A Multi-Scale Evaluation of Screened Diversions in the Yakima Subbasin

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ESSA's Multi-Watershed Project

Larger Context & Purpose of Study: efforts to recover Columbia Basin salmon/steelhead are relying on **habitat restoration** to improve survival and offset impacts of dams

- can we detect/measure the benefits of these actions?

$14 billion spent since 1990 on restoration projects across U.S.; only a small fraction are monitored (*Bernhardt et al. Science. 2005*)

We conducted ‘retrospective’ analyses of past Columbia restoration actions across multiple watersheds to:

- Assess their effectiveness
- Determine what constrains learning
- Improve future regional monitoring designs, implementation and coordination

Two basic approaches to "retrospective" studies (complimentary)

- Intensive:
  - Examine intensively studied restoration projects with both habitat and fish response data
  - n ≈ 3 intensive studies in Columbia Basin
- **Extensive:**
  - Find good long term fish data
  - Look upstream; catalogue major restoration projects
  - Create datasets with contrasts in amount and kind of habitat restoration actions (*pre-treatment conditions*)
  - Assess relationship between Δ survival/productivity and habitat actions

How we chose candidate watersheds for analyses

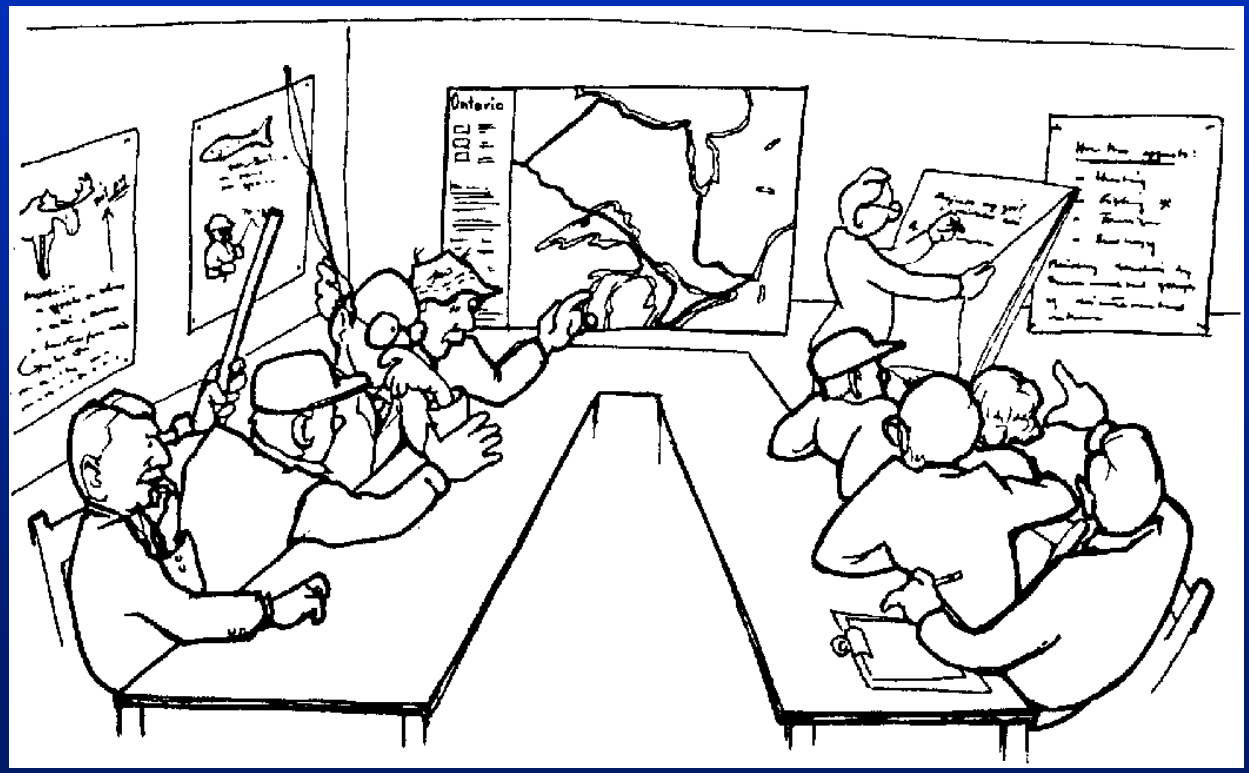
Which subbasins and watersheds have the best biological data?

What major habitat restoration actions occurred in those watersheds historically?

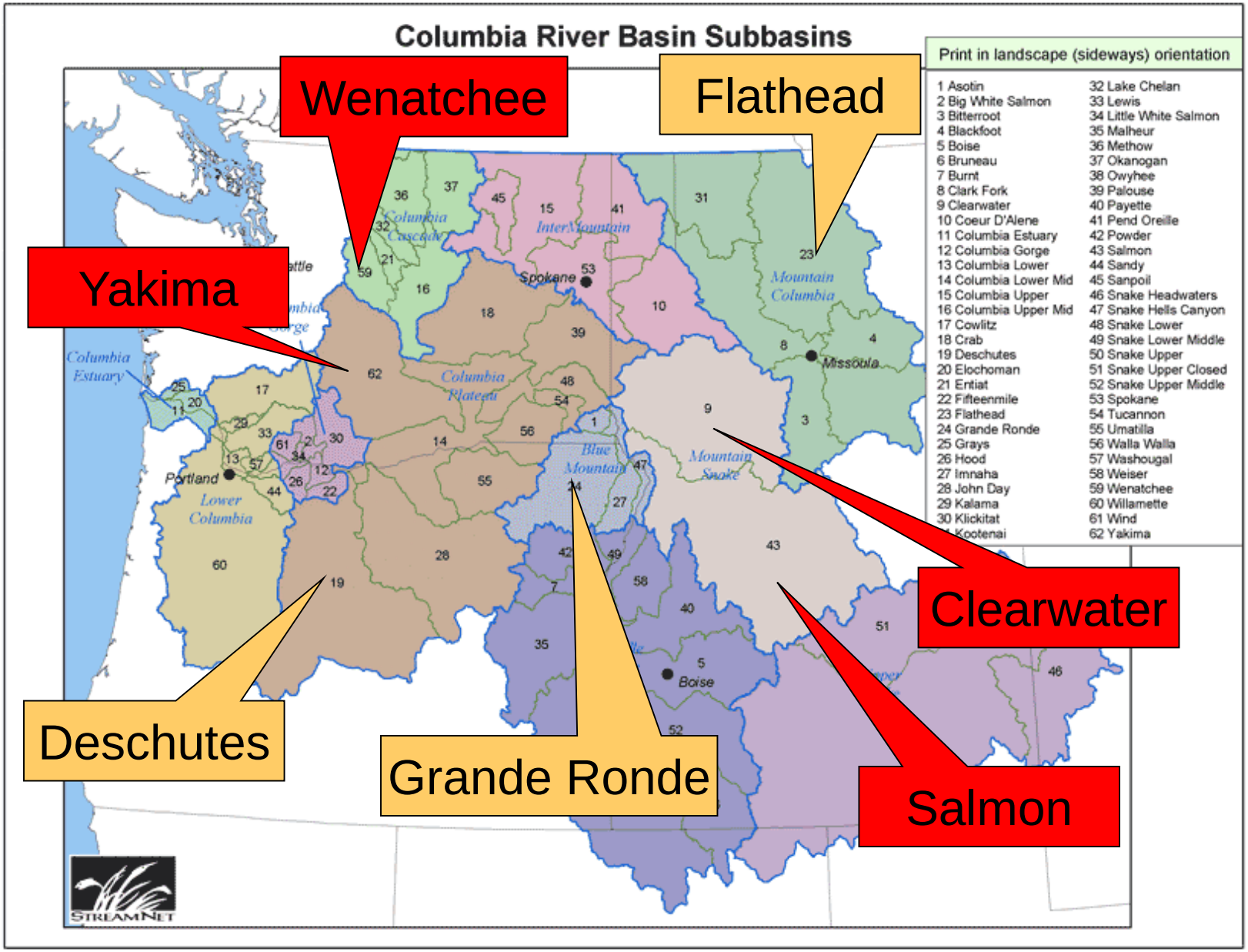
What are potential “treatment” watersheds and potential “controls”?

