



Predation Studies and Management In the Columbia River Basin

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CALFED Workshop on Predation

June 22-23, 2005

Tiburon, California



Dams

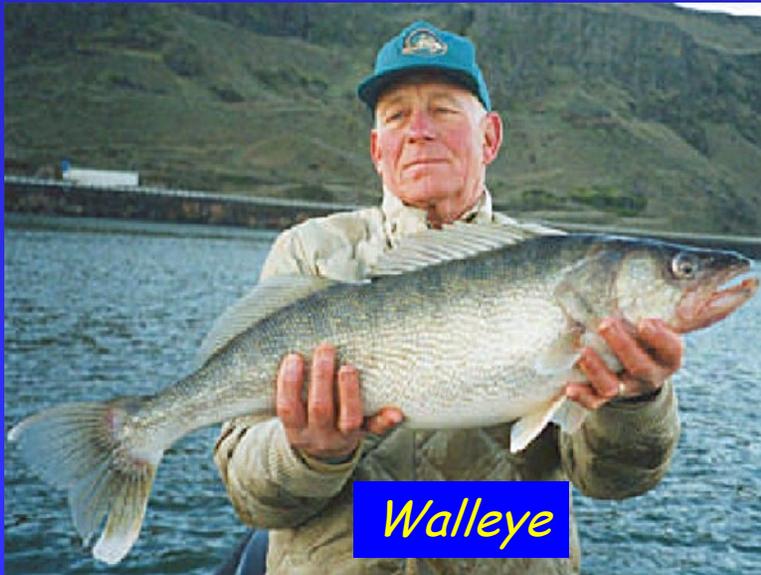
Predators

Major sources of juvenile salmonid mortality

Major Predators



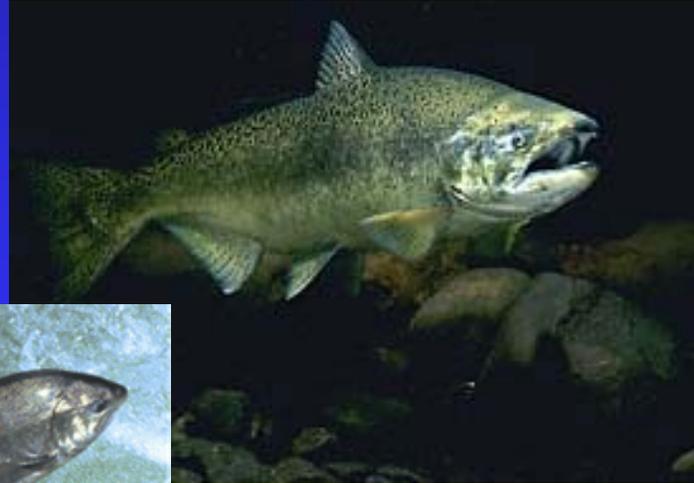
Northern pikeminnow



Walleye



Smallmouth bass

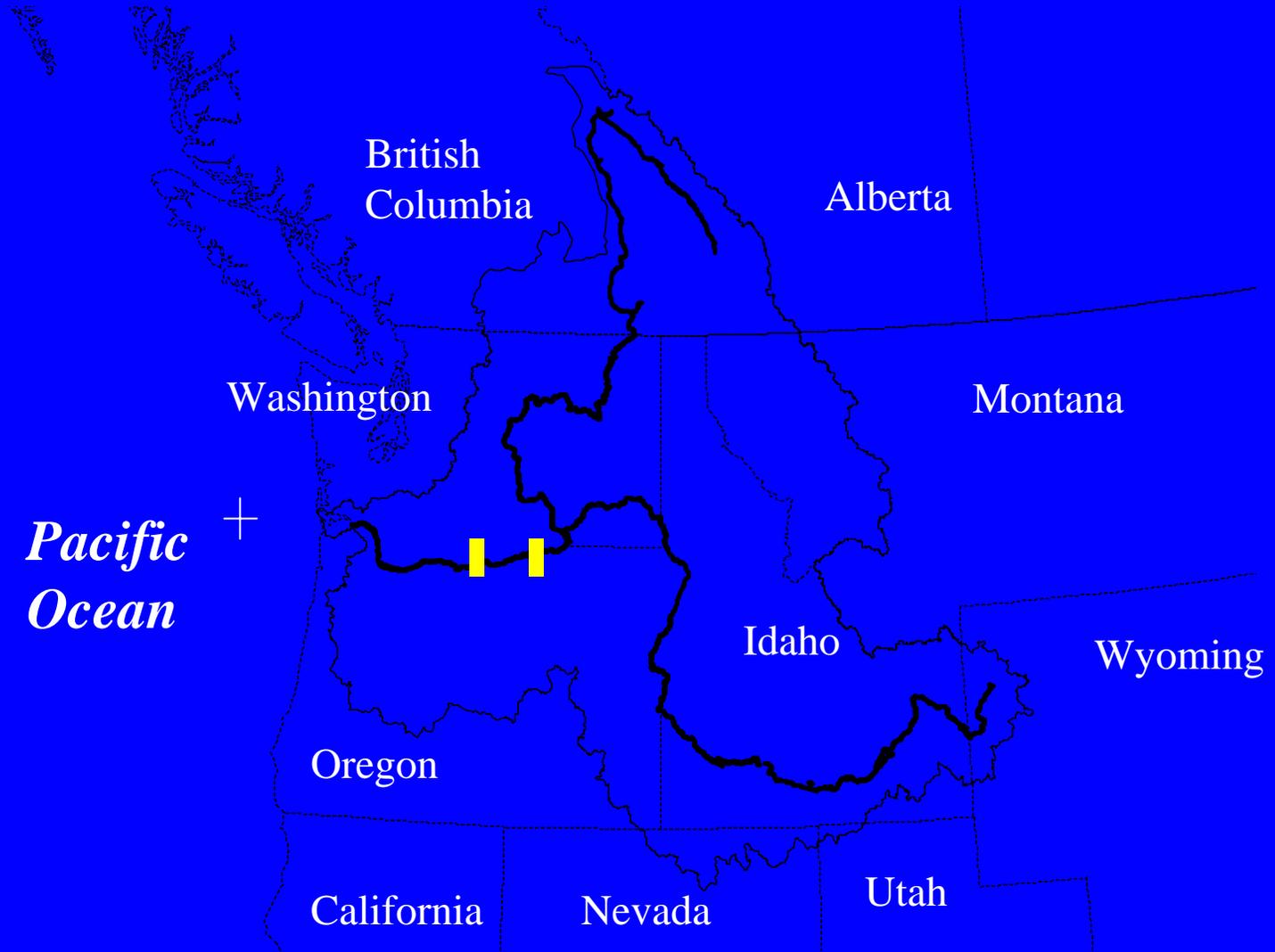


Salmon

Outline

- Predation estimation
- Management tools
 - Predator control
 - Dam passage options to minimize predation
 - Dam removal
- American shad issues in the Columbia
- Predation beyond the river system

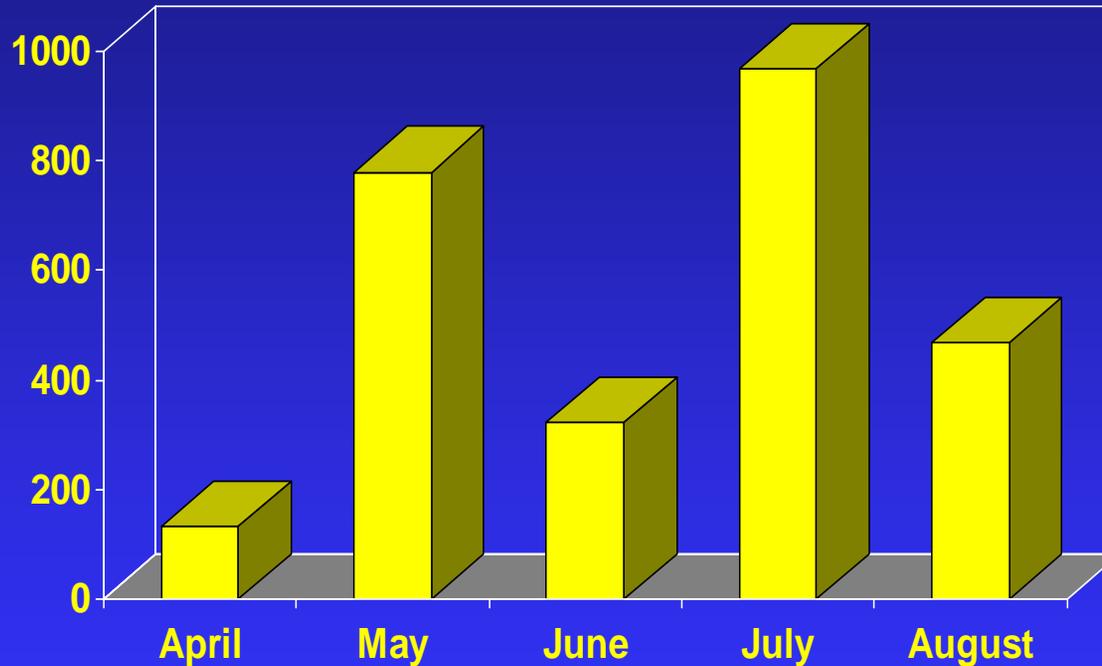
Columbia River Basin



Measure of predation in John Day Reservoir, 1982-1990

- Consumption rate estimation using a meal turnover method – salmonids per predator per day
- Use of a bone key to identify prey species in gut samples
- Population estimates and size structure
- Calculation of monthly “loss” = monthly per capita predation rate x # predators x size ...

Salmonids consumed (thousands) by all predators in John Day Reservoir



Northern pikeminnow consumed 78% of salmonids



**Dam forebays and
tailraces had high
predation losses**

**Mid-reservoir areas
tailraces had low
predation losses**



Model predictions

- **10-20% removal especially of larger predators would decrease loss 50%**
- **Assumed no compensation after removal (reproductive, growth, consumption rate)**
- **Density dependence should be evaluated**

Northern pikminnow management program

- Began system-wide in 1990 (Columbia and lower Snake Rivers)
- Currently consists of a bounty fishery and a tribal fishery near dams.
- 2005 bounty pays \$4-8 per fish > 9 inches; plus special tagged fish worth \$500
- 267,000 caught in 2004; 2.4 million total removed
- Costs BPA approximately \$3.1 million per year

Northern pikminnow management program - evaluation

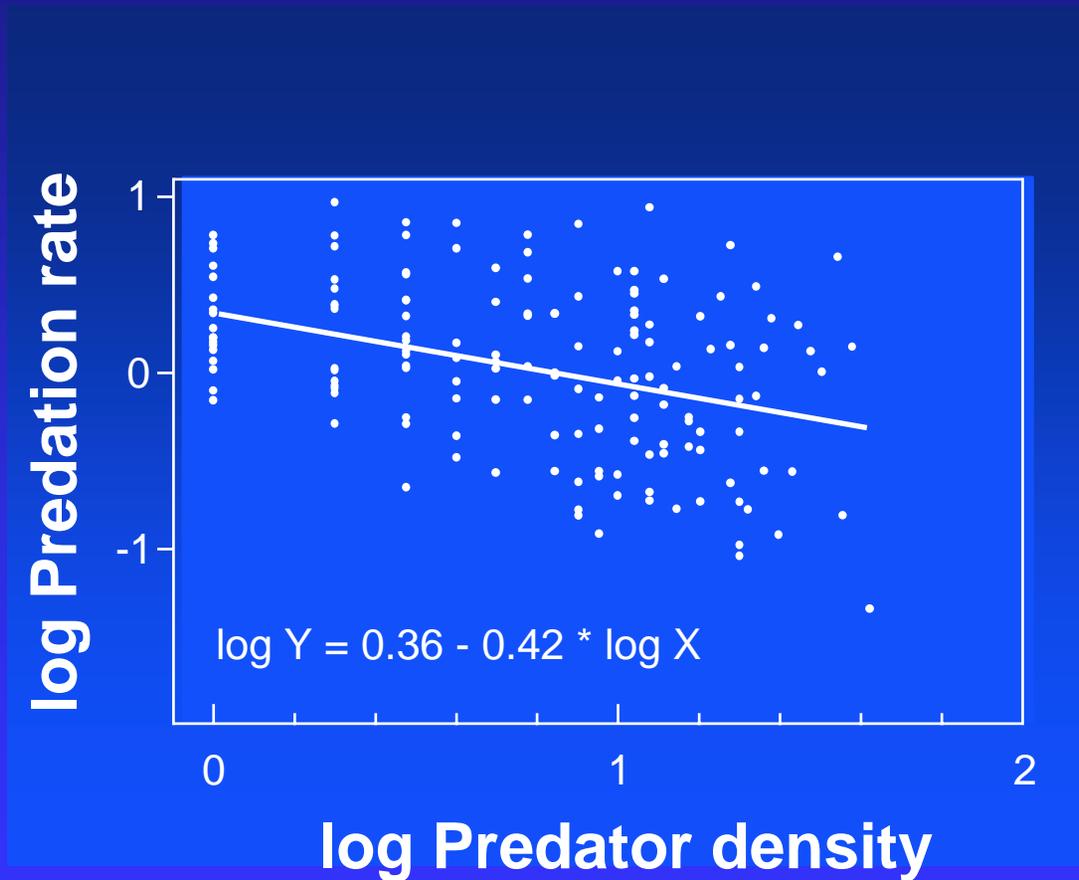
- 9-16% annual exploitation rate
- No detected compensation in growth or fecundity
- No change in diet of other predators, especially smallmouth bass
- “predation on juvenile salmon has been cut by 25%”

Northern pikminnow management program – caveats and questions

- Predator- and prey-density effects have not been evaluated sufficiently
- Predation rates are highly variable (cv = 72-140%) and large sample sizes will be necessary to detect changes of <100%

