Regional Monitoring of Salmonid Abundance:

A Pilot Study in Coastal California

RESOURCES AGENCY
CALIFORNIA
DEPARTMENT
FISH&GAME

THE Campbell GROUP LLC

HAWTHORNE
Timber Company

Fisheries Restoration Grant Program

Dept. Mathematical Sciences

CLEMSON UNIVERSITY

HUMBOLDT STATE UNIVERSITY

NOAA

IDAHO · OREGON · ALASKA
PACIFIC STATES MARINE FISHERIES COMMISSION
WASHINGTON · CALIFORNIA

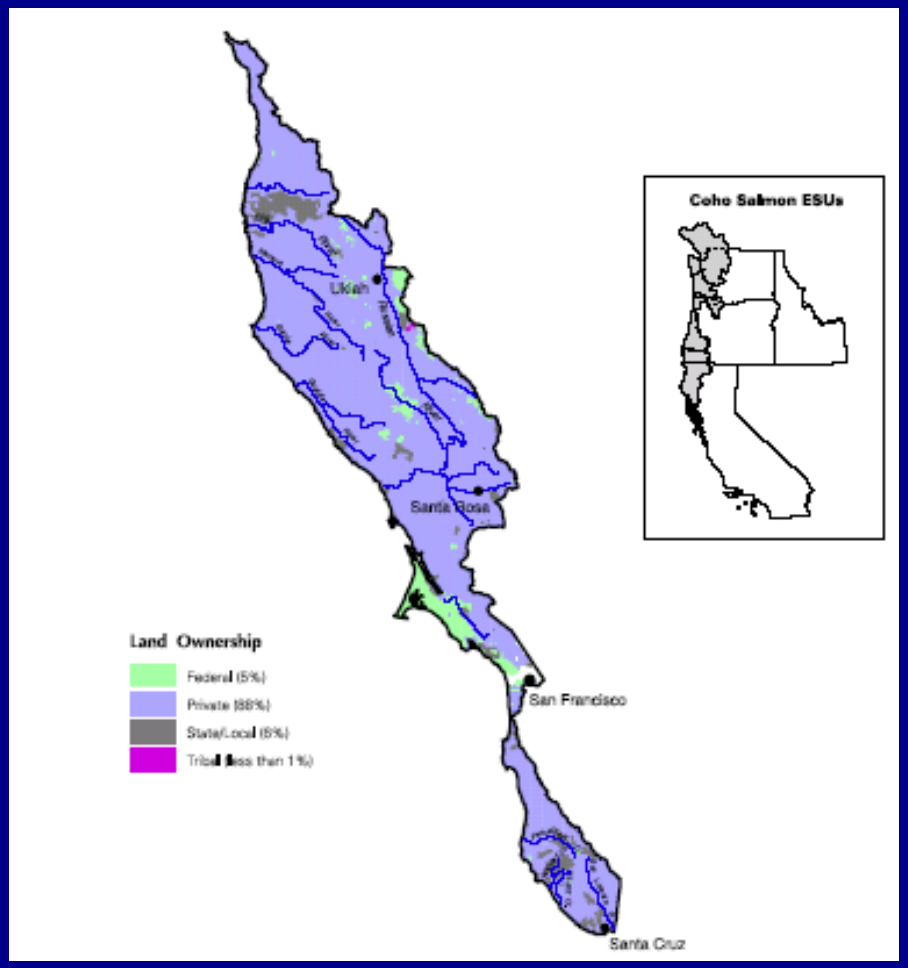
WEST, Inc.

