4 above the water quality data available to us that are pertinent to this element of Gulf sturgeon habitat in the action area. Reported water quality impairment in some reaches that may adversely affect sturgeon include low DO and excessive unionized ammonia. We do not expect low DO to affect the Gulf sturgeon in the action area, as reported incidences have been limited to certain creeks, distributaries, and backwater areas (FDEP 2004, 2002). Elevated unionized ammonia levels have adverse effects on fish species, including sturgeon (Isely and Tomasso 1998). However, the observed violations of unionized ammonia levels in the action area are relatively minor exceedances of a State of Florida water quality standard for freshwater systems, one which closely approximates criteria recommended to the USEPA for protection of aquatic life (Augspurger et al. 2003).

As an anadromous fish, the Gulf sturgeon is adapted to life in both fresh and saline waters; however, juvenile fish develop a tolerance to higher salinity gradually during the first year of life, and thereafter exhibit optimum growth at a salinity level of about 9 ppt (Altinok et al. 1998). Estuarine and later marine habitats provide the primary feeding areas for the species at some point during the first year hatching (see section 2.1.3); therefore, the salinity regime of Apalachicola Bay is likely an important factor in defining juvenile feeding habitat. River flow, along with winds, tides, and local rainfall runoff, controls the salinity of Apalachicola Bay (Livingston 1984).

Using data collected in the bay during 1985 and 1986, two relatively low-flow years, Livingston et al. (2000) developed a spatially explicit hydrodynamic circulation model of the bay that predicts salinity, among other variables, as a function of freshwater inflow. Salinity at most locations in the bay measured and predicted exceeded 10 ppt most of the time, except when river discharge was at its highest levels during these low-flow years. Extended duration of high salinity in the estuarine environment is ecologically significant, because aquatic organisms widely differ in their salinity tolerance. More variable salinity favors those with the widest tolerance, and less variable salinity favors those with narrower tolerance.

Juvenile Gulf sturgeon, at least during their first year of life, are among the aquatic biota for whom periods of extended salinity less than about 10 ppt would likely limit feeding habitat availability. Examining the results of Livingston et al. (2000), it is apparent that periods of high salinity (>10 ppt) in 1985 and 1986 were generally associated with flows less than about 16,000 cfs at the Chattahoochee gage, a condition that persisted for most days of both years. To determine whether this condition is more or less common in the post-West Point period than the pre-Lanier period, we computed the annual maximum number of consecutive days less than 16,000 cfs (Figure 3.6.1.5.A). The post-West Point period shows a noticeable shift towards longer periods of uninterrupted low flow, with a median of 137 days, compared to 110 days during the pre-Lanier period, which is a 25% increase that has probably resulted in reduced availability of low-salinity bay habitat.

The high salinity levels observed throughout the summer of 2007 in Apalachicola Bay, especially the East Bay area, probably continued through October. FDEP reported that the East Bay surface datalogger had not recorded salinity values below 12 ppt since July 2007. Given the apparent importance of the East Bay area to sturgeon particularly juveniles, and the continuing high salinities, it is possible that juvenile sturgeon and to some extent adult sturgeon, could be

affected by both delayed entry to the feeding areas of the bay and potential reduction in productivity of these normally rich feeding areas. This could result in poor growth and/or lower survival of juvenile sturgeon. Adult sturgeon appear to be better adapted to the higher salinity levels and may be able to exploit other feeding areas in the bay and the Gulf.

As noted, portions of the bay appear to provide high value feeding habitat to juvenile and adult sturgeon. Since only the youngest sturgeon feed while in the riverine environment, these estuarine foraging areas are of particular importance, as they provide the first opportunity for feeding when exiting the river. Putland (2005) analyzed the ecology of phytoplankton and microzooplankton in Apalachicola Bay relative to changes in salinity. The analysis indicated that higher salinity levels in the bay, associated with low river discharge periods, resulted in decreased ingestion and production of microzooplankton. Because microzooplankton are key constituents of the estuarine food web in Apalachicola Bay, the analysis suggests that lower discharges in the river that result in lower nutrients and higher salinity (>20 psu, or above 20 ppt) could reduce higher trophic level productivity (Putland 2005).

Water temperature is relevant to Gulf sturgeon migratory movements and particularly to spawning. Gulf sturgeon spawning in the Apalachicola occurs in the spring when water temperature rises to between about 17-25 °C. Using water temperature data from the Chattahoochee gage summarized in section 3.4 (Figure 3.4.A), the mean date by which water temperature rises to 17°C is March 26 (range: January 23 to April 14) and to 25 °C is May 23 (range: May 12 to June 29). Based on the average dates, Gulf sturgeon spawning potentially encompasses a 58-day period.

At this time, the status of the water quality PCE of Gulf sturgeon critical habitat in Units 6 and 13 is not pristine, but we believe it does not likely limit the ability of the designated critical habitat to function for the conservation of the species. We are not aware of water quality impairments that have resulted in death, injury, or reduced growth and reproductive success to Gulf sturgeon in this system, and the Apalachicola population appears to be slowly increasing (see section 3.5.1.2).

3.6.1.6 Sediment quality

> *Texture and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages*

The sturgeon's riverine habitat in the action area is predominantly sandy, with some rock outcrops and gravel in the upper reaches of the river, becoming progressively finer materials (more silt and clay) in the lower reaches. The main channel of the river is mostly sand. Sediments covering most of the bottom of the bay (about 80% of the bay area) are characterized as soft mud; however, most adult and sub-adult Gulf sturgeon feeding activity appears to occur in sandy substrates, which are relatively uncommon in Apalachicola Bay. It is therefore quite possible that the species will exploit somewhat different habitat types in this system than in other systems. Sediment pollution in Apalachicola Bay is relatively low in comparison to other bay systems in the area (USDOC 1997). Since most pollutants attach to finer sediments, sediment quality in the predominantly sandy substrates of the river is probably high.

At this time, we are unaware of specific sediment quality alterations to Unit 6 or Unit 13 that may limit the ability of the designated critical habitat to function for the conservation of the species.

3.6.1.7 Safe and unobstructed migratory pathways

> *Safe and unobstructed migratory pathways necessary for passage within and between riverine, estuarine, and marine habitats (e.g., an unobstructed river or a dammed river that still allows for passage)*

Pathways for Gulf sturgeon of the Apalachicola River are affected by activities in the river and bay and by Woodruff Dam. To avoid the possibility of sturgeon disturbance or entrainment in hydraulic dredge equipment, the Corps delayed the start of channel maintenance until after May 31 each year, when the sturgeon spawning season is most likely concluded. Dredging in the river has not occurred since 2001. The navigation channel leading from the mouth of the river to Sikes Cut (a man-made pass across St. George Island between the Bay and the Gulf) has been dredged several times in recent years. Another navigation channel within the Bay, the Two Mile project, which parallels the bay shore to the west of the town of Apalachicola, was dredged a few years ago. As yet, no sturgeon mortality or injury has been associated with the maintenance of these channels. The death of one juvenile sturgeon is attributed to use of the river navigation channel resulting from propeller injury by a passing barge tug boat in the lower river in 2004. Woodruff Dam limits the upstream movement of Gulf sturgeon to historic habitats. Studies of passage alternatives are ongoing.

At this time, we are unaware of any other ongoing hazards or obstructions that may limit migratory movements within the Units 6 and 13. Most activities in the river and bay can be scheduled to avoid affecting migration. We have determined that access to historic spawning habitats upstream of Woodruff Dam is not essential to the conservation of the species.

3.6.2 Mussels

The three species of freshwater mussels that we address in this BO were listed at the same time with four other species in 1998. The Service has likewise designated critical habitat for these seven mussels in a single FR notice issued November 15, 2007 (72 FR 64286). The entire length of the Apalachicola unit designated as critical habitat for the fat threeridge and purple bankclimber is within the action area. The downstream-most 13.8 miles of the Chipola unit designated as critical habitat for the fat threeridge, purple bankclimber, and Chipola slabshell is within the action area. The action area contains all of the PCEs that we described as features of occupied critical habitat that are essential to these species' conservation. The following is a summary of what is known about the status of these PCEs in the action area.

3.6.2.1 Channel Stability

> *A geomorphically stable stream channel (a channel that maintains its lateral dimensions, longitudinal profile, and spatial pattern over time without an aggrading or degrading*

bed elevation);

Studies of freshwater mussels have found that mussel distributional patterns are influenced by river bed stability (e.g. Vannote and Minshall 1982; Strayer and Ralley 1993; di Maio and Corkum 1995). Generally, mussels can withstand some changes in the river bed due to floods by burrowing deeper into the bed (di Maio and Corkum 1995).

We summarized in section 3.2 observed channel morphology changes in the Apalachicola River. The overall amount of stable riverine habitat available for the listed mussels varies from year to year due to the dynamic nature of the river. Entrenchment following dam construction and various activities associated with the federal navigation channel, such as dredging, snagging and the construction of dike fields, changed channel stability, and probably reduced habitat availability for the fat threeridge, as it is now absent or rare in the upstream-most 30 miles of the river. In the RM 40 to RM 50 reach, including the Chipola Cutoff, and Swift Slough, channel instability most likely explains a substantial recent redistribution of sediments and potentially mussels, which likely resulted in unprecedented mussel mortality during low flow in the summer of 2006. The long-term effects of the channel instability in this reach are unknown.

On the River Kerry in Scotland, Hastie et al. (2001) found that a large number of mussels were moved and killed following a flood of record. However, upon further inspection of previously surveyed sites, they found that most of the mussel population had survived, and that mortality was highest in geomorphically unstable portions of the river. Predicting what would happen to the population overall was not possible as fauna depleted by major floods often take many years to recover (Goldman and Horne 1983 as cited in Hastie et al. 2001).

We believe that the reach between RM 40 and RM 50 is still susceptible to a substantial redistribution of sediments and mussels during future high-flow events. However, most of the river does not likely share this characterization. The Corps' dredging records show that since 1992, 84.1 miles of the 105.4 miles between Woodruff Dam and RM 1.0 received no dredging, suggesting that these portions of the river transport the sediment they receive without substantial aggradation.

Many changes in the channel affect individual mussels, but conservation of the species depends on sufficient stable instream habitat. Strayer (1999a) suggested that mussels might generally be found in areas that are stable at flows with 3 to 30 year recurrence intervals. Morales et al. (2006) developed a model to predict substrate stability that coincided with reported mussel locations. They noted that large areas that seemed stable under low flow conditions have active sediment motion at high and medium flows that would render the locations unsuitable for mussels. They hypothesized that annual peak flows most often limit the spatial distribution of freshwater mussel communities. We have noted previously that high flows during 2005 likely redistributed sediment and fat threeridge in the RM 40 to RM 50 reach of the river. Using the concepts developed by Morales et al. (2006) for a portion of the Upper Mississippi River suggests to us that some areas have remained stable on the Apalachicola following high flows and support mussels. We believe that the sites where we observed mussels not associated with the depositional side channels and areas of lateral channel migration are these more stable sites. We suspect that the observed changes in annual peak flows have reduced the available stable

habitat, but the relative amount is unknown. Additional channel morphology and sediment transport studies of the Apalachicola are needed to estimate the amount of stable habitat and how it changes with changes in flow regime.

The river channel in Unit 8 appears to be continuing to change (Light et al. 2006; Price et al. 2006) as the river seeks dynamic equilibrium. However, at this time, we are unable to quantify the amount of stable habitat or the rate of change that might change the status of the mussel beds found in the most stable instream areas of the river. Based on the species persistence in the river during past periods of instability affecting the entire river, we believe that sufficient stable instream habitat exists in the mainstem of Unit 8 for the conservation of the species. There is no specific information available for Unit 2; however, we are unaware of any factors that may change channel stability and limit the ability of the designated critical habitat to function for the conservation of the species.

3.6.2.2 Substrate

A predominantly sand, gravel, and/or cobble stream substrate.

Substrate used by the fat threeridge varies from gravel to cobble to a mixture of sand and sandy mud (Williams and Butler 1994), and it is found mostly in depositional situations with slow to moderate current within the stream channel (Butler 1993). Brim Box and Williams (2000) found 60% of the specimens were located in a sandy silt substrate. It is possible that channel entrenchment in the upper river may have reduced the depositional areas favored by this species.

The purple bankclimber inhabits sand or sand mixed with mud or gravel substrates in portions of the channel with slow to moderate current (Williams and Butler 1994). Over 80% of the specimens located during the ACF Basin status survey were found at sites with a substrate of sand/limestone (Brim Box and Williams 2000). These collections were often in waters over 10 ft in depth.

The Chipola slabshell inhabits silty sand substrates in portions of the channel with slow to moderate current (Williams and Butler 1994). Specimens are generally found in sloping bank habitats. Nearly 70% of the specimens found during the status survey were associated with a sandy substrate (Brim Box and Williams 2000).

At this time, we are unaware of specific substrate alterations to Unit 8 or Unit 2 that may limit the ability of the designated critical habitat to function for the conservation of the species.

3.6.2.3 Permanently flowing water

Permanently flowing water.

The main channel of the Apalachicola River has consistently contained permanently flowing water, but loop streams, backwaters, tributaries, and distributaries require specific discharges to retain connectivity to the main channel. Flowing water is important because it transports food items to the sedentary juvenile and adult life stages, provides oxygen for mussel respiration, and

with enough depth, it provides protection from terrestrial predators. Flowing water is also likely essential for reproduction through suspension of glochidia or conglutinates (O'Brien and Williams 2000). Above normal flows can affect overall recruitment and where juvenile mussels settle (Hardison and Layzer 2001). The magnitude and duration of flows can have a long-term effect on population dynamics (Vannote and Minshall 1982; di Maio and Corkum 1995).

This constituent element is also necessary for host fishes that spawn in the floodplain. According to Light et al. (1998; 2006) and analyses presented in this Biological Opinion (see Section 3.3 Flow Regime Alterations), the frequency and duration of main channel-floodplain disconnections has increased over time, and these disconnections are exacerbated by low flows associated with droughts and controlled water releases (Walsh et al. 2006). During April and May, spawning there has been about a 25% reduction in floodplain available to spawning fish. See section 3.6.2.5 for additional analysis regarding abundance of host fish.

Mobile animals typically satisfy various life history requirements by relying upon different habitat features in different portions of their range. While juveniles and adults of mussels are relatively immobile animals, their glochidia (larvae) and host fish are not. Dispersal via fish hosts is how the species colonize new areas and is necessary to achieve recovery, although mussels are also sometimes moved into new areas by high-flow events. Mussels will best survive and reproduce in specific areas that consistently provide all of the PCEs, but do not necessarily persist permanently in any one area given the dynamic nature of the riverine environment. Interrupted flow due to the accumulation of sediment in the bed of Swift Slough has recently led to substantial mortality of listed mussels in this stream during periods of low-flow in the Apalachicola River (see Section 3.5.2.2). Stream bed aggradation in Swift Slough signals the need for special management of the channel stability PCE in at least the Swift Slough portion of the Apalachicola River. Because the area at the mouth of Swift Slough continues to aggrade, we do not know the exact current flow necessary to keep Swift Slough connected to the main channel. However, we do know that it will continue to be disconnected at flows less than 5,600 cfs (i.e., the 2006 disconnection flow), and relatively small numbers (less than 400) of fat threeridge likely continue to persist in the slough (Section 3.5.2.2).

Because mussels inhabit the banks and are often found in shallower areas, permanently flowing water is also an issue in the main channel, especially when flows decline and there is an obstacle to movement such as in a shallow sand bar or within a shallow side channel. The elevations where mussels are found in any particular year, versus where they may have been found in previous years (*i.e.,* 2000 versus 2006) is likely dependent upon hydrological conditions prior to the survey. For example, in the year 2000, there had been prior conditions of sustained low flow beginning in May, and mussels may have been located at lower elevations during the fall surveys. In 2005, flows had been maintained above 10,000 cfs for most of the year, which may account for mussels being found at higher elevations in the fall of 2005 and into 2006. In 2007, flows were around 5,000 cfs from May through mid-November, and the EDO operations resulted in flow less than 5,000 cfs and as low as 4,750 cfs for 31 days from November 16 to December 16. Therefore, unless wet years bring higher flows, we expect that corresponding elevation to be the new "ceiling" for mussel presence in the action area.

Although mussels move in response to changing water levels, they sometimes are caught in areas too far from the receding shoreline or areas in which down-slope movement does not lead to deeper water. We found several such sites in the summer of 2006 and 2007 (see Section 3.5.2.2). As described, the high-localized mortality in the middle reaches of the Apalachicola River may inhibit short-term reproductive success. Additional studies are needed to determine the relative effects of drought related mortalities; however, we do not believe that the low flow levels in 2006 and 2007 have permanently limited the ability of the designated critical habitat to function for the conservation of the species in Unit 8 or Unit 2. If flows less than 5,000 cfs occur, we would expect continued mortality in areas where movement is restricted, such as side channel areas and in depositional areas of lateral channel migration adjacent to the main channel.

3.6.2.4 Water quality

> *Water quality (including temperature, turbidity, dissolved oxygen, and chemical constituents) that meets or exceed the current aquatic life criteria established under the Clean Water Act (33 U.S.C. 1251-1387).*

A wealth of evidence supports the dependency of the mussels on good water quality. As animals with limited mobility, mussels must tolerate the full range of water quality parameters to persist in that stream. Most mussels are considered sensitive to low DO levels, high temperatures, and unionized ammonia (Fuller 1974; Johnson 2001; Sparks and Strayer 1998; Augspurger et al. 2003). Recent studies summarized in the Services 5-Year Review have demonstrated: 1) that early life stages are generally more sensitive to copper and ammonia than other organisms, and 2) current EPA criteria for copper and ammonia are not protective of mussels (USFWS 2007b). These early life stages may also be particularly sensitive to pesticides and herbicides such as glyphosate and atrazine (USFWS 2007b).

Various contaminants in point- and non-point-source discharges can degrade water and substrate quality and adversely affect mussel populations through direct mortality, reduced recruitment, or impaired physiological processes (Ahlstedt and Tuberville 1997; Chetty and Indira 1995; Fleming et al. 1995; Fuller 1974; Havlik and Marking 1987; Horne and McIntosh 1979; Jacobson et al. 1993; Keller and Lydy 1997; Keller and Zam 1991; McCann and Neves 1992; Moulton et al. 1996; Naimo 1995; Neves and Zale 1982; Yeager et al. 1994). In general, we believe the numeric standards for pollutants and water quality parameters that are adopted by the States under the Federal Clean Water Act represent levels that are essential to mussel conservation. Furthermore, the federal criteria and State standards are adaptive to new data developments and discoveries as a means to represent the most recent state of our understanding of protective water quality.

The 2001 Impaired Surface Waters Rule analysis identified potential impairments in the action area segments for biology, coliforms, DO, and unionized ammonia (FDEP 2002). Several segments of the Apalachicola and Chipola rivers that are within the action area are included on the 2004 Verified List of Impaired Waters that fail to fully meet their designated uses (FDEP 2004). The impairments included turbidity, coliform bacteria, mercury, and dissolved oxygen. These water quality impairments could influence the health of the aquatic community, including the freshwater mussels, to an undetermined extent (Fuller 1974; Sparks and Strayer 1998;

Johnson 2001; Augspurger et al. 2003). Violations of the unionized ammonia standard are relative to a State of Florida standard for freshwater systems, which closely approximates criteria recommended to the USEPA to protect freshwater mussel species (Augspurger et al. 2003).

Walsh et al. (2006) reported that the middle reach of the main channel of the Apalachicola River had relatively high values for both secchi depth (*e.g.,* low turbidity) and DO, and neutral pH. Water quality in River Styx connectors (*e.g.,* Swift Slough, Hog Slough, and Moccasin Slough) was similar to the main channel when connected, but it was much more variable when disconnected (Walsh 2006). The authors also reported a negative relationship between DO and decreased flow and connectivity to the main river, and there was a significant difference (Sheffe post-hoc multiple pairwise comparison; $p<0.002$) in DO in each category of main channel connectivity (*e.g.,* flowing, connected backwater, isolated <6 weeks, and isolated > 6 weeks). The lowest yearly DO values occurred during mid- to late summer (July to September) when temperatures were highest and flows were lowest (Walsh et al. 2006).

DO level is affected by both flow and the abundance of detritus at the site. Low DO levels were detected at many sites in the summer of 2006 and 2007 when flows were less than about 7,000 cfs. As Swift Slough became disconnected in 2006 and consisted of a series of isolated pools (EnviroScience unpub. data 2006), DO values in all of the isolated pools were less than 5 mg/L, which is less than both the Florida state standard and the USEPA criterion for DO (Florida Administrative Code 2004; USEPA 1986). DO concentrations were less than 1 mg/L in over 62% of the isolated pools (Figure 3.6.2.4.A). When the Slough was reconnected several days later, DO levels rapidly increased to levels above the Florida state standard and USEPA criteria. A study conducted in the Flint River basin during the 1999-2002 drought found that there was accelerated mussel mortality as DO levels dropped below 5 mg/L, and DO levels between 0 and 3 mg/L resulted in variable mortality up to 76% (Johnson et al. 2001; Golladay et. al 2004). The mortality reported in Swift Slough (see Section 3.5.2.2) was likely due to a combination of low DO and exposure. Other shallow depositional areas in this reach probably experienced DO levels less than 3 mg/L also.

Although we have limited water temperature and DO data from 2007, it is reasonable to assume that flows of about 5,000 cfs in the Apalachicola River for an unprecedented duration (from late May to November) during the hottest months of the year has resulted in increased water temperature and localized declines in DO. These alterations could be particularly damaging to the mussel species since their movement capabilities are slow and limited. The most extreme examples of this would occur in shallow backwater areas with little or no connection to the main channel of the river and in shallow isolated pool habitat occurring in distributaries that no longer have a hydrological connection to the main channel of the river (e.g., Swift Slough). Water quality data from Swift Slough indicate that DO and water temperature varied in isolated, stagnant pools, with DO ranging from 0.9 mg/L to 6.7 mg/L and temperature ranging from 20.9-31.1°C (70-88°F) (FFWCC 2007 unpub. data). In shallow back water areas on the main channel like RM46.8, DO did not appear to be intolerable when measured (7.7 mg/L to 7.9 mg/L). However, water temperature was very high (33.1-40.8°C (92-106°F) (FFWCC 2007 unpub. data; USFWS 2007 unpub. data). FFWCC also measured water temperature and DO in isolated pools containing purple bankclimbers on the shoal at RM 105. Water quality did not appear to be intolerable; DO ranged from 7.4-11.0 mg/L, and water temperature ranged from 21-28°C (70-

83°F), suggesting cooling from ground water seepage. Flows were further decreased to around 4,750 cfs from mid-November to mid-December, although cooler ambient temperatures likely improved water temperature and DO conditions.

Although these measurements vary, impacts to the mussels depend on the duration of high temperatures and low flow, which these point-at-time data do not capture. In addition, observations made by Service biologists in the summer of 2007 indicate that mussels found in isolated pools or shallow slack water habitats were showing signs of stress or mortality probably due to high temperatures and low DO. Significant reductions in river flow below 5,000 cfs would probably exacerbate the temperature and DO conditions observed in 2007.

Low DO concentrations during droughts may also be further reduced in response to the decay of soft organs of dead mussels. For instance, the invasive Asian clam (*Corbicula fluminea*) is intolerant to drought conditions and further exacerbates hypoxic conditions (McMahon 1979; Johnson et al. 2001). In the presence of the Asian clam, DO levels are lowered at an accelerated rate, and may contribute to increased competition amongst unionids for limited supplies of DO (Johnson et al. 2001). Many study sites along the Apalachicola have extremely high abundance of Asian clams, and low DO levels during drought conditions are likely to be exacerbated by mortality of Asian clams.

Spawning may also be affected by high water temperatures, as seen in 2006 when fat threeridge were observed expelling glochidia in the absence of fish hosts at high water temperatures. The fat threeridge spawning period begins when water temperatures are 23°C ± 1.5°C (Brim Box and Williams 2002). Using water temperature data from the Chattahoochee gage summarized in section 3.4 (Figure 3.4.A), the mean date by which water temperature rises to 21.5°C is May 1 (range: April 5 to May 14) and to 24.5°C is May 22 (range: April 14 to June 30). Some spawning in 2006 and 2007 was still underway when water temperatures in the very shallow areas exceeded 30°C, and likely resulted in reproductive failure in these individuals. O'Brien and Williams (2002) found gravid female purple bankclimbers in the Ochlockonee River during late winter/early spring when water temperatures were 8 to 15°C. Average temperatures by calendar date (Figure 3.4.A) all exceed 8°C in the available Apalachicola River data. The mean date by which temperatures rise to 15°C is March 13 (range: January 1 to April 1); however, there are no known factors that would affect the normal temperature range during this period. Water temperatures associated with Chipola slabshell reproductive activity have not been investigated.

We believe that fat threeridge mortality due to low DO and high temperatures in the summer of 2006 and 2007 was unusual due to a coincidental change in bed elevation, change in channel morphology, and low flows associated with an extended period of unusually low rainfall in the basin. We do not believe that these temporary changes in water quality have permanently limited the ability of the designated critical habitat to function for the conservation of the species in Unit 8 or Unit 2. Some mussel spawning likely occurred prior to the low flows and several sites on the main channels of the Apalachicola and Chipola rivers supported mussels in areas where they could move to deeper water of adequate temperature and reproduce successfully. Although most mussels in Swift Slough have died as a result of low DO, high temperature, or

exposure, some have continued to survive in the shallow, isolated pools and others buried themselves in wet substrates with adequate DO and temperature.

3.6.2.5 Fish hosts

> *Fish hosts* (*such as largemouth bass, bluegill, redear sunfish, weed shiner, and blackbanded darter*) *that support larval life stages of the mussels.*

The distribution and diversity of unionids is strongly related to the distribution and diversity of fish species (Watters 1992; Haag and Warren 1998). Bogan (1993) identified the dependency of mussels on fish hosts as one of several contributing causes in the extinction of several unionid species worldwide. Host fish availability and density are significant factors influencing where certain mussel populations can persist (Haag and Warren 1998), and simulations of fish-mussel interactions indicate that mussel populations are extirpated if a threshold host fish density is not exceeded (Watters 1997b). The importance of host fish to persistence of mussel populations is well documented. Riverine fish populations in the southeast have been adversely affected by the same habitat alterations that have contributed to the decline of the mussel fauna (Etnier 1997; Neves et al. 1997; Warren et al. 1997).

Host fish species are known only for the fat threeridge and Chipola slabshell (see sections 2.2.3.3.1 – 2.2.3.3.3). Lab-confirmed host fish species for the fat threeridge include the weed shiner, bluegill, redear sunfish, largemouth bass, and blackbanded darter. Researchers also recently confirmed that bluegill can serve as a host fish species for Chipola slabshell. The fat threeridge is considered a host-fish generalist for which the density of host fish species may be of particular importance. Watters (1997b) found that generalists attained higher population sizes than specialists when host fish density was high, but declined when host fish density declined. However, Haag and Warren (1998) found that densities of host-generalist and host-specialist mussels with elaborate host-attracting mechanisms were independent of host-fish densities.

The FFWCC monitored the fish assemblage in the main channel of the Apalachicola River at four fixed stations from 1984-1993 and 2000-2003. Data from these boat electrofishing surveys were taken from the summary provided by Walsh et al. (2006). One of the four monitoring stations was in the middle reach of the Apalachicola River (RM 37.5 to 40.9). This is the general area of the river with the highest known abundance of the fat threeridge, and we have focused on data from this station for purposes of this BO. All five host fish species were collected by the FFWCC in the middle reach of the Apalachicola River from 1984-1993 and 2000-2003. When data from all years are combined, the weed shiner was the most abundant species collected (28.2% of the total catch), and bluegill was the third most abundant species collected (10.4%). The other host fish did not rank as high in percent composition, but were still considered dominant species (*e.g.,* comprising at least 1% of the total catch). Redear sunfish comprised 1.9% of the total number of fish collected (ninth most abundant), and largemouth bass comprised 1.7% of the catch (tenth most abundant). The blackbanded darter was not considered a dominant species and was rarely encountered (0.7% composition). The percent composition of the dominant species varied slightly between the two general sampling periods (1984-1993 and 2000-2003), but the weed shiner and bluegill ranked first (29.5% vs. 24.7%) and third (9.6 vs. 12.4%) in both periods, respectively. These data indicate that host fish are present in the main

channel in areas where the fat threeridge occur, and, with the exception of the blackbanded darter, they comprise relatively large proportions of the fish assemblage (particularly weed shiners and bluegills).

Although the three mussels are not generally found in floodplain habitats, their host fish species are likely to use floodplain habitats, and, as previously mentioned, mussel population viability is likely dependent on fish host population density. Reproduction of many fishes is intricately tied to the floodplain, and alteration of flow regimes can affect reproductive success, year-class strength, growth, condition, and other life-history attributes (Guillory 1979; Welcomme 1979; 1985; Kilgore and Baker 1996; Raibley et al. 1997; Gutreuter et al. 1999; Ribeiro et al. 2004). For example, the largemouth bass is known to use seasonally inundated floodplain habitats for spawning and rearing (Kilgore and Baker 1996). Walsh et al. (2006) documented 64 species of fishes (including all five host species) using floodplain habitats in the middle reaches of the Apalachicola River and firmly established the importance of these habitats for spawning adults and young-of-the-year fishes.

The FFWCC and USGS (Walsh et al. 2006) have monitored the fish assemblage in floodplain habitats (*e.g.,* loop streams, backwaters, tributaries, and distributaries) in the middle reach of the Apalachicola River using backpack and boat electrofishing from 1983-1985 (FFWCC) and 2001-2004 (USGS). FFWCC data presented here are summarized from Walsh et al. (2006), and only samples from Poloway Cutoff, Iamonia Lake, Florida River, and River Styx were used because they are the most comparable to the sites sampled by the USGS. From 1983 to 1985, bluegill was the most abundant species collected (30.9% of the total catch) in floodplain habitats in the middle reach of the Apalachicola River. Largemouth bass was the second most abundant species (7.4% of the total catch), and redear sunfish was the fourth most abundant species (5.8% of the total catch). Weed shiner and blackbanded darter were not detected at these locations by the FFWCC in 1983-1984. From 2001 to 2004, bluegill was also the most abundant species collected (22.9% of the total catch), weed shiner comprised 8.7% of the total catch (third most abundant), and largemouth bass comprised 2.9% of the total catch (ninth most abundant). Redear sunfish and blackbanded darter were not considered dominant species, but they were collected (1.4 and 0.17% composition, respectively).

Results from Walsh et al. (2006) confirm that three components of the hydrologic cycle are especially important for Apalachicola River fishery resources: the timing, extent, and duration of floodplain inundation immediately preceding, during, and following the spawning, early growth, and survival phases. For instance, YOY bluegill and weed shiners were collected in the floodplain over a long period of time (March to September), indicating prolonged spawning periods. These species are characterized as flood-plain exploitative species, which often have breeding seasons that extend well beyond the time of spring flooding (Ross and Baker 1983; Walsh et al. 2006). Therefore, flow connectivity for some portion of the floodplain or adjacent shallow water main channel habitat may be needed in the summer months, beyond the typical spring spawning months. Results of analyses presented in Section 3.3.2 indicate that floodplain connectivity is substantially lower since the construction of dams in the ACF Basin, due primarily to channel morphology changes.

FFWCC biologists recently completed an annual survey of sportfish, including three potential host fish species, in the Apalachicola River, sloughs, and distributaries (FFWCC 2005-2008 unpub. data). These surveys do not include weed shiners and blackbanded darters. The preliminary analysis shows continued impacts to sportfish communities in terms of year-class strength and loss of critical spawning and nursery habitats during low-flow periods. The number of acres of inundated floodplain during the spawning and nursery seasons (April -June) were positively correlated with year-class strength in 2005 and with age-0 largemouth bass CPUE values in September from 2003 to 2007 ($r = 0.9181$). A similar comparison of acres of inundated floodplain during April alone was also positively correlated ($r = 0.9402$). These significant positive correlations suggest that higher flows and more acres of backwater habitats during spring, specifically April, may explain more than 90% of the variation in largemouth bass year-class strength based on our data from 2003-2007. Residuals from catch curve analysis for largemouth bass, redear sunfish, spotted sucker (*Minytrema melanops*), and channel catfish (*Ictalurus punctatus*) indicated that stronger year-classes of these species were identified with greater acres of inundated floodplain during late spring/summer of 2003 and 2005 (Cailteux et al. 2007). Age composition of largemouth bass ($n = 936$) collected in fall 2007 revealed an estimated 41% of the fish sampled were age-2 and age-4 respectively, originating from two strong year-classes produced in wet years during 2003 and 2005 (FFWCC 2008 unpub. data). Strong year-classes of redear sunfish and spotted suckers were also produced in 2003 and 2005, while poor year-classes were observed for these species and largemouth bass in 2004, 2006, and 2007 (FFWCC 2005-2007 unpub. data).

In addition, further examination of largemouth bass data indicate that growth and survival may be impacted by low flows. Mean electrofishing CPUE values and total lengths for age-0 largemouth bass collected in Apalachicola River during fall of 2003 and 2005 were significantly greater than ($P < 0.05$) age-0 fish collected in 2004, 2006, and 2007 (FFWCC 2005-2007 unpub. data). Slow rates of development and growth during low flow years may be critical to the survival of larvae due to increased risk of predation (Jobling 1995). In addition, Houde (1987) suggested that survival during early life stages is a direct function of growth.

In 2007, low numbers of young-of year sportfish were sampled in the sloughs and main channel for the second consecutive year, while high numbers were observed in 2005. Floodplain inundation and major slough connectivity provide suitable aquatic habitats for many fish food items such as macroinvertebrates, crayfish, and adult insects. Relative weights (W_r) are a measure of the condition or health of fish. W_r values for largemouth bass, bluegill, redear sunfish, redbreast sunfish (*L. auritus*), spotted sunfish (*L. punctulatus*), flathead catfish (*Pylodictis olivaris*), and channel catfish were significantly higher in 2005 (wet spring/summer) than in 2006 with lower flows and water levels through late spring and summer (Cailteux et al. 2007). Increased floodplain inundation in 2005 led to increased aquatic habitat and better feeding conditions for most species as indicated by significantly higher W_r values. Continued low flows in spring 2007 resulted in significantly ($p < 0.05$) lower mean W_r for largemouth bass compared to W_r values in 2006 and 2005 (FFWCC 2005-2007 unpub. data).

Additional decreases in floodplain connectivity may contribute to a decrease in productivity of several species of fish, including some that serve as hosts for the listed mussels (Kilgore and Baker 1996; Raibley et al. 1997; Walsh et. al 2006). However, the effect to the critical habitat

and listed mussels is unknown, as the relationship of fish host densities to mussel densities are unknown at this time.

3.7 Factors Affecting Species Environment within the Action Area

This section describes factors affecting the environment of the species or critical habitat in the action area. The baseline includes State, tribal, local, and private actions already affecting the species or that will occur contemporaneously with the consultation in progress. Related and unrelated Federal actions affecting the same species and critical habitat that have completed formal or informal consultation are also part of the environmental baseline, as are Federal and other actions within the action area that may benefit listed species or critical habitat. The following actions have influenced over time to some degree the environment of the listed species in the action area, and these influences are reflected in the flow regime, the channel morphology, and other physical and biological features discussed previously as the baseline for this consultation.

3.7.1 Related Federal Actions

3.7.1.1 Navigation Channel Maintenance

Jeanne (2002) summarized the Corps' history of activity associated with navigation on the Apalachicola River. The first record of this history is in the Corps' annual report of 1832, which refers to clearing obstructions to navigation in the river. The first formal navigation survey of the ACF was commissioned in 1871, and the first navigation improvement project was authorized in 1873. At that time, work began on a 100-ft wide and 4-ft deep channel on the Chattahoochee River, jetties and wing dams to control sand and gravel bars, snag removal, and rock blasting to widen and deepen shoals. Snags were cleared annually on the Apalachicola River to provide for a channel 100 ft wide by 6 ft deep at low water. In 1874, the Corps bypassed six miles of the main channel by widening and straightening an alternate channel through the River Styx and Moccasin Slough.

By 1881, the Corps recognized that these various attempted improvements to navigability in the basin were temporary fixes in the highly dynamic alluvial river system (Jeanne, 2002). Dredged areas filled in more rapidly than anticipated, especially in channels near the mouth of the river. This "excessive silting" eliminated the town of Apalachicola from consideration as the area's deepwater port (Jeanne, 2002). Despite these difficulties, a federal navigation project on the Apalachicola has continued for over 100 years, during which several major federal reservoir projects were authorized and constructed, all of them linked in some way to the navigation project.

The Mobile District's web site includes an "Information Paper on Navigation on the Apalachicola River" that summarizes federal management of the river to date:

> The water resources of the ACF River Basin have been developed to serve multiple purposes, including flood control, navigation, hydropower, water supply, water quality, recreation, and fish and wildlife enhancement. A basin-wide development plan,

authorized by the River and Harbor Act of 1945 and modified in 1946, consisted of three multi-purpose reservoirs on the Chattahoochee above Columbus, Georgia (only two were constructed); three multi-purpose reservoirs on the Flint River above Albany, Georgia (none were constructed); and six locks and dams (three were constructed). Navigation was to be provided by (1) dredging, cutoffs, training works, and other open river methods; (2) a series of locks and dams; and (3) flow regulation from upstream storage projects. The project ultimately constructed consisted of a 9- by 100-ft navigation channel along 107 miles of the Apalachicola River between the Gulf Intracoastal Waterway and Jim Woodruff Lock and Dam. From there the navigation channel extends 155 miles up the Chattahoochee River to Columbus, Georgia, and Phenix City, Alabama, and 28 miles up the Flint River to Bainbridge, Georgia.

The controlling depth for navigation has often been less than the authorized 9 ft channel during a large portion of the normal low flow period of the summer and fall each year. Over the period 1970-1999, a 9-ft channel has been available only about 62% of the time and a 7.5-ft channel 82% of the time. In dry years a 7.5-ft channel may be available only 25% of the time. The original design of the project estimated that a discharge from Jim Woodruff Dam of 9,300 cubic ft per second (cfs) together with dredging would provide a 9-ft channel. In the mid-1980's the discharge providing a 9-ft channel was estimated to be 11,000 (an increase of 18%). The majority of the dredging activity in the Apalachicola River occurs between miles 35 and 45 and between miles 76 to 81, accounting for about 40% of the annual dredging quantities.

Following discussions with navigation users during and after the 1986 drought, the Corps developed a technique to provide for a planned period of navigation called a Navigation Window. This technique involves temporarily storing water in West Point Lake, Walter F. George, and Lake Seminole that then is released over a 10-day to two week period at a rate to provide for economically navigable depths (at least a 7.5-ft channel) in the Apalachicola River. During the Drought of 1988, a Navigation Window was planned for early September 1988, but sufficient rain occurred so that the Window was not necessary. This technique was employed beginning in 1990 and continued throughout the decade. Beginning in the mid 1990's, Navigation Windows were scheduled in advance, approximately one per month during the low water months, in order to provide the waterway users a predictable reliable channel. Because channel conditions were also deteriorating, Navigation Windows were used with increasing frequency, as many as six a year, generally between May and December. Maintenance of navigation depths became increasingly dependent upon flows due to continued channel degradation and a lack of adequate dredged material disposal capacity. In the 1990s, the discharges from Jim Woodruff Dam required to provide a limited 8-ft channel during navigation windows ranged from 13,000 cfs to over 20,000 cfs, dependent upon the condition of the dredged channel. With increased water supply and recreational demands in the upstream reservoirs, fluctuations of reservoir levels necessary to support navigation window releases have become increasingly controversial.

The navigation channel on the Apalachicola River was last dredged in 2001, but the dredge ran aground due to low flow, and the job was not completed. The last complete cycle of dredging a

100-ft by 9-ft channel occurred in 1998 (in 1999, dredging was discontinued in the middle of the dredging season due to lack of dredged material disposal capacity). In 2005, the State of Florida denied the Corps' application to renew its certification under section 401 of the Clean Water Act for maintaining the navigation channel. Although navigation remains an authorized purpose for the ACF system, it does not now figure into daily operational decisions for the reservoirs. The most recent approved Water Control Plan for the system is dated 1959, although operations have been conducted in recent year in accordance with the draft Water Control Plan for the ACF dated 1989, with adjustments as necessary in recent years to accommodate current needs, such as operations in support of fish and wildlife and endangered and threatened species. Finalizing the 1989 draft plan awaits resolution of ongoing litigation filed by State of Alabama in 1990, which is currently the subject of court-ordered mediation.