Predator density effects

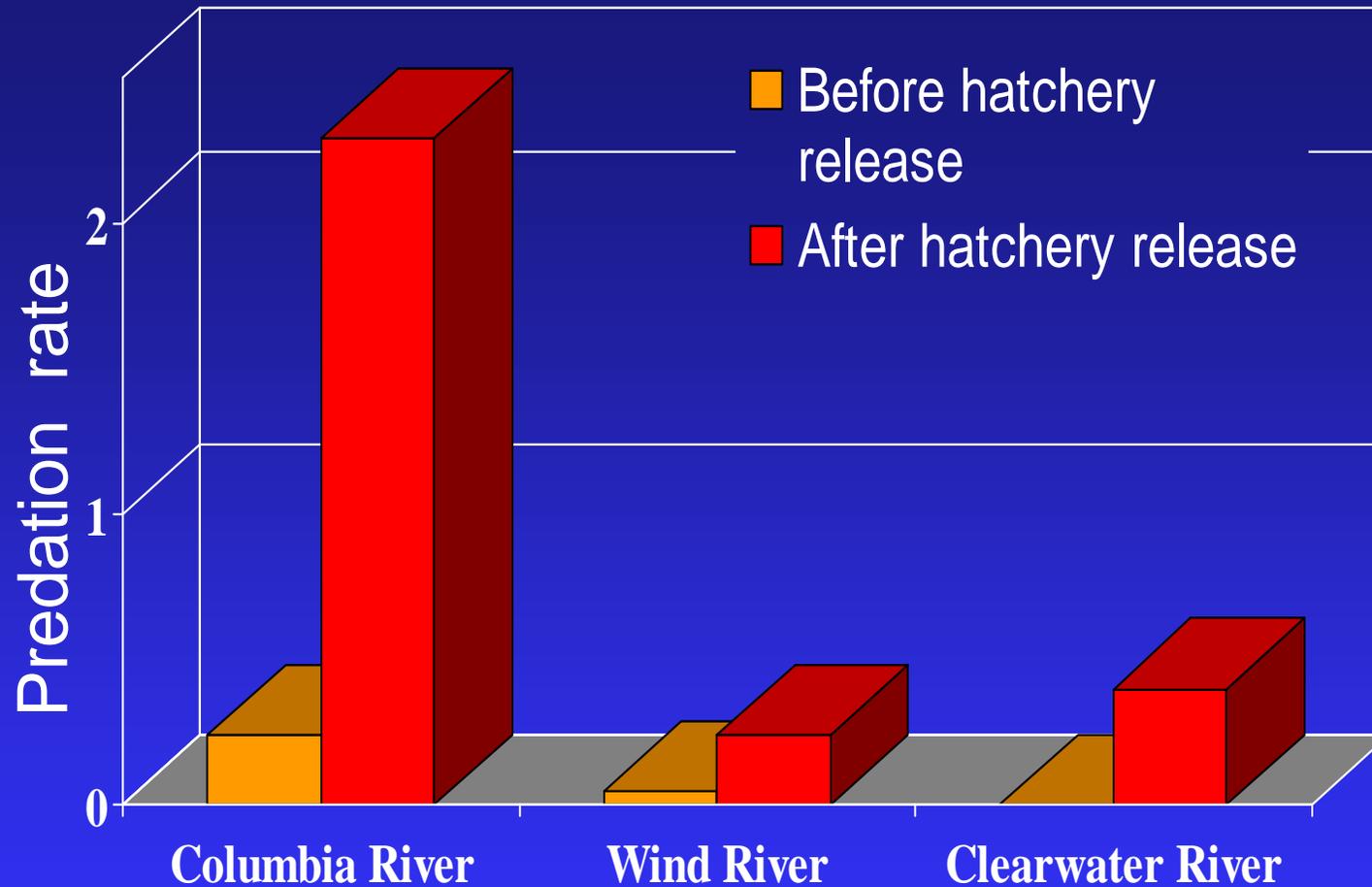
Samples with ≥ 1 salmonid prey



McNary Dam
tailrace

1983-86

Prey density effects



Sample distance 1
(km from release)
Salmon released 14.4
(million)

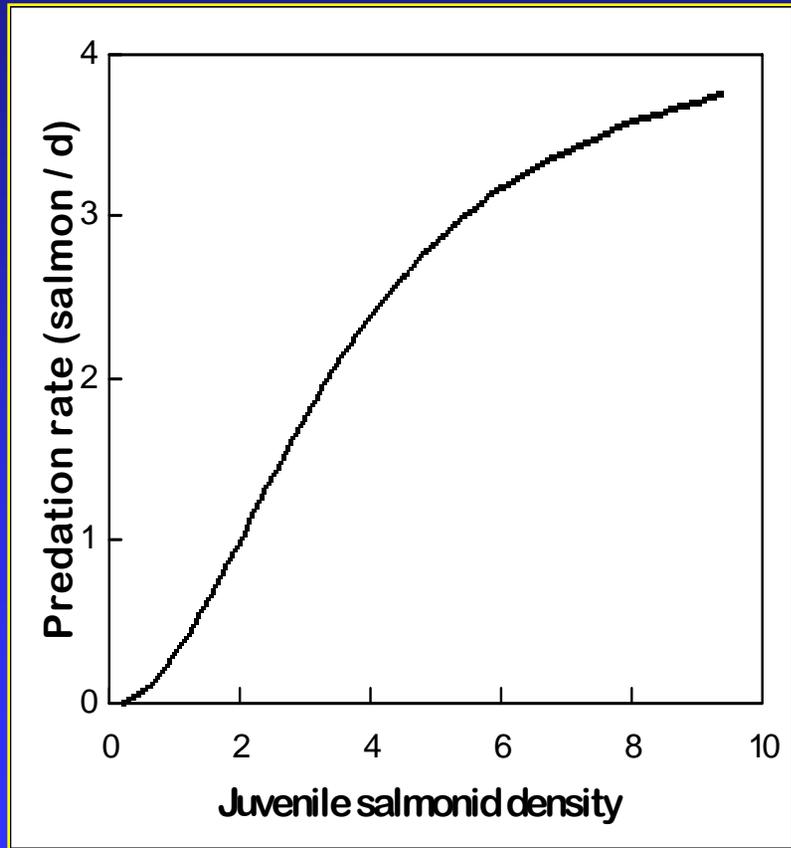
25
2.3

60

1.1 *Collis et al. (1995)*
Shively et al. (1996)

Prey density effects

McNary Dam tailrace

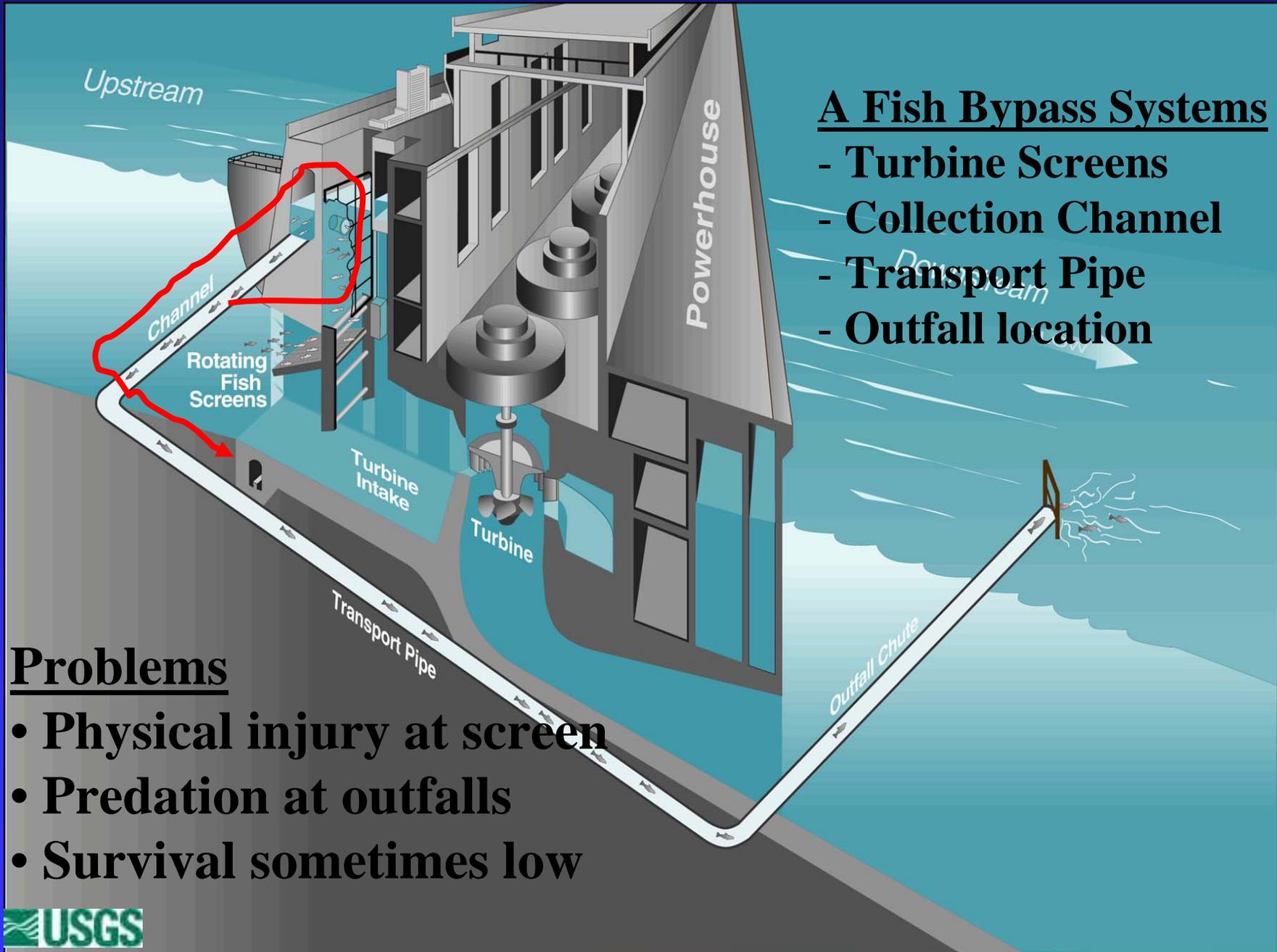


- Type III functional response
- $R^2 = 46\%$
- 1983-86
- $f(\text{density, predator size, prey size, temperature})$

Petersen & DeAngelis (1992)

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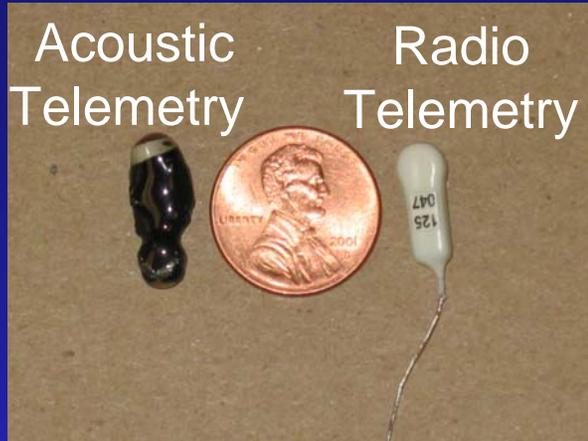
A Fish Bypass Systems

- Turbine Screens
- Collection Channel
- Transport Pipe
- Outfall location

Problems

- Physical injury at screen
- Predation at outfalls
- Survival sometimes low

The Tools



The Studies

- Route specific survival
- Fish passage efficiency
- Passage behavior
- Tailrace egress





