Pallid Sturgeon Population Assessment Program v. 2.0

Pallid Sturgeon Effects Analysis Team

MRT^2

Pallid Sturgeon EA

USGS science for a changing world

MISSISSIPPI STATE

NEBRASKA GAME PARKS

U.S. FISH & WILDLIFE SERVICE

PSPAP v. 2.0 objectives

- Provide essential population-level information needed for the Missouri River Recovery Project to make decisions about fundamental objectives, including, but not limited to:
- Discern status and trends of the pallid sturgeon population.
- Complement and enhance understanding of linkages to management actions.

MRRP Goal: develop a suite of actions that meets ESA responsibilities for pallid sturgeon (PS), while continuing to operate the Missouri River System to meet its authorized purposes

FWS Fundamental Objective for Pallid Sturgeon: Avoid jeopardizing the continued existence of the pallid sturgeon from the USACE actions on the Missouri River.

Sub-objective 1: *Increase pallid sturgeon recruitment to age 1.*

- **Metric_1.1:** catch rates of naturally produced age 0 and age 1 PS
- **Metric_1.2:** model-based estimates of abundance of naturally produced age 0 and age 1 PS using data for age 0-4 fish
- **Metric_1.3:** model-based estimates of survival of naturally produced PS to age 1, using data for age 0-4 fish
- **Target:** measurable recruitment to age 1

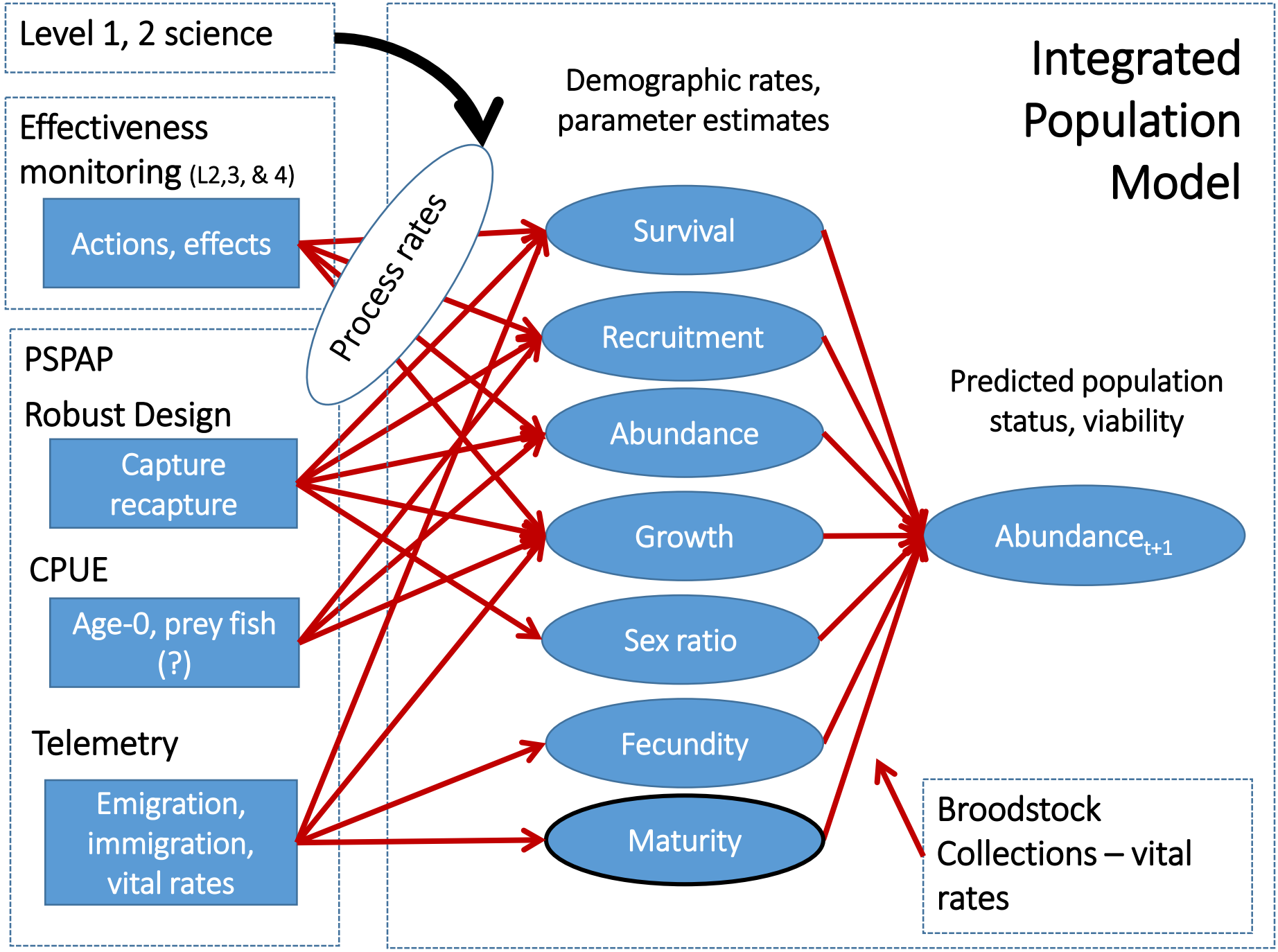
Sub-objective 2: *Maintain or increase numbers of pallid sturgeon as an interim measure until sufficient and sustained natural recruitment occurs.*

- **Metric_2.1:** population estimates for PS by size class, age (particularly ages 2 to 3) and origin
- **Metric_2.2:** catch rates of all PS by size class and origin (to maintain legacy data)
- **Target:** TBD. Possible targets: 1) $\lambda > 1$ for PS age 2 and older; 2) survival rates of all size/age classes sufficient to provide stable population of PS age 2 and older; 3) acceptable probabilities of persistence and recovery (> 0.95) over 50 years (utilizing population models); and 4) > 5000 self-sustaining, genetically diverse PS in each adult population unit.

PSPAP v. 2.0 Redesign Process

Complementarity: PSPAP v. 2.0 is part of a framework; it does not do all the evaluation needed to inform decision making.

1. PSPAP v. 2.0 – abundance and trends, some linkages of actions to population responses (augmentation).
2. Effectiveness monitoring – ecological effectiveness of management actions, but not necessarily to population responses
3. L1 and L2 research – develop process understanding of linkages from actions to demographic rates.
4. Collaborative Population Model (CPM)–tool to integrate information, demographic rates, predict population response.


Level 1, 2 science
Effectiveness monitoring (L2,3, & 4)
Actions, effects
PSPAP
Robust Design
Capture recapture
CPUE
Age-0, prey fish (?)
Telemetry
Emigration, immigration, vital rates
Process rates
Demographic rates, parameter estimates
Survival
Recruitment
Abundance
Growth
Sex ratio
Fecundity
Maturity
Integrated Population Model
Predicted population status, viability
Abundance$_{t+1}$
Broodstock Collections – vital rates

Where we are at

Timeline: PSPAP v. 2.0

1. **Preliminary pilot efforts – ongoing**
2. **Pilot implementation Fall 2018**
3. **Full implementation in Fall 2019**

Where we are at

A road map for designing and implementing a biological monitoring program (Reynolds et al. 2016):

1. Frame the problem
2. Design the program
3. Implement and learn
4. Learn and revise

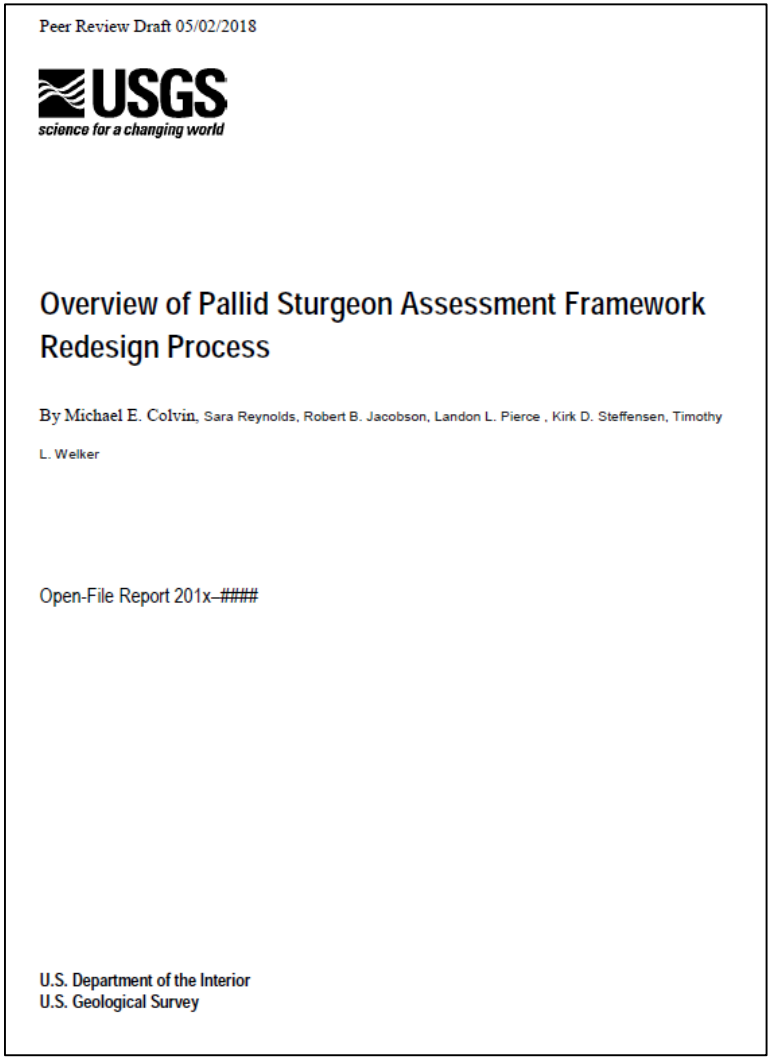
Where we are at

A road map for designing and implementing a biological monitoring program (Reynolds et al. 2016):

1. Frame the problem	✓
2. Design the program	wrapping up: proposals
3. Implement and learn	beginning: pilot season
4. Learn and revise	ongoing

Progress Report

- USGS FSP—Due June 15th
  - Dr. Carl Schwarz
  - Dr. Mark Wildhaber
  - Dr. Drew Tyre
- USACE & USFWS review
- Agency courtesy review
- ISAP courtesy review
- Status: in revision & pending FSP reviews



Peer Review Draft 05/02/2018

USGS
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Overview of Pallid Sturgeon Assessment Framework Redesign Process

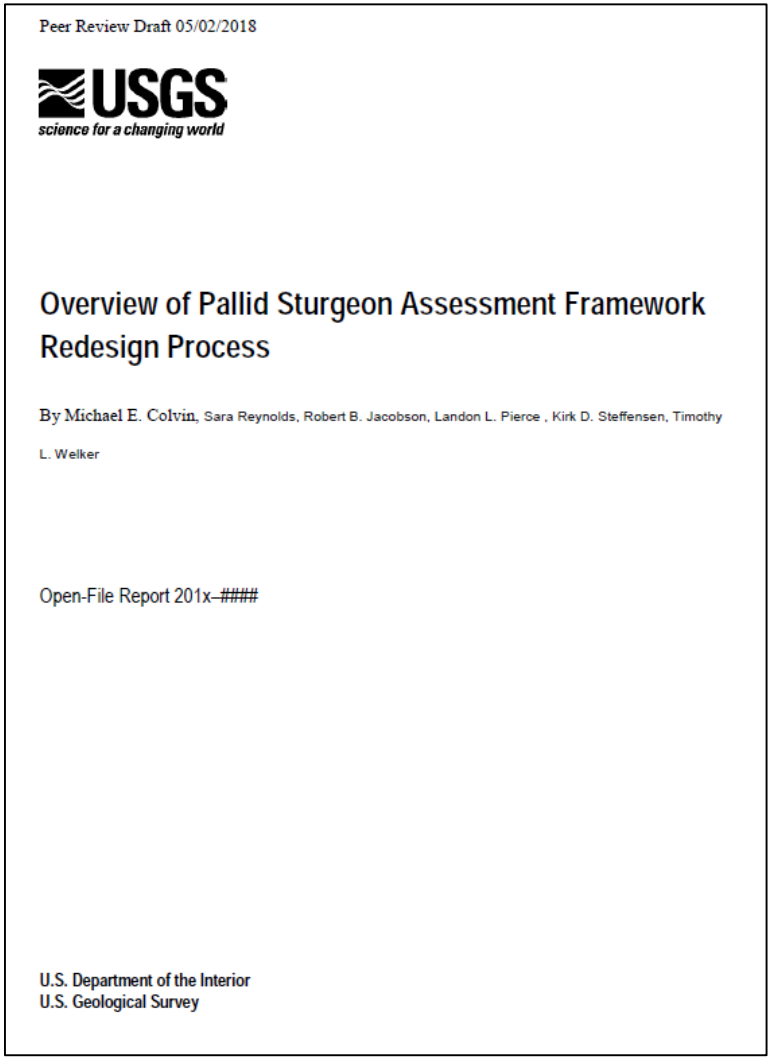
By Michael E. Colvin, Sara Reynolds, Robert B. Jacobson, Landon L. Pierce , Kirk D. Steffensen, Timothy L. Welker

