Using full life cycle habitat requirements to develop and apply metrics for assessing flow changes in a regulated river

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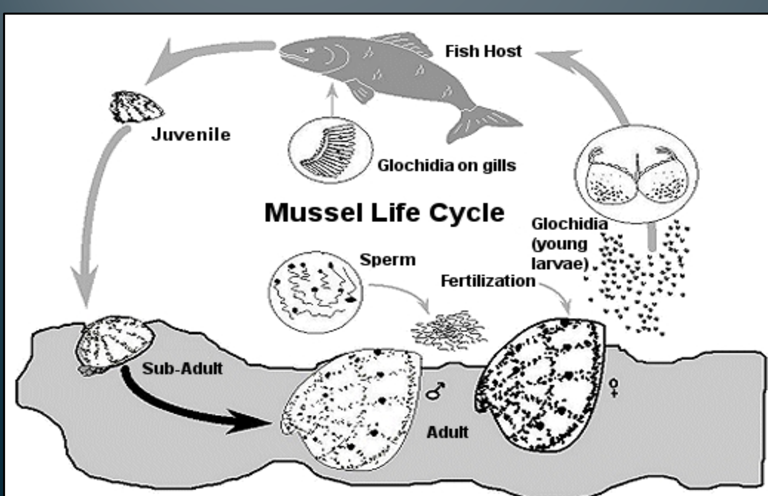
Outline

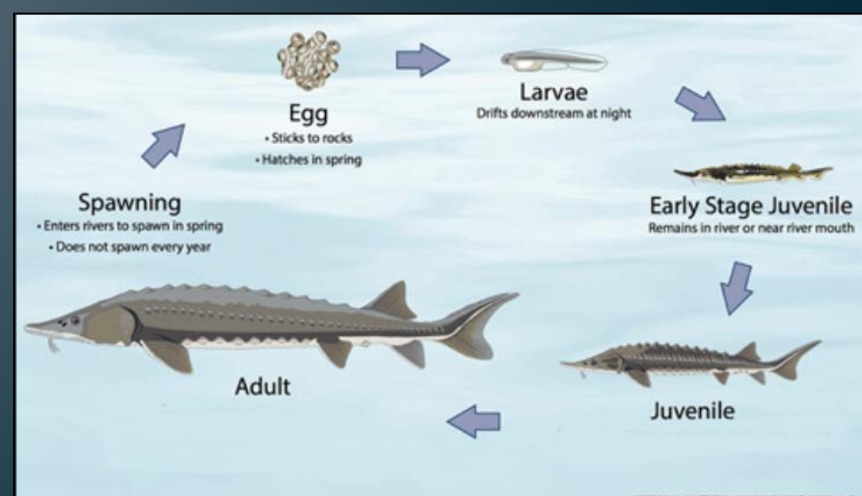
- Full life-cycle conservation
- Background
  - T&E species
  - ACF basin
  - Flow changes in proposed water control manual
- Freshwater mussel metrics and results
- Gulf sturgeon metrics and results
- Full life cycle conservation considerations

➢ This is less on WCM and more on our approach and analyses.

Full life cycle conservation

1. Mussels have a complex life history, with multiple forms, an obligate host-parasite interactions got us thinking about potential link between migratory host fish and mussel life cycle
2. Gulf sturgeon have a migratory pattern with an estuarine/marine cycle





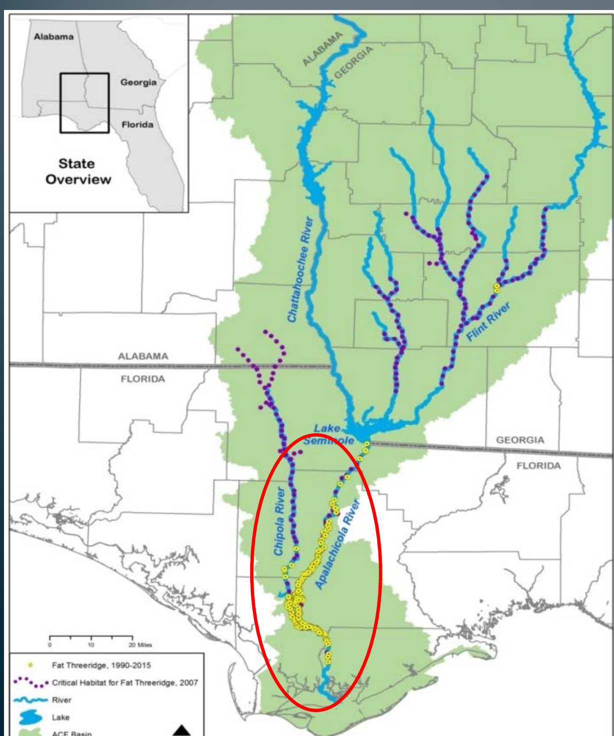
September 2016 Biological Opinion

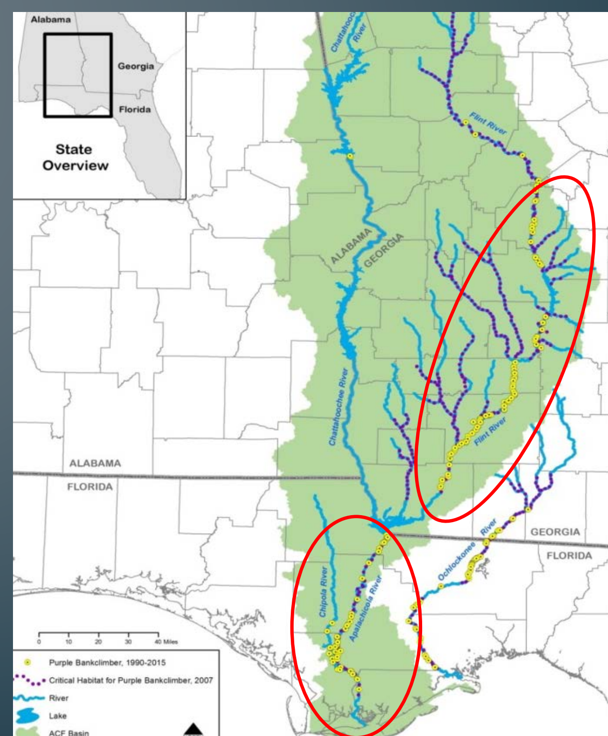
- Endangered Species Act section 7 consultation on the US Army Corps of Engineers (Mobile District) Update of the Water Control Manual (WCM) for the ACF basin in Alabama, Florida and Georgia and a Water Supply Storage Assessment (WSSA)
  - EIS process under NEPA ongoing
  - Broader comments via a planning aid letter and a Fish and Wildlife Coordination Act Report
- Highlights of approach and analyses
- 3 federal T&E mussel species: fat threeridge (E), purple bankclimber (T), Chipola slabshell (T) and their designated critical habitats
- Gulf sturgeon (T) and designated critical habitat

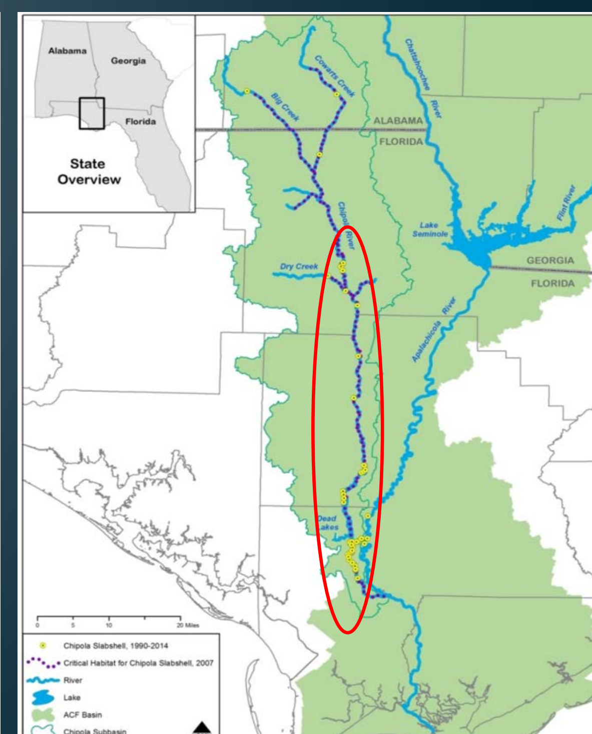
www.sam.usace.army.mil/Missions/Planning-Environmental/ACF-Master-Water-Control-Manual-Update/

