EWA Effects on Salmonids 2001-2004

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EWA Review Panel
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Outline

- Recap EWA uses in the first four years
- Results for salmonids
  - Sacramento River
  - San Joaquin River
  - Upstream
- Conclusions
- Observations

- Acknowledge: Pat Brandes – USFWS,
  other EWA salmon biologists

Conclusions on EWA effects on salmonids

- Reduced fish entrainment at SWP/CVP
- Helped avoided reinitiation of ESA consultation in a few cases
- Increased Delta survival of migrating juvenile salmonids and presumably the abundance of later life stages when substantial actions were taken

Conclusions on EWA effects on salmonids

- Need to quantitatively evaluate upstream actions to compare to Delta actions
- Information to compare EWA effects to those of other actions is lacking
- EWA can be a valuable tool for protecting salmon and contributing to recovery of populations

Conclusions on EWA effects on salmonids

- EWA decision-making has adjusted to increased populations
- If trends reversed perceived value of actions would increase
- Better run-specific information is needed
- Reconsider the effect of exports on salmon survival

Types and purposes of actions

- SWP/CVP pumping curtailments
- River flow augmentation
- Modify hydropower operations for water temperature management

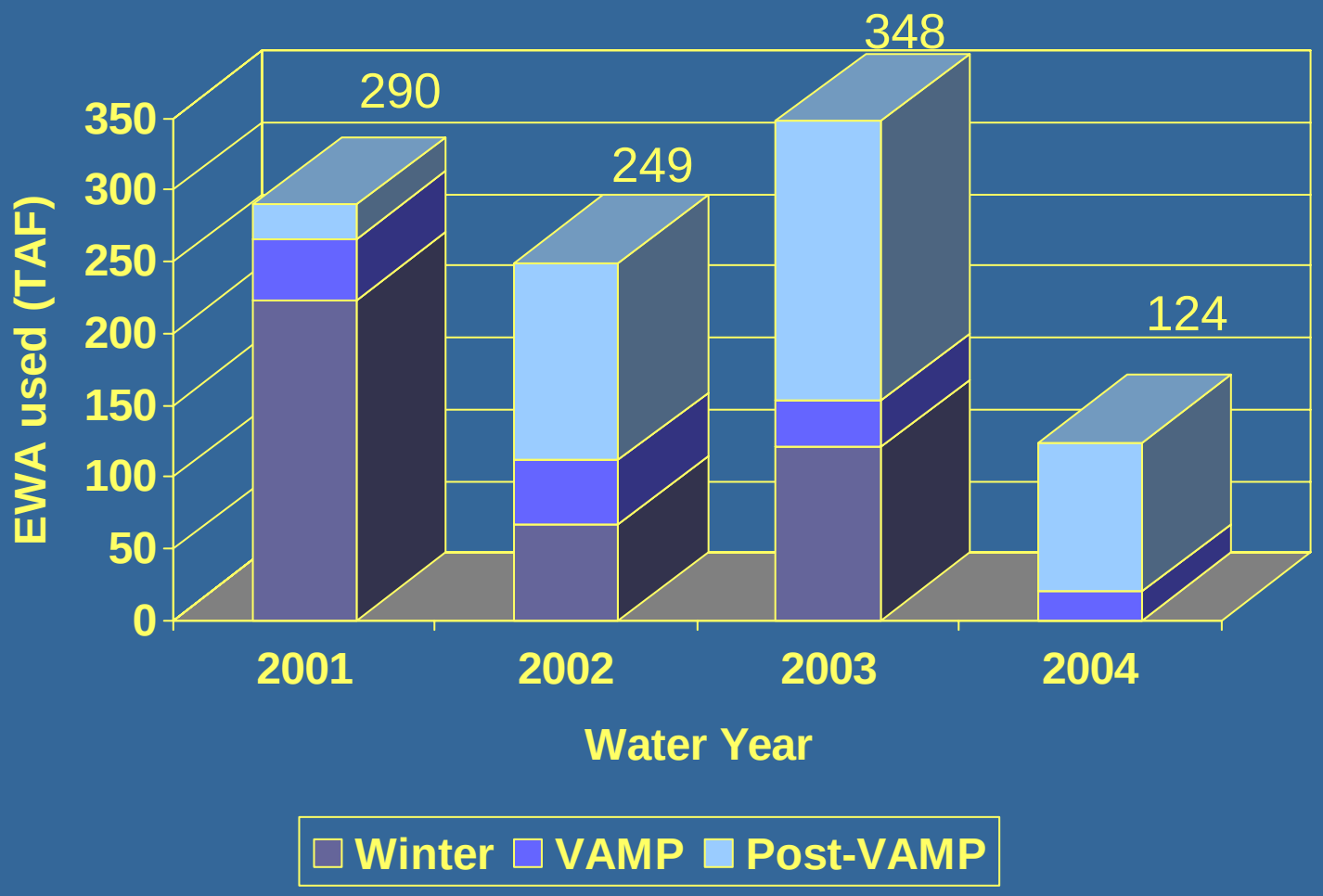
Objective of EWA actions for salmonids

- Minimize “take” of salmonids at SWP/CVP diversions
- Increase Delta survival of emigrating juvenile salmonids
- Increase production upstream

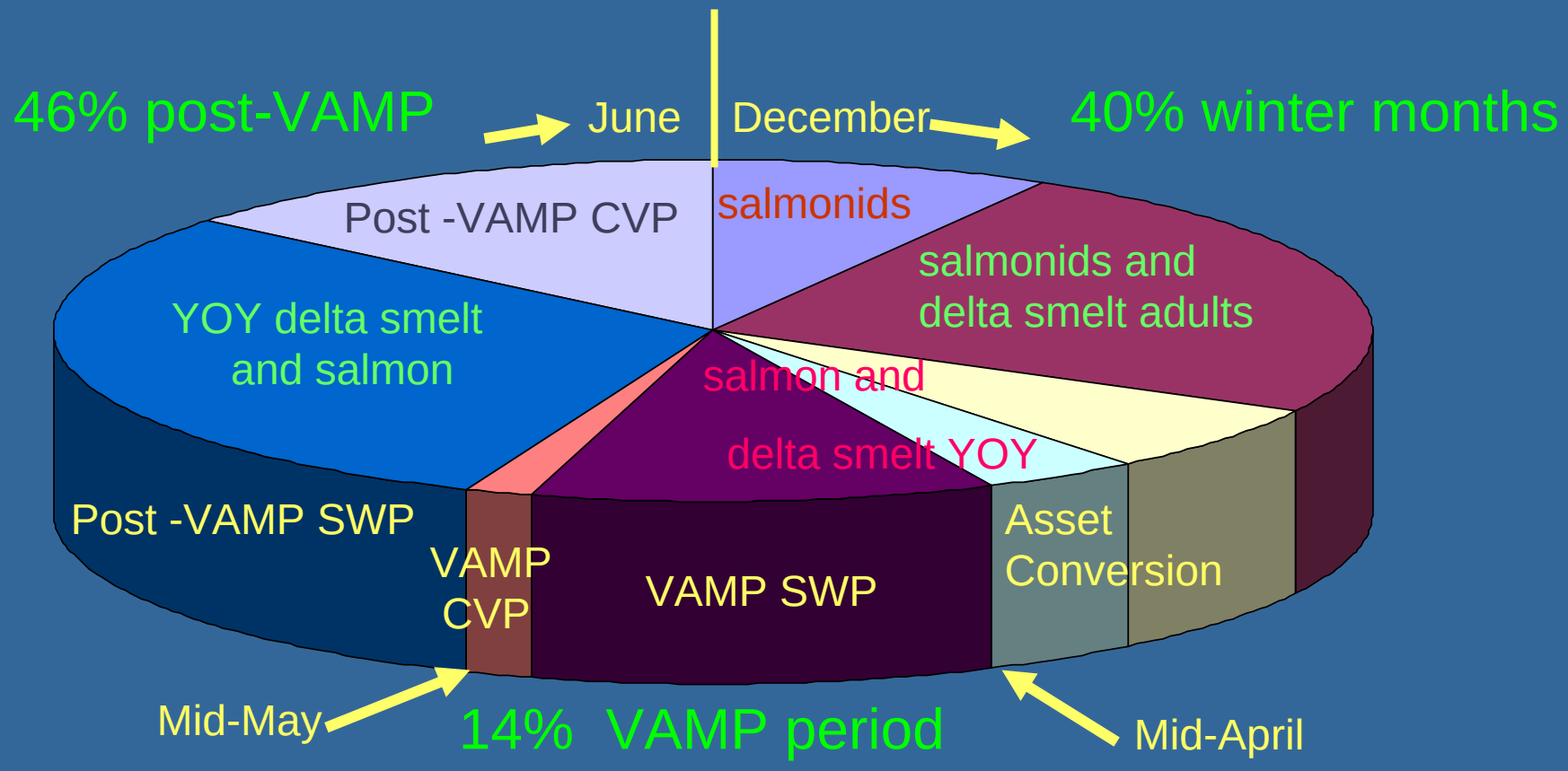
GOAL:

