Summary of Findings

Cursory Geomorphologic Evaluation of the Apalachicola River in Support of the Jim Woodruff Dam Interim Operations Plan

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1. Purpose of Study

A final Biological Opinion (BO) for the Jim Woodruff Dam Interim Operations Plan (IOP) was issued by the U.S. Fish and Wildlife Service (USFWS), Panama City Field Office on 5 September 2006. The BO included five reasonable and prudent measures (RPMs) for further limiting the amount of incidental take associated with water management operations at Jim Woodruff Dam. This current study was undertaken under RPM4, sediment dynamics and channel morphology evaluation. RPM4 was intended to improve the understanding of the channel morphology and the dynamic nature of the Apalachicola River. The objectives of the current study was to provide a cursory fluvial geomorphologic evaluation of the Apalachicola River below Jim Woodruff Dam for the purposes of providing professional opinions regarding trends (especially trends that could impact listed mussels) and potential remedial actions to reduce impacts to mussels. The effort consisted of a two day field trip (June 2007) along the Apalachicola River followed by a limited analysis based on the field observations and review of existing studies and data.

2. Background

The Apalachicola River reflects an integration of natural river processes coupled with various anthropogenic factors. Sorting out the relative contribution of the factors is often a challenge in complex river systems such as the Apalachicola River. A complete listing of alterations to the Apalachicola River is not provided here, but some of the more recent activities are discussed. The modern navigation project began with the construction of the Jim Woodruff Dam (RM) 107) in 1957. Between 1957 and 1971, the U.S. Army Corps of Engineers constructed numerous training structures, and several channel cutoffs. Additional cutoffs were constructed in the 1960's and rock removal in the upper river channel was completed in the 1980's. After about 1971, the major operations on the river consisted of maintenance dredging to maintain the navigation channel. Dredge material is generally placed within-banks in depositional areas such as on point bars. Dredging was stopped in the 2000 timeframe.

Channel degradation is the typical response downstream of a dam due to the retention of bed material sized sediment. However, the channel response to dam construction is highly variable and is a function of both the sediment retention and the altered outflows from the dam. Typically, reservoirs reduce downstream flood flows and increase low flows. The magnitude of these changes is site specific and depends on the manner of operation of the dam. Reduced flood peaks and reduced bed material loads may have somewhat of a compensating effect on downstream morphology. If the reduction in flood peaks is large, then the amount of degradation due to the retention of bed material may be lessened. Conversely, if the dam does not alter the flow regime significantly, then the effects of the bed material retention may be more pronounced.

3. Channel Characteristics

In a detailed geomorphic study, the river system is typically divided into a series of geomorphically similar reaches based on changes in slope, tributary location, geologic outcrops, sediment sources, planform changes, etc. For this cursory geomorphic study, the river was only divided into three broad areas. Reach 1 extends from the dam to about RM 78 near Blountstown. Reach 2 extends from RM 78 to RM 35 near the confluence with the Styx River. Reach 3 extends from RM 35 to RM 0. A brief discussion of these reaches follows.

Reach 1. Reach 1 is a fairly straight reach with an average sinuosity of about 1.3. The limestone outcrops of the Chatahoochee Formation occur frequently in this reach and were observed on the boat trip as far downstream as about RM 92. In fact, rock outcrops between RM 95 and 101.8 were removed in the 1960s and 1980s to provide more satisfactory navigation depths (Odom, 1966; Joanne Brandt pers. Comm.). The reach is also bounded by the Alum Bluffs and the Citronelle Formation. Based on the June 2007 field investigation, there does not appear to be a significant amount of sediment stored within the channel boundaries in this reach, which may reflect the impacts of the dam. Near the lower end of the reach the river encounters the Alum Bluffs at two locations (RM 84.5 and 81). These are very high (greater than 30 feet) bluffs consisting of a mix of sands and cohesive materials. These two locations represent the first major sand source observed downstream of the dam.