www.fws.gov/panamacity/acf

T/E species and critical habitat







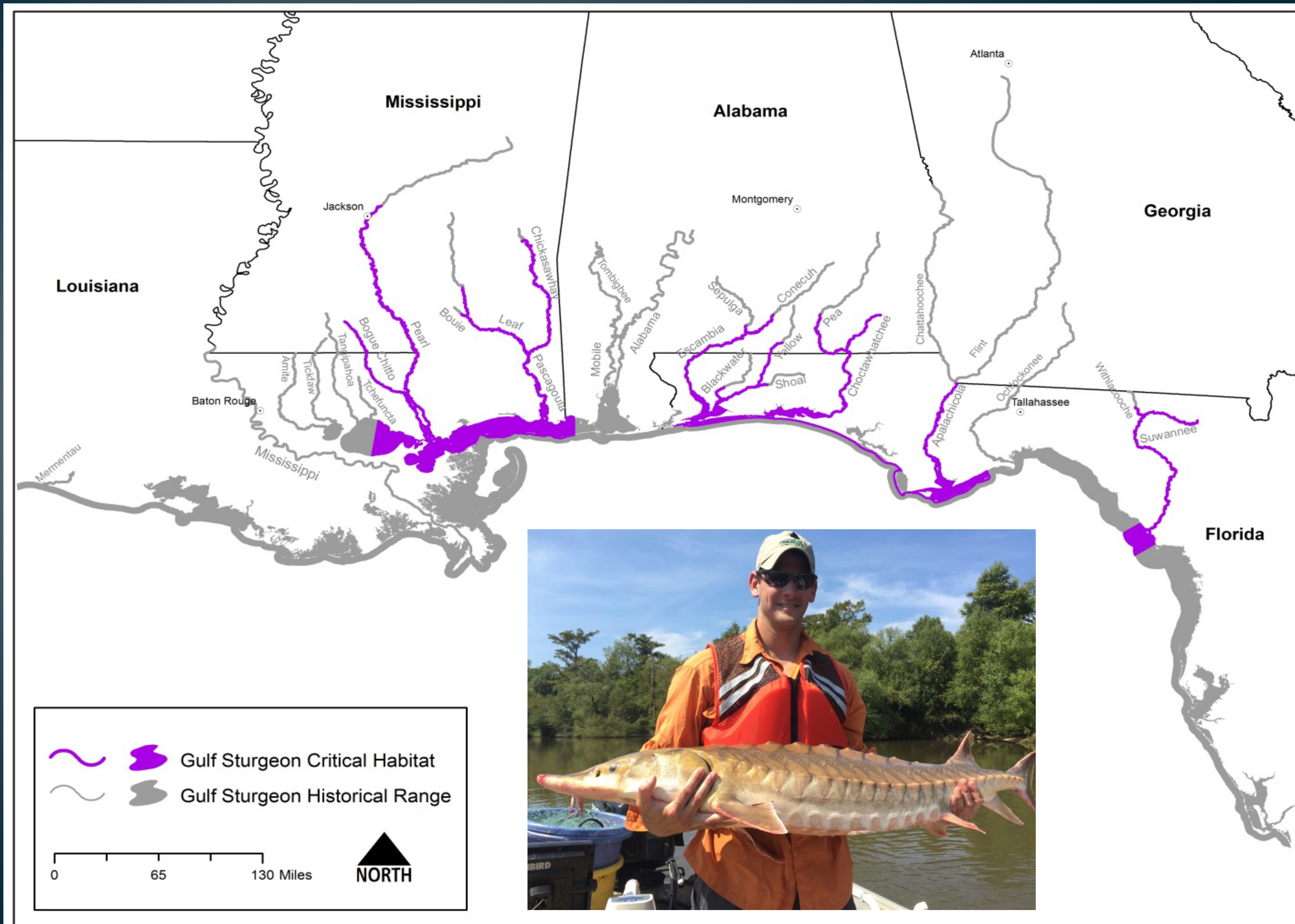
Critical Habitat
Primary Constituent Elements:

Mussels

- A geomorphically stable stream channel
- A predominantly sand, gravel, and/or cobble stream substrate
- Permanently flowing water
- Water quality
- Fish hosts

Photo: Carolina Krom, USFWS

Gulf sturgeon: Historical range and critical habitat



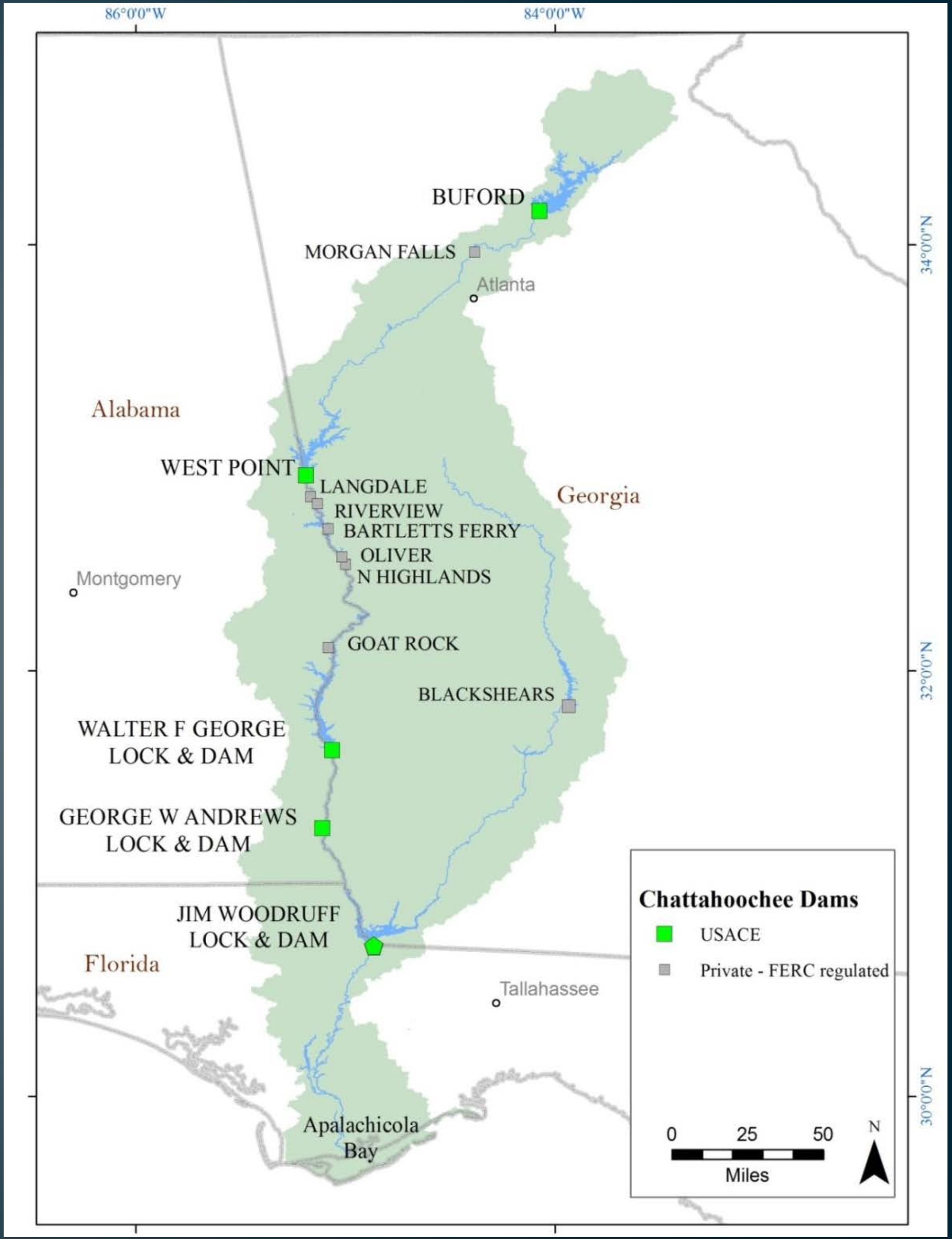
Critical Habitat
Primary Constituent Elements

Gulf sturgeon

- Abundant food items for riverine larvae and juveniles and for estuarine and marine subadults and adults
- Riverine spawning sites
- Riverine aggregation areas
- A flow regime
- Water quality (temperature, salinity, pH, hardness, turbidity, oxygen content, etc.)
- Sediment quality
- Safe and unobstructed migratory pathways

ACF Basin

- 5 USACE projects included in BO
- 14 total projects on mainstem rivers



What is the Water Control Manual?

- Guidelines for continued operations of projects in the ACF basin in a balanced manner to achieve all authorized project purposes…
- Fish and Wildlife Conservation including:
  - Federally-Listed Species - water releases for federally-listed, threatened, and endangered species below Jim Woodruff Dam on the basis of seasonal requirements (spawning, non-spawning, and winter),
  - Fish Passage, Reservoir Fish Spawning, Tailrace Dissolved Oxygen Levels, Management of Project Lands (Eufaula National Wildlife Refuge),
- Water Quality,
- Water Supply,
- Drought Operations,
- Extreme Drought Operations,
- Navigation,
- Flood Risk Management,
- Hydroelectric Power Generation,
- Recreation

What are proposed changes in WCM?

- Compared to existing management, an interim plan, the USACE proposes to modify
  - Action zones
    - Used to manage Lanier, West Point, and George at the highest level possible within balance of authorized purposes (1 more water, 4 less water)
  - Drought operations
    - Triggered when composite conservation storage falls into Zone 3 (rather than Zone 4)
  - Storage at Lake Lanier
    - $<$379 mgd
  - Ramping during prolonged low flow
  - Navigation
    - Provide 16,200 cfs flow (7 ft channel) Jan.-May in Zone 1-2

Conservation Measures

- "Actions that benefit or promote recovery of listed species that a Federal agency includes as in 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."