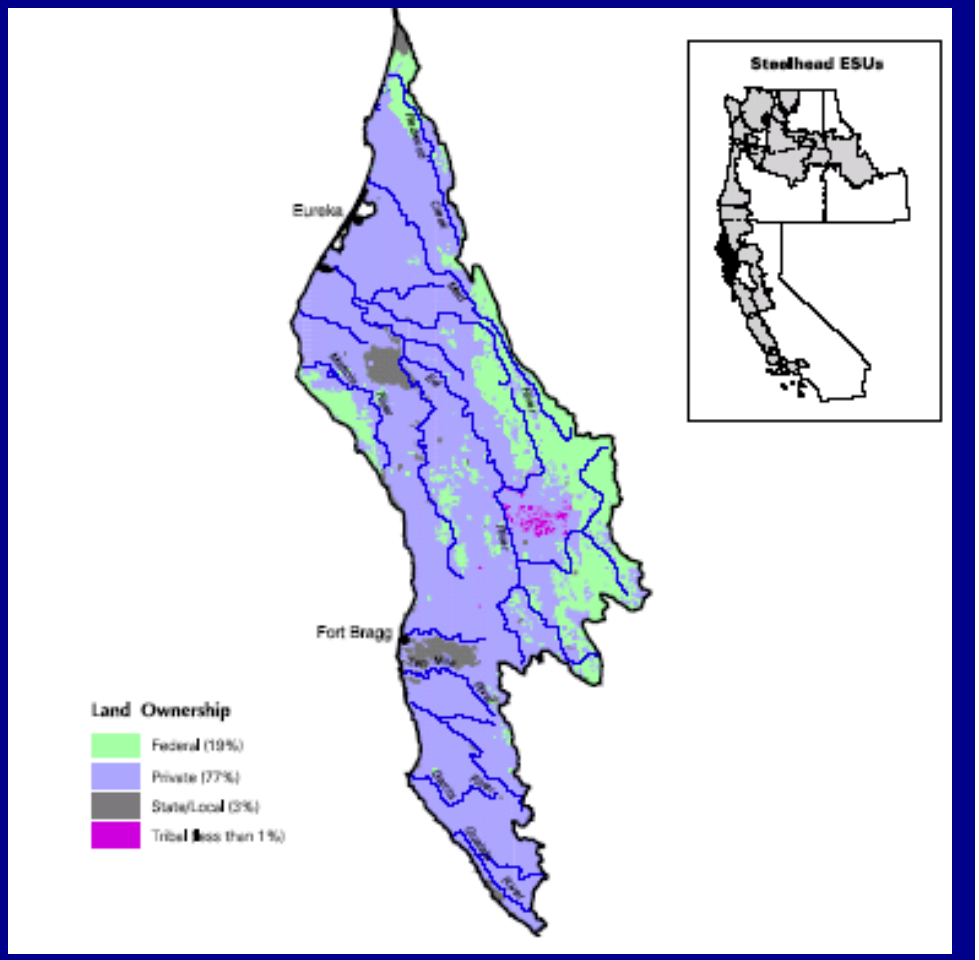
IRE

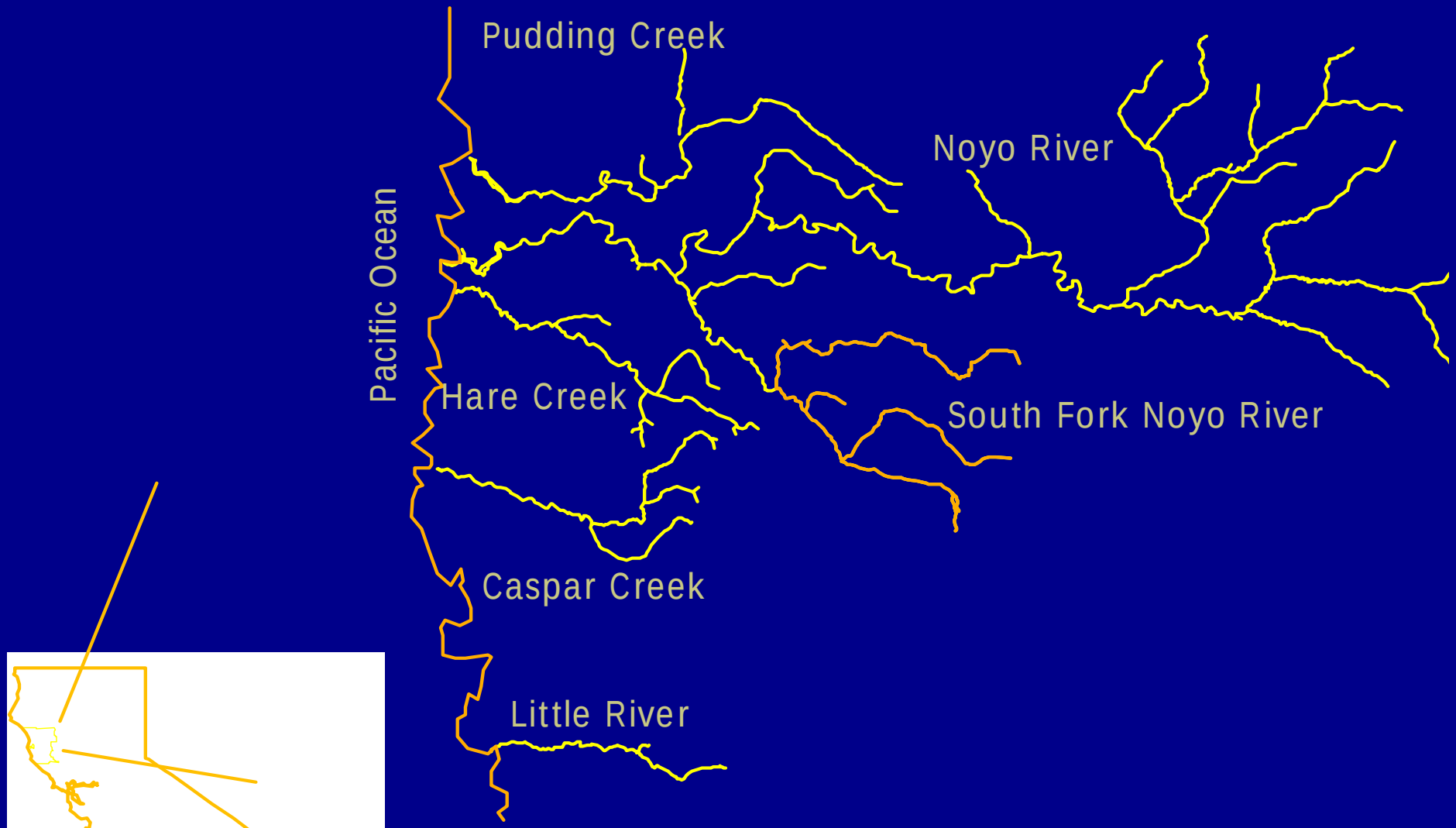
A Tale Of Two-Stages

And a Crossover

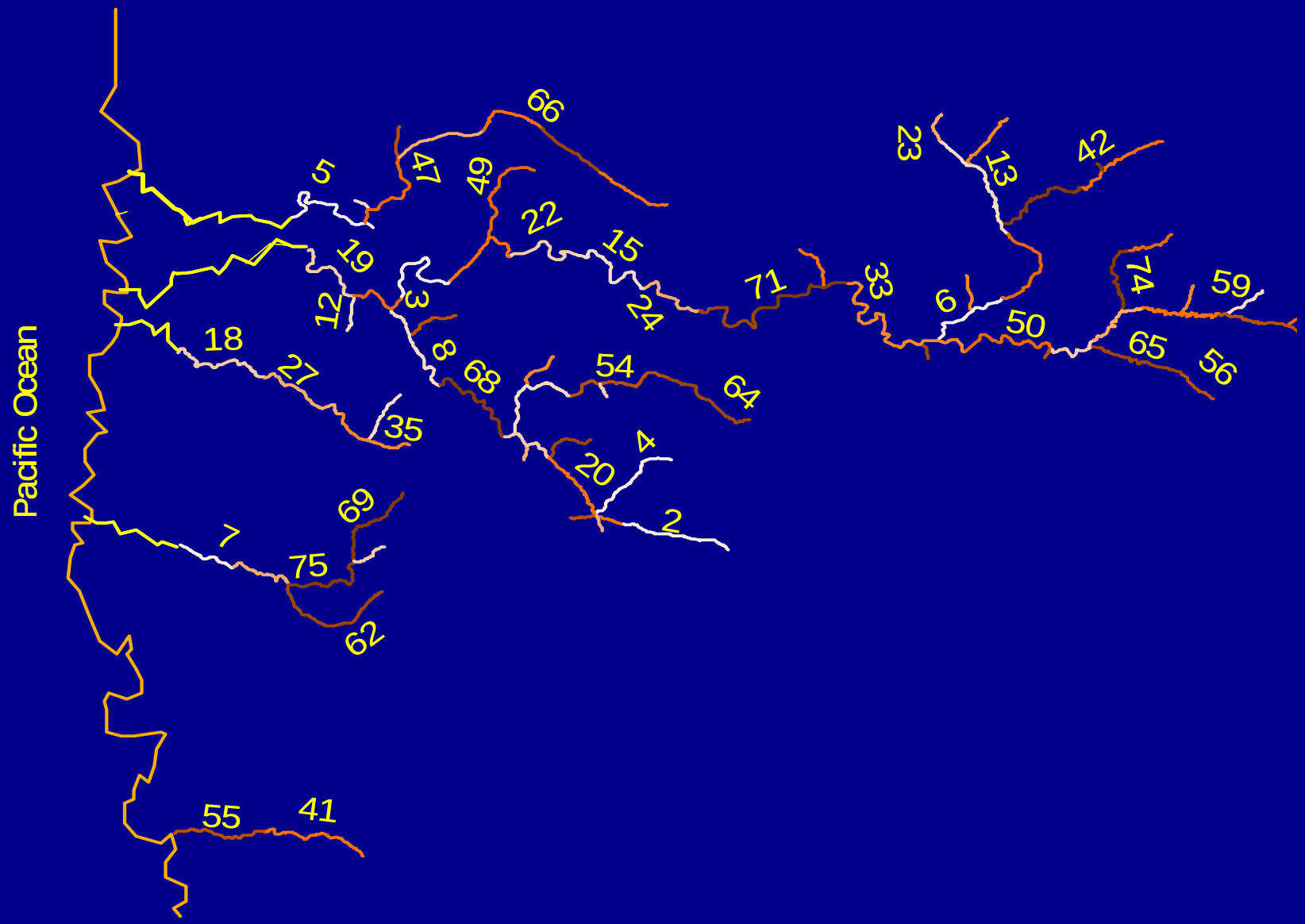
Adult ESU Level Escapement