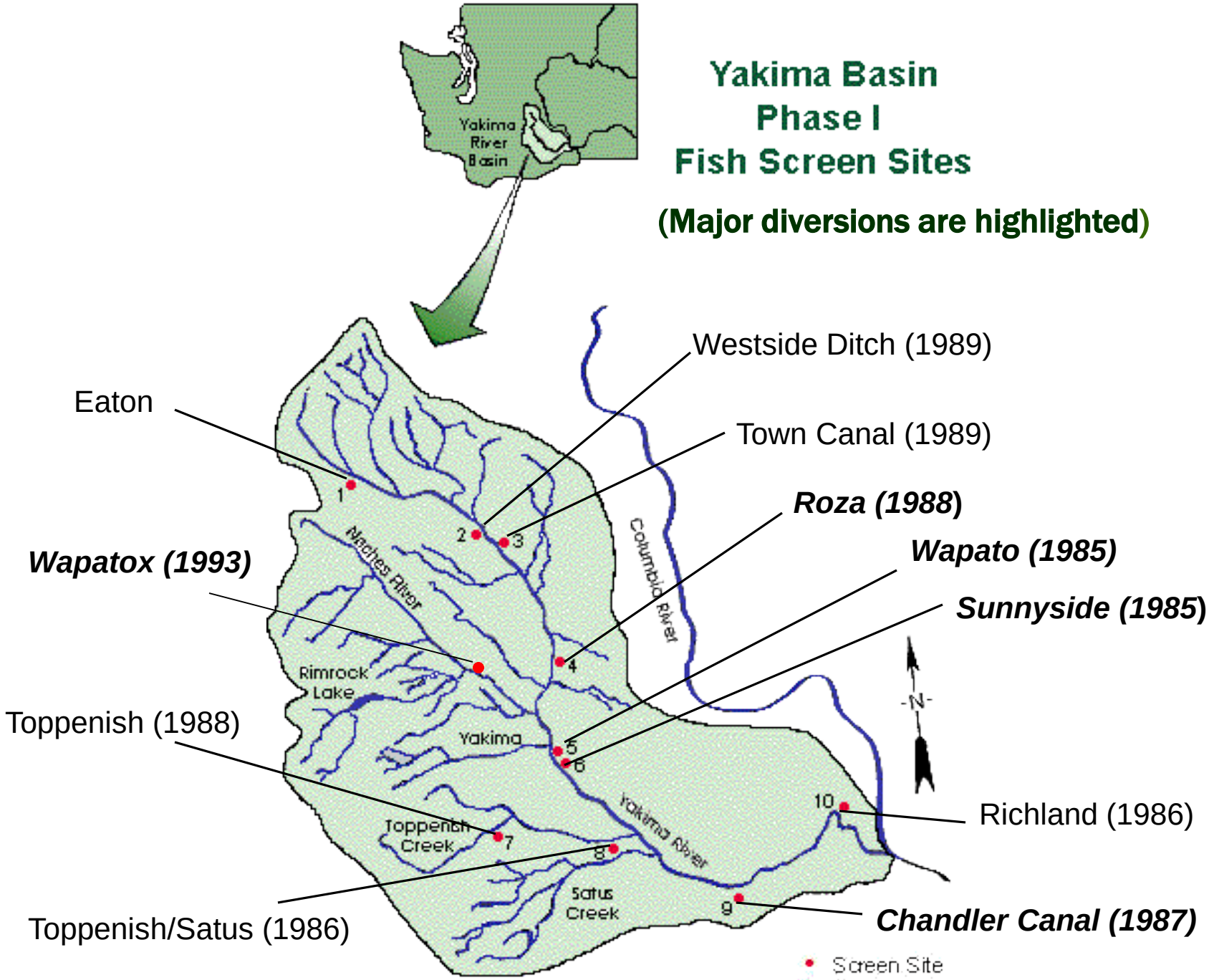
What restoration hypotheses can be tested?

ESSA'S multi-watershed project was very interactive - over 100 people contacted, 4 workshops conducted



Candidate Subbasins




Yakima Basin
Phase I
Fish Screen Sites
(Major diversions are highlighted)
Yakima River Basin
Westside Ditch (1989)
Eaton
Town Canal (1989)
Roza (1988)
Wapatox (1993)
Wapato (1985)
Sunnyside (1985)
Toppenish (1988)
Richland (1986)
Toppenish/Satus (1986)
Chandler Canal (1987)
Naches River
Columbia River
Rimrock Lake
Yakima
Toppenish Creek
Satus Creek
Yakima River
N
1
2
3
4
5
6
7
8
9
10
Screen Site

Costs of Phase I fish screening at major Yakima Subbasin diversions

Screen	Year	Cost
Sunnyside	1985	$1.2 M
Wapato	1985	$1.2 M
Chandler	1987	$7.7 M
Roza	1988	$11.4 M
Wapatox (Naches R.)	1993	? (a lot)