- Fish passage
  - Locking cycles at Woodruff between 0800–1600 hours
  - One in the morning and one in the afternoon
  - Studies ongoing to determine the most appropriate technique and timing
- Daily releases are guided by two parameters:
  - Minimum discharge (cfs)
  - Maximum fall (down-ramping) rate (ft/day)

Minimum discharge

Months	Composite conservation storage zone	Basin inflow (BI)[a] (cfs)	Min. Releases from Jim Woodruff Lock and Dam[b] (cfs)	BI available for storage[a]
March–May	Zones 1 and 2	≥ 34,000 ≥ 16,000 and < 34,000 ≥ 5,000 and < 16,000 < 5,000	= 25,000 = 16,000+50% BI > 16,000 = BI = 5,000	Up to 100% BI>25,000 Up to 50% BI>16,000
	Zone 3	≥ 39,000 ≥ 11,000 and < 39,000 ≥ 5,000 and < 11,000 < 5,000	= 25,000 = 11,000+50% BI > 11,000 = BI = 5,000	Up to 100% BI>25,000 Up to 50% BI>11,000
June–November	Zones 1, 2, and 3	≥ 22,000 ≥ 10,000 and < 22,000 ≥ 5,000 and < 10,000 < 5,000	= 16,000 = 10,000+50% BI > 10,000 = BI = 5,000	Up to 100% BI>16,000 Up to 50% BI>10,000
December–February	Zones 1, 2, and 3	≥ 5,000 < 5,000	= 5,000 = 5,000	Up to 100% BI > 5,000
If Drought Triggered	Zone 3	NA	= 5,000[d]	Up to 100% BI > 5,000
At all times	Zone 4	NA	= 5,000	Up to 100% BI > 5,000
At all times	Drought Zone	NA	= 4,500[e]	Up to 100% BI > 4,500

Notes:

a. Basin inflow for composite conservation storage in Zones 1, 2, and 3 is calculated using the 7-day moving average basin inflow. Basin inflow for composite conservation storage in Drought Operations, Zones 3 and 4 or lower (Drought Zone) is calculated using the one-day basin inflow.

b. Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

c. Drought plan is triggered when the composite conservation storage falls into Zone 3, the first day of each month represents a decision point.

d. Once drought operation triggered, reduce minimum flow to 5,000 cfs following the maximum ramp rate schedule.

e. Once composite storage falls below the top of the Drought Zone ramp down to a minimum release of 4,500 cfs at rate of 0.25 ft/day based on the USGS gage at Chattahoochee, Florida (02358000).

Maximum fall rate

Approximate release range (cfs)	Maximum fall rate (ft/day)
> 30,000 [a]	No ramping restriction [b]
> 20,000 and ≤ 30,000 [a]	1.0 to 2.0
Exceeds Powerhouse Capacity (~ 16,000) and ≤ 20,000 [a]	0.5 to 1.0
Within Powerhouse Capacity and > 10,000 [a]	0.25 to 0.5
Within Powerhouse Capacity and ≤ 10,000 [a]	$\boxed{\text{0.25 or less}}$

Notes:

[a] Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

[b] For flows greater than 30,000 cfs, it is not reasonable or prudent to attempt to control the down-ramping rate, and no ramping rate is required.

Suspended when flows <7,000 cfs for >30 consecutive days and managed to match the fall rate of basin inflow

Two models of river storage and discharge

- Both models used to predict rules for water control manual management compared to RIOP management (Baseline for the BO)
- ResSim
  - Developed by USACE
- ACF-STELLA
  - Developed by Water Without Borders
  - Calibrated with ResSim model (Leitman and Kiker 2015)
  - Slightly different assumption about how to meet navigation
- Dataset based on observed data from 1939-2012
- Daily flow at Chattahoochee gage
- Inference from model that showed greatest effect

We tried to consider active floodplain area – important for spawning, energy flow, carbon inputs, etc.

Smith, M.P., Schiff R. Olivero A., and MacBroom, J. 2008. THE ACTIVE RIVER AREA. A Conservation Framework for Protecting Rivers and Streams

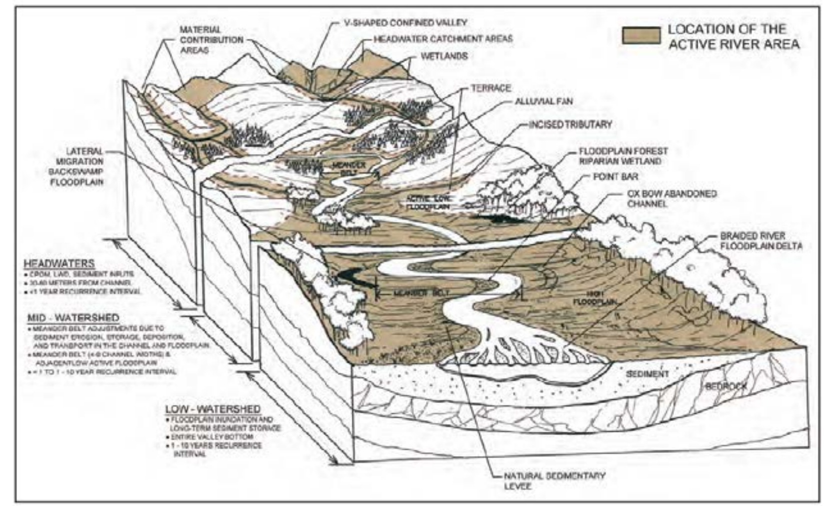


Figure 1.1 – The dominnant processes and disturbance regimes of the *active river area*.

RIVER RESEARCH AND APPLICATIONS
River Res. Applic. (2012)
Published online in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/rra.2604

FISH RECRUITMENT IS INFLUENCED BY RIVER FLOWS AND FLOODPLAIN INUNDATION AT APALACHICOLA RIVER, FLORIDA

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ABSTRACT

High human demand for limited water resources often results in water allocation trade-offs between human needs and natural flow regimes. Therefore, knowledge of ecosystem function in response to varying streamflow conditions is necessary for informing water allocation decisions. Our objective was to evaluate relationships between river flow and fish recruitment and growth patterns at the Apalachicola River, Florida, a regulated river, during 2003–2010. To test relationships of fish recruitment and growth as responses to river discharge, we used linear regression of (i) empirical catch in fall, (ii) back-calculated catch, via cohort-specific catch curves, and (iii) mean total length in fall of age 0 largemouth bass *Micropterus salmoides*, redear sunfish *Lepomis microlophus* and spotted sucker *Minytrema melanops* against spring–summer discharge measures in Apalachicola River. Empirical catch rates in fall for all three species showed positive and significant relationships to river discharge that sustained floodplain inundation during spring–summer. Back-calculated catch at age 0 for the same species showed positive relationships to discharge measures, but possibly because of low sample sizes ($n = 4–6$), these linear regressions were not statistically significant. Mean total length in fall for age 0 largemouth bass in fall showed a positive and significant relationship to spring–summer discharge; however, size in fall for age 0 redear sunfish and spotted sucker showed no relation to spring–summer discharge. Our results showed clear linkages among river discharge, floodplain inundation and fish recruitment, and they have implications for water management and allocation in the Apalachicola River basin. Managed flow regimes that reduce the frequency and duration of floodplain inundation during spring–summer will likely reduce stream fish recruitment.

RIVER RESEARCH AND APPLICATIONS
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IMPORTANCE OF FLOODPLAIN CONNECTIVITY TO FISH POPULATIONS IN THE APALACHICOLA RIVER, FLORIDA

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ABSTRACT

Floodplain habitats provide critical spawning and rearing habitats for many large-river fishes. The paradigm that floodplains are essential habitats is often a key reason for restoring altered rivers to natural flow regimes. However, few studies have documented spatial and temporal utilization of floodplain habitats by adult fish of sport or commercial management interest or assessed obligatory access to floodplain habitats for species' persistence. In this study, we applied telemetry techniques to examine adult fish movements between floodplain and mainstem habitats, paired with intensive light trap sampling of larval fish in these same habitats, to assess the relationships between riverine flows and fish movement and spawning patterns in restored and unmodified floodplain distributaries of the Apalachicola River, Florida. Our intent is to inform resource managers on the relationships between the timing, magnitude and duration of flow events and fish spawning as part of river management actions. Our results demonstrate spawning by all study species in floodplain and mainstem river habitat types, apparent migratory movements of some species between these habitats, and distinct spawning events for each study species on the basis of fish movement patterns and light trap catches. Additionally, *Micropterus* spp., *Lepomis* spp. and, to a lesser degree, *Minytrema melanops* used floodplain channel habitat that was experimentally reconnected to the mainstem within a few weeks of completing the restoration. This result is of interest to managers assessing restoration activities to reconnect these habitats as part of riverine restoration programmes globally.