- Contribute to recovery of salmon and steelhead populations

Allocation of EWA assets by season 2001-2004



Allocation of EWA Assets 2001-2004



Total EWA actions 1.010 MAF

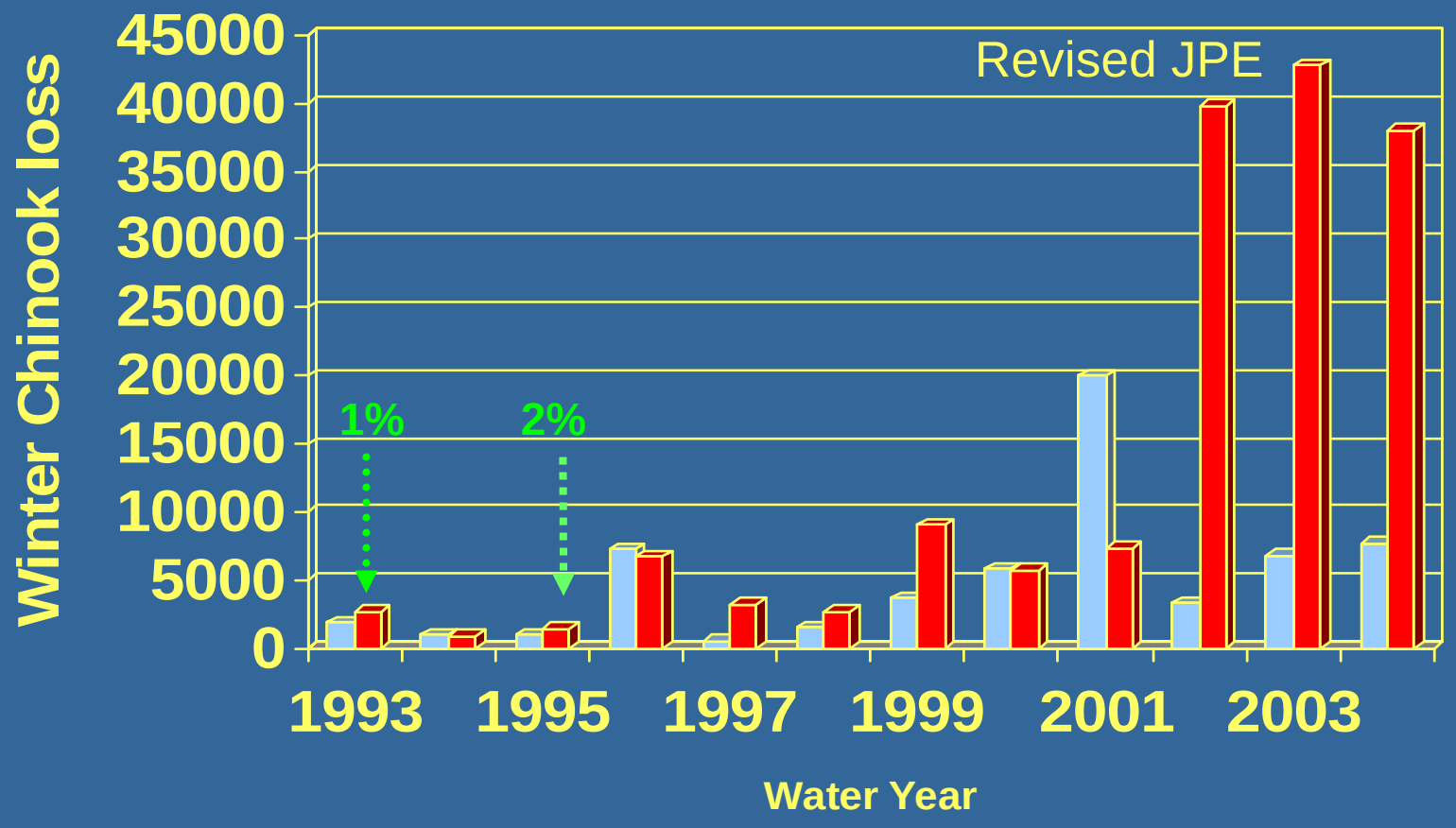
March 2002 asset conversion 38 TAF

Assess effects of EWA pumping curtailments

- Individuals:
  - “Take” relative to authorized level of incidental take and mandatory reinitiation of ESA consultation
  - Reduction in salmon entrainment loss at SWP/CVP
- Populations:
  - Change Delta survival of emigrating juvenile salmon
  - Presumed to translate into proportionate population gains absent density dependence for later life stages

“Take” relative to mandatory reinitiation levels

Winter Run Chinook loss at SWP/CVP



estimated take authorized incidental take

“Take” relative to mandatory re-consultation levels

Spring run Chinook Surrogate Loss at SWP/CVP (authorized level = 1%)

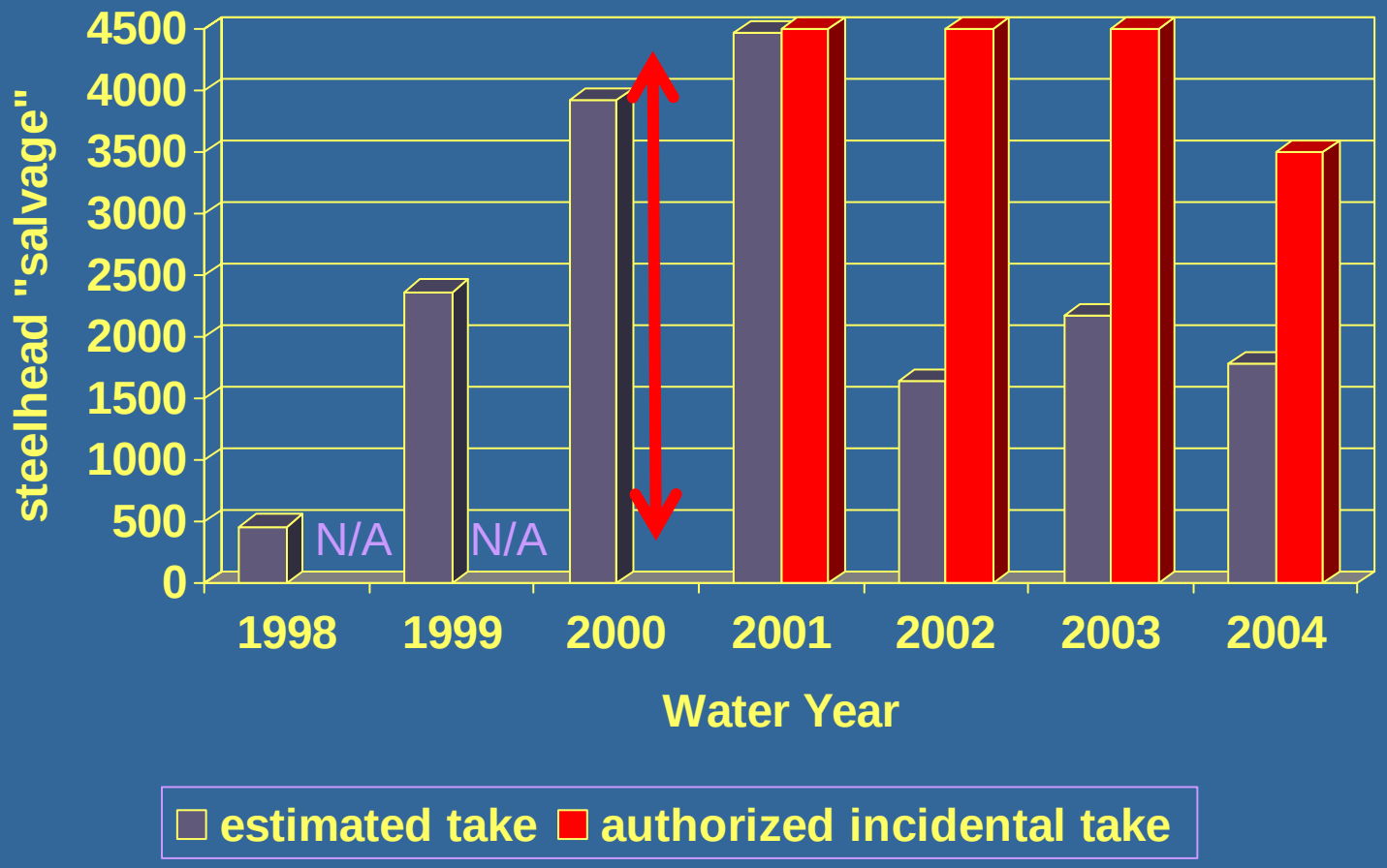
Water Year	Nov. Release % Loss	Dec. Release % Loss	Jan. Release % Loss	Production Release % Loss*
2001	0.11	0.27	0.36	0.39
2002	0.22	0.90	0.73	0.77
2003	0.28	**1.21**	**1.35**	3.29
2004	0.38	**	**1.36**	2.96

* Not used as surrogates ** no fish released

“Take” relative to mandatory re-consultation levels

Steelhead salvaged at SWP/CVP

(unmarked, produced in-river)