Open-File Report 201x–####

U.S. Department of the Interior
U.S. Geological Survey

Progress Report

- Iterative 'living document' similar to PSPAP protocols
- Document
  - Process
  - Pilot efforts
  - Learning
  - Adaptation



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PSPAP v. 2.0 Fundamental Objectives

1. Quantify pallid sturgeon recruitment to age 1 (from natural reproduction) **[Sub-objective 1]**
2. Quantify pallid sturgeon population status and trends, natural and hatchery origin **[Sub-objective 2]**
3. Maintain compatibility with PSPAP v. 1.0 data to extent possible
4. Provide relevant demographic data for pallid sturgeon population model inputs.
5. Evaluate monitoring information in a benefit:cost or utility:cost framework

PSPAP v. 2.0 Redesign Process

Fundamental Objectives of PSPAP:

1. Quantify PS recruitment to age-1
2. Quantify PS population status & trend
3. Provide relevant PS model inputs
4. Maintain compatibility with legacy PSPAP data
5. Stay below cost constraints

Ancillary objectives

1. Contribution is uncertain
2. May mitigate risk, anticipate surprises
3. May support other agency objectives
4. May provide high marginal value (bang for the buck)

PSPAP V2.0 Ancillary Objectives

1. **Population structure:** Age structure, Size structure, Maximum size, Sex ratio
2. **Reproductive status:** Egg quality, Reproductive cycling, Age at maturity, spawning aggregation & synchrony, fecundity
3. **Fish health status:** Stress, Contaminants, Fish condition, Abnormalities
4. **Demographic rates:** Predation, Survival, Growth
5. **Movement & habitat selection:** Drift & dispersal, Use of Mississippi River and tributaries, Habitat availability and selectin, spawning habitat availability & selection, movement, IRC habitat, foraging habitat
6. **Genetics**: local adaptation, hybridization, effective population size
7. **Other objectives:** forage fish trends, diet, fish community, competition with native fish, zooplankton density
8. **Hatchery:** Stocking location & numbers, broodstock production, hatchery production, fin curl & other diseases

Routing ancillary objectives

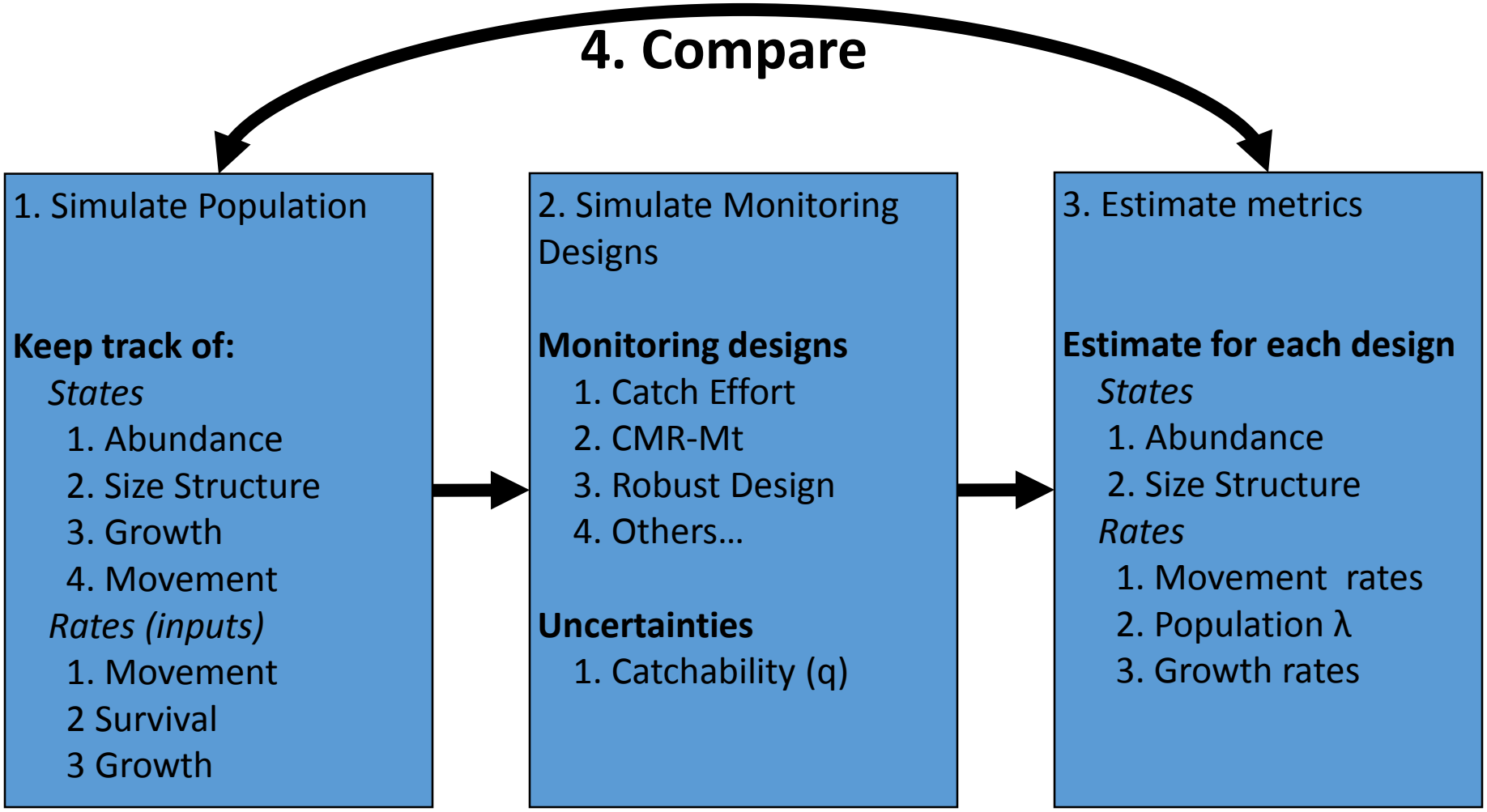
[PSPAP v. 2.0, Pallid Sturgeon Population Assessment Program, version 2.0; CPUE, Catch Per Unit Effort.]

Subobjective	Metric	Action	Recommended program routing	Duration or frequency	Comments
Objective: Population structure					
Age structure	Age distribution, mean age	NONE- continue current sampling	Presently included in PSPAP v. 2.0	Annually	From known age fish
Size structure (RSD)	RSD values	NONE- continue current sampling	Presently included in PSPAP v. 2.0	Annually	
Maximum size	Maximum size	NONE- continue current sampling	Presently included in PSPAP v. 2.0	Annually	
Sex ratio	Ratio of males:females	Analyze blood for hormone profiles	Ancillary, collect as part of broodstock sampling or longitudinal studies of tagged fish.	Annually	Need female and other reproductive rates to estimate effective population size. Role in management hypotheses
Objective: Reproductive status					
Egg quality	Egg volume, egg diameter, fat content	Take egg sample	Ancillary, collect as part of broodstock sampling.	Annually	
Reproductive cycling of mature fish	Number of years between reproductive events	Take blood, Ultrasound	Ancillary, collect as part of broodstock sampling or longitudinal studies of tagged fish.	Annually	
Age at maturity	Probability a pallid sturgeon is mature given length or age	Take blood	Ancillary, collect as part of broodstock sampling or longitudinal studies of tagged fish.	Annually	Use blood work to build function for known age hatchery origin fish
Spawning aggregation and synchrony of reproductive fish	Mapped areas of relatively high numbers of reproductive pallid sturgeon	Identify high use locations	Ancillary, conduct as part of effectiveness monitoring for spawning cues and spawning habitats.	Annually	Can be covered through planned level 1 and 2 science efforts to understand reproductive migrations, responses to pulsed flows, and constructed spawning habitats.
Fecundity of mature females	Number of eggs produced by a female pallid sturgeon	Record volume of eggs released, number of eggs per volume, estimation with ultrasound	Ancillary, collect as part of broodstock sampling or longitudinal studies of tagged fish.	Annually	

PSPAP 2.0 Fundamental Objectives

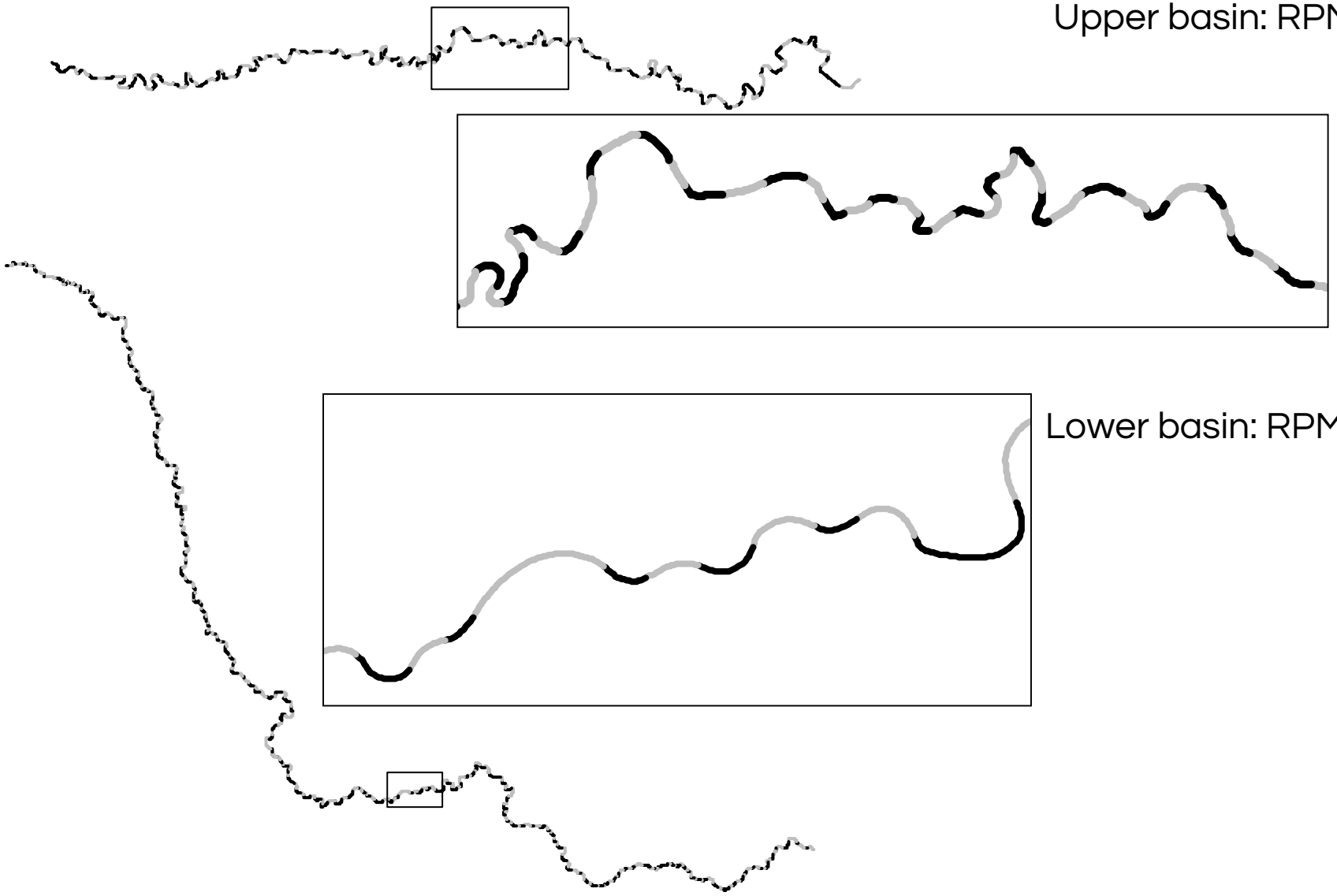
	Objective		Performance metric
1	Quantify pallid sturgeon recruitment to age 1 (from natural reproduction).		Power to detect recruitment if recruitment occurs
2	Quantify pallid sturgeon population status and trends, natural and hatchery origin.	Population abundance	Bias of abundance estimates
			Precision of trend estimates
		Population trend	Bias of population trend estimates
			Precision of population trend estimates
3	Maintain compatibility with PSPAP v. 1.0 data to extent possible		Proportion of randomly selected bends within segment; completeness of sampling.
4	Provide relevant demographic data for pallid sturgeon population model inputs.		Proportion of possible population model inputs.
5	Evaluate monitoring information in a benefit:cost framework.		Estimated costs

