WF4313/6413-Fisheries Management

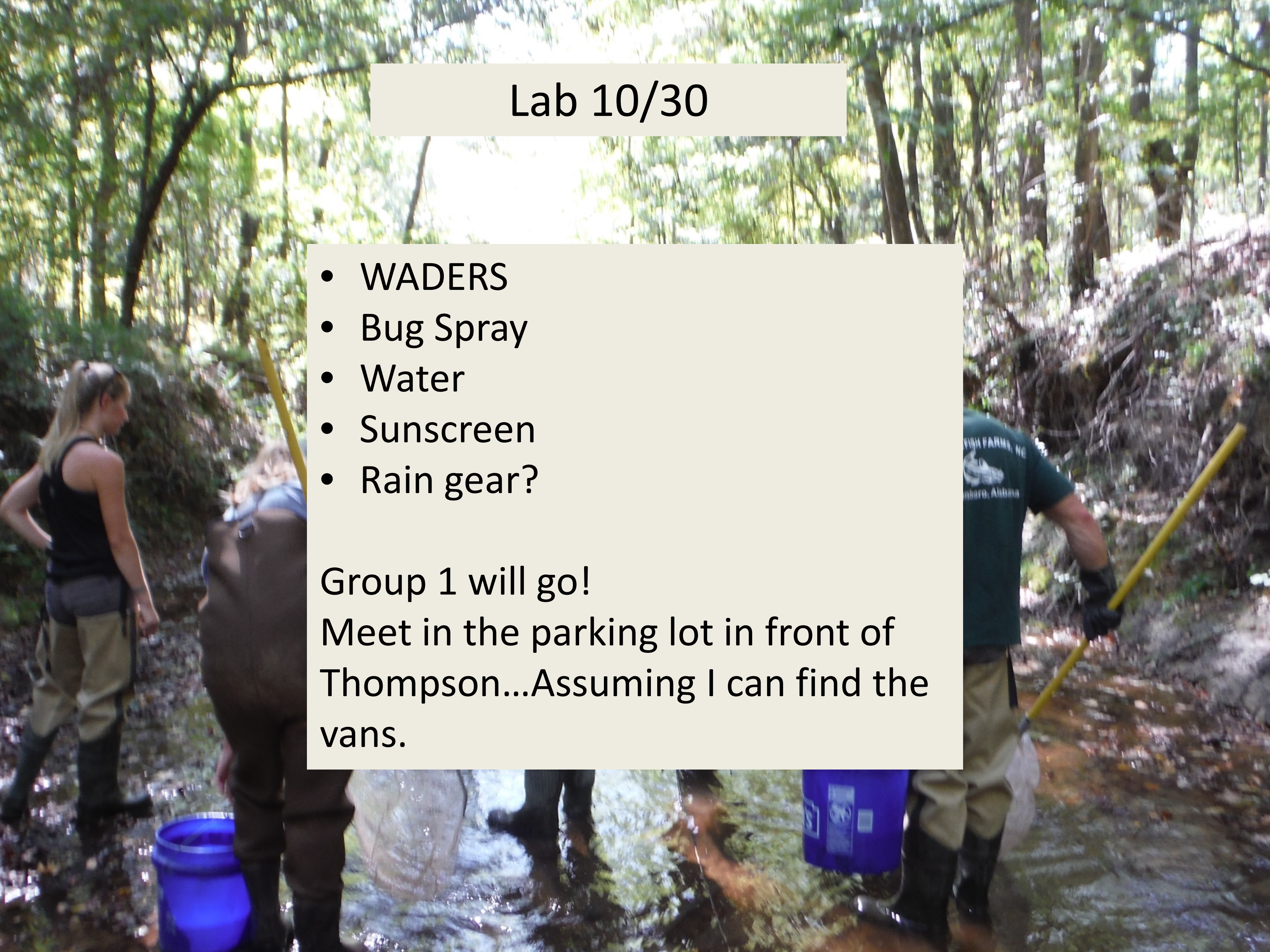
Class 15

Announcements

Revised Schedule**

- October 30 = Group 1 @ Panther Creek
- November 6th = Group 2 we'll do something
- November 13th = NO LAB… ☹
- Exam II = November 14th
- November 20th = Group 1 will do what group 2 did
- November 27th & December 4th ???

** Contingent on van availability



Lab 10/30

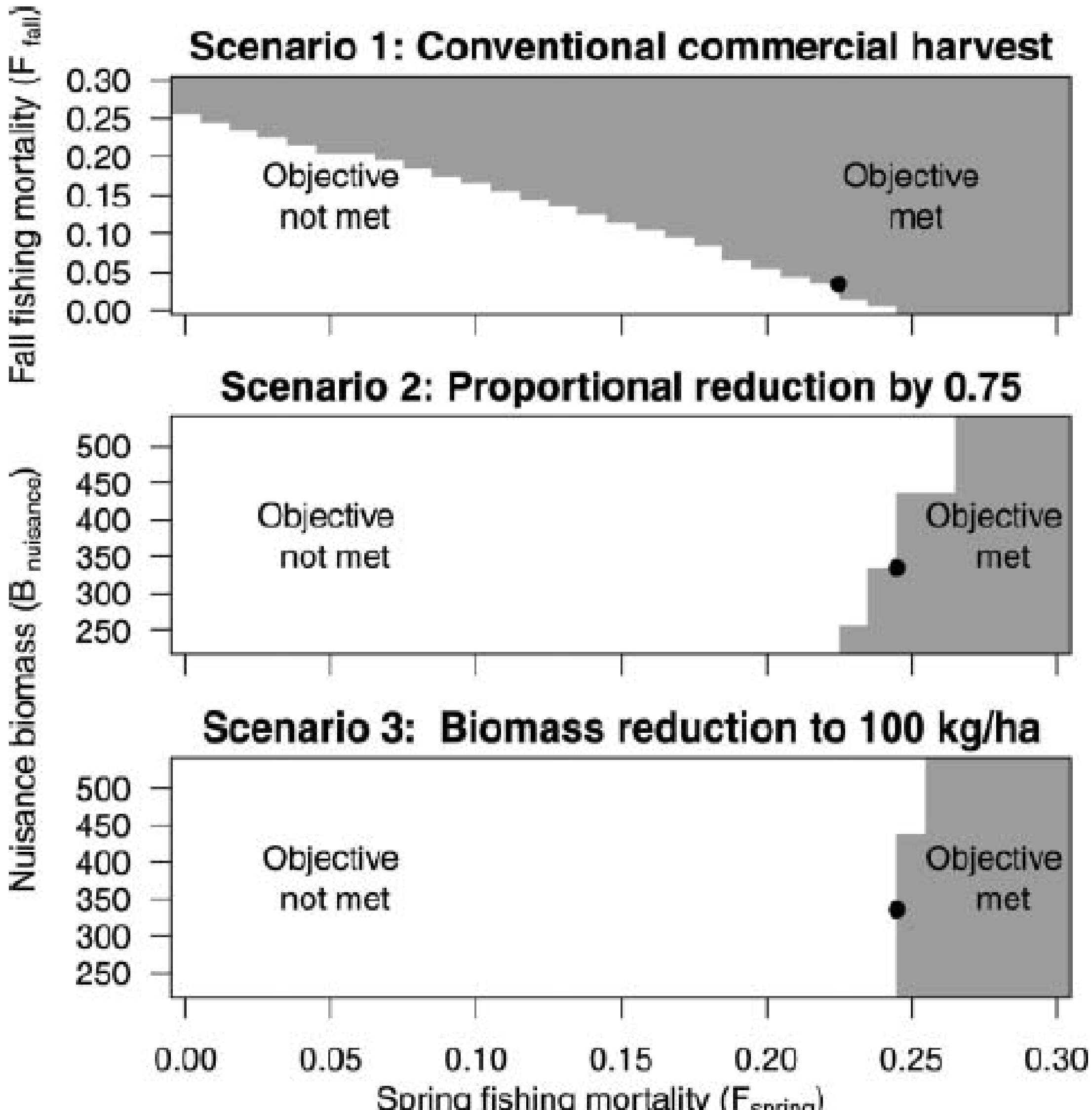
- WADERS
- Bug Spray
- Water
- Sunscreen
- Rain gear?

Group 1 will go!
Meet in the parking lot in front of Thompson…Assuming I can find the vans.

Interested in chasing more lamprey? Opportunities to assist on an undergraduate research project.