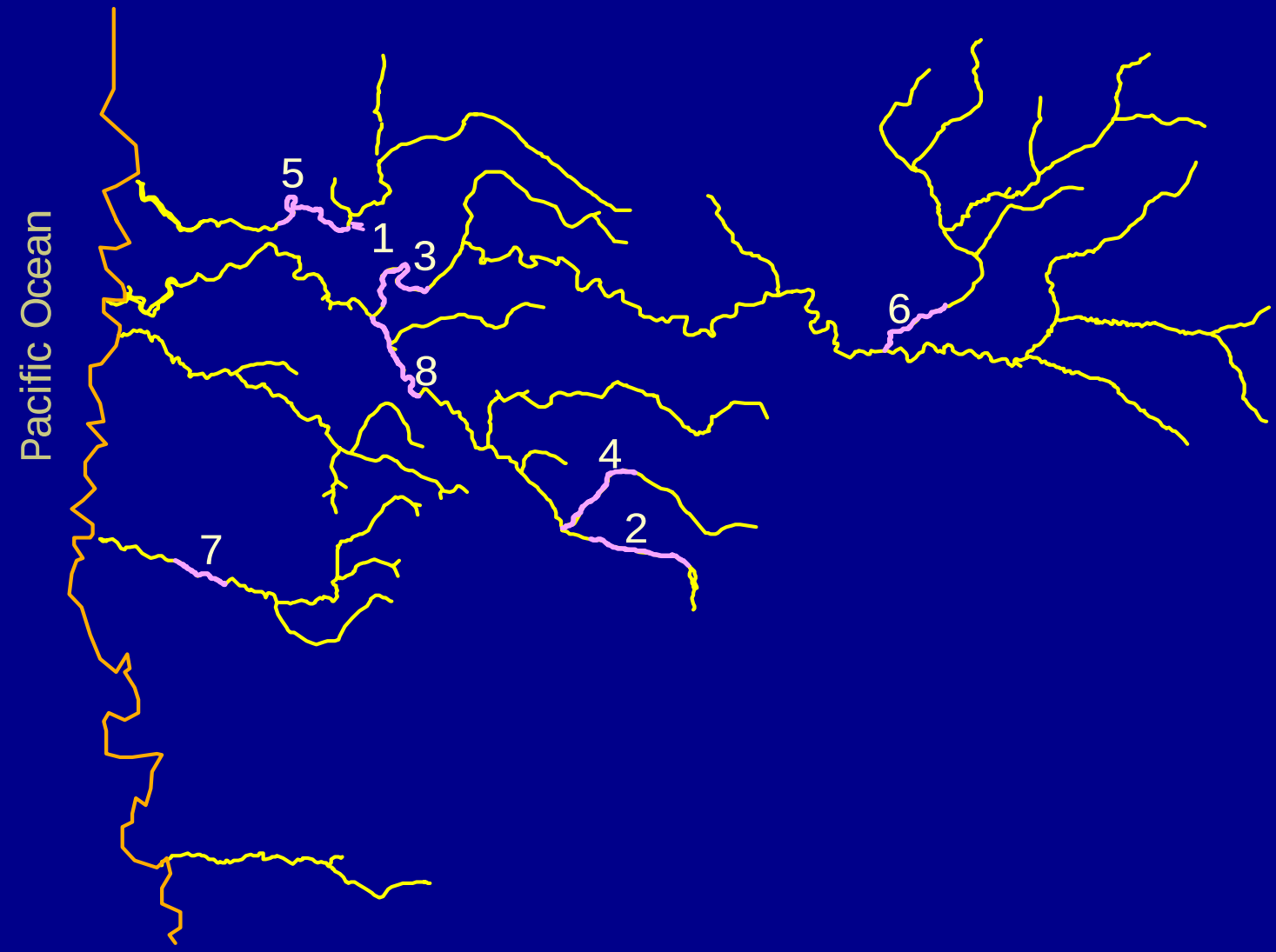




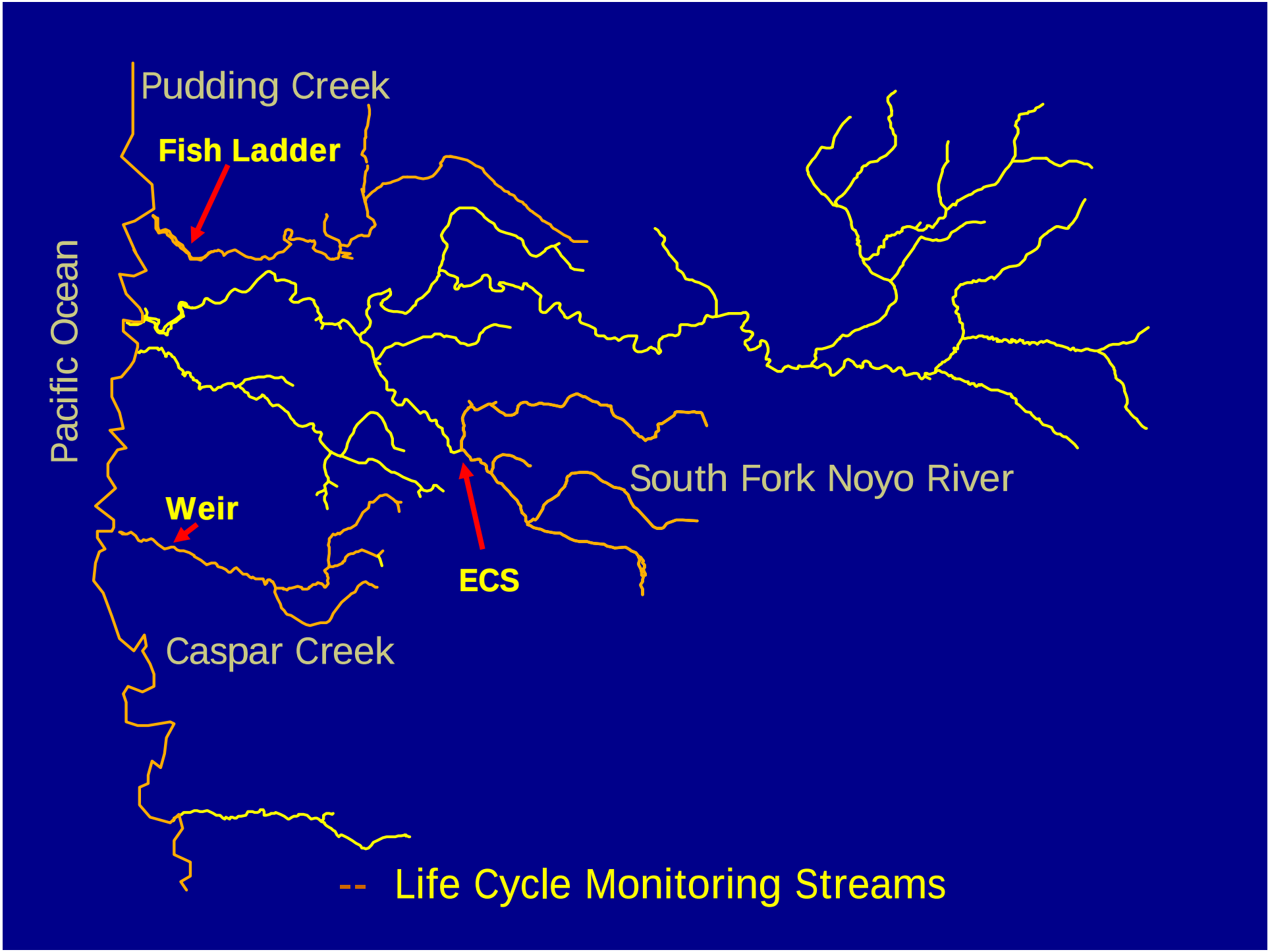
Study Streams in California



Generalized random tessellation stratified (GRTS) sampling



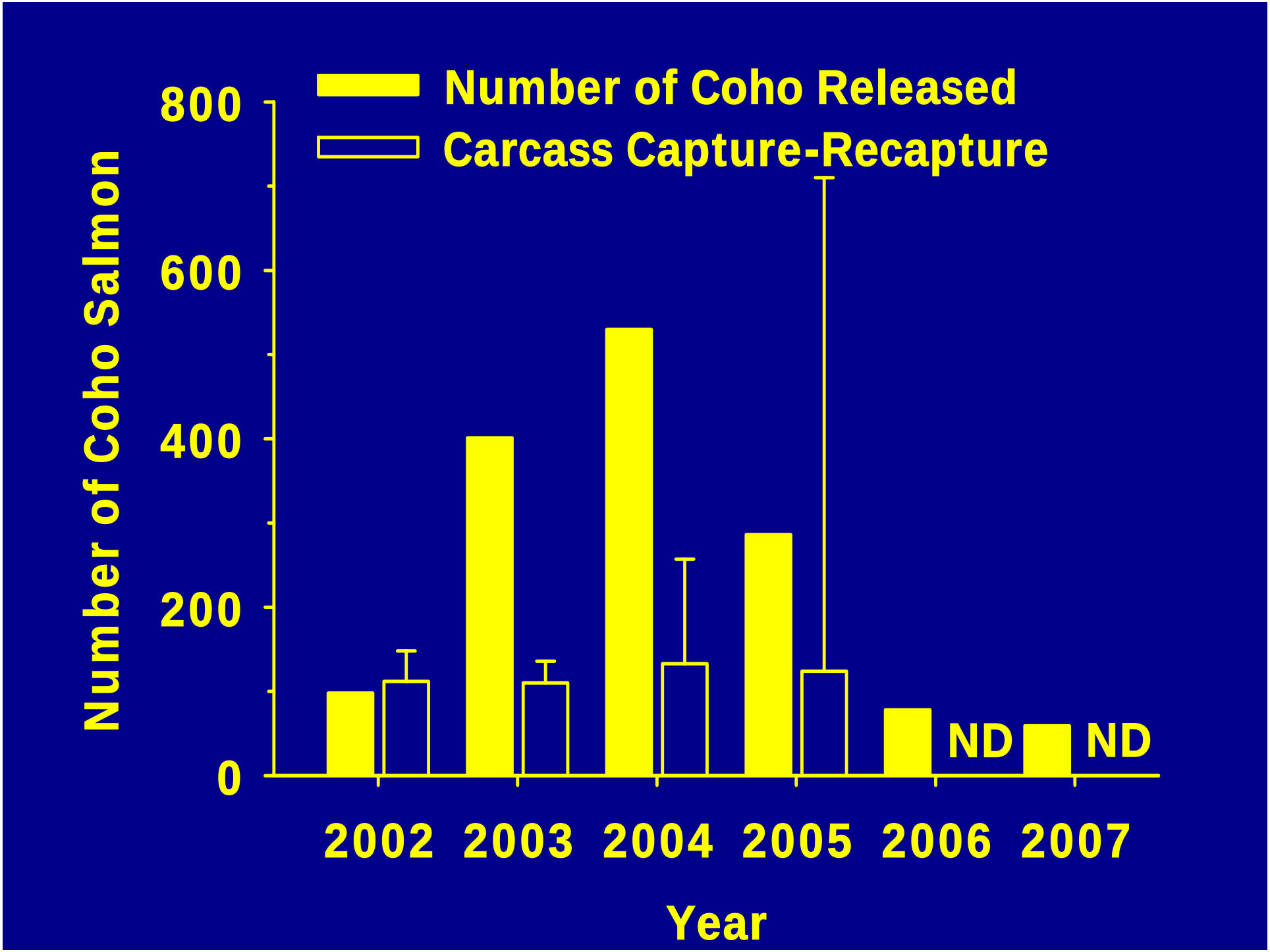