3.7.1.2 Other Authorized Reservoir Purposes

In addition to navigation, the ACF federal dams and reservoirs are authorized for several other purposes, including flood control, hydropower, water supply, water quality, recreation, and fish and wildlife conservation. Power generation is marketed through the Southeastern Power Administration (SEPA), which enters contracts with power customers. Storage in the larger reservoirs is specifically allocated to the hydropower purpose and for flood control purposes. All other project purposes must share the water resources within the conservation pool of the reservoirs. The Corps may enter into contracts for storage with municipal and industrial water users, subject to completion of a reallocation study and approval by higher authority, and potentially requiring Congressional authority. There are currently no water supply contracts in the ACF basin – previous contracts were allowed to expire in 1989-1990, and have not been renewed due to ongoing litigation. Water withdrawals are currently being made under water withdrawal permits issued by the State of Georgia. No allocation of storage in the upstream reservoirs has been made in support of water supply, and no contracts from the Corps authorize water withdrawals or provide for storage in support of water supply. However, the Corps is currently under court order to implement the Southeastern Federal Power Customers, Inc. Settlement Agreement. This settlement involves issuing interim water storage contracts at Lake Lanier pending future permanent reallocation of storage to the water supply purpose, subject to completion of a NEPA document, Section7 consultation, and a determination that the interim contracts may proceed. Water storage contracts do not authorize use of the water, *per se*, only use of the reservoir storage that could provide a source of water supply.

Each of these authorized purposes receives operational consideration, and the operational decisions stemming from such consideration affect how basin inflow is stored and released from the dams. The releases from Woodruff Dam are the downstream end result of all of these decisions, for which the action evaluated in this consultation provides the sideboards of a minimum flow and a maximum fall rate schedule relative to basin inflow. Actions associated with the specific purposes listed above have not yet undergone the section-7 consultation process for effects to listed species in the Apalachicola River. Significant changes in any operating procedures that would appreciably alter the effects analysis of this BO would require reinitation of this consultation.

3.7.2 Unrelated Federal Actions

The Corps administers Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. These permit programs regulate dredge, fill, and construction activities in waters of the United States. Construction activities regulated by the permit programs include: agricultural, municipal, rural, and industrial water intakes; residential, marina, and recreational developments; storm-water and waste-water outlet works; cable, pipeline, and transmission line crossings; bridges; piers; docks; navigational aids; platforms; sand and gravel operations; small dams for recreation and/or water supply; and bank stabilization projects. From 1992 to 2007, four new reservoirs have been constructed in the ACF under these permit programs, including Lake McIntosh (Fayette County) reservoir and the Griffin Reservoir (Pike County).

The National Pollutant Discharge Elimination System (NPDES) permit program authorized by the Clean Water Act regulates point-source discharges of pollutants into waters of the United States. Point sources are discrete conveyances such as pipes or man-made ditches. The NPDES permits issued for discharges within the action area are summarized in section 3.4. The USEPA oversees the NPDES program, but the states of Alabama, Florida, and Georgia, have each been authorized to administer the permitting process.

3.7.3 Contemporaneous Non-Federal Actions

Water use in the basin is regulated independently by each of the three states within their boundaries. Water use in Alabama and Georgia affects basin inflow to Woodruff Dam, which affects the Corps' operations of the federal reservoir projects. Water use in Florida, with the possible exception of water use in Jackson County along the west side of Lake Seminole, does not affect the Corps' operations, but may influence flow downstream of Woodruff Dam.

We summarize the current levels of consumptive water use in the ACF basin upstream of Woodruff Dam in our effects analysis, section 4.2.1. We also consider possible increases in consumptive water use in our cumulative effects analysis, section 7.1.

3.8 Tables and Figures for Section 3

Table 3.5.2.2.A. Results of fat threeridge density found during the quantitative mussel survey conducted by the USFWS from 24-31 October 2007 in RM range 40-50.

Site	River Mile	# Quadrats	Mean Density/ft^2	SD Density/ft^2	Mean Density/m^2	SD Density/m^2
DM09	40.5	23	0.02	0.08	0.04	0.21
DM10	40.6	20	0.07	0.19	0.20	0.52
DM05	42.8	91	0.15	0.31	0.41	0.84
DM06	43.0	28	0.05	0.13	0.14	0.36
DM08	43.4	30	0.12	0.55	0.33	1.47
DM15	43.9	34	0.98	1.45	2.65	3.89
DM14	44.3	76	0.32	0.81	0.86	2.17
DM16	44.5	25	0.03	0.10	0.08	0.28
DM18	46.0	49	0.06	0.14	0.16	0.37
C155	46.8	117	0.64	1.05	1.73	2.83
DM23	48.3	27	0.00	0.00	0.00	0.00
Grand Total	NA	520	0.30	0.77	0.81	2.08

Table 3.5.2.2.B. Results of the habitat and fat threeridge surveys conducted and the resulting predicted densities, habitat, and population estimates. Note that density in the RM 40–50 range was measured by quantitative methods. Density in the rest of the river was predicted using qualitative surveys conducted by the USFWS, FFWCC, and CSU and the relationship between qualitative and quantitative survey methods developed by Miller and Payne (2007).

RM Range	Mean CPUE (hr)	Mean Measured or Predicted Density/ft2	Number of Sites Sampled	Number of Sites of delineated habitat	Mean Site Length (ft)	Total Available Habitat (ft^2)*	Total Number of Fat Threeridge	Percent of Population in Each Reach	Percent of Habitat in Each Reach
Chipola River	51	0.0980	5	42.9**	433***	637,712	62,470	27%	20%
100-106	0	0.0000	1	5	1054	180,761	-	0%	6%
90-99.9	2	0.0055	4	8	947	259,778	1,416	1%	8%
80-89.9	7	0.0215	5	10	533	182,822	3,939	2%	6%
70-79.9	21	0.0437	4	9	582	179,643	7,851	3%	6%
60-69.9	14	0.0362	5	9	801	247,150	8,938	4%	8%
50-59.9	21	0.0474	4	16	522	286,613	13,599	6%	9%
40-49.9	NA	0.2787	11	26	433	386,492	107,729	46%	12%
30-39.9	17	0.0411	8	19	730	475,477	19,552	8%	15%
20-29.9	9	0.0209	11	13	868	387,148	8,094	3%	12%

* assumes 34.3 ft width, which is the average habitat width measured in RM40-50 reach

**estimated using the known length of the Chipola Cutoff and Chipola River downstream of the Cutoff (17 miles) and assuming RM40-50 is similar (26 sites/10 miles)

***assumes the average length of each site in the Chipola River is similar to the average site length measured in RM40-50 reach

Table 3.5.2.2.C. Results from quantitative sampling of fat threeridge for a population estimate in Swift Slough from 3 August 2006 to 7 August 2006.

Reach	Start (m from inflow)	End (m from inflow)	Est. Density (m2)	Est. Abundance	90% CL
4	200	250	4.407	1983	1332-2952
8	400	450	0.957	431	221-840
15	750	800	1.431	644	206-2009
27	1350	1400	0.20*	90	-

*No fat threeridge were detected in these quadrats. 0.20 is a conservative estimate of density at 90% confidence based on non-detection of species using 45 quadrats (EnviroScience 2006b).

Table 3.5.2.2.D. An estimate of the percentage of fat threeridge that would be exposed to the atmosphere at various discharges in the Apalachicola River (Miller 2005). Sites were grouped by location in the river where group A included RM 30.0, group B included RM 41.5, 46.8, 48.4, and 49.0, and group C included RM 73.3.

	Discharge (cfs)							
Location	3000	4000	5000	6000	7000	8000	9000	10000
A	55.0	47.0	19.1	0.0	0.0	0.0	0.0	0.0
B	100.0	85.1	77.0	59.8	15.4	0.0	0.0	0.0
C	84.1	66.5	46.3	33.9	14.8	7.4	0.0	0.0

Table 3.5.2.2.E. Summary of USFWS survey results from all locations sampled between 14 June 2006 and 28 July 2006. Equivalent discharge (cfs) at the Chattahoochee gage was calculated using USGS stage-discharge relationships (Light et al. 2006) and represents the discharge occurring during mussel sampling at the site. "ND" indicates that no data is available. We did not collect information on the number of dead and exposed listed species at site Z142 because this was the relocation site.

Site	Z142	Z141	C155	C152	Z203	Z213	Z218	C157	C156
Stream	Apalachicola	Apalachicola	Apalachicola	Apalachicola	Swift Slough	Swift Slough	Swift Slough	Chipola Cut	Chipola Cut
Navigation Mile	43.7	44.3	46.8	48.3	40.3	40.3	40.3	0.92	0.47
Mean Daily Stage at Wewahitchka Gage	12.55	12.55	12.55	12.55	12.6	12.6	12.6	12.47	12.47
Equivalent Site Discharge at Chattahoochee	6400-6500	7100-7200	6400-6500	6400-6500	6500-6600	6500-6600	6500-6600	6300-6400	6300-6400
Effort (min)	50	45	30	45	45	45	45	45	99
Number of Listed Species	841	91	84	12	110	14	10	63	62
Number of *Amblema neislerii*	841	91	84	12	108	14	10	63	61
Number of *Elliptoideus sloatianus*	0	0	0	0	2	0	0	0	1
Number of Dead Listed Species	ND	75	7	2	21	3	3	12	13
Number of Exposed Listed Species	ND	83	2	0	19	7	4	15	13
CPUE (hr) Listed	1009.2	121.3	168.0	16.0	146.7	18.7	13.3	84.0	37.6
CPUE (hr) *A. neislerii*	1009.2	121.3	168.0	16.0	144.0	18.7	13.3	84.0	37.0
CPUE (hr) *E. sloatianus*	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.6
CPUE (hr) Dead Listed Species	ND	100.0	14.0	2.7	28.0	4.0	4.0	16.0	7.9
CPUE (hr) Exposed Listed Species	ND	110.7	4.0	0.0	25.3	9.3	5.3	20.0	7.9
% Listed Species Dead	ND	82.4%	8.3%	16.7%	19.1%	21.4%	30.0%	19.0%	21.0%
% Listed Species Exposed	ND	91.2%	2.4%	0.0%	17.3%	50.0%	40.0%	23.8%	21.0%
Mean Length (mm) of Dead *A. neislerii*	ND	64	53	55	52	50	52	69	47
Mean Length (mm) of Exposed *A. neislerii*	ND	64	51	None	53	47	53	70	50

Table 3.5.2.2.F. Stage-based life history for fat threeridge mussels occupying the Apalachicola River (from Miller 2008).

Stage Number	Stage Class	Size (mm)	Approximate Age (yrs)	Duration in Stage
1	Young of Year	≤ 29	0 - 0.99	1
2	Juveniles	30 - 36	1 - 2.99	2
3	Small Adults	37 - 51	3 - 6.99	5
4	Medium Adults	52 - 67	7 - 14.99	7
5	Large Adults	>67	15+	

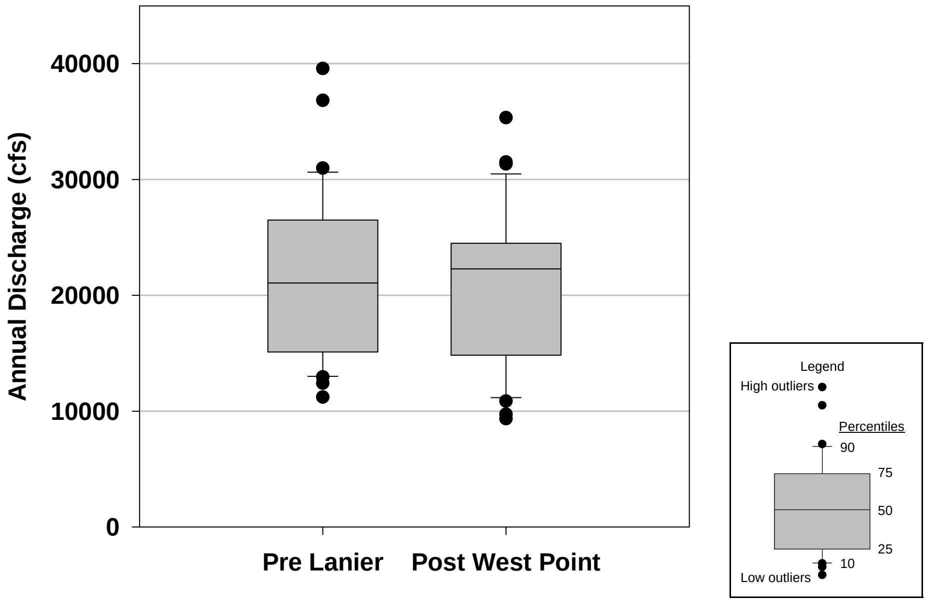

Figure 3.3.1.A. Average annual discharge (cfs) of the Apalachicola River at Chattahoochee, FL, for the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

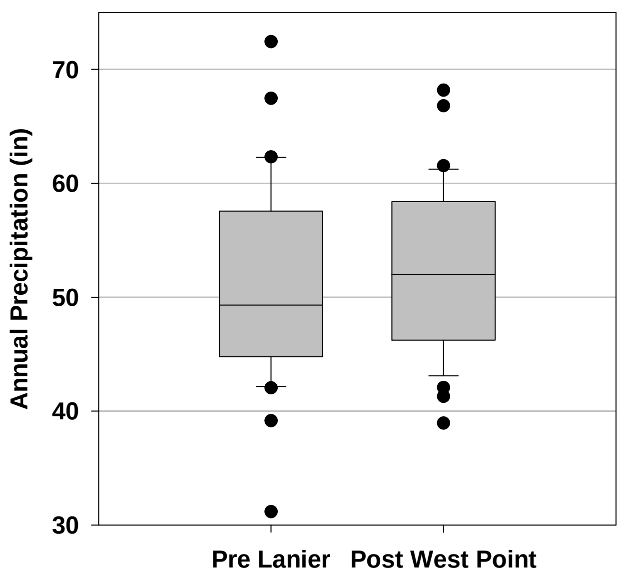

Figure 3.3.1.B. Total annual precipitation (inches) for the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods computed as the average of Alabama climate zones 5, 6, and 7, and Georgia climate zones 1, 2, 3, 4, 5, 7, and 8, weighted by the area of each zone within the ACF Basin.

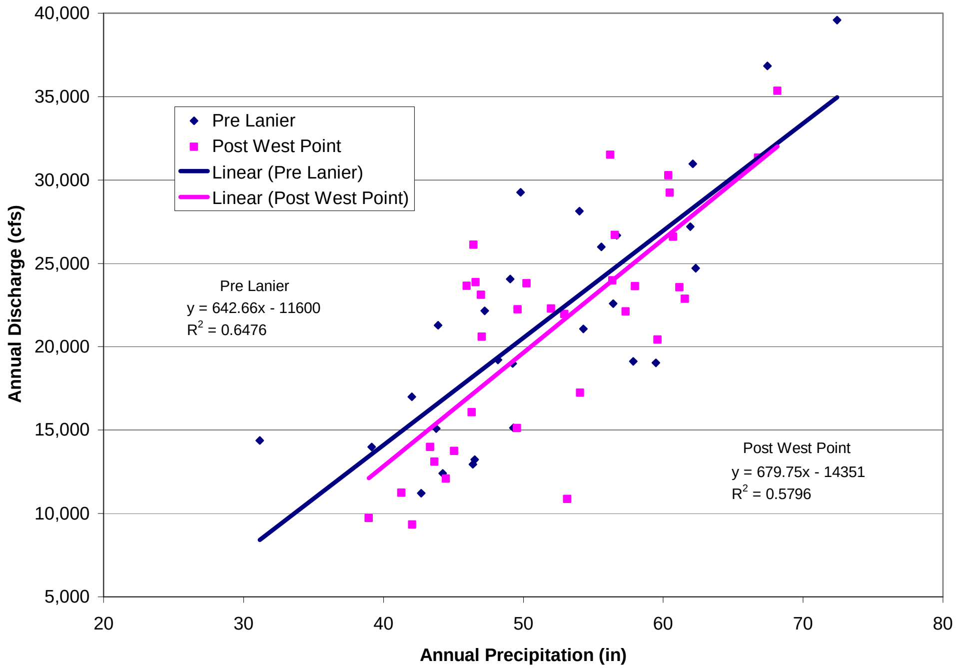

Figure 3.3.1.C. Relationship between average annual precipitation (inches) in the ACF basin upstream of Woodruff Dam and average annual discharge (cfs) at the Chattahoochee gage for the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

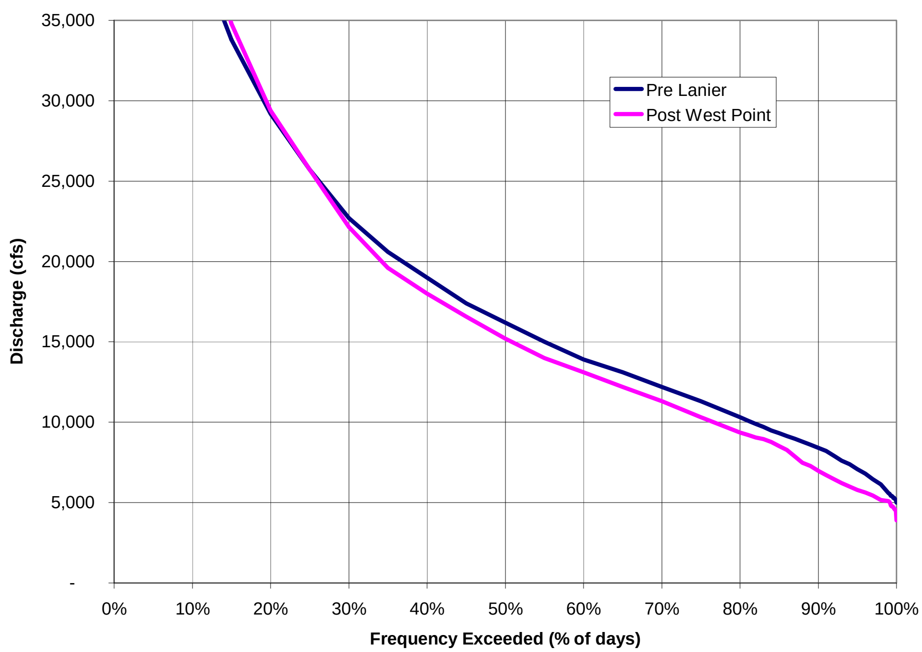

Figure 3.3.1.D. Flow frequency of the Apalachicola River at Chattahoochee, FL, for the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods (discharge rates greater than 50,000 cfs are not shown).

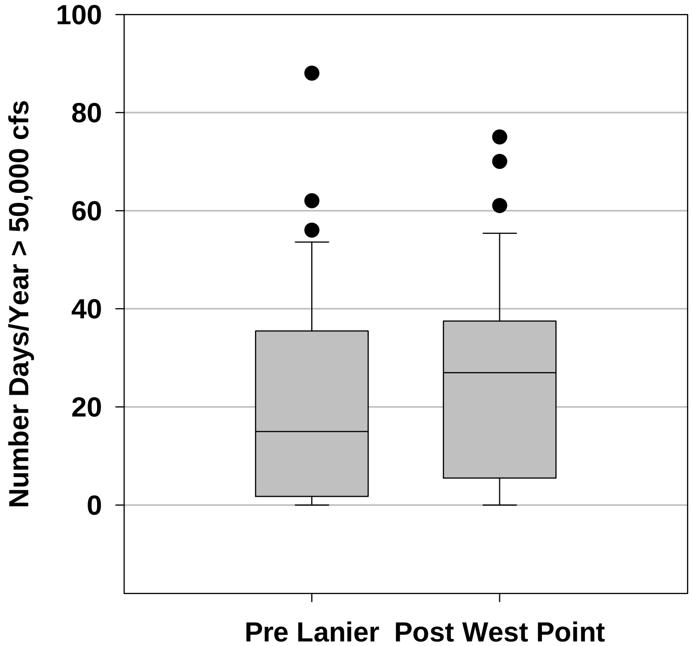

Figure 3.3.2.A. Annual duration of discharge > 50,000 cfs for the Apalachicola River at Chattahoochee, FL, calendar years 1929-1955 (Pre Lanier) and 1975-2007 (Post West Point [baseline]).

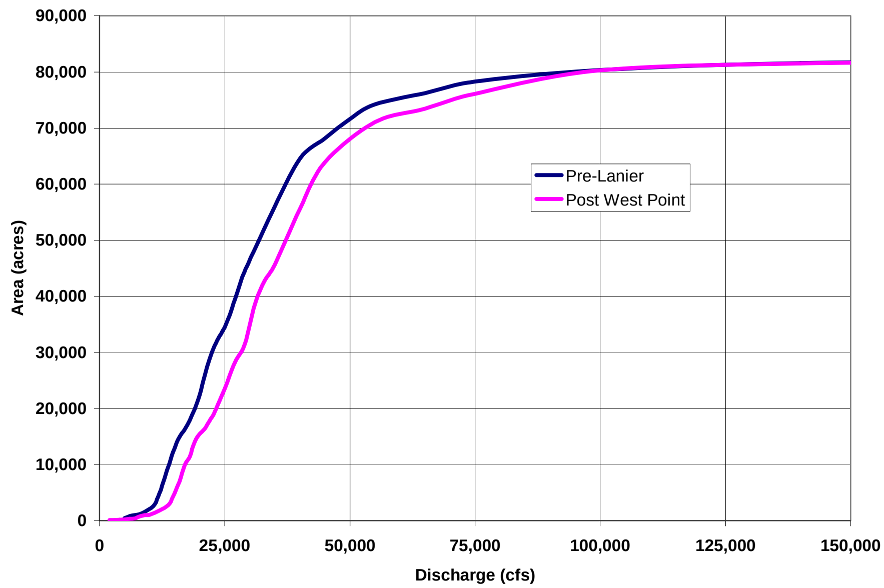

Figure 3.3.2.B. Area (acres) of aquatic habitat connected to the main channel of the non-tidal Apalachicola River at discharges of 5,000 to 150,000 cfs (taken from Light et al. 1998) for the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods, accounting for changes in stage versus discharge relationships between these periods (Light et al. 2006).

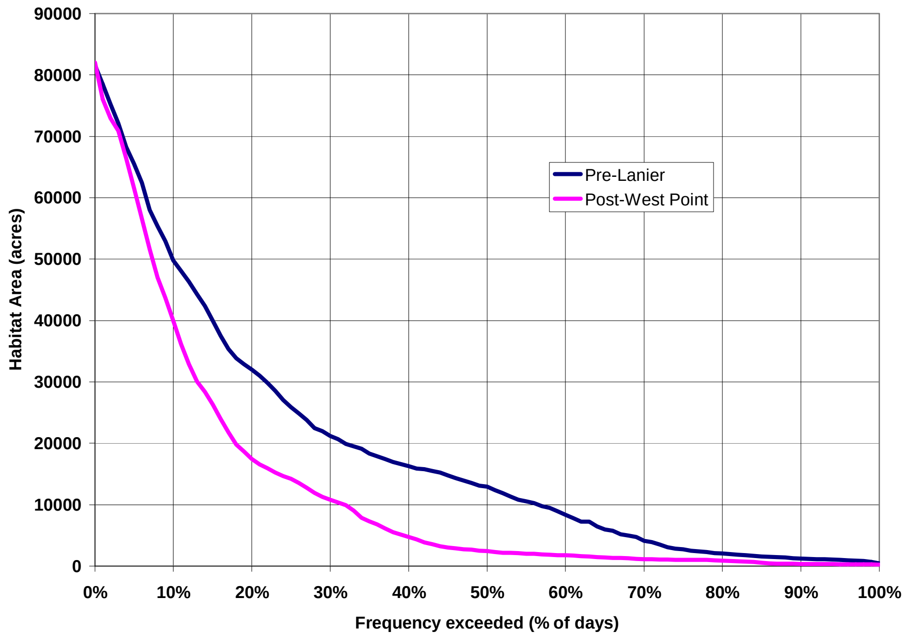

Figure 3.3.2.C. Frequency (% of days) of growing-season (April-October) floodplain connectivity (acres) to the main channel during the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

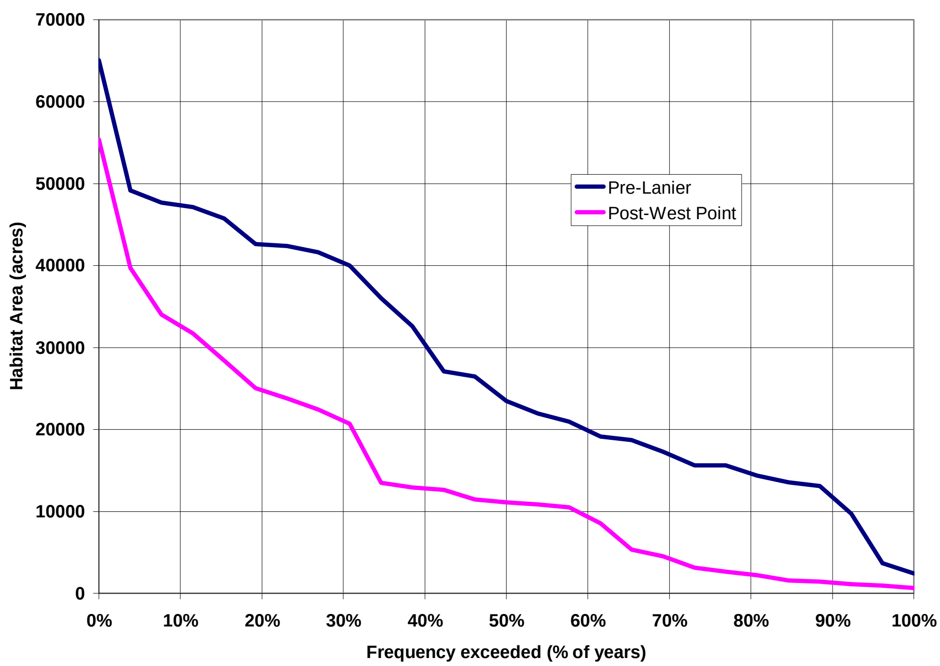

Figure 3.3.2.D. Frequency (% of years) of growing-season (April-October) floodplain connectivity (maximum acreage 30-day continuous connectivity, per year) to the main channel during the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

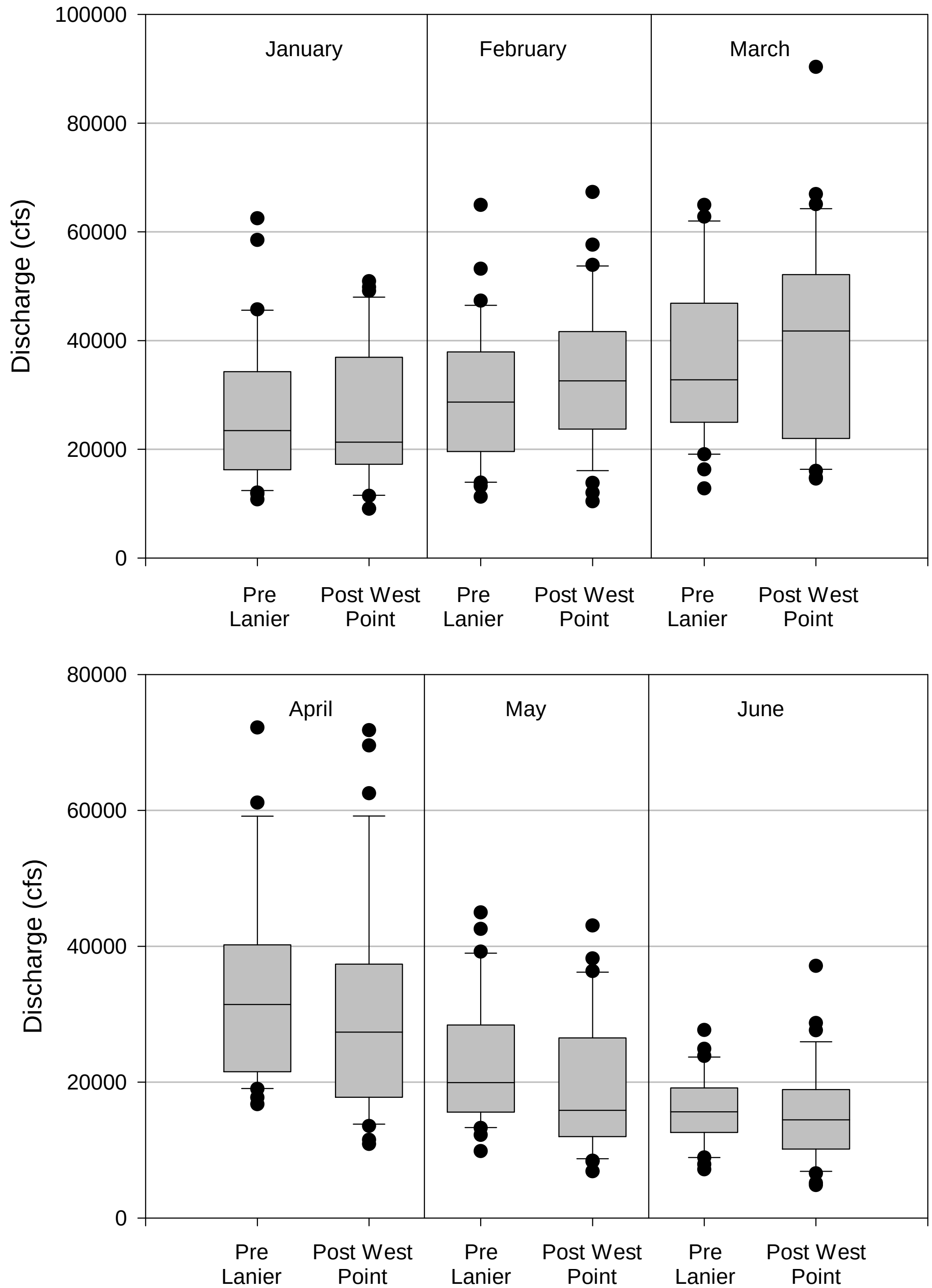

Figure 3.3.3.A. Distribution of January through June average monthly discharge (cfs) during the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

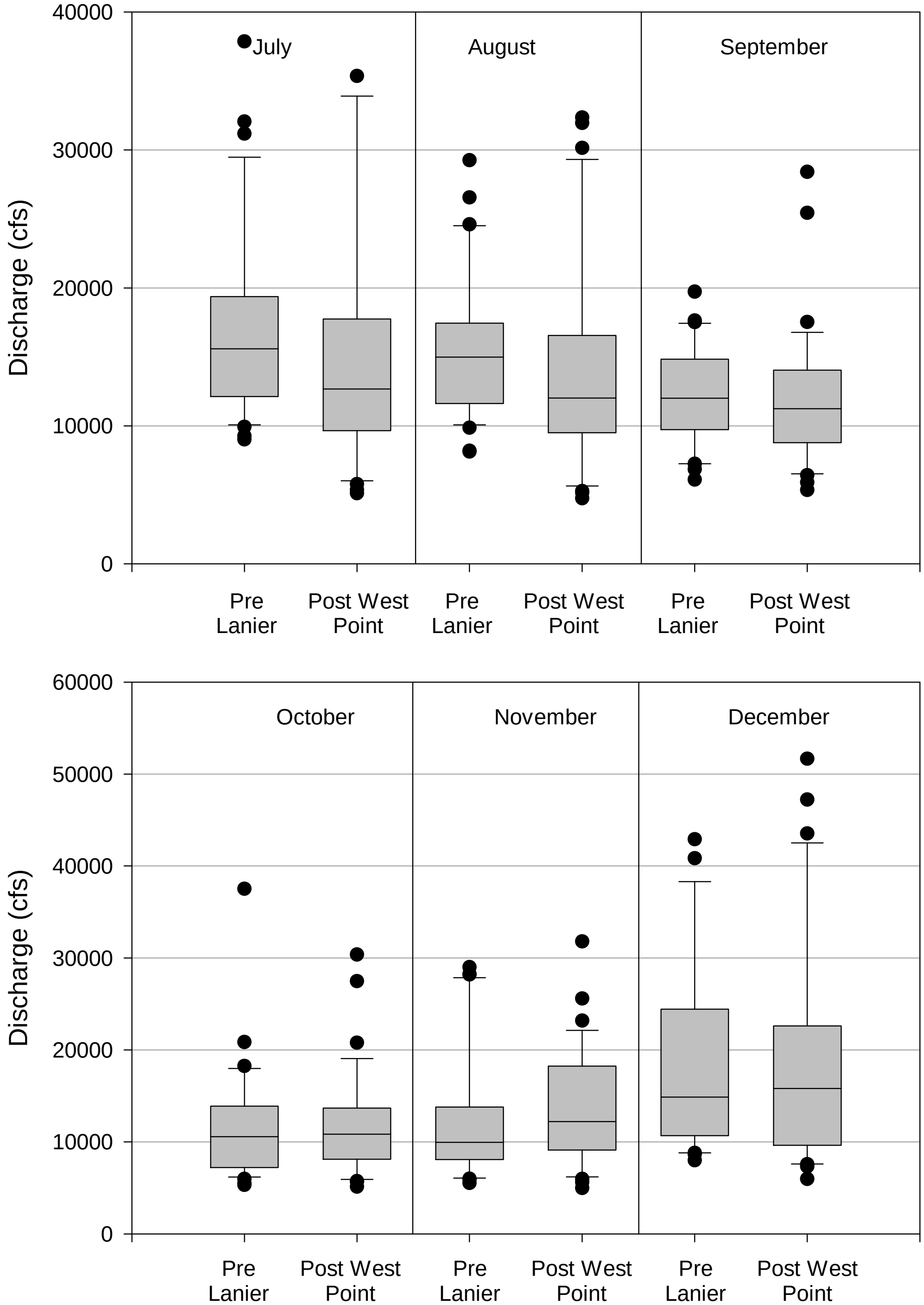

Figure 3.3.3.B. Distribution of July through December average monthly discharge (cfs) during the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

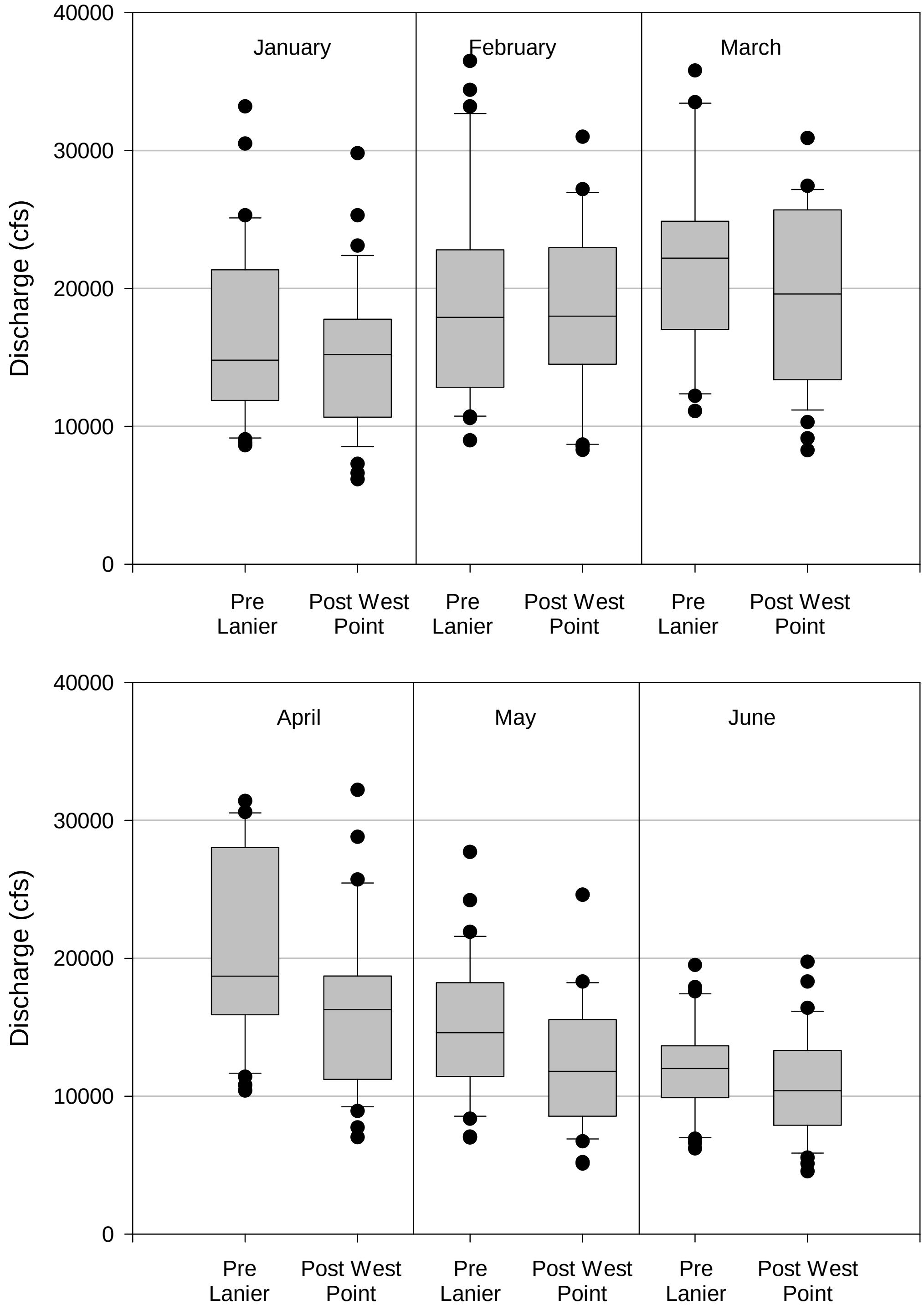

Figure 3.3.4.A. Distribution of January through June monthly 1-day minimum discharge (cfs) during the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

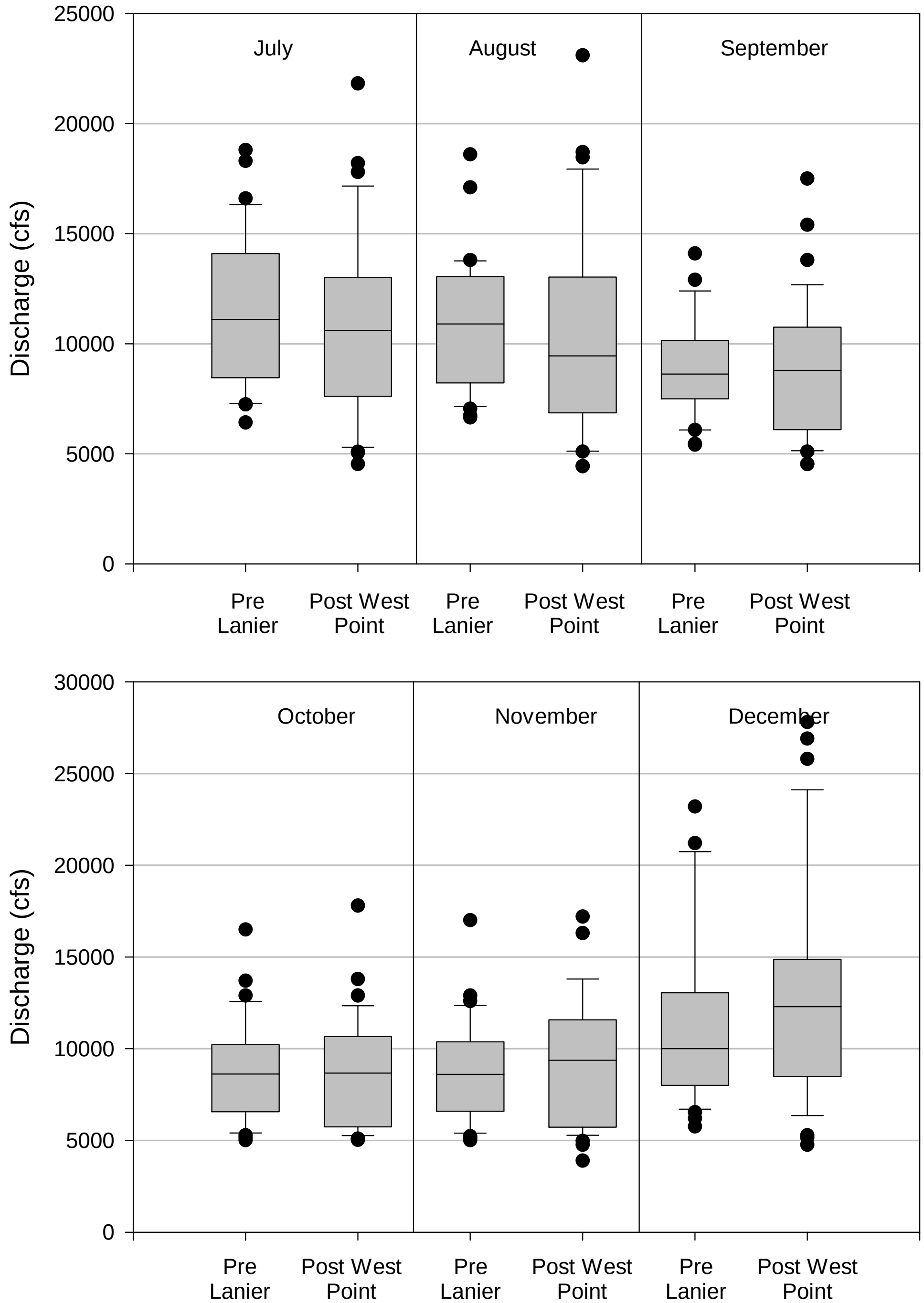

Figure 3.3.4.B. Distribution of July through December monthly 1-day minimum discharge (cfs) during the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