Comprehensive marking of hatchery steelhead - 1998, first STH B.O. 2000

Reduced SWP/CVP entrainment loss of salmon

- 2001 example: 200 TAF EWA actions in January -March
- Targeting juvenile winter run Chinook from Sacramento River
- WR (size) Chinook loss was ~ 20,000
- Without EWA would have been ~ 26,000
- EWA actions reduced entrainment by ~ 6000 salmon – 23% reduction in loss

Reduced SWP/CVP entrainment of salmon

- Using newly revised decision criteria in 2001
  - Defer actions initially
  - Time actions better relative to peak in loss rate
  - Bigger reduction in entrainment with same TAF
- 2002 -2004
  - 0 to 120 TAF for curtailments in winter months
  - Reduced salmon entrainment loss by 0 – 445 fish
  - Impact of extra pumping for EWA partly offsets benefit

EWA effect on Delta salmon survival

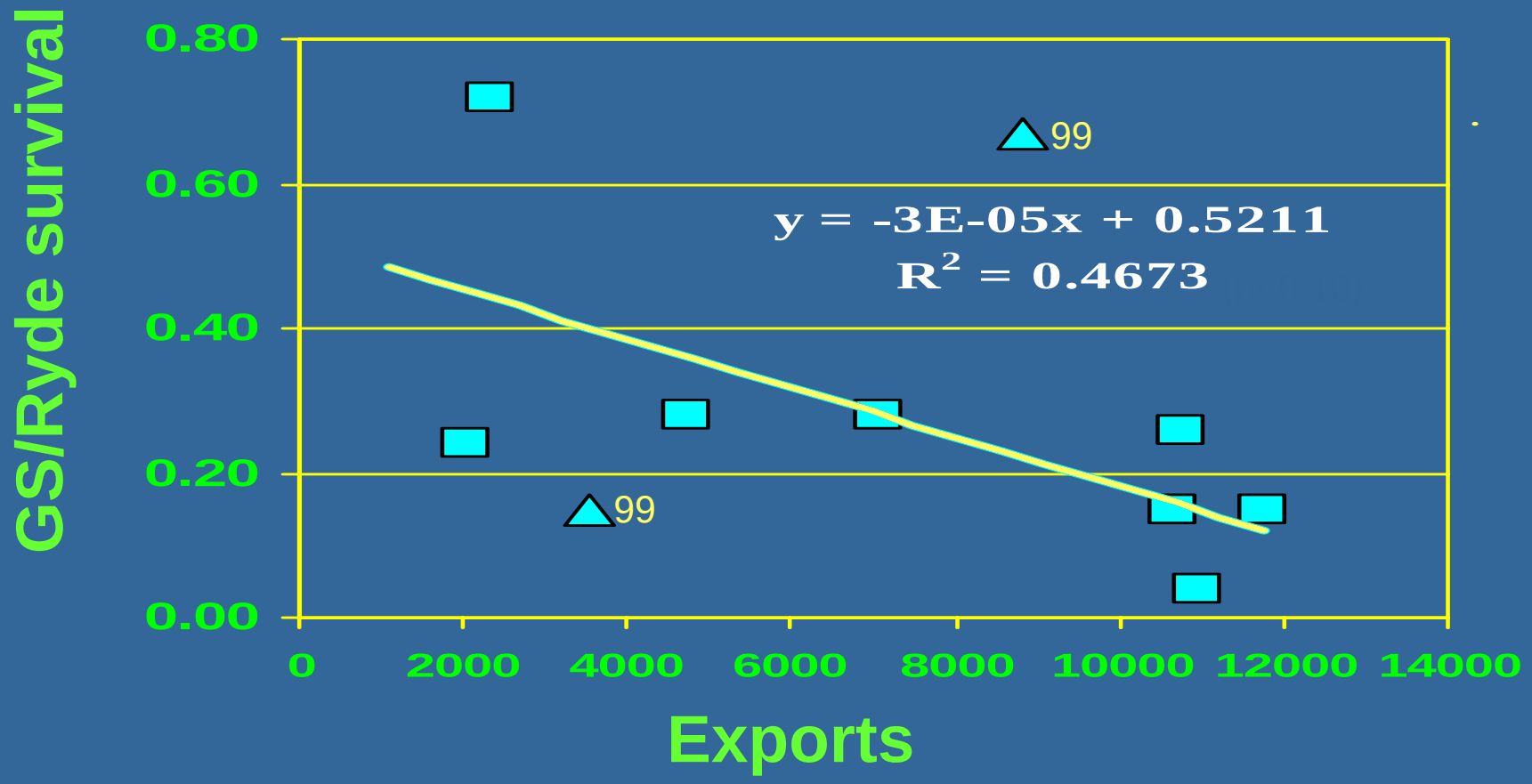
Estimates from:

- 2 models from Georgiana Slough/Ryde paired-release CWT experiments
  Model 1: 1993-1998 Model 2: 1993-2003

- Model relating survival from CPUE ratio to SWP/CVP loss (Model 3)

- Newman (2003) model from fall run CWT experiments (used by Cramer (2004)) (Model 4)

Relationship for Sacramento R. Salmon Delta Survival Model 1



1999 data point is not included in regression.

Ratio of survival for late fall yearlings released into Georgiana Slough relative to those released at Ryde versus mean daily combined CVP+SWP exports 17 days after release. Data from 1993-1998