10% GRTS sampling reaches

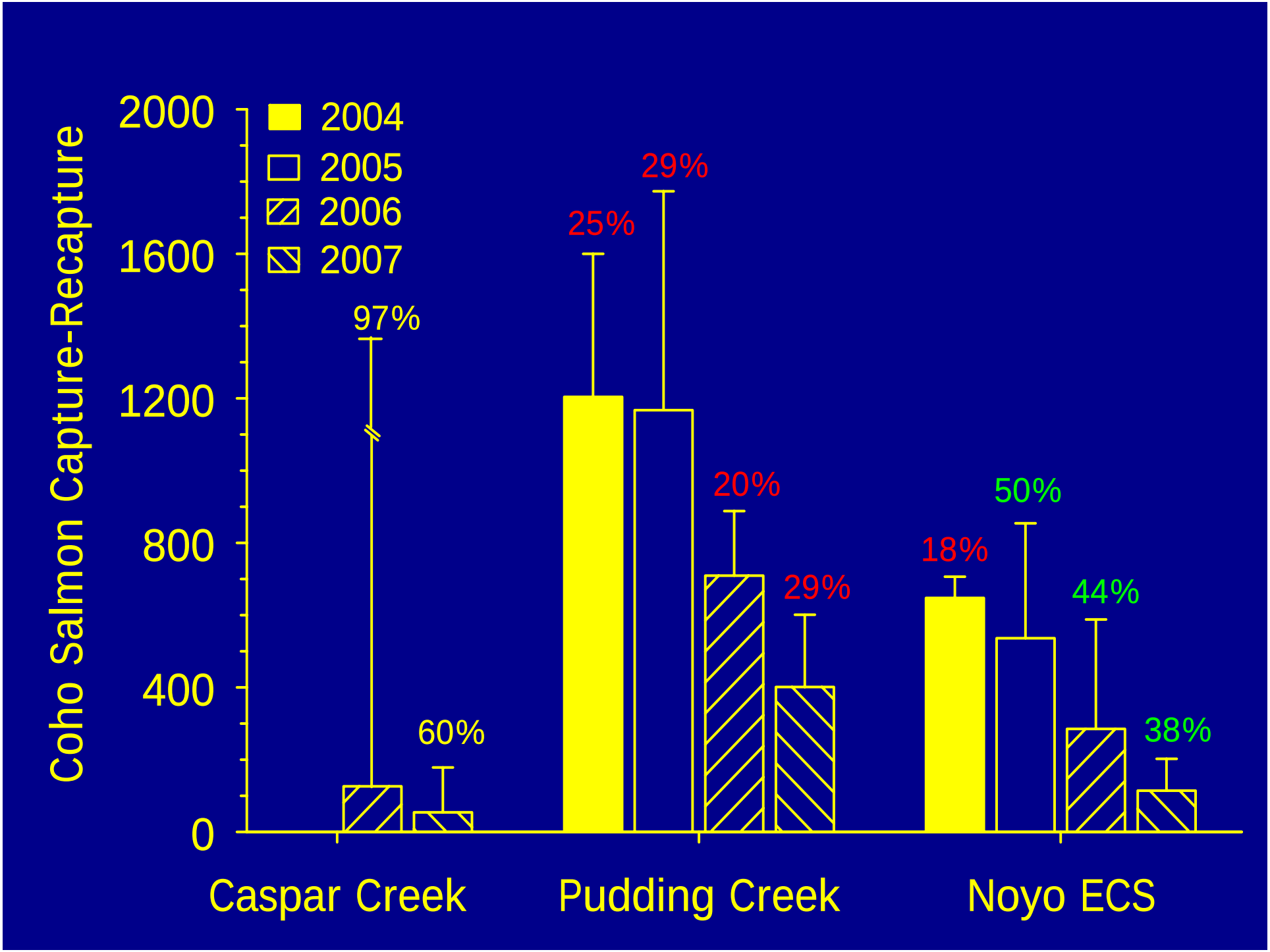

Pudding Creek
Fish Ladder
Pacific Ocean
South Fork Noyo River
Weir
ECS
Caspar Creek
-- Life Cycle Monitoring Streams