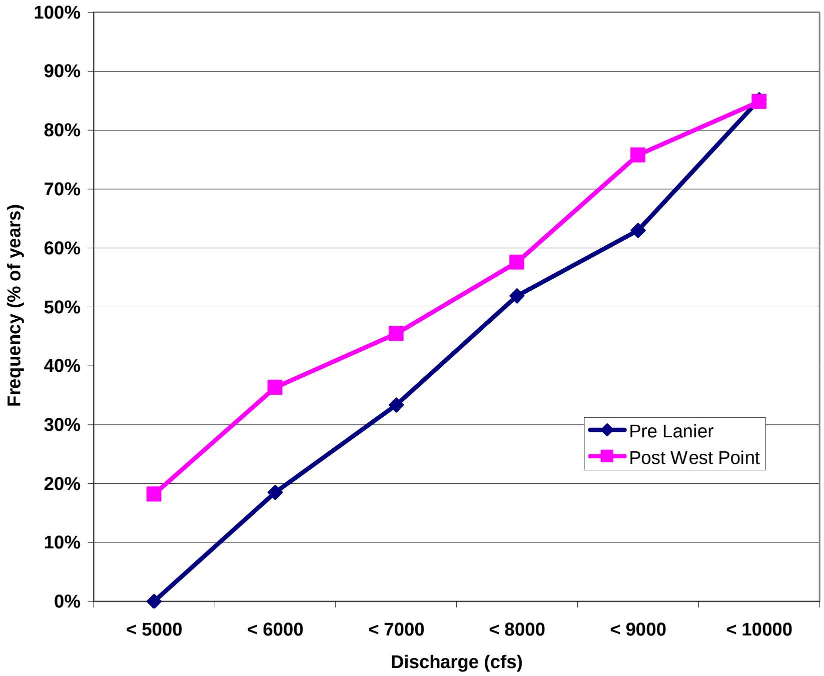

Figure 3.3.4.C. Inter-annual frequency (% of years) of discharge events less than 5,000 to 10,000 cfs during the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

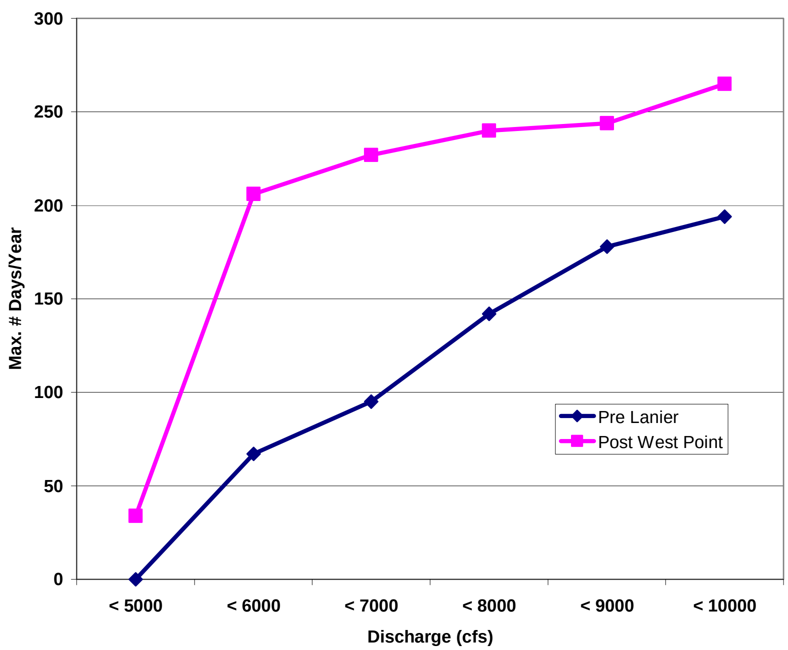

Figure 3.3.4.D. Maximum number of days per year of discharge less than 5,000 to 10,000 cfs during the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

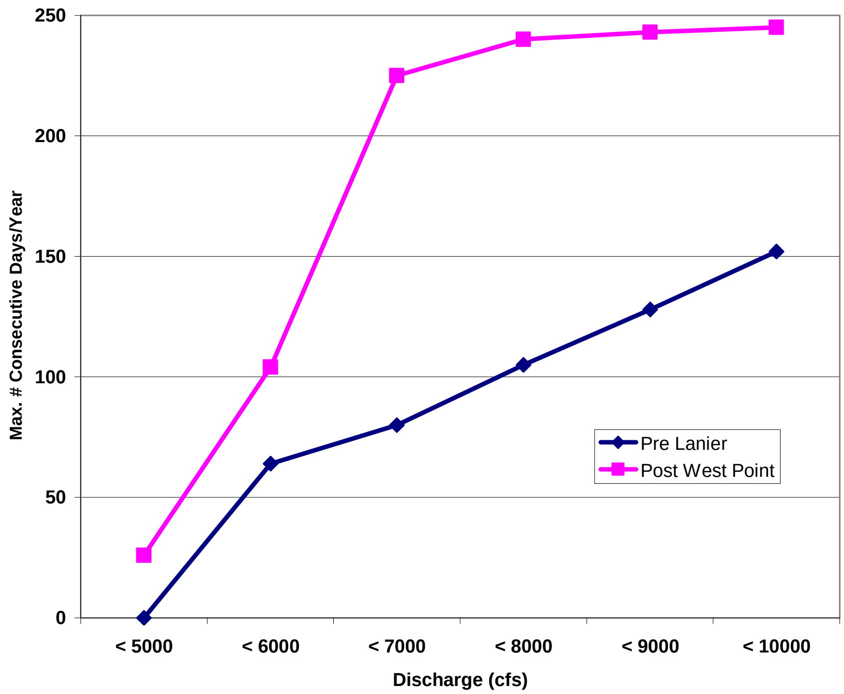

Figure 3.3.4.E. Maximum number of consecutive days per year of discharge less than 5,000 to 10,000 cfs during the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

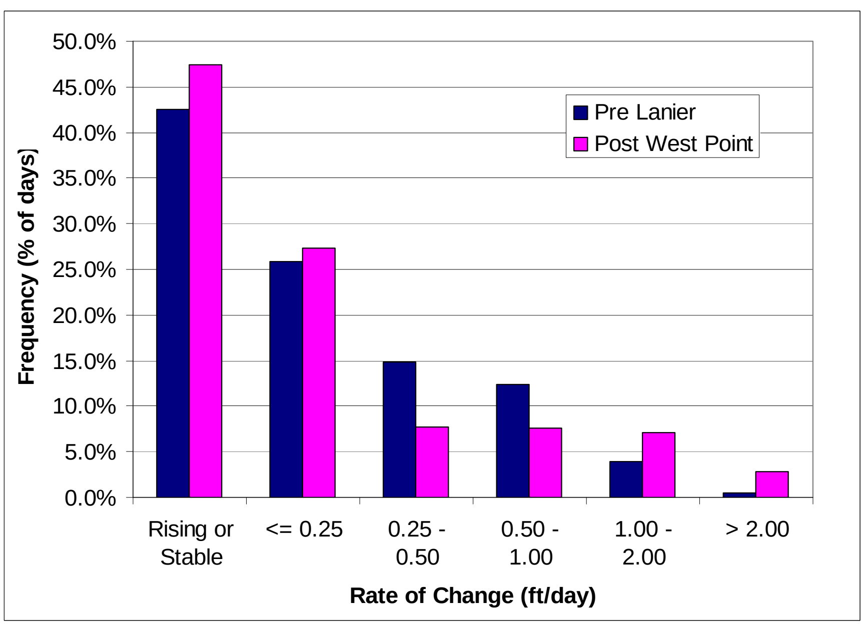

Figure 3.3.5.A. Frequency (% of days) of daily stage changes (ft/day) during the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

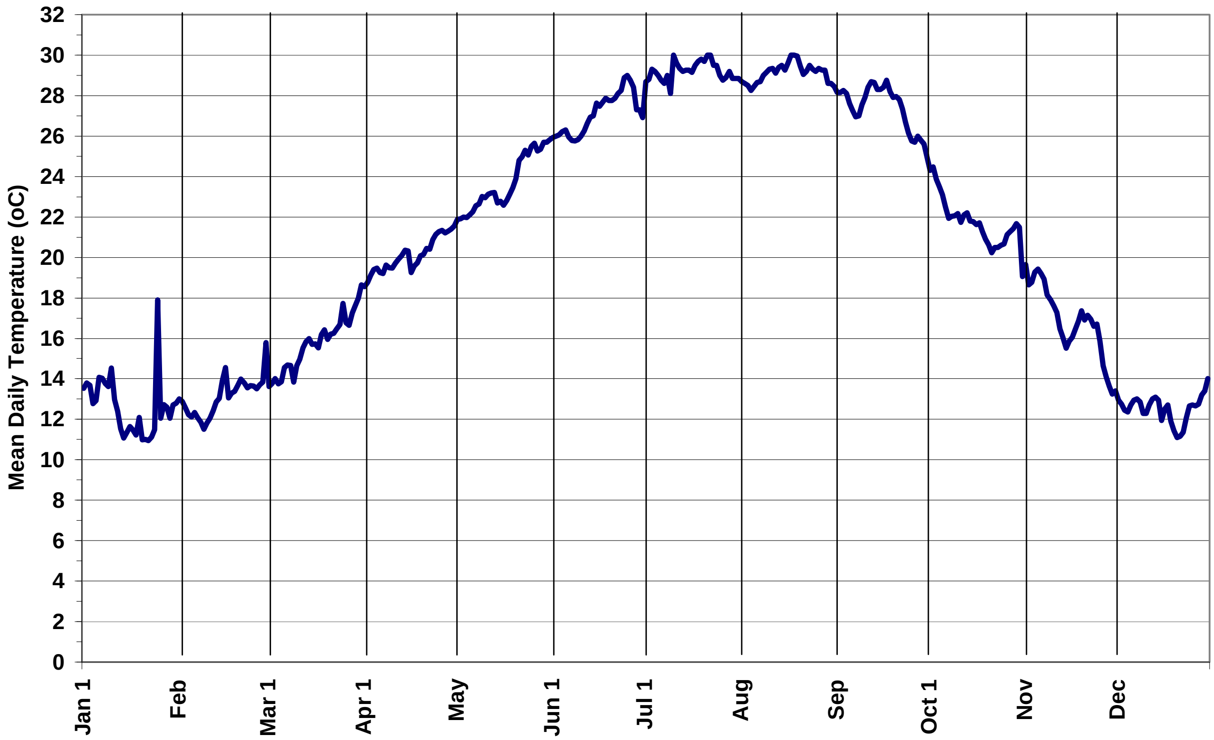

Figure 3.4.A. Mean daily water temperature (°C) by calendar date of the Apalachicola River near Chattahoochee, FL, calculated from available records 1974-1978 and 1996-1997 (source: USGS).

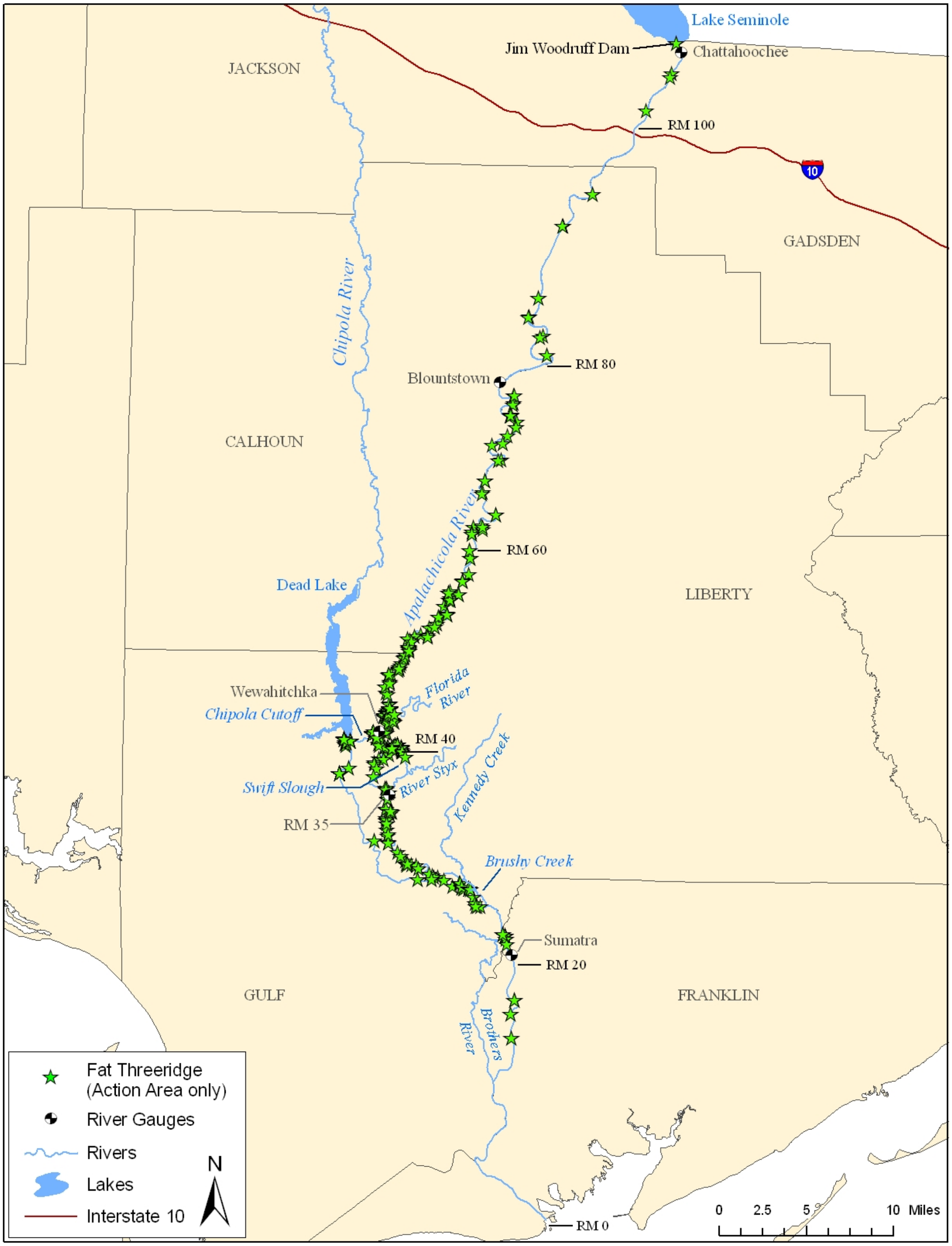

Figure 3.5.2.1.A. Distribution of the fat threeridge in the action area.

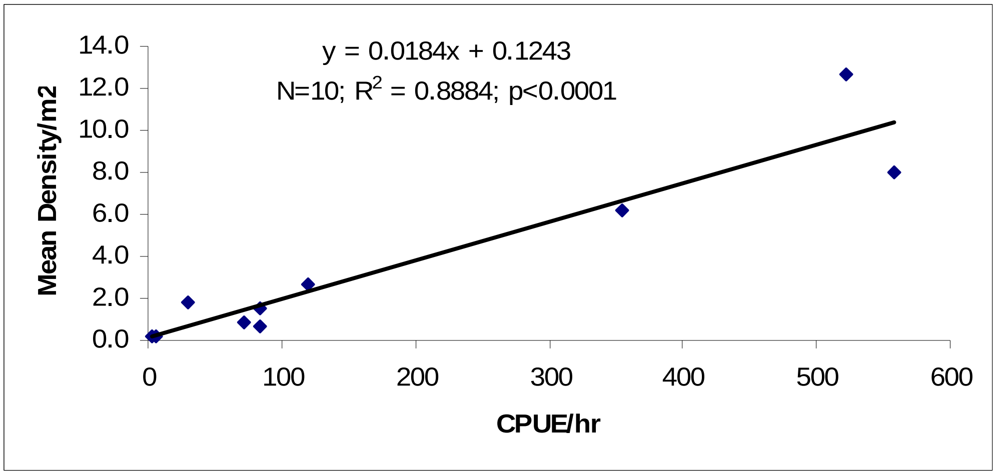

Figure 3.5.2.2.A. Regression relationship between the mean density (m^2) of fat threeridge and the number captured in one hour of effort (Y=0.184X + 0.1243; N=10; p<0.0001).

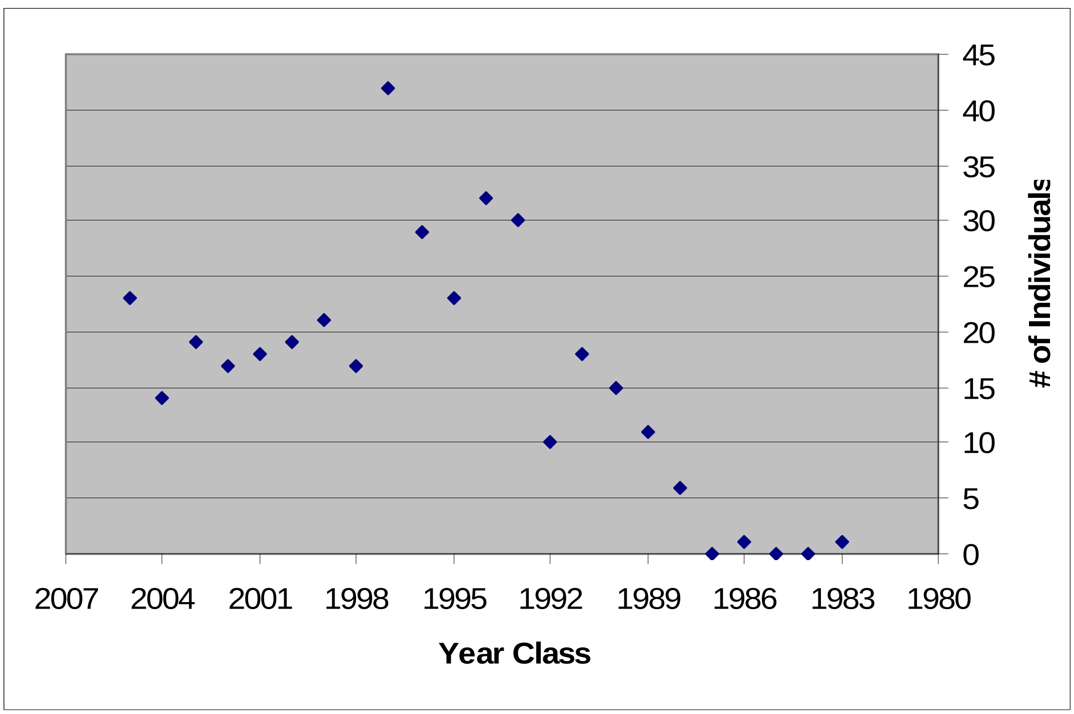

Figure 3.5.2.2.B. The number of fat threeridge in each year class versus the year class for 11 sites in RM40-50 reach of Apalachicola River quantitatively sampled by the USFWS in 2007.

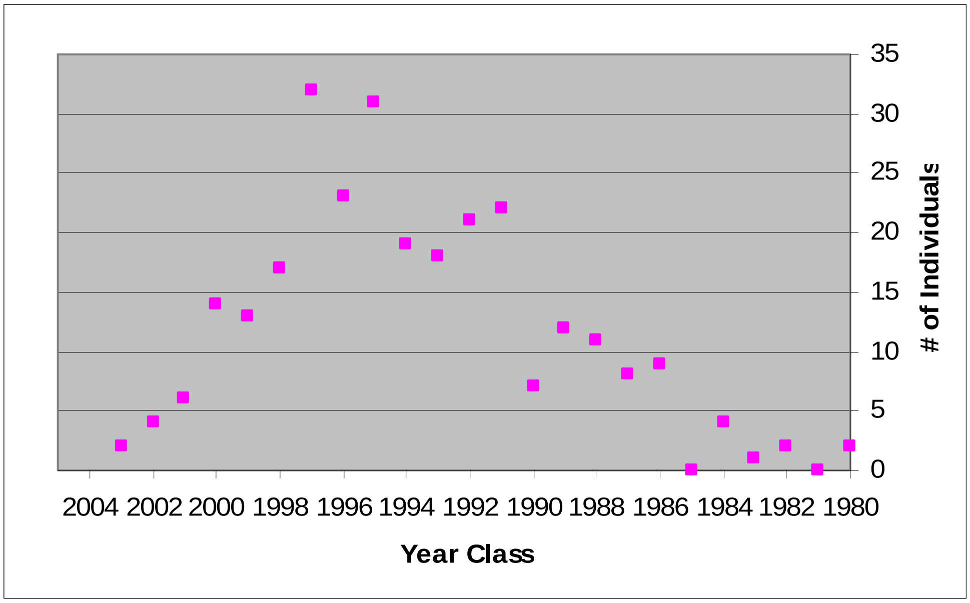

Figure 3.5.2.2.C. The number of fat threeridge in each year class versus the year class for sites in RM40-50 reach of Apalachicola River, Swift Slough, and the Chipola Cutoff quantitatively sampled by EnviroScience in 2005 (EnviroScience 2006 unpub. data).

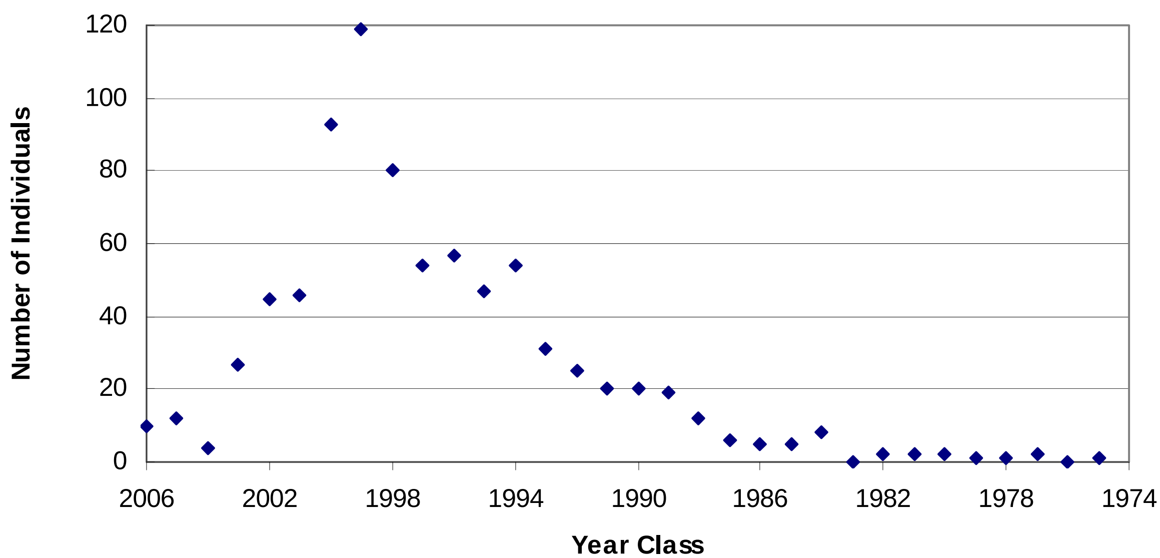

Figure 3.5.2.2.D. Age-class (year class) structure of fat threeridge in the Apalachicola River, Chipola River and Cut, and Swift Slough sampled by qualitative methods in 2005 and 2006 (USFWS 2006 unpub. data; EnviroScience 2006).

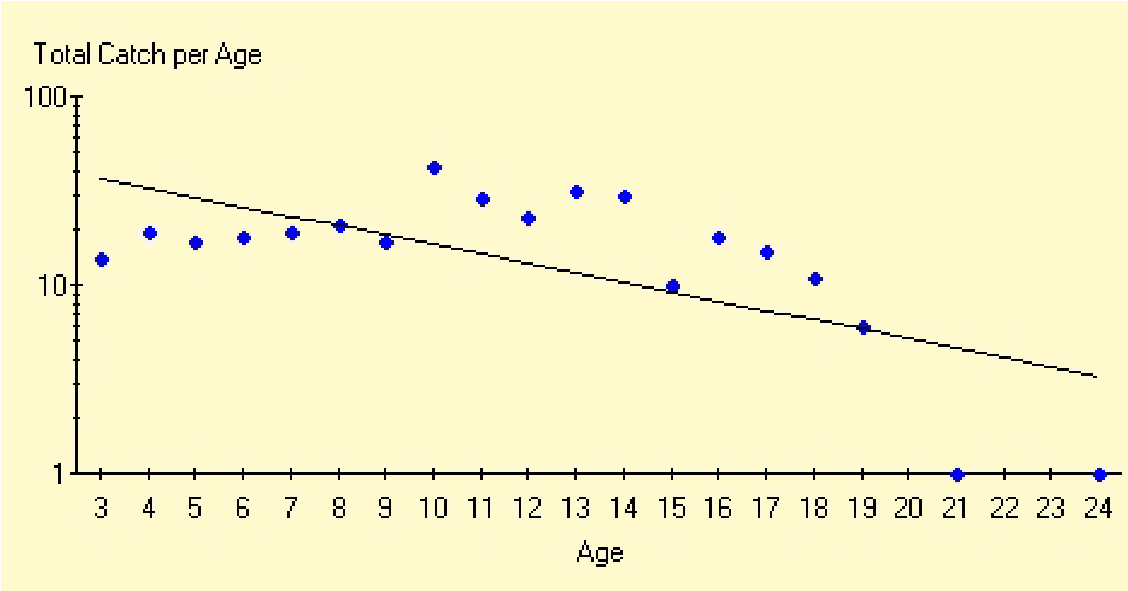

Figure 3.5.2.2.E. Weighted catch curve analysis of fat threeridge from quantitative data collected by the Service in RM 40-50 of the Apalachicola River during October 2007.

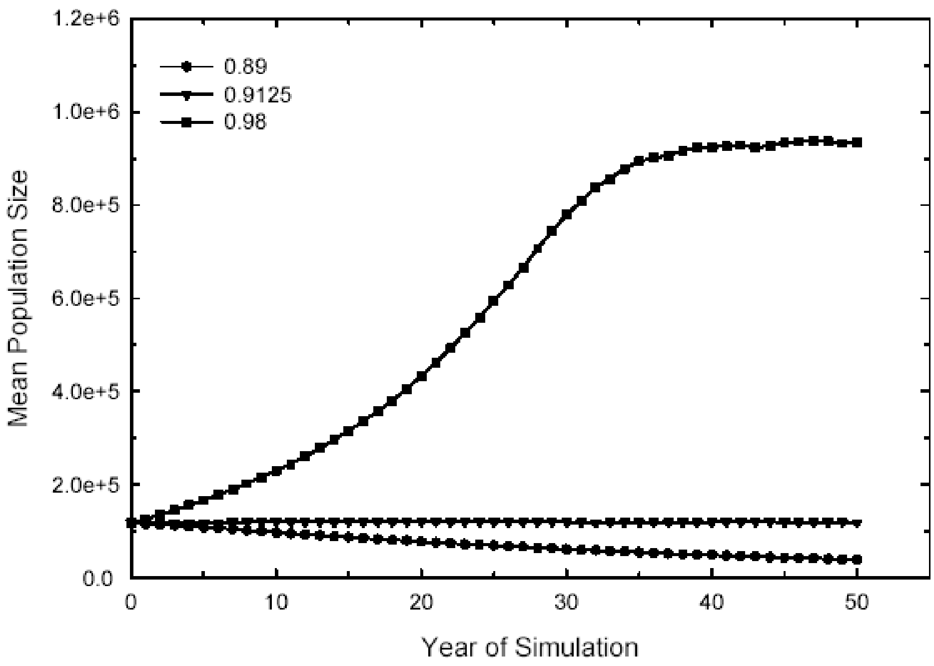

Figure 3.5.2.2.F. Mean trajectories across stochastic simulations of fat threeridge population size for alternative values of adult annual survival (p_{Ad}) (from Miller 2008).

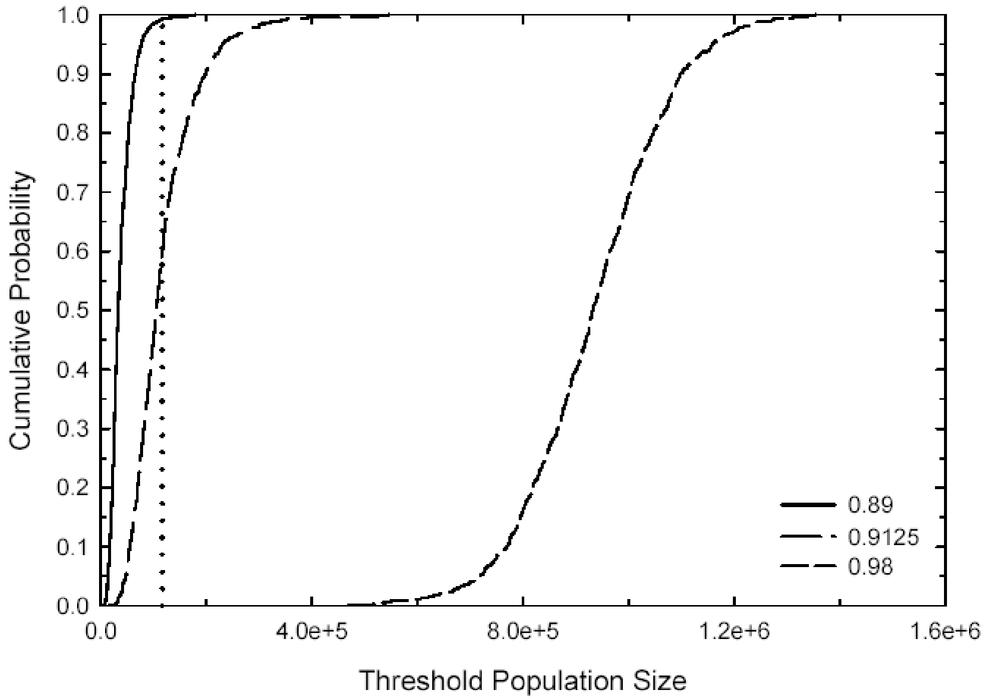

Figure 3.5.2.2.G. Quasi-extinction curves for simulated fat threeridge populations for alternative values of annual adult survival rate (p_{Ad}). The curves give the probability that the population of interest will fall below the range of threshold abundances at the end of the simulation. Initial population size is indicated by the vertical dotted line (from Miller 2008).

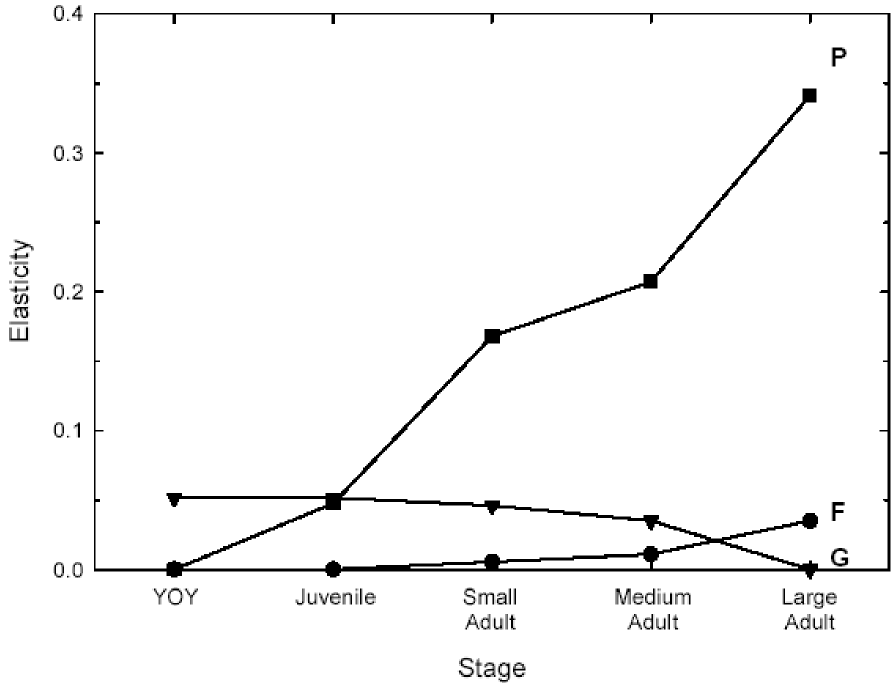

Figure 3.5.2.2.H. Elasticity of population growth rate to changes in stage-specific fecundity (F), survival with growth into the next stage (G), and survival within the same stage (P) for matrix models of fat threeridge population dynamics (from Miller 2008).

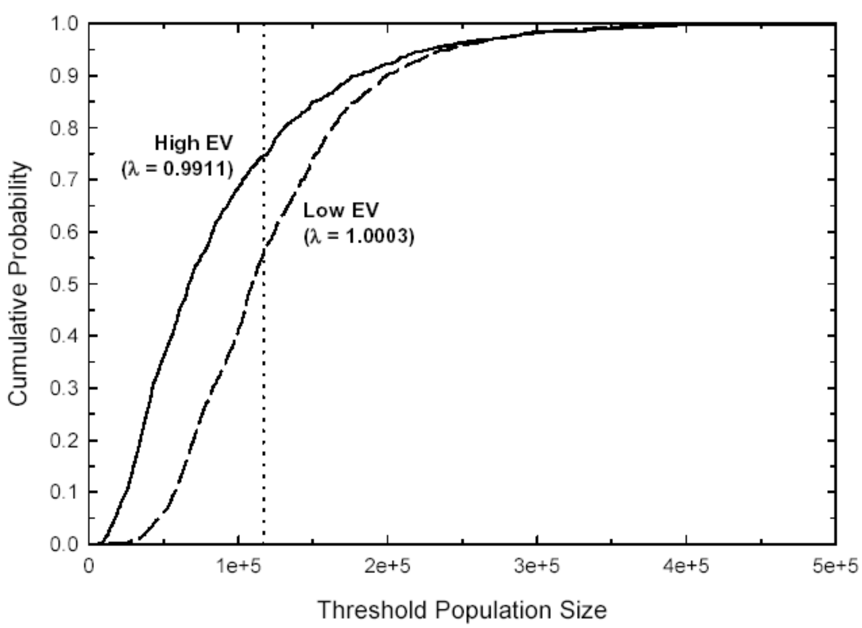

Figure 3.5.2.2.I. Quasi-extinction curves for simulated fat threeridge populations under conditions of intermediate adult survival (p_{Ad} = 0.9125) and alternative levels of environmental variability (EV). Initial population size is indicated by the vertical dotted line (from Miller 2008).

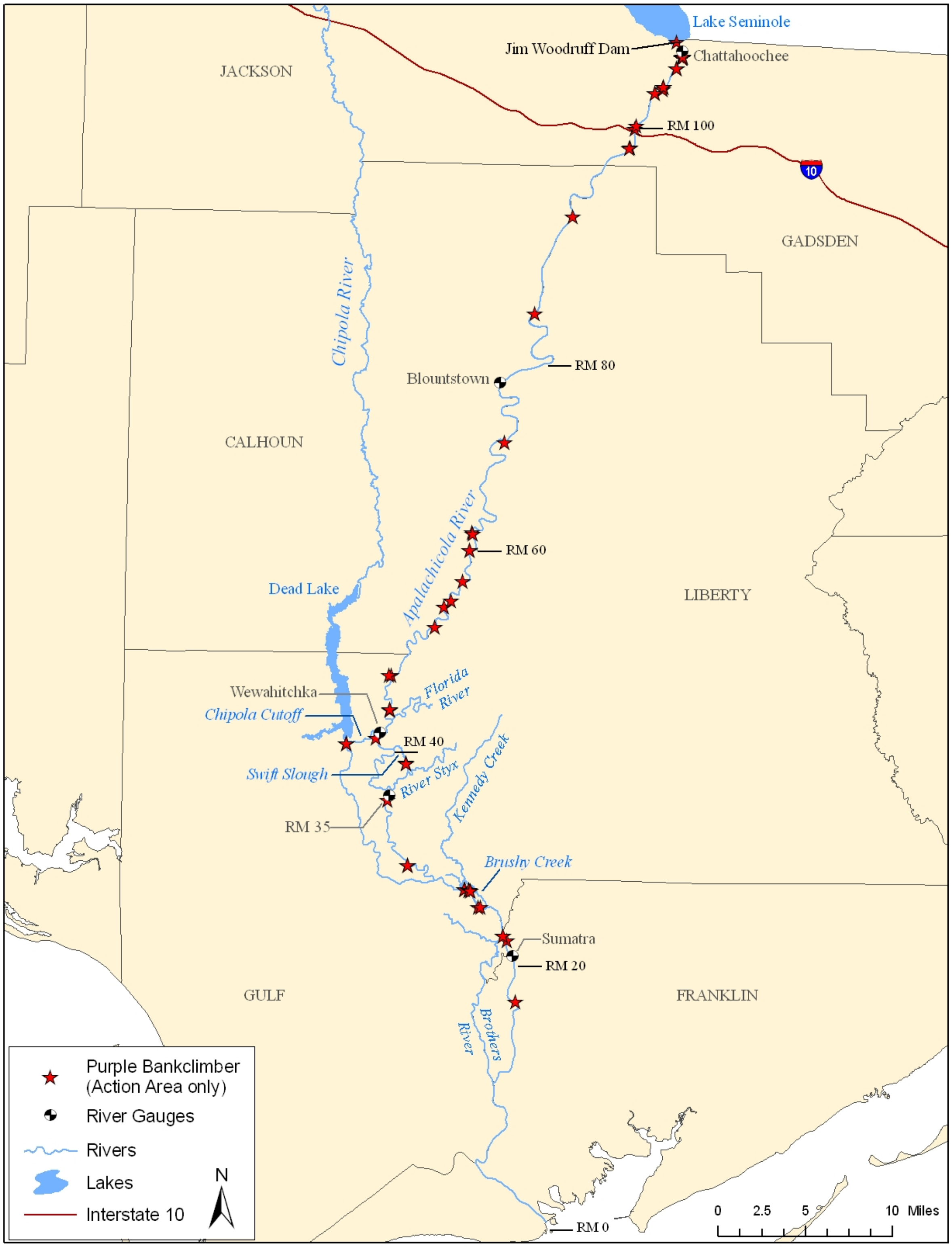

Figure 3.5.3.1.A. Distribution of the purple bankclimber in the action area.

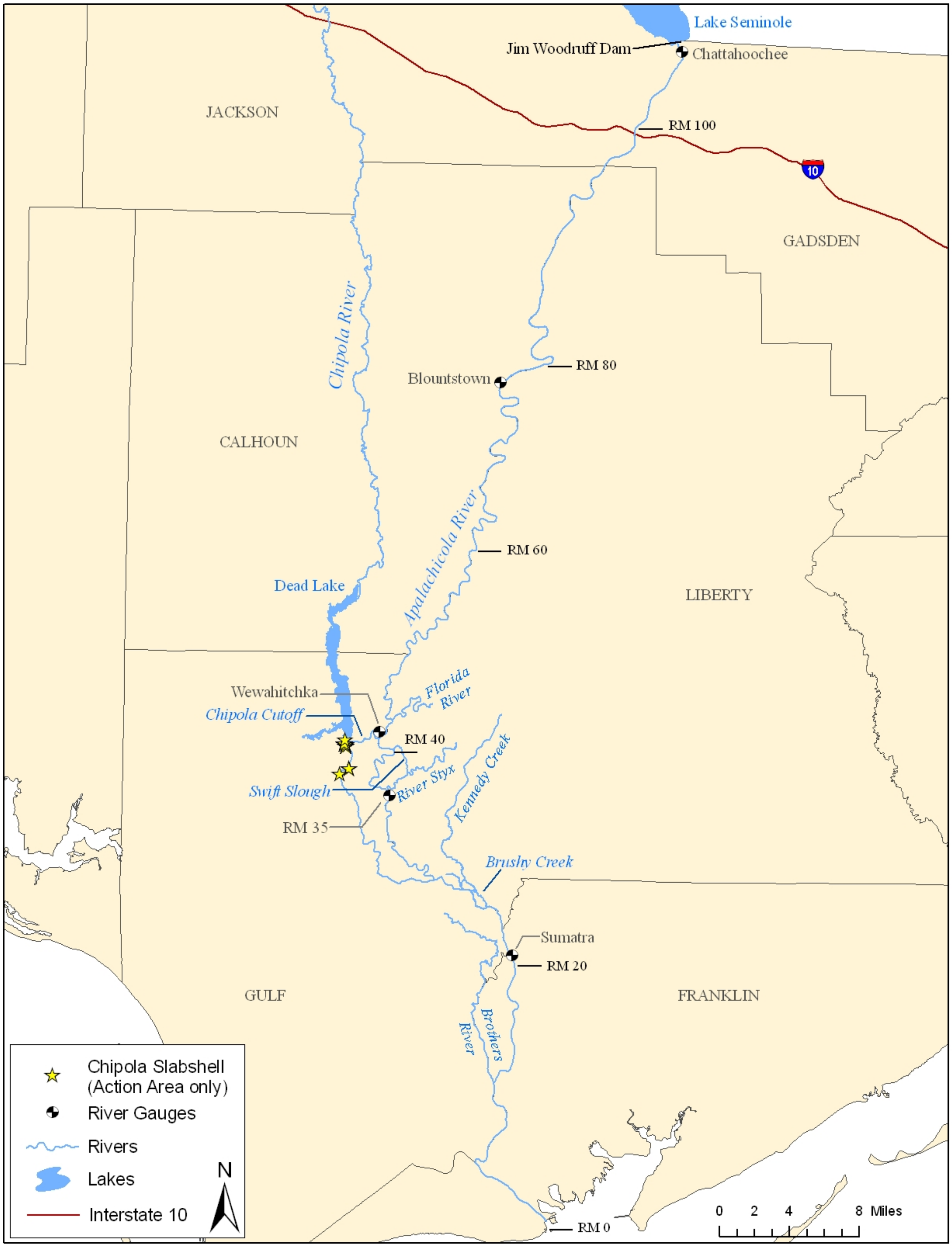

Figure 3.5.4.1.A. Distribution of the Chipola slabshell in the action area.