Relationship used for Sacramento R. salmon Delta survival Model 2

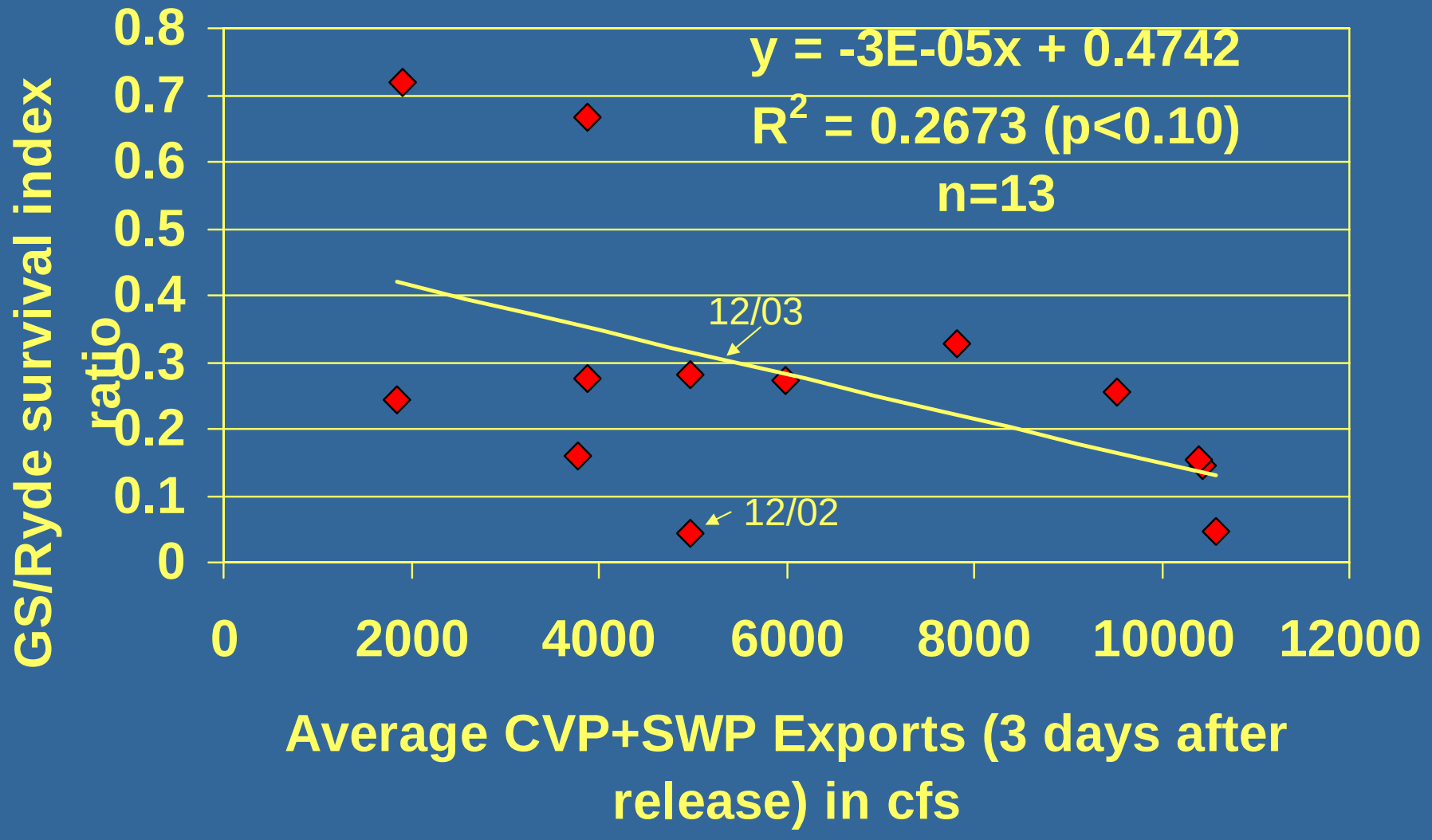


Figure 8: GS/Ryde survival ratio versus exports, 1993-2003

Relationship used for Sacramento R. salmon Delta survival Model 3

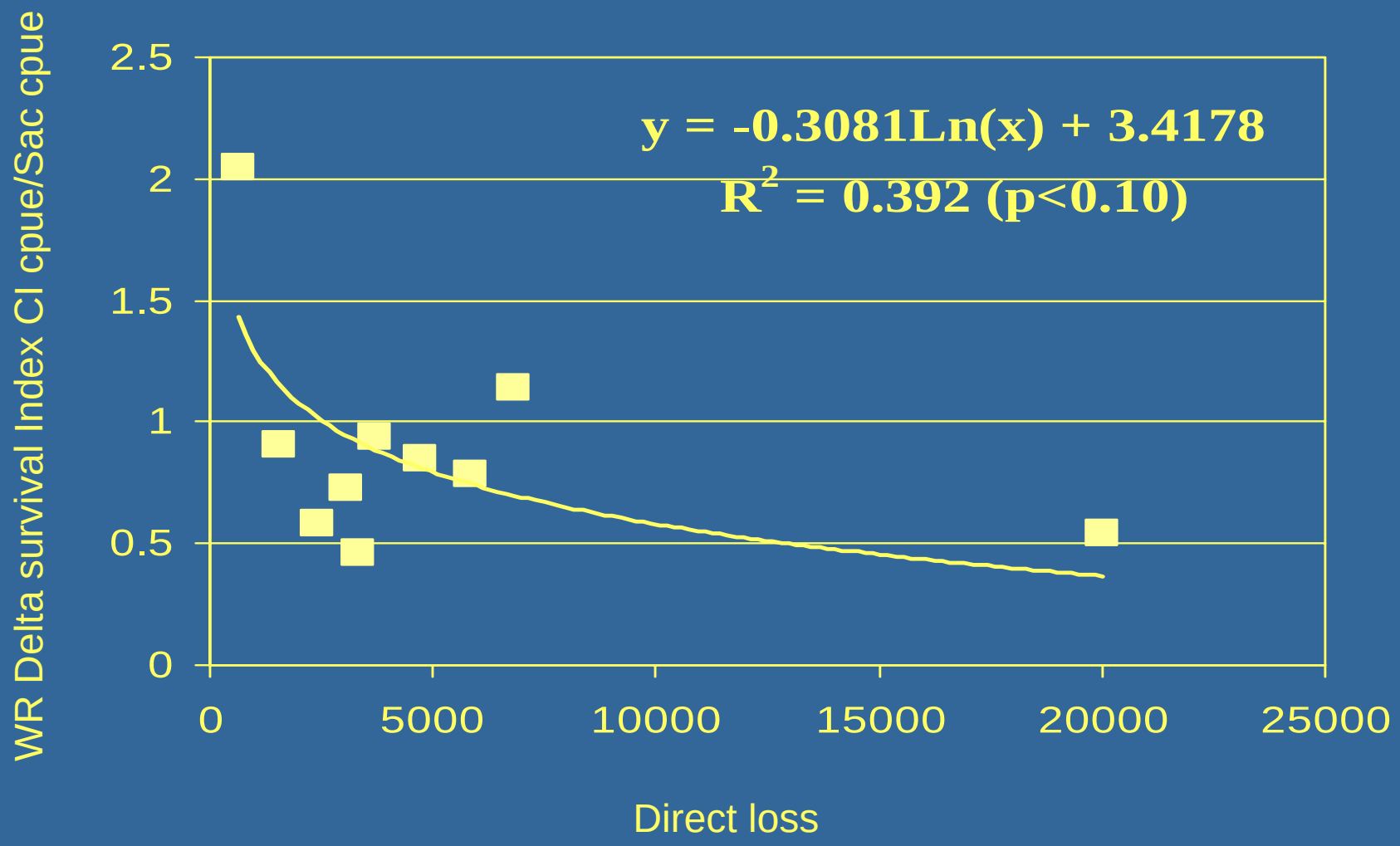


Figure 4: Survival of winter run between Sacramento and Chipps Island (based on FF curves) versus direct loss (Delta curves) at the CVP+SWP, 1993-1994 through 2001-2002.

Relationship used for Sacramento R. salmon Delta survival **Model 4**

Delta juvenile salmon survival model - Newman (2003)

Survival = 0.65+0.86*$\log_e$ (Flow) – 0.81*River Temp. – 0.32*Exports +0.378*Turbidity + 0.35 * Salinity – 0.75*Gate Position

Where:

Flow = Mean flow in cfs at Freeport
River Temp = Mean temperature in degrees F at Freeport (used 58°F)
Export flow = Combined export flow at CVP and SWP
Turbidity = in fromazine turbidity units near Courtland (used default value of 8)
Salinity = measured by conductivity, µmho/cm at Collinsville (estimated on relationship with flow: y= 102,003*$e^{(-0.0002*x)}$)
Gate Position - 1 = open, 0 = closed or fraction thereof
Survival = Logistic transform of proportion surviving to Chipps Island

Newman's Delta survival model is used in Winter run Chinook Salmon Integrated Modeling Framework Model, Version 1.2 (Cramer et al., 2004)

Percent change in survival of juvenile winter run (size) salmon

		Model 1	Model 2	Model 3	Model 4
Year	EWA Actions TAF	Feb, March **(daily)**	Mid-Nov - Mid- Apr **(daily)**	**Variable, juv. WR migration season**	Dec to Mid-April
2001	-233 Jan-Apr + 22 Dec-Apr	1.4	4.5	29	2.4
2002	-66 Jan +76 Feb -38 March	-2.8	-0.1	2.2	0.1
2003	-121 Dec-Jan +60 March	0	0	1.4	0.3

Effect of Delta actions on Sacramento Basin salmon populations

- Increasing survival (1.5-4.5%, perhaps more) with actions of significant magnitude/duration
- Curtailments to reduce impact on survival more valuable and more easily justified in years when abundance of target population is low
- In-season comparison of SWP/CVP loss to other benchmarks besides WR JPE and take limit may help assess need for EWA action (e.g. Chipps I)

Effect of Delta actions on Sacramento Basin salmon populations

- Timing of actions key to maximizing benefits
- Better run identification for juvenile salmon in the Sacramento R. and Delta
- Recognize potential harm caused by extra pumping to get water for EWA
- Correctly depicting timing of salmon vulnerability in survival models is critical to accurate assessment of net effect

EWA used for San Joaquin R. basin Chinook

- EWA used for part of the spring VAMP export reduction beginning in 2001

- Delta smelt protection
- Evaluation of salmon survival relative to river flow and exports, with Head of Old River barrier