Evaluation Process

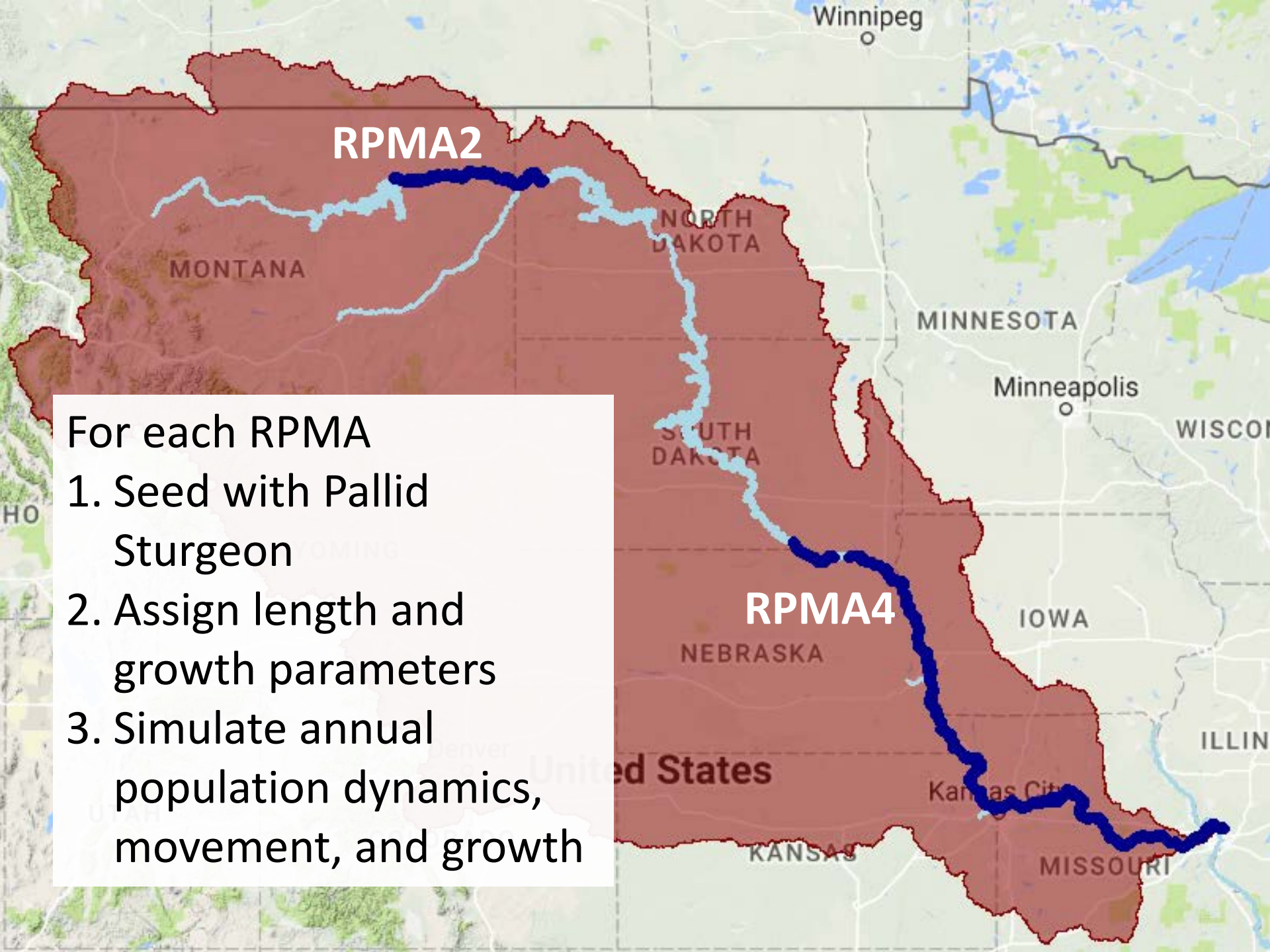


Spatial Grain

Upper basin: RPMA 2



Lower basin: RPMA 4


RPMA2
RPMA4
Winnipeg
MONTANA
NORTH DAKOTA
MINNESOTA
Minneapolis
IOWA
NEBRASKA
KANSAS
MISSOURI
ILLIN
For each RPMA
1. Seed with Pallid Sturgeon
2. Assign length and growth parameters
3. Simulate annual population dynamics, movement, and growth

PSPAP v. 2.0 Components

1. Age-0 & Age-1 catch rates
- June-September
- trawling (OTO4)

2. Adult population
- September-June
- Lower Basin
  - Trotlines
  - Gillnets
- Upper Basin
  - Trammel nets
  - Gillnets

Additional components

2. Broodstock assessment
  - March to April…

4. Telemetry
  - Stations & sweeps
  - Tagged population maintenance
  - Reproductive & passage telemetry
  - Timing varies throughout the year

5. Fish community
  - June to September
  - If ‘must haves’ are met

Age-0 & Age-1 Sampling

Age-0 & Age-1 Sampling

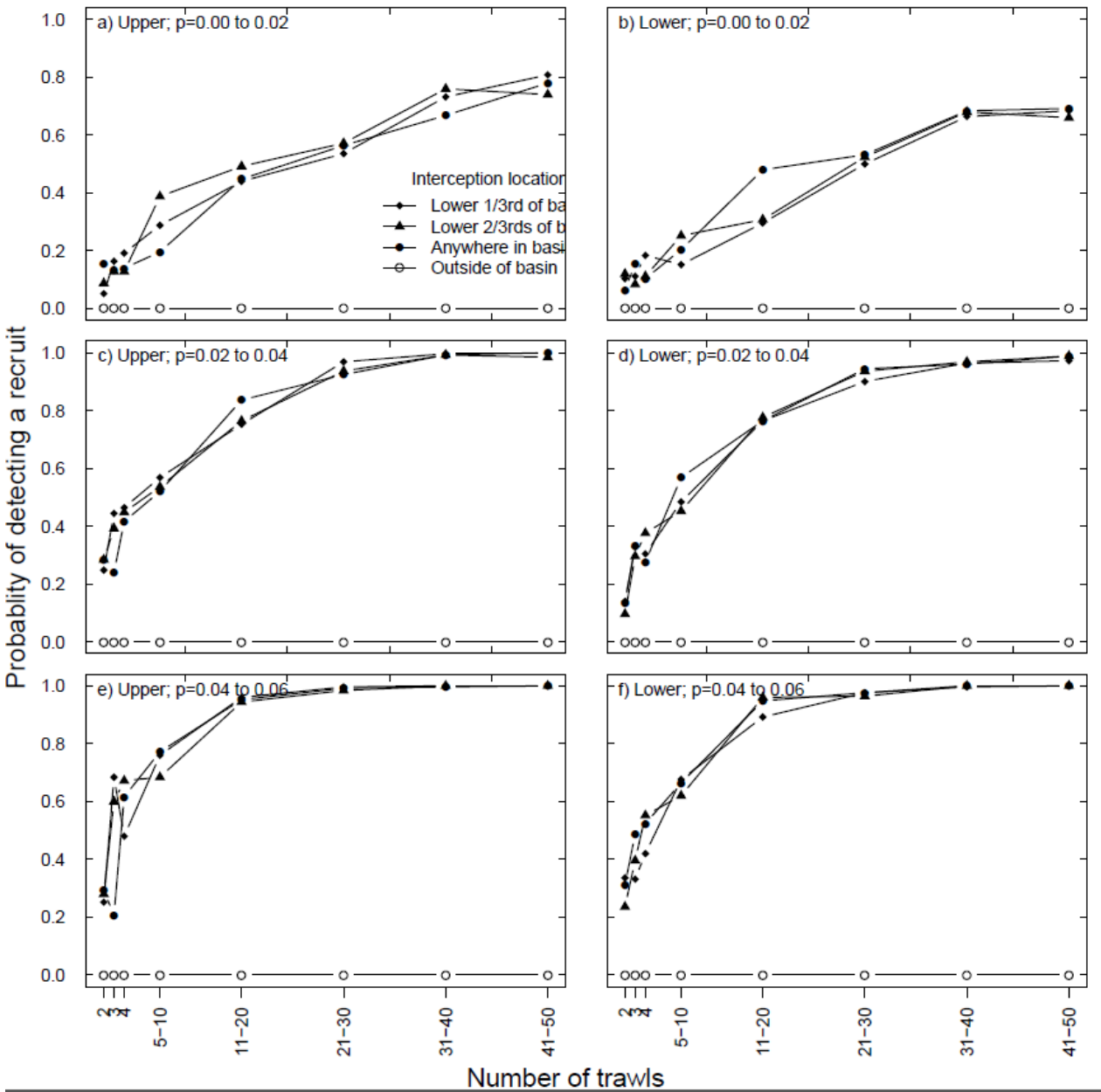
Metric: Catch rates of naturally produced age-1 and age-1 pallid sturgeon

- Upper basin: July-September
- Lower basin: June-September
- Trawling (OTO4)
- Multiple trawls in each bend
  - Decrease probability of missing naturally produced age-0 or age-1 given it is there
- Standard number of PSPAP bends per segment

Age-0 & Age-1 Detection

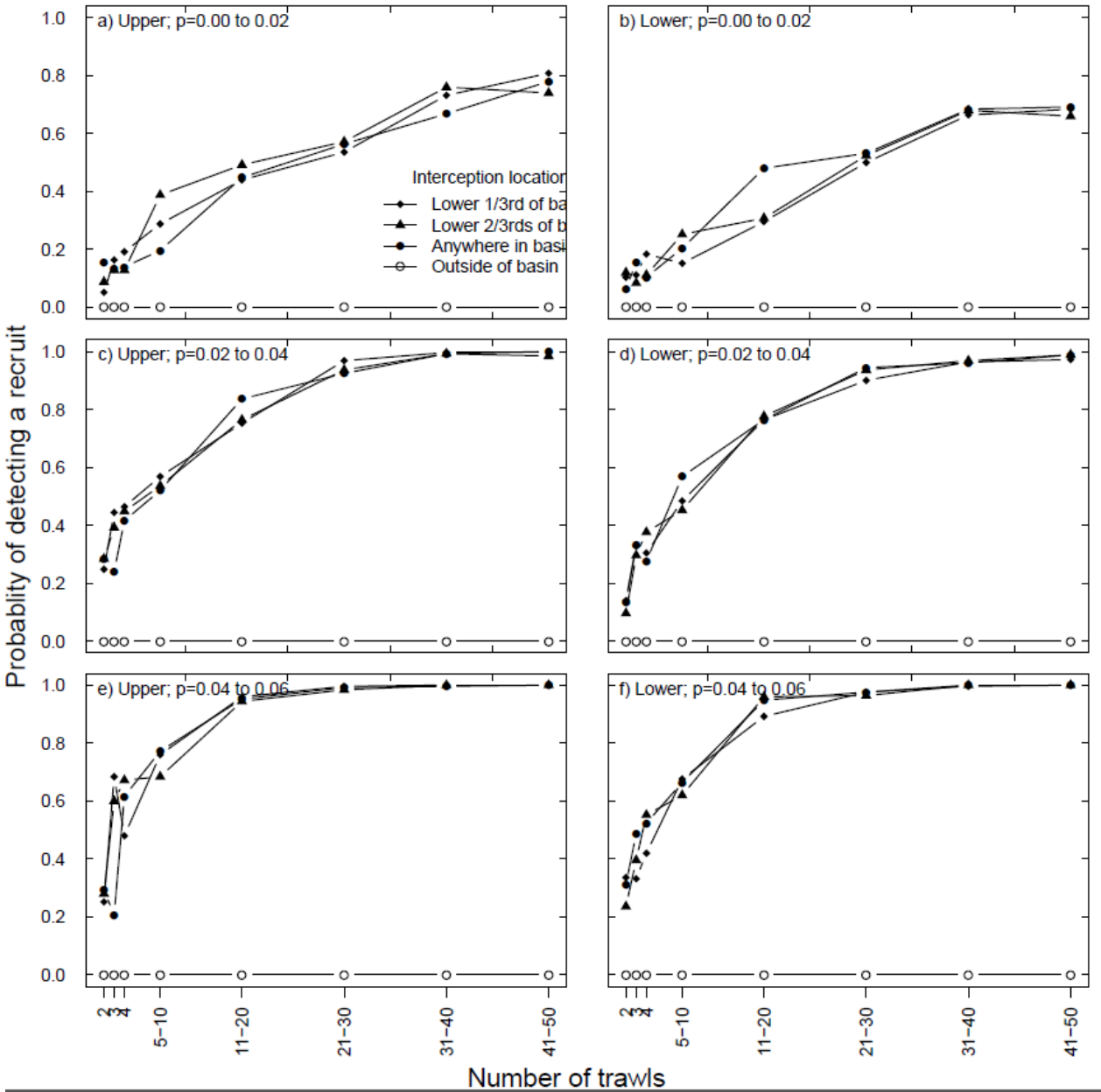
Trawls within bend given varying detection probabilities

Note: this is conservative. We need to be able to detect and then catch rates will follow



Age-0 & Age-1 Detection

Detection & capture probability are critical to optimizing effort (trawls) within bend and at segment level



Age-0 Pilot effort

Age-0 Pilot Effort

Major components

1. Age-0 catchability, capture probability & detection probability
2. Spatial variability in age-0 catchability, capture probability & detection probability
3. Retention of age-0 pallid sturgeon and growth