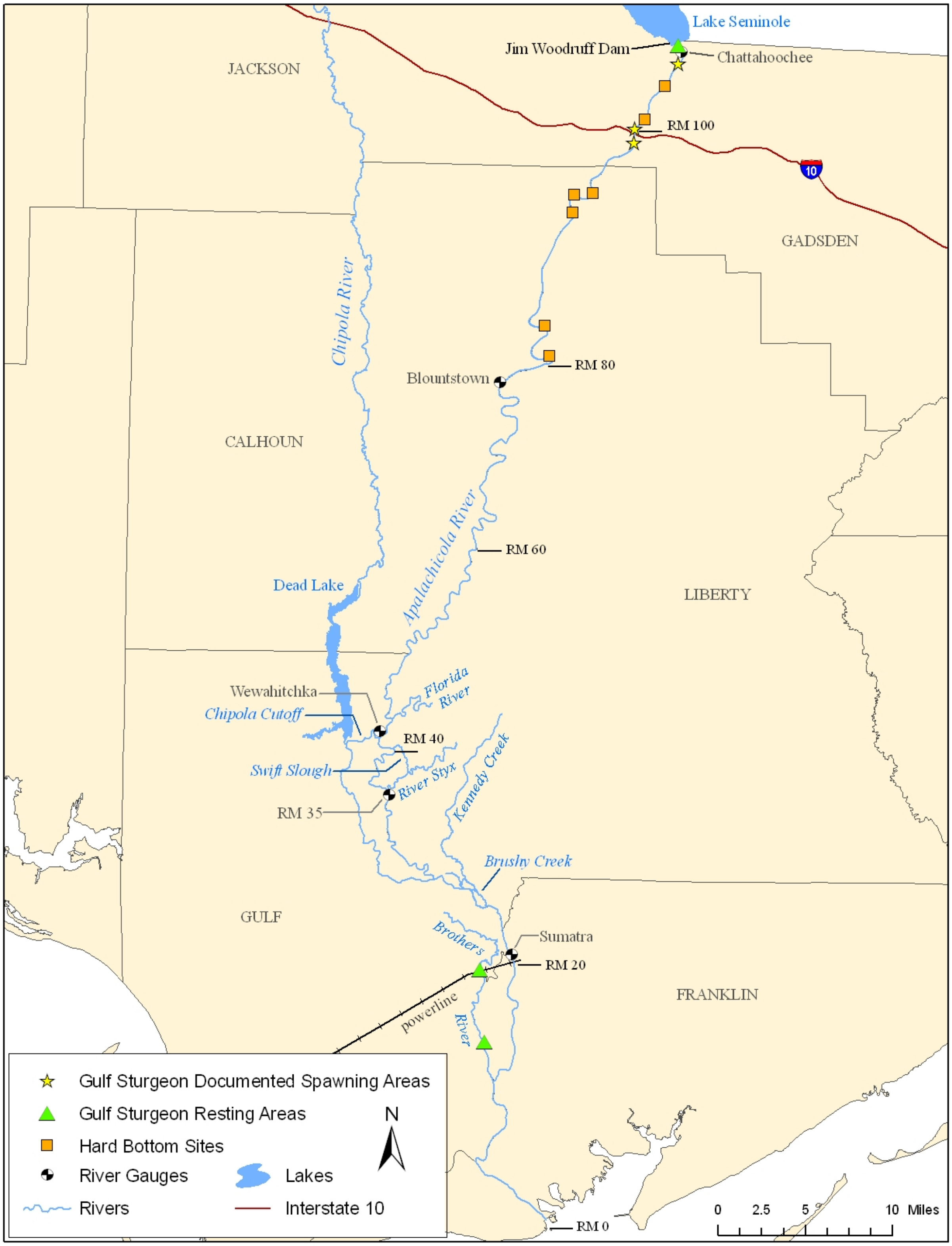

Figure 3.6.1.2.A. Location of documented Gulf sturgeon spawning sites, resting areas, hard-bottom sites (potential spawning sites), and other landmarks in the action area.

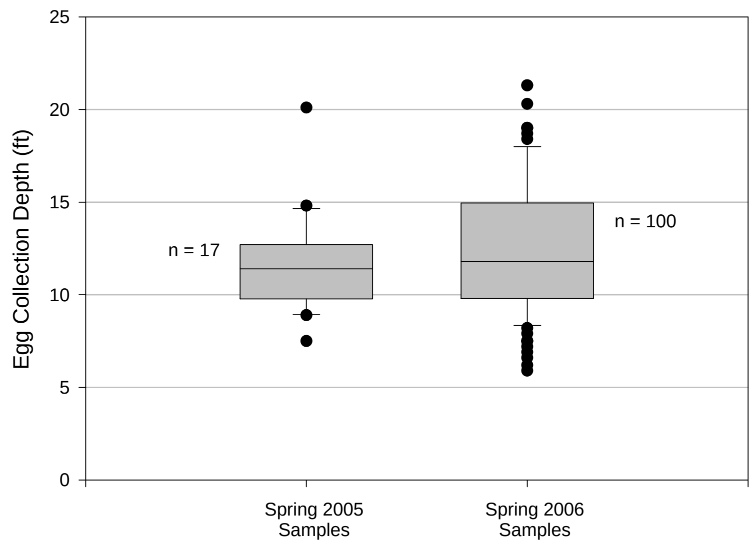

Figure 3.6.1.4.A. Distribution of depths at which Gulf sturgeon eggs were collected during 2005 (USFWS unpub. data 2005) and during 2006 (Pine et al. 2006).

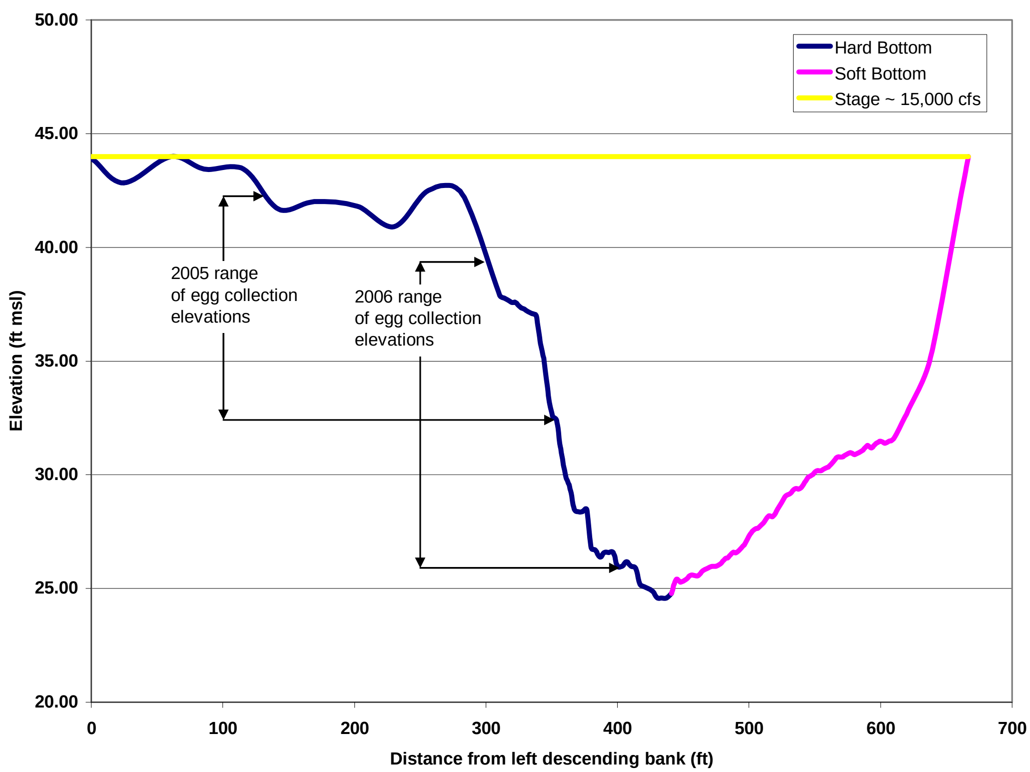

Figure 3.6.1.4.B. Cross section of the river at RM 105, which spans the limestone shoal where sturgeon eggs were collected in both 2005 and 2006.

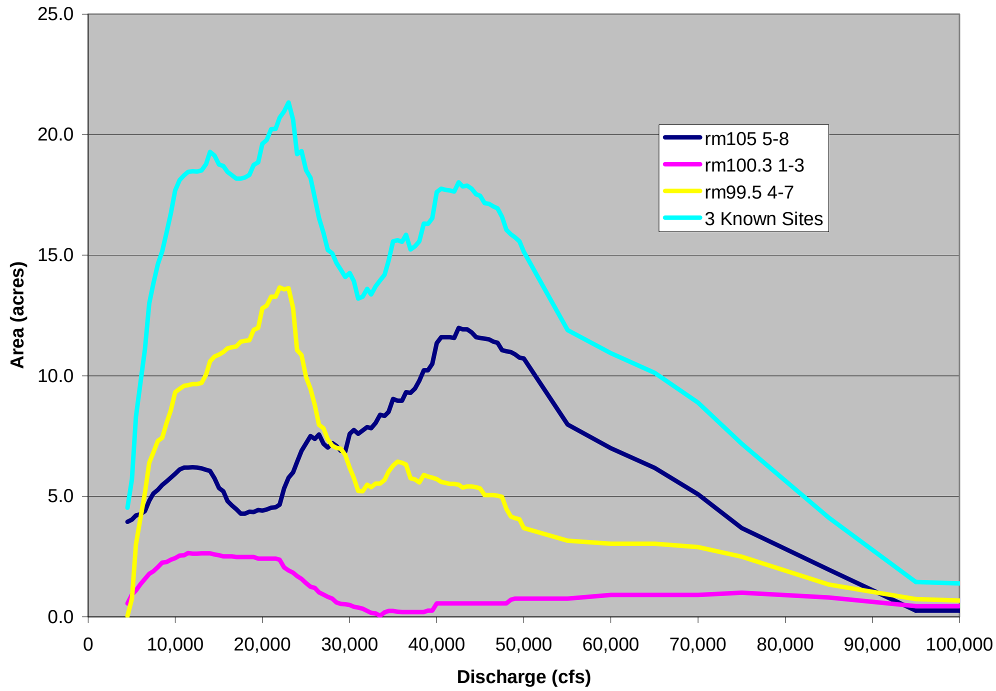

Figure 3.6.1.4.C. Area (acres) of hard substrate inundated to depths of 8.5 to 17.8 ft deep at the three known Gulf sturgeon spawning sites on the Apalachicola River (RM 105, RM 100, and RM 99) at flows of 5,000 to 100,000 cfs, based on the cross sections located closest to egg collections during 2005, 2006, and 2008.

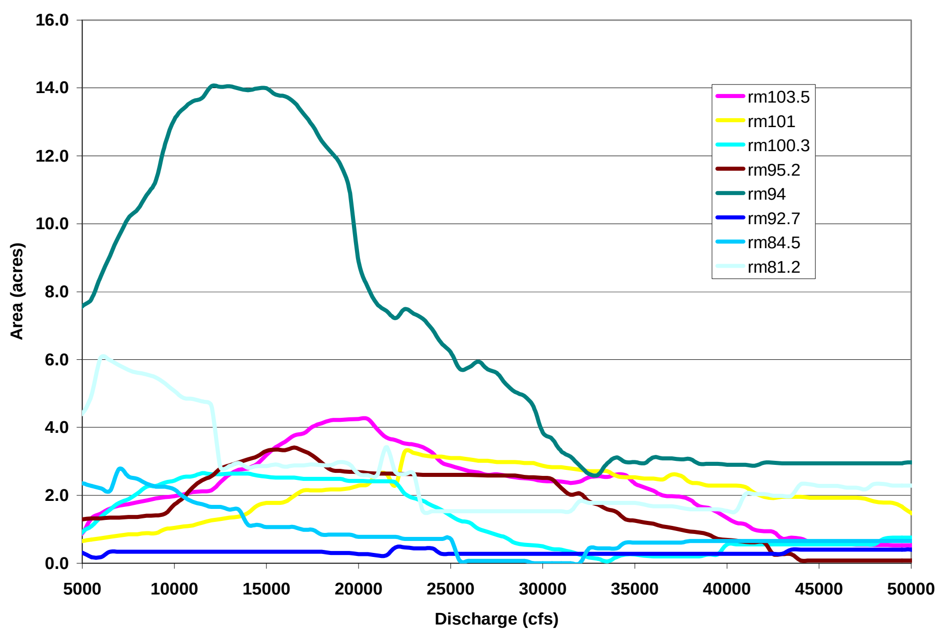

Figure 3.6.1.4.D. Area (acres) of hard substrate inundated to depths of 8.5 to 17.8 ft deep at eight potential Gulf sturgeon spawning sites on the Apalachicola River (river mile [RM] shown) at flows of 5,000 to 50,000 cfs, based on all cross sections measured at these sites.

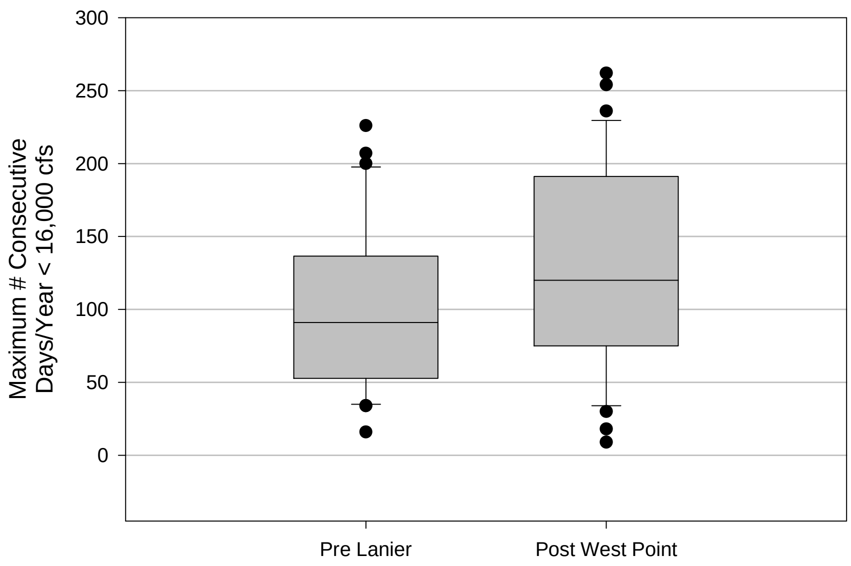

Figure 3.6.1.5.A. Maximum number of consecutive days/year of flow less than 16,000cfs during the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

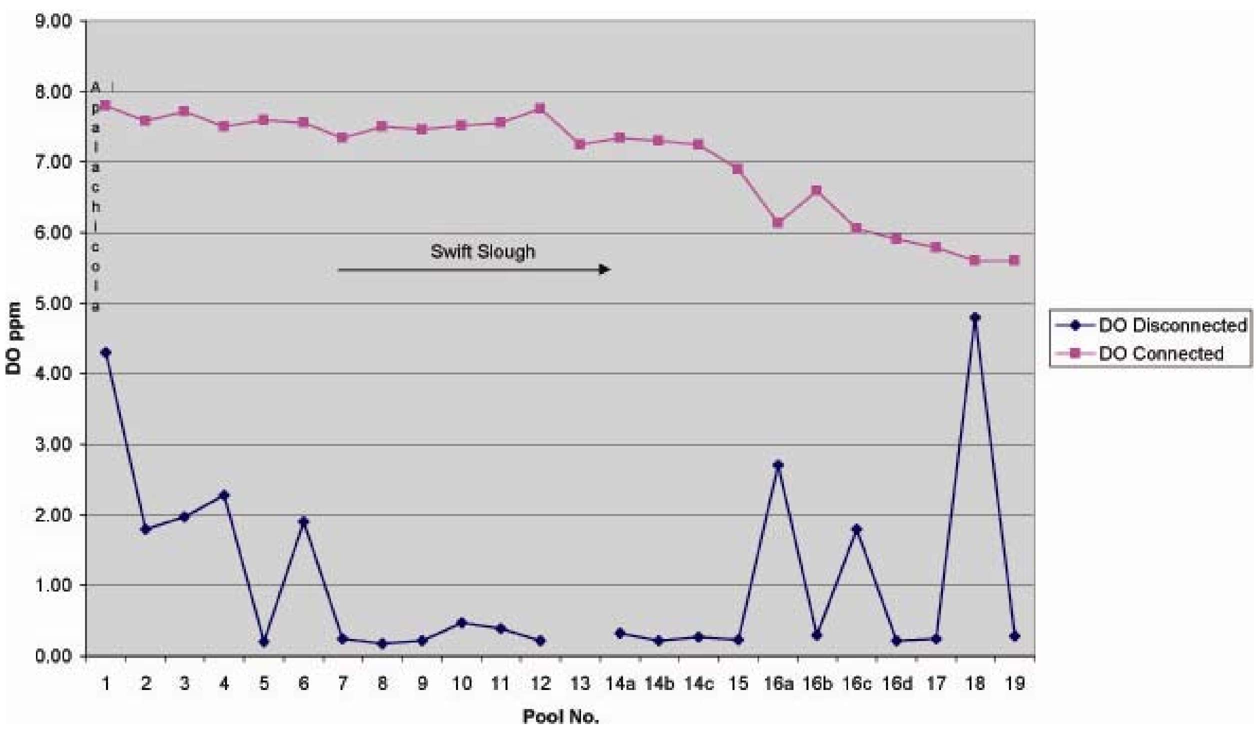

Figure 3.6.2.4.A. Dissolved Oxygen (DO) concentrations in Swift Slough when it was disconnected (4 August 2006) and connected (8 August 2006). Isolated pools were numbered from the head of Swift Slough (where it connects to the main channel) downstream.

4 EFFECTS OF THE ACTION

This section is an analysis of the effects of the RIOP on the species and critical habitat. In most consultations, the Service typically evaluates a project that has not been constructed or implemented. In this consultation, the Service is evaluating the effects of a project that is ongoing. The previous "Environmental Baseline" section described the effects of all past activities, including the effects of past construction and operation of the Corps ACF projects, current non-federal activities, and federal projects with completed section 7 consultations. This section addresses the future direct and indirect effects of the RIOP, including the effects of any interrelated and interdependent activities. Our determination of total effects to the species and critical habitat in the "Conclusion" (section 6) is the sum of the effects evident in the baseline plus effects of the action and cumulative effects.

4.1 Factors Considered

In the "Environmental Baseline" section, we outlined three principal components of the species' environment in the action area: channel morphology, flow regime, and water quality. The Service does not have enough information to determine if RIOP implementation will itself alter the baseline water quality of the action area; however, we recognize a potential for salinity changes in the bay and localized dissolved oxygen changes. Physical habitat conditions for the listed species in the action area are largely determined by flow regime, and channel morphology sets the context for the flow regime. Channel morphology has changed relative to the pre-dam period in the Apalachicola River, but the rate of change has slowed and may have entered a somewhat dynamic equilibrium condition (see section 3.2). We have no ability at this time to predict specific effects on channel morphology due to the influence of the RIOP on the flow regime. The RIOP defines limits on the extent to which the Corps alters basin inflow into the Apalachicola River via operations of the ACF dams and reservoirs; therefore, the primary focus of our analysis is the flow regime of the Apalachicola River with and without project operations. Our analysis of flow regime alteration relative to the listed species and critical habitats considers the following factors.

<u>Proximity of the action:</u> The proposed action will affect habitat occupied by all life stages of Gulf sturgeon in both the Apalachicola River and Bay, which are both designated as critical habitat. The proposed action will also affect habitat occupied by the purple bankclimber, Chipola slabshell, and fat threeridge mussels. These mussels spend their entire lives within the action area, most of which is designated as critical habitat for the mussels. The proposed action is implemented through the releases from Woodruff Dam, which is less than a mile from some of the species' life history stages and habitat features we examine and over 100 miles from others, it affects both.

<u>Distribution:</u> The proposed action could alter flows in the Apalachicola River and its distributaries downstream of Woodruff Dam, and alter freshwater inflow to Apalachicola Bay. The Gulf sturgeon may occur throughout the Apalachicola River and Bay in suitable habitats, and occasionally in the Chipola River downstream of Dead Lake. The Action area includes most of the known range of the fat threeridge, about one third of the range of the purple bankclimber, and a small fraction of the range of the Chipola slabshell. We examine how the RIOP may

variously affect different portions of the action area according to the distribution of the species and important habitat features in the action areas.

Timing: The proposed action could alter flows in the Apalachicola River and into Apalachicola Bay at all times of the year. It will reduce flows when increasing composite storage in the ACF reservoirs and increase flows when decreasing composite reservoir storage. Gulf sturgeon occupy the Apalachicola River year-round as larval and juvenile fish, and then seasonally as subadults and adults, spawning in the Apalachicola River around May. Subadults and adult Gulf sturgeon likewise occupy Apalachicola Bay seasonally, during the coldest months of the year. The fat threeridge and purple bankclimber occupy the Apalachicola River year-round and during all life phases. The fat threeridge, a species that tends to occupy shallower waters, may be more susceptible to effects of low flows during the breeding period, in late spring/early summer. We examine how the RIOP may alter the seasonal timing of biologically relevant flow regime features in our analysis.

Nature of the effect: The proposed action will reduce flows in the Apalachicola River when increasing composite storage in the ACF reservoirs and increase flows when decreasing composite reservoir storage. Two of the Gulf sturgeon primary constituent elements of designated critical habitat may be affected by the actions: flow regime and water quality. Permanently flowing water and water quality are also two of five primary constituent elements of designated critical habitat for the fat threeridge, purple bankclimber, and Chipola slabshell. The RIOP may also affect a third element of designated critical habitat for the mussels: host fish. We examine how the RIOP may affect the listed species and critical habitat elements through specific analyses focused on relevant habitat features, such as spawning substrate, floodplain inundation, and vulnerability to exposure by low flows.

Duration: This proposed action is a Revised Interim Operating Plan applicable until revised or until a new Water Control Plan is adopted. Although the duration of the RIOP is indefinite, the nature of its effects is such that none are permanent. The Corps may conceivably alter its reservoir operations at any time; therefore, flow alterations that may result from the proposed action will not result in permanent impacts to the habitat of any of the listed species. However, we examine how the proposed RIOP may alter while it is implemented the duration of high flows and low flows that are relevant to the listed species and critical habitats.

Disturbance frequency: The proposed RIOP is applicable year round; therefore, changes to the flow regime and water quality parameters may occur at any time and/or continuously until such time as the RIOP is revised or a new Water Control Plan is adopted. However, we examine how the proposed RIOP may alter while it is implemented the frequency of high flows and low flows that are relevant to the listed species and critical habitats.

Disturbance intensity and severity: As proposed, the RIOP may variously affect the flow regime depending on time of year, basin inflow, and composite storage levels as defined in Table 1.2.A, but maintains a minimum flow of 5,000 cfs during most times and 4,500 cfs at all times. We examine how the RIOP affects the magnitude of flow events relative to the baseline and to no action.

4.2 Analyses for Effects of the Action

To determine the future effect of continued project operations as prescribed by the RIOP, we must compare the environmental conditions expected under the RIOP to the environmental baseline. The principal factor we examine is the flow regime of the Apalachicola River and how the flow regime affects habitat conditions for the listed species. For analysis purposes, we consider the flow regime baseline as the observed flows of the river since the full complement of the Corps' reservoirs were completed (calendar years 1975 to 2007 – see section 3.3). However, we cannot attribute all differences between the flow regime expected under the RIOP and the baseline flow regime to the RIOP alone. Some of the differences are due to consumptive water uses in the basin.

The level of consumptive water uses supported in the basin upstream of Woodruff Dam, which affects basin inflow to the Corps' projects, increased throughout the post-West Point period (post-1975) that we use as the baseline flow regime. The Corps is implementing the RIOP using basin inflow available under the present level of consumptive water uses, which is a feature of the most recent years only in the baseline period. Using the inflow based on present consumptive uses means that conditions predicted under the RIOP are due in part to the RIOP and due in part to an increase in consumptive uses.

To isolate the effects of the present level of consumptive water use on the flow regime in the foreseeable future from the effects of implementing the RIOP, we must examine environmental conditions that would result if project operations were not continued, *i.e.,* the effects of no action on the part of the Corps. By "no action", we do not mean continuing reservoir operations without the changes represented by the RIOP; we mean discontinuing reservoir operations that alter the flow regime of the river. In our effects analyses, "no action" is "run-of-river" operations (RoR). RoR is the expected flow regime if the Corps maintained a constant water surface elevation on all of the ACF federal reservoirs, never diminishing basin inflow by raising reservoir levels and never augmenting basin inflow by lowering reservoir levels. RoR is the constant release of basin inflow (as defined in the "Description of Proposed Action") from Woodruff Dam.

The Corps has provided the results of models that represent the flow regime under both the RIOP and RoR based on historically observed flows from 1939 to 2007 (see section 4.2.1. below). These models simulate daily flows and levels in the basin using estimated present levels of consumptive water use in the basin, based on year 2000 data. We recognize that consumptive demands may have increased since 2000. Our analysis of the cumulative effects of increasing water demands is found in section 5, "Cumulative Effects".

Our effects analyses involve comparing the characteristics of three flow regimes: Baseline, RIOP, and RoR. We use flow regime characteristics that are relevant to the listed species and their habitats; the same characteristics that we examined in section 3 of this BO to evaluate baseline effects. For each of these regime characteristics, we compare the values computed for the Baseline, RIOP, and RoR. If the RIOP does not alter the Baseline, its effect on the species/habitat is a continuation of the Baseline effect, if any. If the RIOP condition represents a beneficial or adverse alteration of the Baseline condition, the effect is accordingly beneficial or

adverse; however, whether we attribute the effect to the RIOP depends on the RoR flow regime, *i.e.,* what would occur with no action on the part of the Corps.

Figure 4.2.A shows the logic involved in comparing the three flow regimes by placing all six combinations of the three in a matrix where the columns represent their relative order on an adverse/beneficial gradient of flow regime alteration. Where the RIOP is on the beneficial side of the gradient relative to Baseline and RoR, the RIOP has a clear beneficial effect that exceeds both (rows 2 and 5). Where the RIOP is on the adverse side of the gradient relative to Baseline and RoR, the RIOP has a clear adverse effect that exceeds both (rows 3 and 4).

The adverse or beneficial effect of the RIOP relative to baseline is not attributable to the RIOP in the remaining two combinations (rows 1 and 6) shown in Figure 4.2.A. In these circumstances, reservoir operations under the RIOP are modifying the RoR flow regime, but not so much that it represents an impact or benefit relative to Baseline greater than the impact or benefit of RoR. In these circumstances, no action on the part of the Corps (RoR) would have the greatest benefit (row 1) or the greatest impact (row 6); therefore, these alterations are attributable to actions or lack of actions implied in the RoR flow regime, *i.e.,* consumptive water uses and no retention of water in federal reservoirs. Although not attributable to the RIOP itself, we still consider these alterations in our evaluation of total effects to the species and habitat.

4.2.1 Model Description

The Corps has provided the results of a simulation of ACF project operations under the RIOP using the HEC-5 hydrologic simulation software. The version of the HEC-5 model we examine in this analysis is labeled "CN6_FUL_COE", and represents the revised RIOP operations as described in the April 15, 2008, letter from the Corps to the Service. To represent flow conditions without the influence of Corps project operations, we use the same basin inflow time series upon which the HEC-5 model bases its simulation of the RIOP, to which we refer in the analyses below as the "run-of-river" (RoR) scenario. As previously defined in the "Description of Proposed Action" section, basin inflow is the amount of water that would flow by Woodruff Dam during a given time period if all of the Corps' reservoirs maintained a constant water surface elevation during that period. Basin inflow is not the natural flow of the basin at the site of Woodruff Dam, because it reflects the influences of reservoir evaporative losses, inter-basin water transfers, and consumptive water uses, such as municipal water supply and agricultural irrigation. Both the RoR and RIOP scenarios include these influences, and both use the same estimates of reservoir evaporation and current water demands; therefore, the difference between the two scenarios is the net effect of continued operation under the RIOP apart from the effect of influences that are unrelated to project operations.

The consumptive water demands used in the model represent an estimate of present levels (2007) of the net depletion due to municipal, industrial, and agricultural water uses and evaporative losses from the four largest reservoirs, Lanier, George, West Point, and Seminole. These depletions vary by month, and in the case of agricultural demands and reservoir evaporation, also by year (wet, normal, dry). Table 4.2.1.A summarizes these depletions, which represent a modest increase in the depletions that the Corps estimated for the IOP in 2006, as documented in

our September, 2006, BO. Negative values under the reservoir evaporation columns indicate a net gain due to interception of precipitation.

To provide a potential range of flows that might be experienced while the RIOP is in effect, the HEC-5 model simulates river flow and reservoir levels using a daily time series of unimpaired flow data for a certain period of record. Whereas basin inflow is computed to remove the effects of reservoir operations from observed flow, unimpaired flow is computed to remove the effects of both reservoir operations and consumptive demands from observed flow. The HEC-5 model imposes reservoir operations and consumptive demands onto the unimpaired flow time series to simulate flows and levels under those operations and demands. The unimpaired flow data set is the product of the Tri-State Comprehensive Study, in which the States of Alabama, Florida, and Georgia, participated.

The current unimpaired flow data set represents the years 1939 to 2001. The Corps has not yet computed unimpaired flow for 2002 through 2007, which are years included in our description of the baseline flow regime (section 3 of this BO). To represent these years, the Corps has used the observed basin inflow data for 2002 through 2007 in the model without computing unimpaired flow. Therefore, the model operates with a synthesized basin inflow (unimpaired flow minus present-level depletions) time series for 1939 through 2001, and thereafter through 2007 without adjustments for depletions. This means that the depletions that actually occurred in 2002 to 2007 are those represented in the model, which are not necessarily the same as those listed in Table 4.2.1.A. The Corps analysis of depletion trends is included in section 5, “Cumulative Effects.”

To ensure comparisons that are most likely to reveal anthropogenic differences between the three sets of environmental conditions (RIOP, RoR, and Baseline) and not hydrologic differences between years, we use the output from the models for the period that is also represented in the baseline, which is 1975 to 2007 (33 years). Using only the latter 33 years of the HEC-5 results removes 36 years of model results from our analysis, including a drought during the 1950’s. However, the years at the end of the simulated period appear to represent the most “critical” period for the model, as this is when reservoir levels and flows reach their lowest levels in the simulation. Further, the basin has continued to experience less than normal precipitation and basin inflow levels since the end of 2007 to date in 2008. Composite storage levels have been at the lowest levels ever recorded per calendar date since early March, 2008. For this reason, the period of record through the end of 2007 may not provide a sufficient range of conditions to represent anticipated effects during RIOP implementation.

To examine possible effects during the initial implementation of the proposed RIOP in 2008 and 2009 under possibly drier conditions than observed in the 1939 to 2007 period, i.e., low flows continuing into the future such that the present drought assumes unprecedented duration and severity, the Corps has also provided four short-term “forecast” models. These models simulate the RIOP under four alternative hydrologies from May 14, 2008, through May 13, 2009. Each model begins with the reservoir levels that were recorded on May 14, 2008, and each simulates the operations of the RIOP with drought contingency operations in effect (minimum release from Woodruff Dam is 5,000 cfs regardless of basin inflow). Because the flows under these forecast models are relatively low for extended periods, we discuss the forecast models and their results in greater detail in section 4.2.5 “Submerged Habitat Below 10,000 cfs.”

Figure 4.2.1.A displays data from the HEC-5 model in pie-chart form to show the relative differences in unimpaired flow, basin inflow, estimated depletions, reservoir storage/releases, and Apalachicola River flow during two months of the simulation: a very dry month (June 2000) and a normal month (June 1997). This figure conceptually shows the elements represented in the model to simulate flow in the Apalachicola River. The size of the pies is proportional to the flow amounts indicated, illustrating the relative effect of depletions and reservoir operations on river flow in each of these two climatic situations.

4.2.2 General Effects on the Flow Regime

Table 4.2.2.A compares flow frequency for the Apalachicola River at the Chattahoochee gage observed during 1975-2007 (Baseline), and simulated by the HEC-5 model for 1975-2007 (RIOP and RoR). RIOP is the simulated flow of the river under the operational rules of the proposed action. For the years 1975-2001, RoR is the synthesized unimpaired flow of the river minus the estimated present level of consumptive water use in the basin upstream of Woodruff Dam. For the years 2002-2007, RoR is the observed 1-day basin inflow upstream of Woodruff Dam, i.e., the collective daily inflow to the Corps' ACF projects as defined in section 1.

The ACF reservoirs are operated generally, both in the Baseline and the RIOP, to decrease high flows and to increase low flows. Figure 4.2.2.A shows the net effect of reservoir operations on 7-day basin inflow in terms of frequency (percent of days flow is augmented or depleted) and in terms of magnitude (average annual volume of augmentation or depletion) for both the Baseline and the RIOP. To quantify flow regime alteration, we computed the daily change in total composite storage of lakes Lanier, West Point, and George that occurred during four ranges of 7-day basin inflow: 1) < 10,000 cfs; 2) 10,000-20,000 cfs; 3) 20,000 to 30,000 cfs; and 4) > 30,000 cfs. We used the historic observed 7-day basin inflow series for tallying flow alteration days and volumes for the Baseline, and the computed RoR 7-day basin inflow time series for the RIOP. Days of stable composite storage (i.e., no change relative to the previous day), which occur rarely in the modeled RIOP and almost never historically, were included with the days of rising storage for purposes of computing the frequency (percent of days) of flow depletions. Because the composite storage record including West Point begins in the middle of 1975, we have used data for 1976 to 2007 for this comparison. This method does not account for any flow alteration due to rises and falls in the elevation of Lake Seminole, only the three larger Corps reservoirs upstream.

ACF reservoir operations altered the Baseline flow regime 58.1% of the days by flow augmentation and 41.9% of the time by flow depletion, whereas the RIOP simulation is more evenly divided between augmentation days (49.4%) and depletion days (50.6%). The additional flow depletion days of the RIOP occur mostly in the range of basin inflow > 20,000 cfs. The more striking difference between the Baseline and the RIOP is in the volume of the alterations. Historically, reservoir operations have either captured from or released to basin inflow an average of 4.5 million acre feet per year (about 6,200 cfs per day), mostly during periods of high basin inflow (>30,000 cfs). By contrast, reservoir operations simulated for the RIOP are much more stable, with an average volume of water going into and out of reservoir storage of about 2.0 million acre feet per year (about 2,700 cfs per day). This difference may be due in part to operations in support of commercial navigation throughout most of the Baseline, a practice

which is not simulated in the RIOP. However, even in the more recent years of the Baseline (post 1999), during which the Corps has only occasionally stored water and made releases for navigation, the annual volume of flow alteration was about 50 percent greater than under the same years of the RIOP simulation.

The greatest frequency and volume of flow augmentation of the RIOP and the Baseline occurs in the lowest range of basin inflow (< 10,000 cfs) shown in Figure 4.2.2.A. The RIOP model maintains a minimum of 5,050 cfs, a flow which occurs about 7.4% of the time (897 days). Although the RIOP specifies 5,000 cfs as the non-drought operations minimum release, the model simulates a minimum release of 5,050 cfs to represent how the Corps ordinarily releases somewhat more than a required minimum to ensure compliance. Flows less than or equal to 5,050 cfs occurred for 113 days in the Baseline record, or 0.9% of the time, and the lowest flow observed was 3,900 cfs. The RoR scenario includes 1,004 days less than or equal to 5,050 cfs (8.3%), and the lowest flow computed for this time series is 61 cfs. Figure 4.2.2.B displays in greater detail the frequency analysis of Table 4.2.2.A, focusing on flows that are exceeded 80% of the time or more, *i.e.,* the lowest flows, to illustrate these low-flow differences between the three regimes.

Releases at the minimum level of 5,050 cfs under the RIOP occur mostly (93.5% of the time) during drought contingency operations, when composite reservoir storage has declined into Zone 4 and has not yet returned to Zone 2. Drought contingency operations are in effect for 1,281 days in the simulation from 1975 to 2007 (10.6% of the time). During RIOP drought contingency operations, the Corps stores all available basin inflow in excess of 5,050 cfs and does not exceed the fall rate of 1-day basin inflow during periods of flow decline.

The RIOP is intended to support the minimum flow 5,050 cfs until composite storage falls into the "drought zone" of Zone 4. Only the 5,050 cfs and 4,500 cfs minimum flows are supported with releases from storage: all other minimum release provisions of the RIOP do not require flows that are greater than current levels of 7-day basin inflow. Therefore, the amount of storage required each year *solely* to sustain the minimum release schedule of the RIOP may be computed as the deficit in 7-day basin inflow relative to 5,050 cfs (5,050 minus 7-day basin inflow). Figure 4.2.2.C shows the total deficits for the years 1975 to 2007 for the 7-day basin inflow data used in the HEC5 model of the RIOP. Most years (51.5%) have no deficit, and the non-zero deficit years vary from almost none to about 727,000 acft in 2007. Total storage capacity of lakes Lanier, West Point, and George is about 3.5 million acft, of which 1.6 million acft is considered "conservation" or "active" storage.

To interpret Figure 4.2.2.C correctly, it is important to recognize that the deficit volumes shown represent the storage needs of a single project purpose, namely, support of a 5,050 minimum release at Woodruff Dam. However, the Corps' projects are operated for multiple purposes, and releases typically serve multiple purposes. Substantial reservoir drawdowns occur during years with zero deficits relative to a minimum flow requirement of 5,050 cfs, and substantial drawdowns would occur to serve other project purposes in the absence of a minimum release requirement at Woodruff Dam.

Although the RIOP includes provisions to reduce minimum flow support to 4,500 cfs when composite storage enters the "drought zone", these operations are not triggered in the entire 1939-2007 HEC5 simulation of the RIOP. However, the simulation concludes with the year of the greatest basin inflow deficit relative to 5,050 cfs and the greatest drawdown on composite storage. A subsequent year of low basin inflow in 2008 could trigger a shift to minimum releases of 4,500 cfs. The forecast models described in section 4.2.1 allow us to consider this possibility. Our more detailed evaluation of low-flow effects is included in section 4.2.5 "Submerged Habitat Below 10,000 cfs."

4.2.3 Submerged Hard Bottom

Our principal analysis for effects of the action on sturgeon is an extension of the analysis included in section, 3.6.1.4, which quantified the area of potential spawning habitat available versus discharge based on our physical surveys of river reaches with hard substrate types and sturgeon egg collections in 2005, 2006, and 2008. We combined the relationship shown in Figure 3.6.1.4.C (hard bottom area versus discharge relationship) with the time series of daily flow values from the three flow regimes (Baseline, RIOP and RoR) to obtain time series of available habitat area. A frequency analysis of these habitat availability time series for the three known Apalachicola River spawning sites, located at RM 105, RM 103, and RM 99, is shown in Figure 4.2.3.A. This figure represents how much hard-bottom habitat was inundated to depths of 8.5 to 17.8 feet (the range of 80% of sturgeon egg collections in 2005 and 2006) during the months of March, April, and May, under each of the three flow time series. Although the three curves cross each other multiple times over the full range of 0 to about 21 acres, habitat availability under the three flow regimes is generally equivalent (median daily habitat availability about 18 acres for all three).

The analysis shown in Figure 4.2.3.A combines data from all years of each time series into a single pool for frequency computations and does not examine differences between years or the pattern of habitat availability within a year. It is important to ascertain whether the RIOP would produce exceptionally low and high habitat availability between years or within a year to produce the average conditions that are comparable to the baseline. Spawning may commence when water temperature reaches about 17°C and is concluded by the time temperature reaches about 25 °C (see section 3.6.1.5). Based on available data from the Chattahoochee gage, the mean dates for these events in the Apalachicola River are March 26 and May 23 (Figure 3.4.A), respectively, a span of 58 days. Sturgeon egg collections during 2005 and 2006 spanned a period of 17 and 27 days, respectively (USFWS 2005 unpub. data; Pine et al. 2006). Our sampling of sturgeon spawning activity in 2008 is ongoing at the time of this writing. Eggs require about 2 to 4 days to hatch in this temperature range (Parauka 1991), and probably remain in the rock/gravel matrix for several days thereafter (Sulak et al. 2004:62). To address continuous habitat availability within a year that would encompass the time for adult spawning behaviors, egg incubation, and early larval development, we computed the maximum amount of habitat inundated to the 8.5 to 17.8 ft depth range for at least 30 consecutive days each year, March through May, under the three flow time series (Figure 4.2.3.B). It is important to emphasize that frequency in Figure 4.2.3.B is percent of years (not percent of days as in the previous figure) that a given area of continuously available habitat is exceeded

The RIOP and RoR flow regimes provide generally slightly more 30-day continuous habitat than the Baseline, with median values of about 18 acres versus 17 acres. All three time series provide at least 10 acres of 30-day continuous habitat in the depth range 8.5 to 17.8 ft in all years.