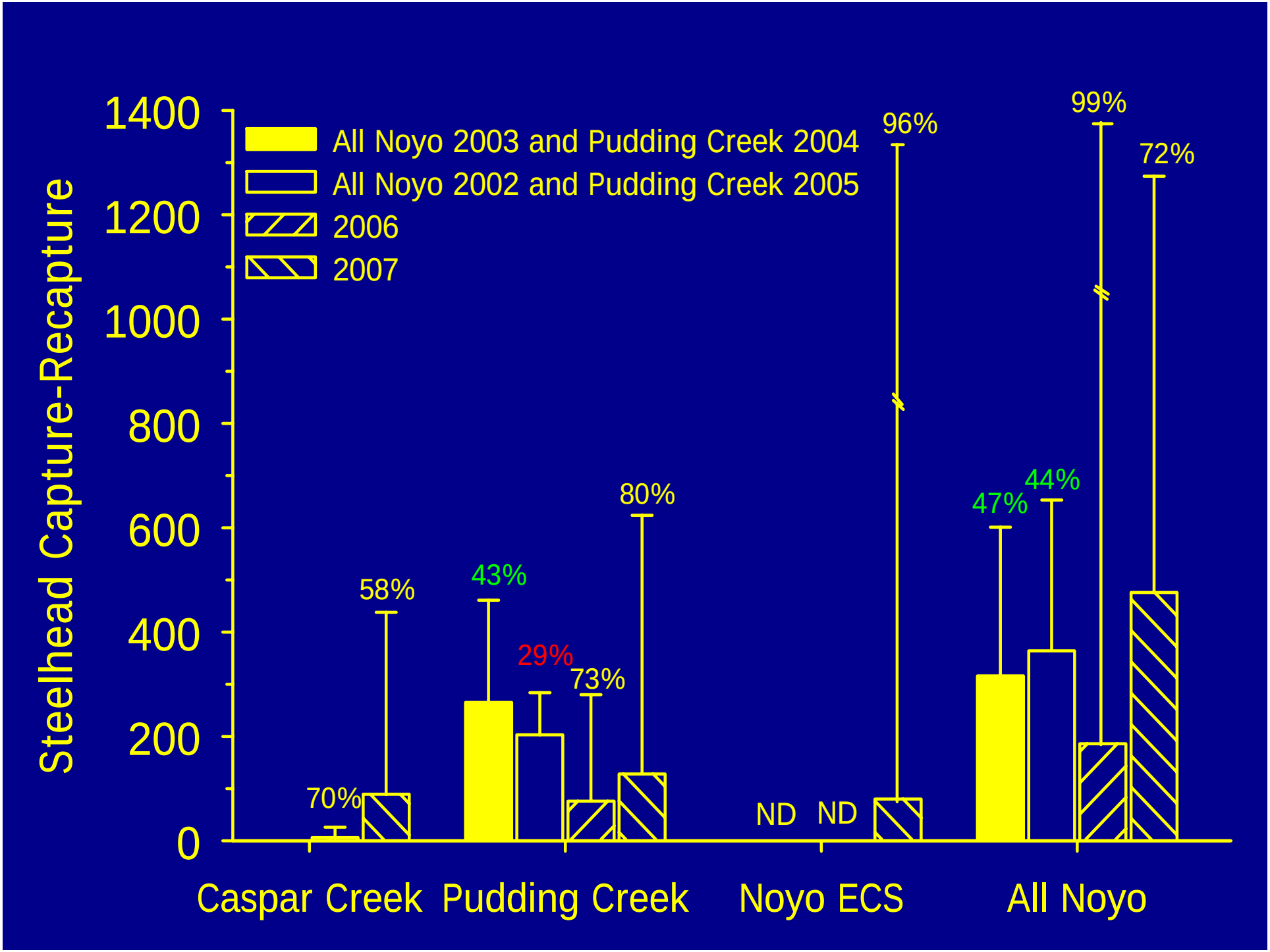
2 3 2004

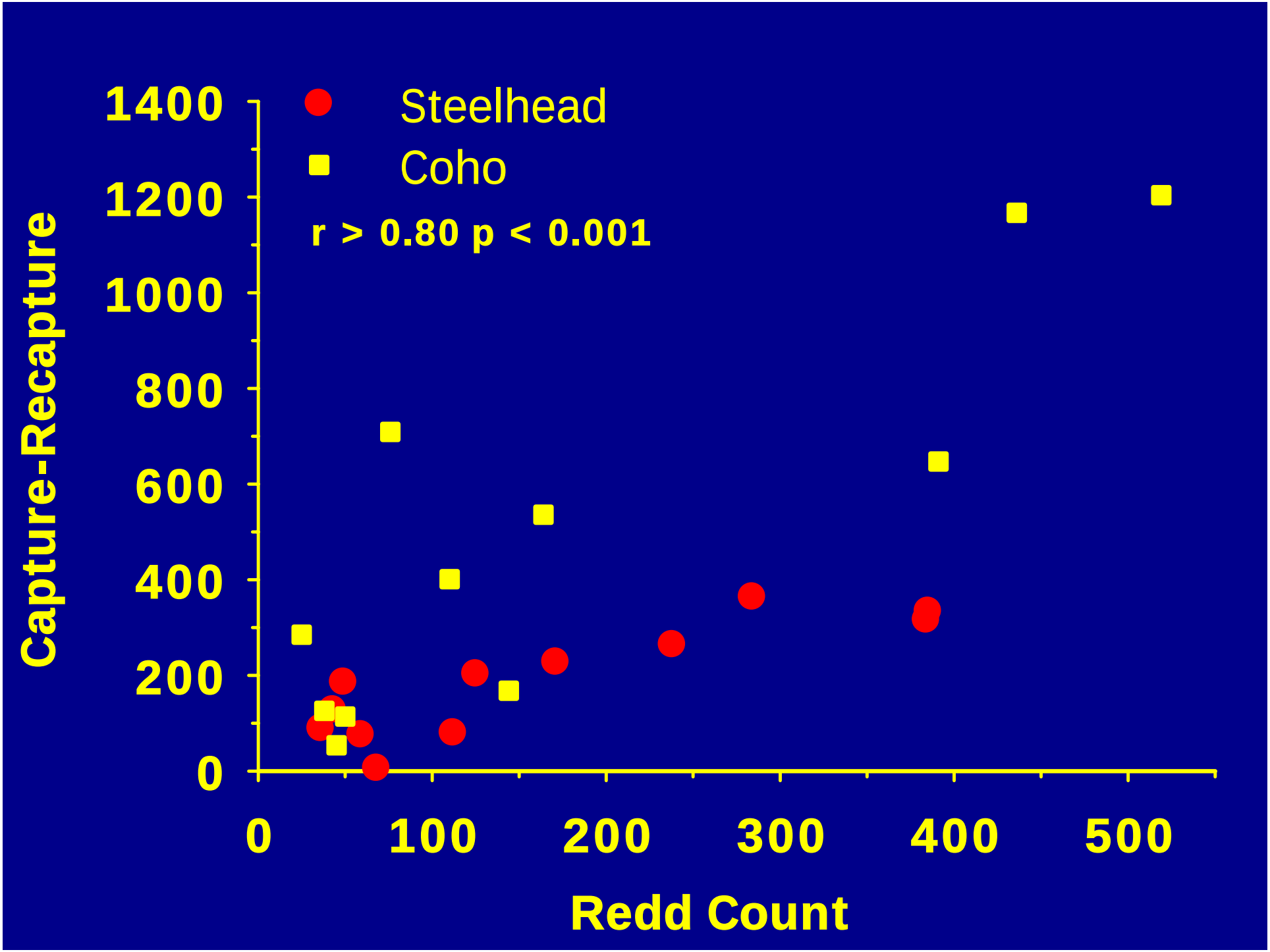
17 2 2004

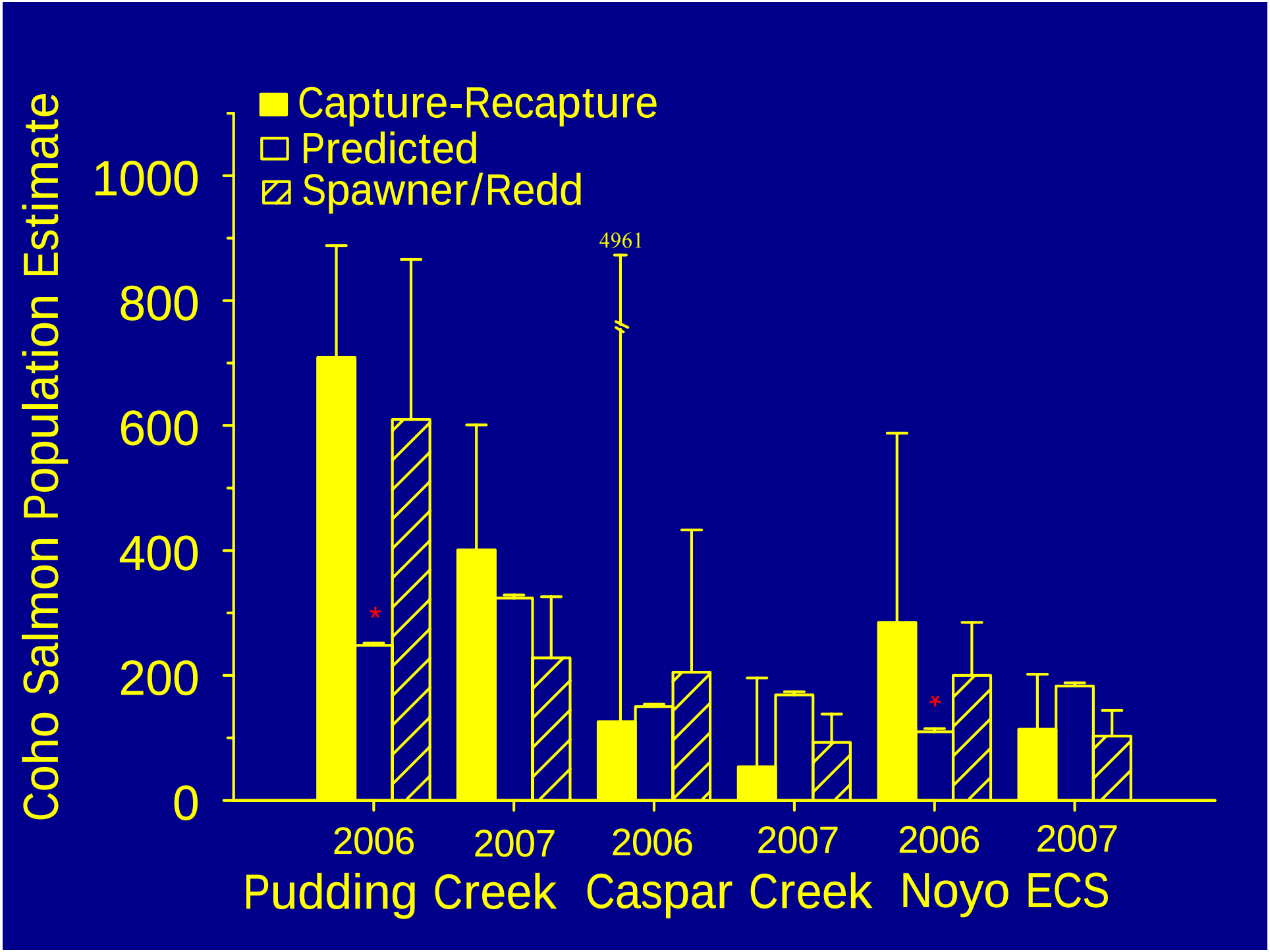
50 ¢

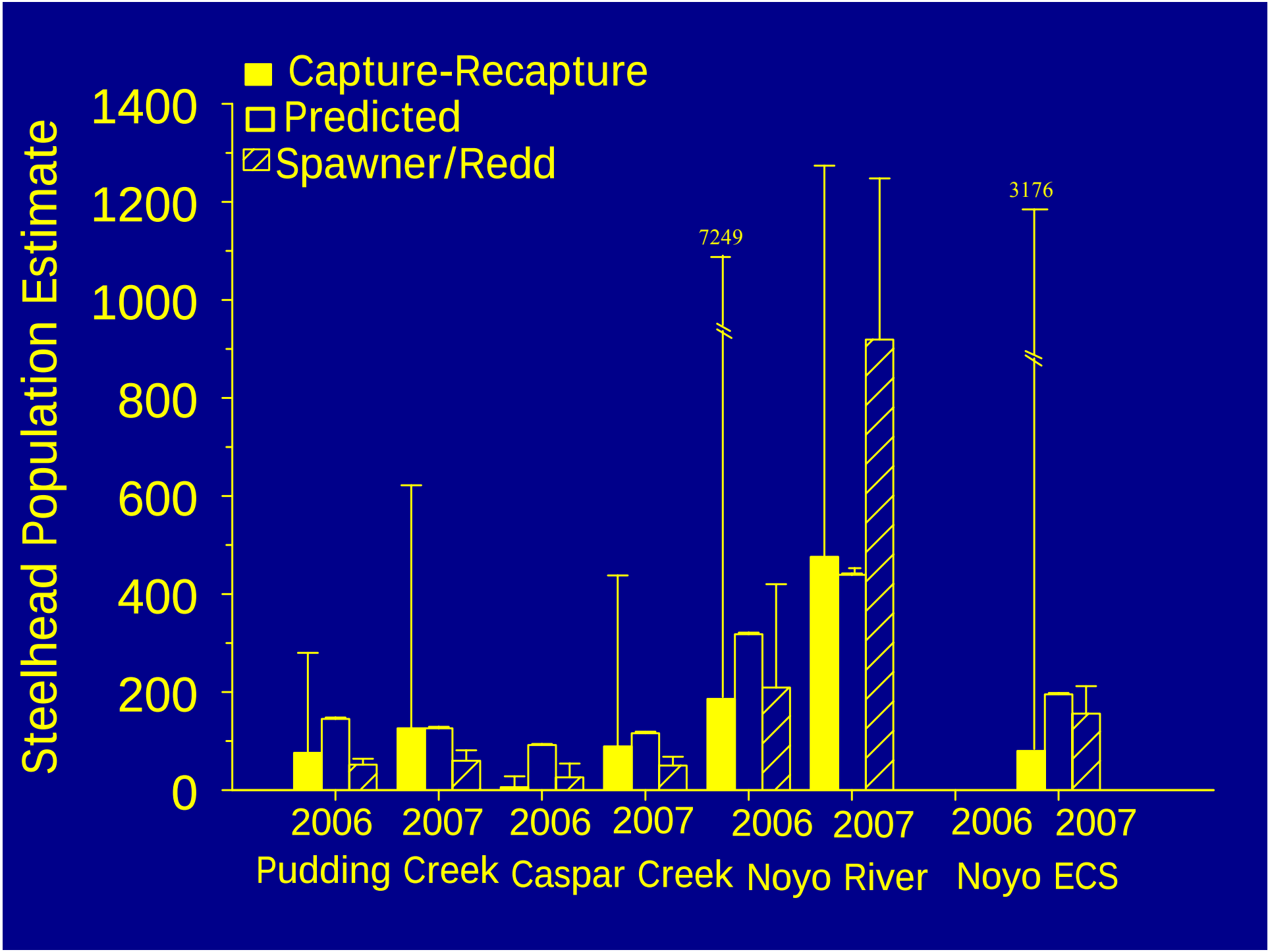

Number of Coho Released
Carcass Capture-Recapture
Number of Coho Salmon
800
600
400
200
0
ND
ND
2002
2003
2004
2005
2006
2007
Year


Coho Salmon Capture-Recapture
2000
1600
1200
800
400
0
2004
2005
2006
2007
97%
60%
25%
29%
20%
29%
18%
50%
44%
38%
Caspar Creek
Pudding Creek
Noyo ECS


Steelhead Capture-Recapture
1400
1200
1000
800
600
400
200
0
All Noyo 2003 and Pudding Creek 2004
All Noyo 2002 and Pudding Creek 2005
2006
2007
70%
58%
43%
29%
73%
80%
ND
ND
96%
47%
44%
99%
72%
Caspar Creek
Pudding Creek
Noyo ECS
All Noyo


Steelhead
Coho
r > 0.80 p < 0.001
Capture-Recapture
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
Redd Count


Capture-Recapture
Predicted
Spawner/Redd
Coho Salmon Population Estimate
1000
800
600
400
200
0
4961
*
*
2006
2007
2006
2007
2006
2007
Pudding Creek
Caspar Creek
Noyo ECS