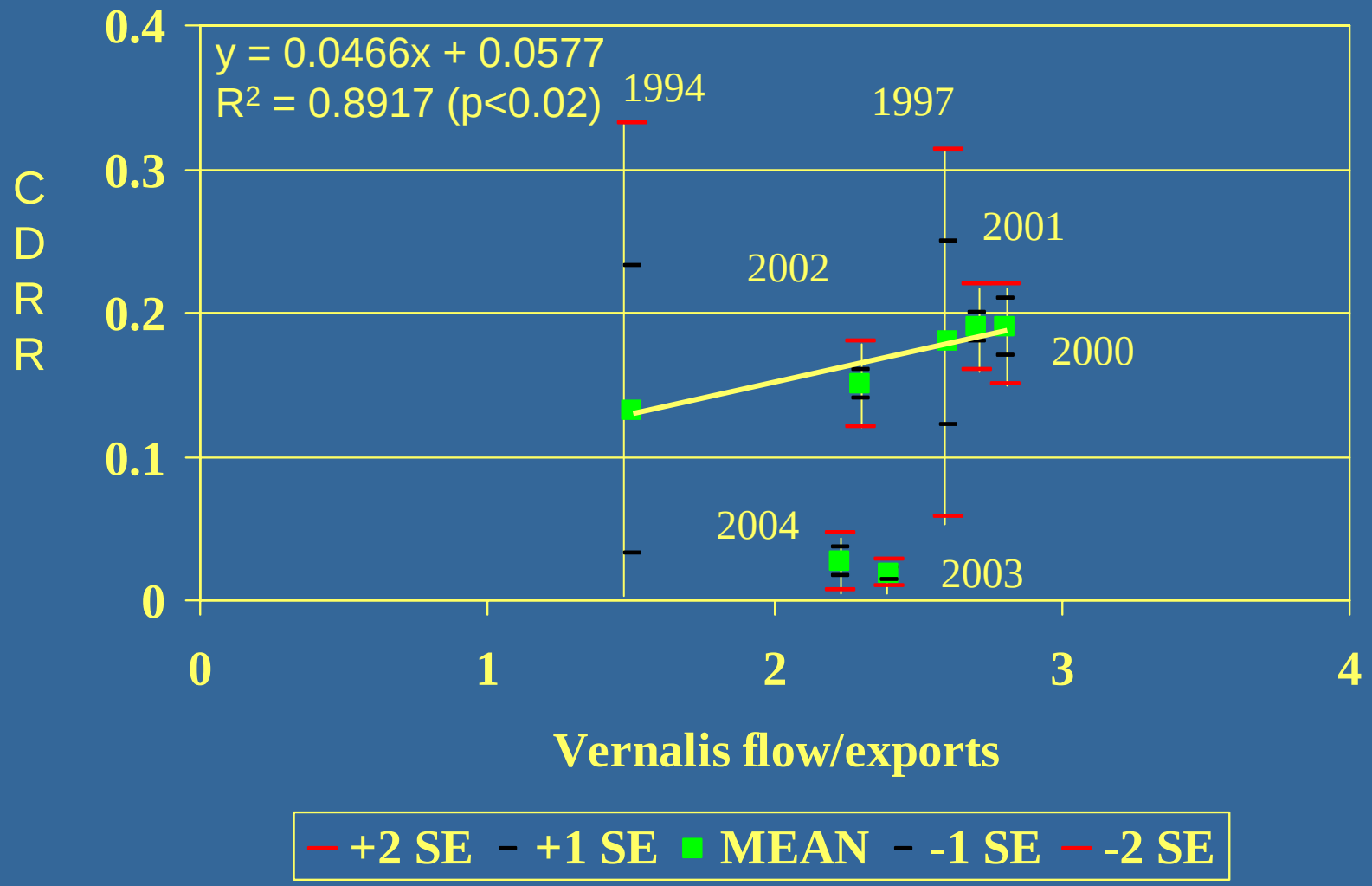
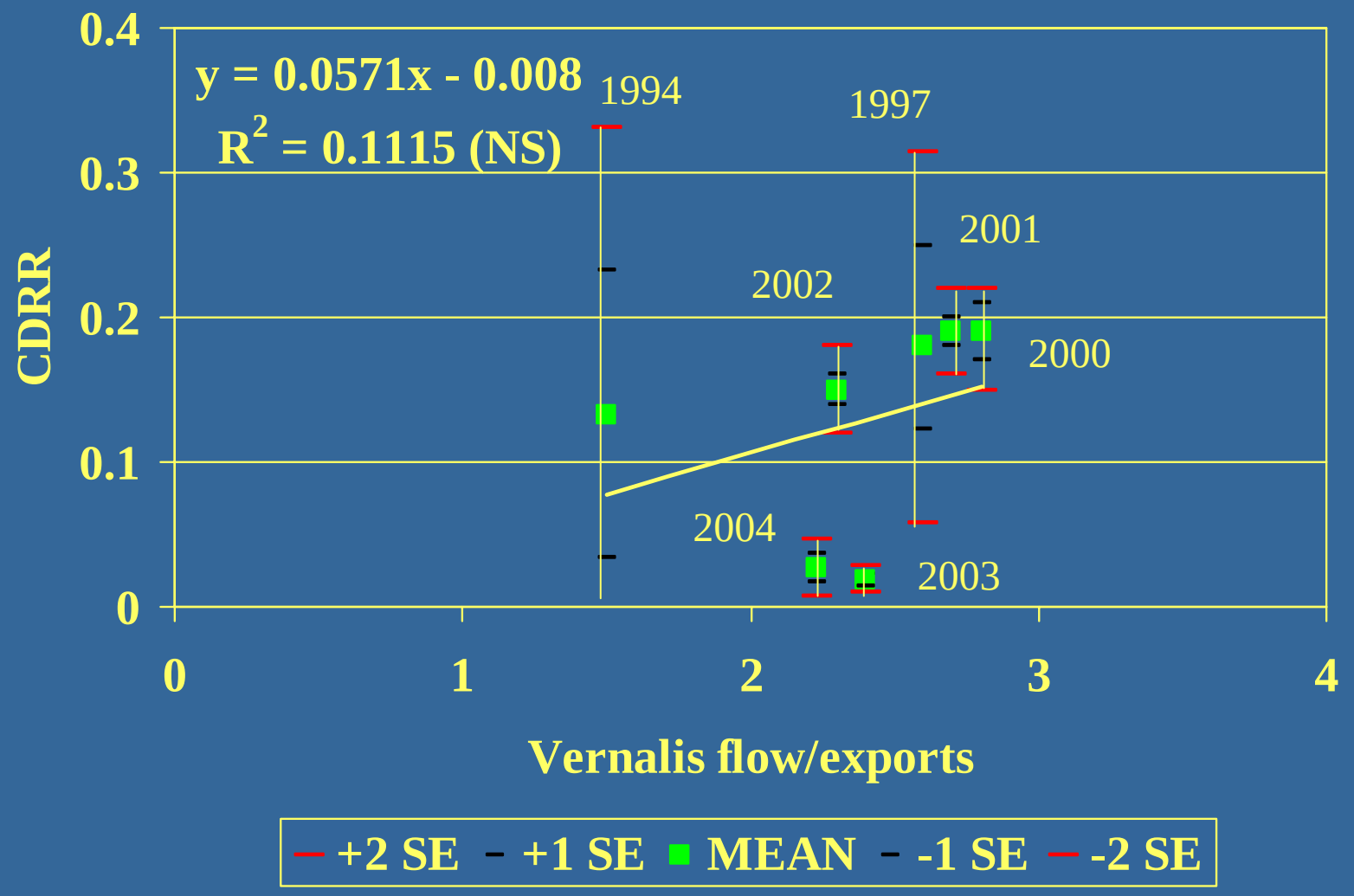


Figure 8. Combined Differential Recovery Rate (CDRR) and (+/- 1 and 2 Standard Errors) from Durham Ferry and Mossdale to Jersey Point with the HORB in place, versus inflow at Vernalis / exports, 1994, 1997 and 2000-2003. Regression line without 2003 and 2004 data.



Combined Differential Recovery Rate (CDRR) and (+/- 1 and 2 Standard Errors) from Durham Ferry and Mossdale to Jersey Point with the HORB in place, versus inflow at Vernalis / exports, 1994, 1997 and 2000-2004.

Effects of EWA for VAMP

- VAMP results preliminary – effects?
- VAMP period - part of the San Joaquin Basin juvenile salmon emigration season
- Reduced spring pumping improves survival of spring run and fall run Chinook salmon from Sacramento R (Newman model)
- Fall run Chinook from east-side Delta tributaries

Post-VAMP Delta action

- SJR flow drops and HORB removed
- Use EWA to extend pumping curtailment to protect juvenile delta smelt (shoulder)
- Some effect on later migrating salmon smolts

Upstream EWA actions

- Release cold water from bottom of Folsom Lake
- Lower American River temperature to 60° F sooner in the fall
- No EWA water used but EWA replaced lost power generation
- Primarily for fall run Chinook

EWA upstream – fall hydropower operation modification – Folsom Dam

- 2001
  - Small cold water supply – wait to initiate
  - 60 deg F on Nov 13 , 10 days earlier than without action
  - Still, 67 % of adult females die without spawning
- 2002
  - Larger cold water pool – begin earlier
  - 60 deg F on October 28, 12 days earlier than without action and 2 weeks earlier than in 2001
  - 30% of adult salmon die without spawning

Effects of hydropower modifications

- Assume reduced mortality of adult Chinook salmon prior to spawning
- Reduced mortality of incubating eggs
- Unknown number of adult salmon saved
- Unknown increase in production of juveniles
- Help preserve diversity in run timing?

Upstream flow augmentation

- Transfer water to the Delta for export
  - primarily in summer
  - less in fall (20 taf American R. and 25 taf Merced R. in 2001)
- EWA water used to augment flow without expecting to recover it in the Delta
  - Lower American River – 2002, fall 2004?

Effects of river flow augmentation

- No quantification of EWA effects
- Actions were short-term and combined EWA with other flow actions (b(2), SJRA water)
- Attraction flows improved migration conditions for adult salmon
- Spawning period flows provide increased habitat area suitable for salmon spawning

Conclusions on effects of EWA

- Reduced fish entrainment at SWP/CVP
- Helped avoid reinitiation of ESA consultation in several instances
- Increased Delta survival of migrating juvenile salmonids when substantial actions were taken in winter and spring

Conclusions on effects of EWA

Increase effectiveness of Delta actions:

- More timely pumping curtailments
- Better information on timing and annual abundance of each salmon run in the Delta
- Concern with extra pumping to get EWA water

Conclusions on effects of EWA

- Further consideration of upstream flow actions

- Better system-wide information on abundance, production and effects of restoration actions and other factors to make comparisons to EWA effects

Conclusions on effects of EWA

- T&E salmon abundance increased since 1990s
- Contributing factors:
  - Habitat restoration
  - Water Quality (temperature, contaminants)
  - Fish passage
  - Harvest restrictions
  - Hatcheries
  - Variation in hydrology and ocean conditions
  - Reservoir and Delta water management

- EWA has affected adult returns for winter run in only 2 years and other runs in one year.