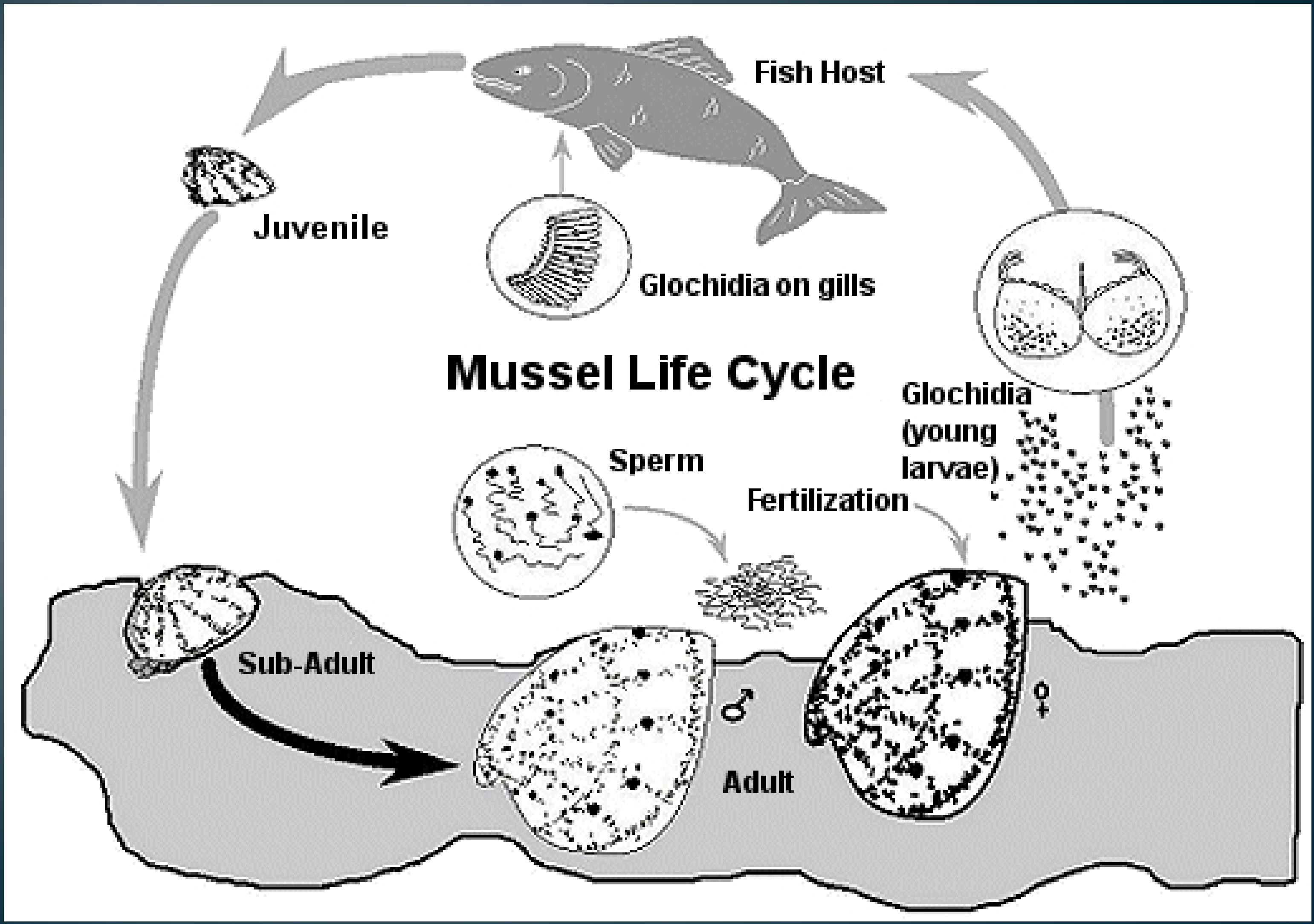
KEY WORDS: river; floodplain; spawning; seasonal flooding

transition

- Apalachicola River is the focus – Endangered Species
- Includes full hydrograph, from droughts to floods

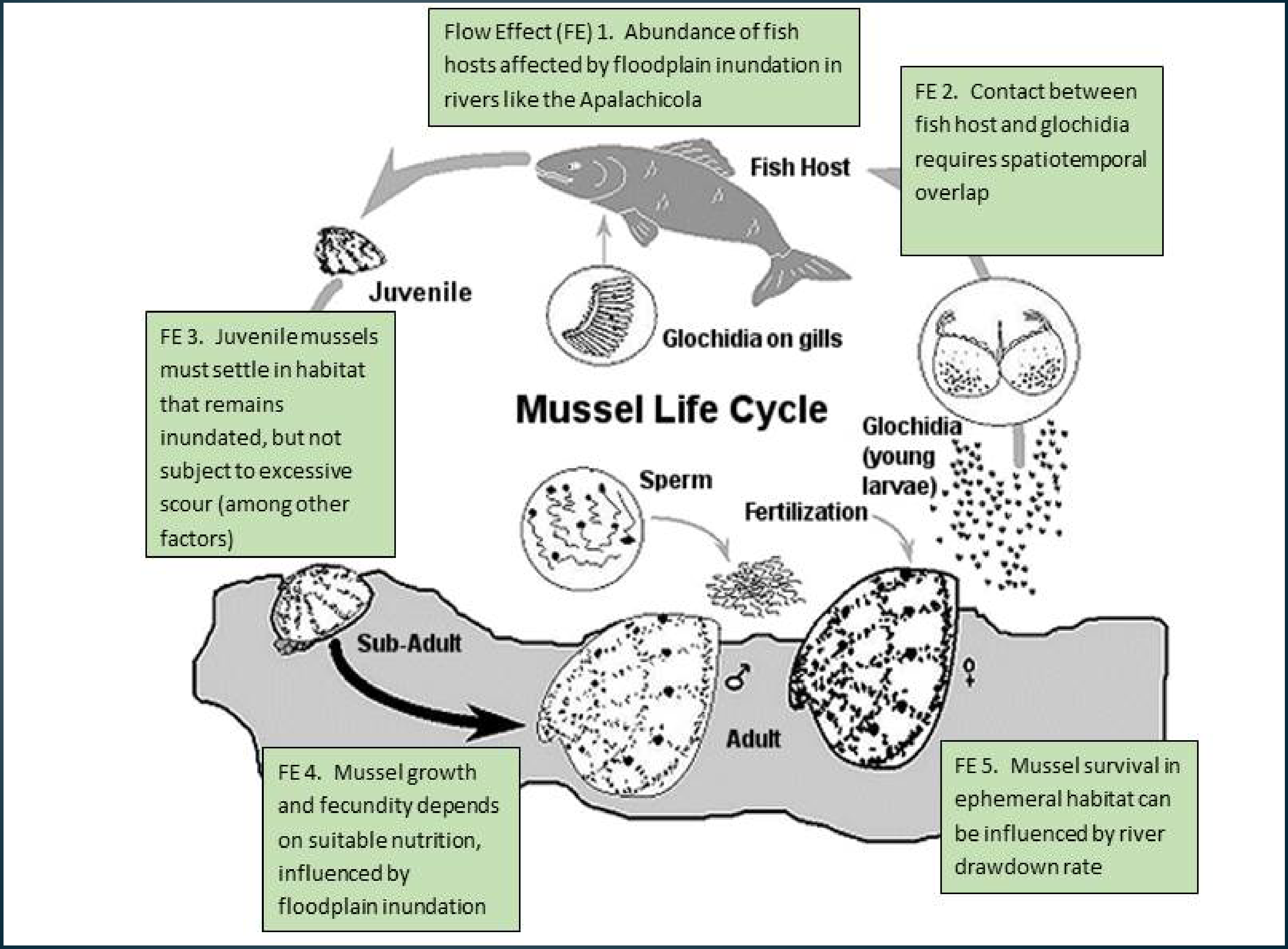
- But we tried to look at complete life histories of listed mussels and fish, their interactions with each other, across the full range of flows to be expected (based on past 74 yrs of hydrology and predicted climate changes).

1st Consideration- life history of mussels

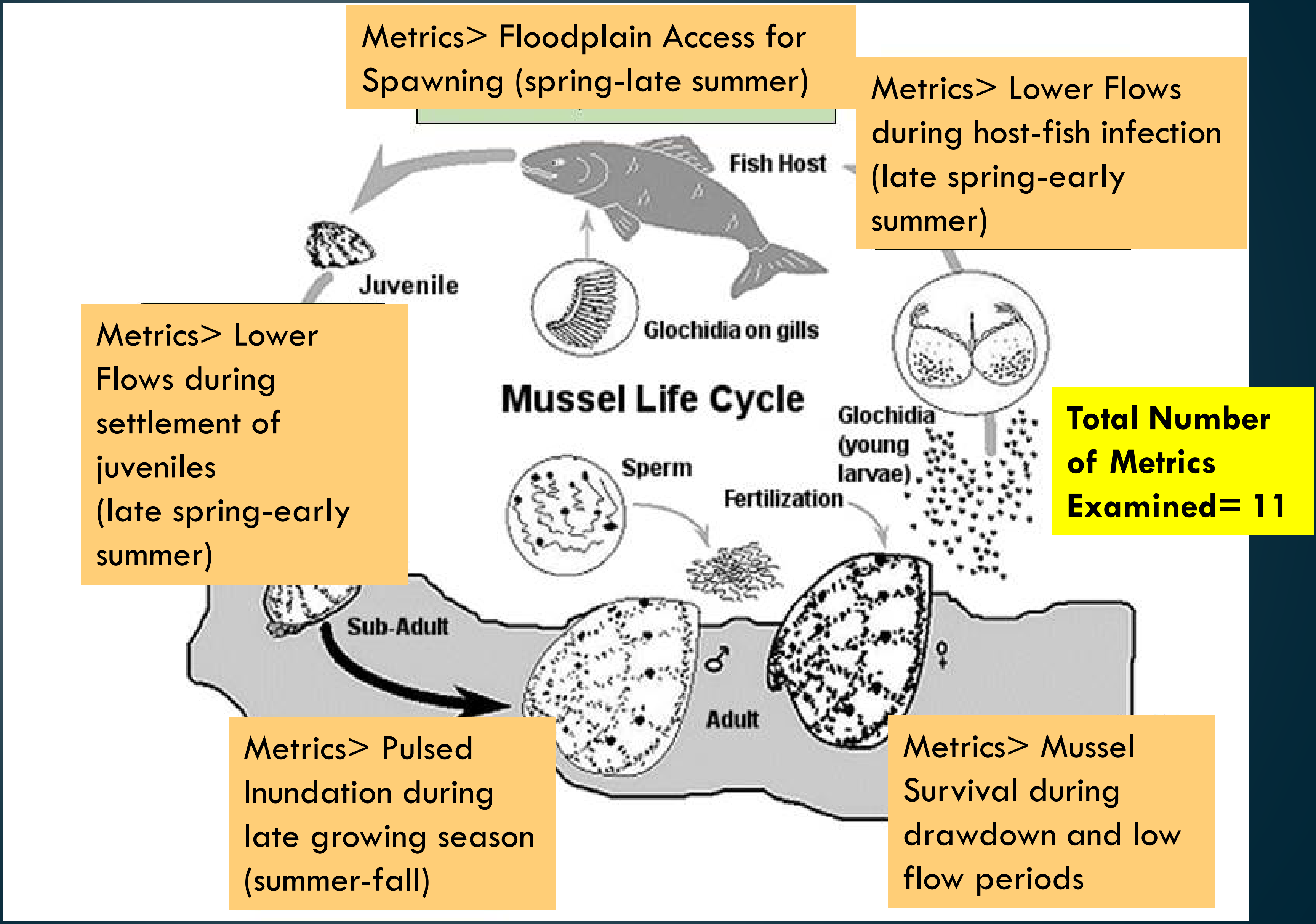


(diagram from Iowa Mussel Team 2002)

How does flow affect mussel life history?