John Day Dam juvenile bypass system

**Old Screen
bypass outfall**



Powerhouse 2

Spillway

Powerhouse 1

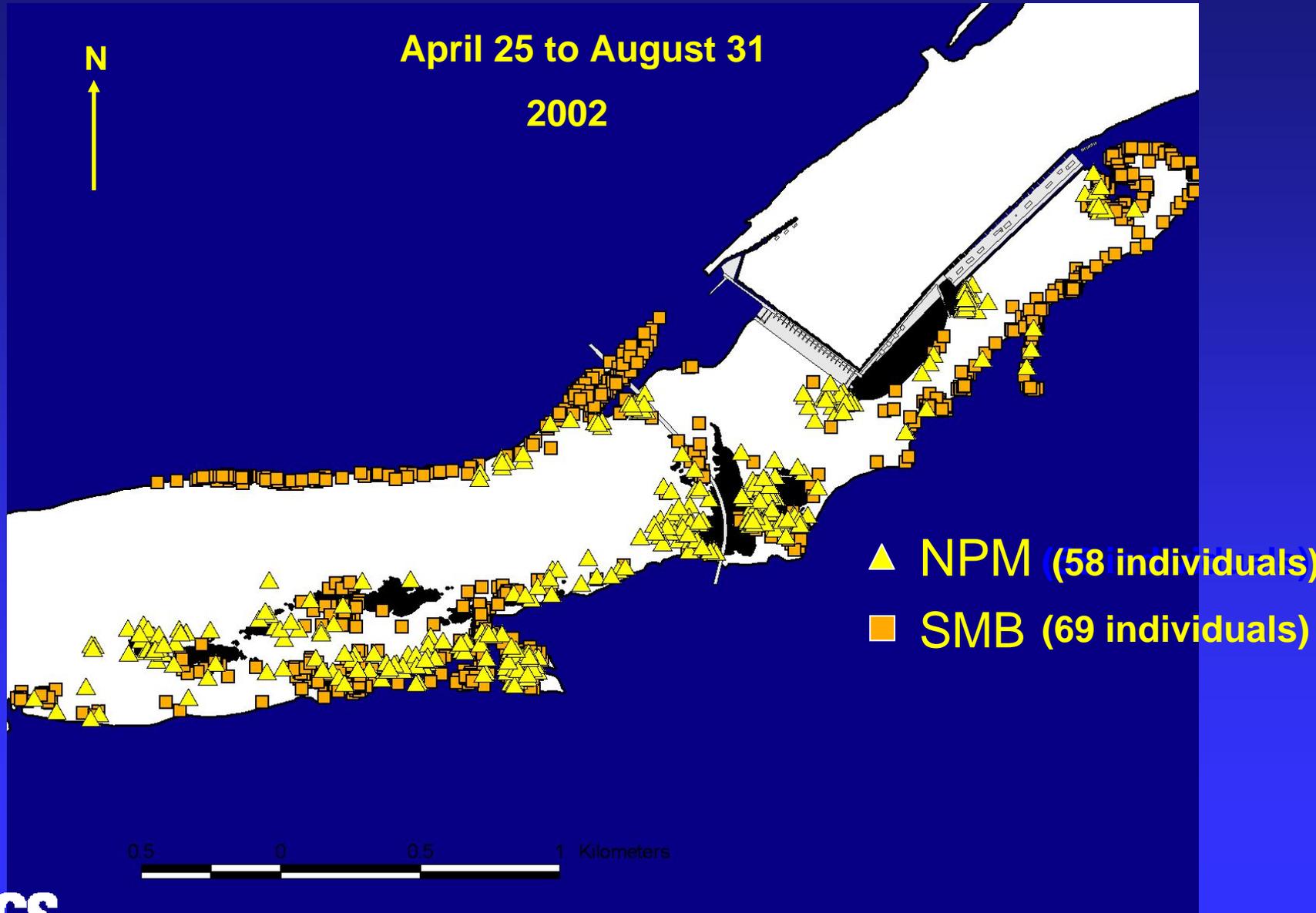
**New surface
bypass outfall**



**New screen
bypass outfall**



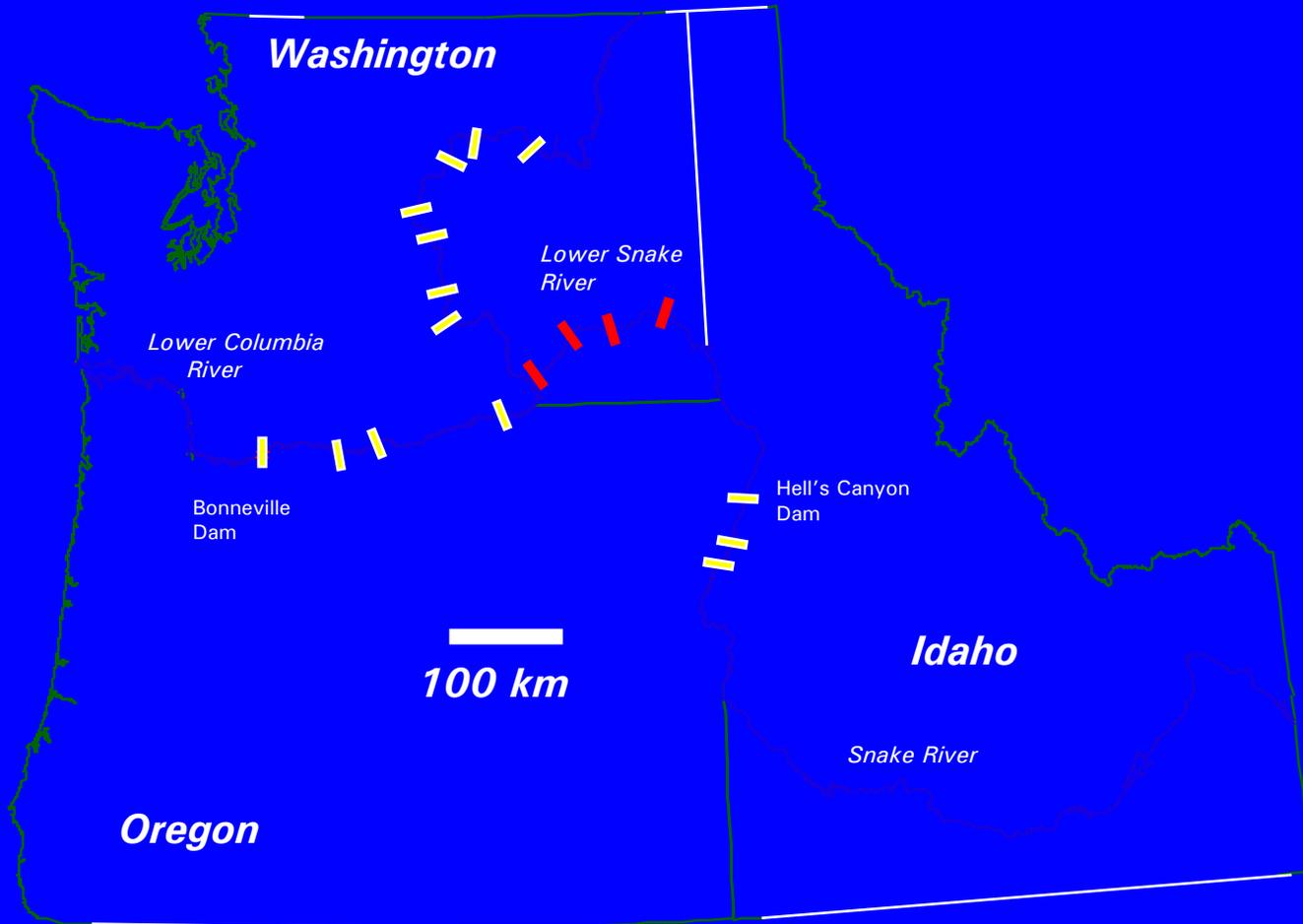
Predator Locations

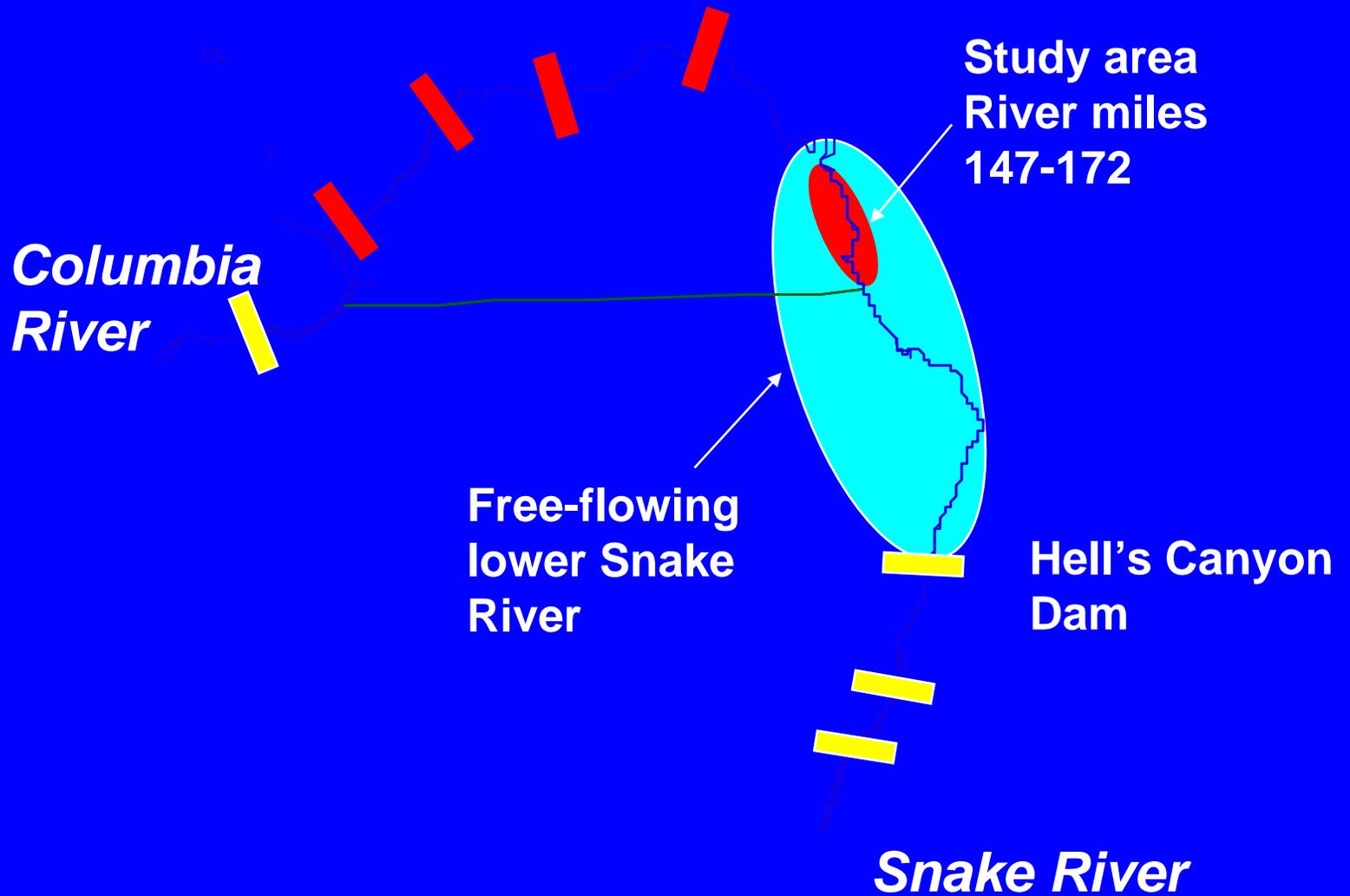


Outline

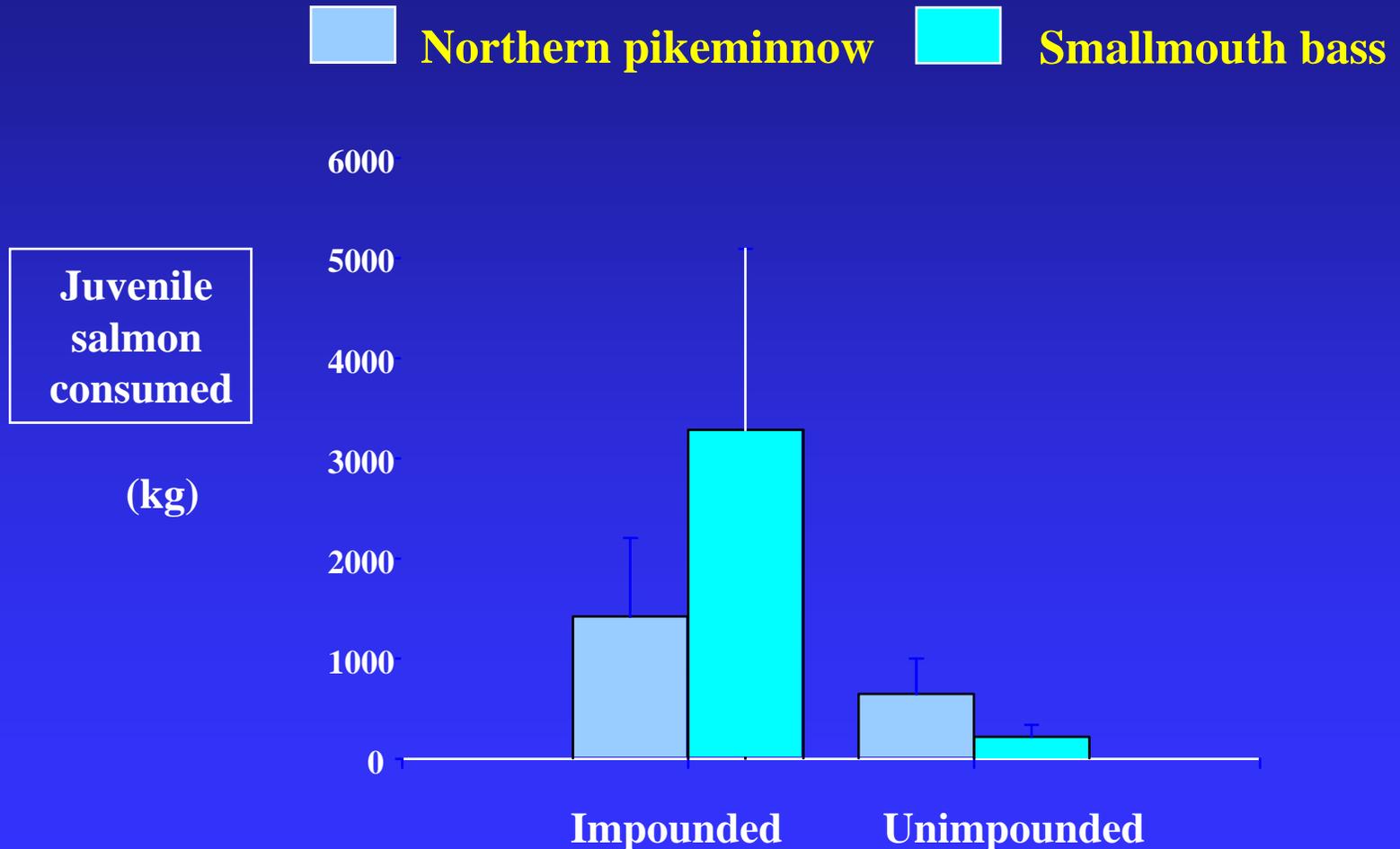
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Dams proposed for breaching on the lower Snake River