Conclusions on effects of EWA

- Small effects can alter the abundance trajectory
- Small benefits can contribute to achieving the desired result at the population level over time
- Decisions to use less EWA for some Chinook based on increases in the abundance
- Premature to conclude what the role of EWA should be in recovering salmonid runs

Abundance estimation issues

- How do we deal with errors and uncertainty in our measurements and estimates of abundance of different salmon life stages at various locations?
- Do the pieces fit together?
- Winter run Chinook in 2001 as an example

Winter run Chinook salmon
2000-2001

Juvenile Production Estimate (JPE)

370,000

Calculated from female spawner abundance

Chipps Island Surviving out-migrants

281,000
(75% of JPE)

Delta mortality
(by difference)

69,000
(19% of JPE)

Chipps and SWP/CVP WR size salmon

SWP/CVP entrainment loss

20,000 (5.4% of JPE)

No EWA action: 26,000 (7% of JPE)

Winter run Chinook
2000-2001

Juvenile Production Estimate (JPE)

370,000

2,600,000 Revised JPE

Chipps Island

Surviving out-migrants

281,000 (75%)

(11% of rev. JPE)

Delta mortality 69,000 (19%)

2,299,000

(88% of revised JPE)

SWP/CVP loss

20,000 (5.5% of JPE)

(0.8% of revised JPE)

What is the error associated with these measurements and estimates?

Estimation errors

- Winter run JPE: errors in individual factors compound
- Chipps Island: catch expanded for time and space, tidal area -not a one-way gate
- SWP loss: pre-screen loss 63-99% so 1 fish at screens may represent between 3 and 100 fish entrained, we assume it’s 4.
- CVP: prescreen loss never measured

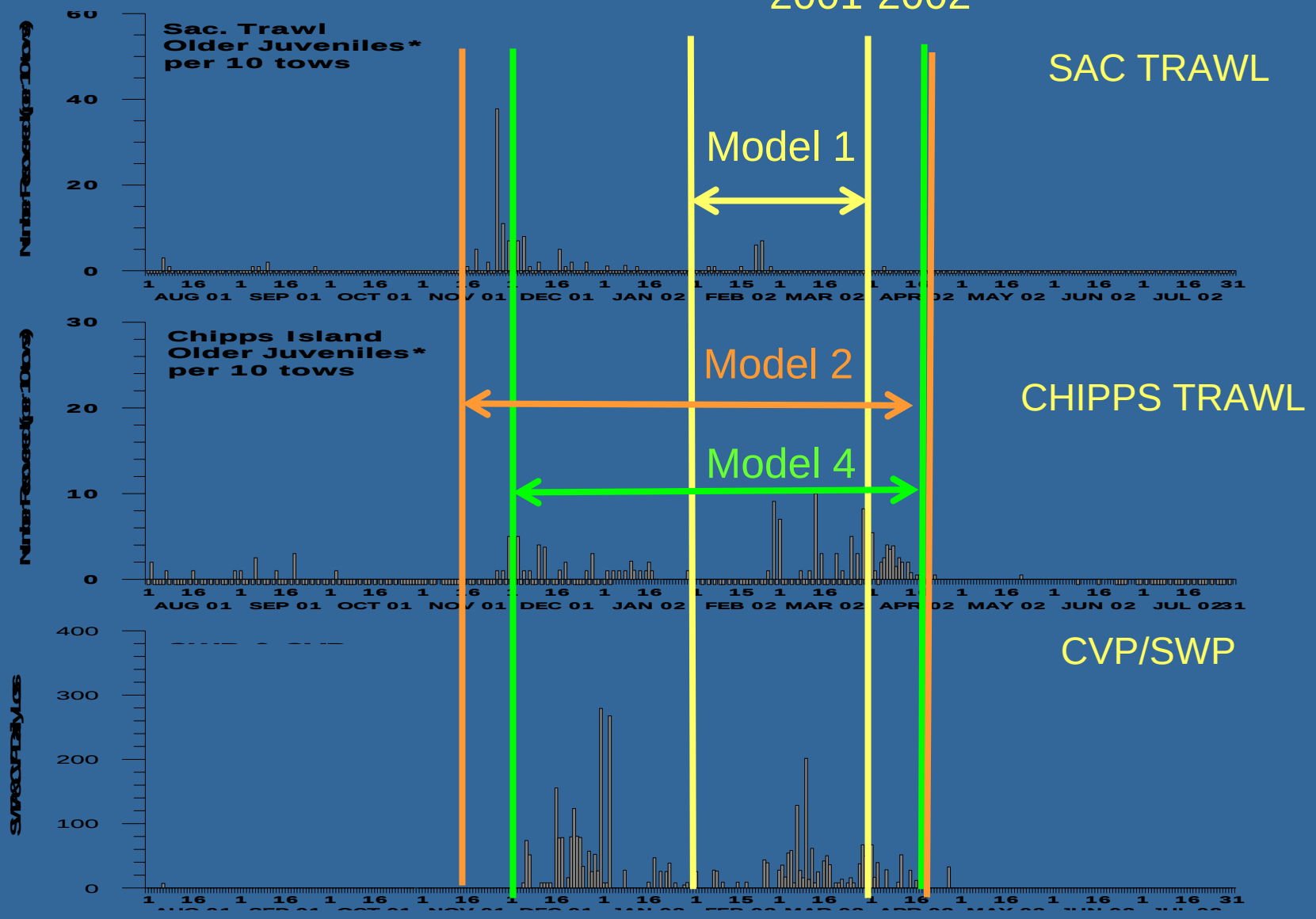
Salmon survival model issues

Model application:

- For models 1 and 2 which calculate daily survival, do the assumed temporal patterns of salmon presence (Sacramento Trawl) reflect periods of greatest vulnerability?

OLDER JUVENILES

2001-2002



EWA effects on populations

Survival model issues

Data collection and model development:

- Ability to control environmental conditions during experiments
- When conditions vary during experiment, how do you describe what was tested?
- Do we measure the salmon survival response with enough precision to detect differences?

Survival model issues

Data interpretation:

- Is regression analysis the right statistical tool?

"…ecological factors may often impose upper ceilings on response variables without strongly influencing the distribution of the response variable below the ceiling" editors note

Thompson et al. Ecology 77(6) 1996 pp.1698-1715

Factor ceiling distribution?

- Simple correlation, Strong relationship
- Factor ceiling or triangular distribution
- Uniform distribution – no relationship

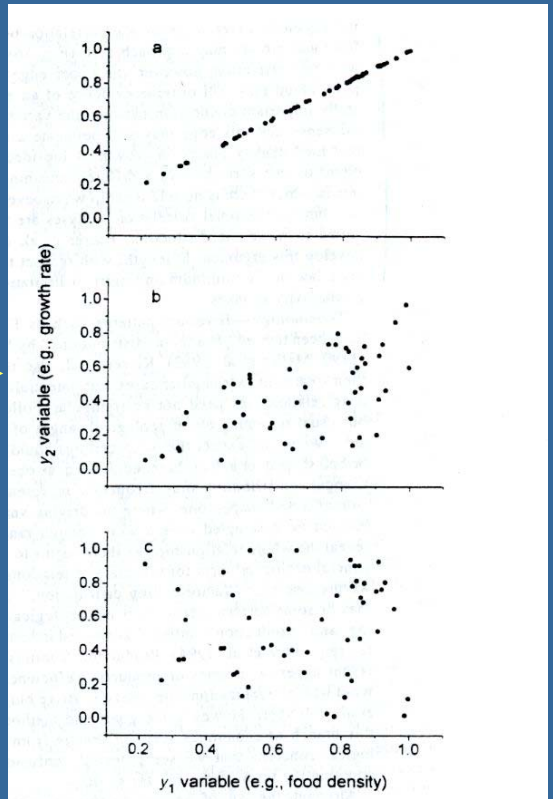


FIG. 1. Examples of possible bivariate distributions. (a) A tight, simple correlation of the form $y_2 = y_1 \pm$ a small amount of random variation. This relationship is well fit by standard techniques. (b) A ceiling function in which both x and y are drawn from random uniform distributions but y_2 is constrained to be $< y_1$. Standard regression would not locate the ceiling. (c) Both y_1 and y_2 are drawn from uniform distributions.

Thompson et al. Ecology 77(6) 1996 pp. 1698-1715

Survival ceiling?