How does flow affect mussel life history?



Flow effect 1: Host Fish Production, 2 Metrics

Specifics of timing and flow thresholds	Flow effect	What's better	Results
Hydroecological Metric	**Species Ecology**	**Interpretation**	**WCM effect**
1) Floodplain Access for Spawning % days flows ≥16,200 cfs between Mar 1-Aug 15	Host Fish Production	higher % days of floodplain inundation better for host fish	negative
2) Floodplain Access for Spawning Max acres continuously inundated for 30 days between Mar 1-Aug 15	Host Fish Production	more acres inundated better for host fish	negative

Analytical Process

74-year basin inflow record (daily)

ResSim

+ 1) WCM rule set, and 2) baseline rule set (RIOP)

STELLA

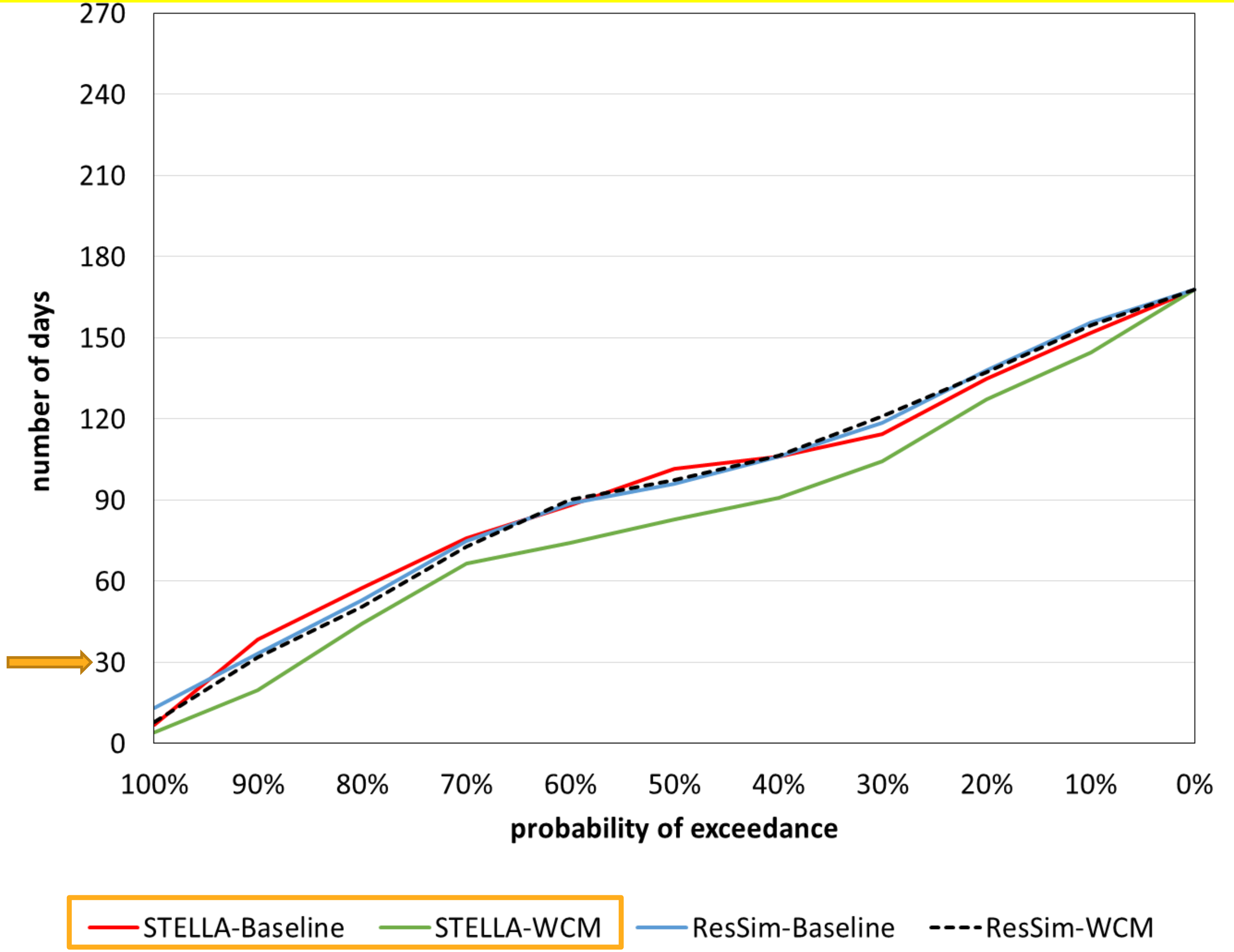
Predicted Daily Discharge at JWLD

Predicted Daily Discharge at JWLD

Excel Worksheet to Calculate each Metric

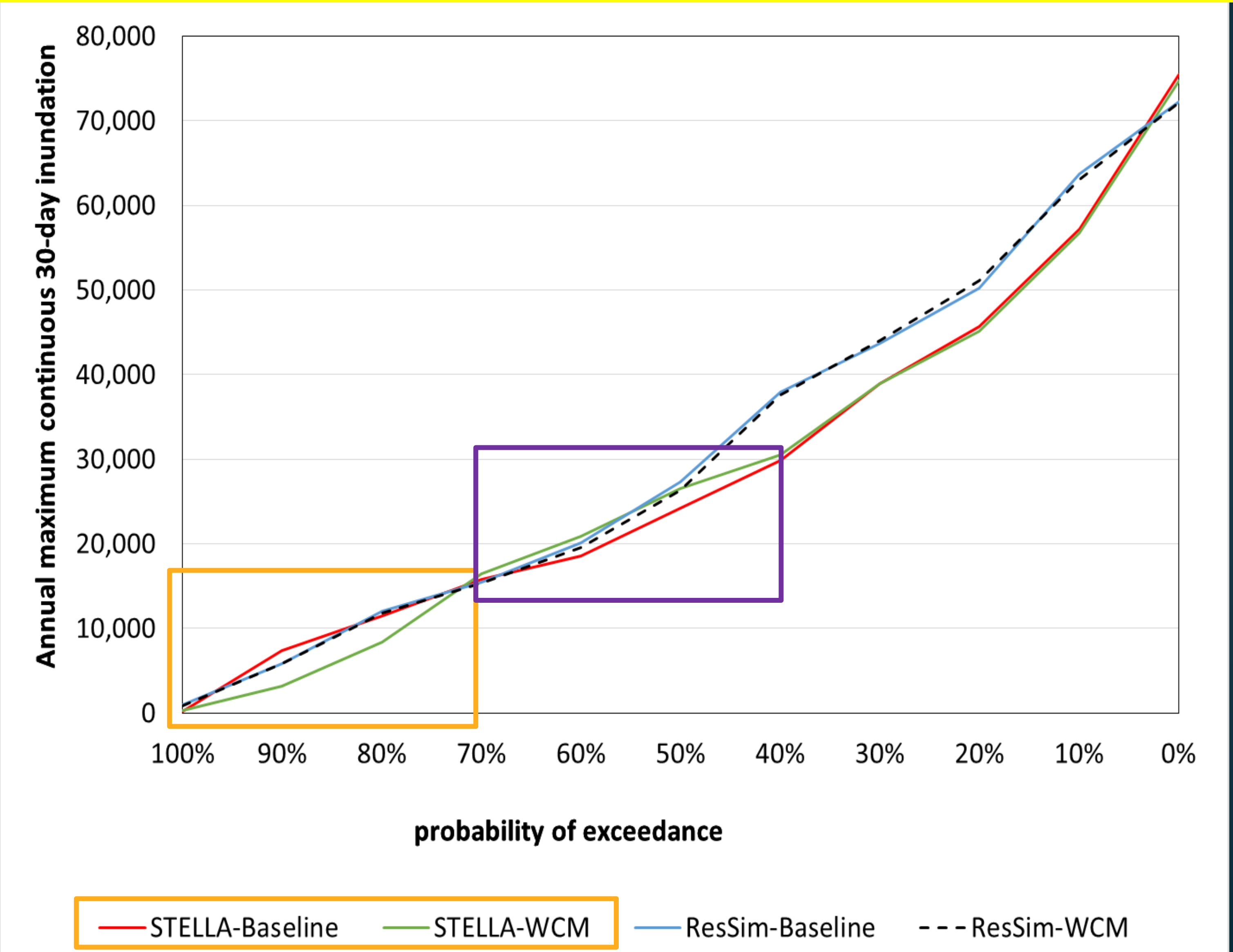
Graph results in terms of exceedance curves, decipher effects, deeper dive when necessary