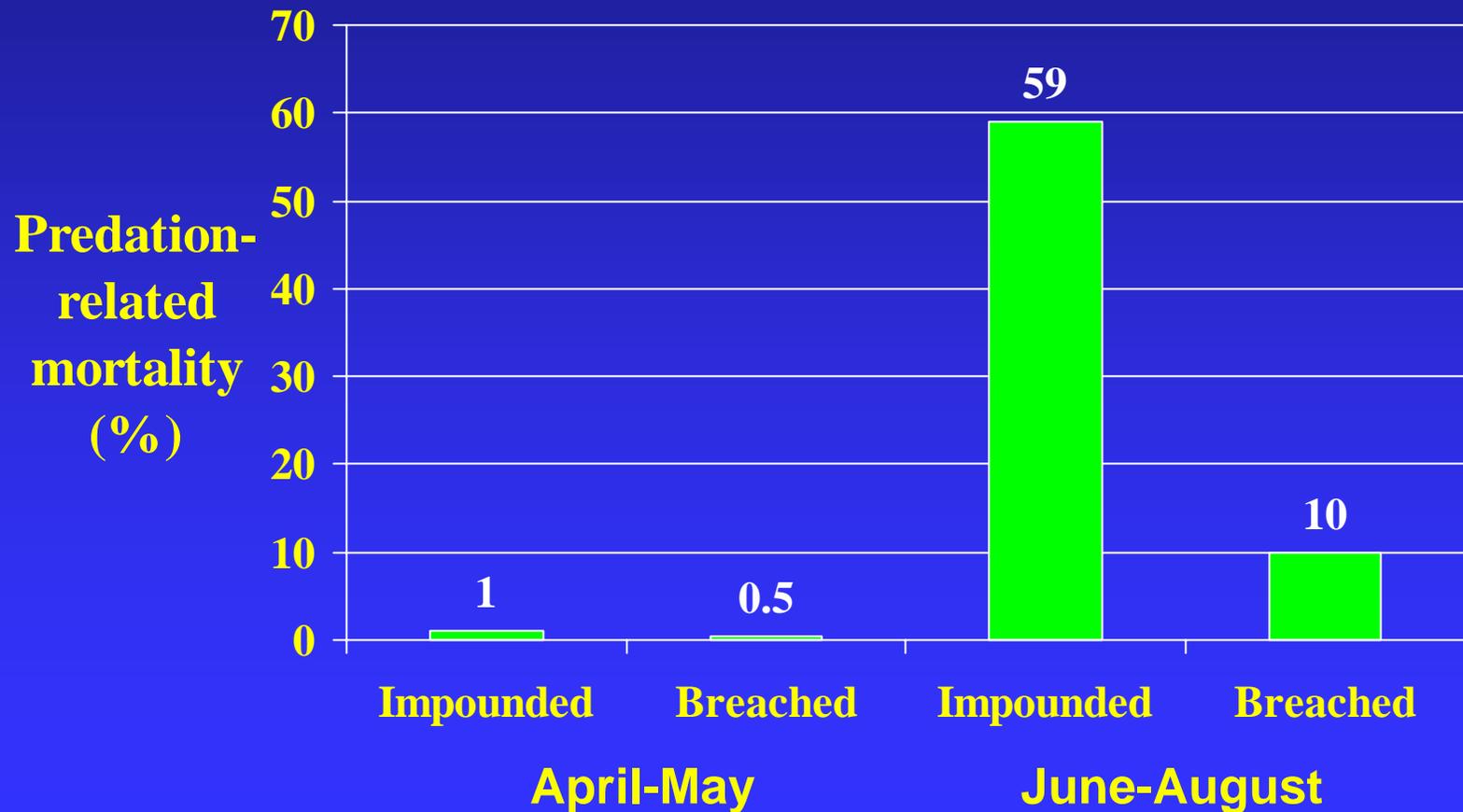




Mass of salmon consumed



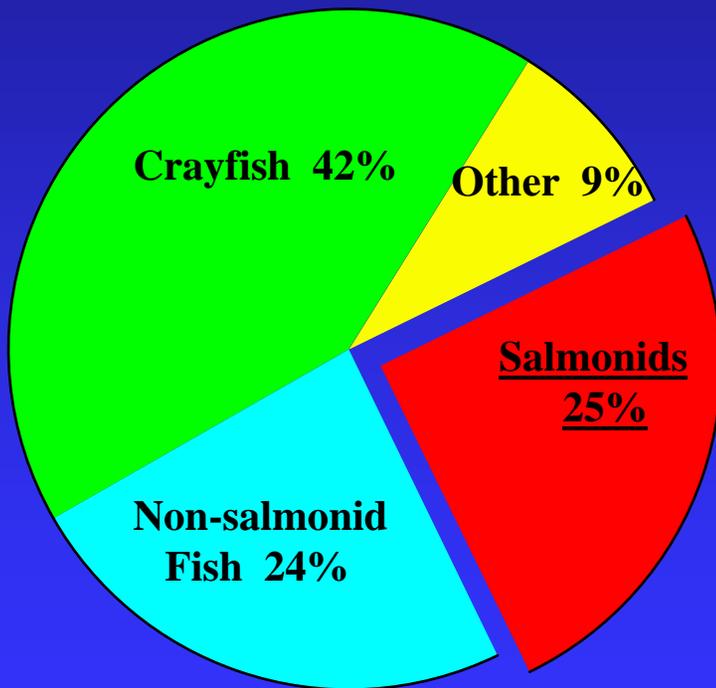
Change in predation mortality (northern pikeminnow and smallmouth bass)



Smallmouth bass June - July

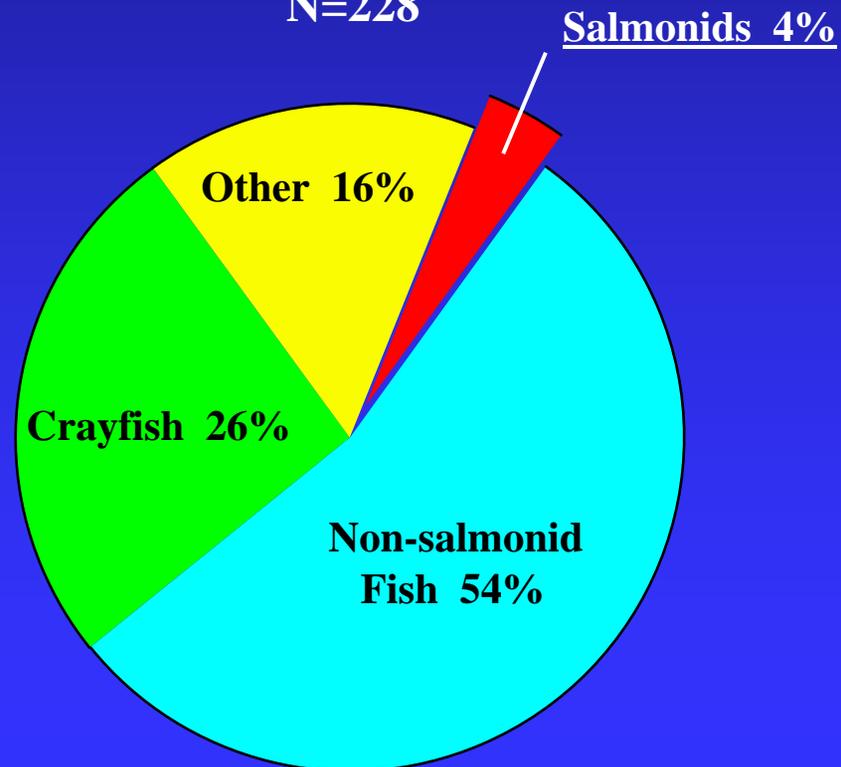
Impounded

N=852



Free-flowing

N=228



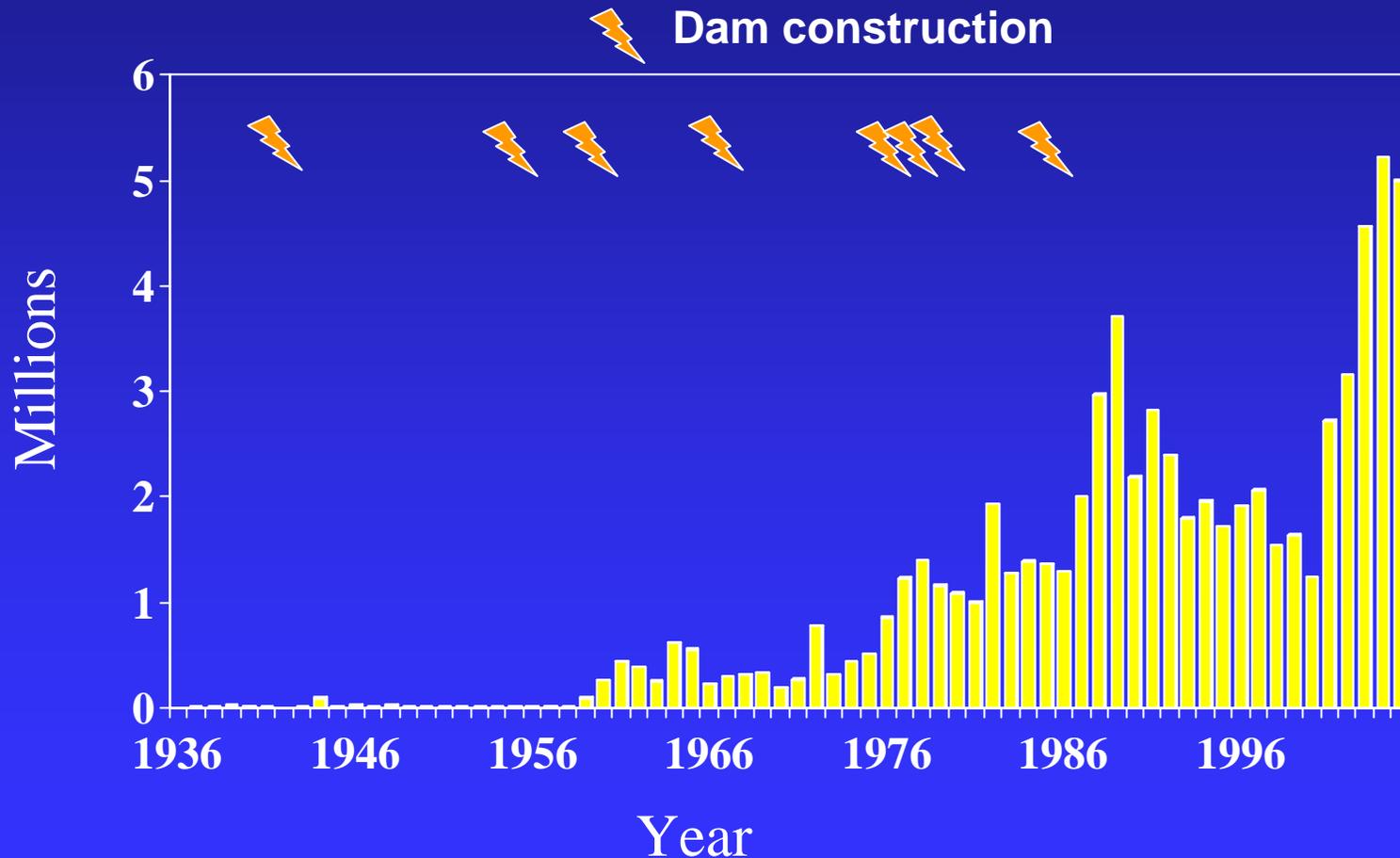
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- **American shad issues in the Columbia**
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American shad migrating past Bonneville Dam

American shad passage at Bonneville Dam

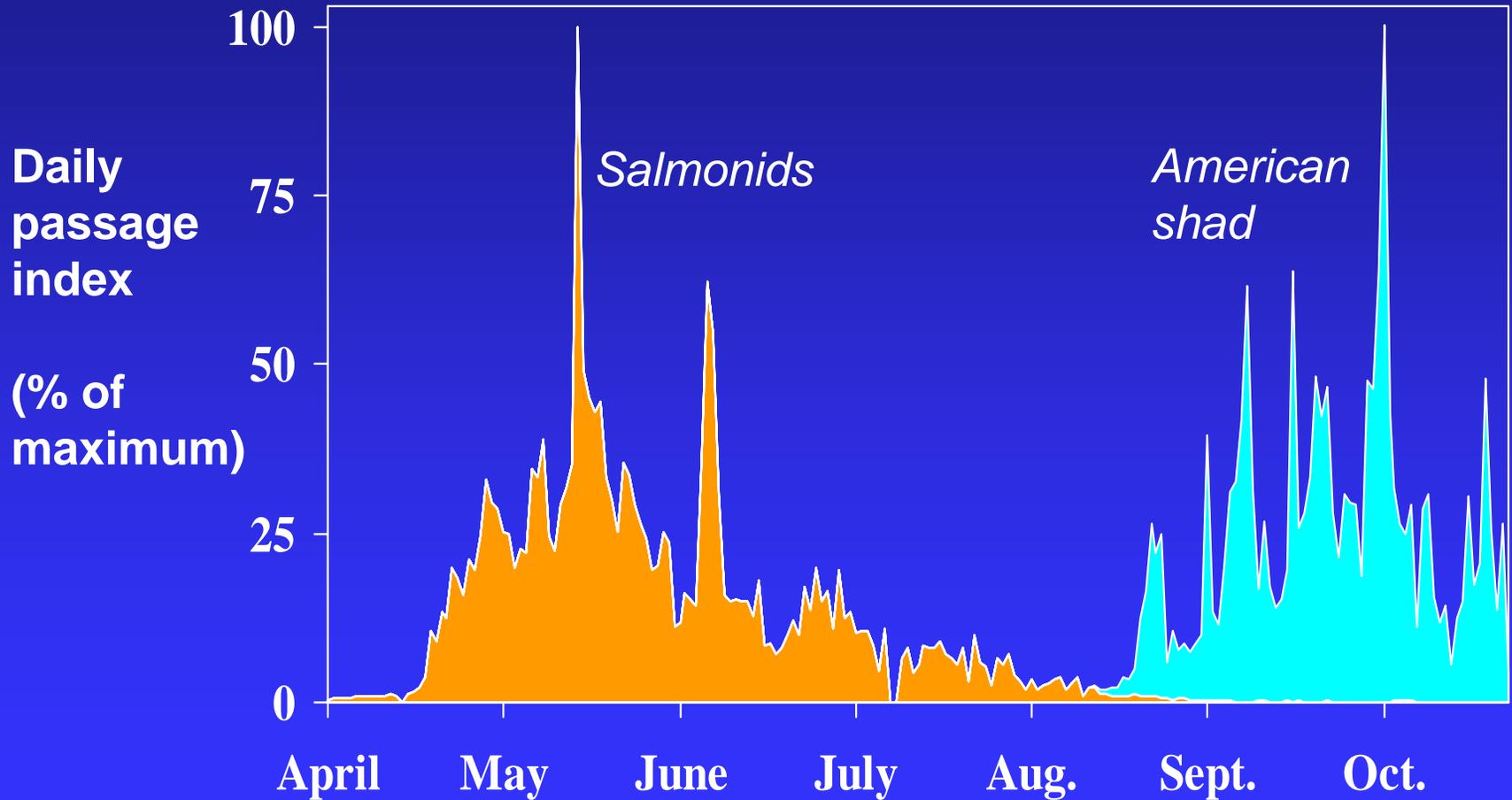


Percent of adult American shad passing dams on the lower Columbia and Snake rivers in 2000