Valley slope was measured for all three reaches from topo maps. The sinuosity was calculated as the length of the reach measured along the channel divided by the straight line length of the reach. The channel slope was calculated by dividing the valley slope by the sinuosity. The results are shown in Table 1. As shown in Table 1, Reach 1 is fairly straight with a sinuosity of about 1.3 and a valley slope and channel slope of about 0.00012 and 0.000093, respectively.

Table 1. Valley slope, channel slope and sinuosity for the three reaches of the Apalachicola River.

REACH	Valley Slope	Channel Slope	Sinuosity
Reach 1 (RM 106 – 78)	0.00012	0.000093	1.3
Reach 2 (RM 78 – 35)	0.00018	0.000094	1.9
Reach 3 (RM 35 – 0)	0.00012	0.000095	1.3

A comparison of the pre and post dam flow duration curves indicates that there has not been a significant impact on the flow regime downstream of the dam. Since the hydrology is not significantly impacted by the dam, the primary impact of the dam would be the trapping of bed material. Following the construction of Jim Woodruff Dam in 1957, the channel immediately downstream began to degrade. It is possible that the amount of degradation immediately downstream of the dam may have been limited by the limestone outcrops in this area. Based on low water gage records from Light et al, (2006), stages at the Chattahoochee gage had dropped about 3.6 feet by the mid 1960s (Figure 1). Stages then stabilized until about 1980 when another foot of lowering occurred. According to Mobile District personnel, there was a series of rock removal in the early to mid 1980’s that may be responsible for this additional lowering. Since that time, stages have remained fairly stable with maybe a very slight downward trend. At the downstream end of the reach near Blountstown, the gage records indicate that that low water stages had dropped about 1.9 feet by about 1970. Since the early 1970s, the low water stage levels have remained fairly constant. A comparative thalweg plot from Lidstone and Anderson (1989) also indicates about 3 to 4 feet of lowering in this reach between 1960 and the early 1980s (Figure 2). The plot of mean bed elevation of the low flow channel for 1961 and 2001 also illustrates the bed lowering in this reach (Figure 3).