Metric1: Floodplain Access for Spawning
of days (Mar 1-Aug 15) flows ≥16,200 cfs



- Interpretation
- To achieve 30 days of inudation, WCM reduces probability from 93% to 84% over 74 year record
- WCM- 14 years don't meet at least 30 days of inundation compared to 5 years under baseline

Metric 2: Max. acres cont. inundated for 30 days between Mar 1-Aug 15 with flows ≥16,200 cfs

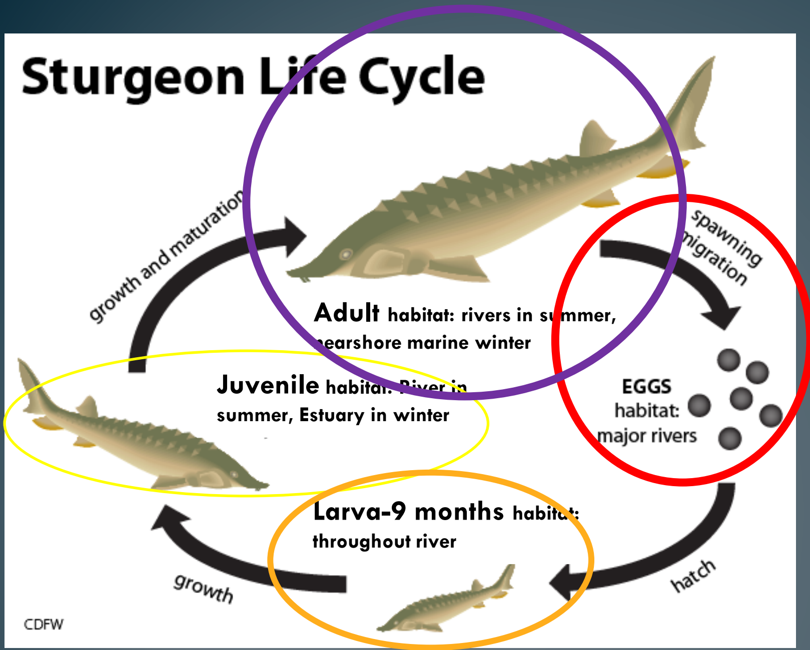


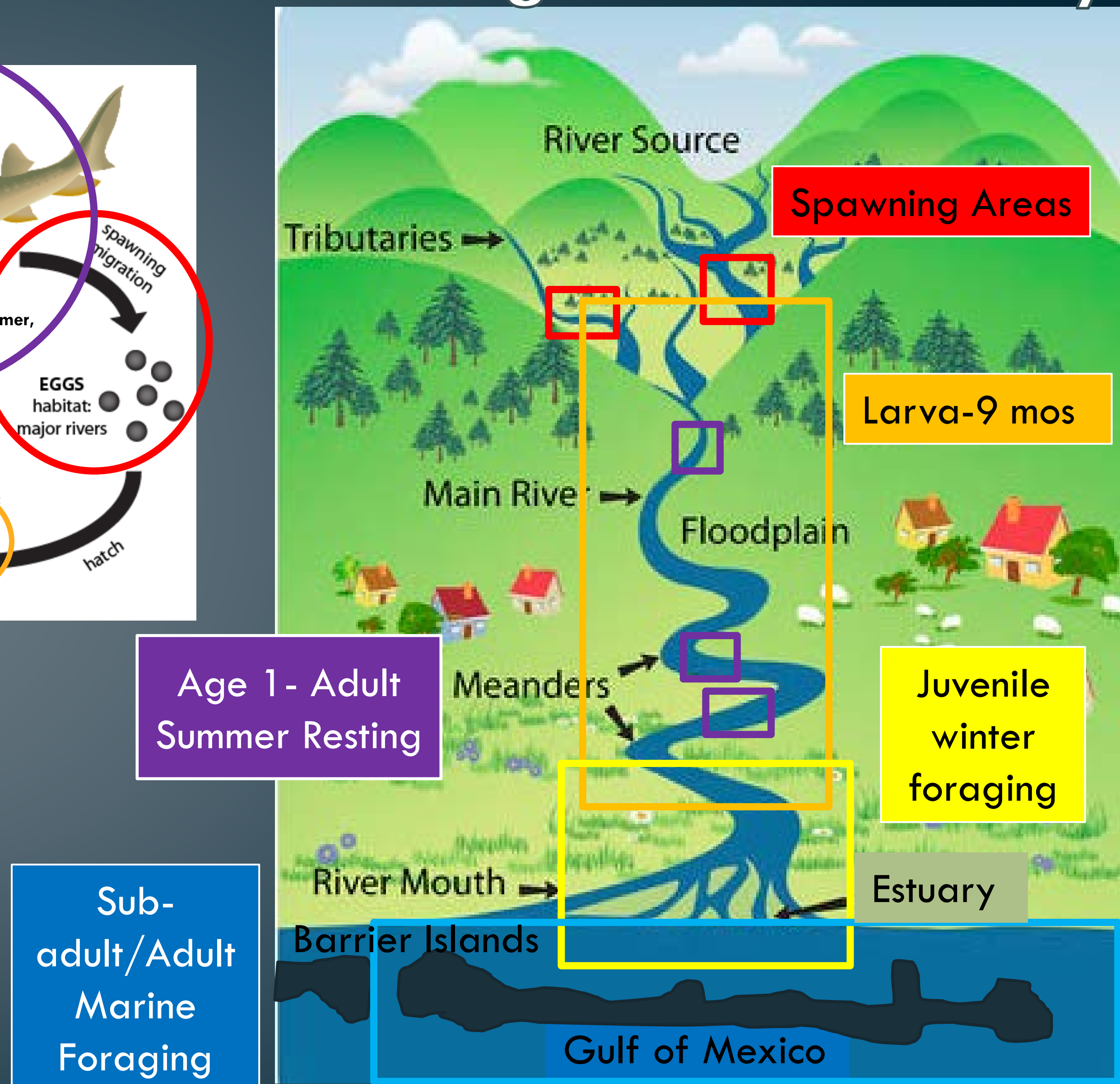
- Avg. 433 ac/year (i.e., 6%) reduction under WCM
- In years with lower inundation, 2,794 ac/yr (38%) reduction
- In years with intermediate inundation, 1,169 ac/yr increase
- Overall less time and less acreage for host fish recruitment

Effects of WCM to critical habitat for mussels with respect to floodplain inundation

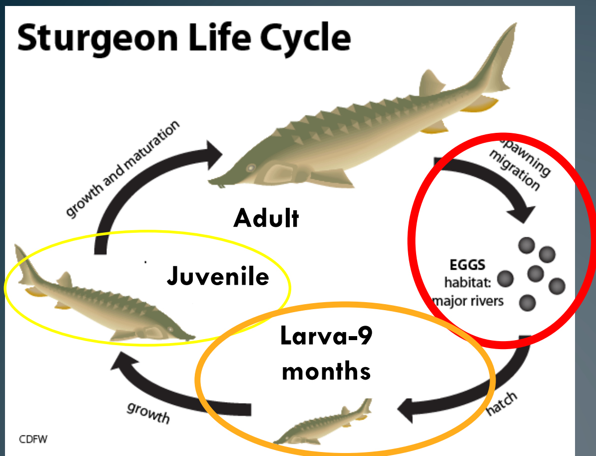
- Fish hosts
  - Reductions in floodplain inundation and time inundated could limit access and, in turn,
  - **Reduced fish recruitment could negatively impact mussel recruitment**
    - USACE will monitor frequency of conditions causing take; a year with less than 30 consecutive days of at least 31,000 ac of floodplain inundation between March 1 and August 15 will not occur more than once in the next five years

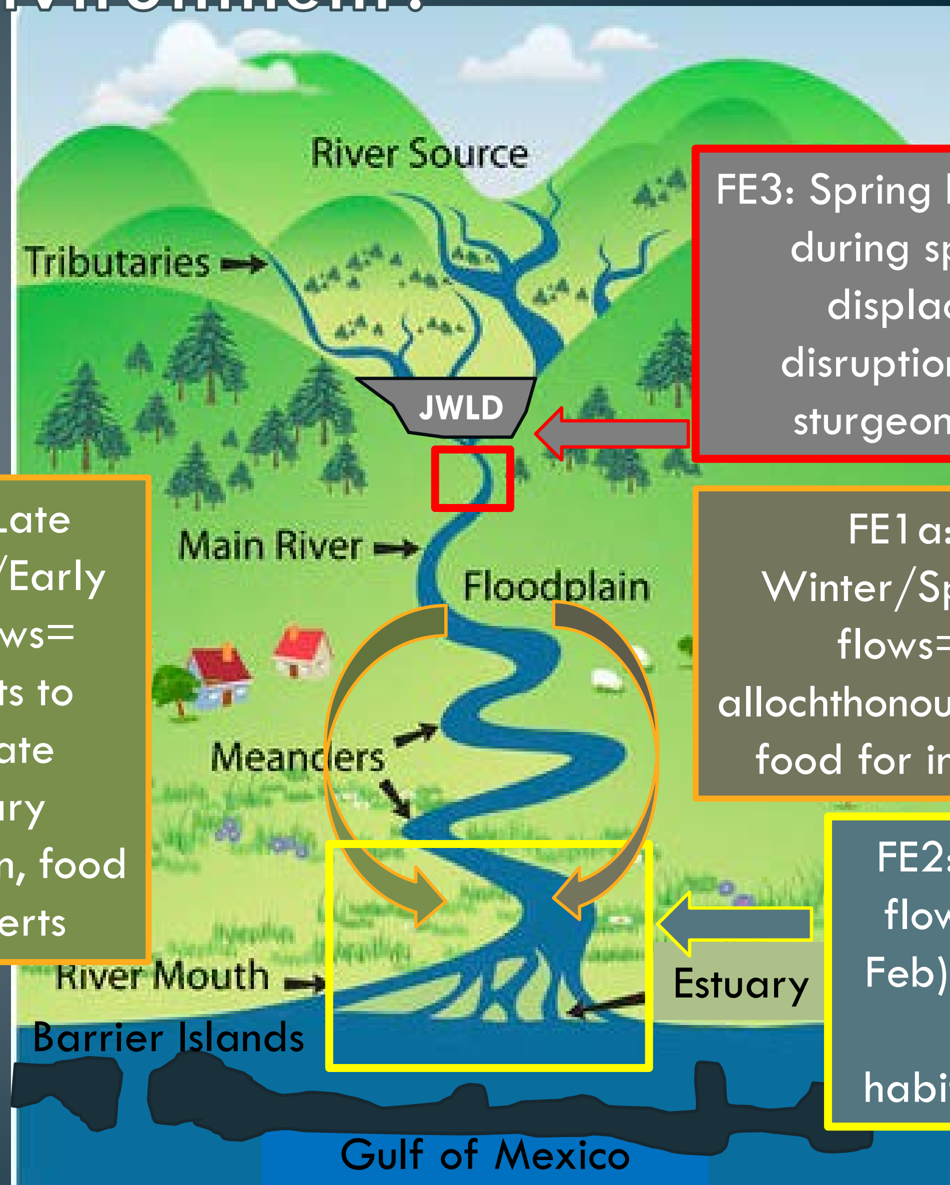
1st Consideration- Gulf sturgeon life history