Component 1. Age-0 catchability, capture probability & detection probability

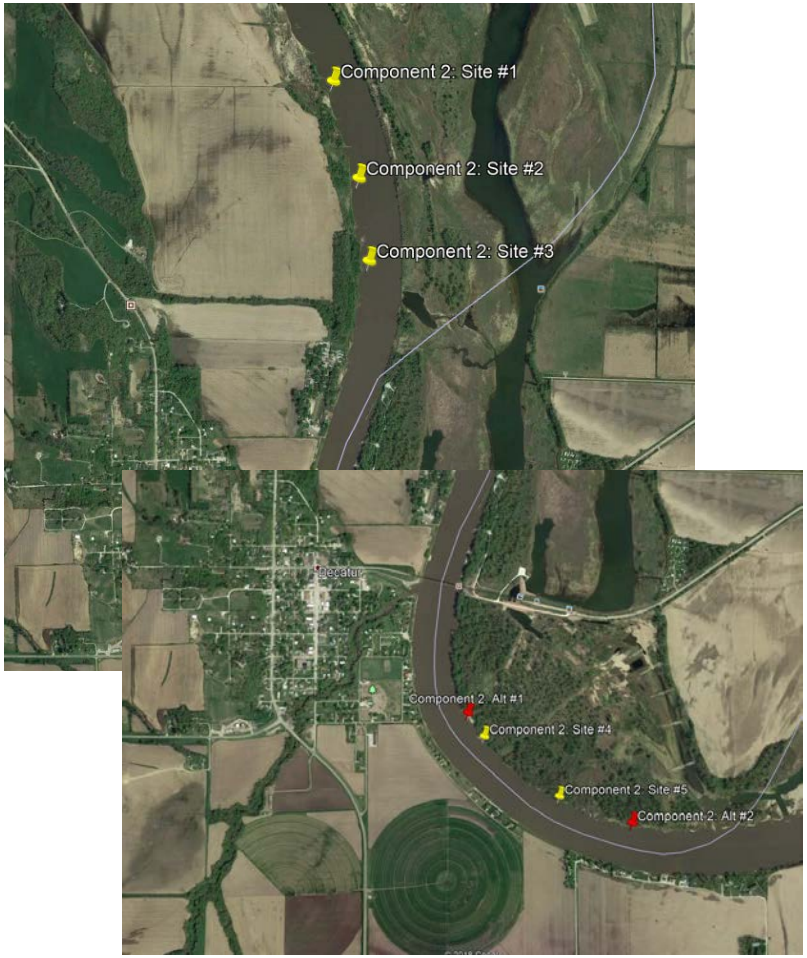
Study component objective: Get an idea of age-0 capture and detection probability

Stock fish at varying densities 0.001 to 1 fish/m^2

Sample repeatedly each day ~ 25 trawls

Tease out density and catch relationship

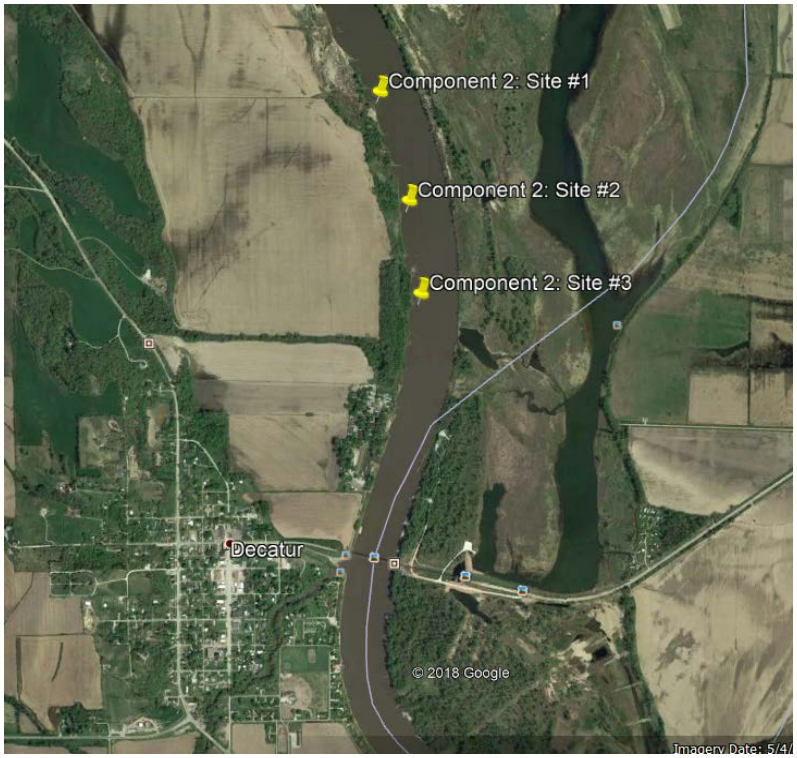
Component 2. Spatial variability in age-0 catchability, capture probability & detection probability



Depending on component 1 & hatchery fish availability

- Stock several site with known age-0 densities
- Repeatedly trawl area
- Quantify spatial variability in capture and detection probabilities

Component 3. Retention of age-0 pallid sturgeon & growth



Using the sites stocked in component 1 & 2:

1. Continue sampling each site weekly for 5 weeks
2. Remove scutes to potentially estimate apparent weekly survival
3. Measure length & weight on recaptures to estimate growth

Additional Age-0 in the works

Potential & feasibility for:

- Microchemistry
- Gatekeeper sampling-cross section repeatedly sampled at boundaries
  - Free embryo &larval sampling across the lower Missouri---Age 0 fish in the thalweg
  - Strategic locations like Confluence of Mississippi and Missouri River
- Seeing additional input?
- Optimization of design (effort, bends, so on)


Adult Sampling

Adult abundance & trend approach

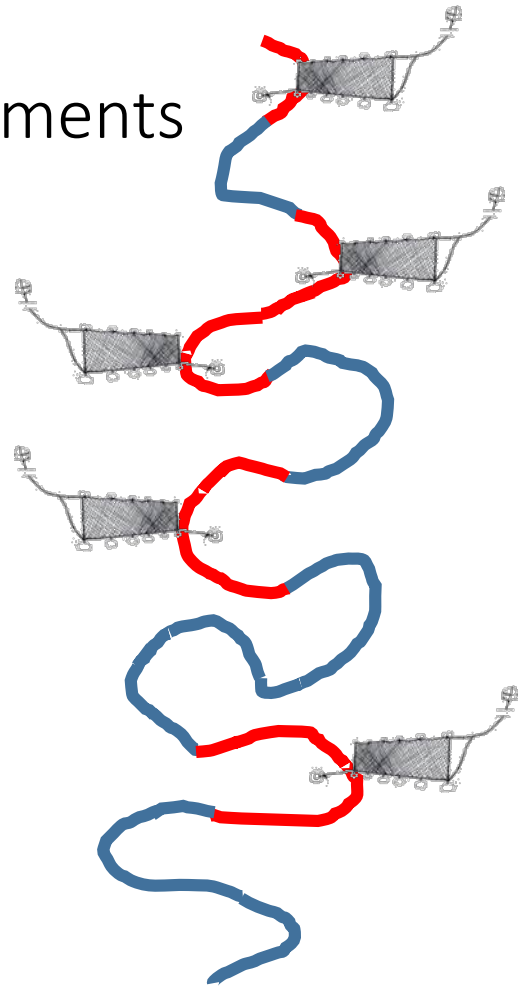
- Capture recapture approach
- Estimates at segment level & aggregated to basin
- Bend level sampling with 2 gears
  - Size selectivity
  - Upper basin: trammel and gill nets
  - Lower basin: trotlines and gill nets
- Focus on bias and precision of segment level estimates
- Not optimized for detecting the effects of management action-confounding, noise, so on.

Reference Populations

- Simulate 100s of reference populations
- Uncertainty dealt with
  - Movement: site fidelity low, moderate, high
  - Recruitment: None, little, some at basin level (1 out of some years)
  - Spawning interval at individual level (1 out of some years)
  - Transport of larvae: throughout basin, lower 1/3, outside

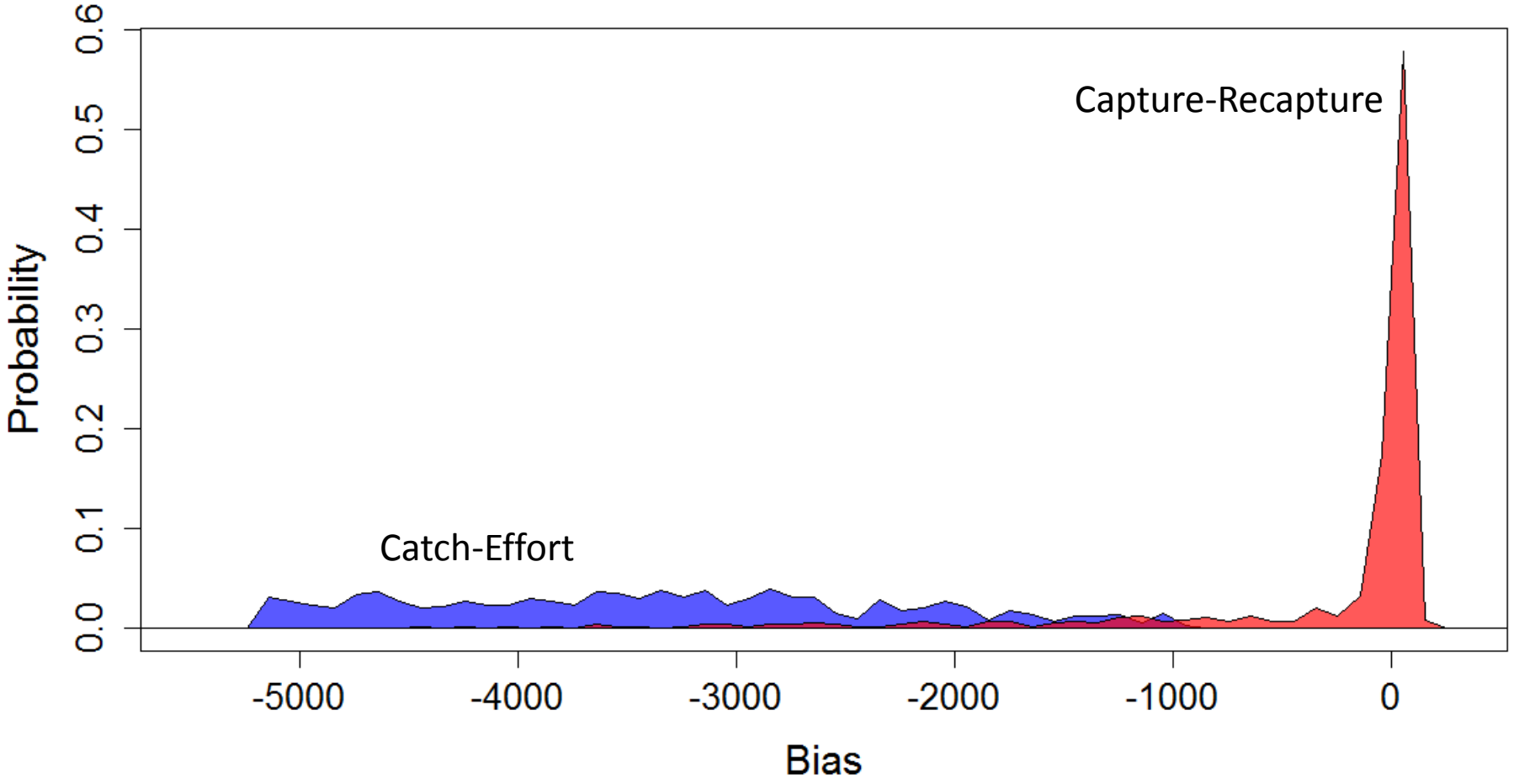
Sampling Designs

- Bends within segments
- Similar to PSPAP
- 12-20 bends/ year depending on bends in segment