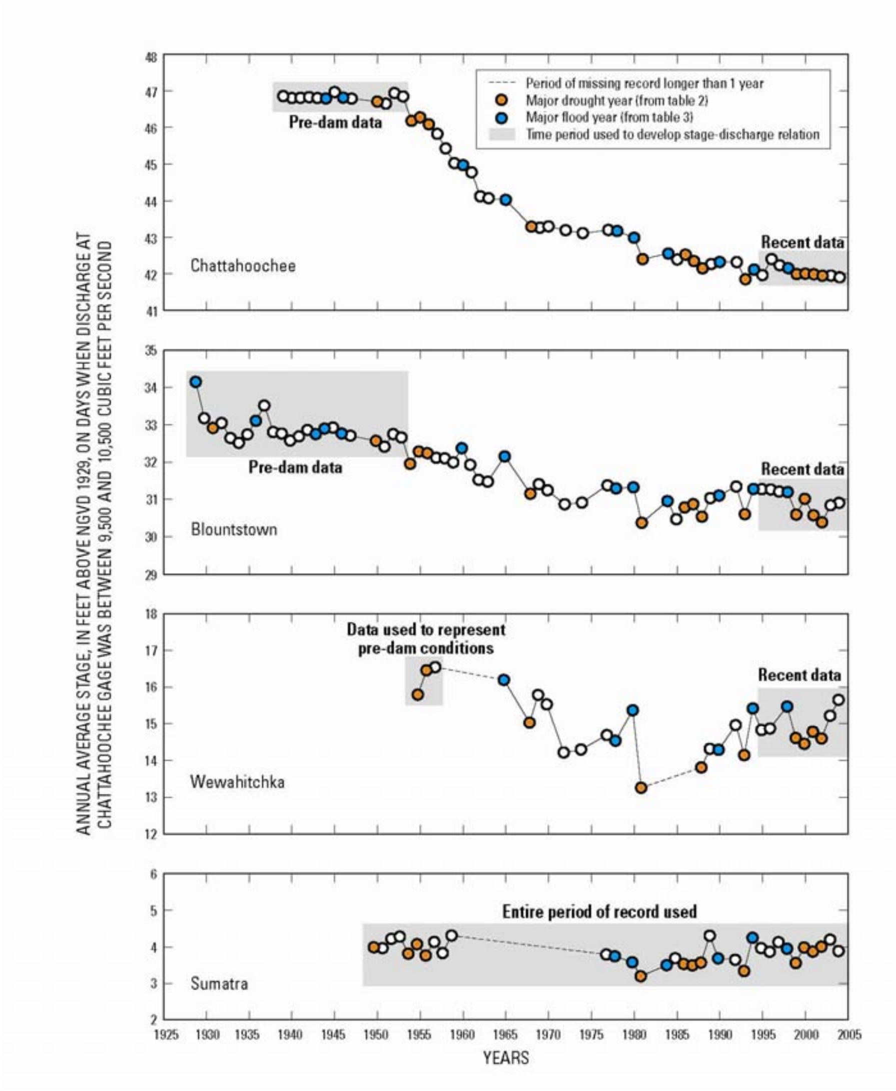

Figure 1. Gage changes at low water along the Apalachicola River downstream of Jim Woodruff Dam (from Light et al, 2006).

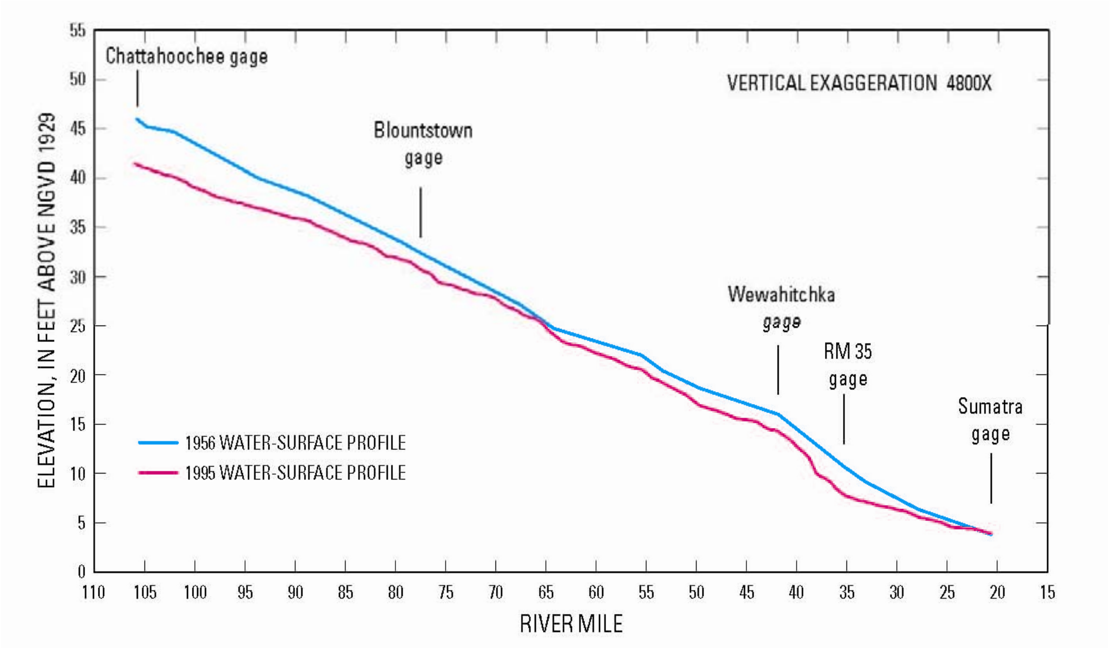

Figure 2. Water surface profiles along the Apalachicola River for the 1956 and 1995 time periods (from Light et al, 2006).