How does flow affect Gulf sturgeon life history in the riverine environment?





FE3: Spring hydropeaking during spawning= displacement/ disruption of larval sturgeon foraging

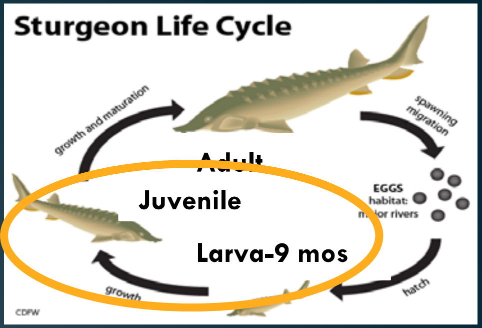
FE1b: Late Summer/Early Fall flows= nutrients to stimulate primary production, food for inverts

FE1a: Winter/Spring flows= allochthonous input, food for inverts

FE2: Winter flows (Dec-Feb)= access to habitat/food

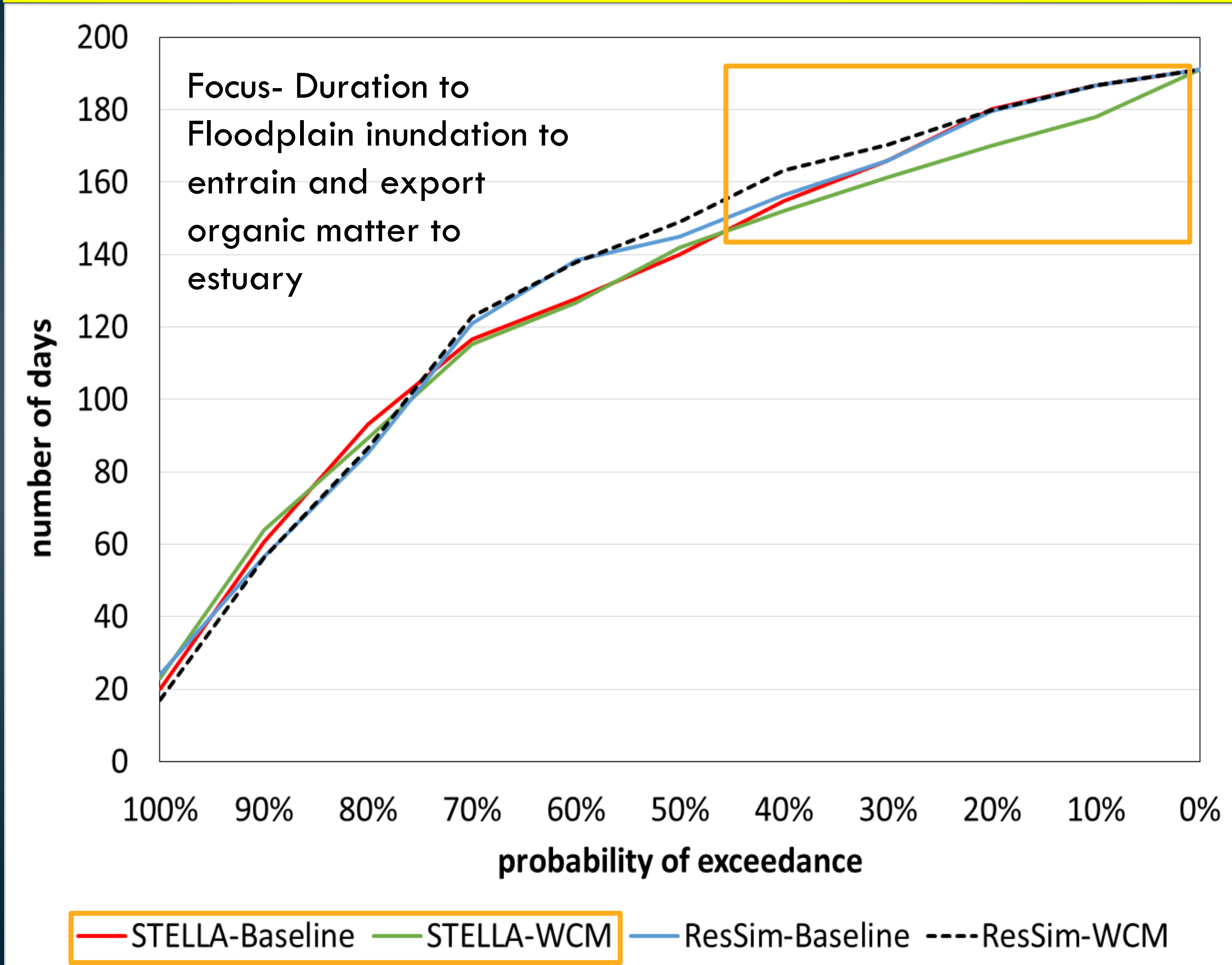
Total Number of Metrics examined for effects on Gulf sturgeon= 11

Flow effect 1: Floodplain Inundation



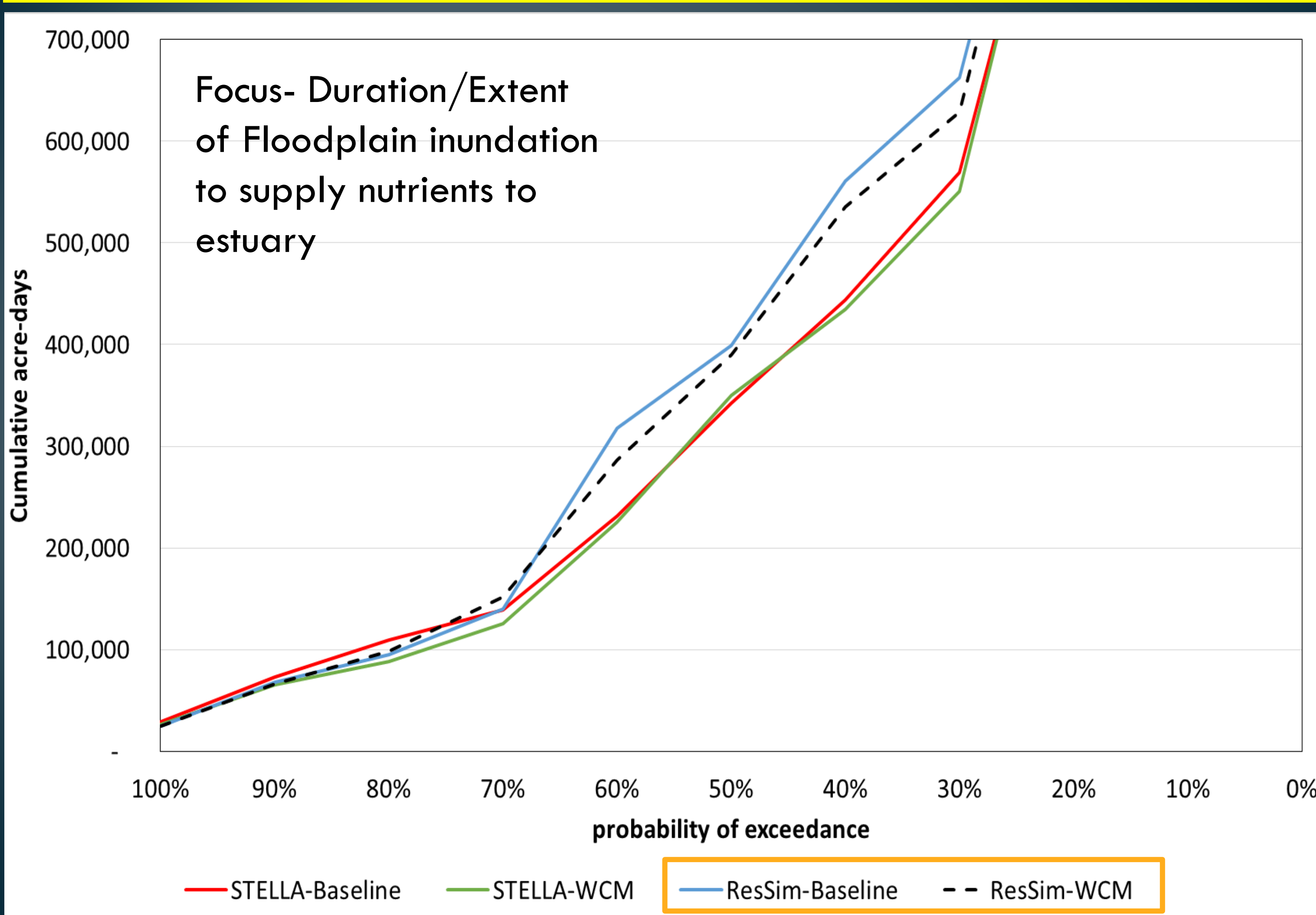
Hydroecological Metric Title	Species Ecology	Interpretation	WCM effect
1) Floodplain Inundation and Organic Matter Supply (Total Days) - Nov 24-Jun 1	Estuarine Invertebrate Production	more days of inundation beneficial	negative
2) Floodplain Inundation and Nutrient Supply (Total Acre-days) - July 15 - Nov 24	Estuarine Invertebrate Production	more acre-days of inundation beneficial	negative