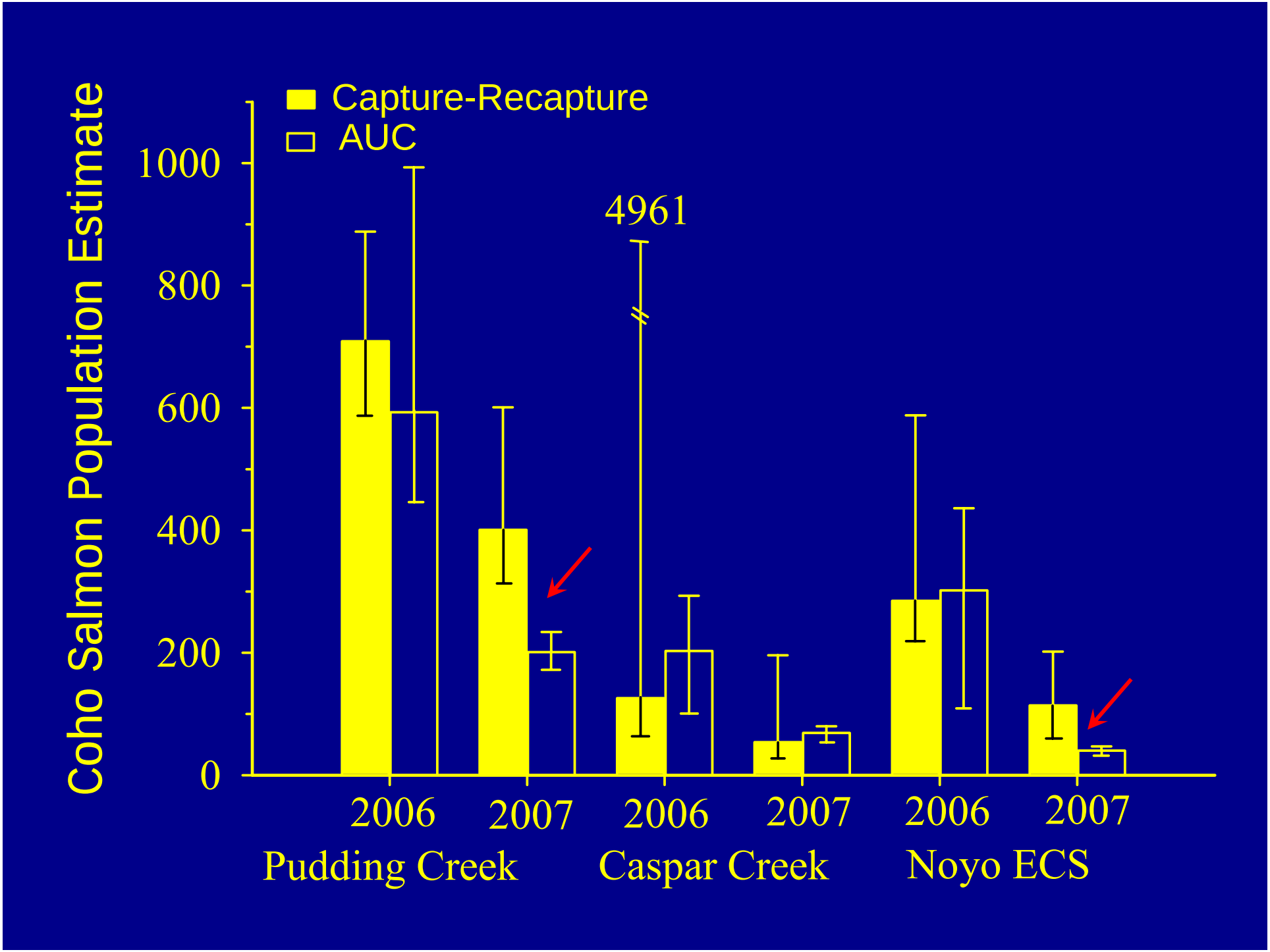

Capture-Recapture
Predicted
Spawner/Redd
Steelhead Population Estimate
1400
1200
1000
800
600
400
200
0
7249
3176
2006
2007
2006
2007
2006
2007
2006
2007
Pudding Creek
Caspar Creek
Noyo River
Noyo ECS

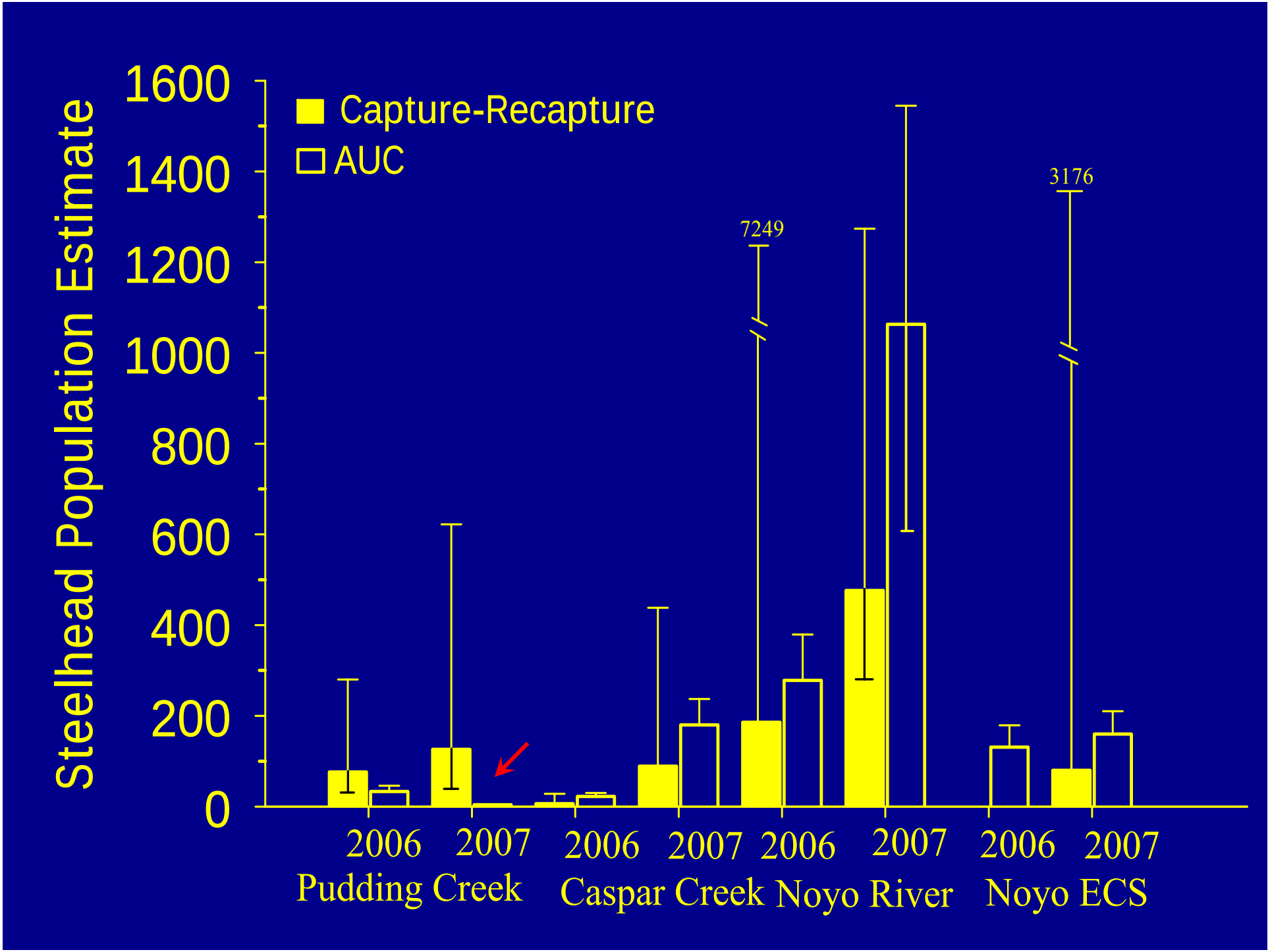
Coho Salmon Residence Time

Year	Data	Coho Salmon Residence Time			
		n	Low 95% CI	Point Estimate	High 95% CI
2005-06	Annual Average	11	15.03	21.73	28.42
2006-07	Annual Average	3	20.00	23.30	29.00
All Years	Grand Mean	164	25.16	26.99	28.83