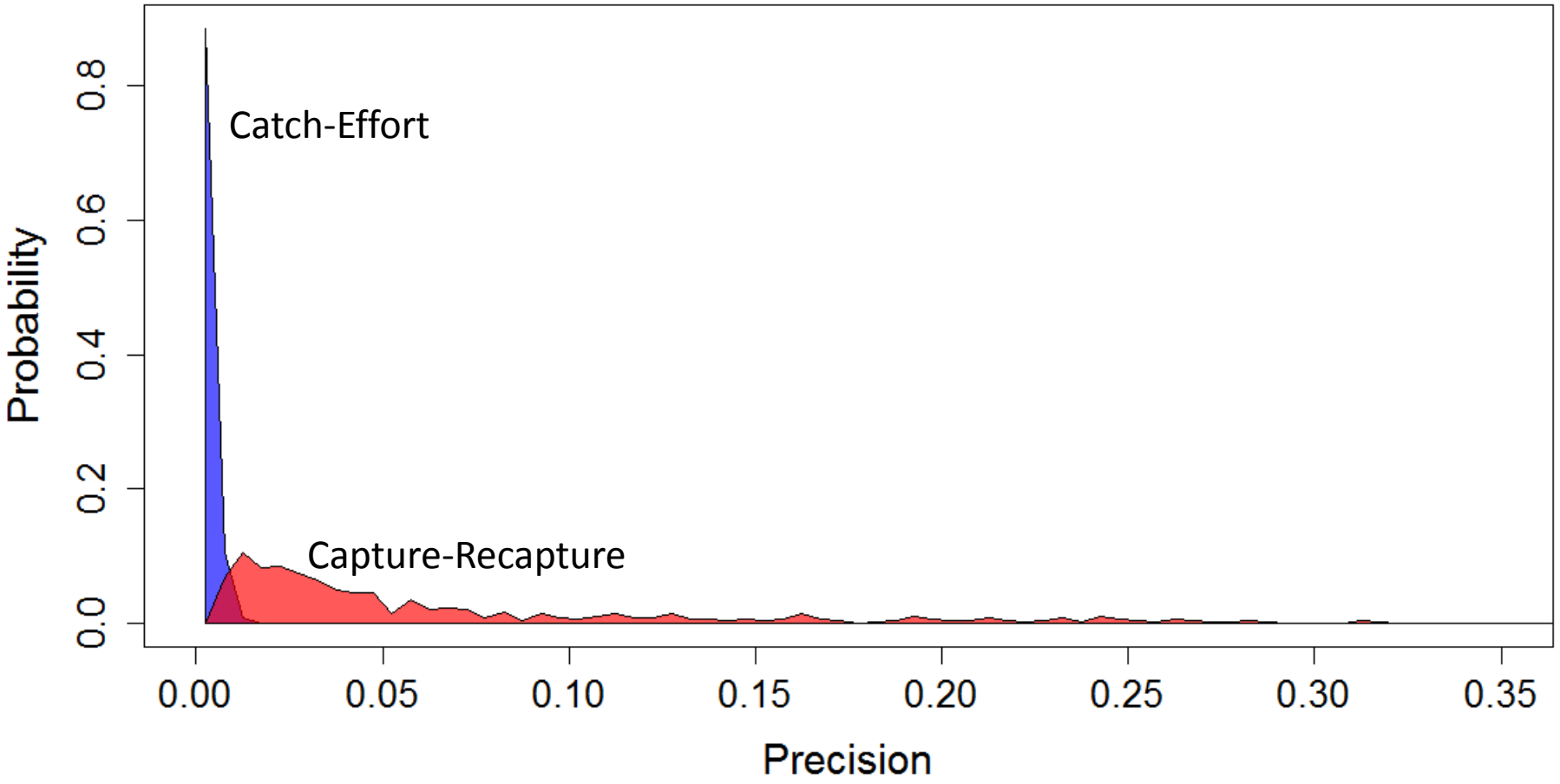


1. Trotlines (RPMA 2 & 4)
2. Trawling (RPMA 2 & 4)
3. Trammel Nets (RPMA 2)
4. Gill Nets (RPMA 2 & 4)
5. Relevant combinations