A rapidly declining river stage immediately following spawning could expose eggs and larvae in shallow areas. As noted in section 3.6.1.4, most of the eggs collected on the Apalachicola River have been taken from depths of about 8 to 18 feet, but some as shallow as about 6 feet. The most extreme fall rates are associated with high flows, and fall rates are not prescribed under the RIOP for flows greater than 30,000 cfs, which are largely uncontrollable by project operations. The Baseline flow regime rarely includes days with fall rates of greater than 2.0 ft per day at flows less than 30,000 cfs (only 93 days from 1975 to 2007), and this is the maximum fall rate proposed for the RIOP for flows between 20,000 and 30,000 cfs. Depending on water temperature, sturgeon eggs may take up to 4 days to hatch. Newly hatched sturgeon larvae require 8-12 days to develop eyesight, absorb the yolk sac, and become swimmers competent enough to forage effectively (Sulak et al. 2004:60-63). A drop of more than 8 ft in river stage during could expose eggs and larvae spawned at the shallowest depths observed by egg collections on the Apalachicola River. A depth of 8 ft over the highest known spawning habitat on the Apalachicola River corresponds to flows of about 40,000 cfs, but about one quarter of the confirmed spawning habitat comes within 8 ft of the water surface at flows of about 30,000 cfs (Figure 4.2.3.C).

The model results for the RIOP generally, but do not always, comply with the proposed maximum daily fall rate schedule. Likewise, the model results for the RIOP generally, but do not always, decline more gradually than 8 ft in 14 days from flows of 40,000 cfs or less during the spawning months. We analyzed the Woodruff releases of the RIOP using the stage-discharge relationship published in Light et al. (2006), and found that RIOP fall rates exceed the daily fall rate schedule on 884 days by an average of 0.72 ft/day, with 77 days exceeding the schedule by more than 2.0 ft/day. The RIOP suspends the fall rate schedule during drought contingency operations, but most of the departures from the schedule occur during normal operations. The Corps informs us (Hathorn 2008 pers. comm.) that these departures from the ramping rate schedule are anomalies in the model output and would not represent actual operations under the RIOP.

During drought contingency operations, the Corps proposes to control fall rates such that a drop in river stage does not exceed the corresponding drop in 1-day basin inflow per day. We analyzed the historic record of 1-day basin inflow (1976 to 2007) and computed fall rates using the stage-discharge relationship published in Light et al. (2006) as though these data represented the discharge from Woodruff Dam. Because 1-day basin inflow is a snapshot of flow rates across the entire basin at one time, it is quite “flashy.” Transforming the daily changes in basin inflow to stage at the Chattahoochee gage results in a time series where 44% of the days of declining stage exceed a fall rate 2.0 ft/day, compared to 0.8% in the pre-Lanier record (1929-1955), and 38% exceed a fall rate of 2.0/ft/day when inflow rates are less than 30,000 cfs. More extreme fall rates in this data are quite common, with 864 days exceeding 4 ft/day.

Therefore, it is apparent that the provision of the RIOP to manage fall rates not to exceed the fall rate of 1-day Basin inflow during drought contingency operations could result in extreme river

stage declines. Further, compliance with the daily maximum fall rate schedule during normal operations does not guarantee that flows do not drop by more than 8 ft (the shallowest depth of most sturgeon spawning activity) in the time frame (about 14 days) that is likely needed for sturgeon egg and larval development. Lacking a model that properly represents the fall rate provisions of the RIOP, we cannot reliably estimate the frequency with which the proposed project operations might expose the hard-bottom habitat that sturgeon use for spawning. However, because the proposed operations do not inherently preclude events that could expose eggs and larvae, the RIOP could result in take of sturgeon eggs and larvae.

4.2.4 Changes in Salinity and Invertebrate Populations in Apalachicola Bay

Our direct knowledge of Gulf sturgeon feeding behavior and habitat selection in Apalachicola Bay is extremely limited. We summarized recent preliminary studies to examine juvenile sturgeon movements and habitat characteristics in the lower river and bay that began in 2006 in section 3.5.1. We discussed in section 3.6.1.5 data indicating that periods of high salinity in most of the bay are associated with flows less than 16,000 cfs.

It is firmly established that almost all adult and sub-adult sturgeon do not feed much, if at all, during the months of riverine residency, and are feeding instead in estuarine and marine environments (see section 2.1.3.1). Juvenile Gulf sturgeon cannot survive direct transition from freshwater into salinities greater than 30 parts per thousand (ppt), but can gradually acclimate to 34 ppt seawater, and juvenile growth rates are highest at 9 ppt salinity (Altinok et al. 1998). Apalachicola Bay is necessarily the first estuarine habitat that both juvenile fish, who cannot tolerate a rapid transition to marine salinity, and older fish, who have not eaten for months, would encounter upon departing the river.

As noted in section 3.6.1.1, about 80% of the open water habitat of Apalachicola Bay is underlain by soft, muddy, unvegetated sediments, and the other 20% is divided between oyster reefs and submerged aquatic vegetation (SAV). In other systems, Gulf sturgeon appear to prefer generally sandy substrates for feeding, and these areas are not necessarily associated with SAV, *e.g.,* sea grasses. Early data on juvenile movements in Apalachicola Bay suggest fish are using very shallow, nearshore areas as winter feeding grounds that have high densities of polychaetes and amphipods (Sulak 2007 pers. comm.).

The role of freshwater inflow in the ecology of Apalachicola Bay was a primary focus of the "Apalachicola River and Bay Water Demand Element" of the Act/ACF Comprehensive Study from 1992 to 1998. One product of this element was a spatially-explicit hydrodynamic model of the Bay that simulated salinity and other parameters as a function of freshwater inflow, tides, and winds. Application of this model, in combination with benthos mapping, could identify areas most likely to support sturgeon; at this time, however, such information has not yet been generated.

Although sturgeon were not specifically investigated in the River and Bay Element of the Comprehensive Study, its findings strongly suggest that altering the flow regime of the river may alter the ecology of the bay. The following is an excerpt from the final report of the River and

Bay Element (Lewis 1998:13-15), which synthesizes the results of the several studies that were included in the element:

> “River flow appears to be one of the most important factors influencing the physical and biological components of the Apalachicola estuarine system. Despite the seasonal and interannual variation, river flow displays a recurrent pattern of winter peaks and summer-fall lows. This pattern is reflected in the seasonality of individual estuarine organisms that display species-specific phase-lagged relationships to flow. These individual, highly variable relationships combine to produce an overall recurrent pattern of trophic organization. Within certain flow constraints, this trophic pattern (whether examined for fishes separately or for the combined assemblage of infauna, macroinvertebrates and fishes) is fairly stable despite its continually changing individual components. However, when events occur outside the range of normal flows (*e.g.,* droughts) the trophic organization may be perturbed. Major changes in the various trophic categories may be initiated that can last for several years after resumption of normal flow patterns….
>
> Primary productivity in Apalachicola Bay is intimately linked to the riverine input of dissolved inorganic nutrients. However, this relationship is mediated by the residence time of fresh water in the estuary, which is clearly a function of river flow(primarily) and winds and tides (secondarily)….
>
> While previous studies suggested that most of the secondary production in the estuary resulted from detrital export from the Apalachicola River floodplain, results from the current studies provide evidence that the bulk of the secondary production in the bay is fueled from *in situ* phytoplankton productivity…. Organisms inhabiting areas closest to the mouth of the river and its distributaries (*i.e.,* East Bay) appear more reliant on riverborne detritus than those living in areas more distant. However, even for these organisms, phytoplankton productivity plays a major role in faunal diets, making up at least half of the carbon transferred on average. Mid- and outer-bay organisms rely heavily on plankton production for subsistence.
>
> These results have important implications to management of the ecosystem. If secondary production within the estuary was supported primarily by a detrital foodchain, then it would be critical to preserve peak or high flood conditions in winter/spring. During this time the river inundates its banks and sweep leaves and organic materials from the floodplain to the estuary. However, since in situ primary production drives much, but not all, of the secondary production within the estuary, it is necessary to preserve or maintain flow during the period when estuarine primary production is greatest. This period generally coincides with low river flow during late summer and early fall. Thus, results of the study suggests that maintaining particular levels of discharge at both the low and high flow end of the flow regime are needed to assure that all organisms in all regions of the bay receive the necessary nutritional inputs.

This synthesis suggests to us that the substantial alteration of the pre-dam flow regime evident in our baseline analysis (see section 3) has probably already affected ecological processes in the bay by changing nutrient input and salinity patterns. However, substantial further alteration of

flow regime features, such as number of consecutive days per year less than 16,000 cfs (Figure 3.6.1.5.A), that may directly relate to sturgeon and sturgeon critical habitat elements is not evident in the flow regime under the RIOP (Figure 4.2.4.A). Simulated flows under the RIOP appear to reduce somewhat the maximum number of consecutive days less than 16,000 cfs compared to both the RoR and Baseline flow regimes. Therefore, at this time, we believe that the RIOP itself is not likely to have an appreciable effect on sturgeon estuarine habitat.

4.2.5 Submerged Habitat Below 10,000 cfs

This section focuses on direct effects to mussels by exposure during low-flow conditions. As discussed in section 3, the Service and others documented large numbers of fat threeridge mussels exposed in the summer of 2006. We found mussels exposed and stranded at elevations as high as about 10,000 cfs during our summer 2006 surveys. Flows up to about 35,000 cfs occurred in March 2007, which is high enough to fill the channel to near the top of its banks. Beginning in May 2007, however, flows declined to about 5,000 cfs and remained at that level for most of the rest of the year. Our surveys in the summer and fall of 2007 did not detect newly stranded mussels at stages greater than 5,000 cfs. Flows rose briefly to about 45,000 cfs in February 2008, and we have not yet begun surveys this year to determine how mussel distribution relative to stage may have shifted, if at all.

At this time, available evidence continues to support the hypothesis we articulated in our 2006 BO that mussel distribution at relatively high stages (between about 5,000 to 10,000 cfs) may occur following very high flow events (e.g., > 100,000 cfs, which occurred twice during 2005) that drop mussels and sediments into depositional areas of the main channel and its distributaries. Mussel distribution at high stages may also occur following 1 or more years without low flows that permit mussels to move and recruit into higher portions of the stream bed. Neither circumstance has occurred in the past 2 years, therefore, we have no reason to believe that flows in the range of 5,000 to 10,000 cfs would expose listed mussels this year. Nevertheless, we must acknowledge that future flows and circumstances may again lead to mussels in areas that are vulnerable to stranding and exposure under the proposed RIOP. It is therefore still appropriate to analyze the differences between the Baseline, RIOP, and RoR flow regimes in the range of flows less than 10,000 cfs as a measure of the effects of the proposed action. Further, the drought contingency provisions of the RIOP stipulate flows as low as 4,500 cfs under certain circumstances, which would expose portions of the channel that have been exposed for less than 60 days in the last 80 years.

Table 4.2.5.A lists the lowest daily flow each year for the Baseline, RIOP, and RoR flow regimes. In all but 5 of the 33 years, the RoR has the lowest flow. The RIOP has the lowest flow in 2 years, 1975 and 1989. The lowest flow in 1975 under the RIOP is greater than 10,000 cfs. The low flow in 1989 occurs in February during a 6-day period of flows less than 10,000 cfs.

Figure 4.2.5.A shows the inter-annual frequency of flow rates less than 5,000 to 10,000 cfs in the Baseline, RIOP and RoR flow regimes. Except for preventing the occurrence of flows less than 5,000 cfs, which occurred occasionally in the Baseline, the inter-annual frequency of flow events less than 10,000 cfs is substantially higher in the RIOP flow regime than in the baseline regime.

At flows greater than 5,000 cfs, inter-annual frequency of low flows under the RIOP almost mirrors that of the RoR. The RIOP simulation includes 1 more year of flows less than 10,000 cfs than the RoR time series.
We use the maximum number of days per year with flows less than 5,000 to 10,000 cfs as a measure of the most severe year for aquatic biota under each flow scenario. In this respect, all three flow regimes include more than 200 days during the driest year at all flow levels except the < 5,000 level (Figure 4.2.5.B). Maximum annual duration of flow less than 5,000 cfs in the RoR was 188 days, which occurs in the year 2007. The 1975-2007 simulation results of the RIOP has no years with flows less than 5,000 cfs, which is a benefit to mussels.

Some mussels may survive brief periods of exposure by closing their shells tightly or burrowing into the substrate, as we saw during 2006 with the fat threeridge, but unless water temperature is extreme, the stress of exposure is most likely a function of exposure duration. In addition to the most-severe year analysis shown in Figure 4.2.5.B, we performed a most-severe event analysis by computing the maximum number of consecutive days of flow less than the 5,000 to 10,000 cfs thresholds, which is shown in Figure 4.2.5.C. The RIOP shows a beneficial effect at the 5,000 cfs level, because the maximum number of consecutive days less 5,000 cfs is zero. The RIOP has an adverse effect at the 6,000 cfs level, because it has a greater maximum number of consecutive days less than 6,000 cfs than both the RoR and the Baseline. However, all three flow regimes have an extreme effect on mussels at the 6,000 cfs level, because it is unlikely that mussels would survive an exposure under even the best of the three, which is the Baseline with 104 days. At the 7,000 cfs level and greater, all three flow regimes are comparable.

Because moderately low flows, not just the most extreme events, constrict aquatic habitat availability and are generally stressful to mussels and other aquatic biota, it is appropriate to also consider the more common low-flow condition, *i.e.,* the magnitude and duration of low flows that occur in half the years of the flow regime. If the common low-flow conditions become even more common or more severe, it would reduce the amount of habitat available to mussels and would increase their vulnerability to exposure-related mortality, including increased predation by terrestrial predators. Figure 4.2.5.D shows the median number of days per year less than the thresholds of 5,000 to 10,000 cfs. The median number of days at all 6 thresholds is greatest for the RoR, and the number of days for the RIOP equals or exceeds the Baseline at all thresholds.

The maximum fall rate schedule of the RIOP (Table 1.3.A) was formulated to facilitate movement of mussels and other aquatic biota from higher to lower elevation habitats. The intent of the schedule is to avoid extreme daily declines in river stage and thereby lessen the potential for exposing or stranding listed mussels, their host fish, and other aquatic biota. The schedule limits operations to more gradual fall rates as flow declines to the river stages where listed mussels may occur. To analyze effects due to altered fall rates, we computed daily rates of stage change of the Baseline period directly from the daily average gage height values recorded for the Chattahoochee gage as the difference between each pair of consecutive daily values (previous day gage height minus current day gage height = change rate associated with current day). For the modeled flow regimes, the RIOP and RoR, we used the Chattahoochee gage rating curve that characterizes the stage/discharge relationship during recent years (Light et al. 2006) to compute the gage heights associated with simulated daily flows, and then computed change rates in the same fashion as for the observed gage heights. As noted previously in section 4.2.3, the model

results for the RIOP generally, but do not always, comply with the proposed maximum fall rate schedule. We analyze the results recognizing the need to improve the model in this respect. Figure 4.2.5.E is a frequency histogram of the rate of change results, which lumps all stable or rising days into one category and uses the ranges that correspond to the RIOP maximum fall rate schedule as categories for the falling days (<=0.25 ft/day, > 0.25 to <= 0.50 ft/day, > 0.50 to <= 1.00 ft/day, > 1.00 to <= 2.00 ft/day, and > 2.00 ft day). Among the falling days, rates less than 0.25 ft day are the most common occurrence in each flow regime except the RIOP, which has a slightly higher percentage of days in the 0.25 to 0.50 ft/day range. Collectively, RIOP has a higher percentage of days in the fall rate categories of greater than 0.25 ft/day than either the Baseline or RoR (34.7% versus 25.2% in the Baseline, and 27.6% in the RoR). This shift increases the relative risk of stranding and exposure of aquatic organisms; however, most of the shift is confined to the 0.25 to 0.50 ft/day category and not the more extreme categories.

As noted earlier, we observed mussels exposed in 2006 at stages as high as about 10,000 cfs. To determine whether an increase in the percentage of days in the greater than 0.25 ft/day ranges of fall rates might directly affect listed mussels, we performed a second analysis that focused on flows less than 10,000 cfs. For this analysis, the flow associated with the rate of change on a given day is the flow of the previous day. Figure 4.2.5.F shows a count of days in the various rate-of-change categories when flow was less than 10,000 cfs. We use a count of days here for the vertical scale of this figure instead of a percentage of days as in Figure 4.2.5.E, because each flow regime has a different number of days less than 10,000 cfs, and this difference is relevant to the effects analysis (Baseline 2,788, RIOP 3,432, and RoR 3,586 days). The number of days in the greater than 0.25 ft/day categories for the RIOP is 607, more than three times the number in the Baseline, and about 40% more than in the RoR. This increase relative to historic operations may represent an increased risk of stranding when mussels are located at stages greater than 5,000 cfs.

We believe that the 0.25 ft/day maximum fall rate for flows less than 8,000 cfs provides sufficient protection of listed mussels that are situated in locations with access to flowing water during declining flow. In 2006, mussel exposure occurred almost entirely where mussels did not have such access by moving laterally downward on the channel cross section; *i.e.,* in the broad, irregular stream bed of Swift Slough or in the side-channel swales along the main river. It is likely that even a more gradual down-ramping rate would not have prevented exposing these mussels. During drought operations, the RIOP proposes to manage river stage declines at a rate that does not exceed the rate of declining 1-day basin inflow. We consider the possible effects of this provision in greater detail in section 4.2.3; "Submerged Hard Bottom".

In the HEC-5 simulation of the RIOP with 1939-2007 hydrology and present-day consumptive demands, composite storage was never in the "drought zone" on the 1^{st} of the month, which serves as the decision point for operational shifts. Therefore, these results suggest that, given the 1939-2007 hydrology and present-day consumptive demands, it is feasible to operate according to the RIOP without invoking its proposed 4,500 cfs minimum flow. However, the simulation ends with the hydrology of the year 2007 and composite storage at the lowest levels computed in the simulation (Figure 4.2.5.G), which was also the lowest levels recorded historically.

The four "forecast" models described in section 4.2.1 were developed to evaluate a continuation of the present drought that would represent a condition more severe than experienced in the 1939-2007 period. These models range from very dry (10th percentile and 2007-8) to moderately dry (1986-7 and 25th percentile) conditions. Under the two moderately dry scenarios, the 1986-87 hydrology and the 25th percentile hydrology, composite storage declines but recovers without triggering the 4,500 cfs minimum flow provision (Figure 4.2.5.H). Under the two driest scenarios (10th percentile and 2007-8), the 4,500 cfs provision is triggered in September and October of 2008, respectively. Storage recovers partially at the end of 2008 and the beginning of 2009, but is lower at the conclusion of the 1-year simulation than at the beginning. Flows are less than 5,050 cfs for 153 and 75 days under the 10th percentile and the 2007-8 hydrologies, respectively.

The 10th percentile hydrology has an annual average basin inflow of 5,393 cfs, which is substantially less than the historic minimum annual discharge of 9,341 cfs in the year 2000. The year 2007 was the second lowest annual discharge with 9,722 cfs. At our request, the Corps analyzed the recurrence probability of low-flow events (J. Hathorn, Corps, April 3, 2008, Memorandum for Record, file "MEM4REC_LowFlowAnalysis.doc"). The sustained low basin inflow of 2007 (183-day mean) was the driest in the 1939-2007 period. The estimated return interval for an event as dry as 2007 is once in 200 years.

Flows in 2008 have been tracking the cumulative basin inflow that is exceeded about 75 percent of the time, which is very close to the 1986 hydrology (Figure 4.2.5.I). Unless the remainder of the year becomes substantially drier, it appears unlikely that the basin would experience an instream flow deficit relative to 5,000 cfs great enough to deplete storage to the "drought zone" and prompt a reduction in minimum flows to 4,500 cfs. The May 15, 2008, U.S. Seasonal Drought Outlook map prepared by the NOAA (2008a) shows the upstream half of the basin in a zone labeled: "drought likely to improve, impacts ease." Nevertheless, we believe it is prudent to evaluate the effects of at least one event of flows as low as 4,500 cfs occurring in the period of record for the hydrology we've considered (1939-2007, or 69 years). This evaluation is in section 4.3; Species Response to the Action.

Many of the comparisons of flow regime features considered in this section show an adverse effect for the RIOP relative to the baseline, but in several of these, the RoR scenario would have greater adverse effects (e.g., annual 1-day minimum flow [Table 4.2.5.A], median number days per year of flows less than 5,000 to 9,000 cfs [Figure 4.2.5.D]). The RIOP eliminates the most severe effects of flow less than 5,000 cfs by supporting this level as a minimum flow with releases from reservoir storage. Although we may attribute many of the adverse differences between the RIOP and Baseline to increased depletions from non-project related water uses and not to the RIOP itself, the reality for mussels and other aquatic biota is increased stress and in the future as the river will experience low-flow conditions more often under the RIOP than under the baseline conditions.

4.2.6 Floodplain Connectivity and System Productivity

We analyze here the indirect effects on mussels and sturgeon via changes to the frequency, timing, and duration of floodplain habitat connectivity/inundation. These productive areas most

likely serve as spawning and rearing habitats for one or more of the host fishes of the listed mussels (see baseline section). Floodplain inundation is also critical to the movement of organic matter and nutrients into the riverine feeding habitats of both the mussels and juvenile sturgeon, and into the estuarine feeding habitats of juvenile and adult sturgeon.

Our analysis uses the relationship documented by Light et al. (1998) between total area of non-tidal floodplain area inundated and discharge at the Chattahoochee gage (Figure 3.3.2.B). Figure 4.2.6.A displays a frequency analysis of the results of transforming the Baseline, RIOP, and RoR daily discharge time series during the growing season months (April – October) to connected floodplain area. Although the overall area/frequency pattern of the RIOP is comparable to the baseline and RoR, the amount of habitat connected to the main channel at a given frequency is consistently less than either the baseline or RoR. The median amount of connected habitat under the RIOP (acres inundated for half of the growing season days 1975-2007) is 1,637 acres, compared to 2,435 and 1,708 acres for the Baseline and the RoR flow regimes.

It is important also to consider the temporal pattern of floodplain inundation to interpret biological effects. In section 3.3.2, we explained our method for quantifying 30-day continuous floodplain habitat inundation. We extend this analysis to the RIOP and RoR flow regimes in Figure 4.2.6.B. Annual 30-day continuous connectivity is roughly comparable between the RIOP and the Baseline, but both are less than the RoR flow regime, which does not reflect the effects of refilling reservoirs to summer pool levels following the winter drawdown. The median amount of 30-day continuous connected habitat under the RIOP (acres inundated for at least 30 days in half of the years 1975-2007) is 11,220 acres, compared to 11,128 and 15,093 acres for the Baseline and the RoR flow regimes, respectively.

4.3 Species' Response to the Action

4.3.1 Gulf sturgeon

As of this year, we have documented sturgeon spawning by egg collection at a total of three sites, as described in section 3.6.1.4. Although we have not yet analyzed the temperature, depth, and other data associated with this effort, which is ongoing at the time of this writing, we incorporated the third site into our analysis of habitat availability vs. flow in section in 4.2.3. This analysis shows that these three sites provide over 13 acres of potential spawning habitat that would be inundated to depths of about 8 to 18 feet over a relatively broad range of flows. The RIOP, Baseline and RoR all provide roughly comparable amounts of 30-day continuous spawning habitat availability in the spring months of 1975-2007.

The combination of low- and high-flow alterations evident in the RIOP relative to Baseline (Table 4.2.2.A) may adversely affect the extent or suitability of Gulf sturgeon estuarine feeding habitats. As discussed in section 4.2.4, we know very little about sturgeon feeding habitats in Apalachicola Bay; however, other studies suggest a strong linkage between freshwater inflow and ecological processes in the bay. Increasing consumptive uses of water will increase the frequency and duration of low freshwater inflow to the bay, with or without implementation of the RIOP. We do not know at this time whether estuarine feeding habitat is limiting the survival or recovery of the Apalachicola sturgeon population. Studies of sturgeon use of the bay and the

effects of low flows on estuarine sturgeon habitat conditions are needed to provide a basis for evaluating effects, and possibly for estimating take of sturgeon, in future assessments of either revisions to the RIOP or the ACF Water Control Plan.

The possibility of rapidly declining stages, especially during drought contingency operations, when the RIOP proposes to manage stage declines at rates slower than the rate of declining 1-day basin inflow, could expose sturgeon eggs and larvae. We analyzed the fall rates associated with historical 1-day basin inflow in section 4.2.3 “Submerged Hard Bottom,” noting the frequent occurrence of extreme fall rates in this record. Because 1-day basin inflow does not represent actual flows at any one point in the basin, but is instead a snap shot of conditions at many locations throughout the basin at one point in time, this data is unusually “flashy.” The HEC-5 model does not comply with the ramping rate schedule proposed for the RIOP (see section 4.2.3), and its departures from the schedule occur both during drought contingency operations and during normal operations. Therefore, we do not believe the RIOP model is a reliable basis for evaluating the potential for the RIOP operations to strand (expose to the air or to lethal water quality conditions in very shallow water) sturgeon eggs and larvae. Lacking this, we are unable to establish the frequency with which take due to project operations may occur. Cases of rapid stage declines are evident in the pre-Lanier flow record (1929-1955) of the Apalachicola River, i.e., stage declines greater than 8 ft in less than 14 days during springtime flows less than 40,000 cfs, and in the Baseline flow record (1975-2007). To establish a means of estimating possible take due to stranding, we will work with the Corps on examining the RIOP operations, the historic flow record, and improving the simulation models before the nest sturgeon spawning season.

4.3.2 Mussels

The previous section on Submerged Habitat Below 10,000 cfs (4.2.5) discussed the effects of flow regime alteration on the habitat of post-larval listed mussels, and the section on Floodplain Connectivity and System Productivity (4.2.6) discussed effects on an important habitat of the fishes that may serve as hosts for the mussel’s larval life stage. The following sections interpret these habitat effects on the listed mussels in light of studies on the spatial distribution and biology of the mussels and their host fishes.

4.3.2.1 Host Fish

Fish hosts that support the larval life stages of the listed mussels are one of the principal constituent elements identified for their critical habitat. Host fishes are not known for the purple bankclimber. Only one host (bluegill) has been identified for the Chipola slabshell, but this work is ongoing. The fat threeridge appears to be a host fish generalist that may infect fishes of at least three different fish families (see section 2.2.3.3.1). Among these are species known to extensively use floodplain habitats for spawning and rearing, such as bluegill, redear sunfish, and largemouth bass. Fish are affected by low-flow events due to constriction of habitat, elevated temperature, reduced dissolved oxygen in backwaters, etc. The measures of low-flow effects that we have used in the mussels exposure analysis apply also to fish. We rely upon floodplain spawning habitat availability as the principal measure of effects to potential host fish of the listed mussels apart from low-flow effects. Most fish spawning activity occurs in the growing-season

months of April through October, but most floodplain inundation occurs in the months of January through April, when discharge exceeds 20,000 cfs substantially more often than in other months. Therefore, April is likely the month of greatest floodplain habitat utilization, with March and May serving when temperature and discharge coincide favorably.

The thresholds for retaining basin inflow in the reservoirs under the RIOP are higher in the months of March through May in recognition of fish spawning and rearing activity in the main channel and in the floodplain. Overall, fewer floodplain acres are inundated for a given number of growing-season days under the RIOP than under the Baseline and under the RoR flow regime (Figure 4.2.6.A). The RIOP shows little overall change relative to the Baseline in the annual maximum 30-day continuous inundation of the floodplain, and a decrease relative to the RoR (Figure 4.2.6.B). These are adverse effects to floodplain-spawning fish that serve as hosts for mussel glochidia. To the extent that host fish density contributes to mussel recruitment, it is also a likely detrimental to mussel reproduction.

4.3.2.2 Chipola slabshell

We have recent survey data for this species that is summarized in Section 3.5.4.1. The species has been detected at 5 sites (80 total animals found) in the action area, all in the Chipola River downstream of Dead Lake. We have not sampled quantitative data (quadrats) at depth for sites in the Chipola River. Mortality due to stranding was limited to sites in the Cutoff only during 2006. In addition, incidental take monitoring by the Corps indicated that no Chipola slabshells were likely exposed at flows as low as 4,750 cfs. The lower Chipola is narrower than the Apalachicola, but we find the listed species in the same types of habitats on the Chipola as on the Apalachicola, namely, along moderately depositional/gently sloping banks. For this reason, we believe that sites supporting the Chipola slabshell and the fat threeridge in the Chipola River are comparable in their distribution of animals at depth to the sites we have surveyed in the adjacent reach of the Apalachicola River (RM40-50), but that animals in the Chipola likely occur at somewhat greater depths than in the Apalachicola. The effects of a river stage decline for the fat threeridge are assessed in section 4.3.2.4.

We are not aware of habitat for the Chipola slabshell that is at river stages greater than about 5,000 cfs as we did not detect this species in the stranding surveys of 2006. Therefore, changes in the flow regime due to the RIOP that affect the frequency and duration of flows greater than 5,000 cfs are unlikely to affect the slabshell, except possibly through effects to host fish and system productivity (see section 4.2.6). The primary impact of the RIOP on the slabshell would occur when its provision to reduce minimum flow to 4,500 cfs is triggered. Assuming that relative abundance at depth is similar to what is found for fat threeridge, site-specific effects on the Chipola slabshell in the action area would be less than or equal to 9%, which is the population percentage found at stages greater than 4,500 cfs in the Apalachicola (see Table 4.3.2.4.A).

The impact of this loss on the population depends on how much of the species' population is within the action area. We do not yet have a population estimate for the slabshell. The recent survey conducted by CSU is a mix of timed searches, density quadrats, and untimed searches and was intended primarily to find sites that support the species, establish its current range, and

gather life history information. These various efforts found a total of 228 individuals at 5 sites upstream of the action area and 79 individuals at 4 sites within the action area. EnviroScience (2006a) also located one individual at an additional site within the action area. These data suggest that the species occurs in greatest density upstream of the action area, and that the action area may support about a quarter of the total population (80/(80+228) = 26%). If 9% of these 80 individuals were to be affected, the potential effects of the proposed action are small (about 2%) relative to the total population. We would expect that less than 100 individuals would be affected.

4.3.2.3 Purple bankclimber

The habitat of the purple bankclimber on the Apalachicola River varies more widely than for the two other listed mussels. We are aware of only two relative “hot spots” for the species: the limestone shoal at RM 105 and the lower river at about RM 26. These two sites are quite different from each other. These were the only two sites where CPUE exceeded 13 individuals per hour in surveys conducted by EnviroScience (2006), which is rather low compared to other species in this river. The RM 105 site is dominated by the limestone shoal, and it is on the shoal among the jagged rocks where the bankclimbers are found. The banks in this reach of the river are relatively high, due in part to the channel entrenchment that has occurred following construction of Woodruff Dam. By contrast, the RM26 site has no rocks, is not entrenched, and the bankclimbers are found in relatively deep water embedded in a sandy substrate.

We find the bankclimber also in small numbers (less than 10 per site) at a few of the sites where we find the fat threeridge, and some of these animals are situated in shallow areas that would be exposed with the reduced 4,500 cfs minimum flow under the RIOP. However, no purple bankclimbers were sampled in the quadrats used to establish a numbers at depth relationship for mussel sites in the RM40-50 reach (see section 4.3.2.4).

Except for a handful of animals at a few sites, our only purple bankclimber depth data was sampled by biologists with the Florida FWCC by qualitative diving and wading methods at RM 105 during October, 2007 (email from T. Hoehn, FFWCC, dated Nov. 7, 2007). This data establishes that bankclimbers occur at a broad range of depths at this site, from 0.6 ft to 15 ft, but was not sampled in a manner that permits an estimate of total abundance at the site. The data sampled by divers on transects at this site could be treated as a sample for estimating percentage of the local population that occurs in depth ranges. However, we know that this transect data would underestimate the numbers at very shallow depths at this site, because it is relatively easy to find bankclimbers on the rocks near the water surface, but none happened to be located on the transects at depths less than 1.2 ft. For instance, FFWCC reported a CPUE (hr) of 96 bankclimbers at depths 0.67 ft to 1.0 ft at this site in a wading timed search during these surveys. In addition, our November survey documented 39 purple bankclimbers in less 2 ft depth when flows were about 4,750 cfs, and FFWCC documented an additional 92 individuals in less that 2 ft when flows were about 5,000 cfs. These numbers are quite high compared to the transect data.

According to a recently applicable rating curve for the river gage at Chattahoochee (rating # 36), reducing the minimum release from about 5,000 cfs to 4,500 cfs would result in a stage decline of 0.31ft. This value was based on analysis completed for the November 2007 BO and may be

different now, but it would only result in a small change if any. Although the Corps estimated that no take occurred at flows from 5,130 to 4,750 in November and December 2007, at least three purple bankclimbers were found dead and 4 were partially exposed at the shoal as a result of these reduced flows. Data collected by the Service and FFWCC during this time also indicate that at least five live individuals were located at depths that would be exposed by a further 0.31 ft stage decline to flows of 4,500 cfs in a relatively small area at the upstream end of the shoal. An additional 82 individuals would occur in depths less than 1 ft at 4500 cfs in this small area. If these numbers are extrapolated to the entire shoal, we believe that no more than 200 animals would be exposed at flows of about 4,500 cfs. Movement at this site is probably very difficult for mussels, due to the highly irregular and jagged nature of the limestone substrate. Those located in shallow water are already at higher risk of predation and stress from high temperatures and low dissolved oxygen, because the shallow portions of the shoal become a nearly stagnant pool environment with excessive algae growth during extended periods of low flow. Decreasing water levels further will harm some fraction of the bankclimber population at this site, but we can not determine the size of that fraction from the information we have.

4.3.2.4 Fat threeridge

In Section 3.5.2.2, we describe our methods for estimating the range-wide population size of the fat threeridge, which is about 233,500 animals. Only two sites of the species range are outside the action area: a site at the upstream end of Dead Lake on the Chipola River, and a site on the lower Flint River. These latter two sites are literally on the upstream fringe of the species' extant range and probably support less than 1% of the species' total abundance. About 46% of the population occurs in RM40-50 reach of the river, based on our estimates of density and habitat availability by 10-mile river reach, including the Chipola Cutoff and lower Chipola River.

<u>Fat Threeridge Distribution by Depth</u>

Our most detailed information about the fat threeridge and its habitat pertains to the RM40-50 reach. This information, summarized in Table 4.3.2.4.A, gives the results of our October 2007, quantitative samples from a random sample of 11 out of 26 sites in this reach that have habitat characteristics suitable for the species. We estimate that the total amount of this kind of habitat is about 74 acres in the entire range of the species, and about 9 acres in the RM40-50 reach (see Section 3.5.2.1). For this effects analysis, we use the numbers and habitat versus depth relationships in the RM40-50 reach as a representation of these relationships for the action area as a whole. We recognize that morphological differences throughout the action area may weaken this assumption to some degree; however, our estimates of fat threeridge density and habitat quantity are based upon surveys of habitats throughout the action area that are morphologically similar to fat threeridge habitats in the RM40-50 reach. The 10-mile core habitat for the species represents only about 10% of the species' range; however, it supports about half of the species' numbers, as densities in the rest of the range are 5 to 77 times less than in RM40-50.

Table 4.3.2.4.A reports the average density, habitat area, and number of animals by 0.1-ft elevation increments relative to the river gage at Wewahitchka, Florida (Wewa gage). The table shows cumulative numbers and percentages for river stages less than a Wewa gage height of 11.2

ft. The table also shows the Corps' latest estimates (James Hathorn, Corps, email dated November 2, 2007) of the releases from Woodruff Dam, as measured at the Chattahoochee, Florida, river gage, that correspond to the Wewa gage heights. These values were based on analysis completed for the November 2007 BO and may be different now, but it would only result in a small change if any. Reducing the minimum flow to 4,500 cfs would affect about 9.0% of the animals located at and above the Wewa gage heights equivalent to these flows.

Probable Impact of River Stage Decline

A decline in river stage to the minimum flow of the proposed action would probably occur over 3 days, depending on basin inflow at the time. During the decline, some mussels would probably either burrow into the substrate or move laterally towards deeper water to avoid exposure. Those not exposed by the stage decline might also move to lower elevations to avoid the higher risk of predation by terrestrial predators in shallower water. After water level declines, we have commonly observed fat threeridge movement trails on sloping banks, which implies that they are moving downward in response to declining water levels. However, the extensive strandings in 2006 and 2007 are also evidence that these movements are not always successful. Several of the 26 sites in the RM40-50 reach have morphological characteristics that are similar to the seven main-channel sites at which substantial mortality occurred in 2006, and portions of these sites would experience a similar disconnection from deeper portions of the river channel with a decline in stage from present levels. We have already observed additional mortality and strandings at these sites during the summer of 2007. Florida FFWCC also periodically reported listed mussel mortality to us during the summer of 2007.

Mussels in newly exposed areas that are located closest to the contour equivalent to water's edge of the new minimum flow of the proposed action would have the highest probability of survival during a stage decline, because they would have the shortest horizontal distance to travel. The average width of habitats in RM40-50 that are less than 3 ft deep relative to a Wewa gage of 11.2 ft is 34.3 feet. Although the slope of the river bed from the banks to the thalweg is steeper at the lateral edges of this habitat zone, the narrow slice of the channel cross section where fat threeridge are presently found is relatively flat, with an average slope of about 5 degrees. Because it is a relatively flat space, a small decline in river stage exposes a broad area of habitat. A 0.6-ft decline in stage (4,520 cfs minimum flow) from a Wewa gage height of 11.2 would expose 25.8% of the habitat we surveyed (Table 4.3.2.4.A). Again, the 0.6 ft decline in stage was based on analysis completed for the November 2007 BO and may be different now, but it would only result in a small change if any. Assuming the habitat geometry measured in RM40-50 applies to the habitats identified in the other river reaches, total habitat availability would shrink from about 74 acres to 55 acres for the duration of a 0.6-ft decline in stage.

Researchers in the upper Mississippi River measured mussel survival during a pool drawdown event and found that site slope and depth of the mussels strongly influenced mussel survival. Survival on sloped sites was 40.6% compared to 12.8% on a flat site at the same depth contour (Wisconsin Department of Natural Resources et al. 2006). Our sites have a relatively moderate slope of 5 degrees towards the channel thalweg, as noted above, because water levels have already retreated from the steeper portion of the banks. They also found that depth made a significant difference in survival rates. For initial depths of 1, 2 and 3 ft, survival was 30.1%,

88.1% and 98.0%, respectively for both sloped and flat sites and 40.6%, 88.1% and 98.0% for sloped sites only (Wisconsin Department of Natural Resources et al. 2006). They also noted that some movement of mussels during the drawdown was shoreward and resulted in mortality. Samad and Stanley (1986) also reported multidirectional, near-random movements in response to a drawdown.

As described in Chapter 3, when flows reached a new minimum of 4,750 cfs during November and December of 2007, some mussels moved, and some mortality occurred. If flow reductions to 4,500 cfs are needed in the summer of 2008, some additional mortality may result as mussels would just as likely move back into the zone between the stages of 4,750 cfs and 5,130 cfs during the higher winter and spring flows. The potential density of mussels in this zone is unknown so additional mortality, if any, cannot be estimated. Without a basis for estimating the degree to which these movements and mortality would occur, we are assuming that the net effect is a simple loss of the fraction of the population that was located at stages above the 4,500 cfs minimum flow level (Table 4.3.2.4.A).

Effect of Reducing Habitat Availability

We do not believe that food availability is presently a limiting factor for fat threeridge in the Apalachicola River. Concentrating mussels into a narrower zone of habitat could have beneficial and/or adverse effects on the mussels. Beneficial effects could include improved reproductive success by increasing fertilization rates or concentrating fish hosts and mussels. Adverse effects could include increased vulnerability to predation and increased stress due to poor water quality.

It is possible that many fat threeridge would move downward in response to a stage decline and maintain about the same distribution of numbers at depth, thereby moving into previously unoccupied portions of the river bed. However, we believe fat threeridge and other mussels do not generally occupy this portion of the channel because it is subject to high velocities and shear stress during higher flows, which is consistent with the substrate characteristics. Our quadrat samples taken by diving methods in October 2007 failed to excavate a single fat threeridge at depths greater than 3 ft on the same transects where animals were found at depths less than 3 ft. The substrate is considerably coarser towards the center of the channel and is best described as loose shifting sand. By contrast, the substrates of the near-bank areas we have identified as fat threeridge habitat have a substantial fraction of silt and clay (up to about 30%) (Miller and Payne 2007) with the sand. It is probable that the portion of fat threeridge that do move into previously unoccupied habitat would be displaced from this habitat in higher spring-time flows and either killed or deposited in areas that may or may not constitute suitable habitat (Hastie et al. 2001). We have no way of estimating the number that may be affected in this way.