The streambanks in this reach are composed primarily of cohesive materials and bank erosion appears to be minimal throughout most of this reach based on the June 2007 field trip. A cursory examination of the bankline overlays for the periods 1941, 1963, 1993, 1999, and 2002 seems to confirm that there has not been any significant systematic channel widening throughout this reach. One factor that may contribute to the bank stability, particularly in the upper portions of this reach is the present of limestone. In many locations the limestone was observed to extend several feet up the banks, thus, providing protection of the bank toe. In contrast to these observations of stability, is the comparison of channel widths between 1941 and 2004 that was provided by the Mobile District. These data were developed from a USGS GIS system and were based on treeline measurements. According to these measurements, the channel in this reach has widened from an average of about 708 feet in 1941 to about 761 feet in 2004, or about 7%.

Reach 2. The character of the stream changes dramatically in Reach 2. Below Blountstown, the channel becomes much more sinuous with an average sinuosity of about 1.9 (Table 1). The streambanks in this reach are typically a mix of sands and cohesive materials, and active bank erosion was observed throughout this reach along the outside of the meander bends. Erosion of these streambanks is a source of sediment for the river system. The point bars in this reach are much larger than in the reach upstream. The exception to this is the sub-reach between about RM 70 and 64, where the point bars do not appear to be as large as upstream or downstream. These lower point bars may reflect the lower sinuosity, longer radius bends, more cohesive bank material, and reduced sediment supply in this reach. At about RM 64 the channel encounters a high bluff which is a significant sediment source. The reach downstream of this bluff is one of the most sinuous in the river. This high sinuosity may reflect the steeper valley slope (0.00018) in this reach. The average channel slope is about 0.000094 which is almost identical to the slopes in Reaches 1 and 3 (Table 1).

Comparison of water surface profiles between 1956 and 1995 (Figure 2) suggest that there has been some minor lowering down to about RM 20. The gage at Wewahitchka indicates that the low water stages may have dropped by about 2 feet by the mid 1970s, but have since rebounded about a foot or more. The comparison of thalweg plots for 1960, 1981, and 1984 (Lidstone and Anderson 1989) shows localized areas of scour and fill but no systematic lowering (Figure 3). The mean bed elevation comparison between 1961 and 2001 indicates that there may have been some slight lowering in the upper part of this reach, but overall, it appears that the reach has experienced localized areas of scour and fill (Figure 4). Thus, it appears that most of the dam induced degradation may have been limited to Reach 1.

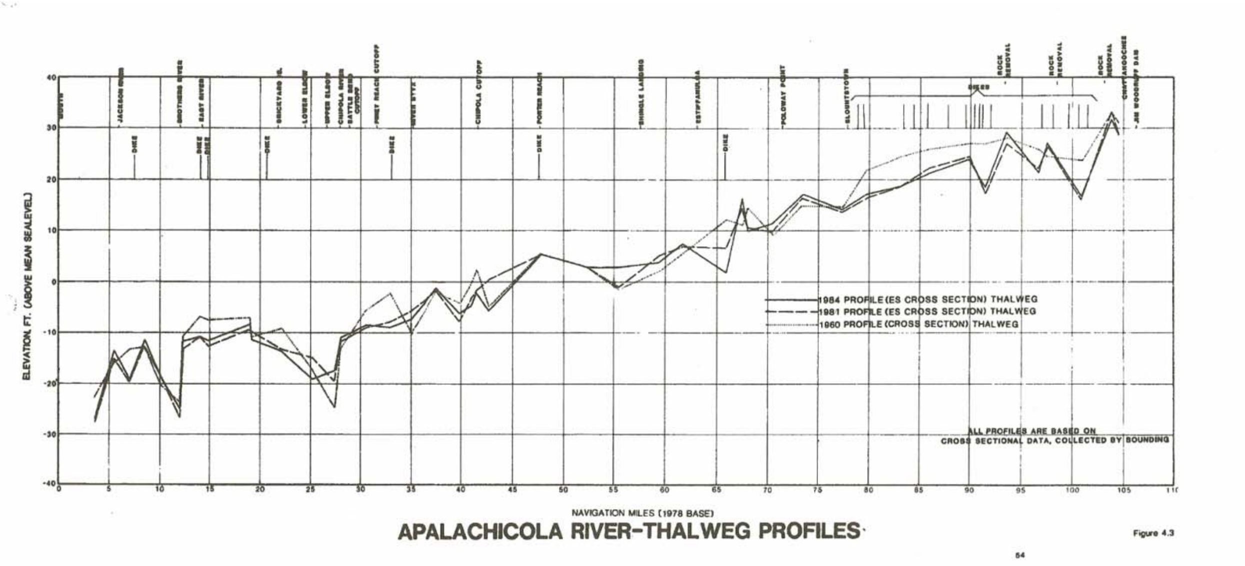

Figure 3. Thalweg comparisons for 1960, 1981 and 1984 (from Lidestone and Anderson (1989)