WHERE WE LEFT OFF

Meeting management objectives

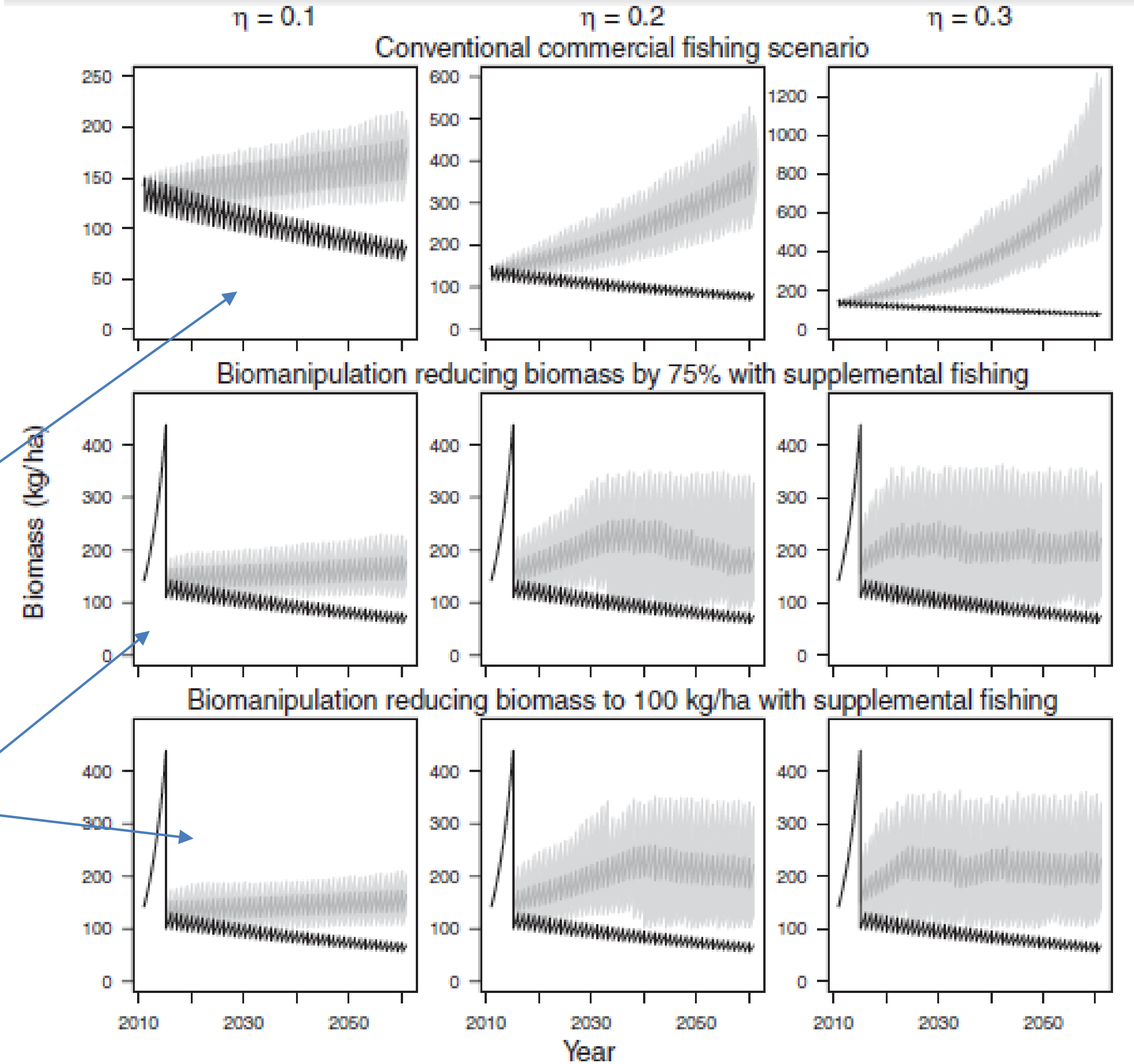


Partial Controllability-not fully implementing a management alternative

What happens if the commercial fisher missing the target by 10, 20, or 30%?

Not very robust to missing the target

Somewhat robust to missing the target

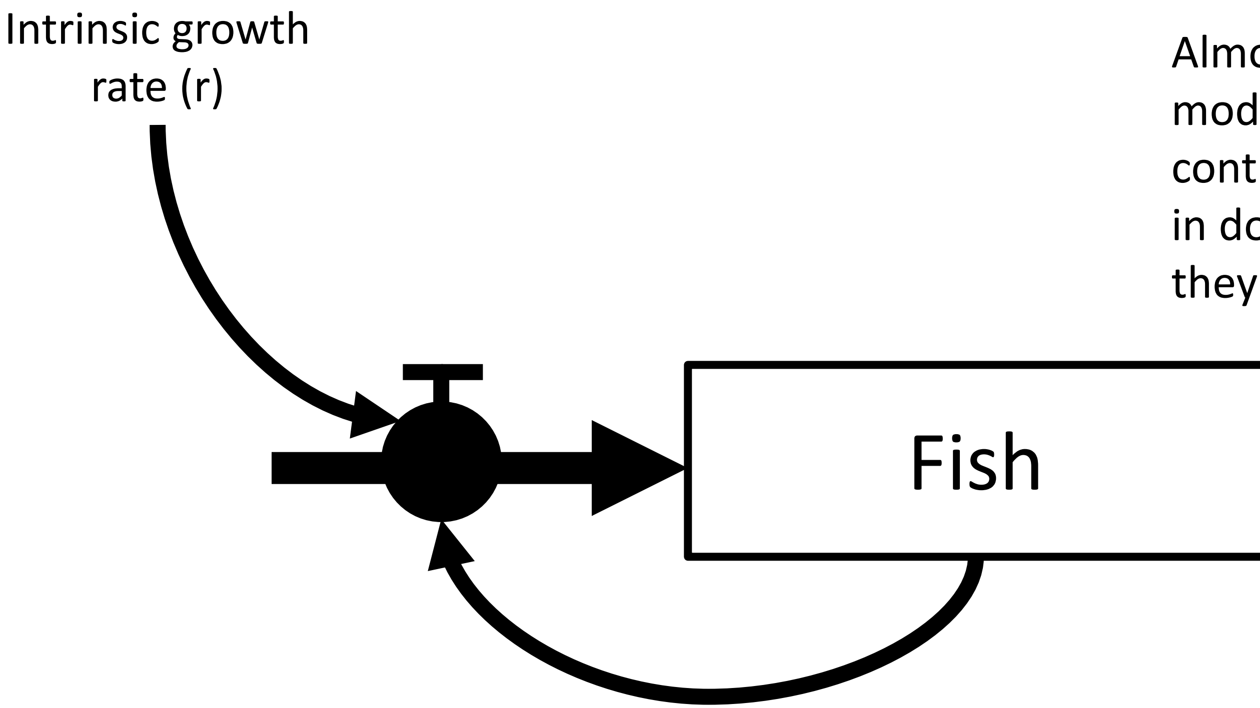


Commercial versus Recreational

Value: Biomass

Value: Size

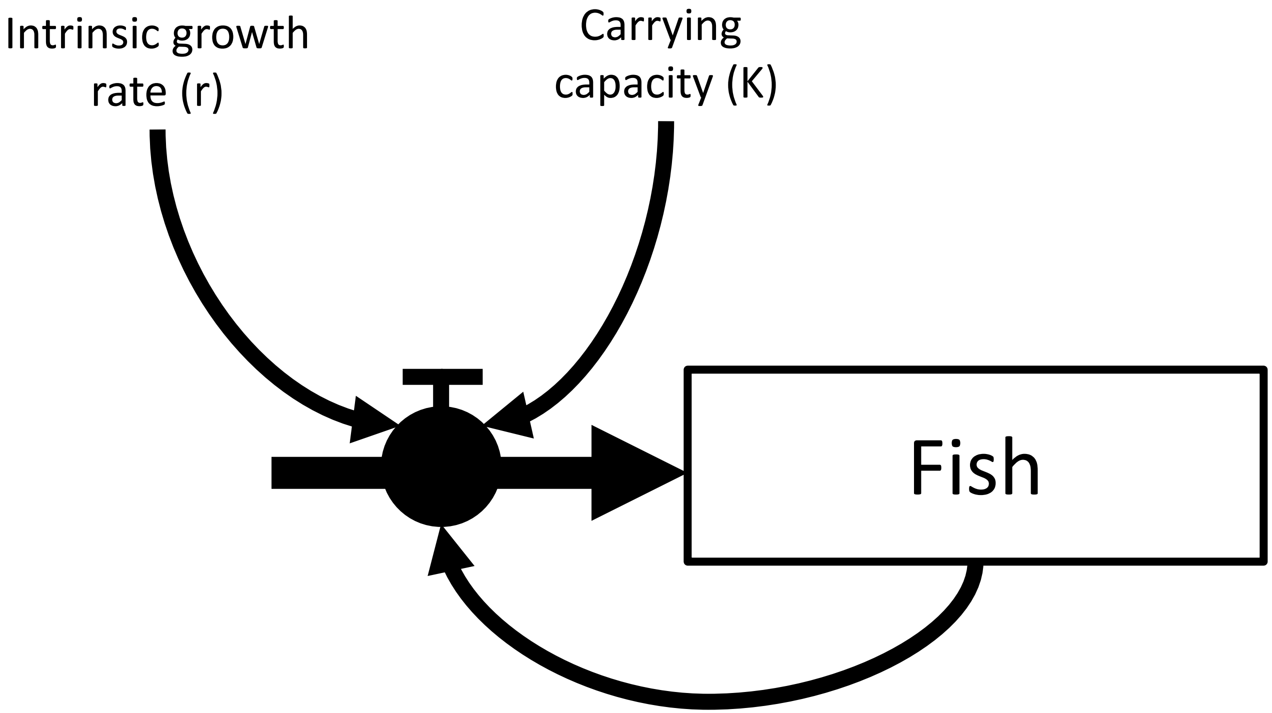
Exponential population model- continuous



Almost all fisheries models are continuous…When in doubt assume they are!