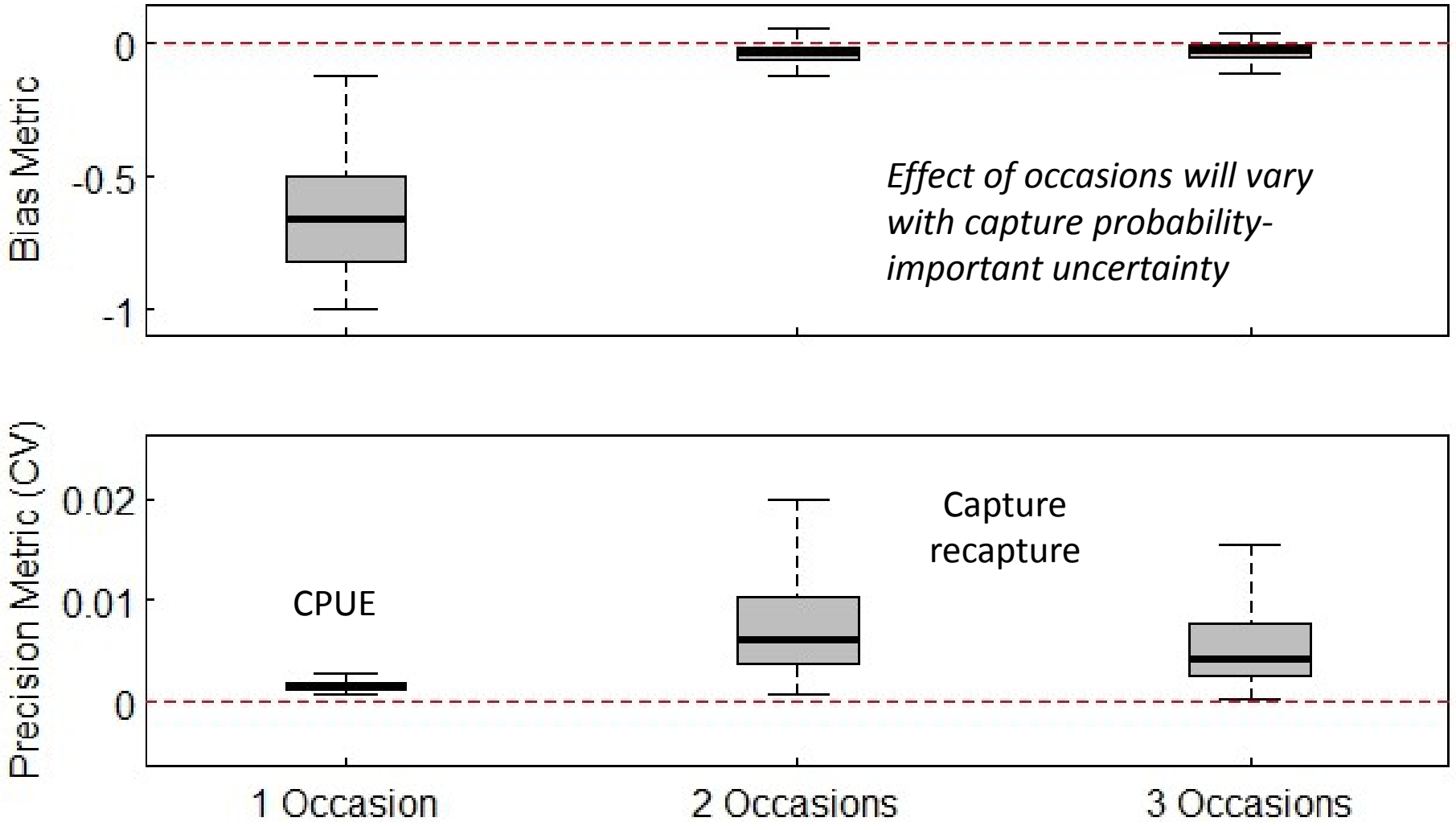
Abundance Estimates: bias



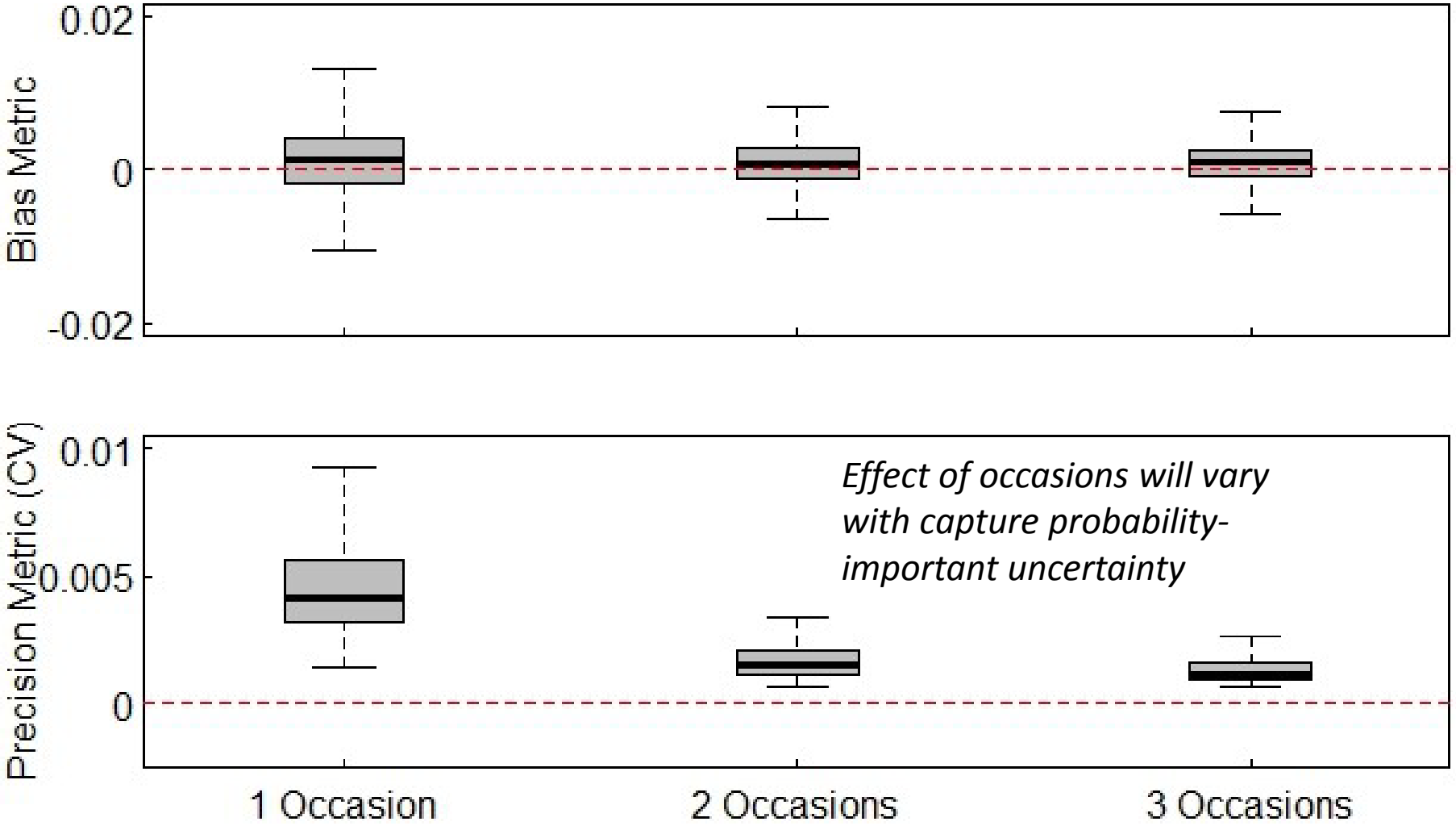
Abundance Estimates: Precision



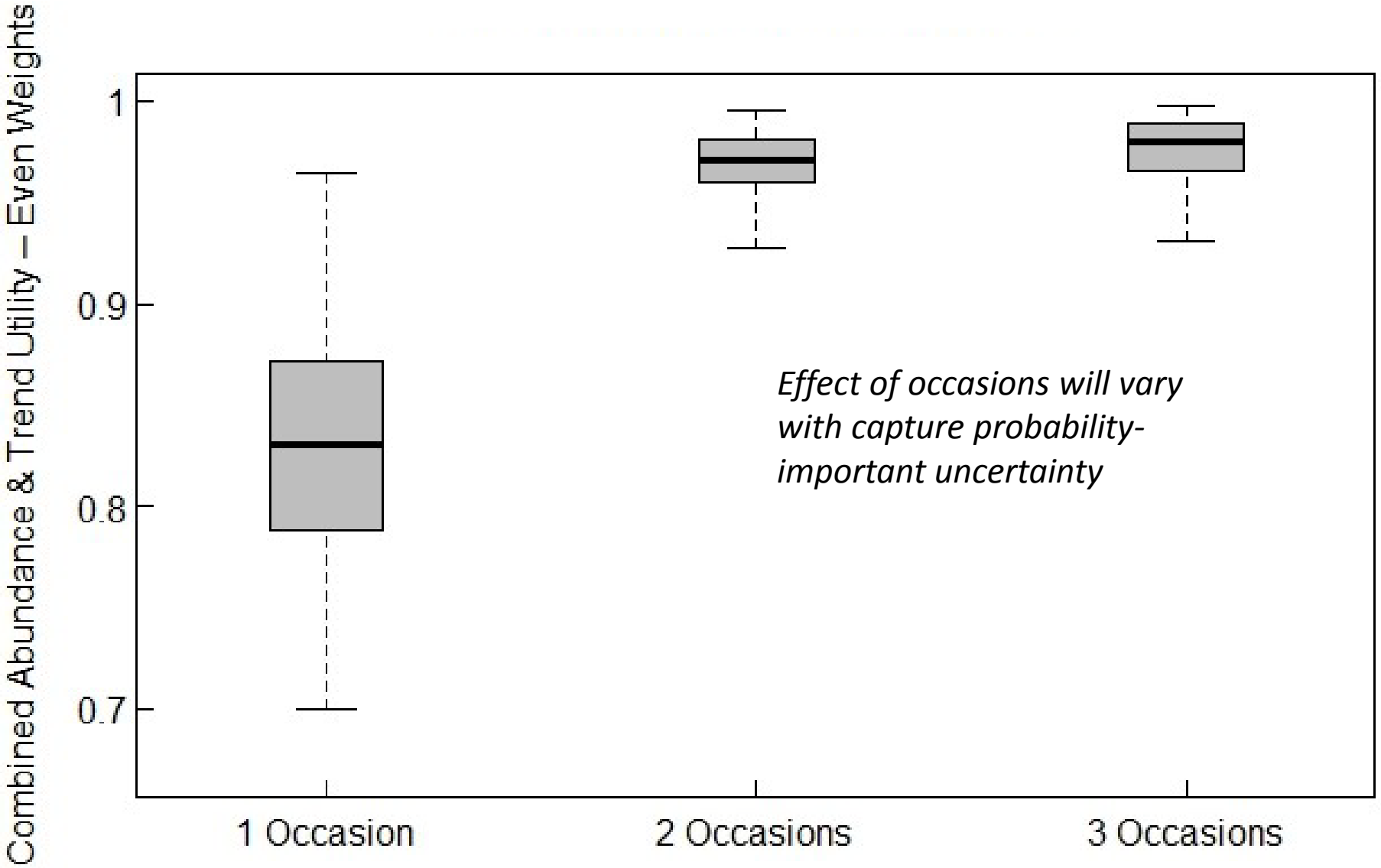
Abundance Estimates



Trend Estimates

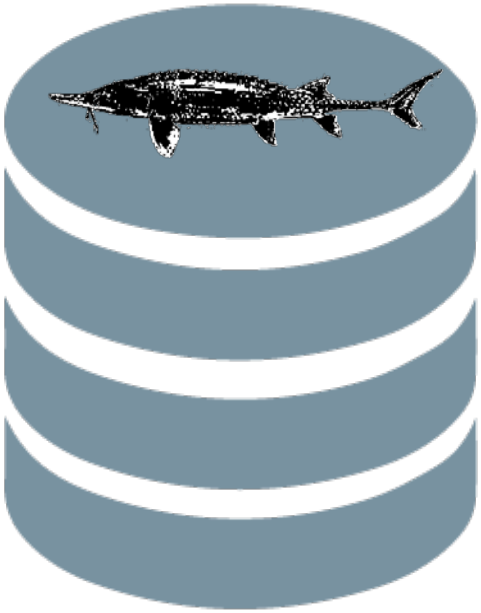


Combined Benefit



Adult Sampling Details & Logistics

- Dates historically sampled
- Lower basin dates exceeding upper temperature risks (no gill nets if temperature > 13)
- Gear constraints



Adult sampling details

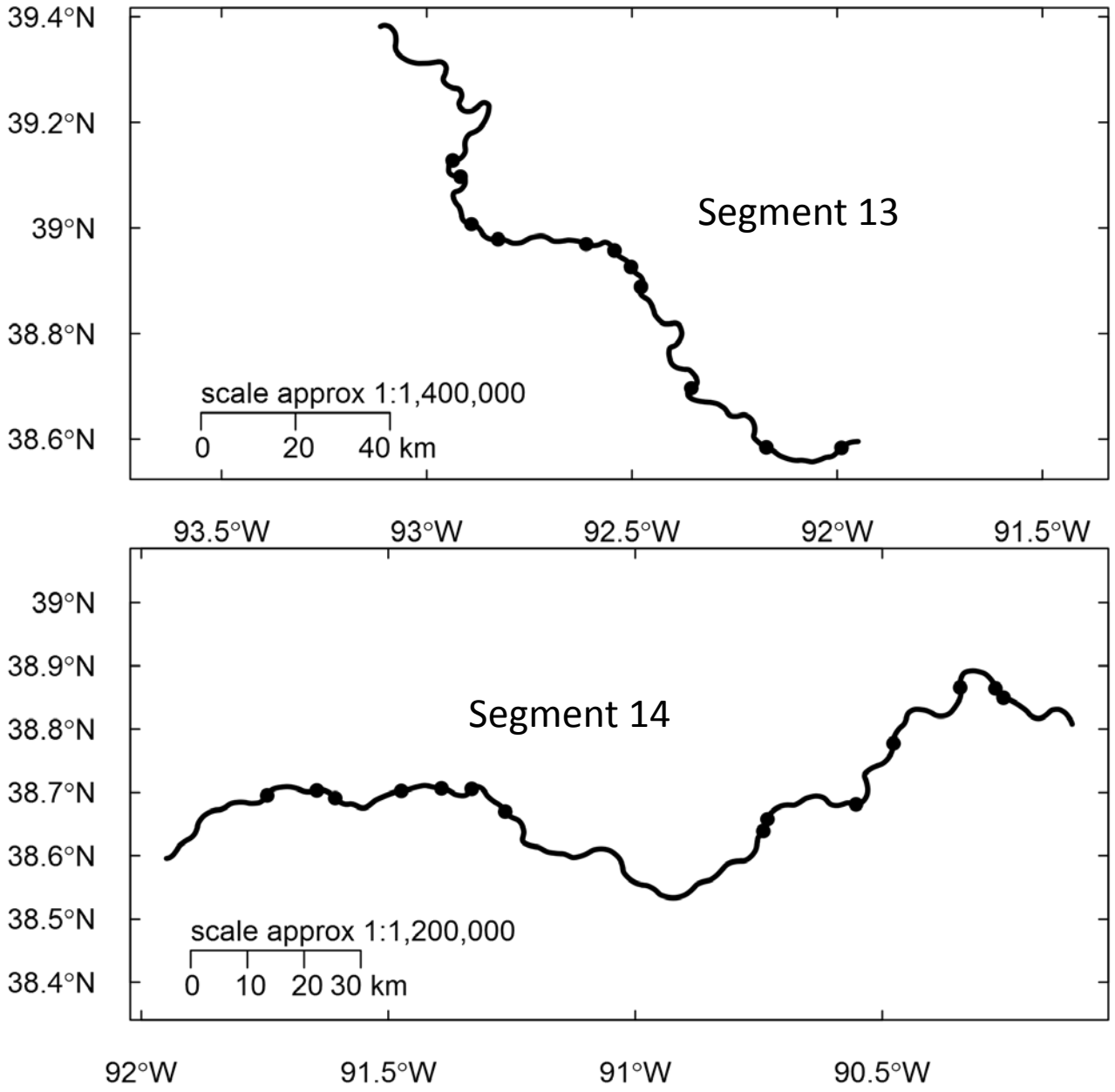
						Week of year (September 1 to June 1)																		
Segment	Group	Bends to sample	Crews	Bends/week	Weeks to complete	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
2	MT	12	1	2	6	2	2	2	2	2	2	x	x	x	x									
3	MT	21	1	2	10.5	x	x	x	x	x	x	x	x	x	x									
4	MR	12	1	2	6	2	2	2	2	2	2	x	x	x	x									
5&6	UFSW S-GP	10	1	2	5									2	2	2	2	2						
7	SD	12	1	2	6							2	2	2	2	2	2	x	x	x	x	x	x	
8	NE	15	1	2	7.5							2	2	2	2	2	2	2	1					
9	NE	10	1	2	5								x	x	x	x	x	x	x	x	x	x		
9	MO	10	1	2	5								x	x	x	x	x	x	x	x	x	x		
10	MO	10	1	2	5							2	2	2	2	2	2	x	x	x	x	x		
13	USACE	11	1	2	5.5									2	2	2	2	2	1	x	x	x	x	
14	USACE	14	1	2	7										x	x	x	x	x	x	x	x	x	x

		Week of year (September 1 to June 1)																								
Segment	Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
2	MT												x	x	x	x	x	x	x	x	x	x	x	x	x	x
3	MT												x	x	x	1	2	2	2	2	2	2	2	2	2	2
4	MR												x	x	x	x	x	2	x	x	x	x	x	x	x	x
5&6	UFSW S-GP										x	x	x	x	x	x	x	x	x	x						
7	SD	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x								
8	NE	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x									
9	NE	x	x	x	x	x	2	2	2	2	2	x	x	x	x	x										
9	MO	x	x	x	x	x	2	2	2	2	2	x	x	x	x	x										
10	MO	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x										
13	USACE	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x										
14	USACE	2	2	2	2	2	2	2	x	x	x	x	x	x	x	x										

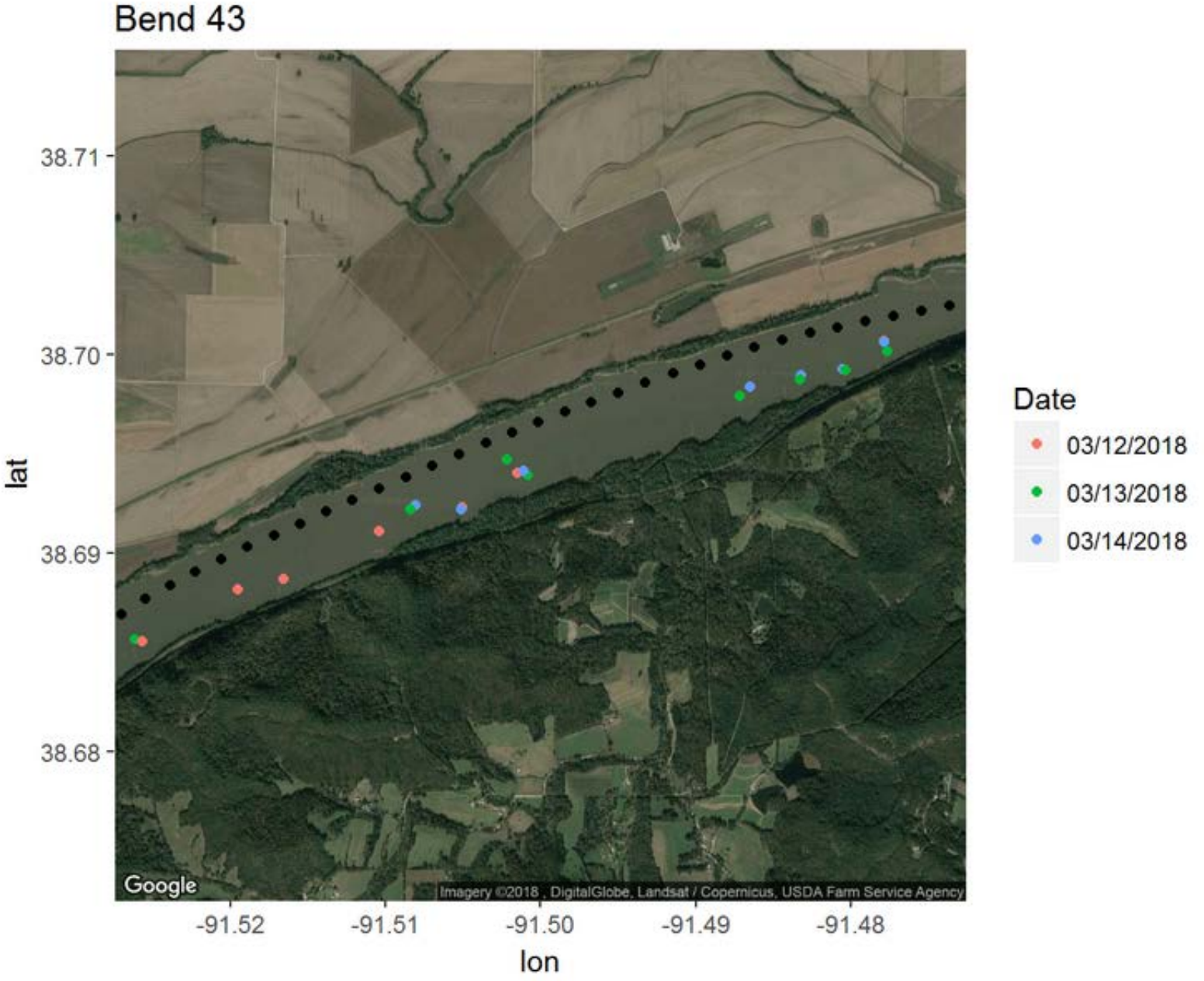
- Sample ~2 bends per weeks, constraints of protocols
- At least 8 deployments per bend
- Maintain compatibility with legacy data
- Capture probability is critical uncertainty
  - Adult PSPAP phase 1 pilot