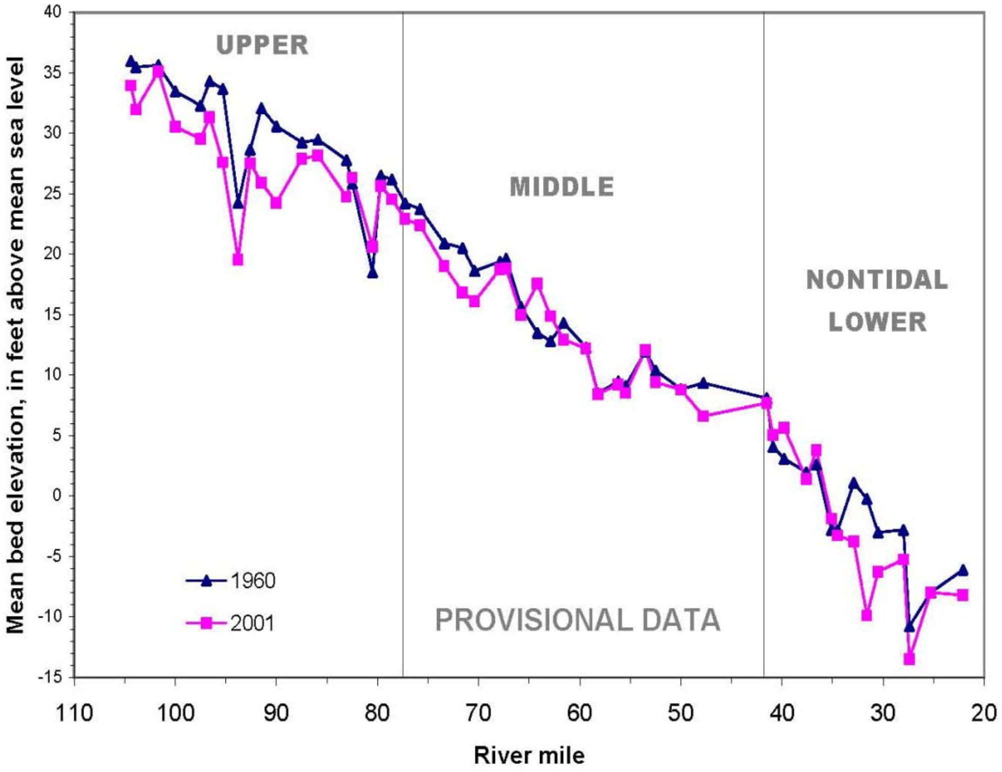

Figure 4. Mean bed elevation for low flows (USGS data provided by U.S. Army Corps of Engineers, Mobile District.

The Chipola Cutoff occurs in this reach at about RM 41.6. According to Mobile District records, the percent of flow entering the Chipola Cutoff has increased from about 25% to 34% over the past 20 years or so. The explanation for this increasing diversion percentage is not clear at this time. A cursory examination of aerial photography suggest that there is very little sediment in the Chipola channel, which would suggest that there is very little sediment being diverted into this system. This lack of sediment being diverted coupled with a 34% reduction in discharge may partially explain why the reach between the Chipola Cutoff and RM 35 has been one of the most frequently dredged areas on the river.