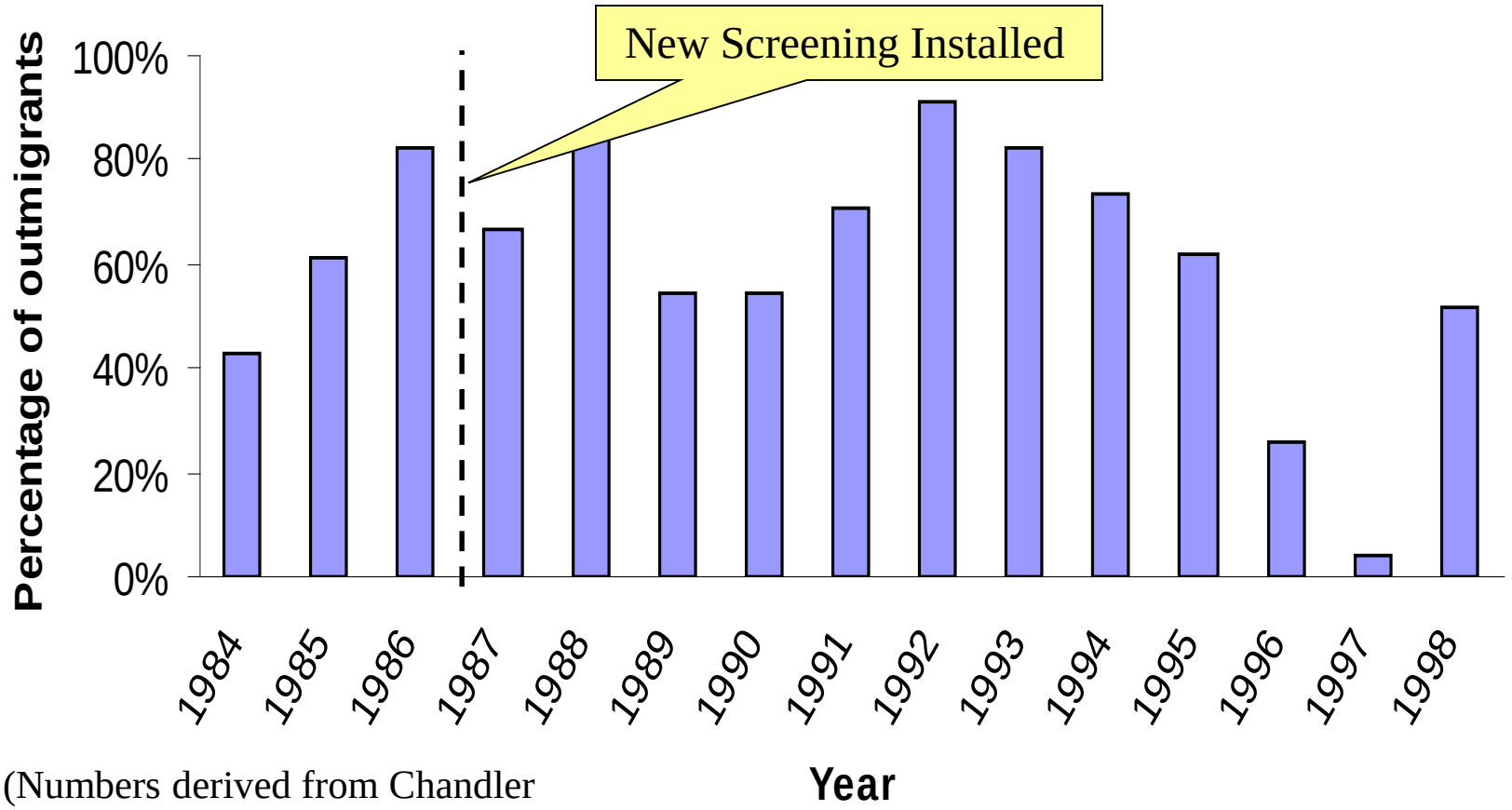
Despite extensive literature on the construction and engineering of fish screens, there is little quantitative analysis of how fish screening diversions affect fish populations.

Moyle & Israel. 2005 (Fisheries)

PNNL evaluations indicate that Phase I screens improved conditions at Yakima diversions:

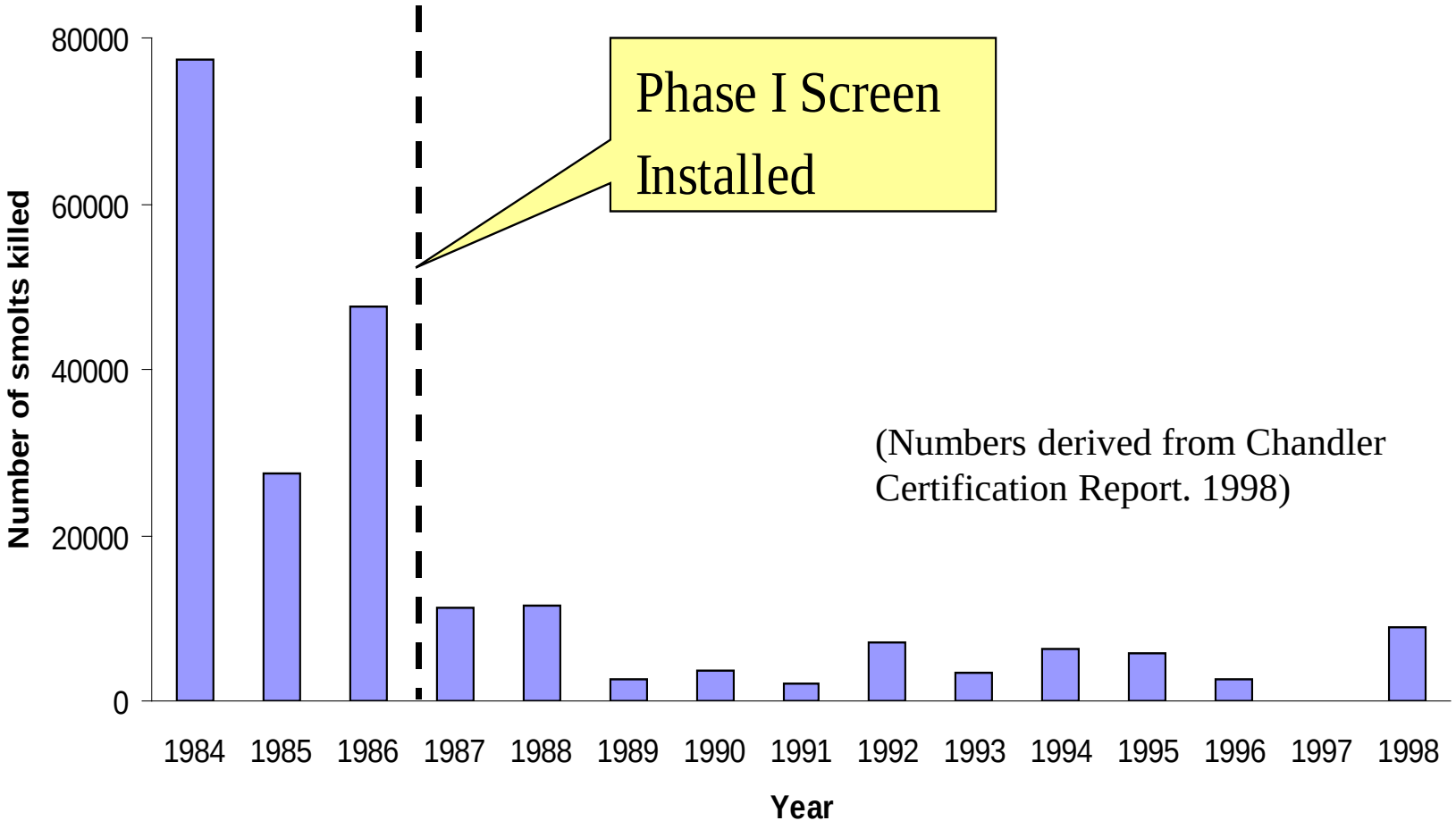
- Reduced the velocity-induced impingement of fish on screens
- Reduced entrapment of fish into canals (e.g., smaller screen meshes)
- Reduced associated migration delays

Estimated percentage of smolt outmigrants entrained each year at Chandler Canal



(Numbers derived from Chandler Certification Report. 1998)

Estimated Number of Chinook Smolts Killed at Chandler Canal



Overarching Study Question

Has Yakima Phase I fish screening had a detectable effect at improving long term population trends for spring chinook at the subbasin scale, relative to control areas and the pre-screening period?