Juvenile anadromous fishes

(Bonneville Dam, 1997)



Hydroacoustic surveys

Species composition by trawl catch

American shad 100%

N = 38

Day

John Day Reservoir

River mile 238.5

9/7/94, 1200 h

American shad 97%

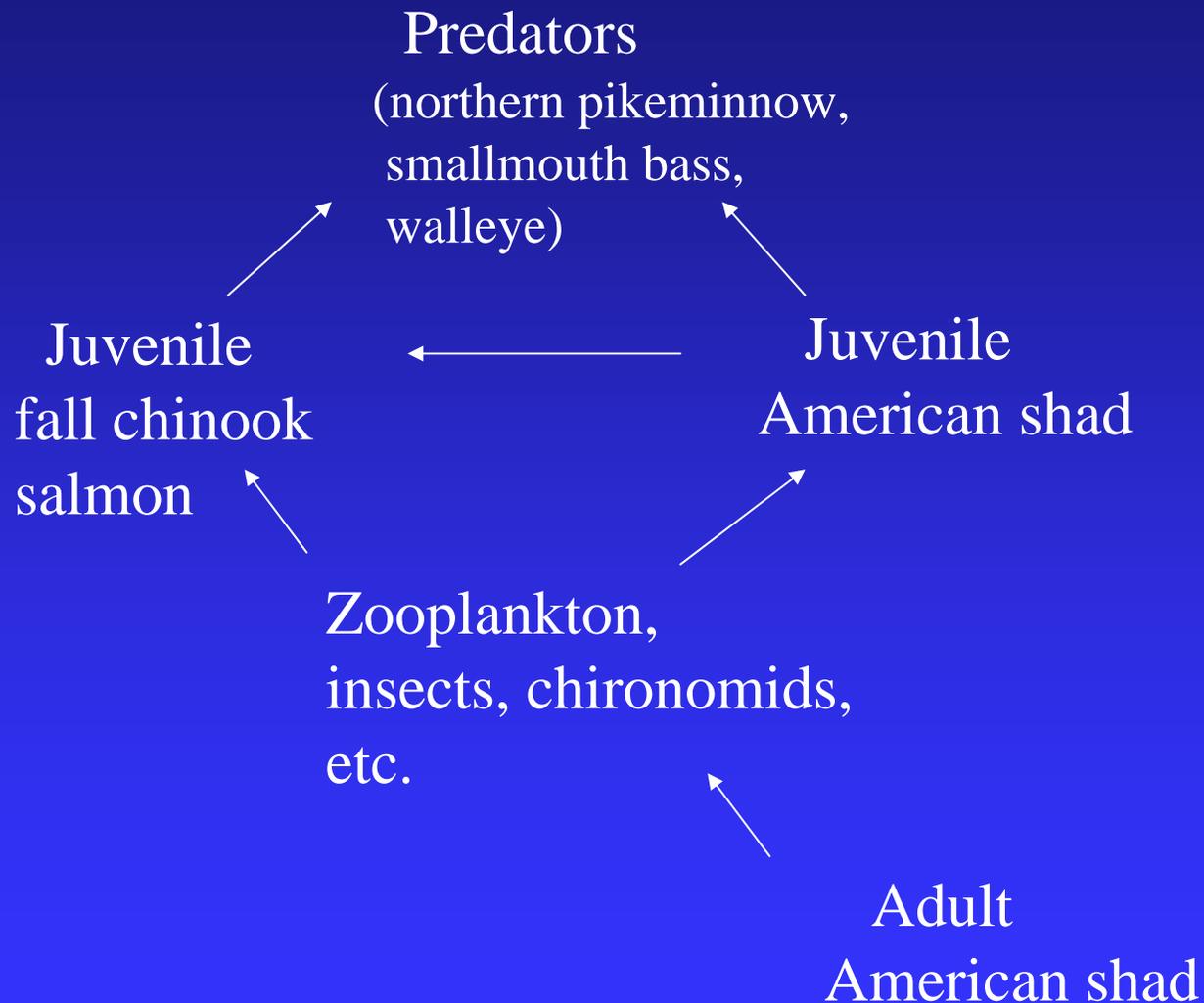
N = 215

Night

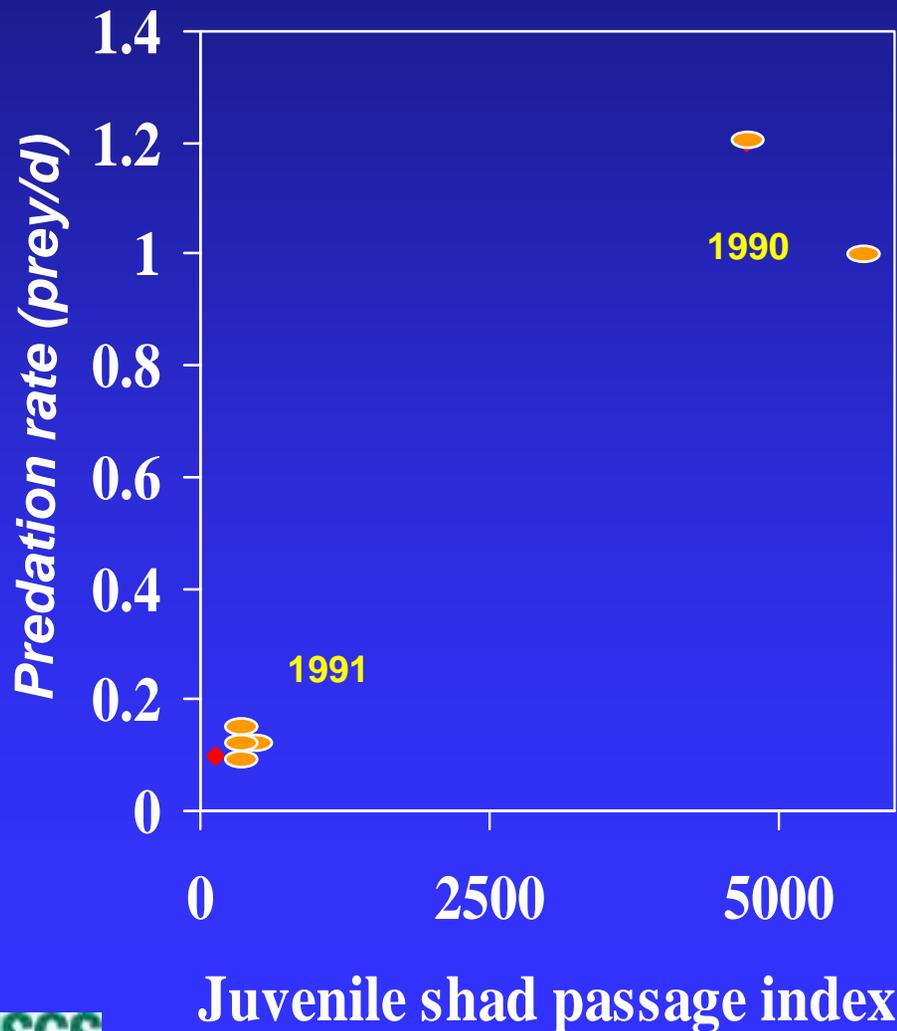
John Day Reservoir

River mile 238.4

9/7/94, 2200 h



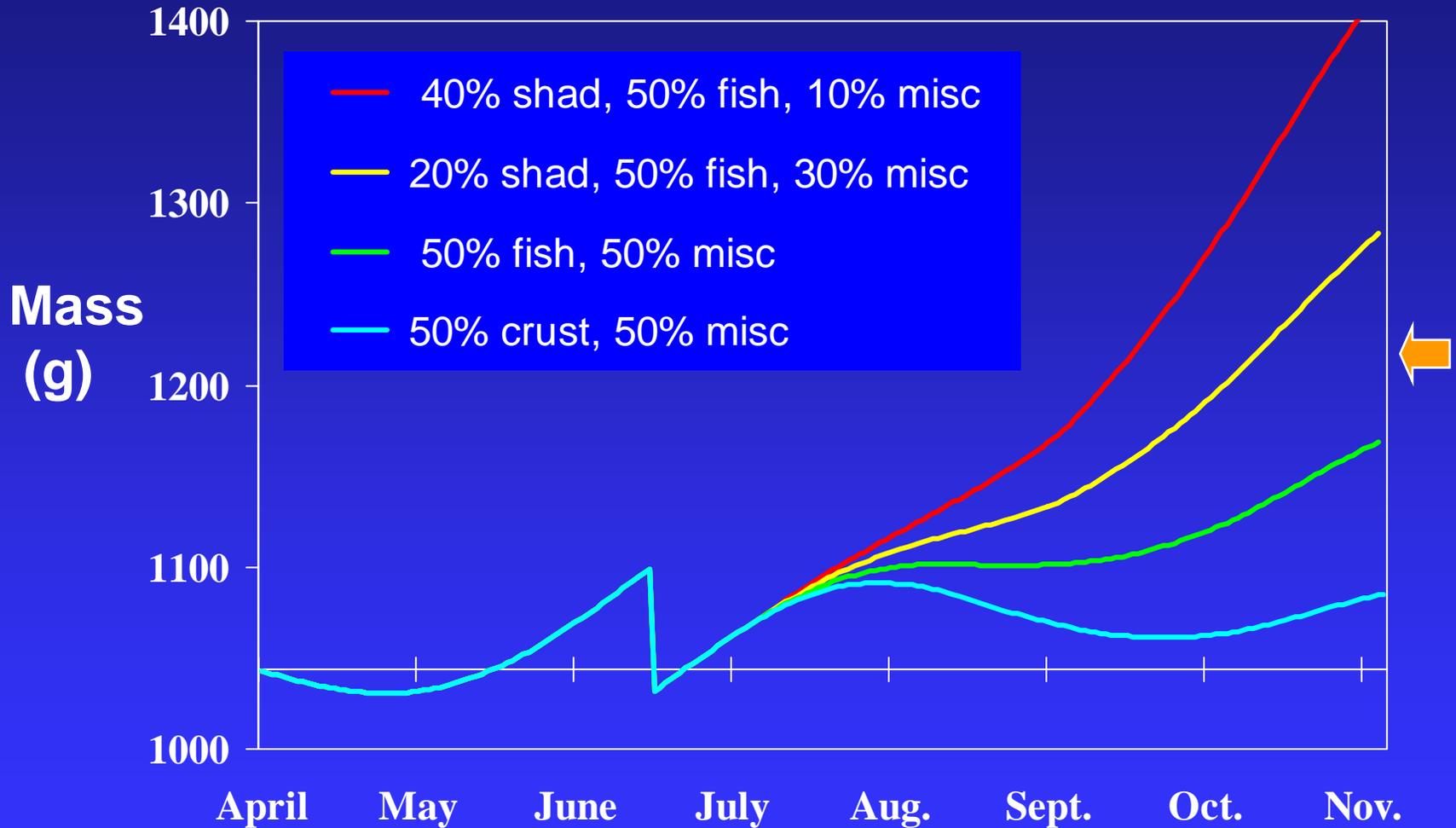
Juvenile American shad in northern pikeminnow diet



- Bonneville Dam tailrace
- Aug.-Sept., 1990-91
- N = 127-398 predators, 6 dates
- Diet: 78% (1990)
5% (1991)

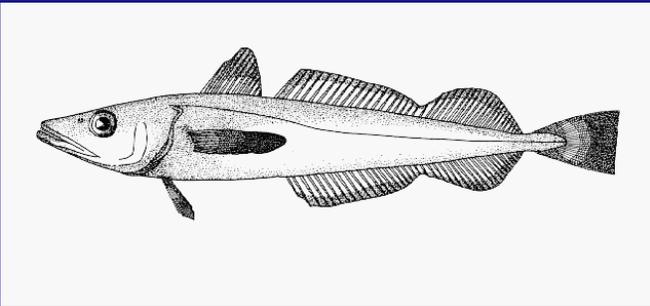
Potential effects of American shad in the diet of northern pikeminnow in the lower Columbia River

Start size = 1044 g, Bonneville temperature, $p = 0.173$



Research needs

- Hypothesis 1 – Competition.
 - Adult shad feed in the lower river and may be competing with outmigrating juvenile salmon.
 - Juvenile shad compete with juvenile fall chinook salmon.
- Hypothesis 2 – Predation supplementation
 - American shad occur in NPM (completed) and SMB diet.
- Hypothesis 4 – Nutrient re-distribution.
 - Marine derived nutrients – see Limburg p 136
- Hypothesis 3 – Disease transmission.
 - American shad may be the vector for transmission of Ichthyophonous to marine herring. (?)
 -