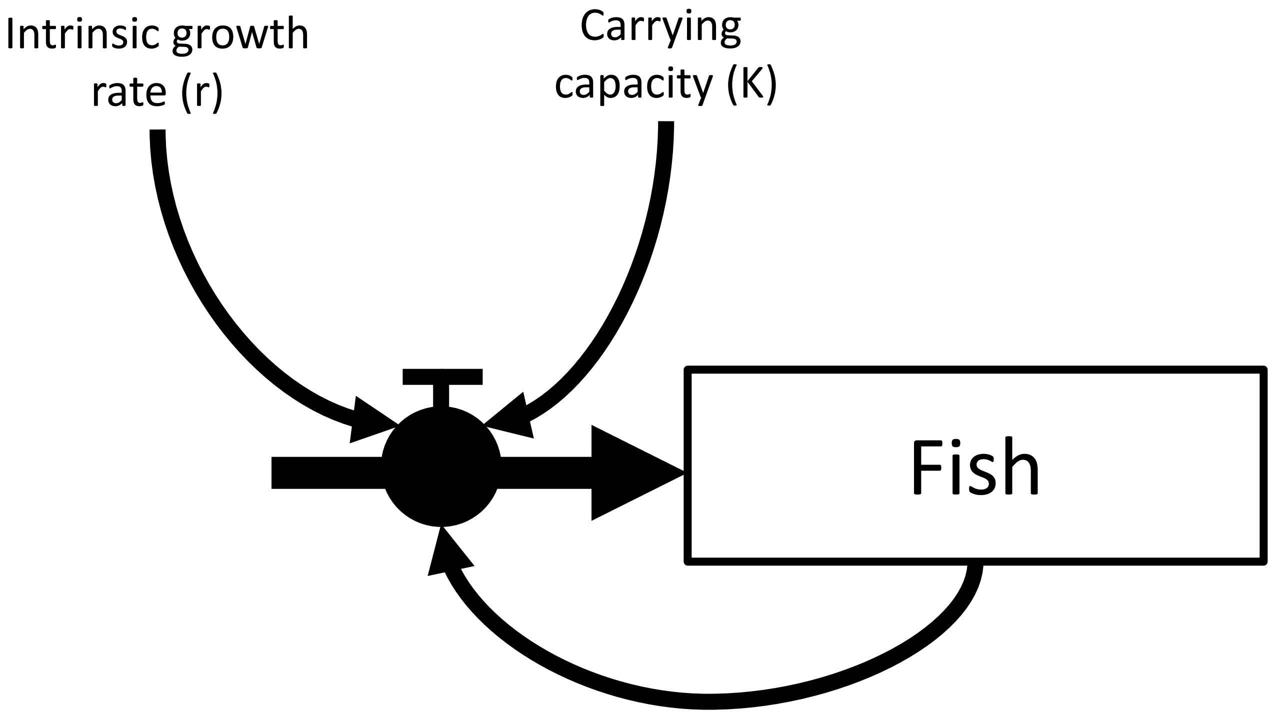
$$\frac{dA}{dt} = r \cdot A$$

Graham-Schaefer model



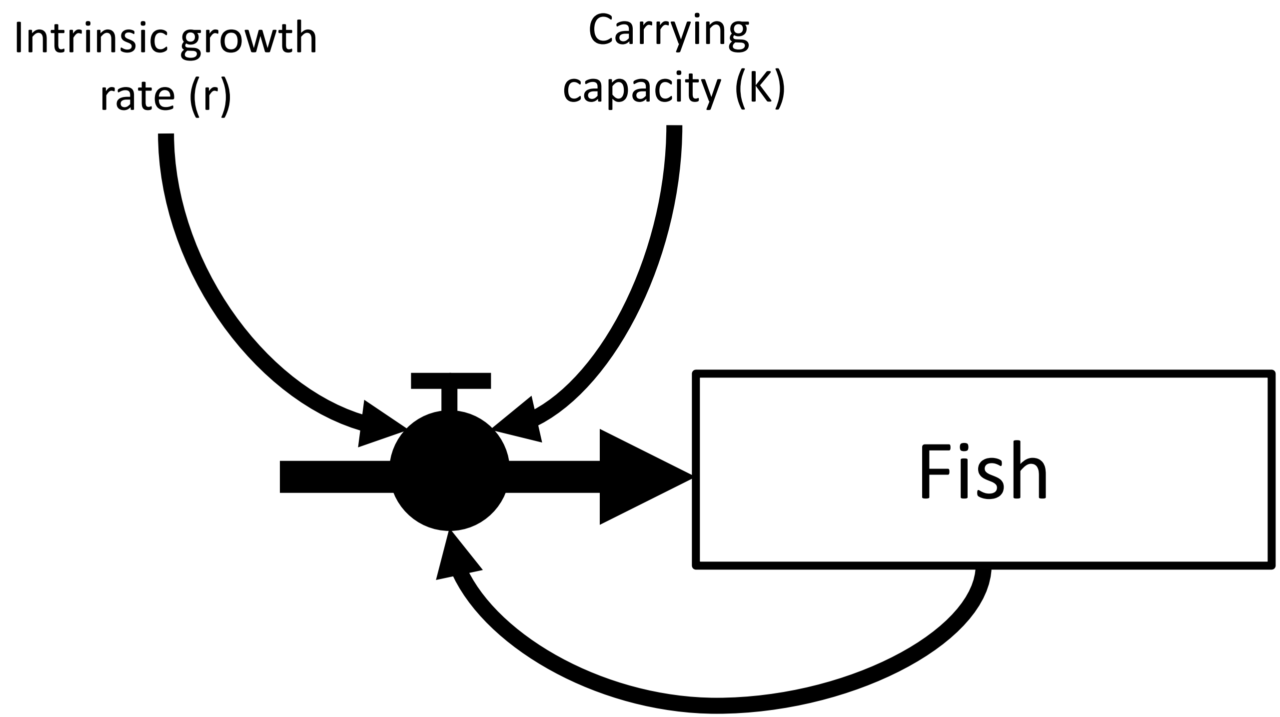
$$\frac{dA}{dt} = r \cdot A_t \cdot \frac{K - A_t}{K}$$

Fox model

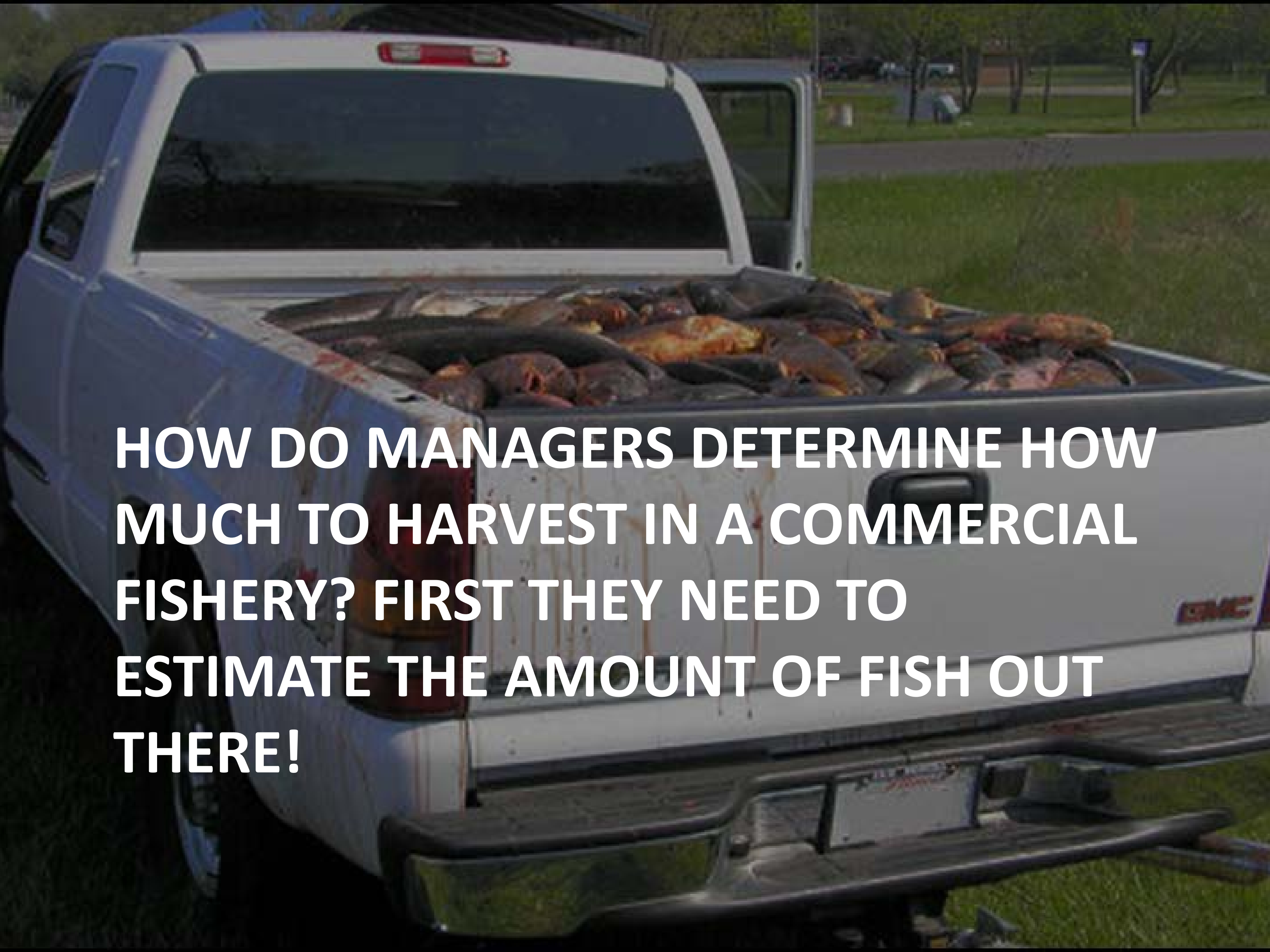


$$\frac{dA}{dt} = rA_t\left[1 - \ln\frac{A_t}{K}\right]$$

Pella-Tomlinson model



$$\frac{dA}{dt} = \frac{r}{p} A_t \left[\frac{K - A_t}{K} \right]^p$$

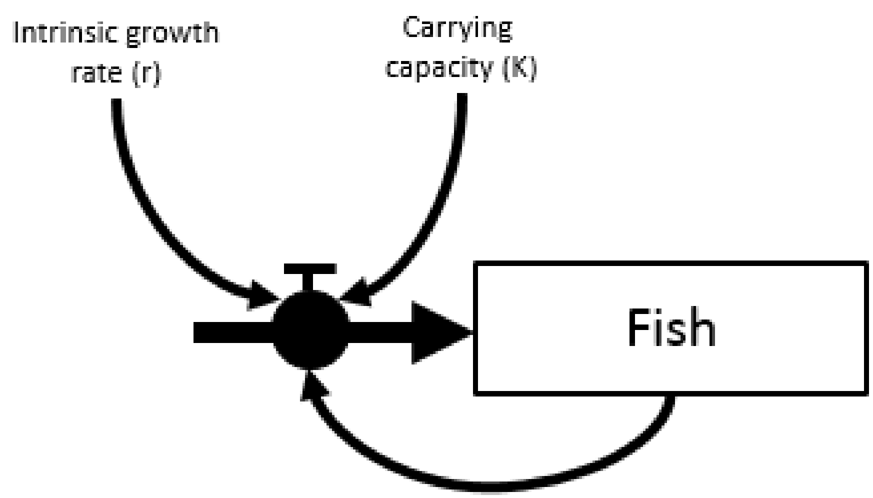


HOW DO MANAGERS DETERMINE HOW MUCH TO HARVEST IN A COMMERCIAL FISHERY? FIRST THEY NEED TO ESTIMATE THE AMOUNT OF FISH OUT THERE!