- Smolts/spawner? (in-basin productivity)
- Recruits/spawner? (overall productivity)

Spring Chinook Spawners

- Counted at Prosser Dam and Rosa Dam (complete census)
- Complete redd counts on Upper Yakima and Naches / American Tributaries
- Allows accurate historical run-reconstructions

Juvenile monitoring at Chandler Canal

Prosser Dam is upstream ⇐

Counts of migrating smolts at Chandler Canal

Monitoring at Chandler provides:

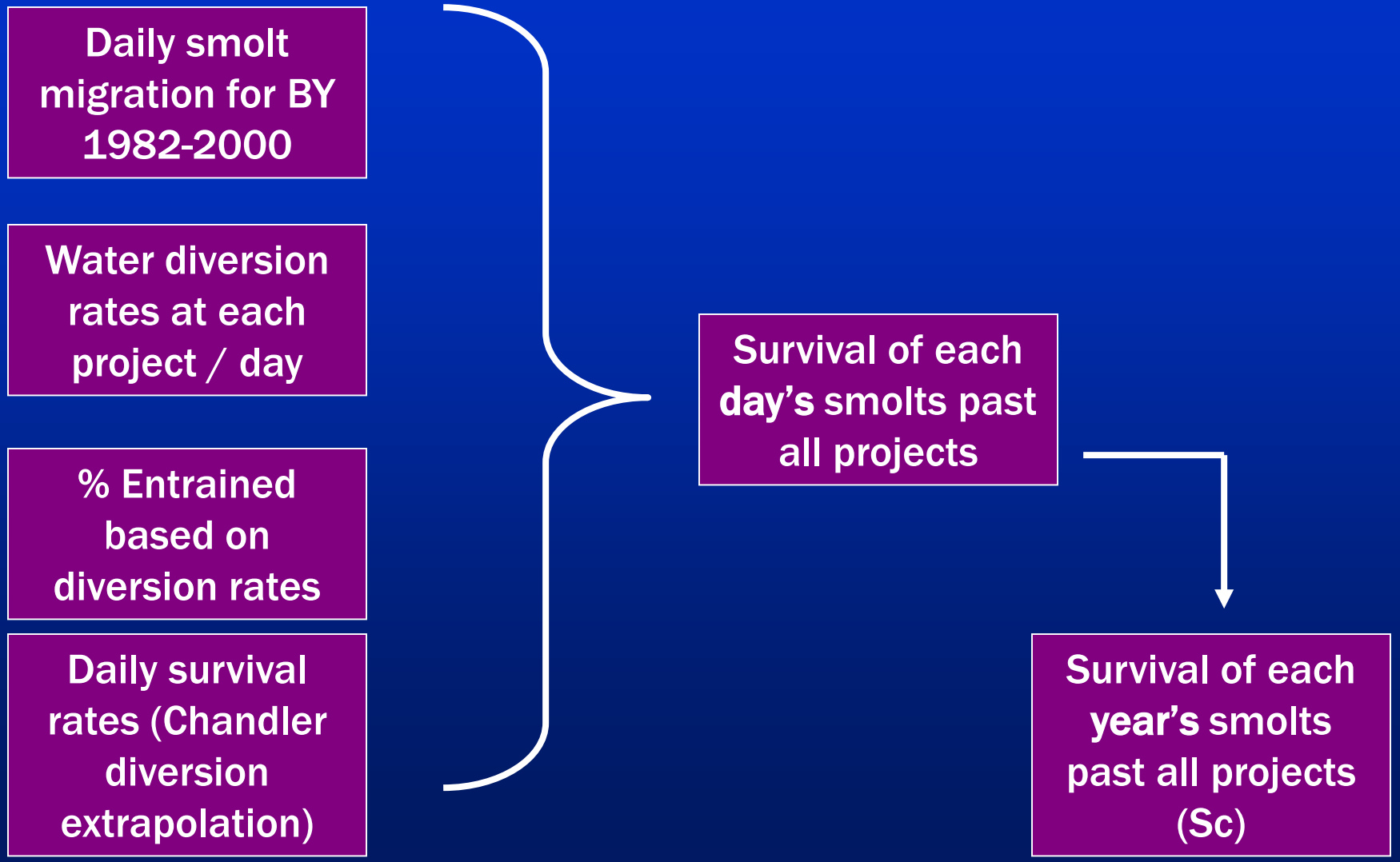
- Daily juvenile outmigration past canal
- Daily fish entrainment rate into canal, and
- Daily survival rate for fish entrained into canal

- estimates based on paired releases of tagged fish (Prosser Dam forebay, Chandler Canal)

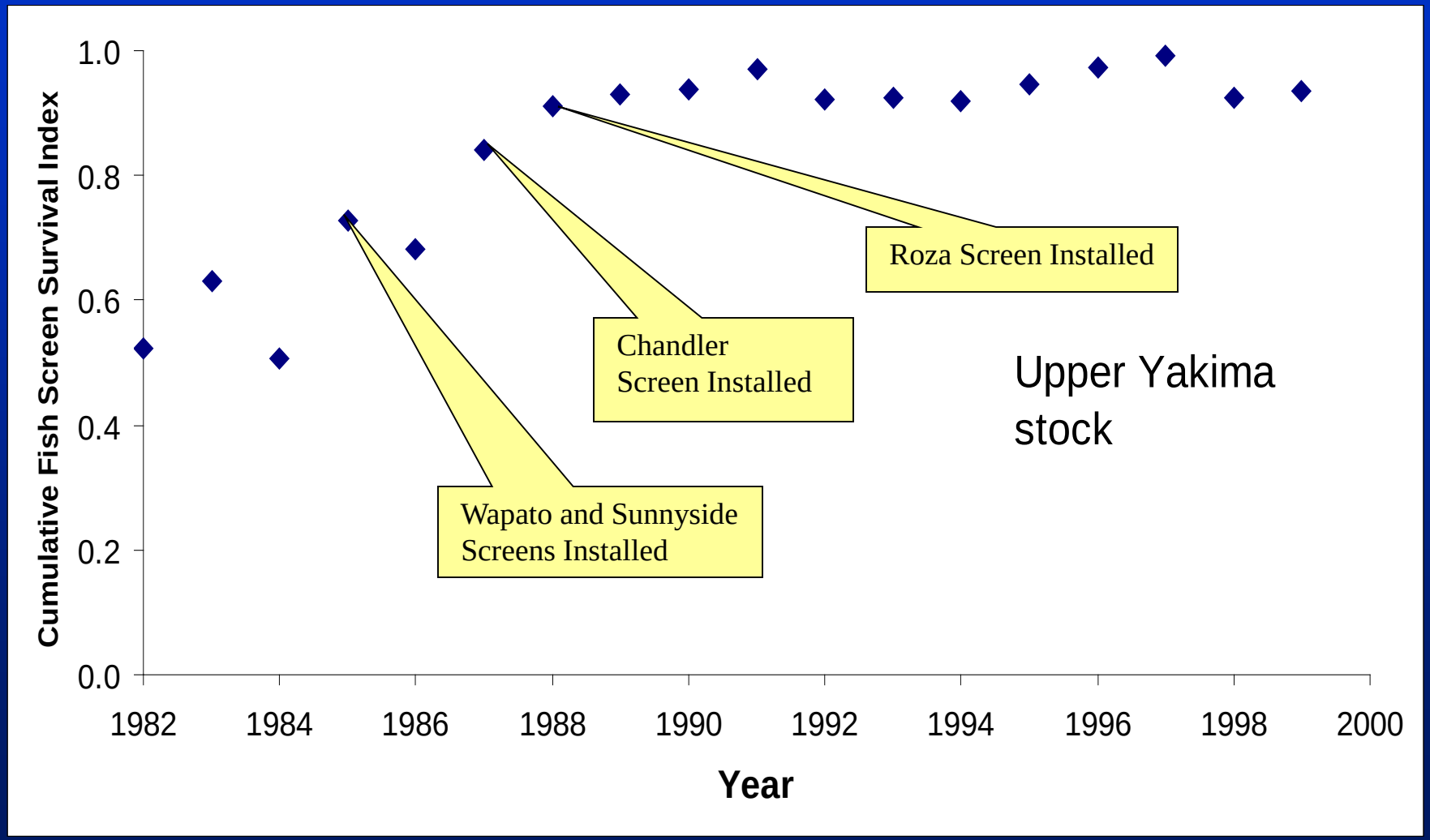
⇒Daily estimates of smolt emigration and mortality at Chandler Canal