Cumulative Mortality 2006-2008

In the Section 3.5.2.2, we estimated that the fat threeridge population before the low-flow-related mortality of the summer of 2006 was about 283,500 range wide. Mortality at several main-channel sites in the RM40-50 reach, the Chipola Cutoff, and Swift Slough was about 50,000, or 18% of the population. Additional take of about 1,500 fat threeridge, or 0.5% of the population, occurred when flows were less than 5,000 cfs in November and December 2007. Flow

reductions that lower river stage by up to 0.6- ft (4,520 cfs minimum flow) could result in an additional 9% mortality (see "Mussels Distribution by Depth" earlier in this section). If so, the species would experience 18.5% plus up to 9% mortality due to low flows. We have no evidence for density-dependent mortality in this species; therefore, we have no reason to believe that this mortality would somehow offset normal levels of natural mortality. We assume that the additional mortality related to flows less than 5,000 cfs would occur in addition to natural mortality (i.e., as additive and not compensatory mortality).

Evaluation of Effects of Estimated Mortality

Interpreting the significance of up to an additional 9% mortality and 25.8% habitat loss resulting from a decline in the minimum flow necessarily involves considering the life history characteristics of the species. The life history of many freshwater mussels is characterized by a generally long lifespan (6-100 yrs), delayed age of maturity (6-12 years), high fecundity (>100,000 glochidia), extremely low juvenile survivorship, high adult survivorship, rapid growth rate before maturity and slower thereafter, regular reproductive activity following maturity, and relatively long population turnover time (McMahon and Bogan 2001). These characteristics are considered typical for the genus *Amblema* (Haag and Staton 2003) and are consistent with what we know about *A. neislerii*. It has been shown that small chronic increases in adult mortality rates, e.g., harvesting, results in population declines for mussels (Hart et al. 2004).

Some researchers (Musick 1999; Powles et al. 2000) have hypothesized that high fecundity facilitates rapid recovery from a population decline; however, this idea has not received theoretical (Hutchings 2001a, 2001b; Dulvy et al. 2003) or empirical support (Reynolds et al. 2002). Several highly fecund fishes have failed to recover from overexploitation, such as Atlantic cod (COSEWIC 2003). Denney et al. (2002) suggest that high fecundity is actually associated with a low recovery potential.

The current range of the fat threeridge is about 40% of its historic range (USFWS 2003b), and may continue to decline still as it now appears to be almost entirely absent upstream of RM 90. (see Table 3.5.2.2.B). Its population suffered substantial mortality (almost 19%) in 2006 and summer 2007 (see Section 3.5.2.2). Although we estimate that the current population size of fat threeridge is about 233,500, this seemingly large number does not necessarily guarantee its survival or recovery, depending on its demographic characteristics and the threats to its habitat. Hutchings and Reynolds (2004) cautioned against assuming that apparently high levels of abundance in populations that were formerly much more abundant assures long-term population survival. Although population abundance can appear high, population estimates do not reflect the actual number of individuals that contribute genes, as reflected by the effective population size, which can be substantially lower (Nunney and Elam 1994; Frankham 1995; Vucetich et al. 1997; Turner et al. 2006). For example, Turner et al. (2002) studied the effective population size versus the population size of red drum (*Sciaenops ocellatus*), which is a marine fish that is similar in life history to the fat threeridge. They found that estimates of effective population size of red drum were three orders of magnitude less than the adult population size. Populations with small effective population size may suffer reduced capacity to respond to changing or novel environmental pressures, inbreeding depression, and/or accumulation of deleterious alleles (Frankham 1995; Higgins and Lynch 2001), and populations with enormous adult census

numbers may still be at risk relative to decline and extinction from genetic factors (Turner et al. 2002).

As discussed in Section 3.5.2.2, a PVA model for fat threeridge was recently developed to assess the status of the population (Miller 2008). The PVA was also constructed to assess the potential impacts of low-flow events in the Apalachicola River on future viability of the fat threeridge. Current hydrologic modeling suggests the possible scenario is a reduction in flows to 4,500 cfs occurring one or two times in a 69-year period. Available depth distribution data described above indicate that such limited flows may result in a 9% reduction in survival across all stage classes. Therefore a series of scenarios (low-flow events) was developed to investigate the impacts of such potential mortality events. The information that follows is a summary from the report; refer to Miller (2008) for a more detailed description of the methods and results.

Low-flow events were modeled as stochastic (random) and deterministic (non-random) phenomena. Under the stochastic formulation, the event was allowed to occur randomly at a minimum of one time in a 69-year period and a maximum of five times during the same period of time. In the year following the event, all survival rates return to their baseline values. Lacking data to suggest otherwise, it was assumed that fecundity is not affected by these low flow events. Deterministic models were designed so that the low-flow event occurred in the first two or four years of the simulation in order to evaluate the capability of the population to recover from reduced survivorship. The severity of the event in the deterministic formulation was identical to that defined by the stochastic treatment of the event. Confidence intervals on population growth and quasi-extinction rates were not calculated. As discussed in Section 3.5.2.2, we believe the most appropriate estimate of adult survival is the lower bound estimated from the catch curves (p_{Ad}=0.89), and the fat threeridge population in the Apalachicola River is in a long-term, relatively slow decline. However, low-flow impacts were modeled under the three different adult survivorship values (low=0.89, intermediate=0.9125, and high=0.98) to assess uncertainty in the estimate of adult survival, and therefore, estimates of extinction risk.

Without the inclusion of low-flow events, the simulations with low adult survival (p_{Ad}=0.89) resulted in a declining population, and the simulations with intermediate adult survival resulted in a slightly increasing population (Section 3.5.2.2). Under these same adult survival estimates, the inclusion of one to two stochastic low-flow events resulted in only very slight changes to the long-term population growth rate of simulated fat threeridge populations (Table 4.3.2.4.B, Figure 4.3.2.4.A). Both simulations resulted in declining populations, but if two low-flow events occur in a 69-year period on the Apalachicola River (annual probability = 0.0290), the long-term stochastic growth rate declines by just 0.2 – 0.25%. However, the inclusion of low-flow events in the simulations with intermediate adult survival (0.9125) resulted in a shift from a long-term population increase to a long-term population decline. When adult survival is high, the inclusion of these events had effectively no impact on the long-term growth dynamics, as the vigorous survival rates basically overwhelm any instability that the low-flow events may introduce (Miller 2008).

Similar to the results modeling long-term population growth rates, the shifts in quasi-extinction risk (i.e., probability that a population will be at or below a given threshold at the end of a simulation) with the inclusion of stochastic low-flow events are also small (Figure 4.3.2.4.B).

Under the low adult survival scenario, there is about a 90% chance that the population will be reduced by about 50% of the initial size in 50 years when the low-flow event occurs once or twice in 69 years. However, when no low-flow events were included in the model, there was an 85% chance that the population will be reduced by about 50% . Under the intermediate adult survival scenario, the probability of a 50% population decline increases from about 12% in the absence of the event to about 15% and 17% when the low-flow event occurs once or twice in 69 years respectively. When adult survival rates are high, the additional risk imposed by the low-flow events is negligible (less than 0.5%) (Miller 2008).

When the low-flow event occurs deterministically in the first few years of the simulation, the resulting population is at a lower abundance. Because of the depressed abundances following these deterministic events, quasi-extinction risks are slightly higher compared to the corresponding scenarios incorporating stochastic low-flow events (Figure 4.3.2.4.C). For example, under the low adult survival scenario when the low-flow event occurs twice in 69 years, the probability of a 50% population decline increases from about 90% when the event is modeled stochastically to about 91% when the event is modeled deterministically. These increases are small, and in no case do they lead to total extinction of the fat threeridge; however, these deterministic simulations suggest that multi-year events would have a more noticeable impact on the long-term abundance of fat threeridge. It is therefore valuable to more accurately consider the likelihood of low flows occurring in consecutive years – whether governed by stochastic or deterministic processes (Miller 2008).

Taken together, the results suggest that a low-flow event occurring once or twice in a 69-year period in the Apalachicola River and thereby reducing the survival of all stages of fat threeridge by about 9%, could adversely affect the long-term growth dynamics of a population that is already declining, such as when adult survival is lower (p_{Ad}=0.89). However, if the fat threeridge population was increasing as a result of higher survival rates (p_{Ad} =0.98), it would appear to be largely immune from the destabilizing effects of periodic low flows in the river (Miller 2008). This further highlights the need for more precise estimates of adult female survival in the Apalachicola River based on multiple years of data. As discussed in Chapter 3.5.2.2, we believe the fat threeridge population in the Apalachicola River is in a long-term, relatively slow decline largely as a result of drought conditions. Therefore, if these conditions persist, the population will continue to be negatively impacted. However, the simulations presented here suggest that, given the frequency of such an event occurring and its predicted effects, the absolute impact of an isolated low-flow event would be minor, and as a result, survival and recovery would not be appreciably reduced.

4.4 Interrelated and Interdependent Actions

We must consider along with the effects of the action the effects of other federal activities that are interrelated to, or interdependent with, the proposed action (50 CFR sect. 402.02). Interrelated actions are part of a larger action and depend on the larger action for their justification. Interdependent actions have no independent utility apart from the proposed action. At this time, the Service is unaware of actions that satisfy the definitions of interrelated and interdependent actions that will not themselves undergo section 7 in the future, or that are not already included in the Baseline or in our representations of flows under the RIOP and RoR.

4.5 Tables and Figures for Section 4

Table 4.2.1.A. Summary of depletion estimates (cfs) based on year 2007 data in the ACF Basin upstream of Woodruff Dam used in the HEC-5 model of the RIOP. Negative values for reservoir evaporation indicate a net gain from precipitation.

		Reservoir Evaporation			Agriculture			Total		
	M&I	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet
Jan	290	-49	-131	-163	2	1	1	243	159	128
Feb	320	-17	-92	-85	29	0	0	332	228	235
Mar	384	38	-14	-99	117	45	45	538	415	330
Apr	500	248	181	68	258	113	113	1,006	794	681
May	711	298	245	212	702	397	397	1,711	1,353	1,320
Jun	699	278	231	232	945	488	488	1,922	1,418	1,419
Jul	656	182	179	51	1,068	695	695	1,906	1,529	1,401
Aug	800	230	195	191	1,152	688	688	2,182	1,682	1,679
Sep	679	213	177	183	828	370	370	1,721	1,226	1,233
Oct	507	179	174	165	307	150	150	994	831	822
Nov	395	37	-9	-5	238	100	100	670	486	489
Dec	360	-85	-106	-100	207	88	88	483	342	349
Average	525	129	86	54	488	261	261	1,142	872	840

Table 4.2.2.A. Observed and simulated flow frequency (% of days flow exceeded) of the Apalachicola River at the Chattahoochee gage for the Baseline (observed flow 1975-2007), RIOP (HEC-5 simulated flow 1975-2007) and RoR (HEC-5 simulated run-of-river or basin inflow 1975-2007).

Frequency Exceeded	Baseline	RoR	RIOP
0%	227,000	188,945	233,205
5%	56,500	55,114	56,669
10%	43,500	42,774	43,013
15%	34,800	35,576	35,449
20%	29,400	30,110	29,659
25%	25,700	26,350	25,237
30%	22,140	23,140	22,126
35%	19,600	20,473	19,697
40%	18,000	18,561	17,845
45%	16,560	16,682	16,227
50%	15,200	14,979	14,584
55%	14,000	13,537	12,920
60%	13,100	12,176	11,924
65%	12,200	10,973	10,985
70%	11,300	10,052	10,252
75%	10,300	9,023	9,419
80%	9,360	8,125	8,603
81%	9,210	7,946	8,440
82%	9,060	7,768	8,288
83%	8,950	7,569	8,110
84%	8,780	7,334	7,924
85%	8,510	7,070	7,669
86%	8,280	6,845	7,480
87%	7,858	6,583	7,237
88%	7,472	6,312	6,962
89%	7,270	6,035	6,738
90%	6,980	5,784	6,399
91%	6,720	5,549	6,093
92%	6,460	5,236	5,744
93%	6,210	4,902	5,360
94%	5,990	4,524	5,050
95%	5,790	4,230	5,050
96%	5,640	3,879	5,050
97%	5,430	3,364	5,050
98%	5,150	2,923	5,050
99%	5,080	2,393	5,050
99.1%	5,035	2,281	5,050
99.2%	4,934	2,191	5,050
99.3%	4,804	2,099	5,050
99.4%	4,773	2,007	5,050
99.5%	4,760	1,957	5,050
99.6%	4,692	1,863	5,050
99.7%	4,632	1,667	5,050
99.8%	4,570	1,571	5,050
99.9%	4,530	1,273	5,050
100.0%	3,900	766	5,050

Table 4.2.5.A. Annual 1-day minimum flow (cfs) of the Apalachicola River at the Chattahoochee gage for the Baseline (observed flow 1975-2007), RIOP (HEC-5 simulated flow 1975-2007) and RoR (HEC-5 simulated run-of-river or basin inflow 1975-2007).

Year	Baseline	RIOP	RoR
1975	12,400	11,748	14,631
1976	11,600	7,868	7,656
1977	9,220	5,856	5,856
1978	8,190	5,925	4,366
1979	9,590	6,415	6,301
1980	8,790	5,361	4,979
1981	4,980	5,050	3,885
1982	11,500	7,930	7,640
1983	10,800	7,795	7,226
1984	10,300	7,998	7,817
1985	8,550	6,259	5,443
1986	4,430	5,050	2,571
1987	3,900	5,050	3,972
1988	4,430	5,050	2,991
1989	9,140	6,505	7,185
1990	5,540	5,648	5,313
1991	6,580	8,454	7,813
1992	7,650	7,532	7,152
1993	5,150	5,118	4,453
1994	7,590	9,419	10,334
1995	7,130	5,700	5,269
1996	6,350	6,417	6,224
1997	6,250	5,050	3,876
1998	8,130	7,480	6,108
1999	5,280	5,050	1,985
2000	4,530	5,050	979
2001	5,360	5,050	2,480
2002	5,250	5,050	766
2003	8,050	6,876	5,108
2004	7,360	5,605	3,848
2005	8,670	6,287	4,393
2006	5,030	5,050	2,718
2007	4,760	5,050	1,436

Table 4.3.2.4.A. Estimate of fat threeridge numbers by depth from FWS quadrat samples and habitat area bathymetry taken at 11 sites in the RM40-50 reach, October, 2007.

Wewa gage (ft)	Depth relative to Wewa gage 11.2 ft	Average density (#/ft2)	n quadrats	% habitat area	Cumulative habitat at depth	# per 100 linear ft habitat	Cumulative # at depth	Cumulative % at depth	Wewa flow (cfs)	Chattahoo-chee flow (cfs)*
11.1	0.1	0.0000	18	4.0%	4.0%	0	0	0.0%	5,802	5,010
11.0	0.2	0.0076	49	5.8%	9.8%	169	169	0.2%	5,720	4,900
10.9	0.3	0.0715	26	5.0%	14.8%	1,392	1,561	1.4%	5,640	4,800
10.8	0.4	0.0691	43	4.0%	18.8%	1,058	2,619	2.4%	5,559	4,710
10.7	0.5	0.0778	43	3.7%	22.5%	1,125	3,744	3.5%	5,480	4,610
10.6	0.6	0.4757	25	3.3%	25.8%	6,004	9,748	9.0%	5,400	4,520
10.5	0.7	0.2997	31	3.0%	28.8%	3,520	13,268	12.3%	5,321	4,420
10.4	0.8	0.4267	27	2.9%	31.7%	4,802	18,070	16.8%	5,243	4,320
10.3	0.9	0.2555	16	3.0%	34.7%	2,940	21,010	19.5%	5,164	4,240
10.2	1.0	0.3567	25	3.2%	37.9%	4,441	25,451	23.6%	5,087	4,140
10.1	1.1	0.4860	13	2.9%	40.8%	5,427	30,878	28.7%	5,009	4,040
10.0	1.2	0.6636	28	3.2%	44.0%	8,228	39,106	36.3%	4,929	3,960
9.9	1.3	0.5203	20	3.1%	47.1%	6,247	45,353	42.1%	4,849	3,860
9.8	1.4	0.4212	15	3.4%	50.5%	5,487	50,840	47.2%	4,770	3,770
9.7	1.5	0.2676	25	3.2%	53.7%	3,275	54,114	50.2%	4,691	3,690
9.6	1.6	0.6370	21	2.8%	56.5%	6,980	61,094	56.7%	4,612	3,590
9.5	1.7	0.2001	13	2.8%	59.3%	2,183	63,277	58.7%	4,533	3,500
9.4	1.8	0.6937	15	3.7%	63.1%	10,010	73,286	68.0%	4,453	3,413
9.3	1.9	0.1394	8	3.6%	66.7%	1,955	75,242	69.8%	4,374	3,325
9.2	2.0	0.3902	20	3.3%	70.0%	4,957	80,199	74.4%	4,295	3,237
9.1	2.1	0.8671	12	3.1%	73.1%	10,496	90,694	84.2%	4,216	3,150
9.0	2.2	0.2123	7	2.9%	76.0%	2,419	93,113	86.4%	4,137	3,064
8.9	2.3	0.6194	6	2.8%	78.9%	6,802	99,915	92.7%	4,058	2,978
8.8	2.4	0.1239	3	2.6%	81.5%	1,254	101,169	93.9%	3,979	2,894
8.7	2.5	0.1858	2	2.6%	84.1%	1,883	103,051	95.7%	3,900	2,809
8.6	2.6			3.0%	87.2%	0	103,051	95.7%	3,821	2,726
8.5	2.7			2.9%	90.1%	0	103,051	95.7%	3,742	2,643
8.4	2.8	0.0000	1	2.8%	92.8%	0	103,051	95.7%	3,663	2,560
8.3	2.9			3.9%	96.7%	0	103,051	95.7%	3,584	2,479
8.2	3.0	0.3716	8	3.3%	100.0%	4,678	107,729	100.0%	3,505	2,398

Table 4.3.2.4.B. Stochastic growth rate for simulated fat threeridge mussel populations incorporating low-flow events as a stochastic phenomenon, under alternative annual adult survival rates. Event probabilities of 0.0145 to 0.0725 correspond to the average occurrence of one to five low-flow events, respectively, in a 69-year period as predicted by hydrologic modeling (from Miller 2008).

Event Probability	Adult Annual Survival, p_{Ad}		
	0.89	0.9125	0.98
0	0.9781	1.0003	1.0424
0.0145	0.9761	0.9988	1.0424
0.0290	0.9755	0.9981	1.0423
0.0435	0.9744	0.9969	1.0421
0.0580	0.9734	0.9961	1.0423
0.0725	0.9732	0.9945	1.0419

Biologically Relevant Flow Regime Characteristic

	Adverse ←	Condition Gradient	→ Beneficial	Interpretation of IOP Alteration
1	Baseline	IOP	RoR	Beneficial, but not attributable to the IOP
2	Baseline	RoR	IOP	Beneficial
3	IOP	Baseline	RoR	Adverse
4	IOP	RoR	Baseline	Adverse
5	RoR	Baseline	IOP	Beneficial
6	RoR	IOP	Baseline	Adverse, but not attributable to the IOP

Figure 4.2.A. Matrix showing the interpretation of effects of the RIOP relative to Baseline, depending on the condition in the Roar flow regime, which provides the basis for isolating the effects of the RIOP from the effects of simulated non-project related water depletions.

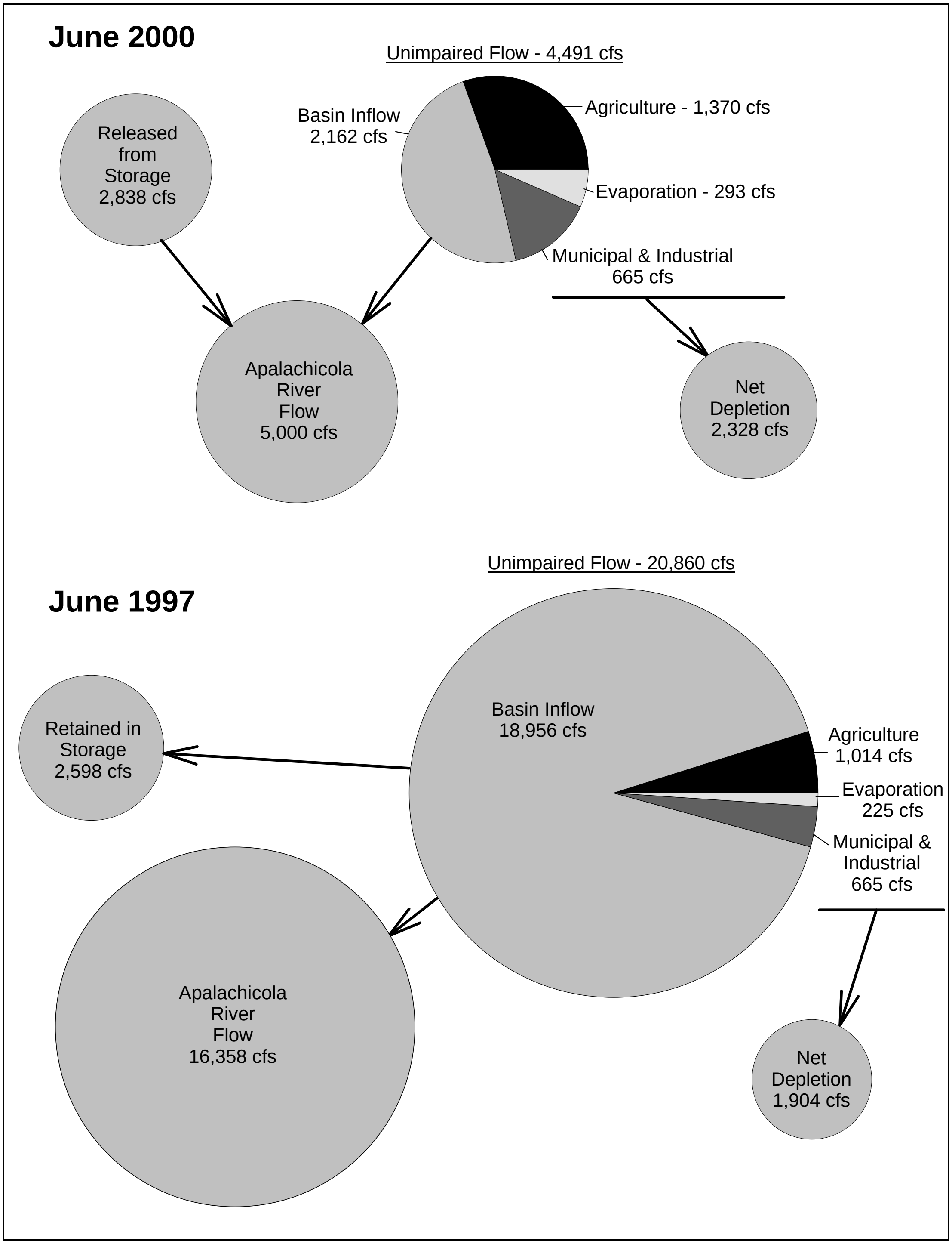

Figure 4.2.1.A. Monthly average unimpaired flow, estimated depletions, change in reservoir storage, and Apalachicola River flow from the HEC-5 model of the RIOP during a dry summer month (June 2000, three upper circles) and a normal summer month (June 1997, three lower circles). The relative sizes of the circles are proportional to the cfs values indicated.

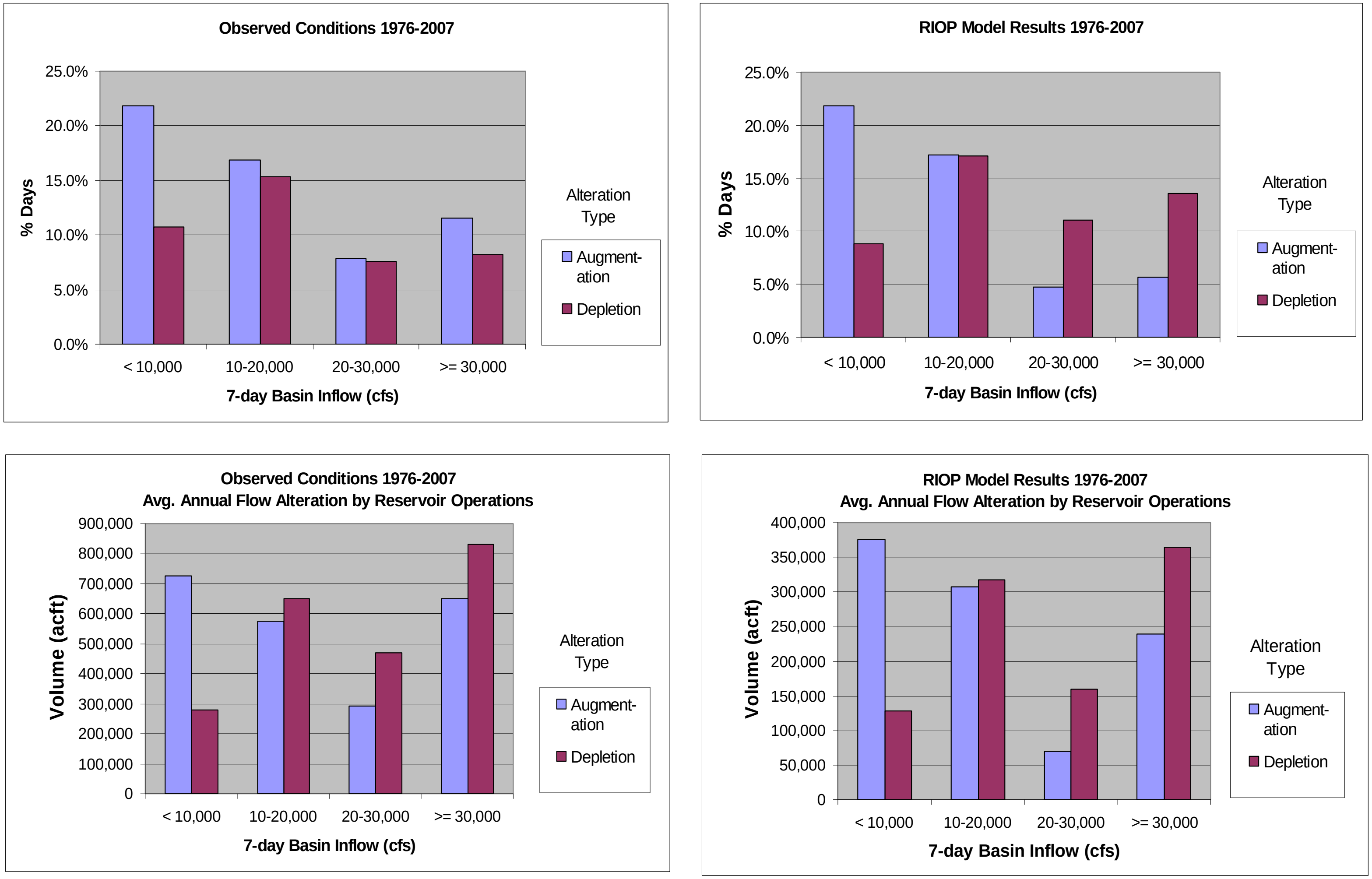

Figure 4.2.2.A. Frequency (percent of days) and volume (acre feet per year) of flow alteration by operations of Lakes Lanier, West Point, and George, 1976 to 2007, as measured by daily changes in composite reservoir storage relative to current rates of 7-day basin inflow, for actual historic operations (Observed Conditions) and for the HEC-5 simulation of the RIOP (note difference in scale of vertical axis of the two annual volume charts).

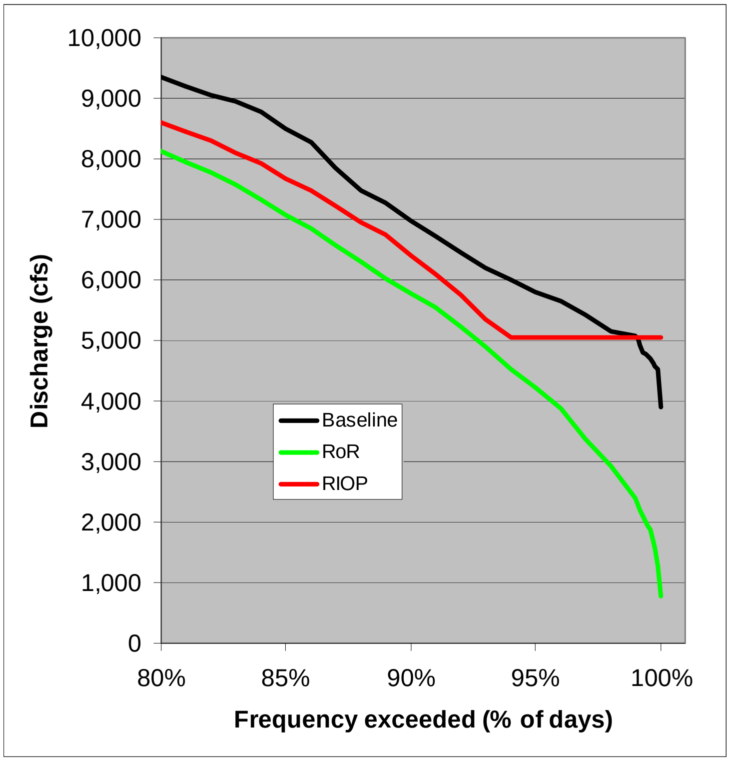

Figure 4.2.2.B. Observed and simulated flow frequency (% of days flow exceeded) of the Apalachicola River at the Chattahoochee gage for the Baseline (observed flow 1976-2007), RIOP (HEC-5 simulated flow 1975-2007) and RoR (HEC-5 simulated run-of-river or basin inflow). The graph displays in greater detail the frequency analysis of Table 4.2.2.A, and focuses on flows that are exceeded 80% of the time or more.

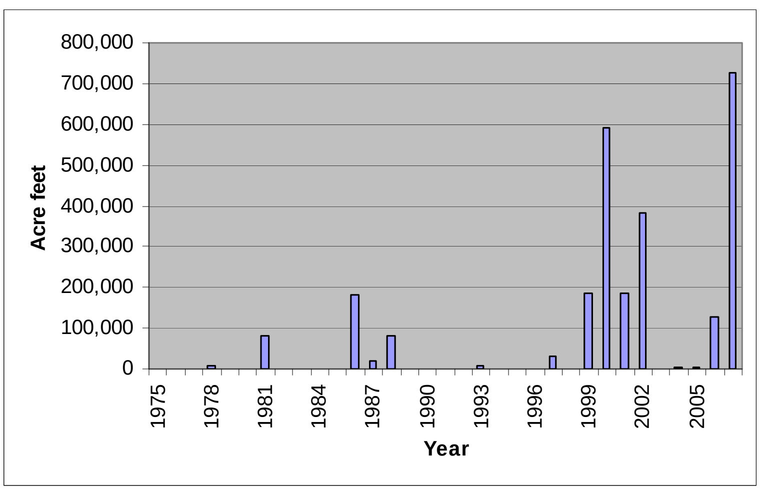

Figure 4.2.2.C. Annual volume of the basin inflow deficit relative to a minimum flow of 5,050 cfs at Woodruff Dam, 1975-2007 for 7-day basin inflow data used in the HEC5 model of the RIOP.

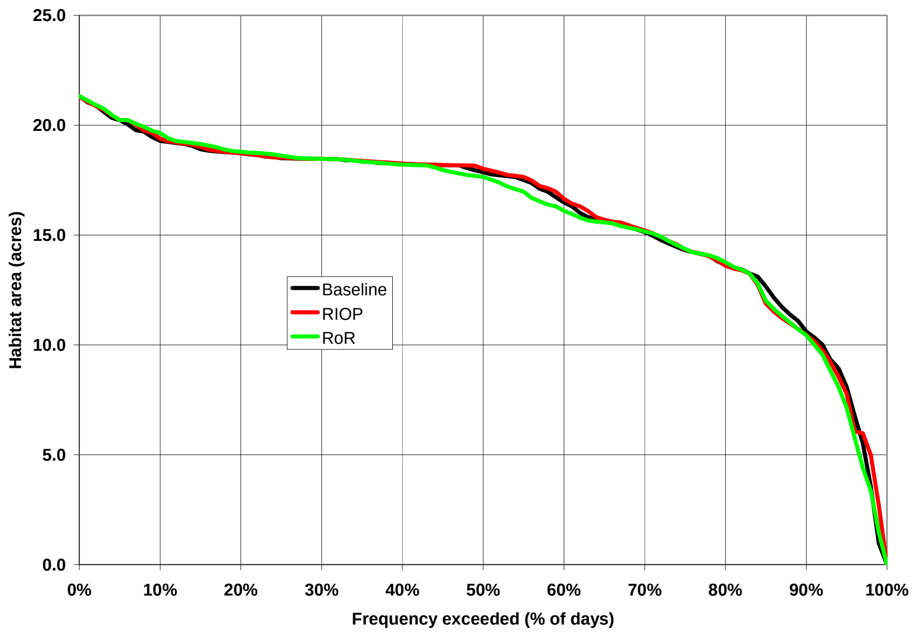

Figure 4.2.3.A. Frequency (% of days) of Gulf sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet), on each day March 1 through May 31, at the two sites known to support spawning, under Baseline (observed flow 1975-2007), RIOP (HEC-5 simulated flow 1975-2007) and RoR (HEC-5 simulated run-of-river or basin inflow).

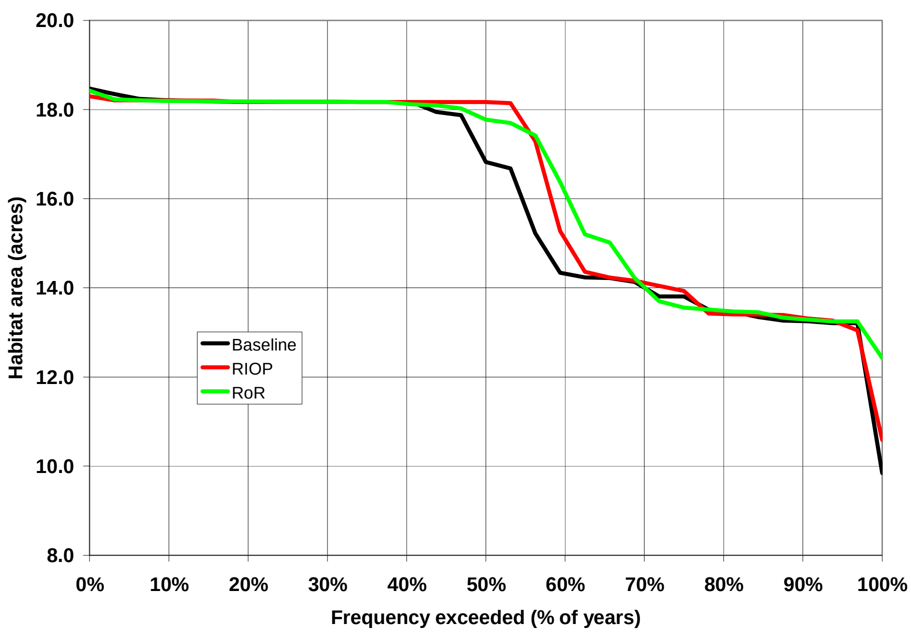

Figure 4.2.3.B. Frequency (% of years) of Gulf sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at least 30 consecutive days each year), March 1 through May 31, at the two known spawning sites, under the Baseline (observed flow 1975-2007), RIOP (HEC-5 simulated flow 1975-2007) and RoR (HEC-5 simulated run-of-river or basin inflow).

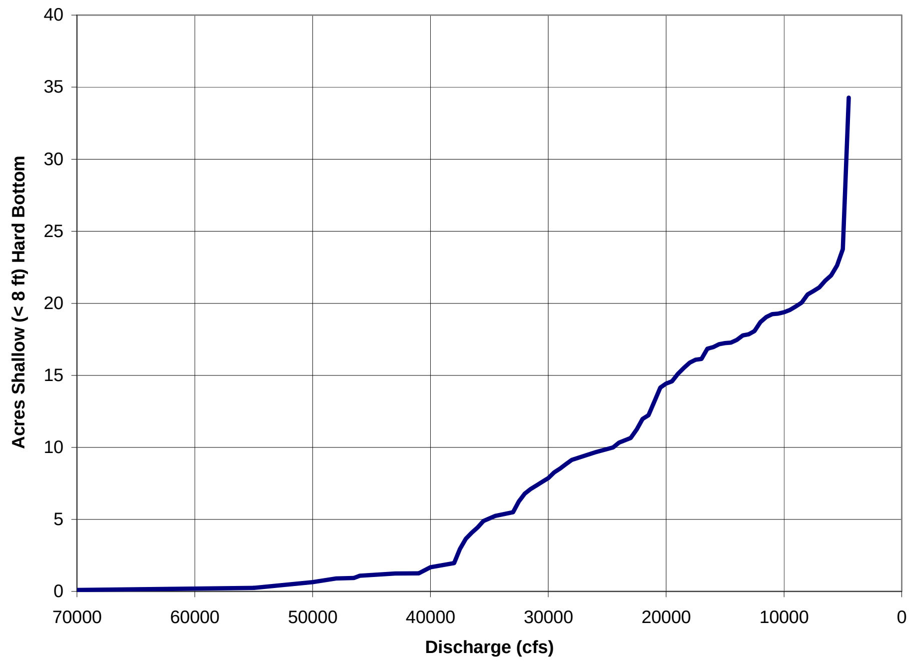

Figure 4.2.3.C. Acres of suitable sturgeon spawning habitat (hard bottom) that is at least 8 ft deep versus discharge at the three known spawning sites on the Apalachicola River. A river stage decline of 8 ft from the discharge values shown would expose the acres of hard bottom shown on this curve.

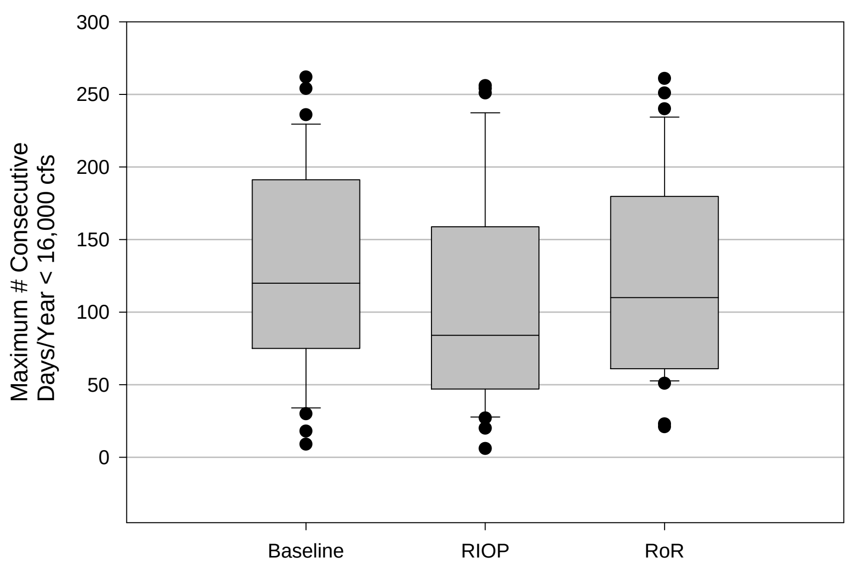

Figure 4.2.4.A. Maximum number of consecutive days/year of flow less than 16,000 cfs under the Baseline (observed flow 1975-2007), RIOP (HEC-5 simulated flow 1975-2007) and RoR (HEC-5 simulated run-of-river or basin inflow).

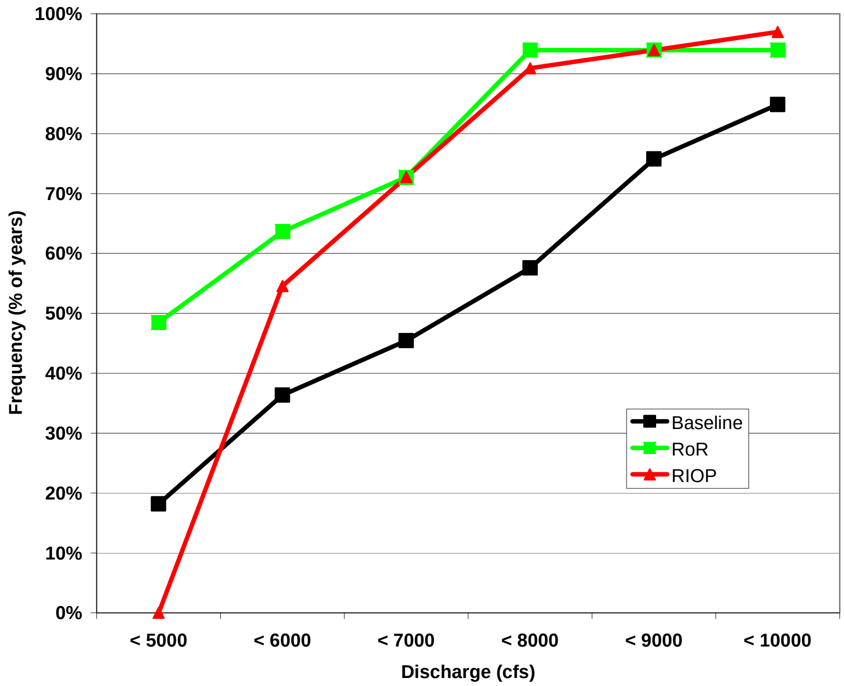

Figure 4.2.5.A. Inter-annual frequency (percent of years) of discharge events less than 5,000 to 10,000 cfs under the Baseline (observed flow 1975-2007), RIOP (HEC-5 simulated flow 1975-2007) and RoR (HEC-5 simulated run-of-river or basin inflow).