Pacific hake



Caspian terns



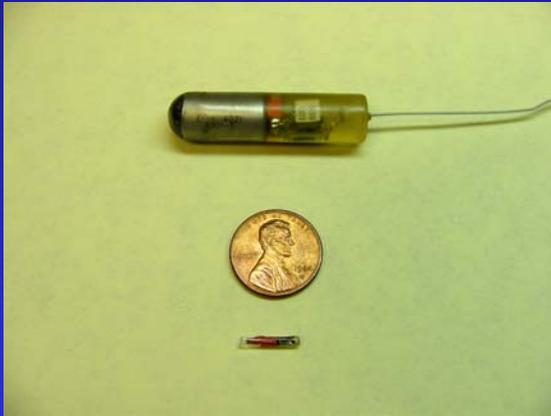
Cormorants



Gulls

Other predators on juvenile salmon

Emerging Tools



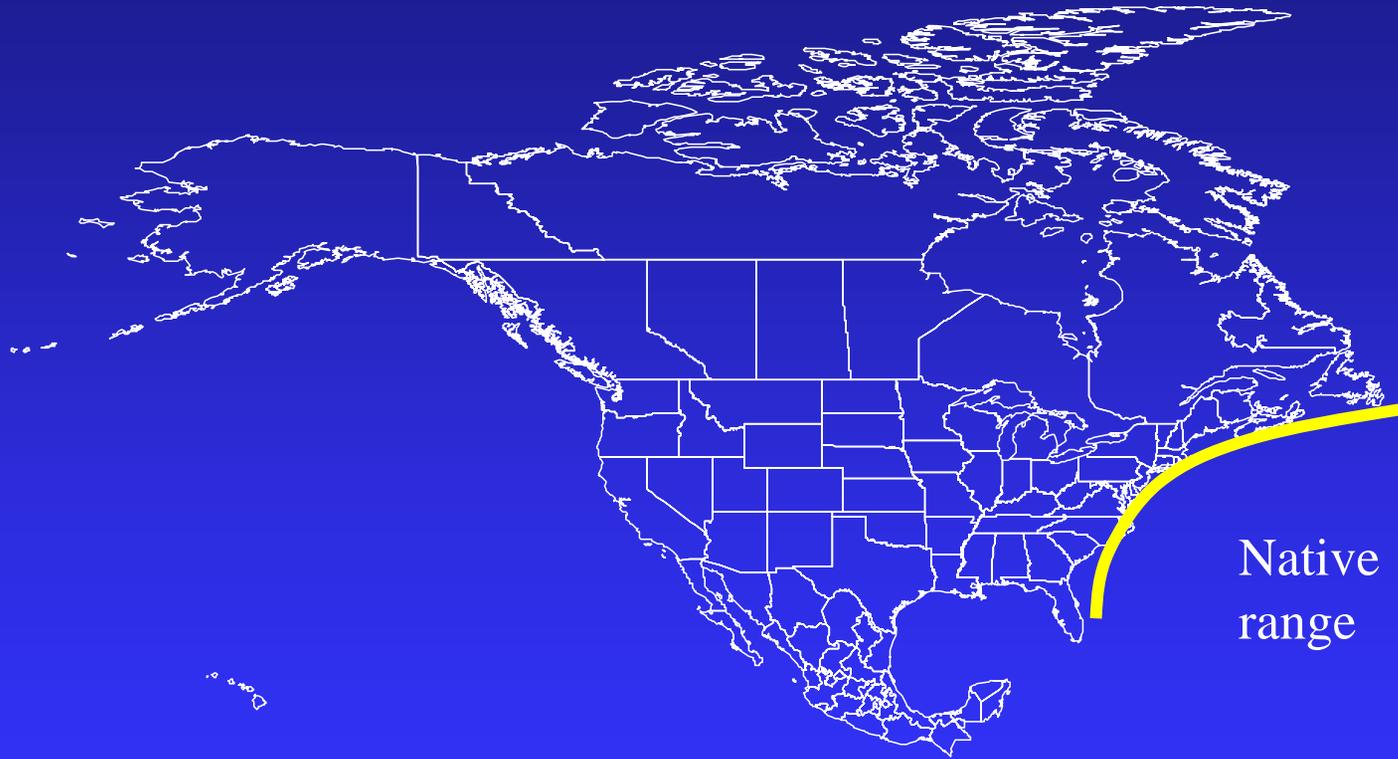
Use of Passive Integrated Transponder (PIT) tags and development of new antenna systems





American Shad

American shad
Alosa sapidissima



American shad *Alosa sapidissima*

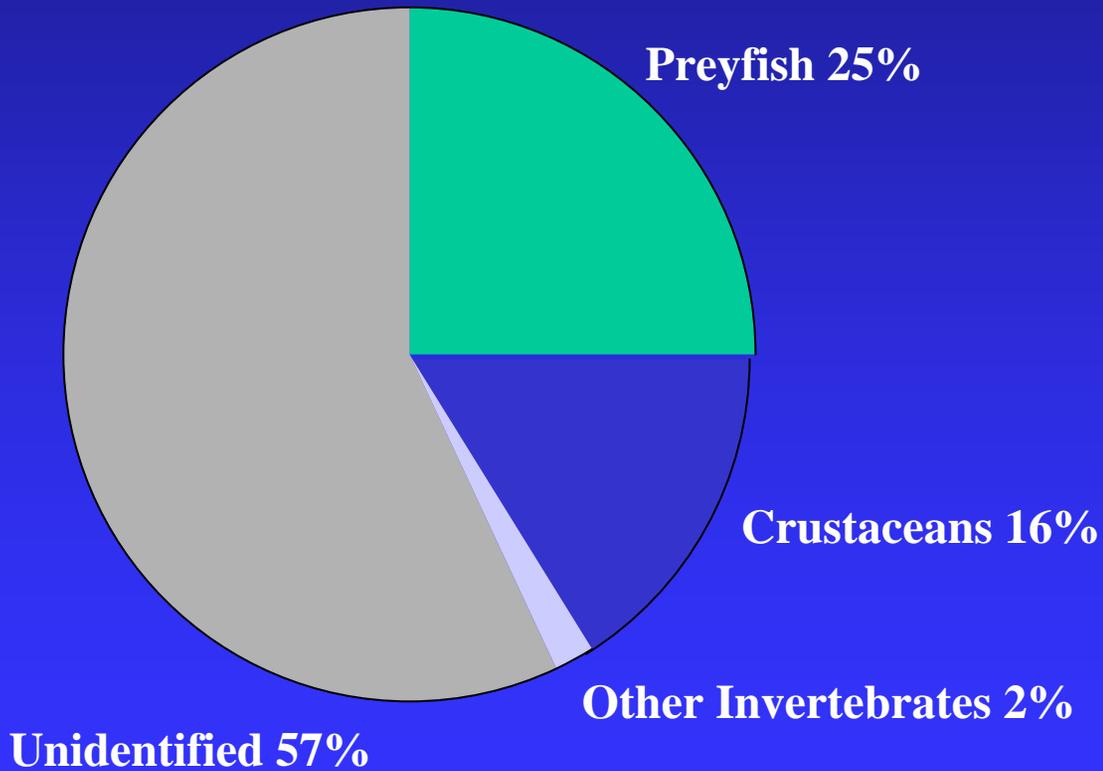




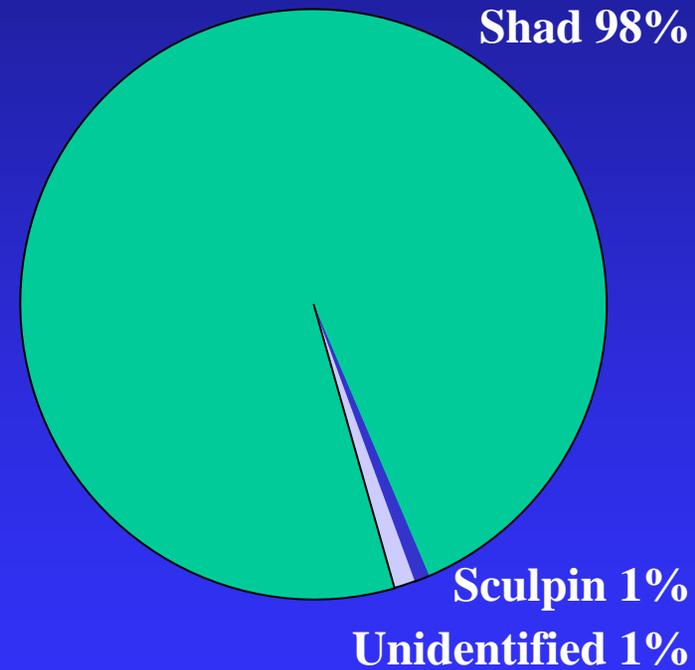
Gut contents of northern pikeminnow

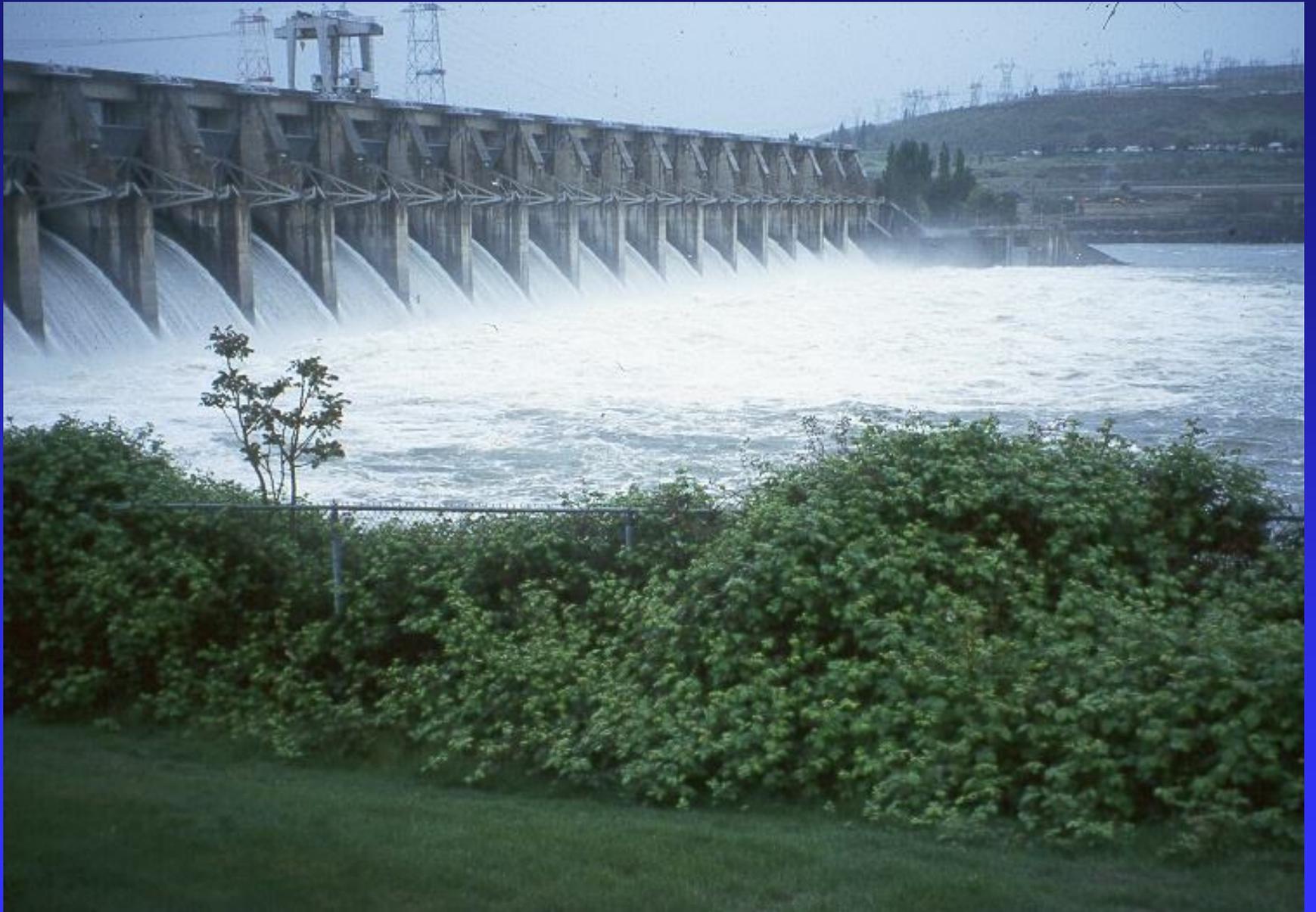
Diet Categories (%)