Some pre-screen data; more for post-screen period

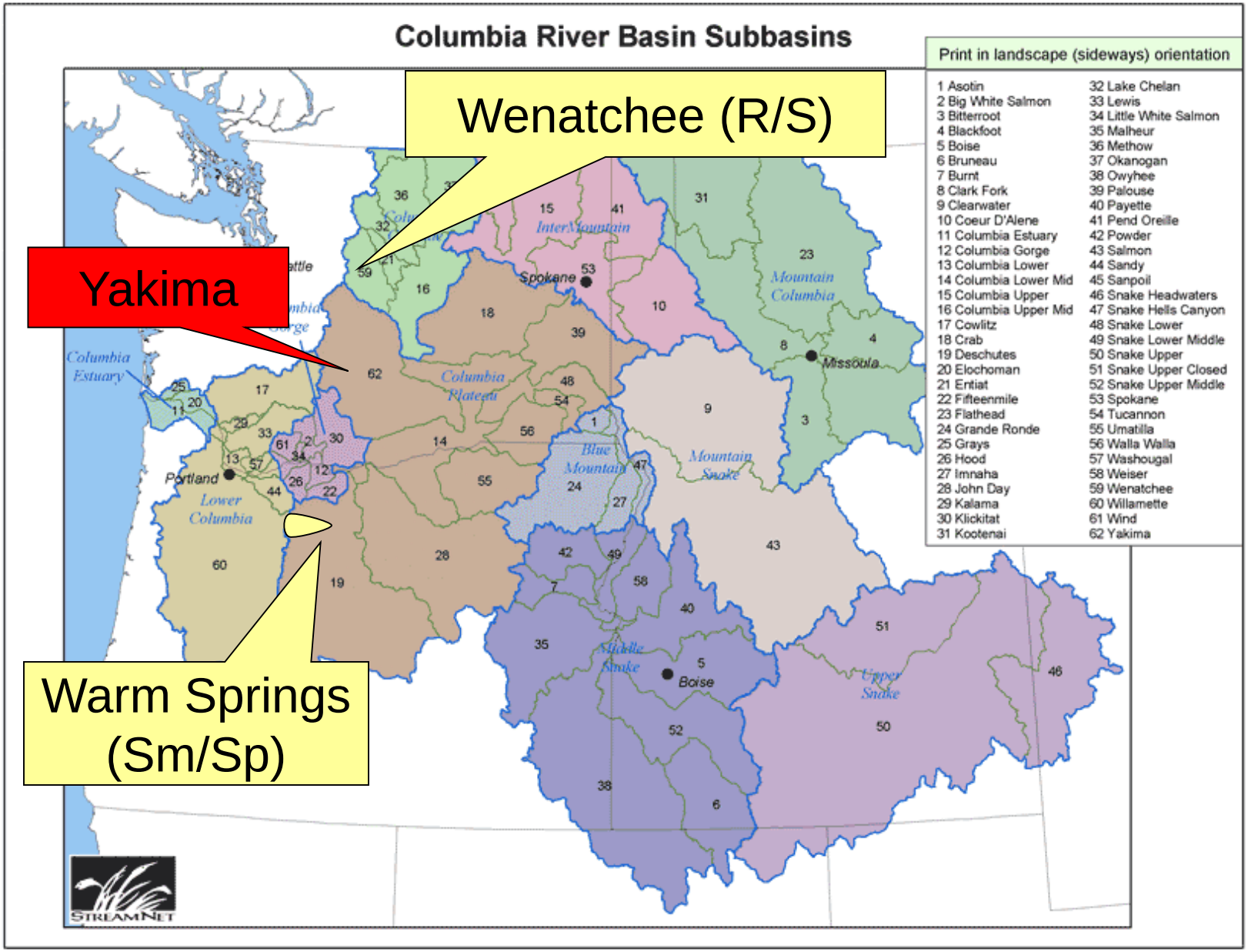
Annual Index of Survival Past Screens (*Sc*)



2 X increase in cumulative yearly canal survival rates for Yakima Spring Chinook smolts



Treatment & Control Sub-basins



1) **Recruits/Spawner** log-linear regression models:

- 2 treatment stocks -Upper Yakima & Naches/American (impacted watersheds; BY 1982-98)

- 1 control stock – Wenatchee (relatively pristine, similar geoclimatic zone)

Covariates: # spawners, ocean productivity indices or dummy coded common year effect, river flow, temperature, mainstem spill, **Screen Survival Index (*Sc*)**

2) Smolts/Spawner log-linear regression models:

- 1 treatment stock – Yakima (Upper Yakima and Naches combined; BY 1982-2000)
- 1 pseudo-control stock – Warm Springs (relatively pristine, dissimilar geoclimatic zone; 1982-2000)

Covariates: # spawners, river flow, temperature, **Screen Survival Index (*Sc*)**

Regression models were compared and ranked using Akaike's Information Criterion (AIC)

$$AIC = n \log (RSS/n) = 2k$$

Where n = number of observations
k = number of model parameters
RSS = residual sum of squares