What do we need to figure out ho much to harvest?

What is in the biomass dynamics models?

1. States: Fish abundance & biomass
2. Parameters:
    1. Intrinsic growth rate
    2. Carrying capacity



How do we estimate abundance?

Estimators types

1. Removals
   - 3 pass removal
   - Harvest removal
2. Capture-recapture
   - Closed population estimators
   - Open population estimators

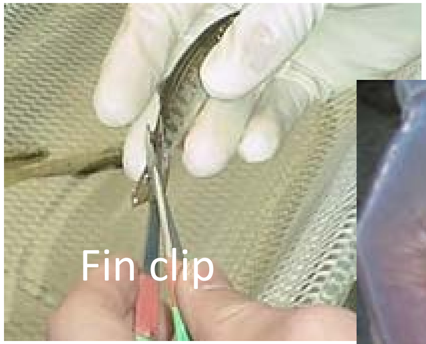
Removals: 3 pass depletion

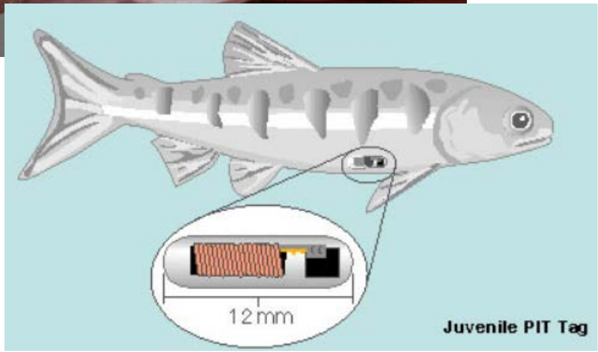
If we remove fish with a constant probability or exploitation then we can relate the cumulative catch and actual catch to estimate capture probability and estimate abundance

See lab 6 for more details & lab @ Panther Creek

Capture-Recapture

1. Capture fish and mark them with a tag that can't get lost





Capture-Recapture

2. Release tagged fish back into the population to mix

Capture-Recapture

3. Go back for another capture occasion, hopefully you catch a few that you caught before.

Underlying concept of capture-recapture

- A sample of animals is Caught (C1), marked, and released (M2).
- Later a sample of C2 animals is Captured, of which R2 animals are recaptures that were previously marked.
- If capture probability (p) is independent of marking status, then the proportion of marked animals in the second sample should be equivalent to the proportion of marked animals in the total population so that

$$\frac{C}{R} = \frac{M}{N}$$

Underlying concept of capture-recapture

- If N is the total *catchable* population size. Solving for N yields the estimator:

$$N = \frac{(M \cdot C)}{R}$$

Estimating N if sample size is small

- If sample size is small, the L-P estimator is biased.
- For example, what happens if the number of recaptures is zero? A modified version with less bias was originally developed by Chapman (1951) and is commonly called the modified Petersen estimate in fisheries:

$$N = \frac{(M+1)\cdot(C+1)}{R+1} - 1$$

Lincoln-Petersen estimator assumptions

- The population is closed (geographically and demographically).
- All animals are equally likely to be captured in each sample.
- Capture and marking do not affect catchability.
- Each sample is random.
- Marks are not lost between sampling occasions.
- All marks are recorded correctly and reported on recovery in the second sample.

What is capture probability (p)?

- Defined as the probability of an animal being caught in <u>any</u> trap.
- Possible sources of variation in p include:
  - *heterogeneity* (e.g., sex, age, social status, size of fish),
  - *behavior* (e.g., trap happy or trap shy), and
  - *time* (e.g., effects of weather or sampling effort on p).

Example of Lincoln Peterson Estimator

- Suppose you caught and tagged 948 crappie
- Then you caught 421 the next day of which 167 were tagged.

$$N = 2390 = \frac{421 \cdot 948}{167}$$

Biased

$$N = 2383 = \frac{(421+1) \cdot (948+1)}{167+1} - 1$$

Unbiased

>2 Occasions Schnabel Estimator

- Extends the Lincoln-Peterson method to a series of samples in which there are 2, 3, 4,..., n samples.
- Individuals caught at each sample are first examined for marks, then marked and released.
- Only a single type of mark need be used because we just need to distinguish 2 types of individuals:
  - marked, caught in one or more prior samples; and
  - unmarked, never caught before.

>2 Occasions Schnabel Estimator

- For each sample t, the following is determined:
  - Ct = Total number of individuals caught in sample t
  - Rt = Number of individuals already marked (Recaptures) when caught in sample t
  - Mt = Number of marked animals in the population just before the sample is taken.
- Schnabel treated the multiple samples as a series of Lincoln-Peterson (L-P) samples and obtained a population estimate as a weighted average of the L-P estimates to estimate N:

$$N = SUM (Mt*Ct) / ((SUM\ Rt) + 1)$$

Assumptions of the Schnabel method

- Same as Lincoln-Petersen estimator
- Assumptions apply to all sampling periods.
- Every individual in the population is assumed to have the same capture probability for a given sampling occasion
- Capture probabilities can vary among sampling periods).

The major advantage of multiple sampling is that it is possible to evaluate the data for violations of assumptions, such as unequal capture probabilities.

Example of Schnabel Estimator

$$\sum C_t M_t = 10{,}740$$

$$\hat{N} = \frac{10{,}740}{24} = 447.5 \text{ sunfish}$$

TABLE 2.2 Mark-recapture data obtained for a Schnabel-type estimate of population size

Date, t	Number of fish caught C_t	Number of recaptures[b] R_t	Number newly marked (less deaths)[c]	Marked fish at large[d] M_t
June 2	10	0	10	0
June 3	27	0	27	10
June 4	17	0	17	37
June 5	7	0	7	54
June 6	1	0	1	61
June 7	5	0	5	62
June 8	6	2	4	67
June 9	15	1	14	71
June 10	9	5	4	85
June 11	18	5	13	89
June 12	16	4	10	102
June 13	5	2	3	112
June 14	7	2	4	115
June 15	19	3	-	119
Totals	162	24	119	984

[a] S.D. Gerking (1953) marked and released sunfish in an Indiana lake for 14 days and obtained these data.

[b] The number of fish already marked when taken from the nets.

[c] Note that there were two accidental deaths on June 12 and one death on June 14.

[d] Number of marked fish assumed to be alive in the lake in the instant just before sample t is taken.

Capture-Recapture in practice more than 2 occasions

Suppose you go out 4 times to catch fish and your capture probability is 0.3. If there are 10,000 fish in the population the fish can be:

Captured ($p=0.3$) or not ($p=0.7$) on occasion 1

Captured ($p=0.3$) or not ($p=0.7$) on occasion 2

Captured ($p=0.3$) or not ($p=0.7$) on occasion 3

Captured ($p=0.3$) or not ($p=0.7$) on occasion 4

Capture histories of individuals

Capture History	Count
0000	24241
0001	10396
0010	10164
0011	4324
0100	10170
0101	4316
0110	4375
0111	1898
1000	10458
1001	4395
1010	4381
1011	1924
1100	4437
1101	1881
1110	1876
1111	764

Never captured → 0000

Capture history (1 is captured and 0 is not) → 0110

Captured every time → 1111

Adds up to 10,000 (all rows)