A plot of erosion rate versus the radius of curvature to width ratio (R/W) was developed and examined. The relationship between erosion rate and R/W was similar to most other meandering rivers. However, the erosion rates were quite low, generally less than about 4 feet per year, which is low compared to many large river systems. For instances, average erosion rates on the Red River in Louisiana and Arkansas range from about 25 ft/year to over 150 ft/year (Biedenharn et al, 1989). As expected the maximum erosion rates (between about 6 and 10 feet per year) occurred in the meander bends where the R/W was between about 1 and 3. The maximum erosion rate bends were all located in Reach 2. The field investigation confirmed that this is a very active reach with bank erosion being observed at most all meander bends. This erosion appears to be part of the natural down-valley meander migration which is common to most meandering streams, and does not appear to be the result of some system-wide adjustments such as degradation, aggradation, or channel widening. However, the comparison of the 1941 and 2004 channel widths in this reach indicate that the channel is much wider today than prior to the dam (Figure 4). In fact, the reach between RM 69 and 77 was reported to have increased on average by 143 feet, or 21%. The reach between RM 35 and 40 apparently increased about 171 feet, or a 51% increase. These are significant width increases when one considers that this reach has experienced only minimal bed lowering (less than 2 feet) and that the hydrology has not been significantly altered. Consequently, these width increases should be investigated in more detail to determine if these increases are real, and if so, what are the driving factors responsible for them.

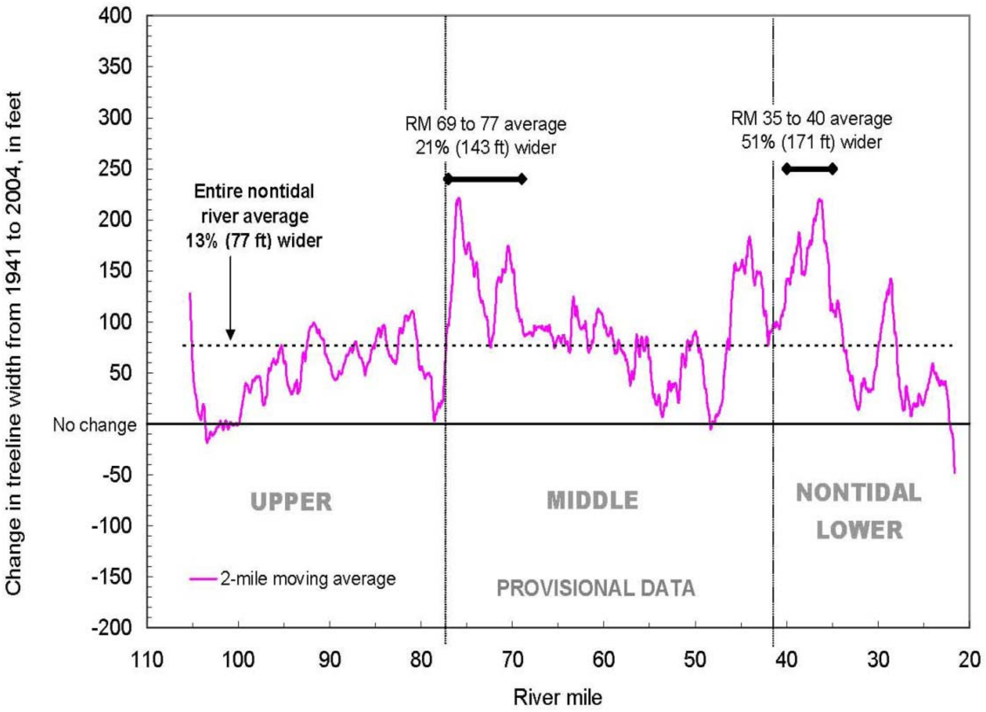

Figure 4. Changes in treeline width of main channel of the non-tidal portion of the Apalachicola River.

Based on data from Dr. Drew Miller, the highest mussel counts occur in the reach between about RM 43 (Florida River confluence) and 47.5. The highest mortality sites from 2006 also occur in this reach at RM 44, and 43.6, and in Swift Slough at RM 40.2.