- Highest ranked models are those that best fit data with fewest parameters

Summary of Results

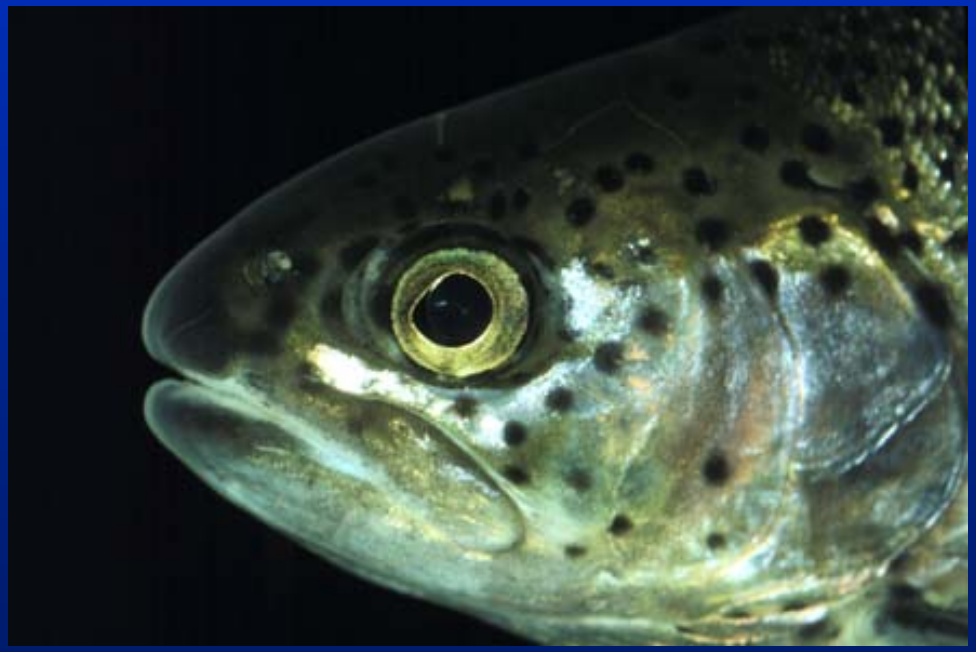
- Chandler project data indicate that new fish screening improves smolt survival at canals

But, no detectable benefit of screens to basin productivity:

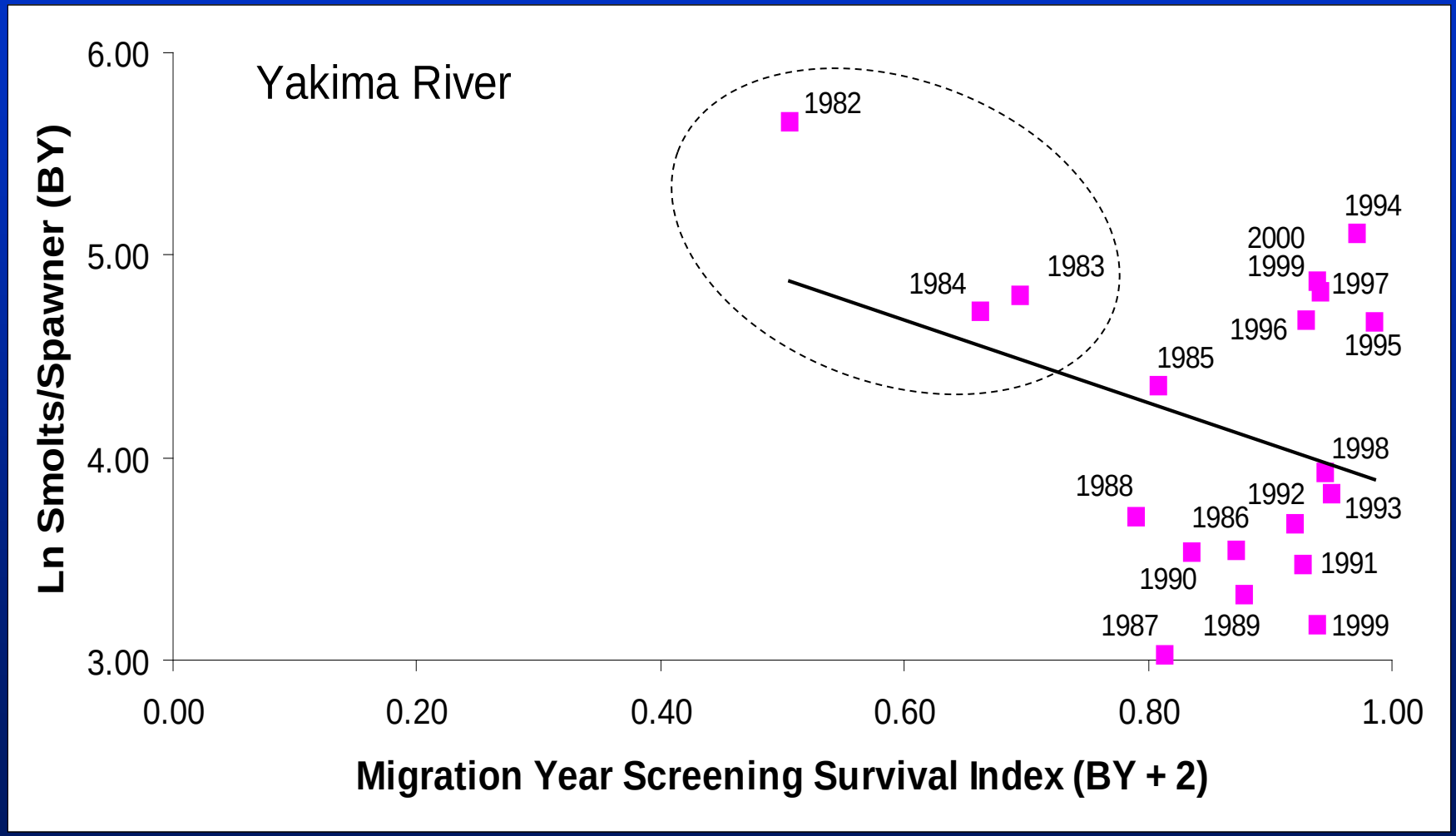
- Smolts/spawner (best 3 of 11 models): correlated with river flow (+) , spawner abundance (-), ***Sc*** (-, non significant)

- R/S (best 3 of 20 models): correlated with river flow (+), dam spill (+), ocean productivity, year affect, ***Sc*** (-, non significant)