Probability of not being captured

(1-p)*(1-p)*(1-p)*(1-p)=Probability no capture

(1-.3)*(1-.3)*(1-.3)*(1-.3)=Probability no capture

(.7)*(.7)*(.7)*(.7)=0.24

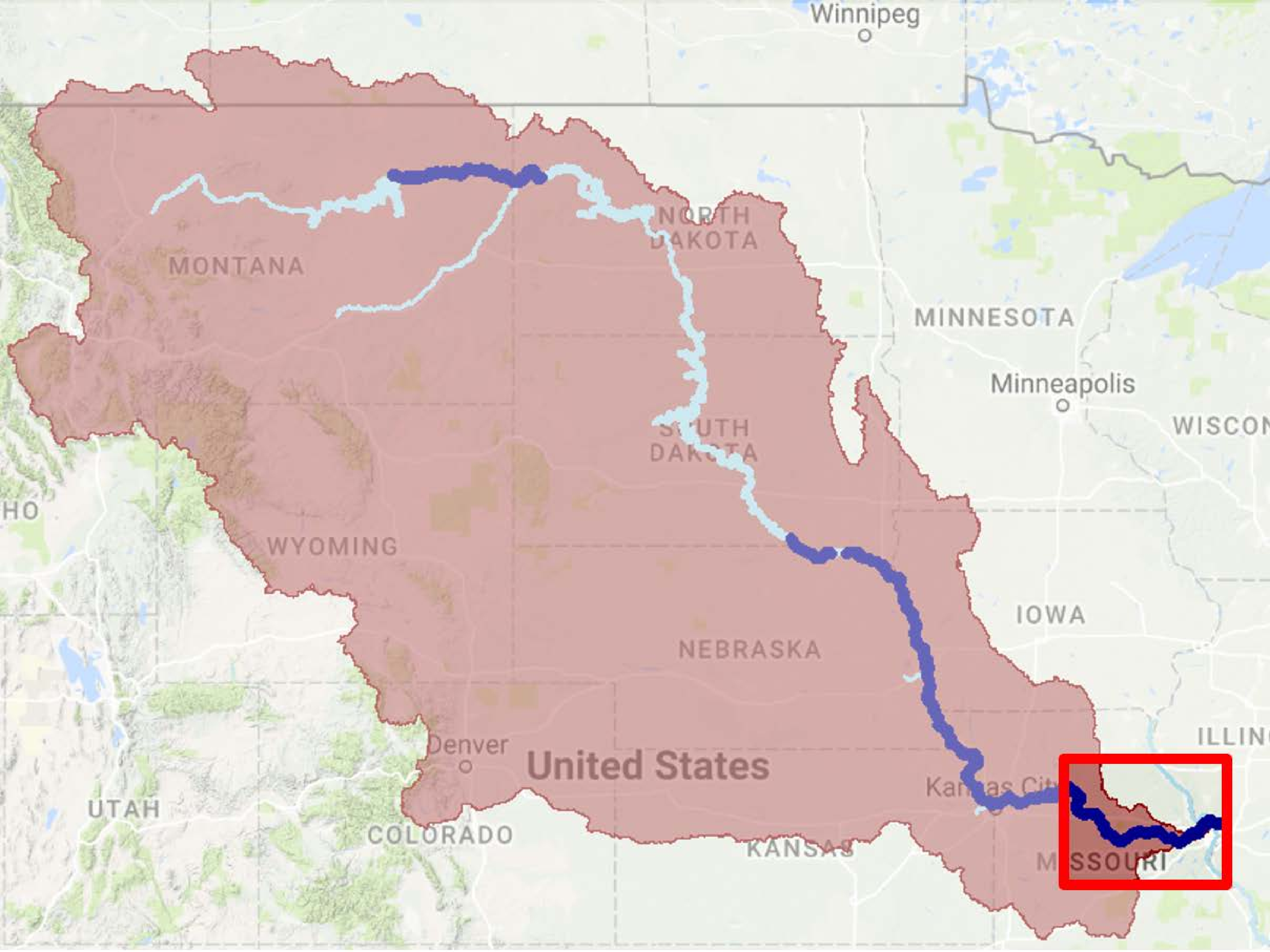
```
0000 24241
0001 10396
0010 10164
0011  4324
0100 10170
```

This number is ~100,000*0.24!

Benefits of individual capture histories?

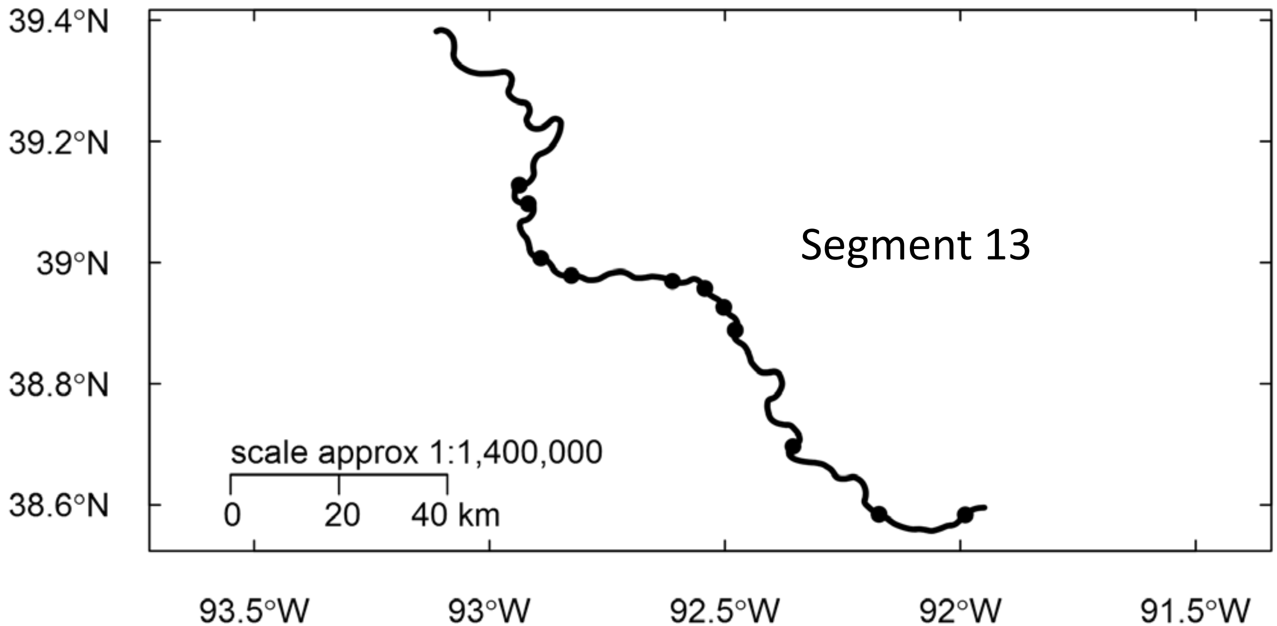
- Can deal with heterogeneous *P*
- Behavior (trap happy, trap shy)
- Time effects
- Individual covariates (e.g., size)

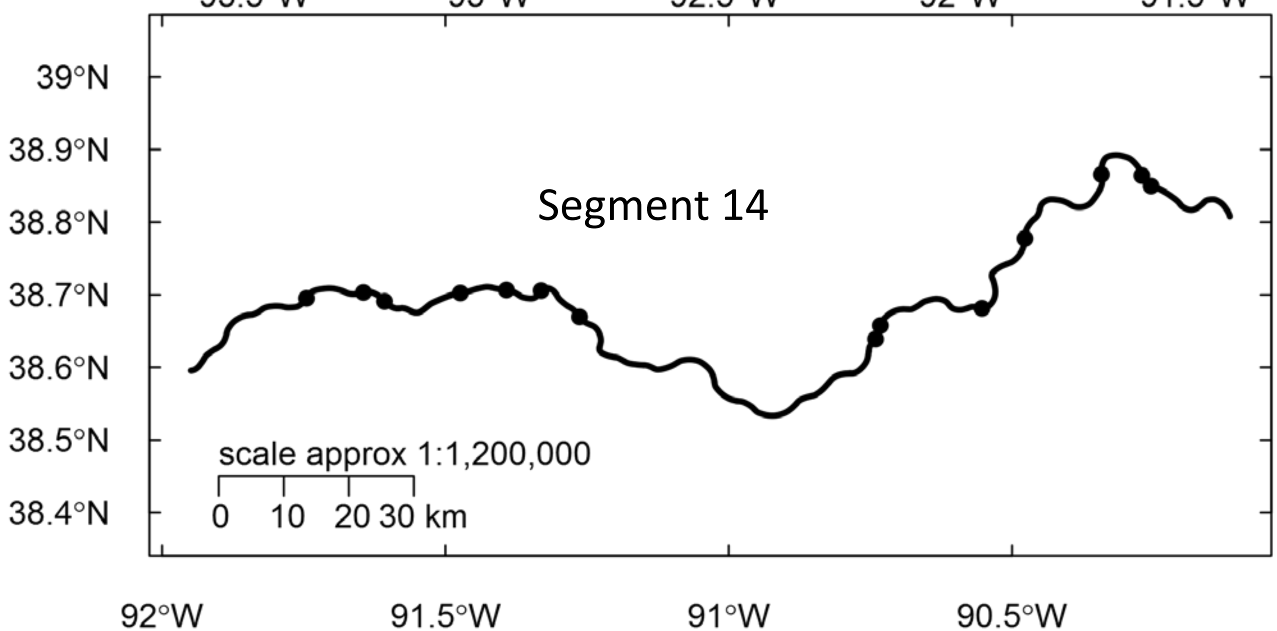
MANAGEMENT CASE STUDY: PALLID STURGEON ABUNDANCE