Average Observer Efficiency

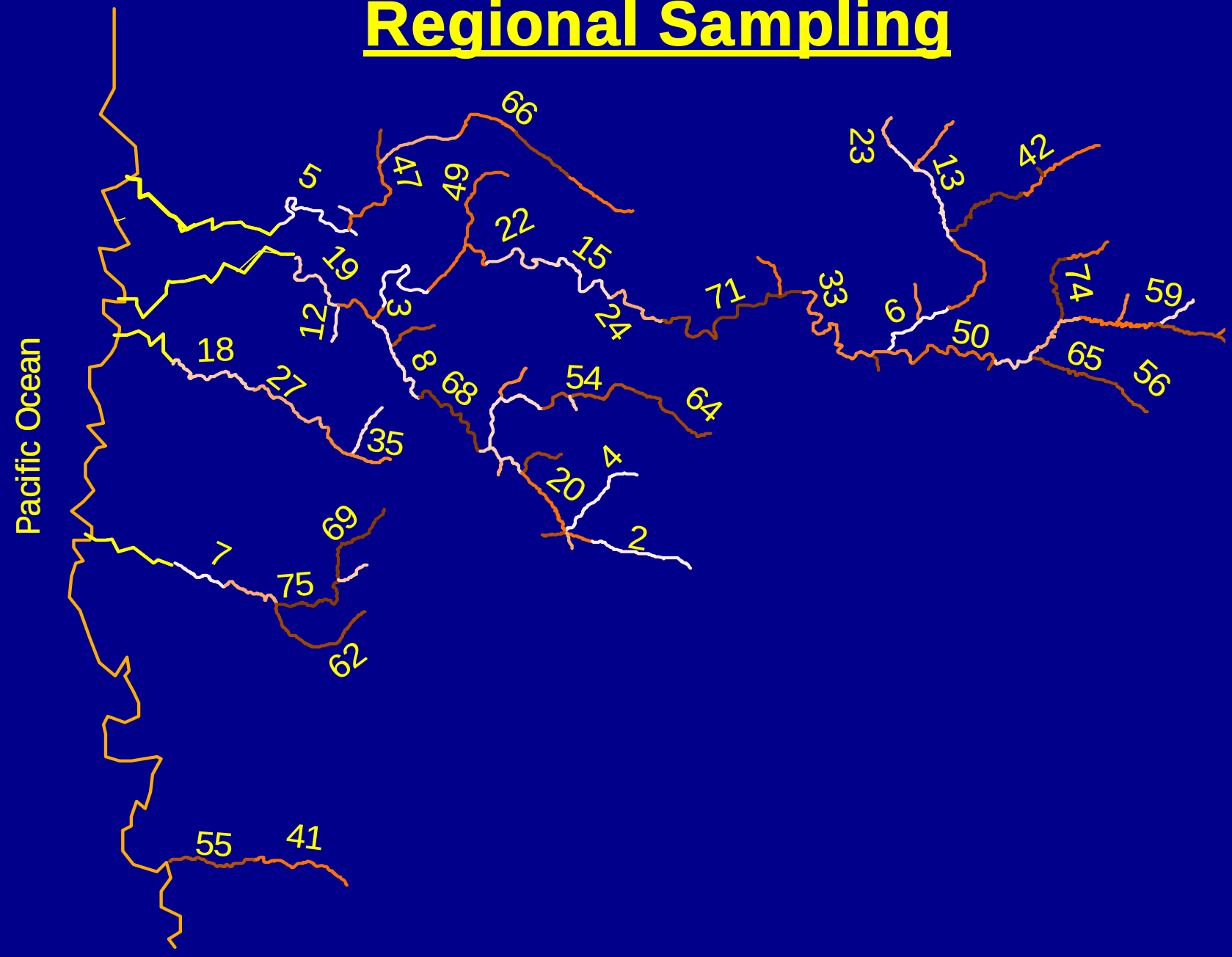
Coho Salmon	Steelhead
0.20 ± 0.03 (95%ci)	0.11 ± 0.0.7 (95%ci)

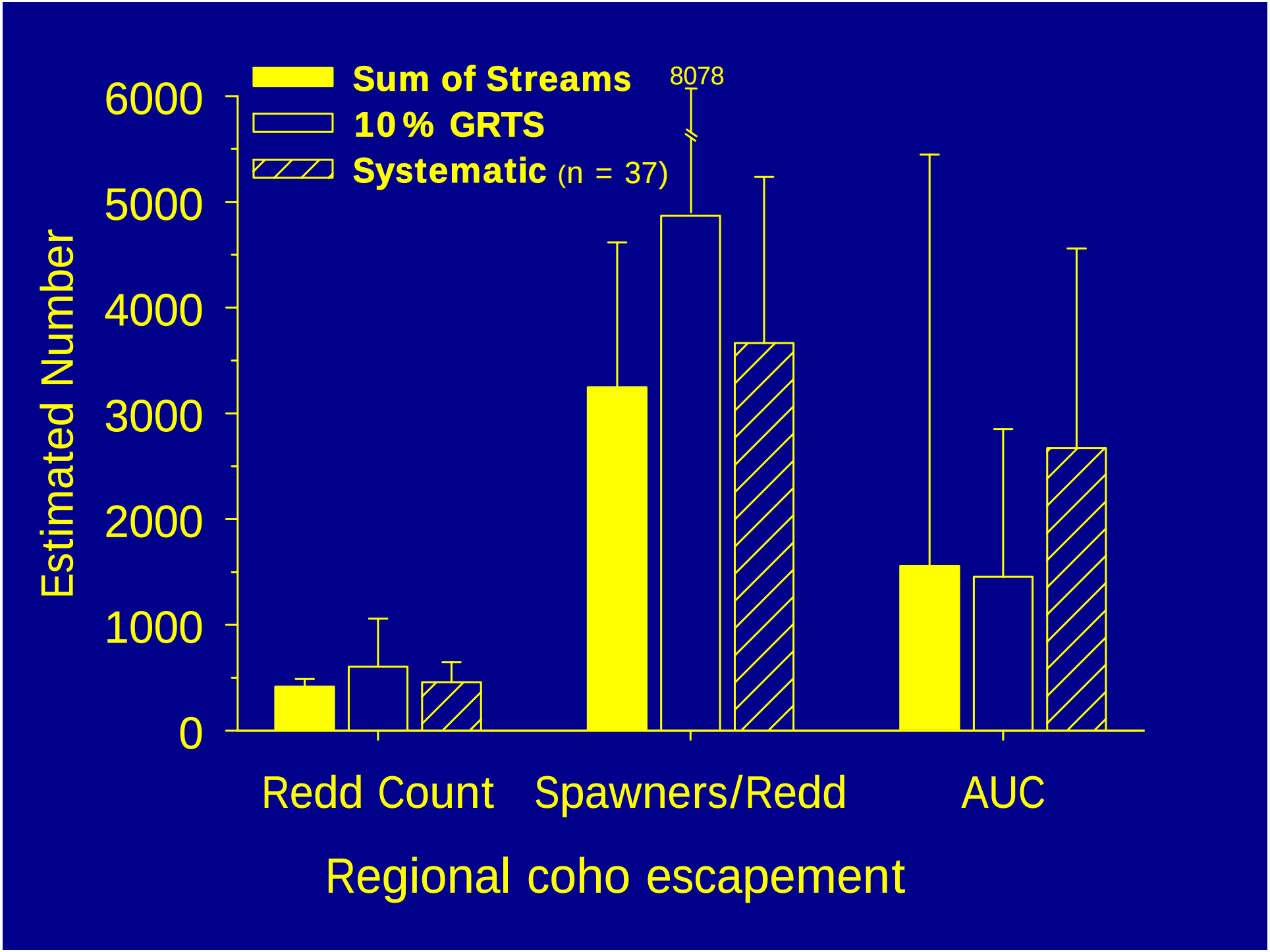

Coho Salmon Population Estimate
Capture-Recapture
AUC
1000
800
600
400
200
0
4961
2006
2007
2006
2007
2006
2007
Pudding Creek
Caspar Creek
Noyo ECS

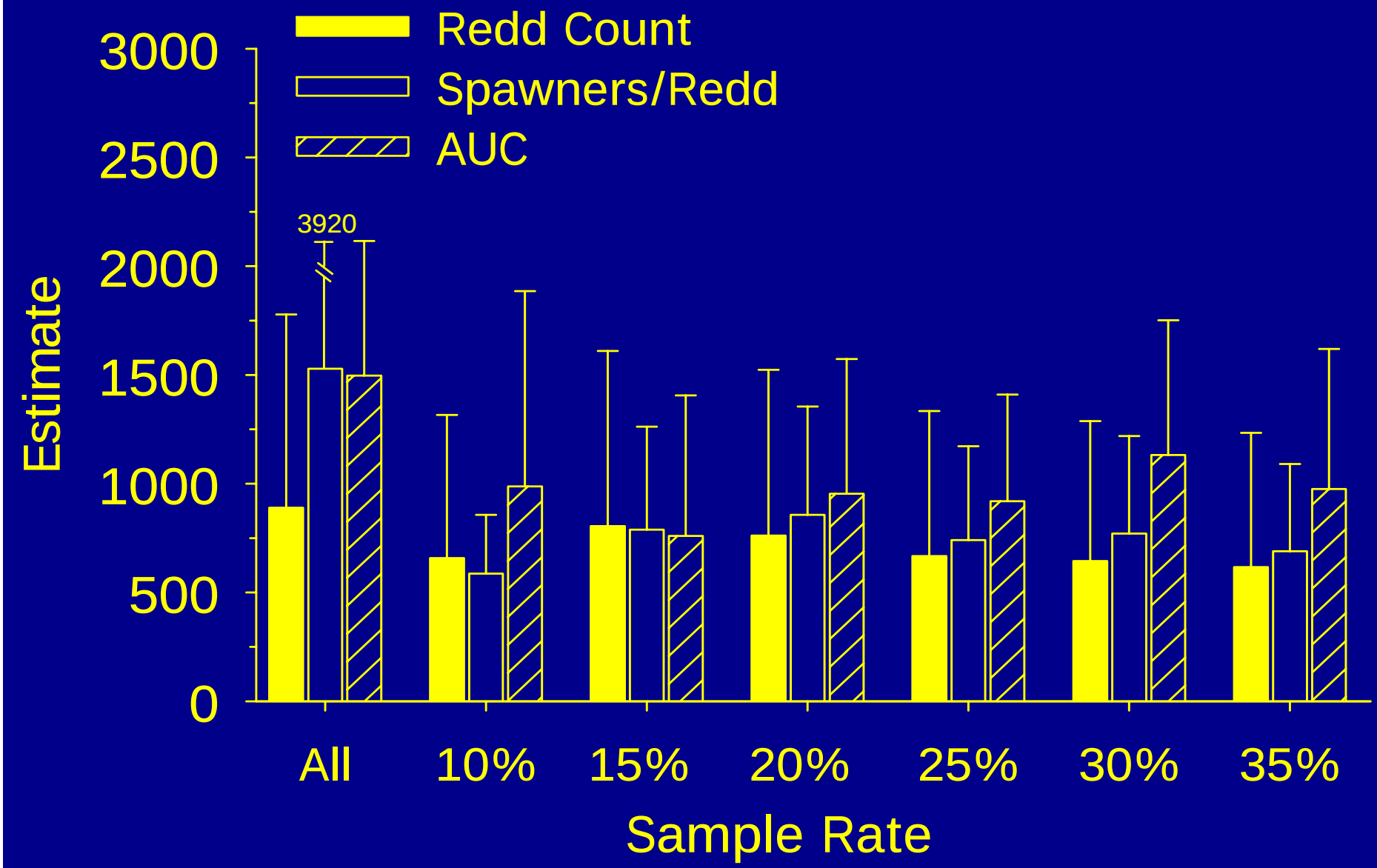

Steelhead Population Estimate
1600
1400
1200
1000
800
600
400
200
0
Capture-Recapture
AUC
7249
3176
2006
2007
2006
2007
2006
2007
2006
2007
Pudding Creek
Caspar Creek
Noyo River
Noyo ECS