All Diet Categories
Fish with food in gut
N = 141

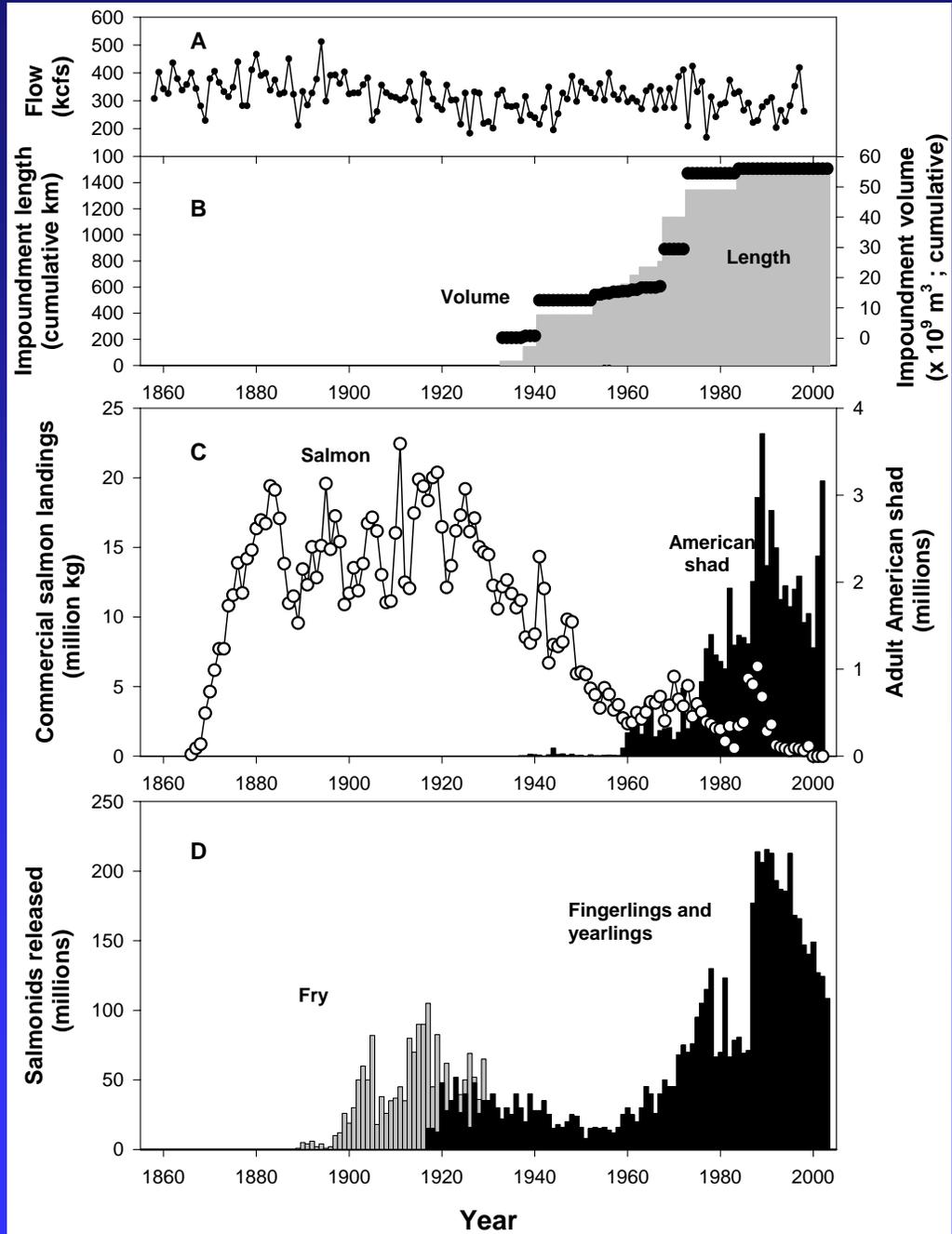


Preyfish Only
N = 42









Juvenile American shad



80 mm

70 mm

60 mm

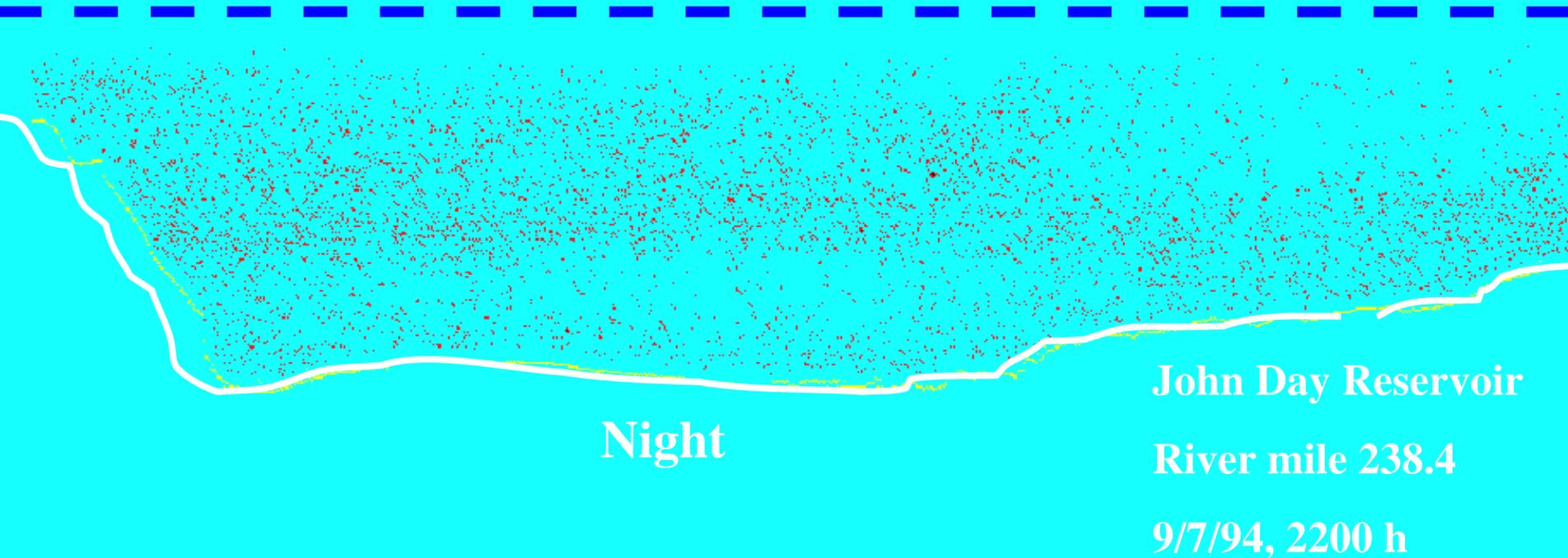
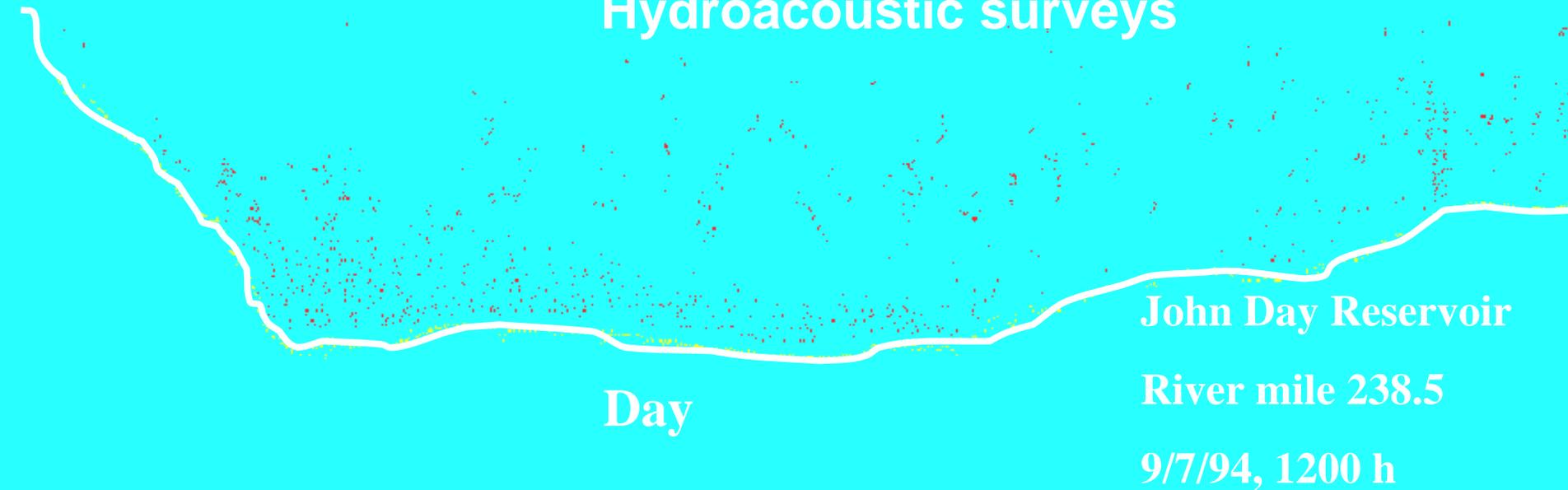
50 mm

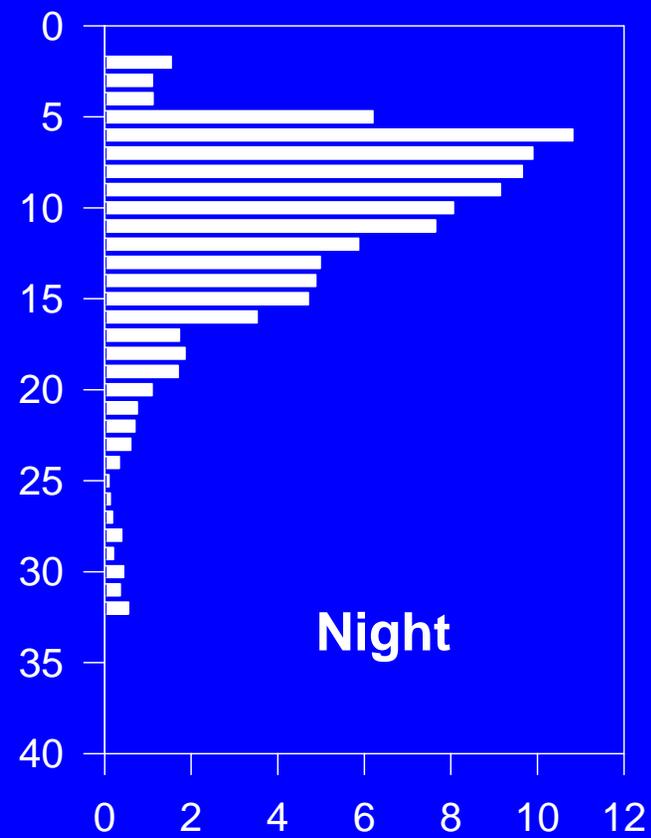
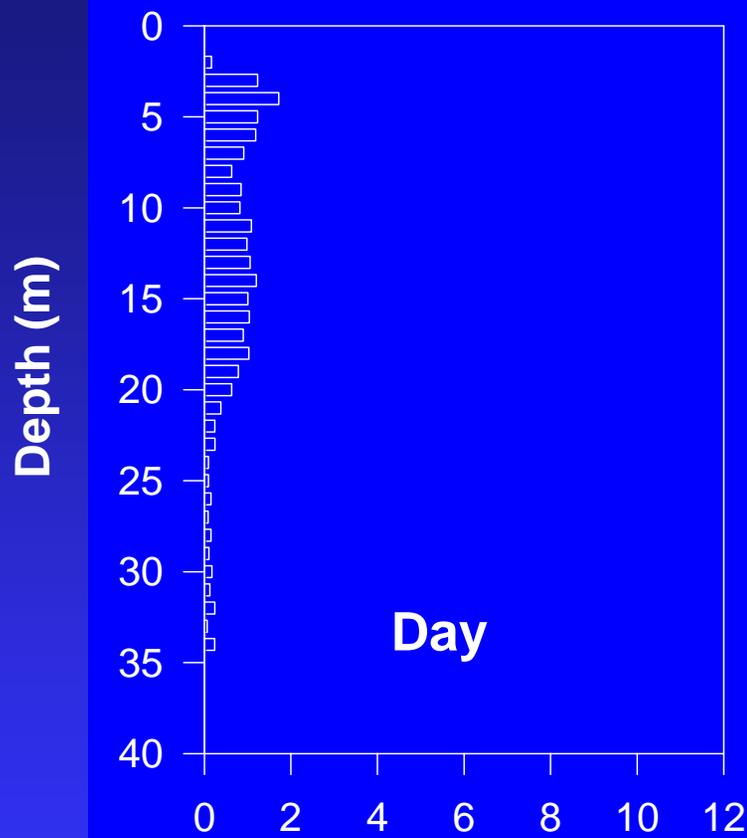
40 mm

Research needs

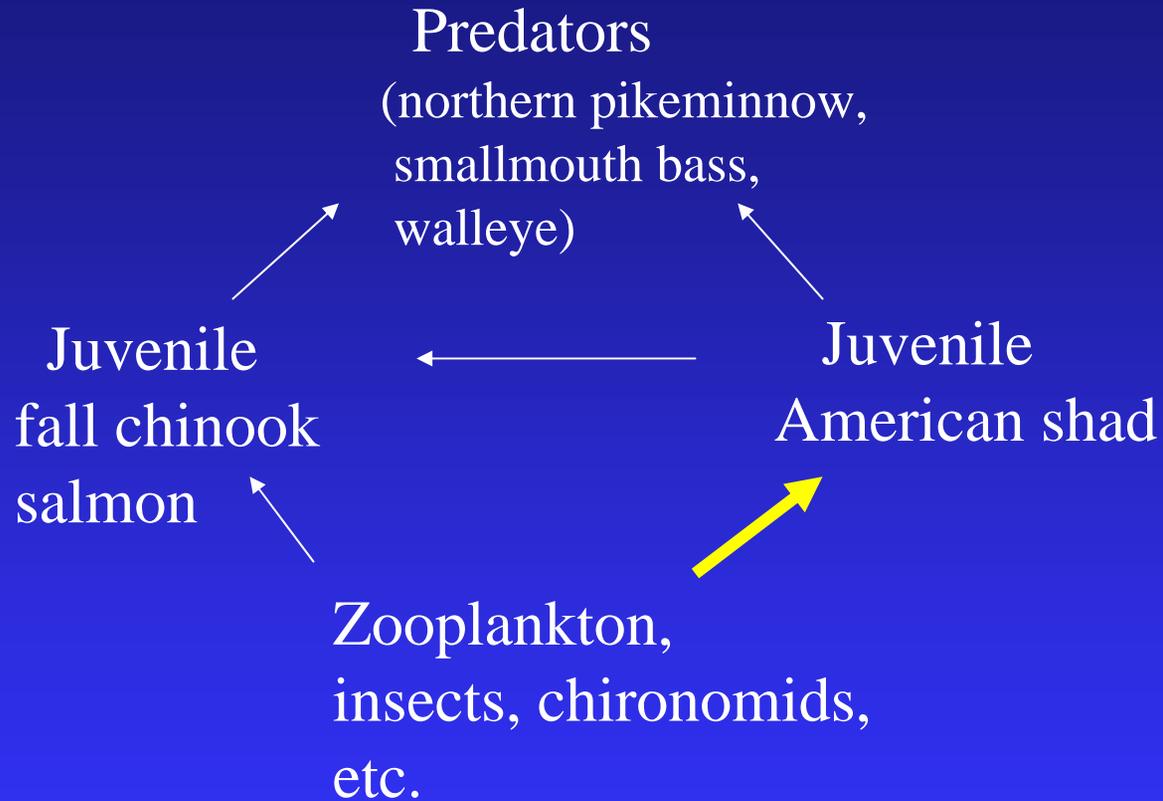
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Hydroacoustic surveys