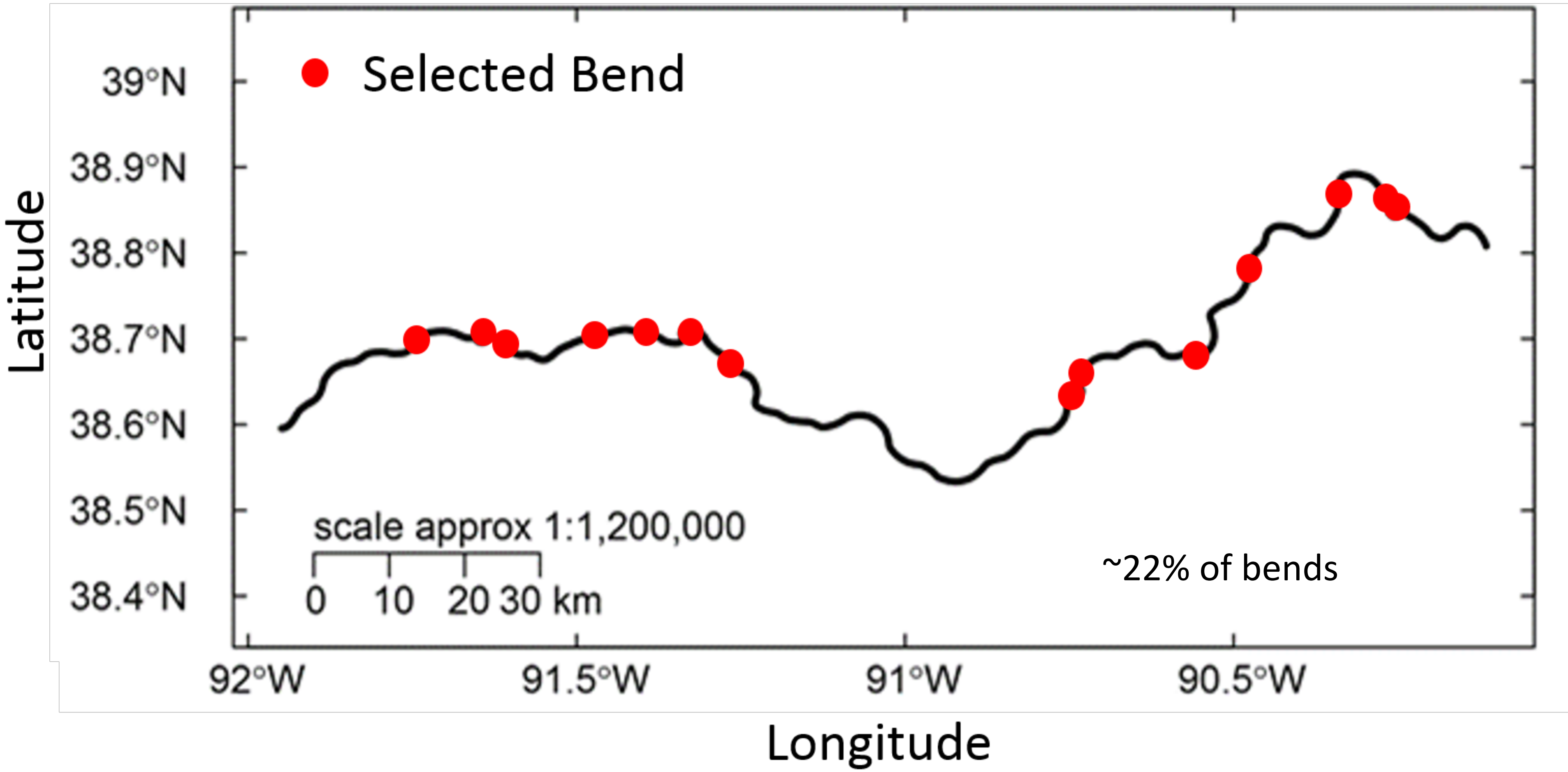
Winnipeg
NORTH DAKOTA
MONTANA
MINNESOTA
Minneapolis
WISCON
SOUTH DAKOTA
HO
WYOMING
IOWA
NEBRASKA
ILLIN
Denver
United States
Kansas City
UTAH
COLORADO
KANSAS
MISSOURI

Adult PSPAP phase 1 pilot



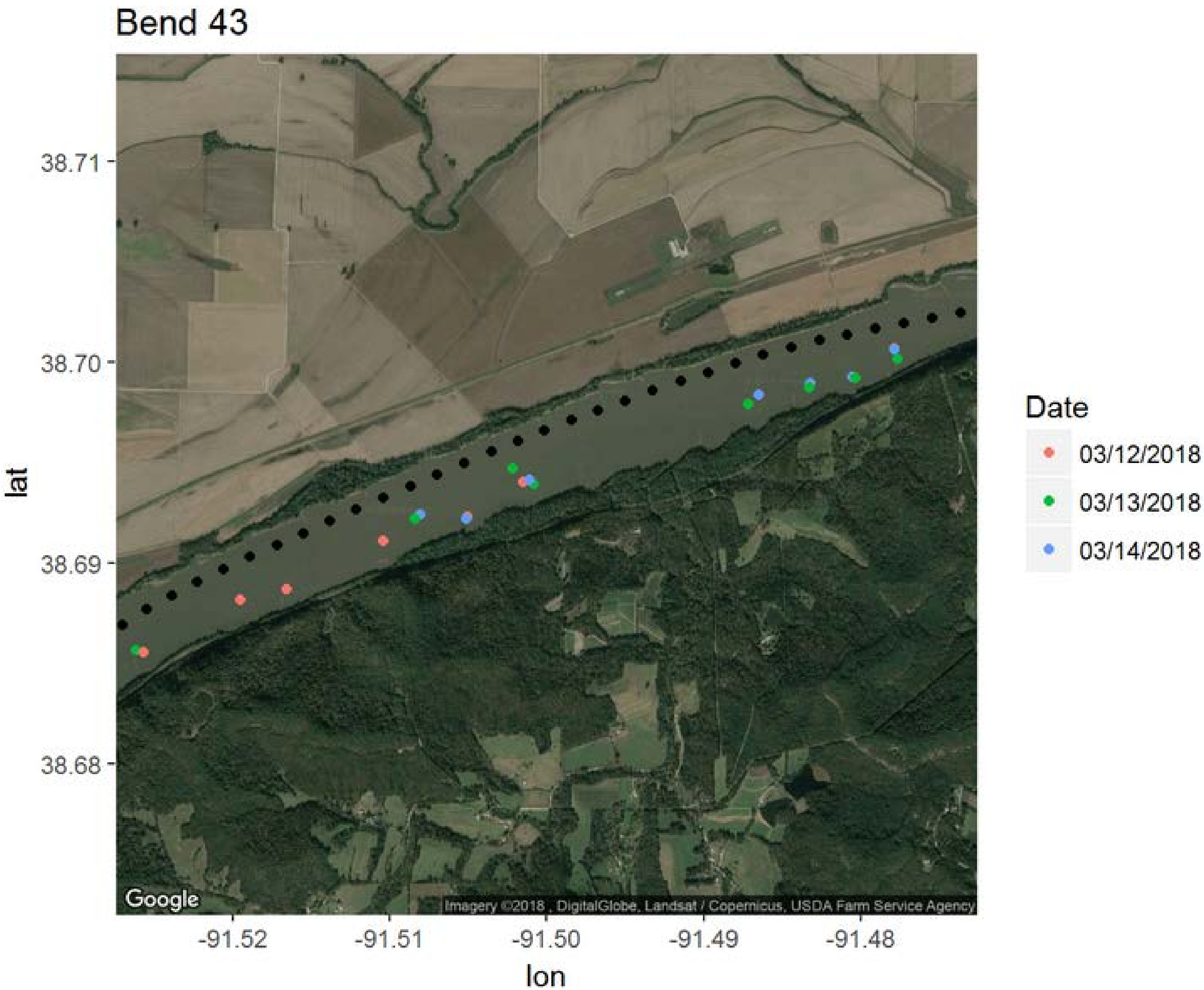


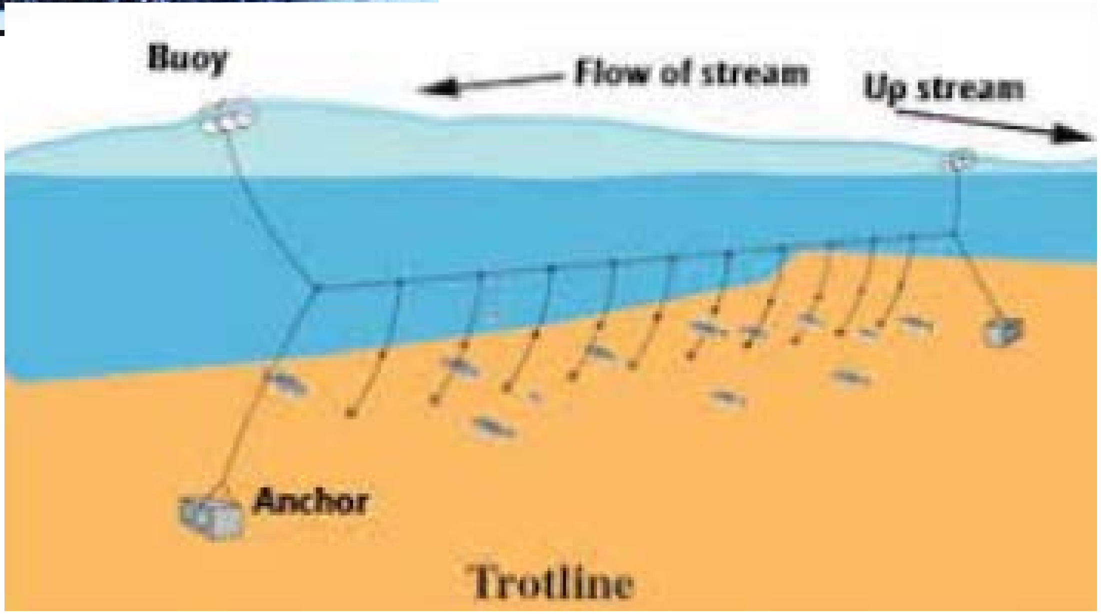
Segment 14



Selected Bend
39°N
38.9°N
38.8°N
38.7°N
38.6°N
38.5°N
38.4°N
Latitude
scale approx 1:1,200,000
0 10 20 30 km
~22% of bends
92°W
91.5°W
91°W
90.5°W
Longitude