22 1 2004

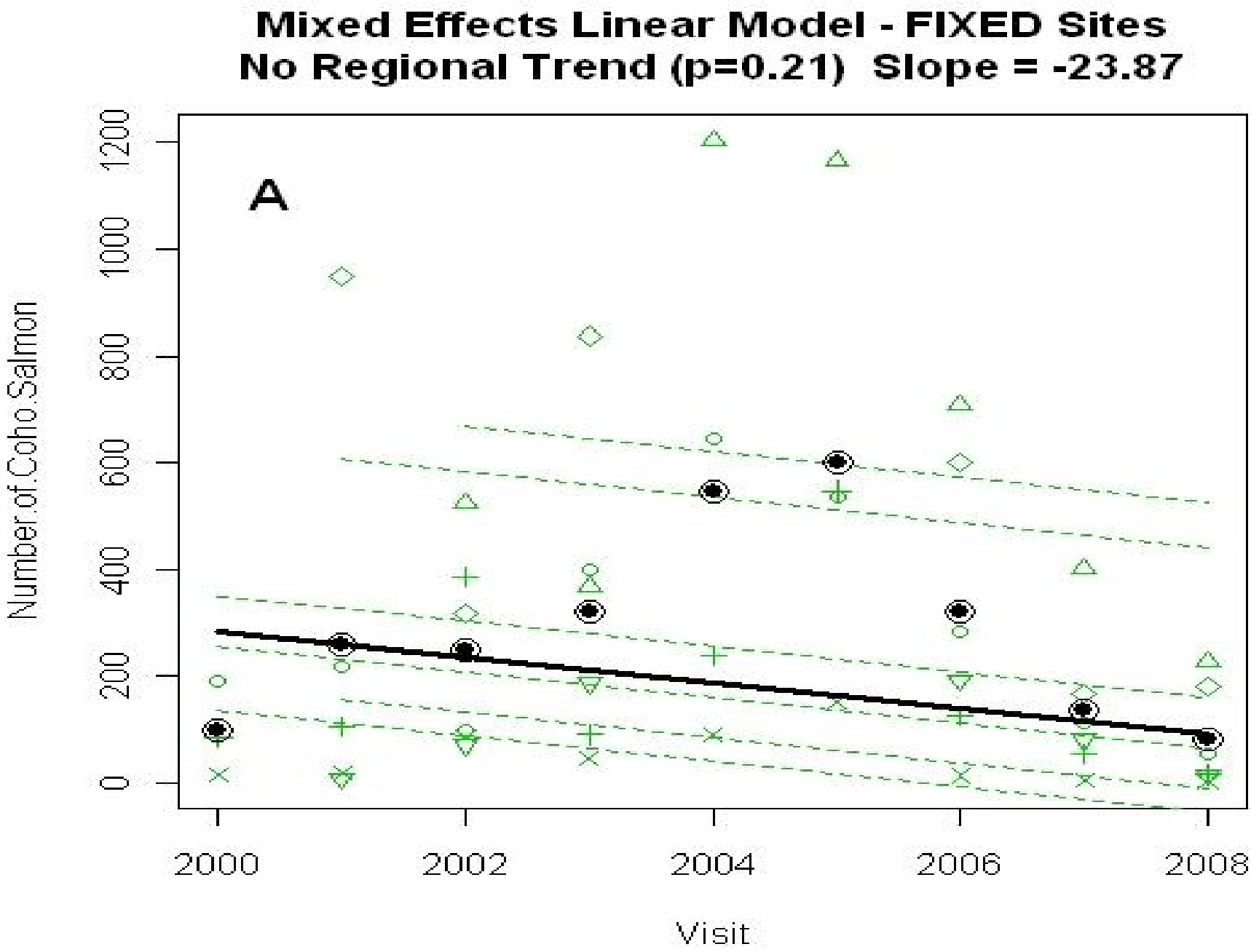
Regional Sampling

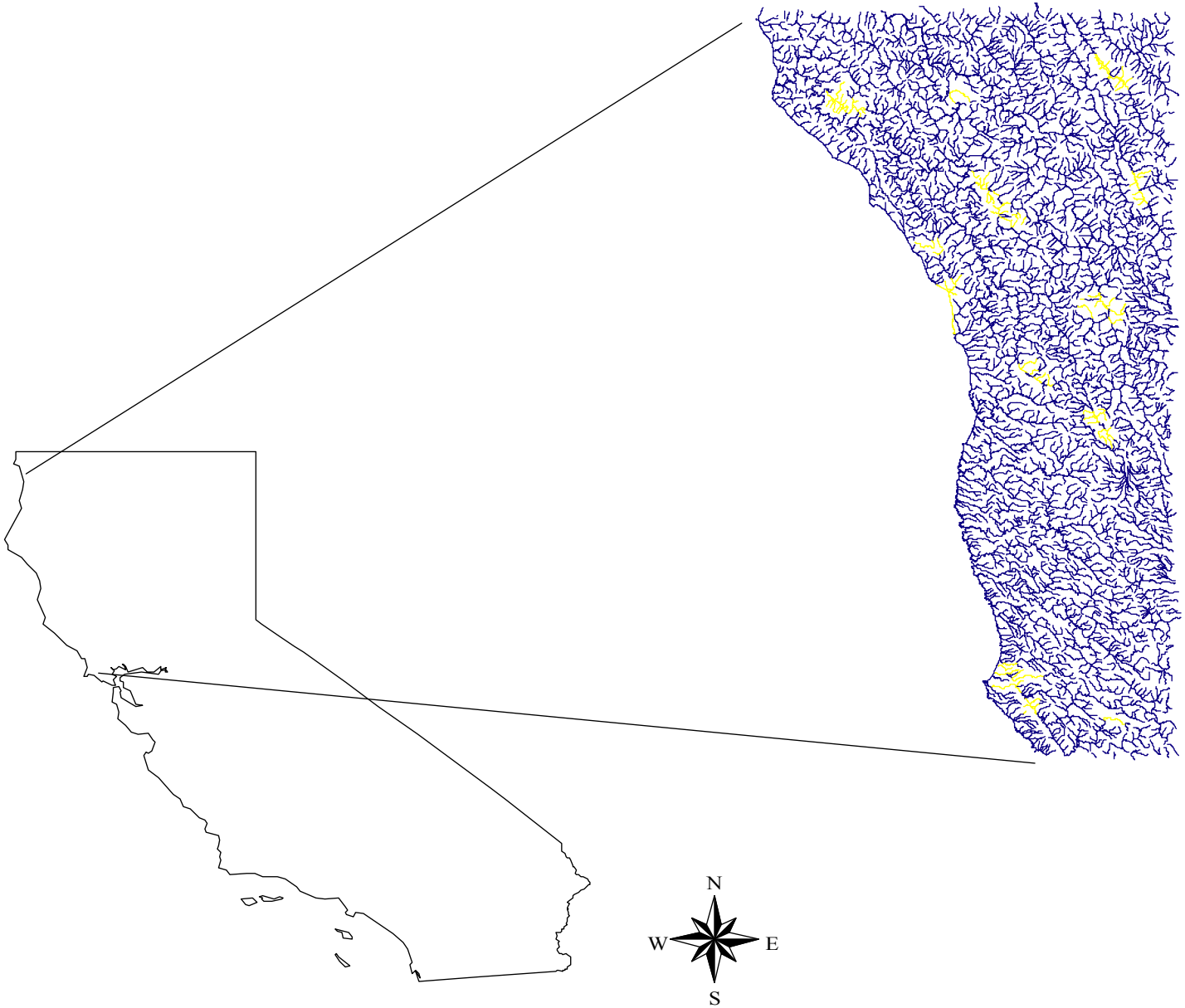



Sum of Streams
10% GRTS
Systematic (n = 37)
8078
6000
5000
4000
3000
2000
1000
0
Estimated Number
Redd Count
Spawners/Redd
AUC
Regional coho escapement



Steelhead estimates by GRTS sample rate


Mixed Effects Linear Model - FIXED Sites
No Regional Trend (p=0.21) Slope = -23.87
A
Number.of.Coho.Salmon
0
200
400
600
800
1000
1200
2000
2002
2004
2006
2008
Visit


N
W
E
S

Sample Size and Precision

$$n \approx \frac{(100 t_{\alpha})^2}{r^2}\left(\frac{1}{\bar{x}} + \frac{1}{k}\right)$$

$\bar{x}$ is the mean value expected in data

k is the negative binomial exponent

R is desired level of error as a percentage (10%, 25%, 30%, and 50%)

t_{α} Probability of not achieving desired level of error

Sample Size for Regional Estimates

30% Precision	Probability of not Achieving Desired Error			
	90%		95%	
	Steelhead	Coho	Steelhead	Coho
Redd Counts	34	43	49	62
AUC	122	102	174	146