Reach 3. Although Reach 3 encompasses the entire river below RM 35, the study focused primarily on the non-tidal zone down to about RM 20. The channel morphology changes dramatically downstream of the Styx River confluence (RM 35). The valley slope flattens to about 0.00012, and the channel becomes much less sinuous (sinuosity about 1.3). The channel slope through this reach is about 0.000095 (Table 1). The field investigation indicated that there was much less bank instability in this reach than in Reach 2.

The comparison of water surface profiles between 1956 and 1995 (Figure 2) indicate that there may have been a couple of feet of bed lowering in this reach. The mean bed elevation comparison (Figure 4) also shows that there was some local bed lowering between about RM 28 and 34, with localized scour and fill occurring throughout the other parts of the reach. The comparative thalweg plots from Lidstone and Anderson (Figure 3) also showed similar patterns. The exact cause of this localized lowering between RM 28 and 34 is not known, but it may be in response to some of the local meander cutoffs that were constructed in this reach.

The lowest known mussel site is in this reach at about RM 21.5 in the vicinity of the Brickyard Island.

4. Mussel Habitat.

A significant component of the June field investigation was the opportunity to learn about the preferred habitat of the Fat Three Ridge Mussel. It appears that the preferred habitat is in the lower energy environments such as occur in the flow separation zones (eddies) at the upstream and downstream transitions between meander bends. During the boat trip there was considerable discussion about the recent loss of some of these habitat areas and the stranding of mussels. A characteristic of meandering rivers such as the Apalachicola River is that they are continually changing in space and time. The size and location of the eddie zones change with flow and through time as the meanders migrate though the floodplain. This dynamic behavior is illustrated by examining the bankline overlays from 1941, 1963, 1993, 1999, and 2002. It is important to remember is that as the river meanders through the system, eddies may be destroyed at one location, but are being created at another. Consequently, the mussel habitat areas are constantly being destroyed and created and will vary with space and time. The question is whether there is a net increase or decrease in mussel habitat or is it in some sort of dynamic equilibrium. A more detailed analysis would be needed to answer this question.

The mortality site at RM 44.3 is a good example of mussel habitat being impacted by the natural processes in the river. At this location, an area that provided good habitat a year or so ago became depositional this past year, stranding many mussels. One explanation for this might be that the channel is experiencing some sort of systematic change in its morphology. However, upon closer examination, it became clear that this situation occurred as part of the natural meandering process of the river as the channel migrates downvalley. The mortality site at RM 43.6 also appears to be a result of the natural meander process.

Another area of concern was the mussel strandings in Swift Slough. Swift Slough is a distributary stream that diverts off the river at RM 40.2. According to Jerry Ziewitz (personal communication), Swift Slough was a perennial stream that was disconnected for the first time in July 2006. During the field investigation we were able to walk several hundred yards down Swift Slough. The channel is currently clogged with sand. The depth of sand in the channel was determined, by probing, to be over 4 feet in depth. It appears that during high flows there is a considerably amount of sediment that is delivered from the Apalachicola River into Swift Slough. A sand bar located near the entrance to Swift Slough may be a source of the sand that is entering the slough. The location of this bar may have been further upstream a few years ago, and may have only recently moved into the Swift Slough entrance location as this meander bend migrates down-valley. It is also possible that prior to about 2000, this bar may have been routinely removed by maintenance dredging (Terry Jangular, personal communication). At this time, there is insufficient information to develop a complete understanding of these processes. A more detailed investigation of this site is warranted.

5. Conclusions.

A summary of conclusions based on the cursory geomorphologic study is presented. The conclusions are divided into morphological and biological categories.