Metric1: Number of days between Nov. 24 and Jun. 1 with flows $\geq$16,200 cfs



- Interpretation
- Average decrease of 2.4 days per year (133.4 to 131.0) under WCM
- Effects greatest in wet years

Metric 2: Number of acre-days at ≥16,200 cfs between July 15 and November 24



- Under ResSim, overall average reduction of 18,904 ac-days/yr
- During years with low inundation >83% exceedance (dry years) WCM reduced inundation by 6.3%

Effect on Gulf sturgeon population with respect to floodplain inundation

- Reduced floodplain inundation in
  - late summer and fall (July 15-November 24)
  - winter and spring periods (November 24-June1)

Reduced estuarine invertebrate production

For more information…

https://www.fws.gov/panamacity/resources/USFWSBiologicalOpinionforACFWaterControlManual2016.pdf

Biological Opinion

Endangered Species Act
Section 7 Consultation

on the

U.S. Army Corps of Engineers
Mobile District

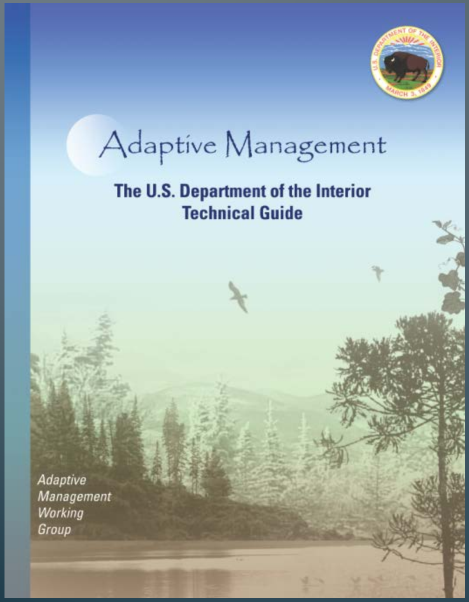
Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin in Alabama, Florida, and Georgia and a Water Supply Storage Assessment

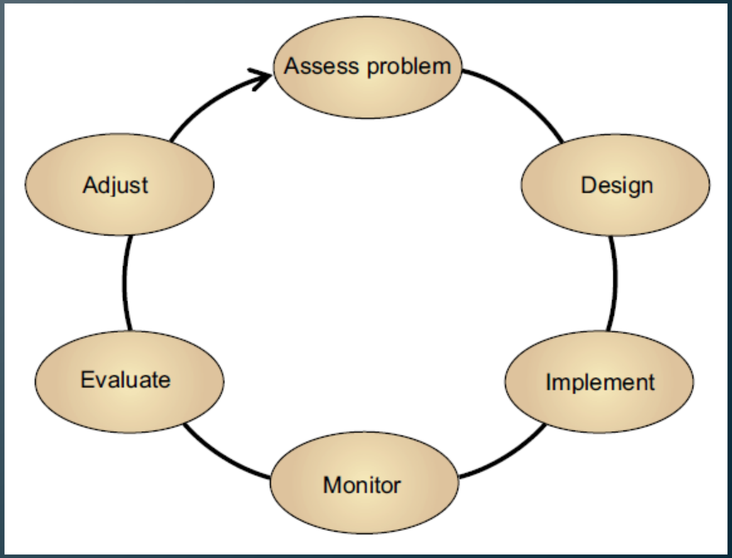
Prepared by:
U.S. Fish and Wildlife Service
Panama City Field Office, Florida
September 14, 2016

USFWS Log No: 04EF3000-2016-F-0181

Adaptive management

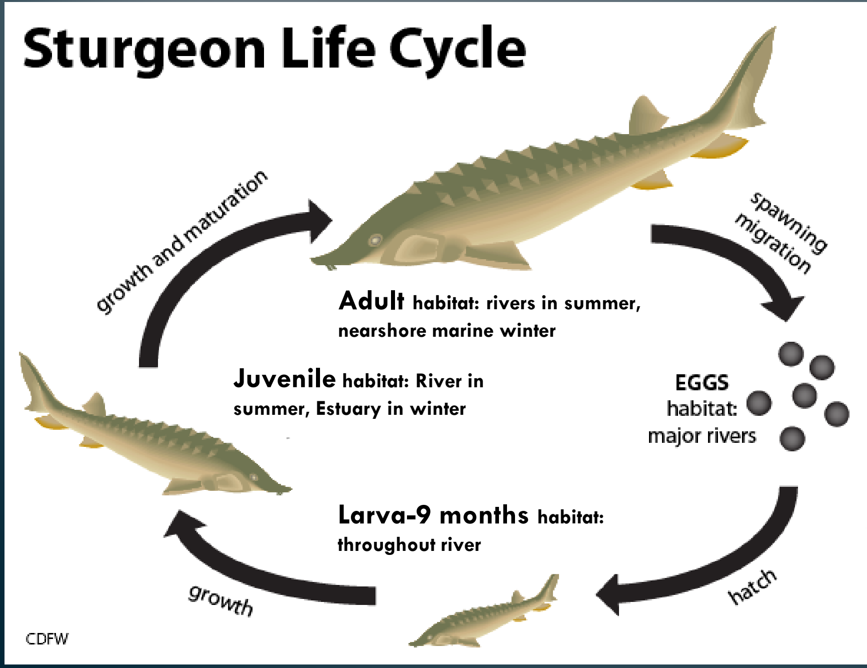
- Develop and adaptive management framework for the basin that will incorporate new information
- Establish an Adaptive Management Technical Team (AMTT)
- Evaluate and refine avoidance and minimization efforts and monitoring for listed species based on input from AMTT

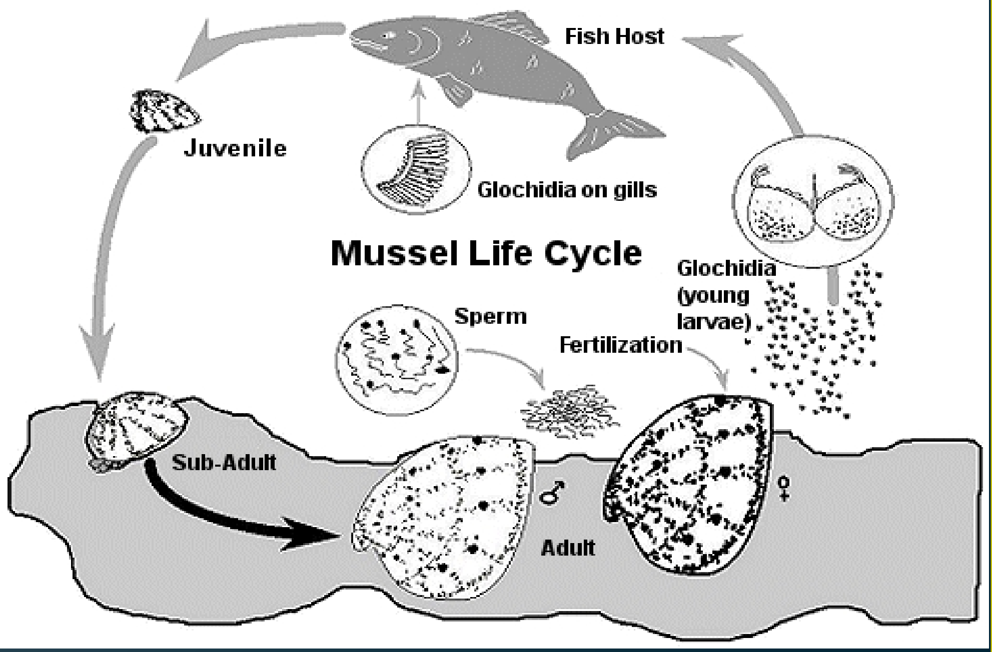




Full life cycle considerations

- Space - Habitat needs at each life stage
- Time - Timing connected to key points in life history





Conclusions

- Framework for analyses has led to an agenda for monitoring and hypothesis testing → adaptive management
- How can we understand how these flow effects weighted for their effects on the listed species? What are the resulting biological responses?

Questions?

More details at: www.fws.gov/panamacity/acf