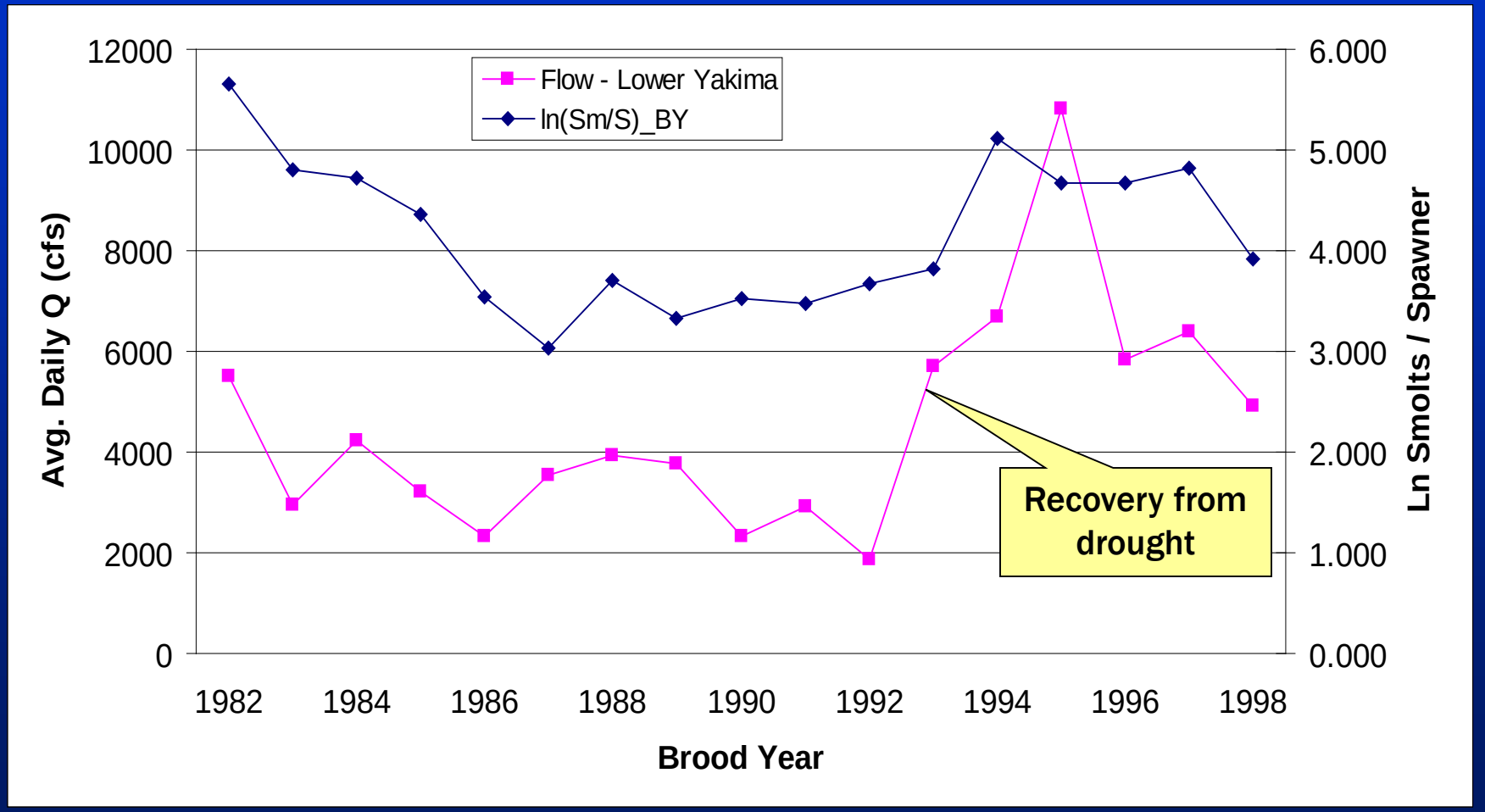
Why no apparent benefit to chinook productivity?



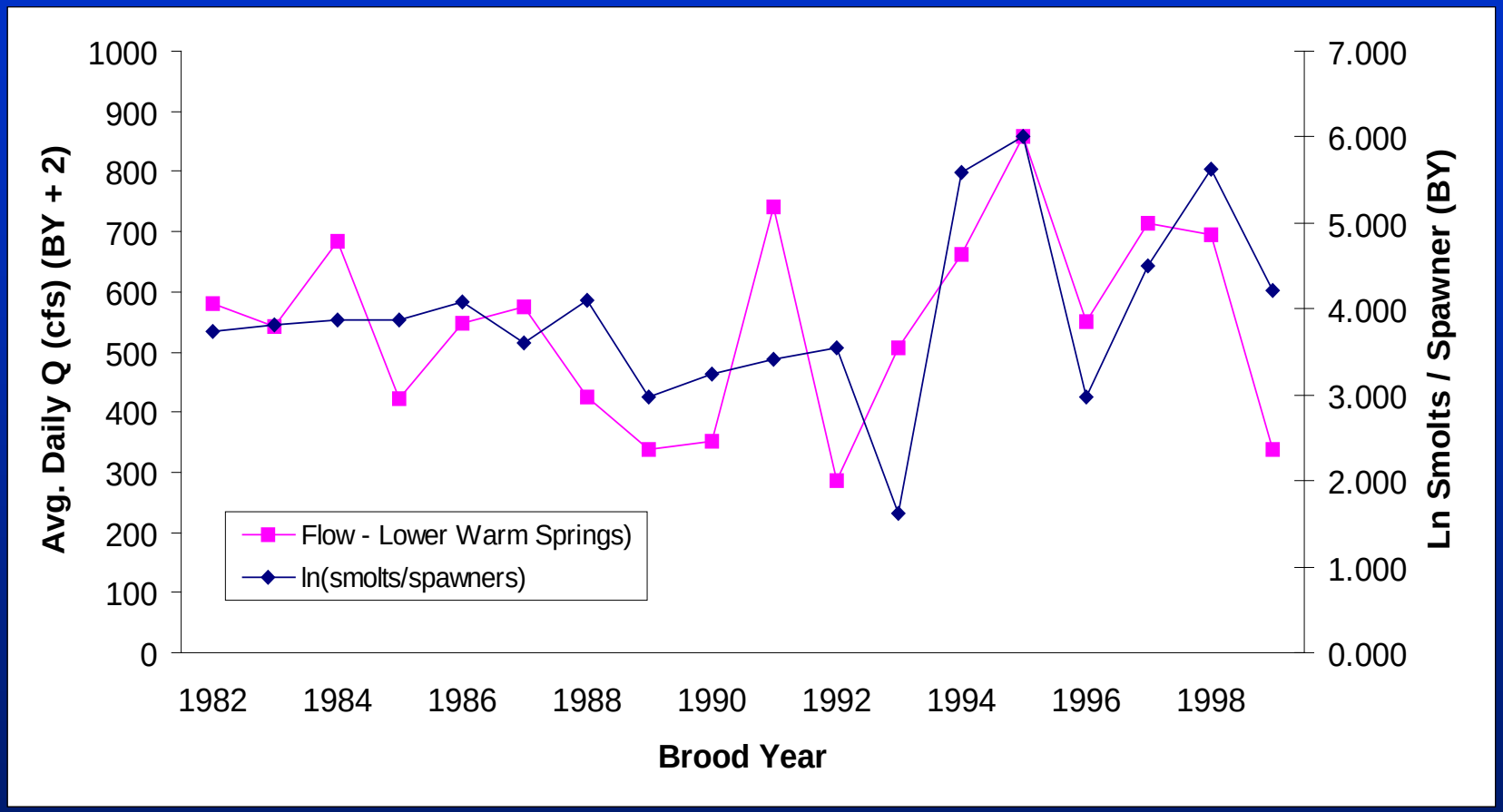
Bad luck? Highest smolt/spawner numbers were before first screens went in...



Yakima flows correlate well with smolts/spawner, except after all the screens are in place!



Warm Springs flows (control stream) correlate well with smolts/spawner throughout entire period of record...



Statistical Interpretation: increased ***Sc*** apparently suppressed concomitant increase in productivity with increased river flow

Why you might not detect an overall benefit from habitat restoration actions

- Proposed actions not implemented or implemented poorly
- Actions did not address factors limiting productivity
- Overriding influence of covariates
- Insufficient time for system to respond
- Insufficient baseline for valid comparison
- Effective footprint of action too small
- Confounding factors affected treatment and/or control (e.g., a freak flood, drought, etc.)
- Low statistical power: fish responses naturally highly variable, high measurement error

Survival rates of tagged PIT tagged smolts from Rosa Dam to McNary (1999 –2003) (source: Yakama Nation Fisheries Program)

Migration Year	Stage	Number Tagged	Survival, Rosa to Prosser	Survival, Rosa to McNary
1999	Smolt	470	0.58	0.48
2000	Smolt	2105	0.83	0.53
2001	Smolt	2179	0.31	0.24
2002	Smolt	7710	0.38	0.25
2003	Smolt	7802	0.37	0.27

Even after all major screens, low smolt survival rates persist within the Upper Yakima

Broader Project Recommendations

- Develop designs with good treatment/control pairings and strong spatial/temporal contrasts in treatments
- Establish extensive pre-treatment monitoring – this is critical to detecting post- treatment effects
- Assess effectiveness both close to actions in space and time, as well as across entire fish life cycles
- Monitor key covariates that confound treatment effects
- Develop a multi-project, multi-tributary, multi-watershed perspective for project funding and evaluation

... until basic questions relating to the benefits of screens are answered and uncertainty is reduced, it does not seem appropriate to use public funds to provide new screens for most diversions, unless the projects have a strong evaluative component to them, including before and after studies.