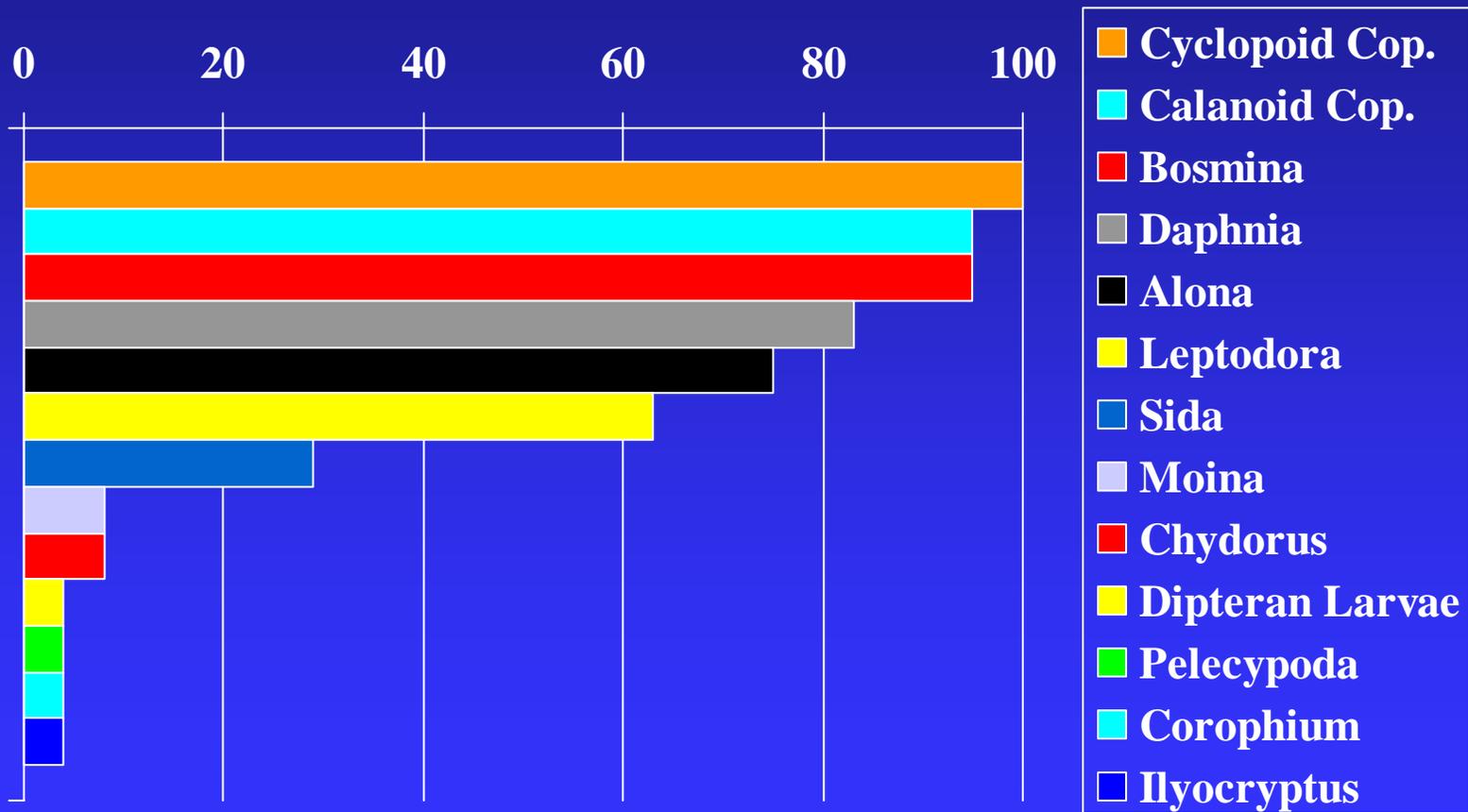




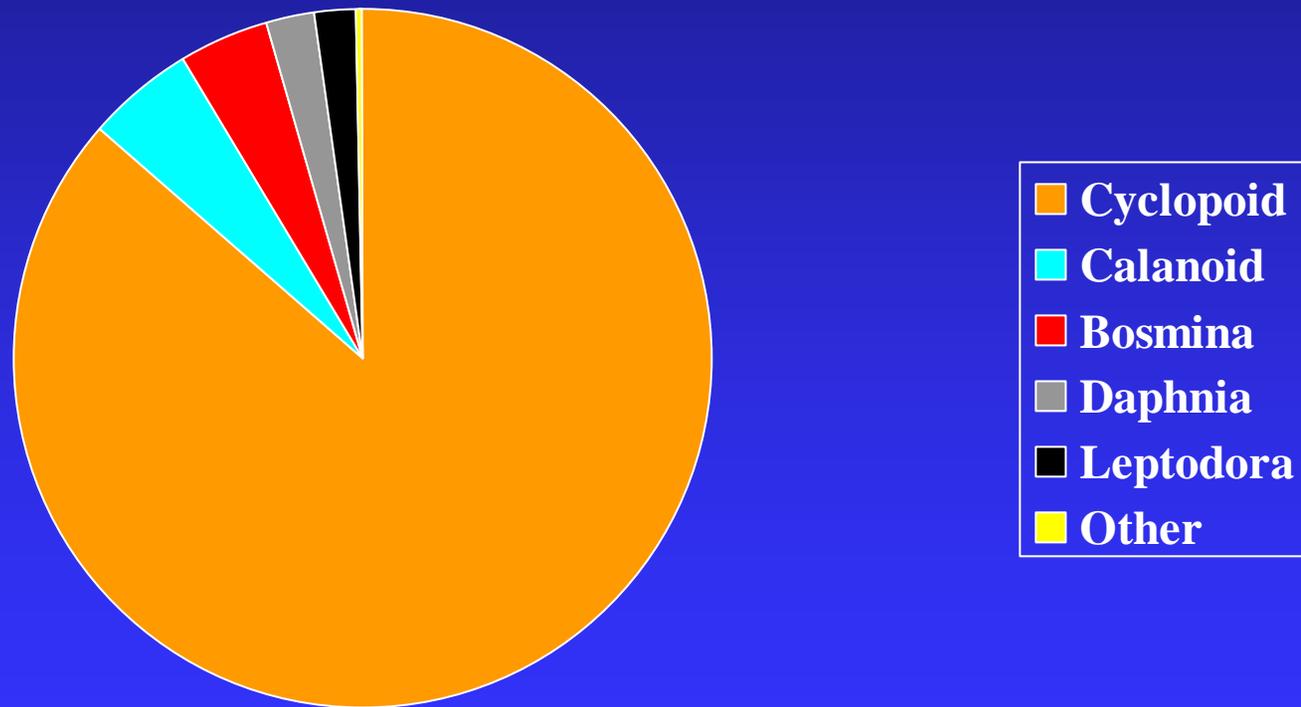
Fish / 10,000 m³



Juvenile American shad diet (% occurrence)



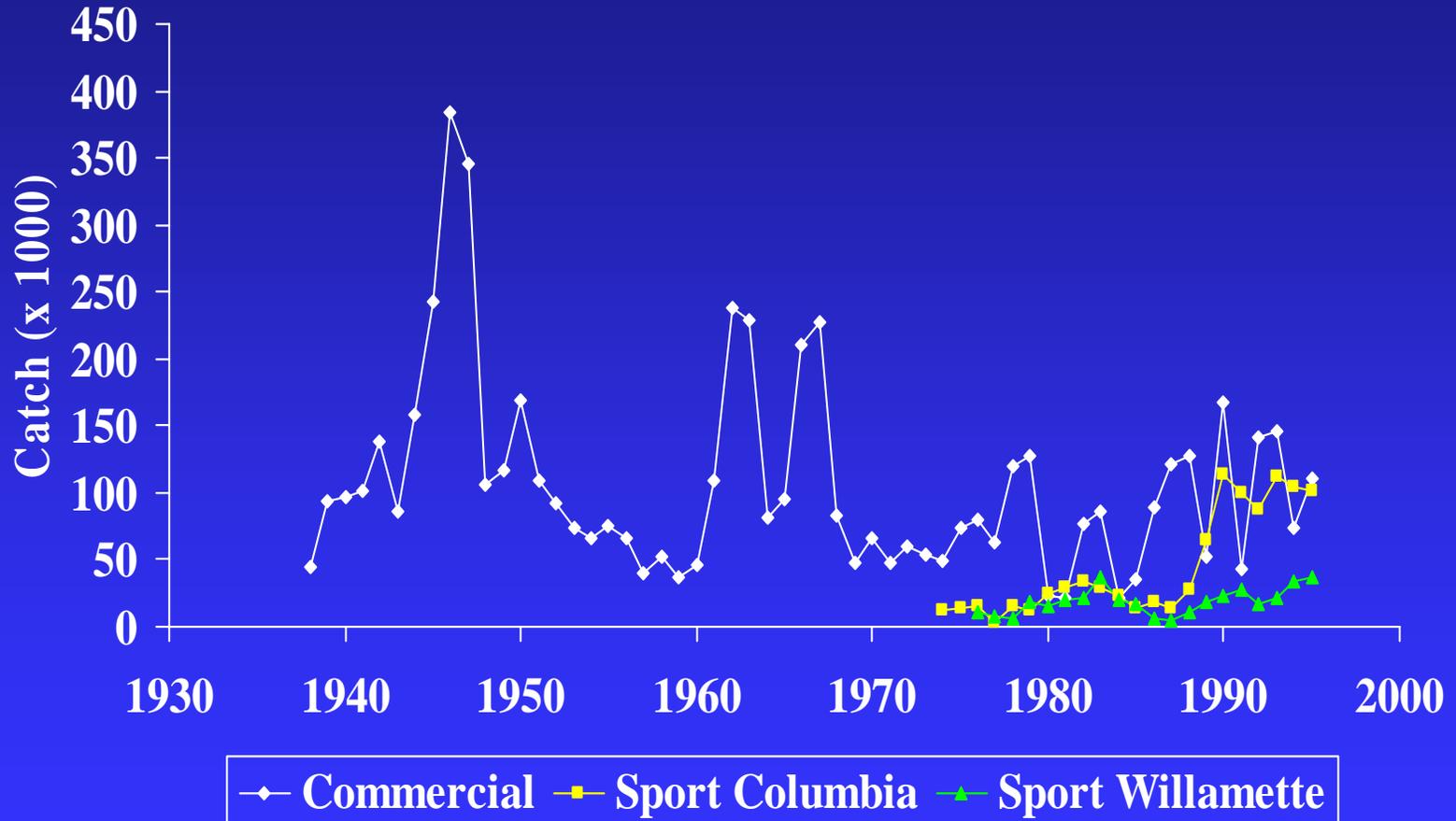
Juvenile American shad diet (% number)





Fishing for American shad in the Bonneville Dam tailrace

Exploitation





Bonneville Dam, Columbia River

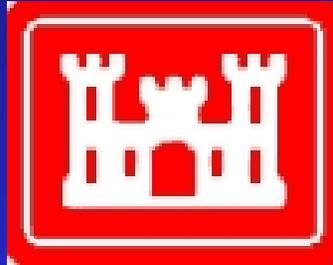
Research needs

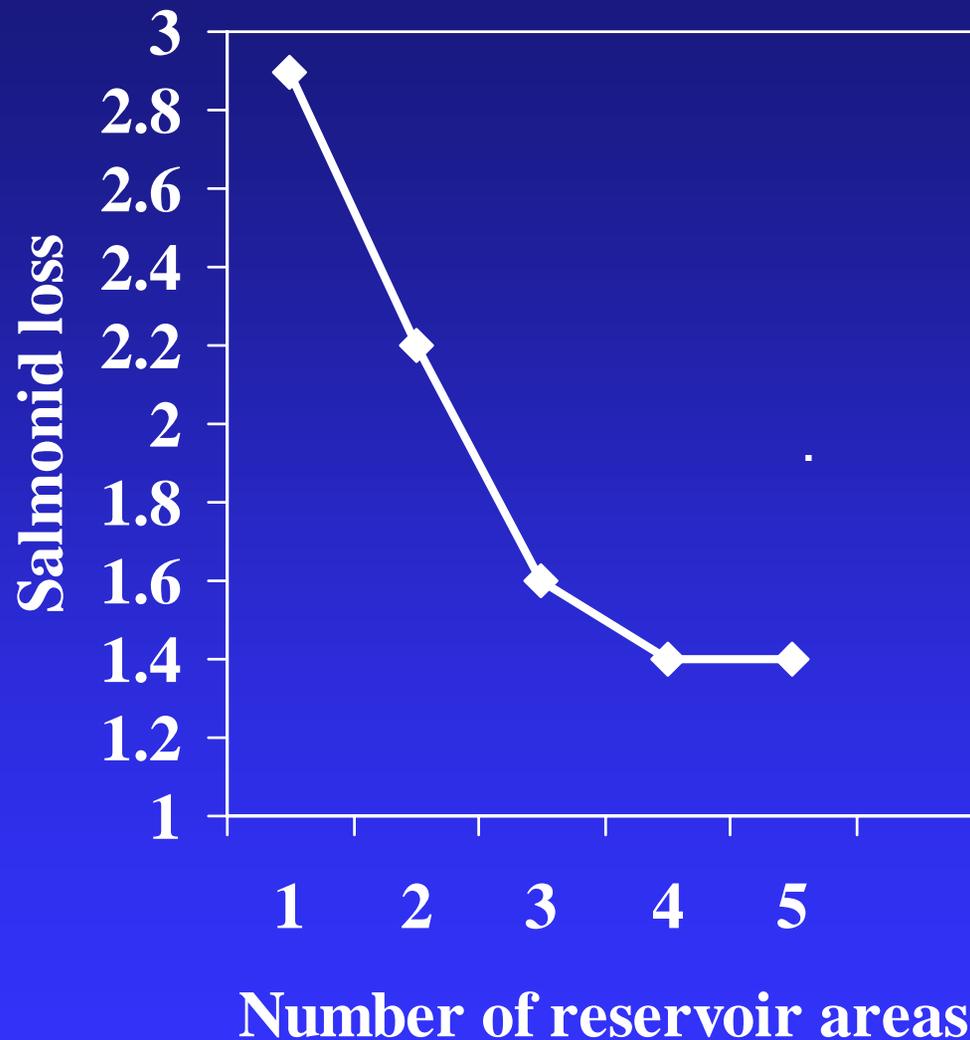
- Role of American shad in salmon recovery efforts
 - Competition at adult ladders
 - Competition with juvenile salmon for food or space
 - Indirect effects, such as supplements to predators
- Effects of shad on zooplankton community
- Effects of shad in the lower Columbia River and the estuary
- Nutrient dynamics
- Abundance and effects in other river systems of western North America

Columbia River Basin Predator Removal



Collaborations





- Pooling data influences overall loss estimates
- Higher predation losses in dam forebays and tailraces