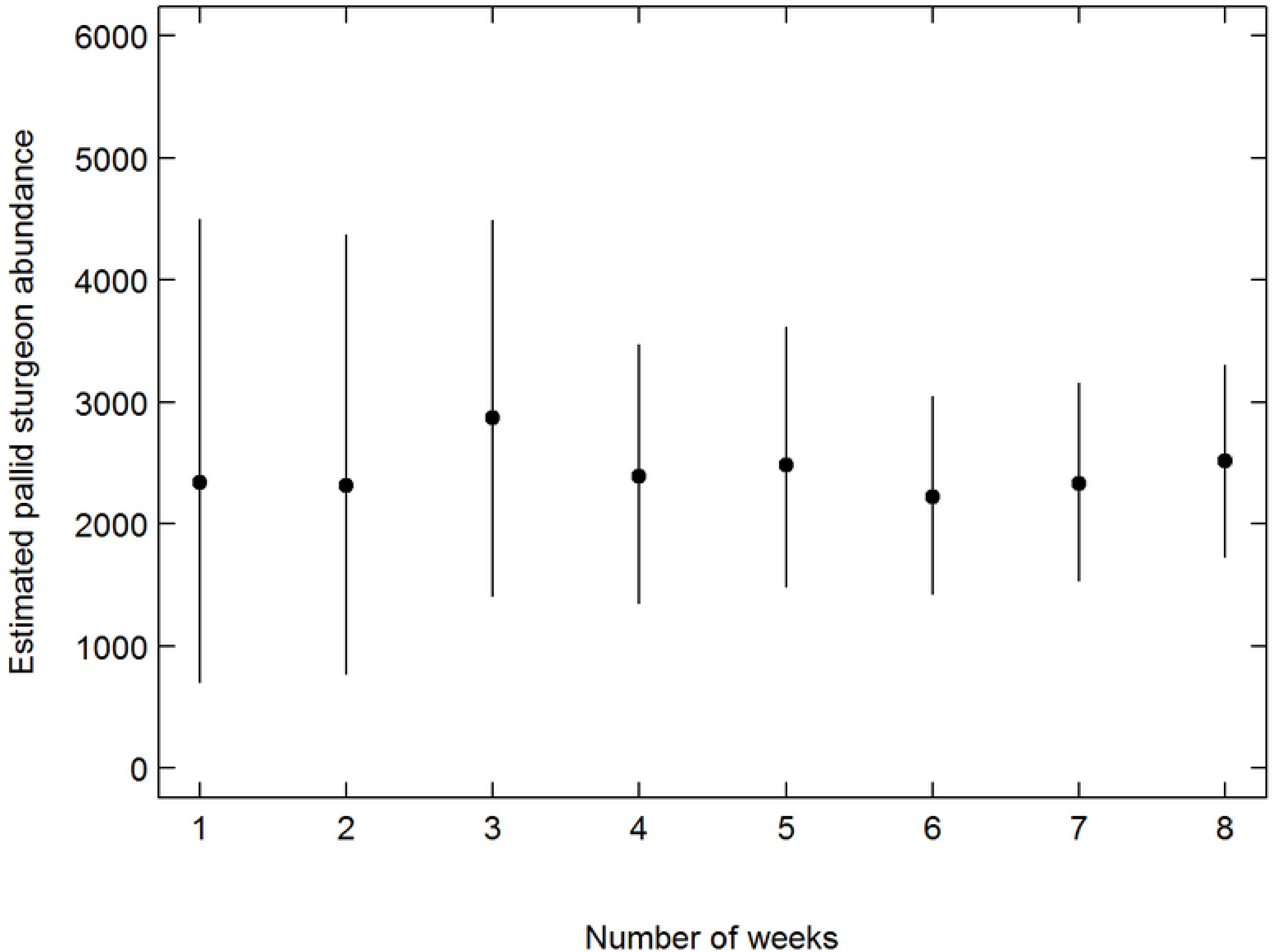
Adult sampling pilot



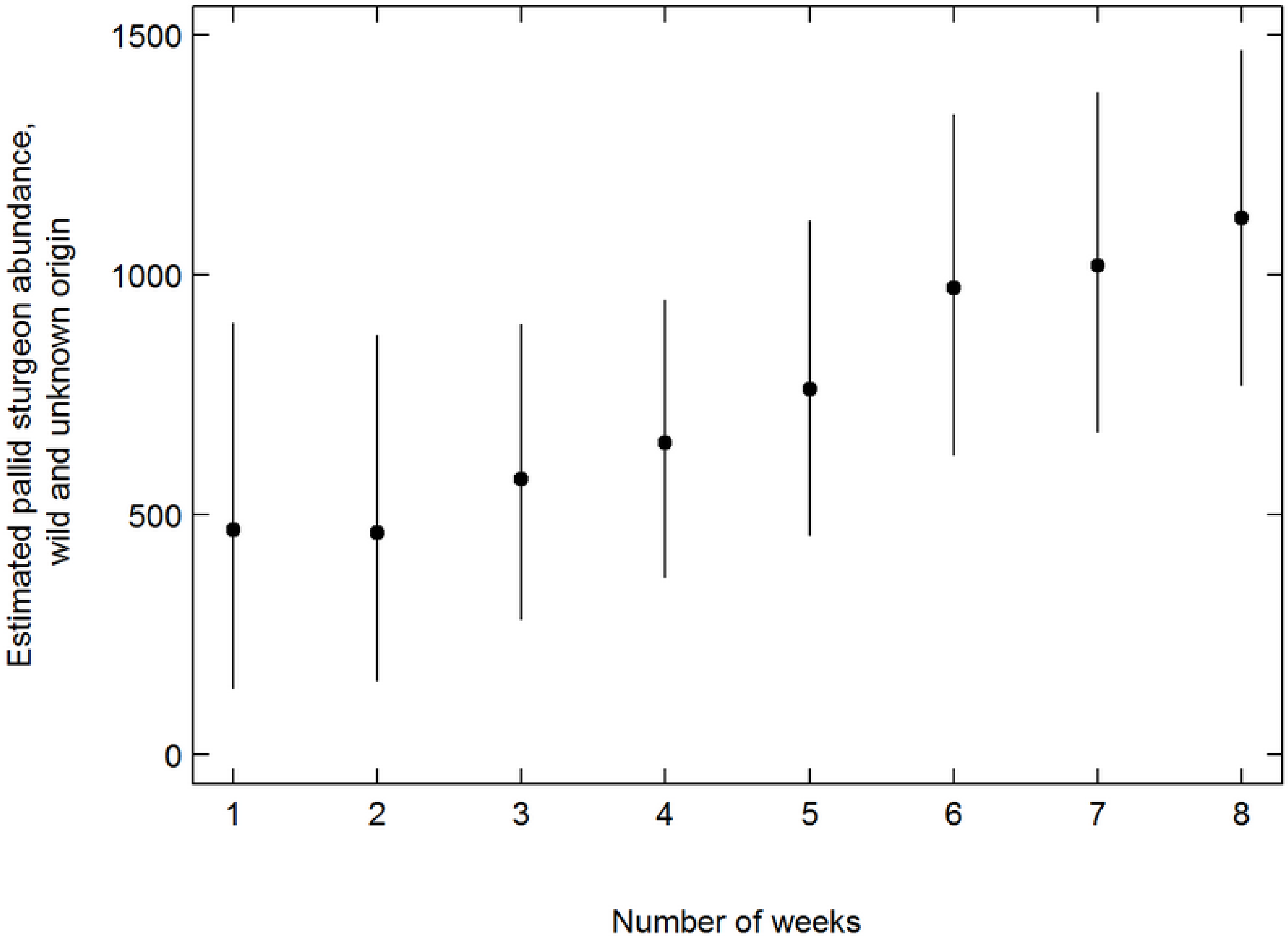

Buoy
Flow of stream
Up stream
Anchor
Trotline


Pit tagged
US Army Corps
of Engineers

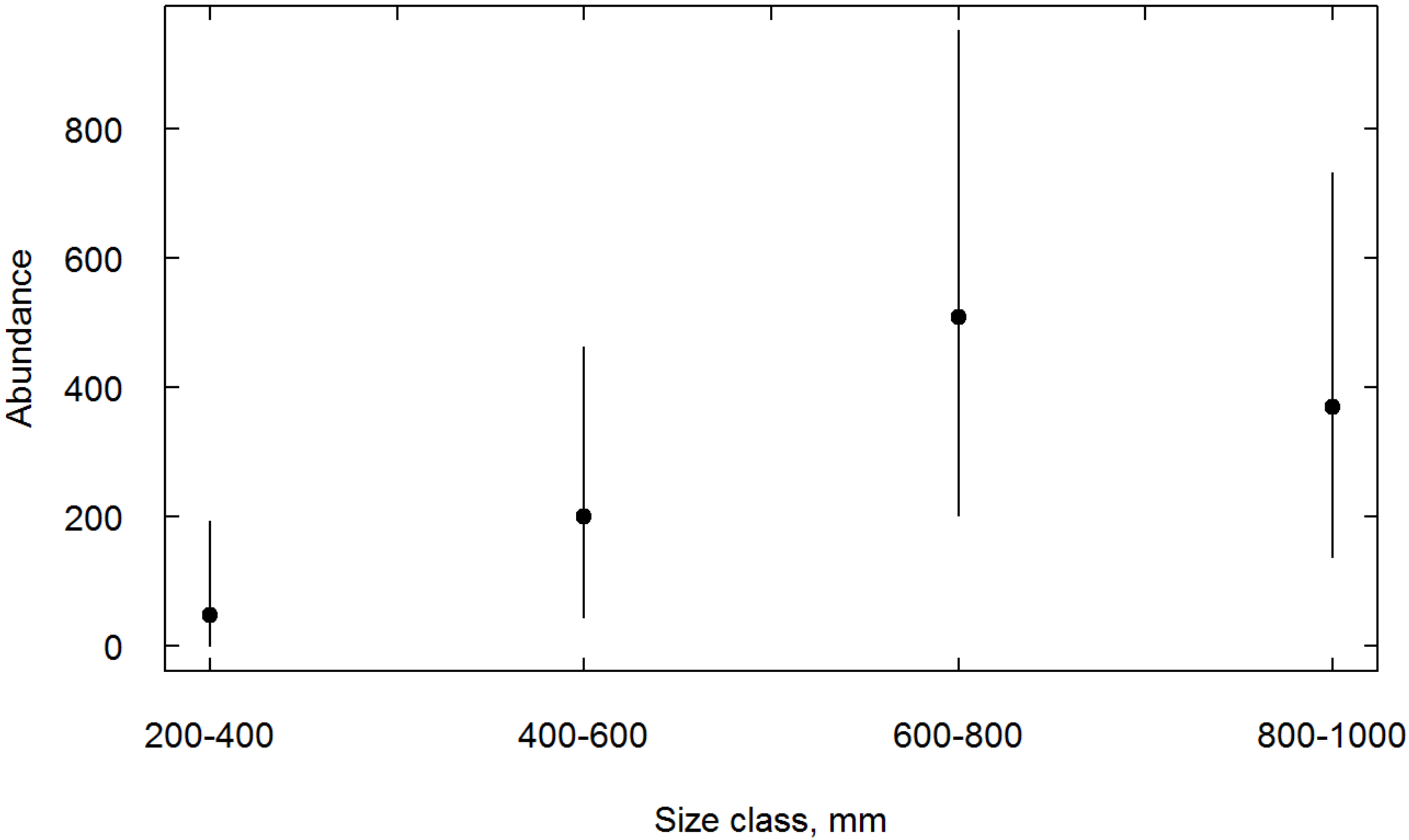
Abundance estimates



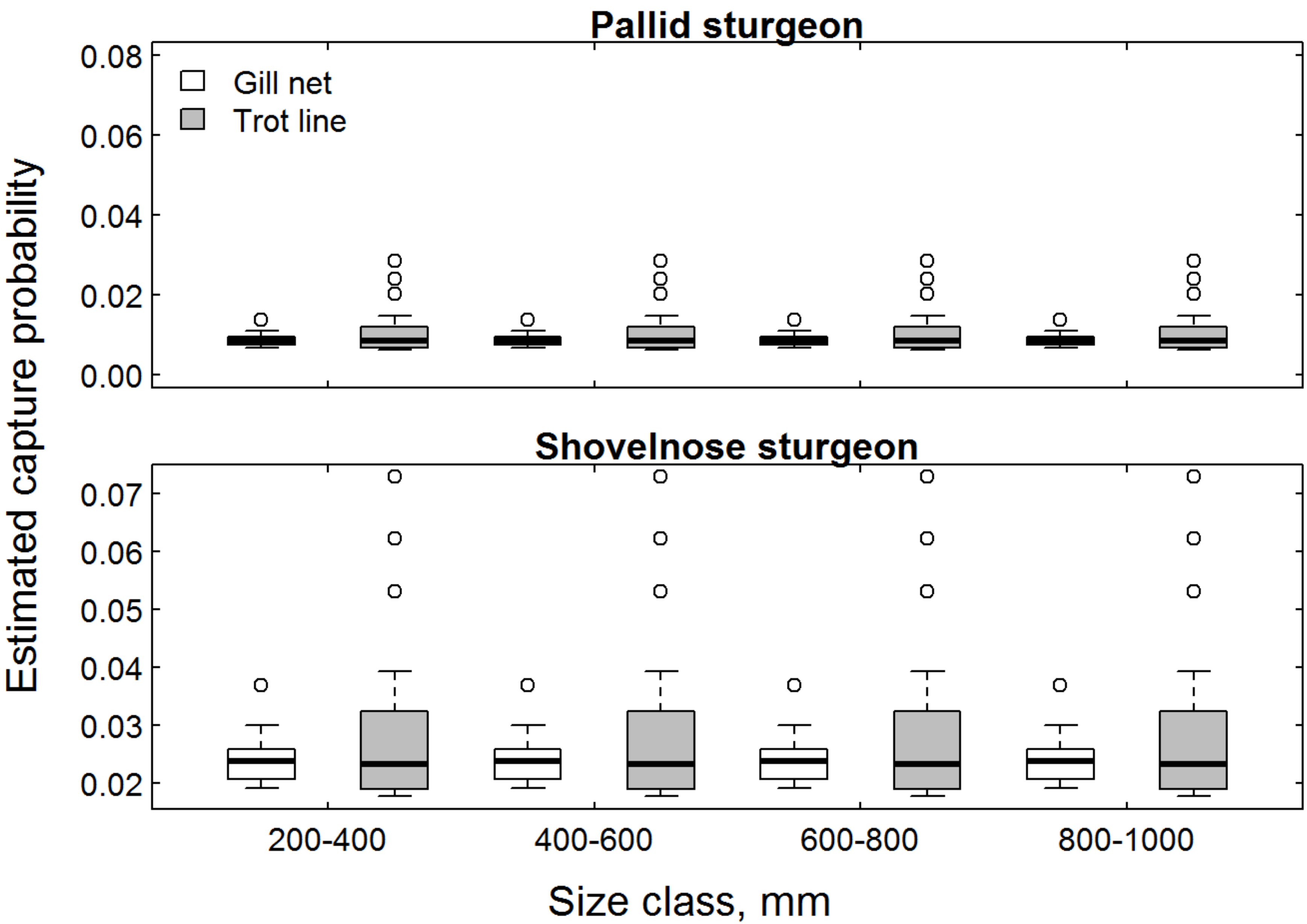
Abundance estimates: Wild & unknown origin



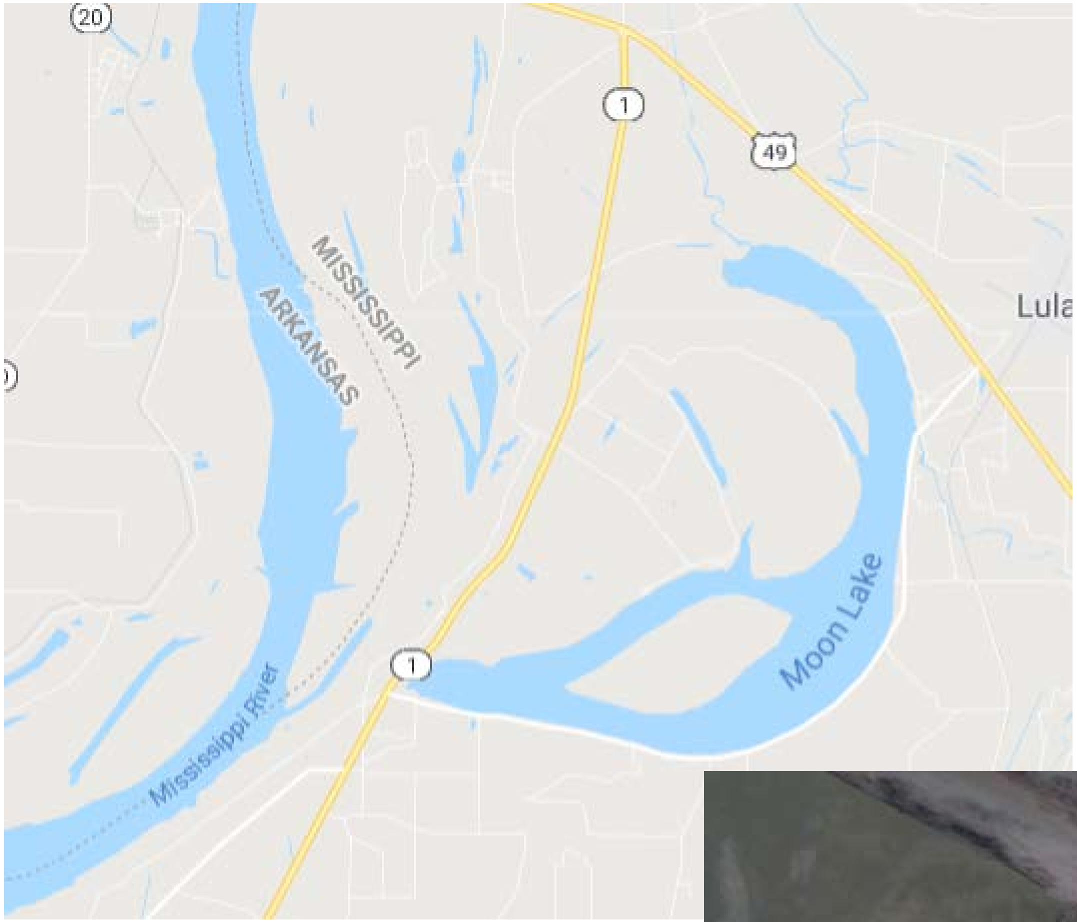
Abundance estimates: Size class



Capture probability



Moon Lake Paddlefish Fishery



MS -434

MISSISSIPPI FRESHWATER COMMERCIAL FISHERY AND PADDLEFISH COMMERCIAL FISHERY DURING FISCAL YEAR 2011

Report For Project 109:

Freshwater Commercial Fishery Coordination

Freshwater Fisheries Report No. 279

Project Leader: Garry Lucas

Sections:

PADDLEFISH COMMERCIAL FISHERY
MOON LAKE SPECIAL FISH HARVEST SEASON
FRESHWATER COMMERCIAL FISHERY HARVEST SURVEY

Used a Lincoln Peterson estimator

MOON LAKE PADDLEFISH POPULATION ESTIMATE

$$\frac{\text{Fish caught and tagged in the marking event } (\mathbf{M}) \times \text{ Total fish recaptured } (\mathbf{C})}{\text{Total recaptured fish that were also tagged } (\mathbf{R})}$$

Table 8. Five estimates of Paddlefish population size for Moon Lake ranged from 1,109 to 2,056 fish, with an average value of 1,625 fish.

Date	Total Catch (C)	Harvest	Tagged Fish Harvest	Available Tagged (M)	Recaptured Fish that were Tagged (R)	Population estimate for date
2/7	217	132	5	92	18	1109
2/8	263	168	4	86	11	2056
2/9	314	148	4	82	12	2146
2/11	175	101	7	75	11	1193
2/12	137	60	4	71	6	1621
Total	1140	609	24	67	58	Avg. =1625

Assumptions violated? You Betcha…Marked and unmarked fish were harvested! Population was not closed.