Phase 1 Adult Sampling Pilot

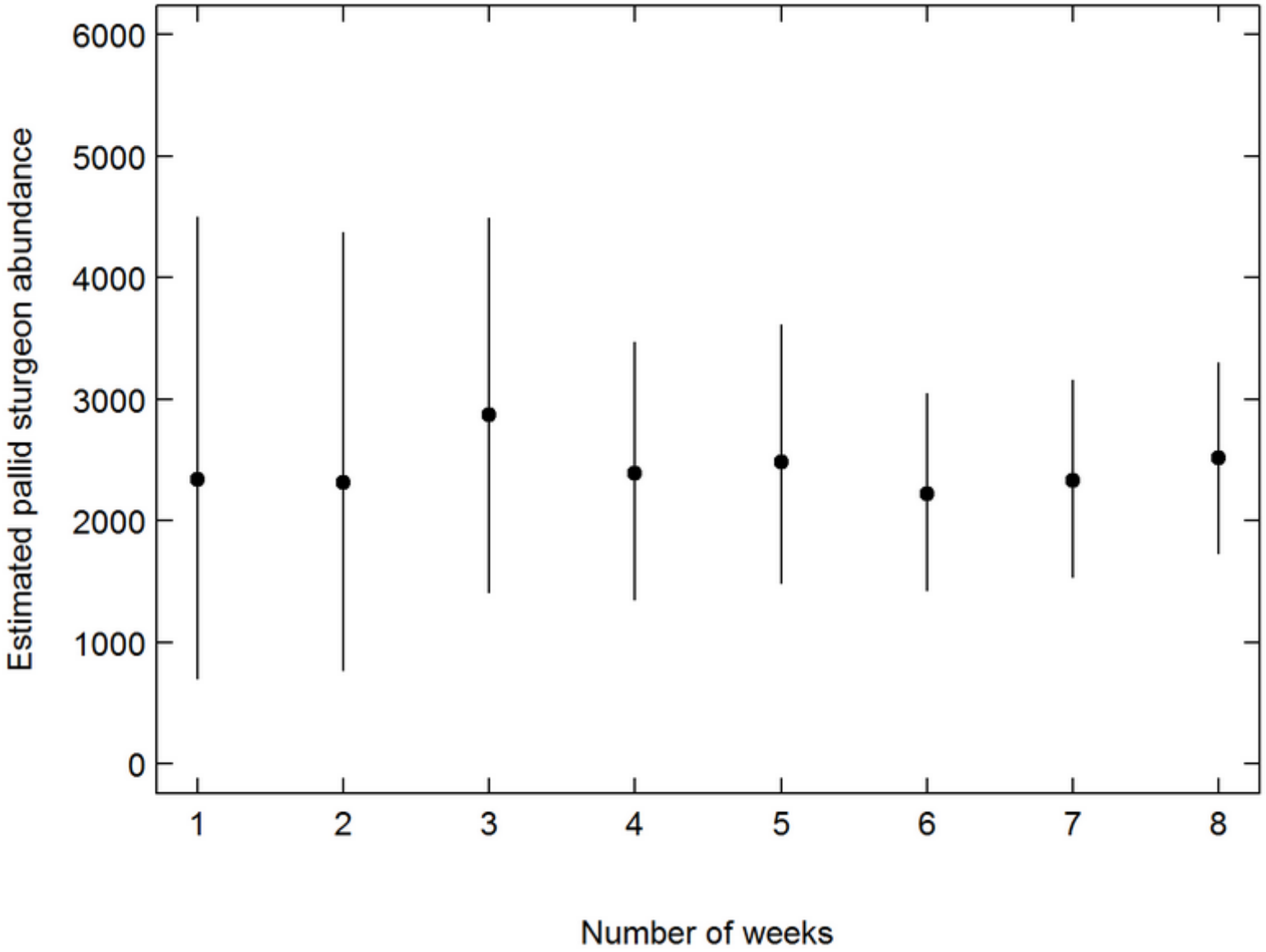
Adult PSPAP phase 1 pilot



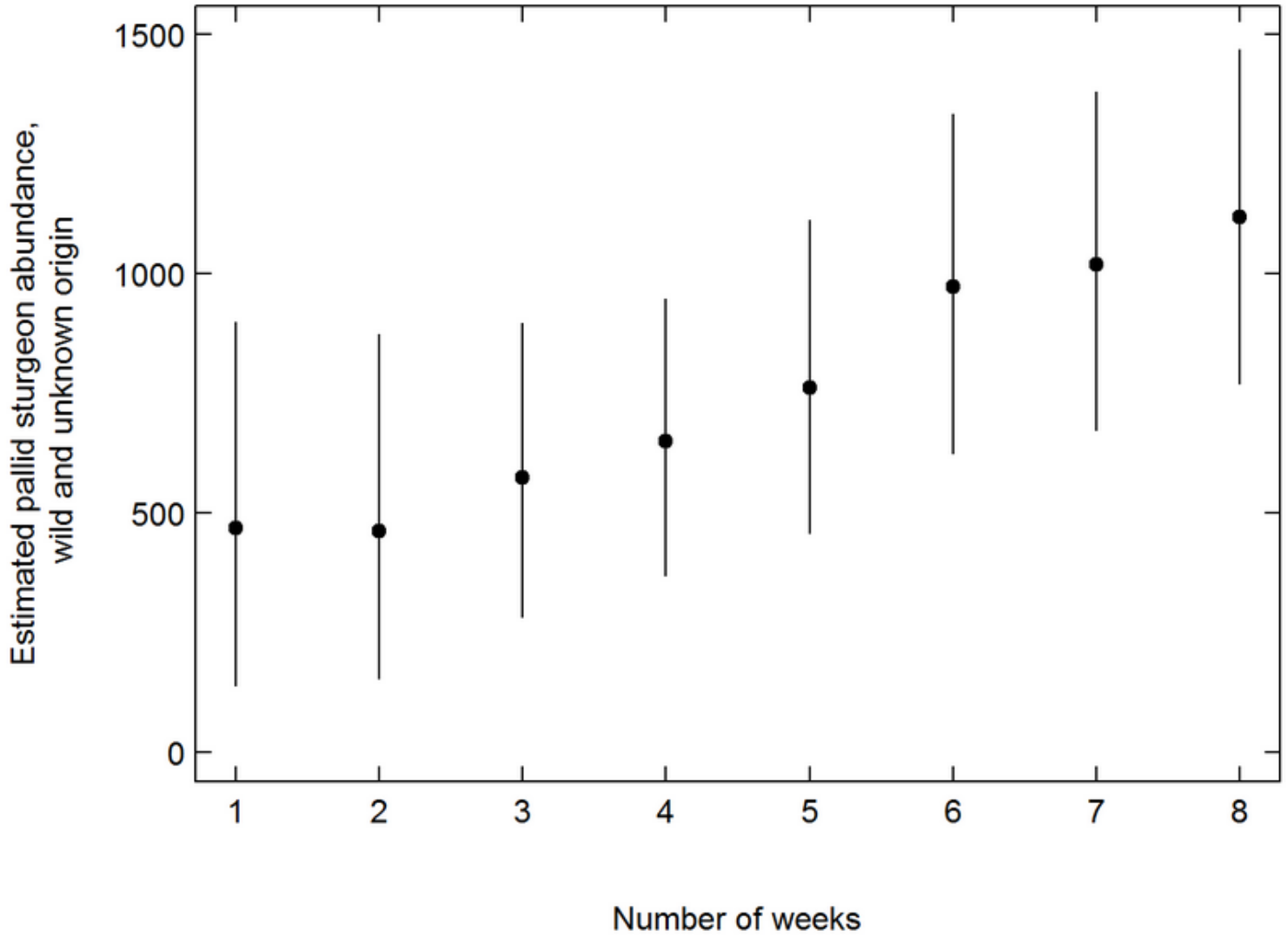
Adult sampling pilot



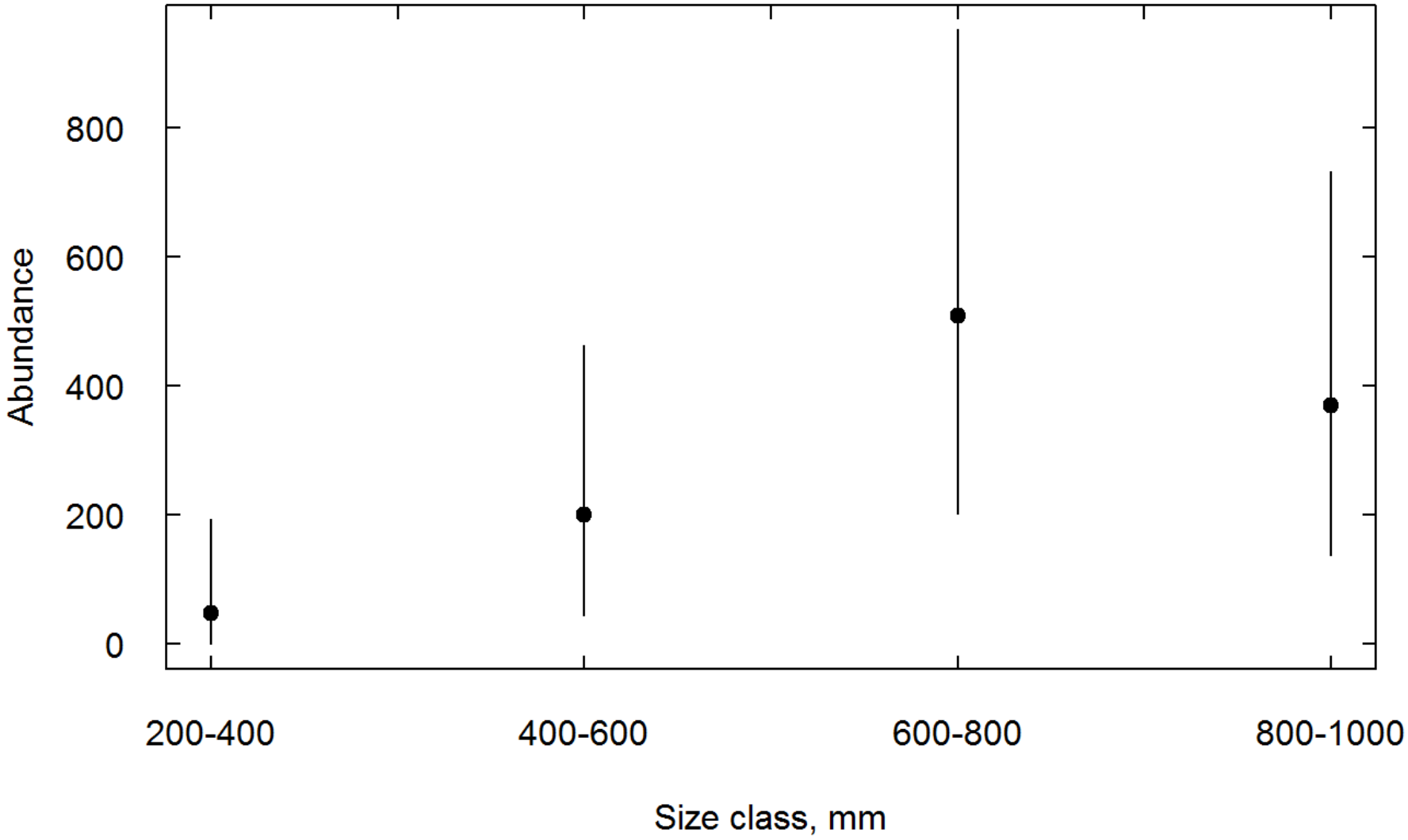
Abundance estimates



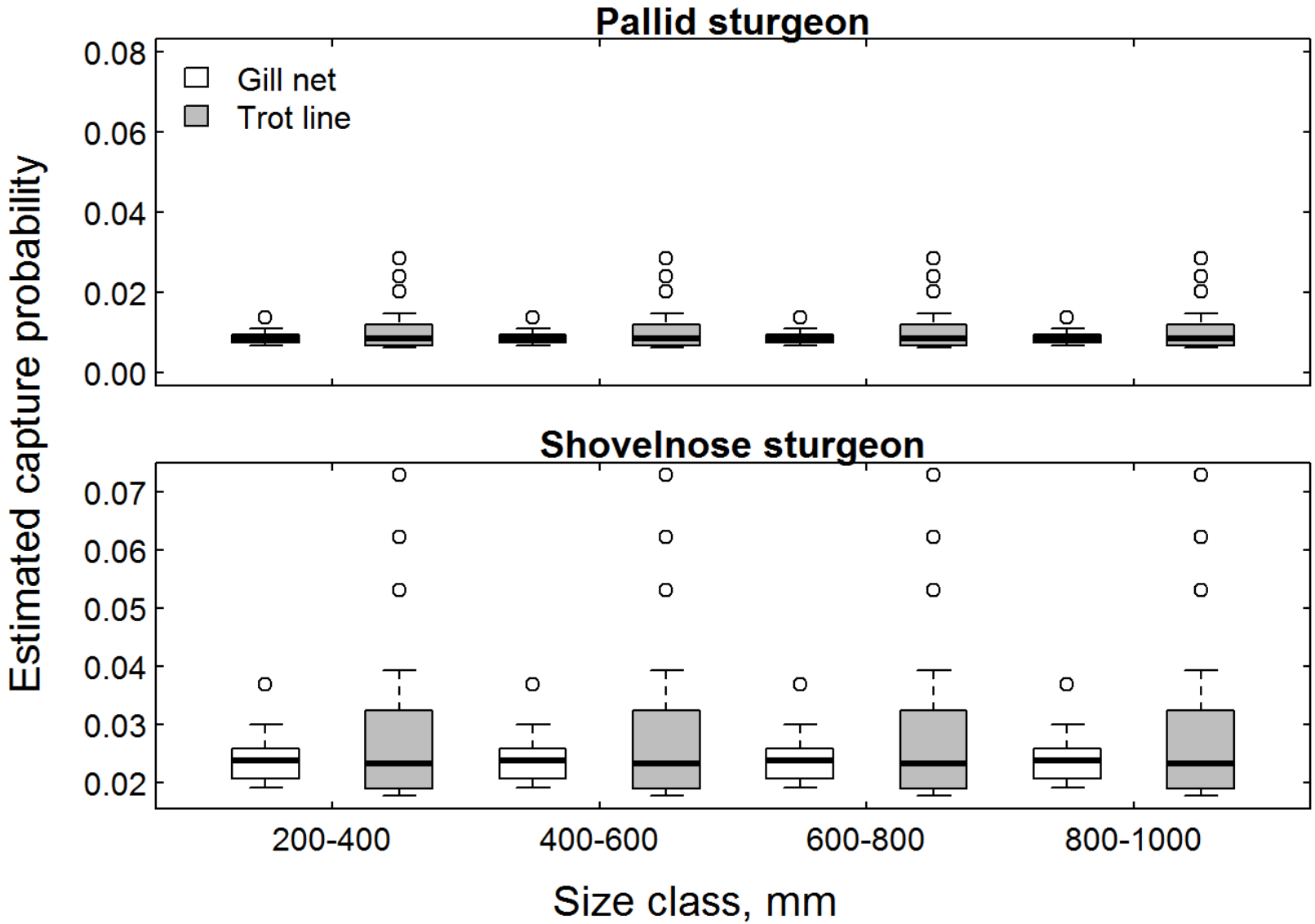
Abundance estimates: Wild & unknown origin