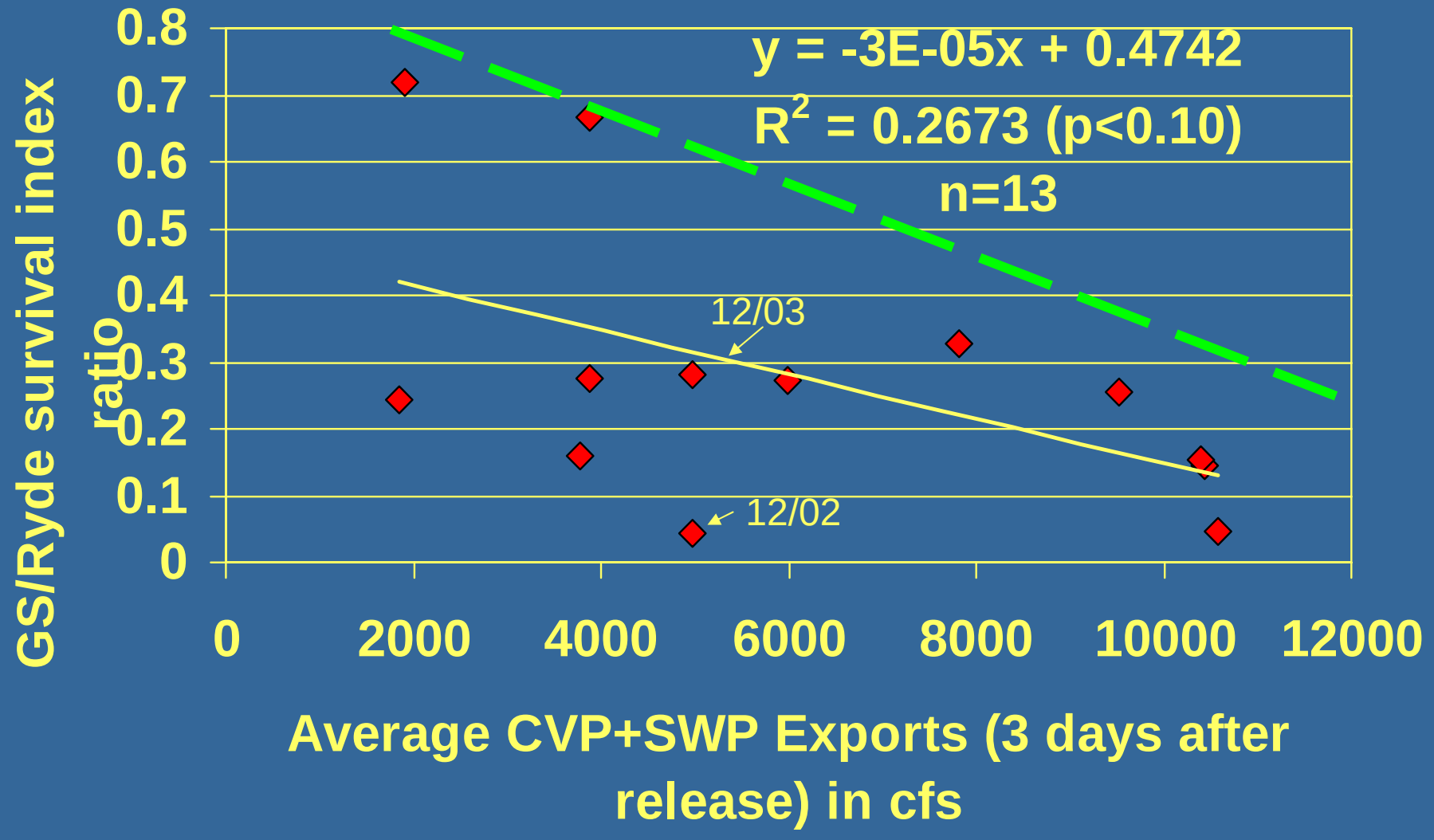


Figure 8: GS/Ryde survival ratio versus exports, 1993-2003

Effects of EWA on salmonids

Salmon population modeling highlights uncertainties

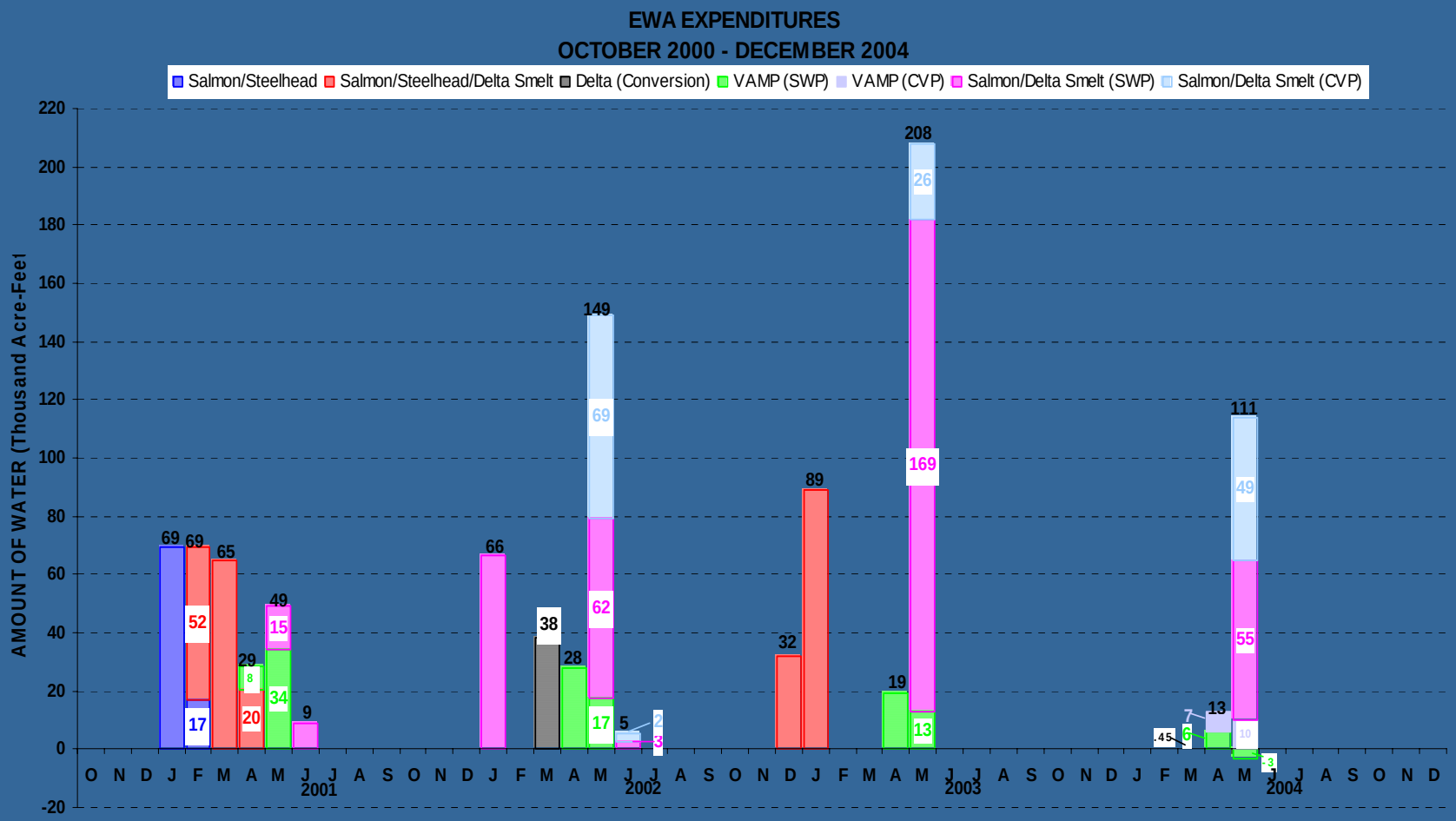
Premature to conclude what the role of EWA should be in recovering salmonid runs

The End,
or the beginning?

Types of EWA actions

- SWP/CVP pumping curtailments
- River flow augmentation
- Modify hydropower operations for downstream water temperature improvement