Morphology

1) The flow regime (based on pre-and post-dam flow duration curves) downstream of Jim Woodruff Dam has not been changed significantly between the pre- and post-dam periods.
2) The primary impact of Jim Woodruff Dam on the downstream channel appears to be the trapping of bed material sized sediments.
3) The amount of bed material that is transported through Jim Woodruff Dam is not known.
4) Other alterations impacting the Apalachicola River include localized meander cutoffs, distributary flows, channel training structures, maintenance dredging, and the cessation of maintenance dredging in the 2000 timeframe.
5) The degradational response due to the dam appears to extend downstream to about RM 77 near Blountstown. About 4 to 5 feet of lowering has occurred in this reach. Some of this lowering (perhaps one foot) may have been the result of rock removal from the bed in the early 1980's.
6) Reach 1 (Dam to RM 78) is a relatively straight reach with little sediment stored in the channel, and is controlled in places by local geologic outcrops of limestone.
7) The streambanks in Reach 1 are predominately composed of cohesive material and bank erosion and channel widening is minimal.
8) The dike fields in Reach 1 do not contain significant amounts of sediment.
9) The river in Reach 2 (RM 78 to RM 35) downstream of Blountstown is a much more active meandering channel with a high sinuosity (sinuosity =1.9).

10) Low water gage records and water surface profiles indicate that the channel between Blountstown and RM 20 has experienced about 1 to 2 feet of lowering. However, comparative thalweg plots between 1960 and the early 1980s indicate that the channel has experienced localized areas of scour and fill.
11) There is considerable sediment storage in Reach 2 as evidenced by the large point bars.
12) Reach 2 has the largest erosion rates on the river. This erosion appears to be part of the natural down-valley meander migration which is common to most meandering streams, and does not appear to be the result of some system-wide adjustments such as degradation, aggradation, or channel widening.
13) The channel between the Chipola Cutoff and RM 35 has been one of the most frequently dredged areas on the river. It appears that little sediment is diverted into the Chipola Cutoff, which might be a partial explanation for the frequent dredging just downstream.
14) The processes responsible for the apparent increase in the percent of flow (25% to 34%) diverted at the Chipola Cutoff warrants further study.
15) The effects of the cessation of dredging in the 2000 timeframe on the morphology of the channel warrants further study
16) Comparison of the 1941 and 2004 channel widths by USGS indicated that channel widening throughout the river down to RM 20. Further analysis is needed to determine if these width increases are real, and if so, what are the factors responsible for them.
17) The river downstream of the River Styx (RM 35) has a lower sinuosity (1.3) and less bank erosion.
18) Local meander cutoffs downstream of the River Styx may be responsible for some of the bed lowering in this area.

Biological Impacts

1) Preferred mussel habitat appears to occur in the lower energy environments associated with the flow separation zones (eddies) in the transition between meander bends
2) The size and location of the eddie zones change with flow and through time as the meanders migrate though the floodplain
3) Reach 2 contains some of the highest mussels counts on the river
4) Eddies, and consequently mussel habitat, are constantly being destroyed and created through the natural process of meander migration
5) The mussel mortality sites at RM 44.3 and RM 43.6 appear to be the result of the natural migration of the channel and not some systematic channel changes.

6) The mussel stranding in Swift Slough appears to be the result of deposition of sands from the river. It appears that a sand bar has moved to the entrance to the Swift Slough and may be the source of the sediment. However, a more detailed analysis of this area is needed to establish the exact processes responsible for this situation.

6. Recommendations

The conclusions from this cursory geomorphic study should be considered as preliminary due to the limited nature of the study. Although this cursory investigation did provide considerable insight into many of the morphologic processes occurring on the Apalachicola River, there are still many issues that need to be explored in further detail. A key example is the lack of understanding about exactly what processes are responsible for the apparent width increases that have occurred along the river. In order to develop a better understanding of the system, I would recommend a more detailed study be conducted. I could envisage some sort of a three tiered approach. The first tier would be an eco-geomorphic assessment of the system to fully develop how the system has responded in the past and where it is today with emphasis on the connection between the morphology and mussel habitat. I think this would go a long way towards developing a clearer understanding of these complex processes. The next tier would be relatively simple 1D sediment continuity model of the river. This would provide the big picture assessment of the entire river system below Jim Woodruff dam with respect to sediment continuity, channel stability, impacts of flow diversions, etc. I think the SIAM (Sediment Impact Analysis Methods) model might be a good candidate model for this. The third tier might be a 2D hydrodynamic model for selected reaches. Once again the key would be linking these detailed hydrodynamic processes to the mussel assemblages.

7. References

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