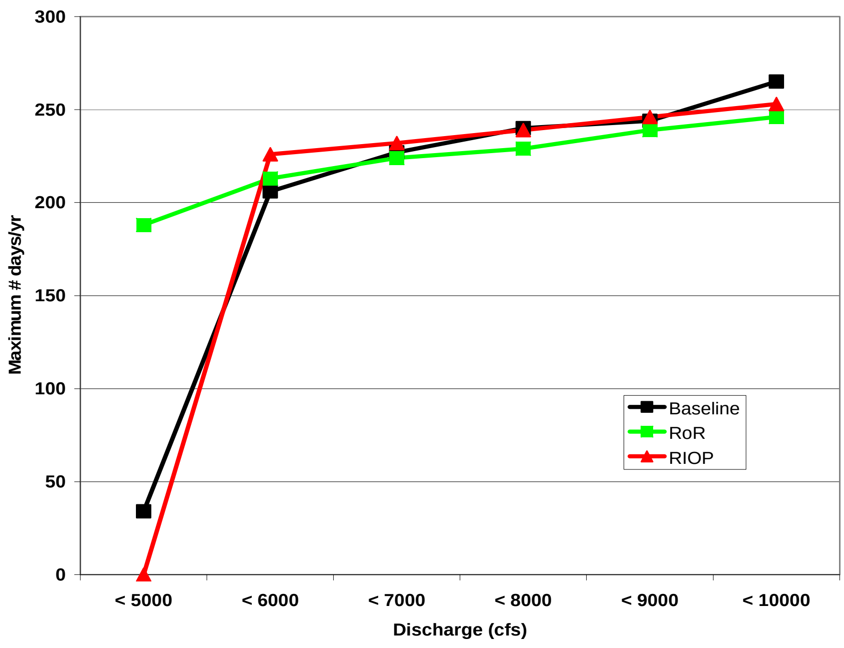

Figure 4.2.5.B. Maximum number of days per year of discharge less than 5,000 to 10,000 cfs under the Baseline (observed flow 1975-2007), RIOP (HEC-5 simulated flow 1975-2007) and RoR (HEC-5 simulated run-of-river or basin inflow).

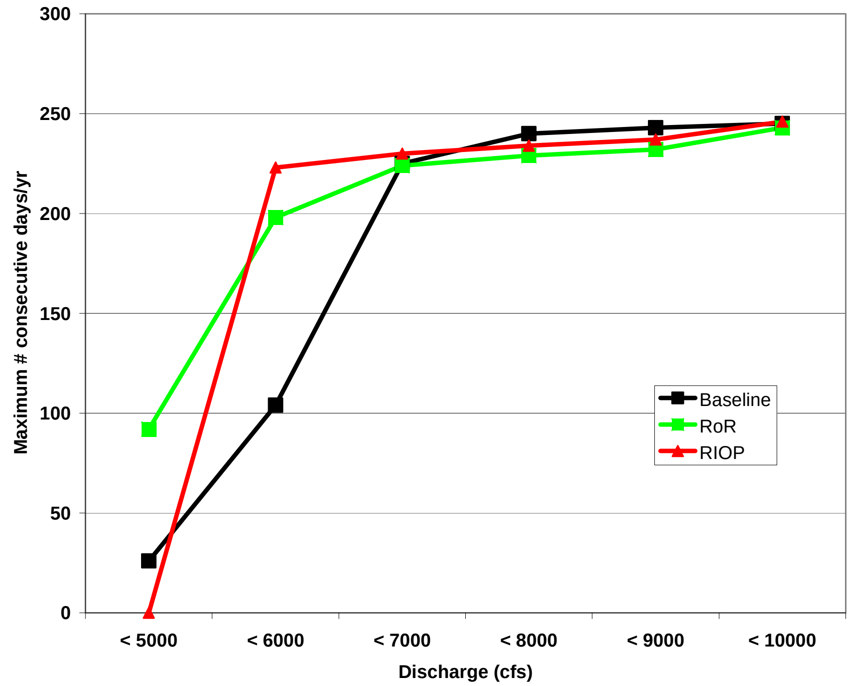

Figure 4.2.5.C. Maximum number of consecutive days per year of discharge less than 5,000 to 10,000 cfs under the Baseline (observed flow 1975-2007), RIOP (HEC-5 simulated flow 1975-2007) and RoR (HEC-5 simulated run-of-river or basin inflow).

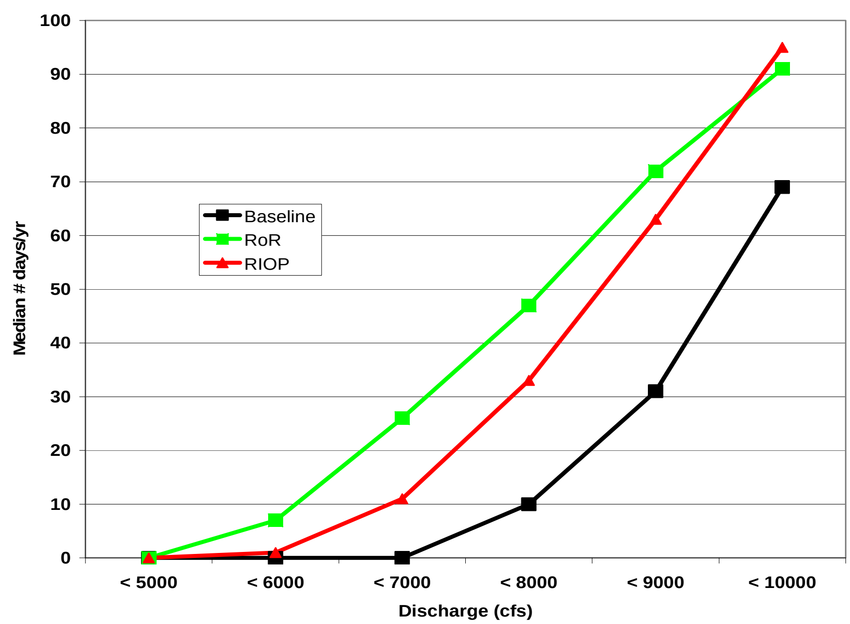

Figure 4.2.5.D. Median number of days per year of discharge less than 5,000 to 10,000 cfs under the Baseline (observed flow 1975-2007), RIOP (HEC-5 simulated flow 1975-2007) and RoR (HEC-5 simulated run-of-river or basin inflow).

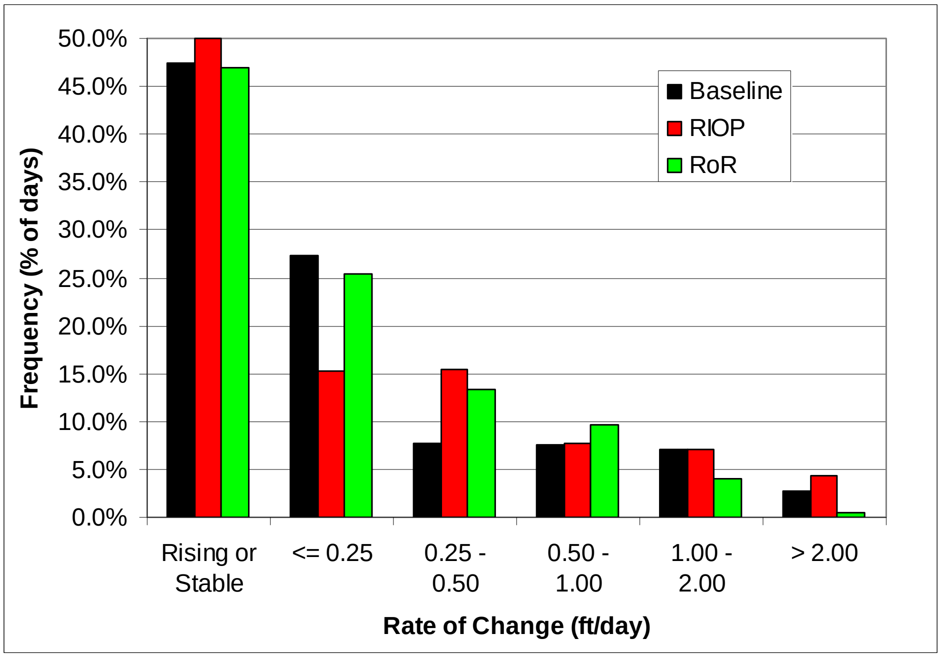

Figure 4.2.5.E. Frequency (percent of days) of daily stage changes (ft/day) under the Baseline (observed flow 1975-2007), RIOP (HEC-5 simulated flow 1975-2007) and RoR (HEC-5 simulated run-of-river or basin inflow).

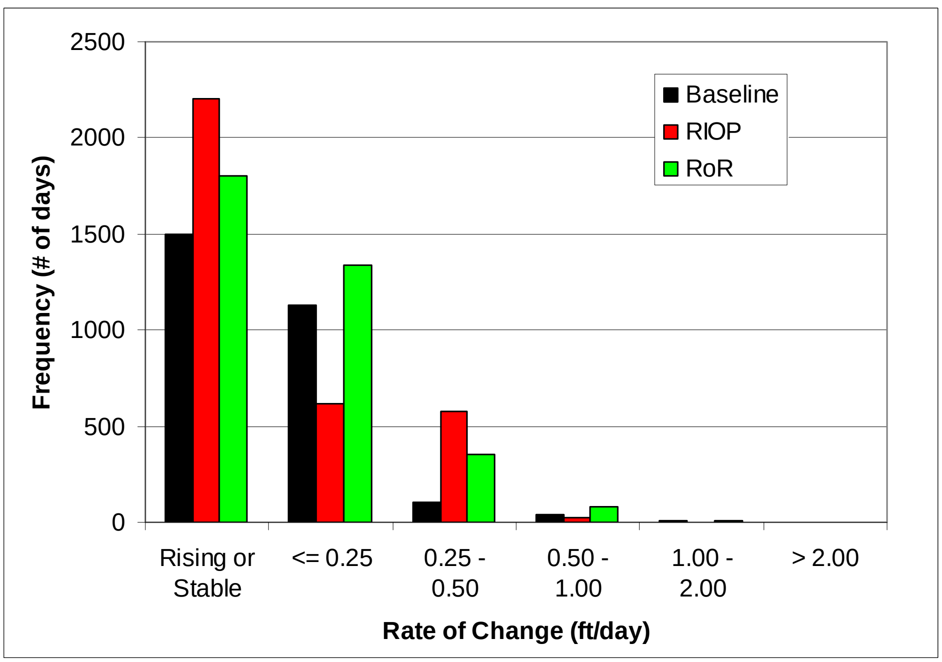

Figure 4.2.5.F. Frequency (number of days) of daily stage changes (ft/day) when releases from Woodruff Dam are less than 10,000 cfs under the Baseline (observed flow 1975-2007), RIOP (HEC-5 simulated flow 1975-2007) and RoR (HEC-5 simulated run-of-river or basin inflow).

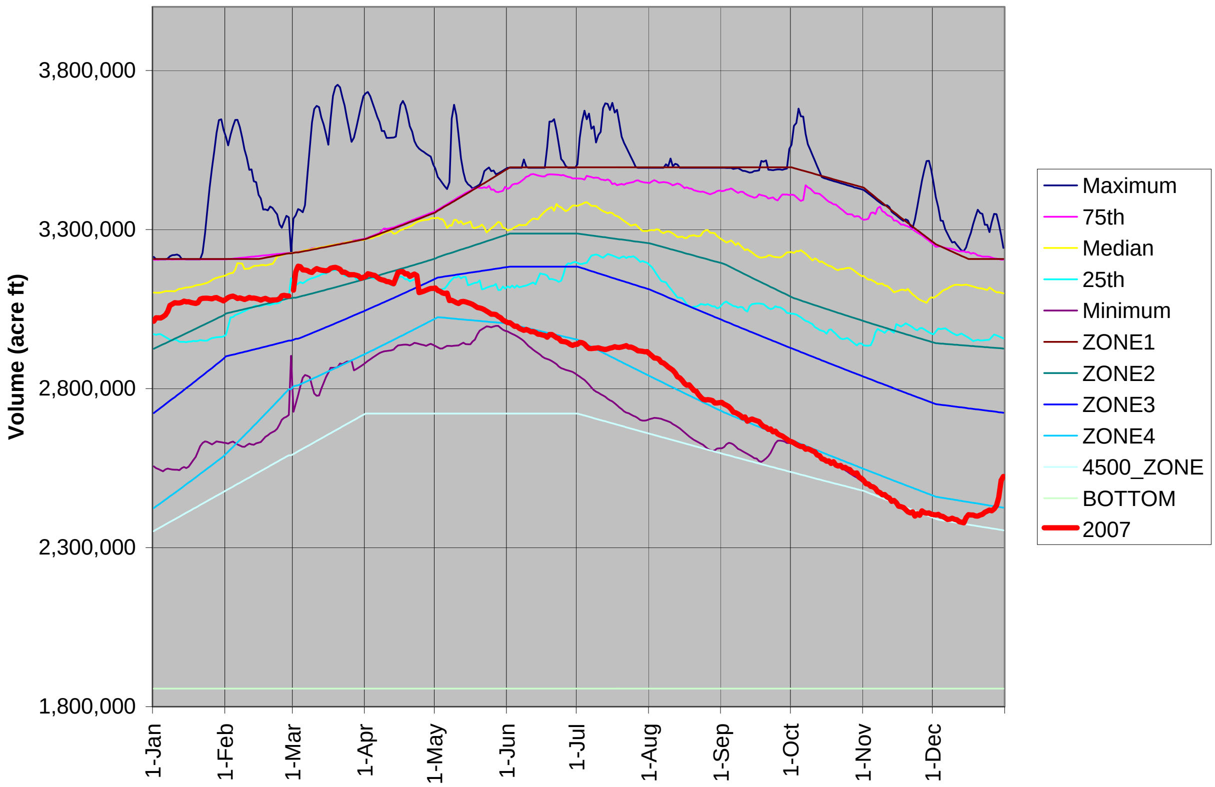

Figure 4.2.5.G. Simulated (HEC-5 RIOP model) composite storage (acft) for lakes Lanier, West Point, and George, 1976-2007. Lines depict statistics (maximum, 75th, median, 25th, and minimum) of the simulated storage levels for each day of the calendar year, the zones used in RIOP operational decisions, and the simulated year 2007 levels. The line for the 2007 storage levels overlays the minimum storage line beginning about October 1.

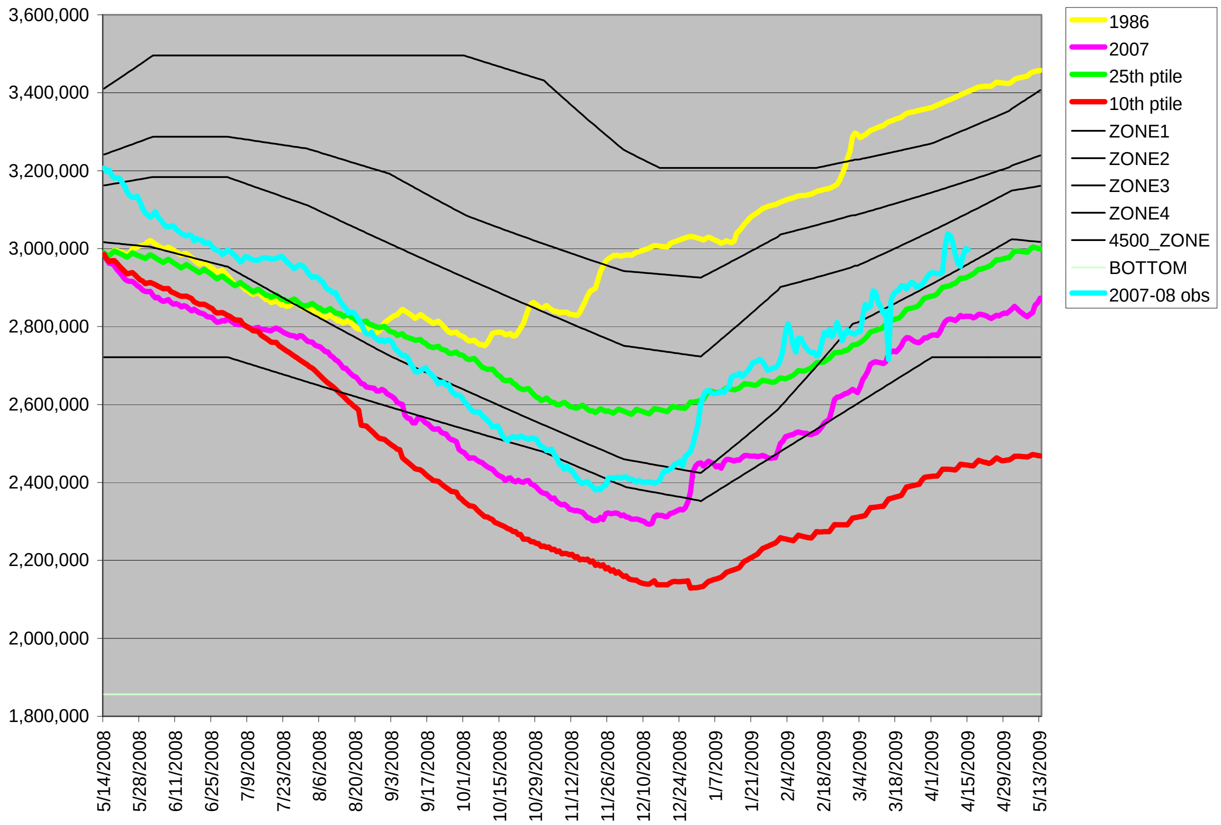

Figure 4.2.5.H. Simulated (HEC-5 RIOP model) composite storage (acft) for lakes Lanier, West Point, and George, for the four 1-year forecast models. The colored lines depict the simulated storage levels for each day of the simulation, May 14, 2008, to May 13, 2009, and also the actual observed levels, May 14, 2007 though April 15, 2008. The black lines depict the zones used in RIOP operational decisions.

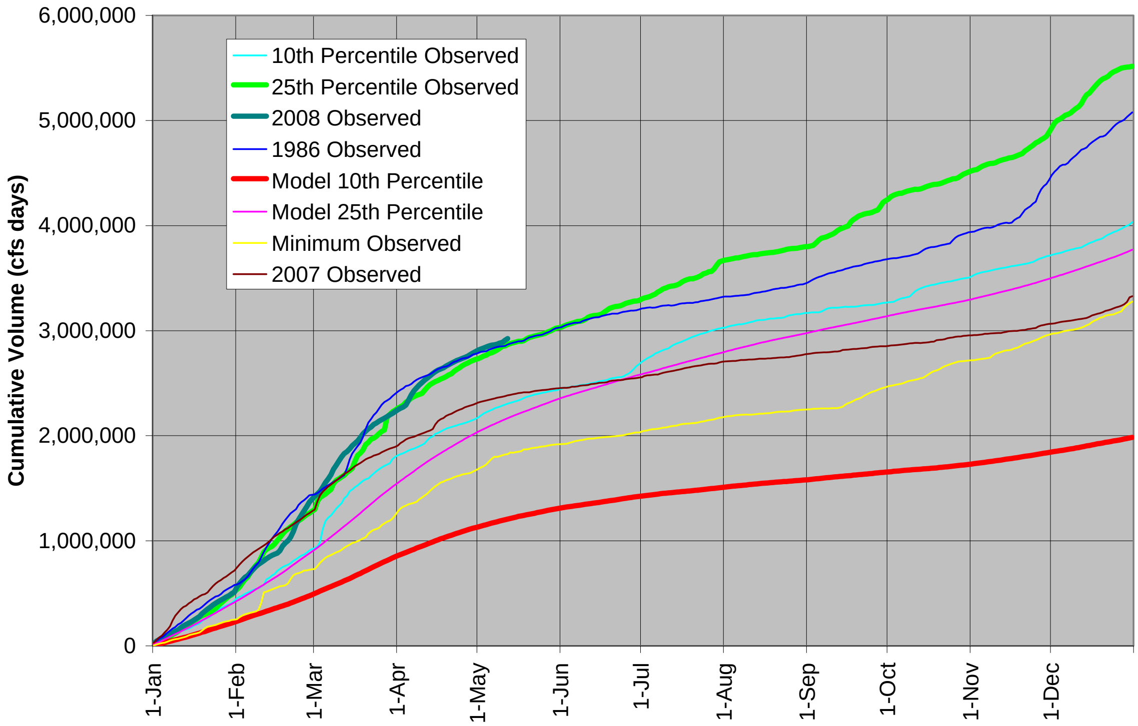

Figure 4.2.5.I. Cumulative volume (cfs days) by calendar day of observed basin inflow and synthesized basin inflow data used in the forecast models (Model 10th Percentile and Model 25th Percentile). Lines depicting observed data represent either specific years (1986, 2007, 2008) or statistics (minimum, 10th percentile, 25th percentile) of the historic record of basin inflow data, 1976-2007.

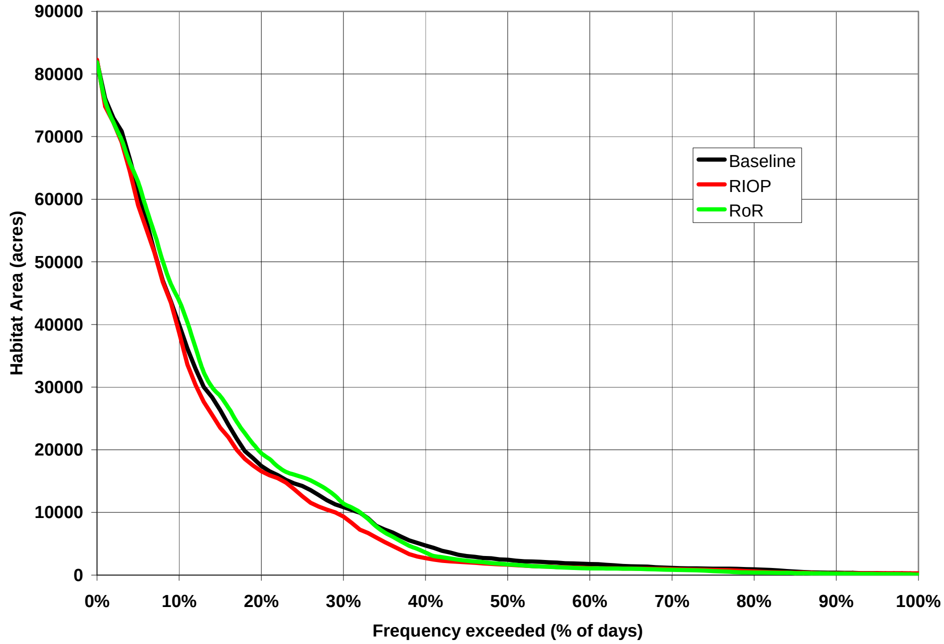

Figure 4.2.6.A. Frequency (percent of days) of growing-season (April-October) floodplain connectivity (acres) to the main channel under the Baseline (observed flow 1975-2007), RIOP (HEC-5 simulated flow 1975-2007) and RoR (HEC-5 simulated run-of-river or basin inflow).

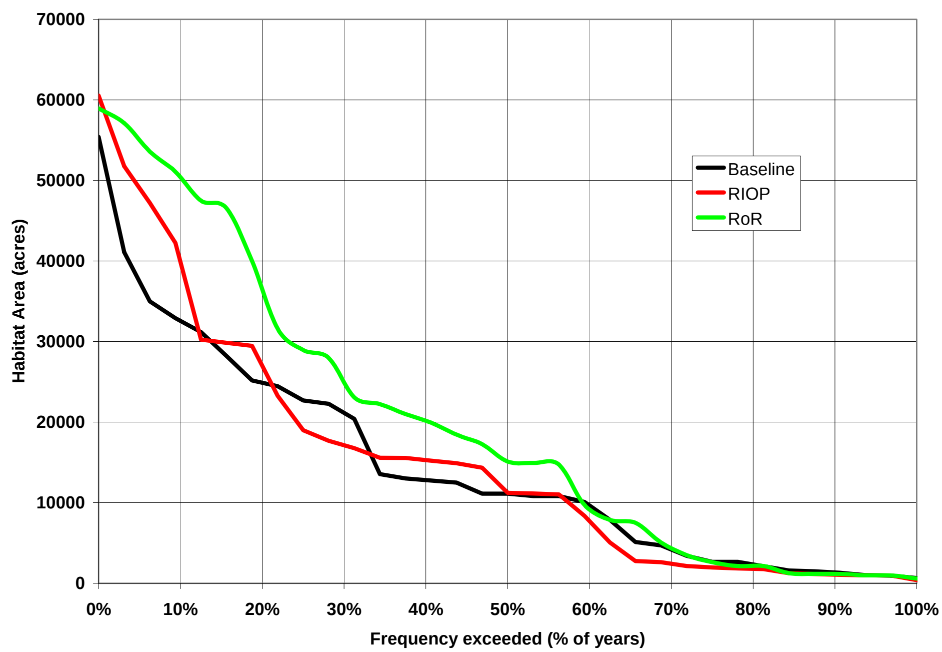

Figure 4.2.6.B. Frequency (percent of years) of growing-season (April-October) floodplain connectivity (acres) to the main channel under the Baseline (observed flow 1975-2007), RIOP (HEC-5 simulated flow 1975-2007) and RoR (HEC-5 simulated run-of-river or basin inflow).

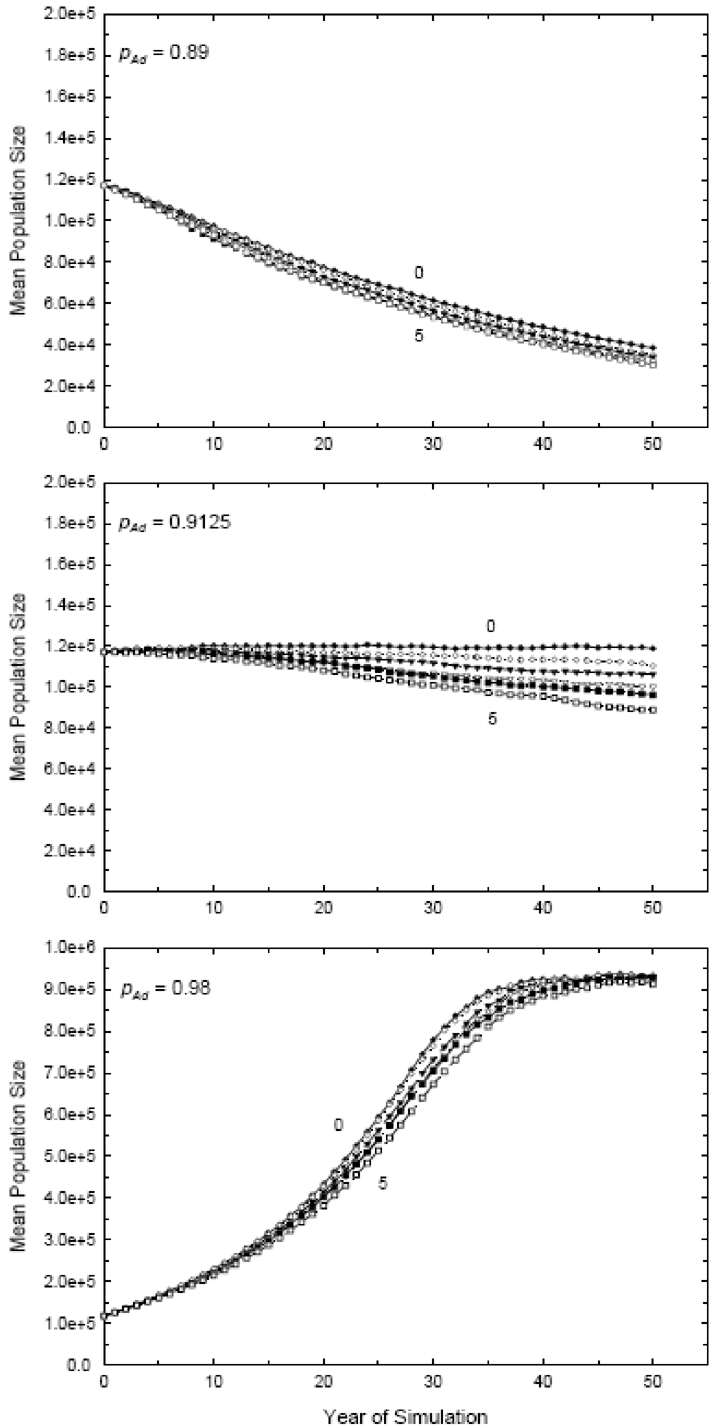

Figure 4.3.2.4.A. Fifty year projections in mean size of simulated fat threeridge populations, under conditions of lower (top panel), intermediate (middle panel) and higher (bottom panel) adult survival rates. Within each panel, individual models incorporate low-flow events as stochastic phenomena with probabilities of occurrence corresponding to zero to five events occurring on average in a 69-year period (from Miller 2008).

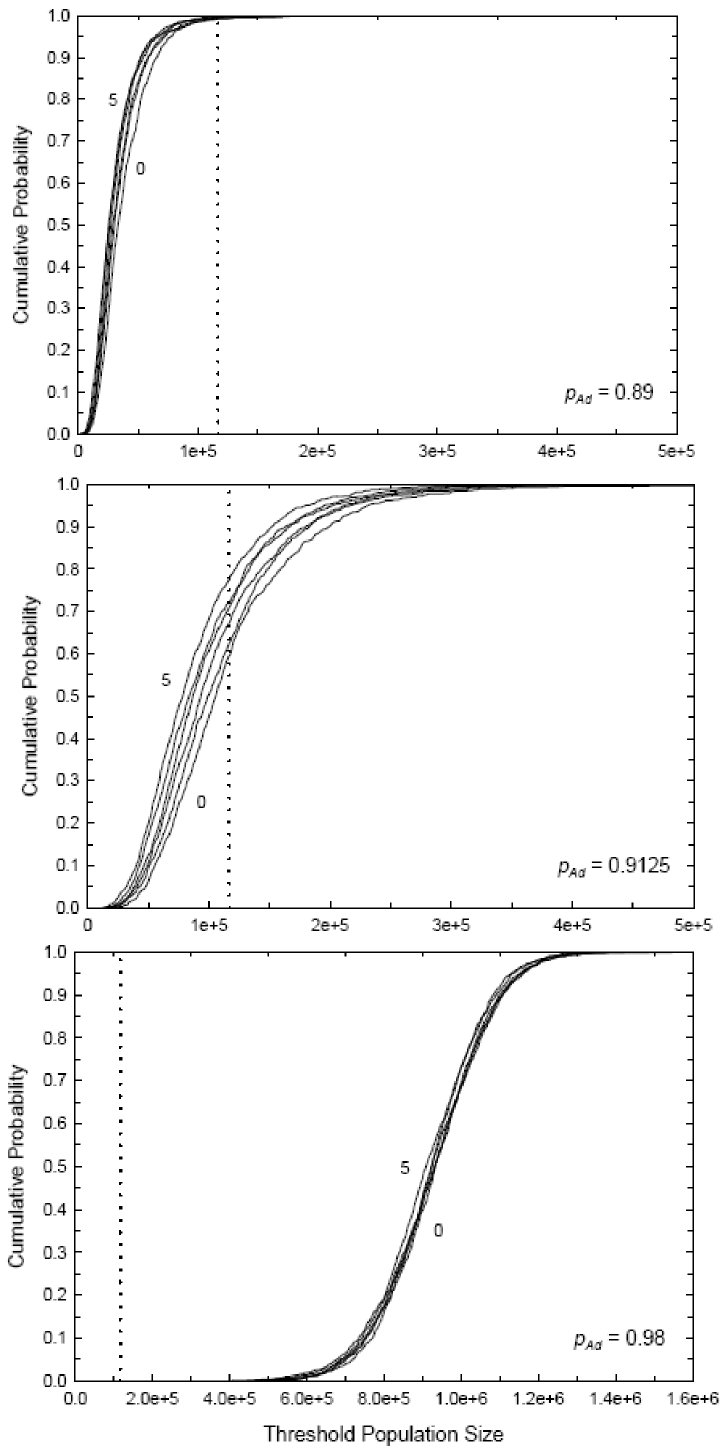

Figure 4.3.2.4.B. Quasi-extinction curves for simulated fat threeridge populations, under conditions of lower (top panel), intermediate (middle panel) and higher (bottom panel) adult survival rates. Within each panel, individual models incorporate low-flow events as stochastic phenomena with probabilities of occurrence corresponding to zero to five events occurring on average in a 69-year period. Initial population size is indicated by the vertical dotted line (from Miller 2008).

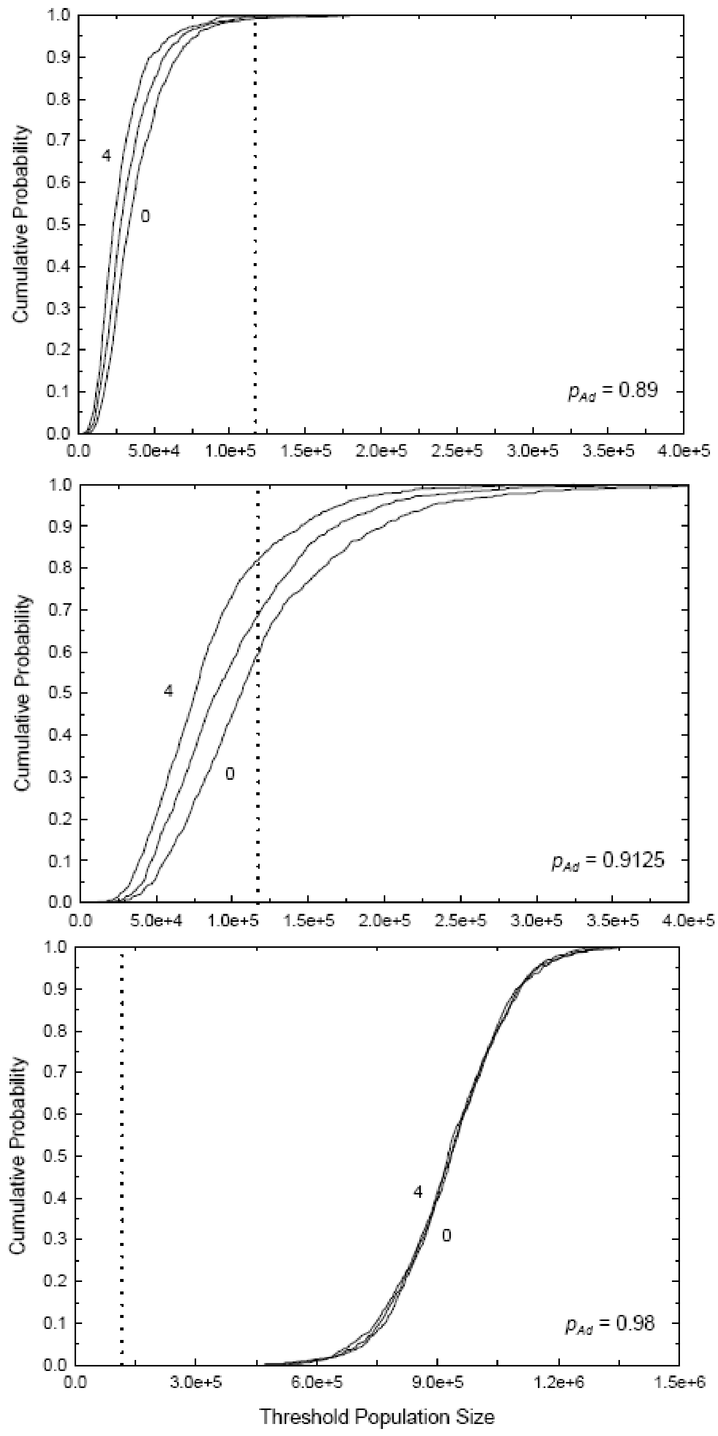

Figure 4.3.2.4.C. Quasi-extinction curves for simulated fat threeridge populations, under conditions of lower (top panel), intermediate (middle panel) and higher (bottom panel) adult survival rates. Within each panel, individual models incorporate low-flow events as deterministic phenomena that occur during the first two or four years of a given simulation. Following this period of low flow, all survival rates return to their baseline values. Initial population size is indicated by the vertical dotted line (from Miller 2008).

5 CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, Tribal, local or private actions that are reasonably certain to occur in the action area considered in this BO. The Corps' time frame for the applicability of the RIOP is five years pending a future update to the WCP. Therefore, we have considered potential nonfederal activities that may also change the primary factors considered in Section 4.1, as well as any other non-federal actions that may affect the listed species during this period. Since the basin inflow calculation is a primary input variable to the Corps' modeling, the cumulative effects evaluation focuses on this variable and how it may change in the next five years.

5.1 Water Depletions Forecast

The effect of increasing depletions is to reduce basin inflow to the Corps' reservoir projects, which affects the magnitude, frequency, and duration of releases from Woodruff Dam, and in turn affects the listed species and their habitats. Depletions have been estimated for reservoir evaporation, agricultural irrigation, inter-basin transfers, and municipal and industrial (M&I) use. The Corps did not project an increased agricultural water demand based on statements by the Georgia Environmental Protection Division that that most acres in the basin for which irrigation is economically feasible are already irrigated, and that agricultural demand has likely "plateaued" at close to the year 2000 demands. Possible changes in the amount of water applied per acre were not considered. Depletions due to evaporation from the federal reservoirs is partly a function of reservoir surface area, which varies between simulations depending on the operations, but the loss per acre per month is unchanged relative to the 2000 depletion estimates. Large increases in M&I consumption are projected. Such projections were developed in the Tri-State Comprehensive Study and were a subject of the failed interstate compact negotiations. Water use in the basin is reported by the Alabama Office of Water Resources, Florida Northwest Water Management District, and Georgia Environmental Protection Division. The Corps recently received updated information through 2007 and has used this data as a basis for estimating future depletions.

The Corps used reach-specific M&I withdrawals and returns (waste water discharges) data to compute net M&I depletions for the years 1994 through 2007. They fit a linear (least squares method) trend line to the M&I data from 2000 to 2007 to estimate an increase of about 14.4 cfs per year. Applying the same method to the data from 1994 to 2007 results in a steeper trend of 22.8 cfs annually. Demands increased faster in the years 1994 to 2000 and appear to have leveled off somewhat since then. Water conservation programs could reduce the per capita M&I consumption and/or per acre agricultural consumption and result in lesser increases in depletions, but the possible effects of such programs were not incorporated into the trend estimates. Table 5.1.A summarizes an estimate of depletions for the year 2017 if depletions increase by 14.4 cfs per year for the next 10 years. This would represent a 27% increase in M&I depletions relative to year 2007 M&I depletions. Although we refer to Table 5.1.A as the year 2017 projection, and it is based on an increase in M&I use only, the total amount of depletions that this table represents could occur sooner or later than 2017, depending on population growth and other factors. Likewise, the total amount of depletions in Table5.1.A could result from a combination of increased M&I and agricultural demands. We believe that this estimate is a reasonable one

for our analysis because it represents an increase that is based upon the most recent years of data (2000-2007). This period includes the two most extreme droughts on record, but shows a leveling off of demand growth relative to the previous years. The longer-term trend from 1994-2007 represents a much higher rate of increase that is not likely to continue.

The Corps provided the results of a simulation of the RIOP using the projected 2017 depletions (+27% for M&I). The model results show that reduced basin inflow results in reduced river flows and reduced reservoir storage levels. For example, the model simulates for the years 1939-2007 an additional 315 days in the 69 years of flows less than 10,000 cfs, of which 236 are days with less than 5,000 cfs basin inflow.

Reduced basin inflow imposes a greater burden on the reservoir storage to maintain the minimum releases from Woodruff Dam. Figure 5.1.A shows the results of the same type of analysis that produced Figure 4.2.2.C, which is an annual summation of the volume of the daily basin inflow deficit relative to the modeled 5,050 cfs (i.e., how much water is required to augment basin inflow to release at least 5,050 cfs from Woodruff Dam). Figure 5.1.A compares the annual basin inflow deficit of the basin inflow time series computed with estimated year 2007 demands versus the time series computed with the projected 2017 demands. An additional 5 years have a deficit with the basin inflow data computed using year 2017 demands, and the amount of the deficit in non-zero deficit years is increased. For example, the year of the maximum deficit, 2007, has an additional deficit of about 57,000 acre feet. The additional instream flow deficit imposes a greater drawdown on the reservoirs, and storage enters the "drought zone" during two periods (droughts similar to that experienced in 2000 and 2007) of the RIOP simulation. Minimum releases are reduced to 4,500 cfs in the simulations of these two extreme drought years.

By maintaining minimum releases of 5,000 cfs, the RIOP offsets the impact of an increase in depletions unless there are additional extreme droughts in the next five years. Climate change models indicate an increase in droughts and an increase in intensity of rainfall events, but the model results are mixed (Burkett 2006). The probability of additional extreme drought in the next five years is very small. The 2007 drought was a 1-in-200 year event. Therefore, it is unlikely that the factors of significant additional consumption along with extreme drought will occur in the next five years that may trigger a minimum flow reduction to 4,500 cfs. However, due to the significance of the M&I demand, the Corps must be vigilant regarding increases in demand and changes in climate and reinitiate consultation if necessary.