EWA uses 2001-2004



Change in WR (size) Survival with EWA

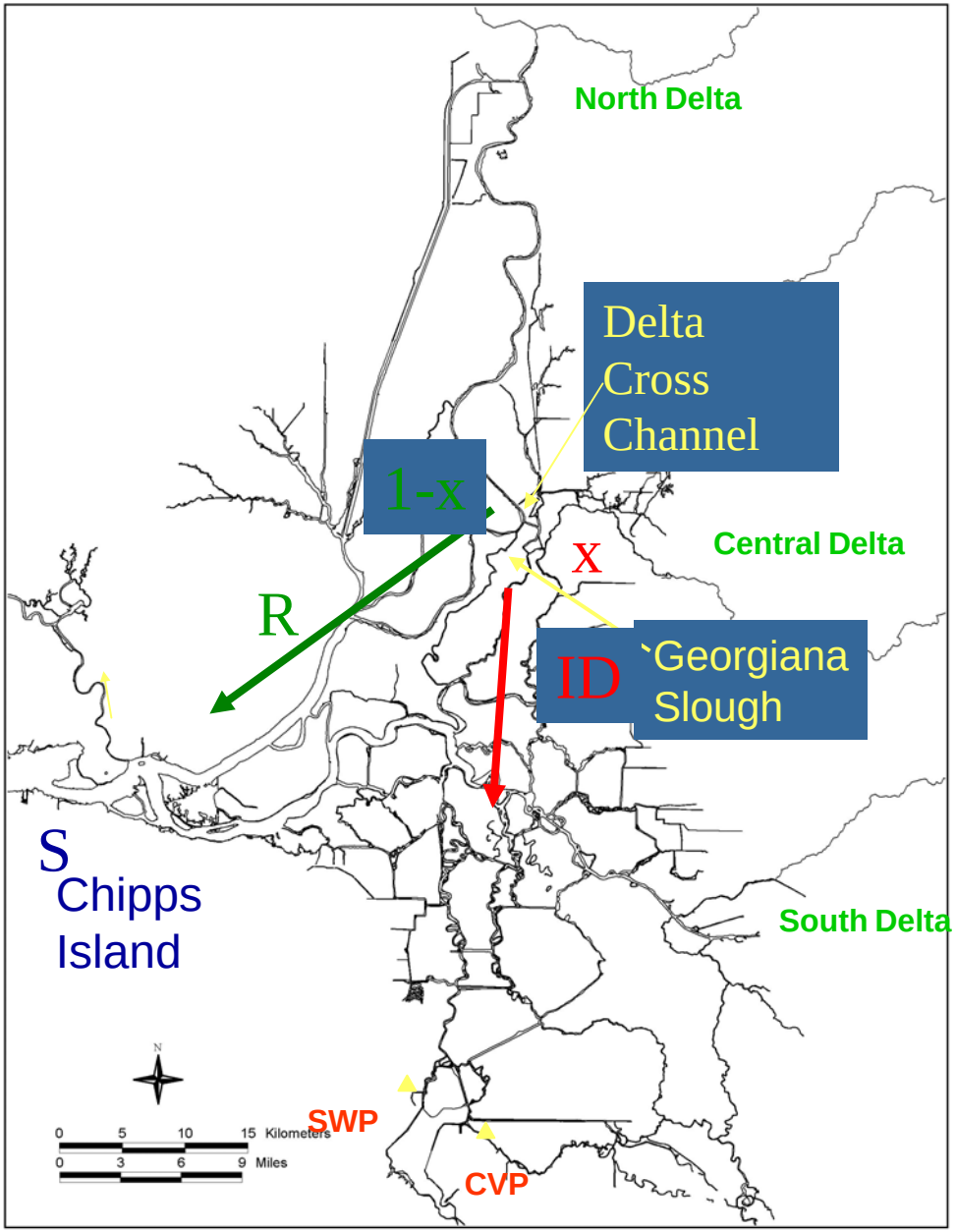
	Model	1	2	3	4
2000-2001 6 targeted WR actions (233 TAF) -22 TAF State Gain Dec-Apr	Base	0.69	0.66	0.28	0.82
	EWA	0.70	0.69	0.36	0.84
	Difference	0.01	0.03	0.08	0.02
2001-2002 No targeted WR actions 1 targeted to SR in Jan (66 TAF), 38 TAF used in March -76 TAF Relaxation of E/I in Feb	Base	0.71	0.676	0.90	0.872
	EWA	0.69	0.675	0.92	0.873
	Difference	-0.02	-0.001	0.02	0.001
2002-2003 3 SR actions Dec-Jan (121 TAF) -60 TAF E/I relaxation, debt repayment and State Gain in March	Base	0.68	0.68	0.69	0.908
	EWA	0.68	0.68	0.70	0.911
	Difference	0.00	0.00	0.01	0.003

2003-2004 No actions
Dec 1 – Apr 14

Effect of VAMP flow and export conditions on the Delta survival of San Joaquin River basin juvenile salmon

	Without VAMP				With VAMP					Percent of smolts migrating	
Year	Flow	Exports	Ratio	Survival	Flow	Exports	Ratio	Estimated survival	Observed survival	VAMP	Post-VAMP Shoulder
2000	4815	4815	1.0	0.10	5869	2155	2.72	0.18	0.19	31	27
2001	2920	2920	1.0	0.10	4220	1420	2.97	0.20	0.19	58	17
2002	2757	2757	1.0	0.10	3300	1430	2.31	0.17	0.15	66	18
2003	2290	2290	1.0	0.10	3235	1446	2.24	0.16	0.02	76	8
2004	2088	2088	1.0	0.10	3155	1331	2.37	0.17	0.03	72	10
		Mean		0.10				0.18			

MODELS 1 and 2



WR Delta survival between 2/1 and 3/31(model 1) and 11/15 and 4/15 (model 2)

(S) = ((1-x) * R) + (x * ID) * P

Where :

x = % water diverted

R = Ryde survival = (0.8)

ID= ((GS/Ryde survival ratio *(Ryde survival)))

P is the % of the population passing Sacramento +2day lag and GS/Ryde survival = 0.52 - 0.00003*exports (model 1) (newest relationship: 0.47-0.00003*exports) (model 2)

Estimate survival on daily basis with and without EWA export curtailments to estimate benefits

Juvenile Salmonids in the Delta

Month	Winter	Spring	Fall	Late Fall	Steel-head
Oct-Nov	x		x	x	
Dec-Jan	xx	xx	x	xx	x
Feb	xxx	xxx	x	xx	xx
March	xxx	xxx	xx	x	xx
April	x	xxx	xxx		x
May		x	xxx		
June			x		
Jul-Sep					

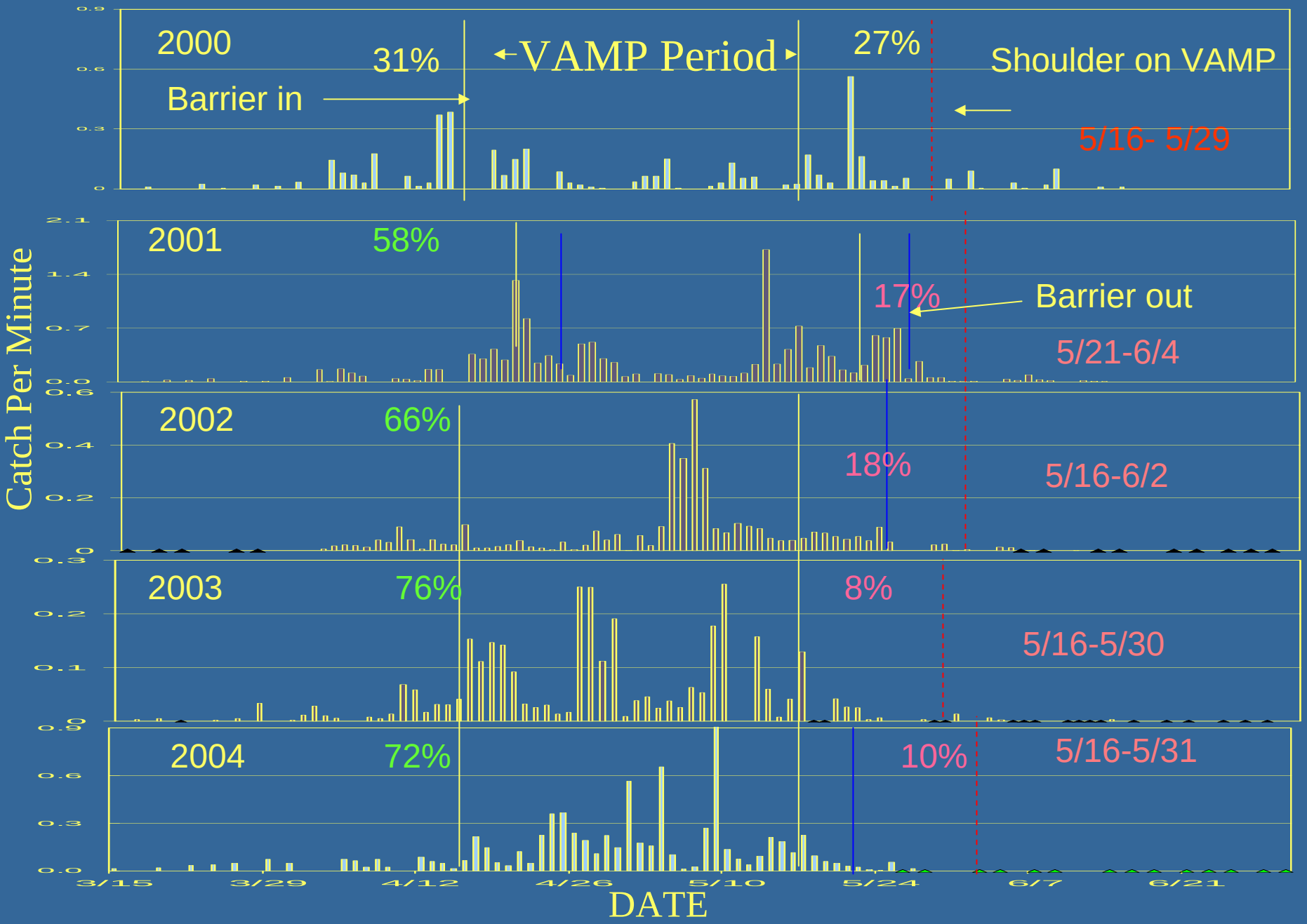


Figure 9: Catch per minute of all unmarked juvenile Chinook in the Mossdale Kodiak trawl between March 15 and June 30. The barrier was in at the start of the VAMP period except in 2001 when the VAMP started later and the barrier went in a few days later. It was taken out at the end of the VAMP period in 2000 and 2003 and on the date indicated by the blue line in 2001, 2002 and 2004.