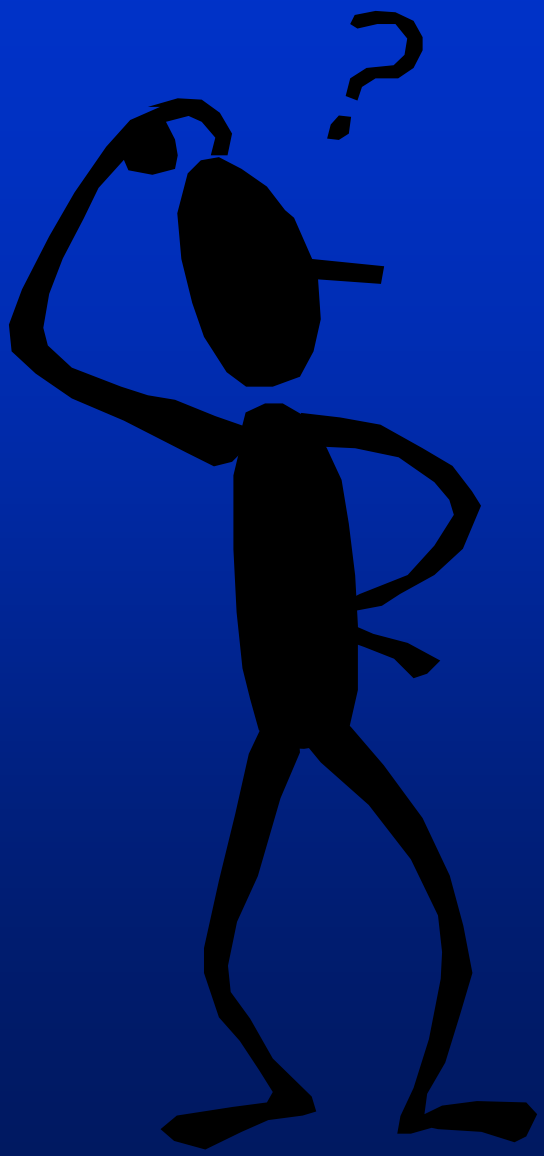
(Moyle and Israel. Fisheries. 2005)

For more information

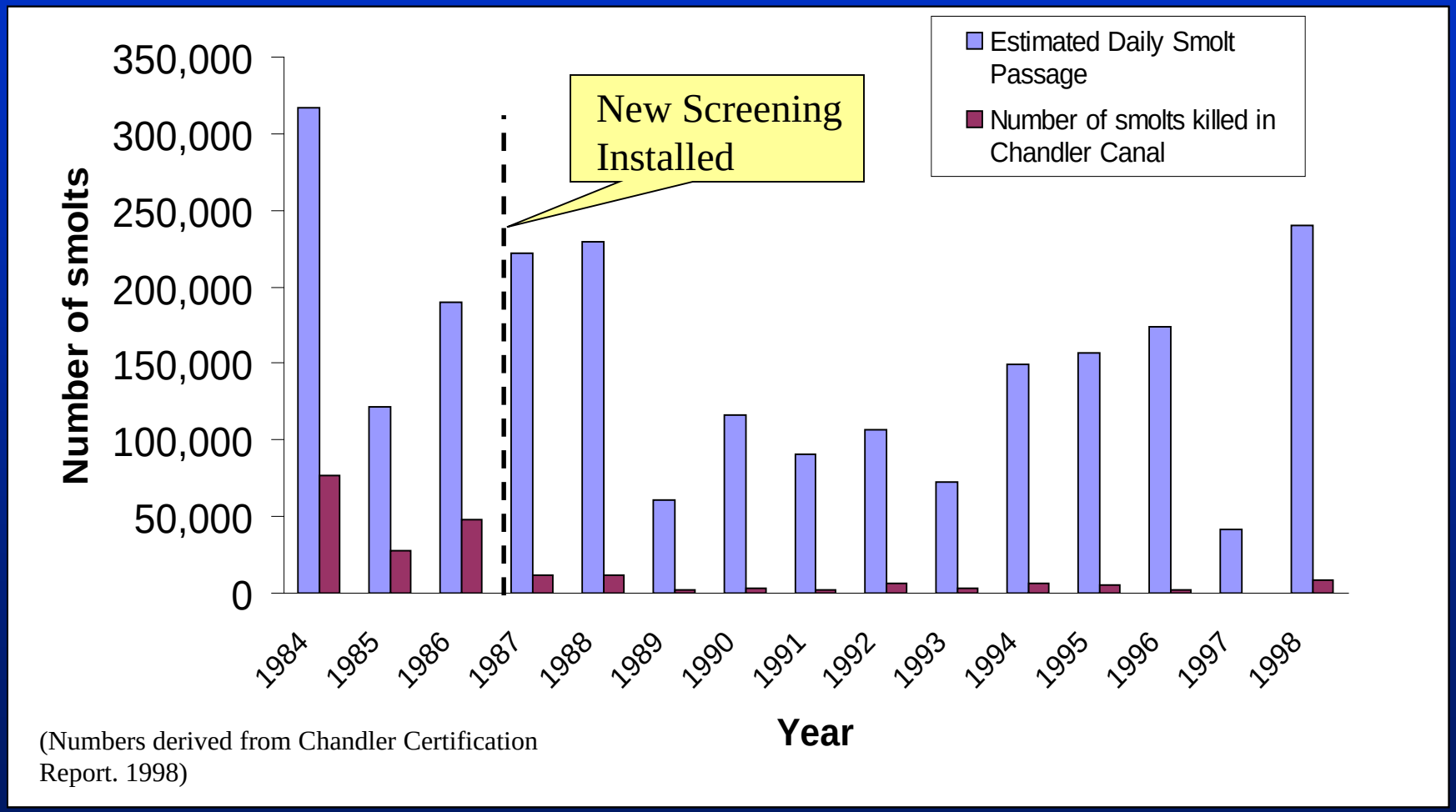
A Multiple Watershed Approach to Assessing the Effects of Habitat Restoration Actions on Anadromous and Resident Fish Populations (2004):
http://www.essa.com/watersh-rpt.pdf

Columbia Basin Collaborative Systemwide Monitoring and Evaluation Project (CSMEP):
www.cbfwa.org/Committees/CSMEP

Questions?



Estimated numbers of smolts killed annually at Chandler Canal relative to estimated total numbers counted at Chandler



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Life stage survival indices used to evaluate action effectiveness