5.2 Other Factors

Government and private actions may include changes in land and water use patterns, including ownership and intensity, any of which could affect listed species or their habitat. It is difficult, and perhaps speculative, to analyze the effects of such actions, considering the broad geographic landscape covered by this BO, the geographic and political variation in the action area, extensive private land holdings, the uncertainties associated with State and local government and private actions, and ongoing changes in the region's economy. Adverse effects to riverine habitat from continued urbanization in the basin are reasonably certain to occur. However, state and local governments have regulations in place to minimize these effects to listed species, including

regulations regarding construction best management practices, storm water control, and treatment of wastewater.

5.3 Federal Actions Not Considered Under Cumulative Effects

Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act. These actions include channel maintenance dredging and disposal, water quality criteria, new pesticides and/or uses, pipes in rivers for water withdrawals, small impoundments, new reservoirs, and revisions to the WCP. By notice published February 22, 2008 (FR 73(36):9780-9781), the Corps announced its intent to prepare a draft environmental impact statement for updated water control manuals for the Apalachicola-Chattahoochee-Flint (ACF) River Basin. This process is expected to take two to five years.

The Service completed consultations on several reservoirs since the species were listed. There have been additional reservoir proposals but none is undergoing consultation at this time. In its 2008 session, the Georgia General Assembly passed legislation aimed at expediting the permitting and construction of water supply reservoirs. The "Water Conservation and Relief Act" gives additional authority to the Georgia Soil and Water Conservation Commission to receive and make grants. Under this authority, the Commission may fund up to 20% of the cost of improvements to existing dams, and up to 20% of the cost of new dams. The "Georgia Water Supply Act of 2008" creates a Water Supply Division of the Georgia Environmental Facilities Authority with authority to receive money and acquire land, and responsibility for all activities related to developing new water supply reservoirs. Other aspects of the statute provide for enhancing the federal regulatory process, allowing inter-basin water transfers, and creating a system for prioritizing uses in cases of water conflicts. Actions under either Georgia Act that would require permitting under section 404 of the federal Clean Water Act (CWA) or other federal approval/funding would also require compliance with Section 7 of the Endangered Species Act. Since federal permitting and construction could take over five years, we do not expect any additional reservoirs to be constructed in the next five years.

5.4 Tables for Section 5

Table 5.1.A. Summary of depletions (cfs) to basin inflow estimated for the year 2017 by the Corps of Engineers. For depletions that vary by year in the HEC-5 model, values for dry, normal, and wet years are given. The municipal and industrial (M&I) depletions estimated for the year 2007 are also given for comparison with the 2017 M&I depletions. Negative values for reservoir evaporation indicate a net gain from precipitation.

	M&I		Reservoir Evaporation			Agriculture			Total		
	2007	2017	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet
Jan	290	402	-49	-131	-162	2	1	1	354	271	240
Feb	320	444	-17	-91	-85	29	0	0	456	352	359
Mar	384	516	38	-13	-98	117	45	45	672	548	464
Apr	500	661	247	180	69	258	113	113	1,167	954	843
May	711	884	297	244	209	702	397	397	1,883	1,524	1,490
Jun	699	864	278	230	231	945	488	488	2,086	1,581	1,583
Jul	656	815	183	178	51	1,068	695	695	2,066	1,688	1,561
Aug	800	968	233	195	191	1,152	688	688	2,352	1,850	1,846
Sep	679	834	215	177	184	828	370	370	1,878	1,381	1,387
Oct	507	632	181	175	165	307	150	150	1,120	957	947
Nov	395	523	37	-9	-5	238	100	100	798	614	618
Dec	360	487	-85	-106	-100	207	88	88	610	470	476
Average	525	669	130	86	54	488	261	261	1,287	1,016	984

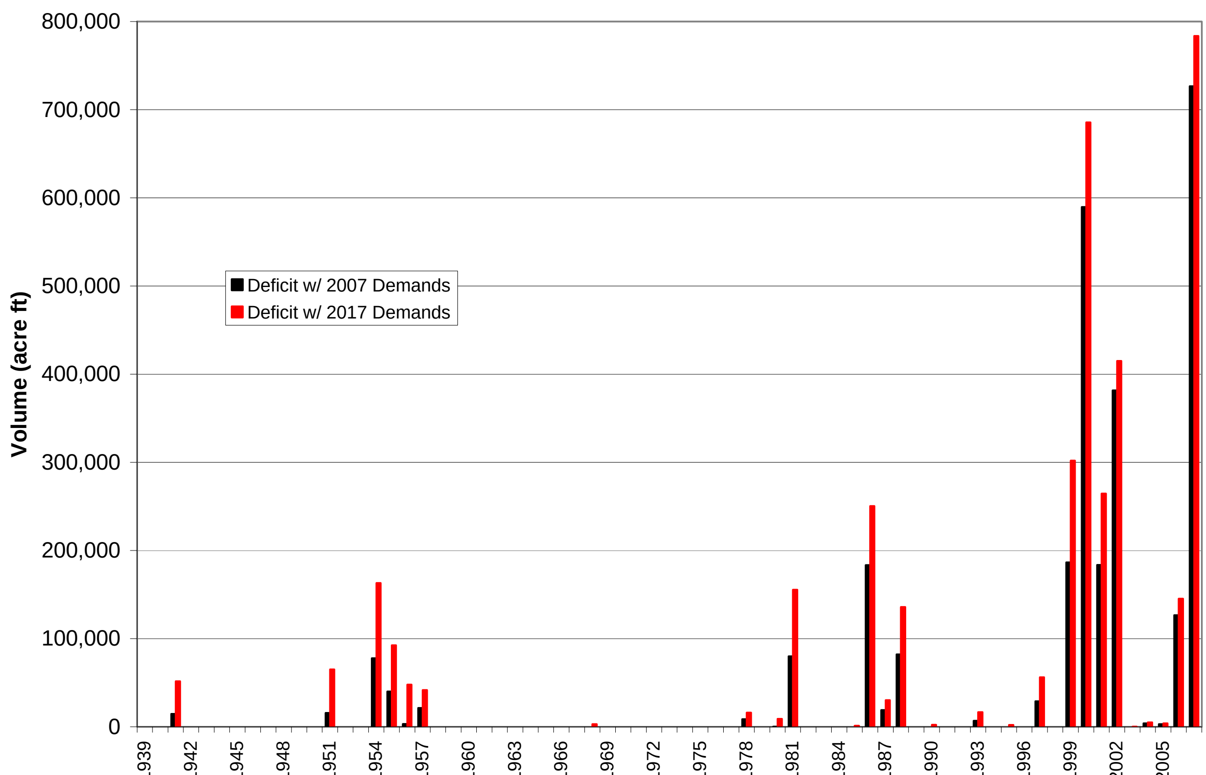

Figure 5.1.A. Annual volume of the basin inflow deficit relative to a minimum flow of 5,050 cfs at Woodruff Dam, 1939-2007, computed using estimated consumptive water demands for the year 2007 versus demands for the year 2017.

6 CONCLUSION

The proposed action has a mix of both beneficial and adverse effects to the species and designated/proposed critical habitats. Those attributable to the RIOP and not to depletions in basin inflow are summarized in general form below (for more details, see sections 4 and 5):

Beneficial Effects

- Basin inflow augmented when less than 5,000 cfs; no days less than 5,000 cfs. However, if exceptional drought provisions are triggered, this benefit would become no days less than 4,500 cfs (Figure 4.2.2.B).
- Decrease in maximum number of consecutive days/year less than 16,000 cfs (Figure 4.2.4.A).

Adverse Effects

- Increase in inter-annual frequency of flows less than 10,000 cfs **(**Figure 4.2.5.A).
- An increase in maximum number of days per year of flows less than 6,000 cfs **(**Figure 4.2.5.B).
- An increase in maximum number of consecutive days per year of flows less than 6,000 cfs **(**Figure 4.2.5.C).
- An increase in median number of days per year of flows less than 10,000 cfs **(**Figure 4.2.5.D).
- Increase in number of days with fall rates greater than 0.25 ft/day (Figure 4.2.5.E).
- Increase in number of days with fall rates greater than 0.25 ft/day during low flows (less than 10,000 cfs) (Figure 4.2.5.E).
- Decrease in acres of floodplain inundation most of the time (Figure 4.2.6.A).

Most of these effects, both the beneficial and the adverse, derive from relatively minor differences between the RIOP, Baseline, and RoR flow regimes. Generally, it appears that the Corps would store water more often under the RIOP (about 9% more often) than has occurred historically, which means that the river would have less water about 9% of the time. The RIOP uses this stored water to maintain a minimum flow of 5,000 cfs, but the frequency of flows less than 10,000 cfs is increased by about 5%.

The remainder of this section summarizes and consolidates our findings in the previous sections for each listed species and critical habitat in the action area.

6.1 Gulf sturgeon

The current population of Gulf sturgeon in the Apalachicola River appears to be slowly increasing. The principal effects to the Gulf sturgeon in the action area are those we described in section 3, Environmental Baseline. Woodruff Dam precludes migratory movements to additional spawning habitat located in the Flint and Chattahoochee basins. Substantial changes to both the low and high ends of the flow regime in the post-West Point period compared to the pre-Lanier period may have adversely affected estuarine habitat availability and/or suitability for

sturgeon feeding. The RIOP does not worsen these potential effects, and may have a moderate beneficial effect by decreasing the maximum number of consecutive days/year less than 16,000 cfs (Figure 4.2.4.A). Therefore, we anticipate only minor changes in salinity regimes or estuarine habitat due to the RIOP. However, future depletions to basin inflow from non-project related water uses might further change sturgeon estuarine habitats by increasing the duration of flows less than 16,000 cfs during drought years. The effect of depletions on the sturgeon's estuarine habitats is unknown at this time pending results of studies of sturgeon use of the bay and application of appropriate hydrodynamic models that may predict salinity regime changes and benthic food resource responses.

The RIOP does not appear to cause additional alterations of habitat availability at known spawning sites downstream of Woodruff Dam. However, take of Gulf sturgeon eggs and larvae due to the RIOP may occur when river stage declines by 8 feet or more in less than 14 days in the spring when flows are less than 40,000 cfs in March through May. Such take may occur while operating under both normal and drought fall rate provisions of the RIOP, because the fall rate schedules apply only to daily rates of stage decline. We are unable to reliably estimate the extent of Gulf sturgeon take at this time because the HEC-5 model of the RIOP does not properly simulate compliance with the proposed fall rate schedules. Stage declines rapid enough to expose sturgeon spawning habitat when eggs and larvae are present are evident in the historic record. Such declines are also evident in some, but not all years of the RIOP simulation. Therefore, we believe it is necessary to further evaluate the effects of the RIOP on sturgeon eggs/larvae survival with an improved simulation of fall rates under the RIOP before the next spawning season.

Designated critical habitat for the Gulf sturgeon in the action area includes the Apalachicola River unit, and the Apalachicola Bay unit. In the effects analysis, we discussed how the RIOP may affect the six PCEs of sturgeon critical habitat. Flow management under the RIOP could affect four of these: 1) food items in both the riverine and estuarine environments; 2) riverine spawning areas; 3) water quality; and of course, 4) the flow regime. Droughts substantially change the nature of all of these PCEs compared to normal flows, but we find that the RIOP would not appreciably change the quantity or quality of the PCEs relative to the Baseline under the same drought conditions.

Therefore, our analysis indicates that the RIOP would not appreciably affect the survival and recovery of the Gulf sturgeon and would not appreciably affect the ability of designated critical habitat to provide its intended conservation role for Gulf sturgeon in the wild.

6.2 Fat threeridge

Given the loss of almost 19% of the population in the past two years and the potentially poor recruitment of the last decade, we believe the fat threeridge population in the action area is in a long-term, relatively slow decline for the foreseeable future (Section 3.5.2.2). Because over 80% of the species' range is in the action area, the species is likely declining range-wide. The principal effects to the fat threeridge in the action area are those we described in section 3, Environmental Baseline. Channel morphology changes have likely contributed to a substantial decline of the species in the upstream-most 30 miles of the river. The channel dynamics

(actively meandering) in the middle reaches in combination with low flow, especially between RM 50 to RM 40, adversely affected large numbers of the species in 2006. The inter-annual frequency and the intra-annual duration of low flows substantially increased between the pre-Lanier period and the post-West Point periods. Due mostly to lower modeled basin inflow (the RoR flow regime), flows under the RIOP will further increase the frequency and duration of low flows. Flows less than 5,000 cfs were not recorded in the pre-Lanier period. The RIOP supports a minimum flow of 5,000 cfs, which benefits the fat threeridge, except when exceptional drought operations are triggered and minimum flow support is reduced to 4,500 cfs. Flows less than 5,000 cfs are relatively frequent events in the modeled basin inflow time series (7.3% of the time under estimated present water demands; 8.3% of the time with M&I demands increased by 27%). Supporting a minimum flow of 5,000 cfs in the future with less basin inflow would require greater storage releases from the reservoirs, which could trigger the 4,500 cfs minimum flow provision of the RIOP. However, a rapid growth in demands by this amount plus a lengthy continuation of the exceptional drought conditions of the past two years are unlikely to occur in the next 5 years.

Flows less than 6,000 cfs would occur in about 1 out of every 2 years under the RIOP, compared to about 1 out of every 3 years under the Baseline. We do not yet know how this change may affect the fat threeridge. We observed mussels at stages between 5,000 and 10,000 cfs in 2006, but these habitats have not been recolonized to date. Successive years without low flows (less than 10,000 cfs) and/or floods of sufficient magnitude and duration that would aggrade occupied areas or transport mussels into higher areas are probably necessary for mussels to again occupy stages greater than about 5,000 cfs. Under the RIOP, the Corps may store water when basin inflow is less than 10,000 cfs during the winter months and during drought contingency operations. However, in all instances except for 3 consecutive winter days in 1989, whenever the RIOP stores water during low flows (releases less than 10,000 cfs), flows drop to lower levels under the RoR flow regime during the same year. This means that although flows are sometimes reduced to low levels (5,000 to 10,000 cfs) by RIOP operations, flows would get even lower without the influence of reservoir operations. The RIOP maintains minimum flows of 5,000 cfs, which is comparable to pre-Lanier minimum flows. The RoR flow regime, which estimates flows in the absence of reservoir operations, has flows less than 5,000 cfs in almost half the years 1975-2007. Therefore, we do not attribute to the RIOP an appreciable affect to flows in the range of 5,000 to 10,000 cfs.

The Corps may or may not exercise the 4,500 cfs minimum flow provision of the RIOP. It is not triggered in the 1939-2007 HEC-5 simulation of the RIOP, but that simulation concludes with the critical year of the period of record. Two of the four forecast models that the Corps provided include conditions that would trigger 4,500 cfs flows. We anticipate take of not more than 21,000 fat threeridge (9% of the population) if the 4,500 cfs minimum release is triggered, although current climatic forecasts predict that drought conditions will ease and not worsen in the coming months. The potential to deplete storage increases with increasing consumptive demands, because higher demands reduce basin inflow to the reservoirs and increase the augmentation burden on the reservoirs to maintain flows. The Corps provided to us the results of a simulation of the RIOP using a 27% projected increase in M&I demands (section 5). This reduction in basin inflow was sufficient to trigger the 4,500 cfs provision of the RIOP twice during the 1939-2007 simulation.

Designated critical habitat for the fat threeridge in the action area includes most of the Apalachicola River unit, and the downstream-most part of the Chipola River Unit. In the effects analysis, we discussed how the RIOP may affect the five PCEs of fat threeridge critical habitat. Flow management under the RIOP could affect three of these: 1) permanently flowing water; 2) water quality; and 3) fish hosts. The RIOP appears to reduce the amount of floodplain habitat available to fish hosts, some of which likely rely upon floodplain habitats for spawning and rearing habitat. To the extent that mussel recruitment is dependent on host fish density, this flow regime alteration is an adverse effect to mussels, but this relationship is not known, and therefore, we do not ascribe a level of take to this effect. Droughts substantially change the nature of all of these PCEs compared to normal flows, but our analysis does not show that the RIOP would appreciably change the quantity or quality of the PCEs relative to the Baseline under the drought conditions represented in the 1975-2007 record.

Therefore, our analysis indicates that the RIOP would have a measurable, but not appreciable impact on the survival and recovery of the fat threeridge due to take if flows are reduced to 4,500 cfs. This finding is based upon the results of the population viability analysis included in section 4.3.2.4, in which we modeled the effects of an infrequent additional mortality of 9% associated with flow drops to 4,500 cfs. While the RIOP may also adversely affect fat threeridge critical habitat primary constituent elements by reducing minimum releases to 4,500 cfs, the circumstances triggering this action would occur infrequently, if ever. We do not anticipate that reducing minimum releases to 4,500 cfs once in the next 5 years would alter or affect the critical habitat in the action area to the extent that it would appreciably diminish the habitat's capability to provide the intended conservation role for fat threeridge in the wild.

6.3 Purple bankclimber

Recent survey data from the Ochlockonee and Apalachicola rivers suggest possible widespread reproductive failure; therefore, we believe the purple bankclimber may be declining throughout its range. Based on the rarity of the species in the action area, potential recruitment problems, and mortality experienced in 2006 and 2007, we believe the purple bankclimber may also be declining in the action area. The principal effects to the purple bankclimber in the action area are those we described in section 3, Environmental Baseline. Channel morphology changes may have contributed to a decline of the species in the upstream-most 30 miles of the river, although the species may still be found in this reach in low numbers. Flow regime alterations discussed above (section 6.2) for the fat threeridge apply also to the bankclimber, but probably to a lesser extent, because this species appears to occur more often in deeper portions of the stream channel than the threeridge.

We anticipate take of a small number (less than 200) of purple bankclimbers if flows are reduced to 4,500 cfs, primarily at the limestone shoal at RM 105. We do not have a population estimate for the purple bankclimber in the Apalachicola River. The species is much more detectable, and probably much more abundant, in other parts of its range, such as the Flint River and the Ochlockonee River. The effects to the PCEs of designated critical habitat summarized above (section 6.2) for the fat threeridge apply also to the designated critical habitat of the purple bankclimber.

Therefore, our analysis indicates that the RIOP would have a measurable, but not appreciable impact on the survival and recovery of the purple bankclimber if flows are reduced to 4,500 cfs. Bankclimbers are rarely found at stages greater than 4,500 cfs in the Apalachicola. While the RIOP may also adversely affect purple bankclimber critical habitat primary constituent elements by reducing minimum releases to 4,500 cfs, the circumstances triggering this action would occur infrequently, if ever. We do not anticipate that reducing minimum releases to 4,500 cfs once in the next 5 years would alter or affect the critical habitat in the action area to the extent that it would appreciably diminish the habitat's capability to provide the intended conservation role for purple bankclimber in the wild.

6.4 Chipola slabshell

Based on recent range extensions and the discovery of twelve new subpopulations with many individuals, we believe the Chipola slabshell population is improving range-wide. Given a lack of data to suggest otherwise, we assume this range-wide improving trend also includes the smaller fraction of the population (about 14%) within the action area. Many of the effects we described in section 3, Environmental Baseline, do not apply to the Chipola slabshell, as its known range within the action area is limited to the Chipola River downstream of the Chipola Cutoff. Most of the species range is in the Chipola River upstream of the action area. Channel morphology appears less altered in the Chipola River than the Apalachicola River. Flow regime alterations discussed above (section 6.2) for the fat threeridge apply also to the slabshell, but probably to a lesser extent in the narrower channel of the Chipola.

We anticipate take of a small number of Chipola slabshells if flows are reduced to 4,500 cfs. Based on limited recent survey data, we assume that not more than about 2% of the slabshell population could be affected by stage declines of this magnitude (section 4.3.2.2). The effects to the PCEs of designated critical habitat summarized above (section 6.2) for the fat threeridge apply also to the designated critical habitat of the Chipola slabshell.

Therefore, our analysis indicates that the RIOP would have a measurable, but not appreciable impact on the survival and recovery of the Chipola slabshell due to take if flows are reduced to 4,500 cfs. Slabshells were not detected in the take monitoring surveys when flows were reduced to about 4,750 cfs in 2007. While the RIOP may also adversely affect Chipola slabshell critical habitat primary constituent elements by reducing minimum releases to 4,500 cfs, the circumstances triggering this action would occur infrequently, if ever. We do not anticipate that reducing minimum releases to 4,500 cfs once in the next 5 years would alter or affect the critical habitat in the action area to the extent that it would appreciably diminish the habitat's capability to provide the intended conservation role for Chipola slabshell in the wild.

6.5 Determinations

After reviewing the current status of the listed species and designated critical habitat, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the Service's biological opinion that the proposed action:

a) will not jeopardize the continued existence of the Gulf sturgeon, fat threeridge, purple bankclimber, and Chipola slabshell; and
b) will not destroy or adversely modify designated critical habitat for the Gulf sturgeon, fat threeridge, purple bankclimber, and Chipola slabshell.

The RIOP is intended to apply until a new WCP is adopted. The Corps has already initiated the process for developing a new WCP, which should require 2 to 5 years. Therefore, the findings of this BO shall apply for 5 years until June 1, 2013, or until amended through a reinitation of consultation or superseded with a new opinion for a new proposed action.

7 INCIDENTAL TAKE STATEMENT

Section 9 of the Act and federal regulations pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering [50 CFR §17.3]. Incidental take is defined as take that is incidental to, and not the purpose of, an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of an Incidental Take Statement (ITS).

The measures described below are non-discretionary, and the Mobile District Corps must insure that they become binding conditions of any contract or permit issued to carry out the proposed action for the exemption in section 7(o)(2) to apply. The Mobile District Corps has a continuing duty to regulate the action covered by this incidental take statement. If the Mobile District Corps: (1) fails to assume and implement the terms and conditions or, (2) fails to require any contracted group to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Mobile District Corps must report the progress of the action and its impact on the species to the Service as specified in the ITS [50 CFR §402.14(I)(3)].

7.1 AMOUNT OR EXTENT OF TAKE ANTICIPATED

The Service anticipates that Gulf sturgeon, fat threeridge, purple bankclimber, and Chipola slabshell could be taken between now and June 1, 2013, as the result of this proposed action. The extent of the take is described below.

7.1.1 Gulf sturgeon

Take of Gulf sturgeon eggs and larvae may occur due to the RIOP when the Corps allows rapid declining stages, especially during drought contingency operations. The form of this take is mortality of fertilized eggs or larvae that results from habitat modification leading to oxygen stress, temperature stress, and/or increased sedimentation. The take may occur in hard-bottom microhabitats that become shallow or exposed when releases from Woodruff Dam are less than 40,000 cfs and decline more than 8 feet in less than 14 days during the months of March, April, and May. In most instances it will be difficult to detect, monitor, and quantify the level of incidental take because: (1) Gulf sturgeon are wide-ranging, (2) they occur in habitats and at low densities that make detection difficult and finding a dead or impaired specimen unlikely, and (3) changes to fitness parameters (e.g., decreased recruitment) are difficult to assess in small populations. Therefore a reasonable surrogate measure of take is a measurement of fall rates and

their frequency. However, due to the complexities of the analysis of fall rates, the anomalies in the HEC-5 model results with respect to the fall rates of Woodruff releases, and the fact that take would not occur until the spring of 2009, at the earliest, we do not have at this time a direct or surrogate measure of anticipated take of this form. The Service will work with the Corps to produce surrogate measure of anticipated take by January 31, 2009.

7.1.2 Fat threeridge, purple bankclimber, and Chipola slabshell

Take of listed mussel species due to the RIOP may occur when conditions are such that the Corps reduces the releases from Woodruff Dam to 4,500 cfs. The form of this take is mortality that results from habitat modification leading to oxygen stress, temperature stress, and/or increased predation. The take may occur in moderately depositional microhabitats that become exposed or isolated from flowing water when releases from Woodruff Dam are less than 5,000 cfs.

Mussels move in response to changing flow conditions, but their ability to move is limited. Mortality due to water level declines occurs when mussels are not successful at remaining within flowing water and are exposed to the air or to stagnant water long enough to expire from lack of oxygenated water, excessive temperature, and/or predation. Mortality, reduced growth and/or reproduction may also occur when mussels move in response to water level declines into areas that are unsuitable as habitat, such as portions of the channel where shear stress is excessive during high flows.

Model results provided by the Corps indicate that the probability of implementing a reduction in flows less than 5,000 cfs is less than once in 69 years, because the 1939-2007 simulations, which begin with full reservoirs, do not trigger the exceptional drought provision of the RIOP. To address today’s situation, which has composite reservoir storage in Zone 4, the Corps also provided a set of four 1-year “forecast” simulations. Each simulation uses a different set of basin inflow data (see section 4.2.1) and each begins with composite storage at the levels observed May 14, 2008. The results indicate that if basin inflow is similar to or less than basin inflow during the year 2007, a reduction in storage triggering an operational reduction to a minimum release less than 5,000 cfs may occur in 2008. The Corps estimates that the extended duration of low basin inflow in 2007 has a recurrence probability of once in 200 years. We discussed in section 4.2.5 how precipitation and basin inflow this year has been tracking a pattern similar to the year 1986, which would not result in triggering drop to 4,500 cfs minimum releases. We believe it is unlikely that 2008 will prove as dry or drier than 2007; however, it is possible. Changing climatic patterns, which we discussed briefly in section 3.3.1, could increase the likelihood of severe droughts of extended duration.

Therefore, we believe that take of listed mussels attributable to the RIOP would at most consist of one event in the foreseeable future. Take would be greatest in the RM40-50 reach of the main channel of the Apalachicola River where densities of the fat threeridge are highest. Since the result of the habitat alteration is mortality of individuals, which is observable, the best way to monitor the take is to count the number of individuals taken. We believe a maximum of 200 purple bankclimbers may be exposed on the rock shoal near RM 105 and at a few locations elsewhere in the action area; and a maximum of 100 Chipola slabshells may be exposed in the

Chipola River downstream of the Chipola Cutoff. A maximum of 21,000 fat threeridge (9% of the population) may be exposed in the Apalachicola River, Chipola Cutoff, and Chipola River downstream of the Chipola Cutoff when the minimum flow is reduced to 4,500 cfs. Exceeding this level of take for these three species shall prompt a reinitiation of this consultation.

Although take of listed mussels may also occur when mussels occupy stages greater than 5,000 cfs and when reservoir operations reduce basin inflow to expose these mussels, we do not anticipate take of this nature at this time. We have not yet observed a recolonization of habitats at stages greater than 5,000 cfs. Further, in the absence of flow augmentation from reservoir storage (i.e., the RoR flow regime), flows would dip to lower levels than the RIOP simulated flows in all years except two of the comparison period (1975-2007). In the logic of our effects analysis, this means that the increased frequency and duration of low flows under the RIOP are generally attributable to depletions and not operations. Therefore, we do not attribute mortality to mussels resulting from exposure at flows greater than 5,000 cfs to the RIOP.

7.2 EFFECT OF THE TAKE

In the accompanying BO, the Service determined that the level of anticipated take for declining fall rates and reductions in flow as low as 4,500 cfs would not result in jeopardy to the species or destruction or adverse modification of designated or proposed critical habitat, assuming one such event occurs within the duration of the biological opinion.

7.3 REASONABLE AND PRUDENT MEASURES

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize the impacts of incidental take of Gulf sturgeon, fat threeridge, purple bankclimber, and Chipola slabshell on the Apalachicola River. The measures described below supersede the measures described in previous biological opinions. The numbering system used in this opinion includes the year in order to avoid confusion with the previous opinions.

RPM 2008-1. Adaptive management. Identify ways to minimize harm as new information is collected.

Rationale. Additional information will be collected about the listed species and their habitats in the action area, water use upstream, and climatic conditions. This information needs to be evaluated to determine if actions to avoid and minimize take associated with the Corps' water management operations are effective or could be improved.

RPM 2008-2. Drought Operations. Clarify the drought contingency component of the RIOP that provides for reducing the minimum release to 4,500 cfs so that this option is exercised only when necessary to balance impacts to other project purposes that are reasonably certain to occur without the reduction.

Rationale. Take of listed species will occur when minimum releases are reduced below 5,000 cfs. This occurs under the RIOP when composite storage declines into the drought zone and considering "recent climatic and hydrological conditions experienced and meteorological

forecasts." Reducing the minimum release at certain times of year under certain circumstances may result in little improvement in composite storage levels. The Corps can minimize mussel mortality by using a minimum flow reduction only when it is reasonably certain that doing so will result in an appreciable increase in storage and thereby avoid impacts to other project purposes, including support of minimum releases for water quality and fish and wildlife conservation.

RPM 2008-3. Basin Inflow Calculation. Evaluate alternative methods to estimate current levels of depletions to basin inflow so that this information can inform monthly operational decisions.

Rationale. The basin inflow calculation is an underpinning of the RIOP. It is not a true measure of the total surface water flow of the basin to Woodruff Dam, but rather a calculation of total flow minus depletions. In the cumulative effects section, we discussed the possibility of increases in consumptive use triggering a minimum flow reduction. Improved estimation of current and ongoing depletions due to withdrawals and inter-basin transfers would allow the Corps to better forecast flows and levels in the system. Improved estimation of current depletions may also help to inform state and local governments when to implement water conservation steps that would avoid the harm to listed species associated with minimum flow reductions.

RPM 2008-4. Fall Rates. Evaluate alternative strategies for avoiding stranding Gulf sturgeon eggs and larvae when flows are declining from 40,000 cfs during the months of March, April, and May.

Rationale. Take of Gulf sturgeon eggs and larvae due to the RIOP may occur when river stage declines by 8 feet or more in less than 14 days when flows are less than 40,000 cfs in March, April, and May. Such take may occur while operating under both normal and drought fall rate provisions of the RIOP, because the fall rate schedules apply only to daily rates of stage decline. Results of the current HEC-5 model of the RIOP include numerous fall rate anomalies that preclude an accurate assessment of fall rate impacts due to the RIOP. Operating to slow declining fall rates may require storage drawdowns that are not necessarily prudent during droughts. Therefore, the Corps should develop improved models that more realistically represent fall rates, re-assess the effects of the RIOP on fall rates and sturgeon spawning, and formulate appropriate strategies to avoid and minimize adverse effects.

RPM 2008-5. Monitoring. Monitor the level of take associated with the RIOP and evaluate ways to minimize take by studying the distribution and abundance of the listed species in the action area.

Rationale. Take of Gulf sturgeon eggs and larvae will be difficult to monitor, and we anticipate developing a surrogate measure of such take through RPM 2008-4. Take of sturgeon eggs/larvae would have a direct effect on spawning success and recruitment, for which no data have been previously collected. Take of mussels due to exposure from declining minimum releases needs to be monitored within 4 days to ensure that the anticipated level of take (section 7.1) is not exceeded. Further, as habitat conditions change, it is necessary to monitor the numbers and

spatial distribution of the populations to determine the accuracy of the take estimates. Monitoring populations and relevant habitat conditions will also serve the Corps' information needs for future consultations on project operations, water supply contracts, hydropower contracts, etc.

7.4 TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the Corps must comply with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are mandatory. Studies and other outreach programs in the RPMs and conservation measures are subject to the availability of funds by Congress. The Corps will exercise its best efforts to secure funding for those activities. In the event the necessary funding is not obtained to accomplish the RPM activities by the dates established, the Corps will reinitate consultation with USFWS. These terms and conditions supersede those of the previous biological opinion and its amendments. These terms and conditions are effective until replaced by a biological opinion on a new proposal for managing the releases from Woodruff Dam.

7.4.1 Adaptive management (RPM 2008-1)

a) The Corps shall organize semi-annual meetings with the Service to review implementation of the RIOP and new data, identify information needs, scope methods to address those needs, including, but not limited to, evaluations and monitoring specified in this Incidental Take Statement, review results, formulate actions that minimize take of listed species, and monitor the effectiveness of those actions.
b) The Corps shall assume responsibility for the studies and actions that both agencies agree are reasonable and necessary to minimize take resulting from the Corps' water management actions.
c) The Corps shall evaluate alternative hydrologic modeling tools and techniques for operating the reservoirs and for assessing the impacts of water management alternatives. The goal of this evaluation is to identify tools and techniques that might improve the Corps' ability to forecast flows and levels during droughts and to more realistically simulate flows and levels (e.g., fall rates) for impact assessments. The Corps shall report the results of its evaluation as part of the annual report due January 31, 2009.
d) The Corps shall provide an annual report to the Service on or before January 31 each year documenting compliance with the terms and conditions of this Incidental Take Statement during the previous federal fiscal year, any conservation measures implemented for listed species in the action area; and recommendations for actions in the coming year to minimize take of listed species.
e) The Corps shall provide by email or other electronic means to the Service on a monthly basis the status of RIOP implementation including the hydrology of the system, composite system storage, and any data related to any other adopted criteria.

7.4.2 Drought Operations (RPM 2008-2)

a) In consultation with the Service, the Corps shall provide to the Service by August 30, 2008, written clarification of the process and criteria that shall apply to the decision to reduce minimum releases to levels less than 5,000 cfs.
b) The clarification of the RIOP shall describe, at minimum, the methods by which the Corps will estimate the impacts to other project purposes if a minimum release reduction is not implemented and the expected magnitude and duration of the reduction.
c) The Corps shall establish internal communication procedures to address unanticipated events that could have adverse effects to listed species. These procedures should be written and include 1) alerting the Service and appropriate State agencies, and 2) completing a summary on how the event was handled and recommendations to further improve procedures that will assist in minimizing harm to listed species.

7.4.3 Basin Inflow Calculation (RPM 2008-3)

In consultation with the appropriate water resource and management agencies, the Corps shall provide to the Service by June 1, 2009, an evaluation of methods to estimate total surface water flow of the basin to Woodruff Dam by accounting for the depletions to basin inflow. The goal of this evaluation is to outline the steps whereby the Corps may integrate up-to-date estimates of water depletions into its monthly operational decisions.

7.4.4 Fall Rates (RPM 2008-4)

The Corps shall provide to the Service by January 31, 2009, an updated assessment of the effect of fall rates on sturgeon spawning based on the past operating procedures and results of a model that accurately represents the operational rules of the RIOP, including it's fall rate provisions. The Corps shall propose appropriate means to avoid and minimize any impacts identified in this analysis.

7.4.5 Monitoring (RPM 2008-5)

In consultation with the Service, the Corps shall plan and implement the following monitoring efforts relative to the listed species and their habitats that will develop information necessary to understand the impact of incidental take and to ensure that the authorized levels of incidental take are not exceeded.

a) By January 31, 2009, the Corps shall design studies to estimate Gulf sturgeon recruitment rates to age 1 in the Apalachicola River. The Corps will implement these study plans as soon as practicable thereafter.
b) By July 15, 2008, the Corps shall update its previous study plan for estimating mussel take following minimum release reductions. Within 4 days of a reduction in minimum releases from Woodruff Dam to flows less than 5,000 cfs, the Corps will implement the listed mussels take monitoring plan.
c) By July 15, 2008, the Corps shall update its previous study plans for estimating the number of listed mussels present in the action area at 0.1-ft elevation intervals between

the stage that is equivalent to a release of 5,130 cfs from Woodruff Dam and an elevation that is 3 ft lower than that stage. The Corps will implement this study plan as soon as practicable thereafter when flow levels permit an effective sampling of this range of stages.

d) By July 15, 2008, the Corps shall update its previous study plans for: 1) identifying listed mussels age structure at various depths; 2) determining mussel movements in response to changes in flow using mark-recapture methods; 3) estimating age-specific survival rates; 4) estimating age-specific-fecundity rates; 5) identifying other anthropogenic factors that may affect mussel habitat; and 6) characterizing the habitat of the purple bankclimber and Chipola slabshell in the action area. The Corps will implement these study plans as soon as practicable thereafter.

The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. The Service believes that the action will result in the mortality of no more than 100 Chipola slabshell, 200 purple bankclimber, and 21,000 fat threeridge, if minimum flows are reduced to 4,500 cfs. The Service believes that the action may result in mortality of Gulf sturgeon eggs and larvae; however, the Corps must provide an assessment of this possible impact by January 31, 2009, which is before the next time such take could occur, as stipulated under the terms and conditions for RPM 2008-4. If, during the course of the action (until June 1, 2013), the level of incidental take is exceeded, such incidental take represents new information requiring the reinitiation of consultation and review of the reasonable and prudent measures provided. The Corps must immediately provide an explanation of the causes of the taking, and review with the Service the need for possible modification of the reasonable and prudent measures.

8 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to use their authorities to further the purposes of the Act by conducting conservation programs for the benefit of endangered and threatened species. Towards this end, conservation recommendations are discretionary activities that an action agency may undertake to minimize or avoid the adverse effects of a proposed action, help implement recovery plans, or develop information useful for the conservation of listed species. The following conservation measures are an update of the measures listed in our previous opinions.

The Service recommends that the Mobile District of the U.S. Army Corps of Engineers:

1. Work in consultation with the states and other stakeholders to assist in identifying ways to reduce overall depletions in the ACF basin, particularly the Flint River. For example, if water users and managers can work together to identify alternatives to agricultural use or incentives to reduce agricultural use of water in the Flint River basin, inputs from the Flint River will increase baseline flow to the Apalachicola River. This would improve the baseline status of the listed mussel species and reduce the Corps' reliance on upstream system storage to meet minimum flows below Jim Woodruff Dam.

2. Improve the public understanding of water management of the ACF system, the related conservation needs of listed species, and the management of the multiple purposes of the federal reservoirs. For instance, there is a pervasive misunderstanding regarding the changes in reservoir levels particularly at Lake Lanier where a combination of evaporation, within reservoir withdrawals, and releases to meet metro Atlanta water supply and water quality needs are likely to reduce reservoir levels by 6 to 9 feet in years with precipitation that is less than normal.

3. Assist stakeholders to plan future water management to reduce trends in water consumption so that listed mussel mortality due to low flows does not become a chronic or annual source of mortality.

4. Consider alternatives that would increase flexibility in the management of reservoir storage including the feasibility of flood control alternatives (e.g. moving structures from the floodplain, land acquisition) and providing for recreational access at a variety of pool elevations.

5. Provide additional data and hydrodynamic models that would assist in determining areas that should be surveyed for listed mussels.

6. Implement freshwater mussel recovery actions including developing habitat suitability indices, conducting life history and population studies of the listed mussels of the Apalachicola River, restoring reaches to provide suitable habitat, assessing sediment quality including possible chemical contamination, and validating aging techniques for these species.

7. Implement Gulf sturgeon recovery actions including assessing fish passage needs, developing habitat suitability indices, conducting life history and population studies of Apalachicola River and Bay, restoring reaches to provide suitable habitat, assessing sediment quality including possible chemical contamination, and validating aging techniques for these species.

8. Establish a clearinghouse for biological and water resource information about the ACF system and make such information readily available in several key locations in the basin.

9. Encourage and jointly lead stakeholder discussions to develop a long-term biological monitoring program for the ACF system and support, as feasible, implementation of a long-term program.

10. Update, as soon as practicable, tools for assessing the effects of ongoing and future system operations, including estimates of basin inflow and consumptive demands. The tools should assist in identifying flows that provide sufficient magnitude, duration, frequency, and rate of change to support the survival and recovery of the listed species in the ACF.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations in the annual report required in 7.4.1.d.

9 REINITIATION NOTICE

This concludes formal consultation on the action outlined in the BO. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information shows that the action may affect listed species in a manner or to an extent not considered in this BO; (3) the action is subsequently modified in a manner that causes an effect to the listed species not considered in this BO; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

10 FISH AND WILDLIFE COORDINATION ACT PLANNING ASSISTANCE

In accordance with the planning aid provisions of the Fish and Wildlife Coordination Act, the Service recommends that the Mobile District of the U.S. Army Corps of Engineers incorporate this preliminary list into its formulation of a plan to update the Water Control Plan for the ACF system. We will continue to provide technical assistance throughout the WCP process so that fish and wildlife resources receive equal consideration to other project purposes and that appropriate mitigation is identified.

1. Consider developing an adaptive management program, consistent with the authorized purposes of the ACF reservoirs, for achieving specific ecological and social goals for the management of the ACF system including specific releases for Woodruff Dam. The program would formulate hypotheses about how such benefits might be achieved through dam operations, implement those operations, monitor ecosystem responses, and revise the operations based upon lessons learned.

2. Work with the Florida Fish and Wildlife Conservation Commission to:
    a. Complete an analysis of the relationships of fish abundance in the river to actual discharges by season.
    b. Complete analyses of relationship of freshwater inflow the benthic communities of Apalachicola Bay and changes in fish and shellfish abundance.

3. Assess the potential beneficial or adverse effects of each water control plan alternative on the ability of Eufala National Wildlife Refuge manage for migratory waterfowl and other migratory birds.

4. Identify fish and wildlife recreation facilities that need infrastructure improvements to operate at a wider range of flows and/or reservoir elevations.

5. Include opportunities for restoration of important fish and wildlife habitats including:
    a. Passage of anadromous and migratory fish at dams;
    b. Restoration of connectivity with tributaries and distributaries; and
    c. Restoration of floodplain habitats below the upper three dams.

We appreciate the cooperation of your staff in preparing this BO. We look forward to working closely with you in implementing its provisions and other conservation actions for the listed species and critical habitat of the Apalachicola River and Bay ecosystem.

Sincerely,

/s/ Gail A. Carmody
Field Supervisor

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