Abundance estimates: Size class



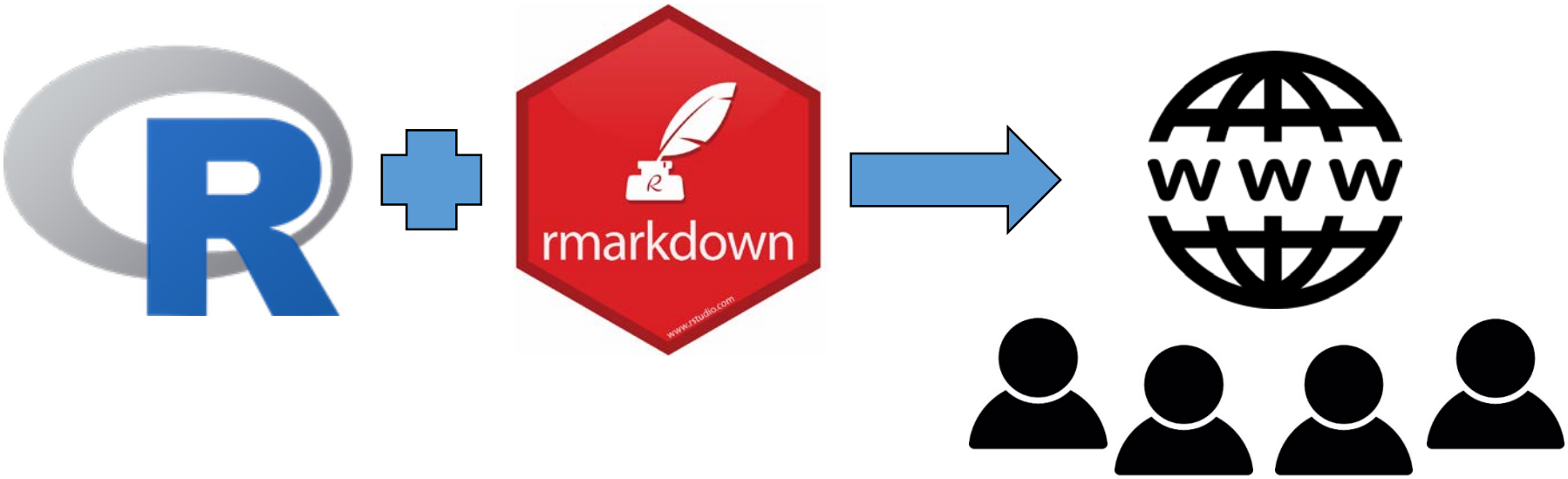
Capture probability



Almost real time estimates

Weekly estimates

Data received from field crews then:



PSPAP Segment 14: Weekly Update

04 May, 2018

Sampling and estimation overview

1. 14 bends were randomly selected in segment 14
2. Each bend was sampled on 3 occasions
3. Each bend as assigned a standard gear, either gill nets, trotlines, or combination of the 2.
4. Captured shovelnose sturgeon were floy tagged and information from shovelnose recapture used to inform capture probabilities.
5. Size class specific abundance was estiamte for each bend and aggregated for a segment level estimate using a capture-recapture estimator in a Bayesian framework.

Please note:

1. **Results are provisional and subject to change! This is a work in progress**
2. **This is a work in progress to demonstrate automated real time reporting.**
3. **There is much on going improvements to account for river conditions on capture probability estimates and include shovelnose sturgeon estimates.**

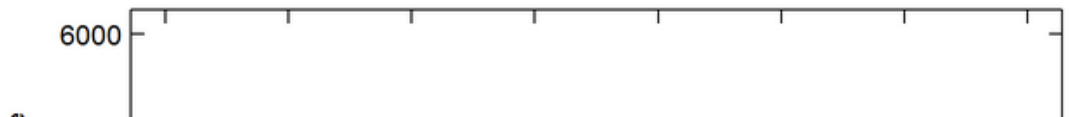
Each tab below contains information, processed data, and estimates from field crew sampling.

1. Sampling year summary-provides information from sampling including weekly abundance estimates.
2. Segment level estimates-provides segment level estimates of:
    a. abundance (total, wild and unknown origin) by size class,
    b. ratio of wild and unknown to hathchery, and
    c. capture probilities by gear, size class, and sturgeon species.
3. Catch per unit effort-provides a summary of:
    a. catch per unit effort by gear type and sturgeon species, and
    b. proportion of deployments capturing at least 1 sturgeon by gear type and sturgeon species.
4. Bend maps-Provides a segement level overiew of the randomly selected bends and gear deployments by occasion within each bend.

1. Sampling year summary | 2. Segment level estimates | 3. Catch per unit effort | 4. Bend maps

- Sampling within segment 14 is 100% done (14 bends out of 14 bends).
- 53.5 km of segment 14 have been sampled representing 26.8% of the segment length

The figure below illustrates the segment-level abundance estimates with increasing information, i.e., addition of bends each week.



Ongoing development

- Alternative capture probability models
  - Behavior
  - Chao estimator
- Evaluating estimator assumptions
  1. Shovelnose & pallid sturgeon capture probability (NGP broodstock data from 2008 & 2009)
  2. Incorporation of telemetry pallid sturgeon (NGP broodstock data 2017)
  3. Pallid sturgeon capture probability (MDC broodstock data 2018)
- Cost:benefit analysis

Additional PSPAP V2.0 Tasks

Additional PSPAP V2.0 Tasks

1. Age-0, intensive [MRRP Sub-objective 1]
2. Sturgeon season mark/recapture [MRRP Sub-objective 2]
3. Broodstock assessment
4. Background telemetry
    1. Stations & sweeps
    2. Tagged population maintenance
    3. Reproductive & passage telemetry
5. Overwintering telemetry
6. Data QA/QC, analysis & writing
7. Fish community sampling

Telemetry Benefits

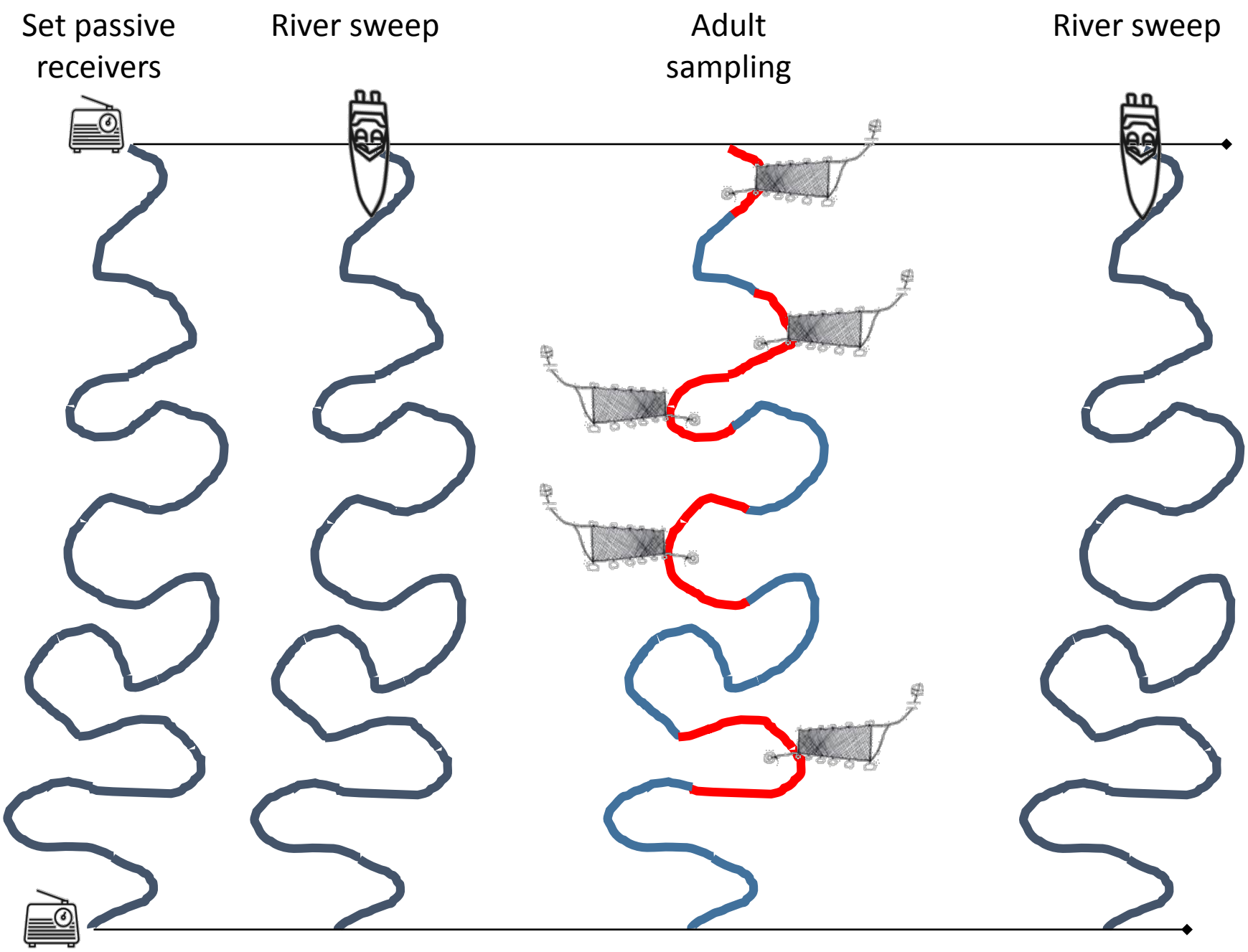
- Immigration & Emigration:
  - Provide data and parameter estimates for fish movements into and out of the sampling area (e.g., Mississippi, Yellowstone, Platte)
- Provide data on other model violating movements (between bends within the sampling year)
- Provide reproductive movement and overwintering location data

Telemetry Lower basin

- Depth and conductivity precludes radio tracking
- Mobile bed in lower basin creates noisy environment and limits acoustic telemetry
- USGS evaluating
  - High frequency tags
  - VEMCO R-code architecture at 69 kHz (Mississippi Compatibility)
  - Passive stations-for example gates on segment ends

Telemetry Upper Basin

- Fewer environmental challenges but conditions of high flow and conductivity can limit use
- Radio tags are usable
  - Track at 12-20 miles per hour
- Expand on existing telemetry network
- Challenges in number of tags and code space per frequency
- Addition of passive monitoring systems at tributary junctions and segment boundaries
- Research on tag types feasibility and benefitsis ongoing


Set passive receivers
River sweep
Adult sampling
River sweep

Provide additional information to asses & estimate

1. Capture probability
2. Assumption violations
3. Annual movement
4. Indirect estimates of emigration to systems like the Mississippi River… with caveats

Telemetry in the works

- Technology evaluation
  - Passive receivers for gatekeeping among segments and tributaries
  - Radio, acoustic, both?
  - Costs
  - Compatibility with tributary programs
- Data structure, database, & cooperators
- Links to big questions and ancillary objectives
  - Drift & dispersal, Use of Mississippi River and tributaries, Habitat availability and selectin, spawning habitat availability & selection, movement, IRC habitat, foraging habitat

Broodstock Collection

- Ensure the continuation of broodstock data collection (broodstock programs may change)
- Current broodstock programs provide data that informs model inputs for the collaborative population model (fundamental information objective 4)
- Expand broodstock sampling, as needed, to meet ancillary sub-objectives & link to big questions

Fish community sampling

- Legacy data compatibility
- Use existing protocols & selected bends
- Sampling dependent on age-0, adult, broodstock, telemetry first
- May not be included if cost & time constrains efforts
- May be more efficient as a science component to address big questions

Wrapping up

- Work to include ancillary objectives within constraints
- Iterative and adaptive process
- Learn from small scale pilots
- Learn from pilot implementation at basin level
- Adjust, optimize, & inform future sampling
- PSPAP v. 2.0 is developed to estimate metrics needed to assess species status and but is part of a larger information network