Delta smelt, salmon, & exports Spring 2005

Presented to

CalFed Ops Group

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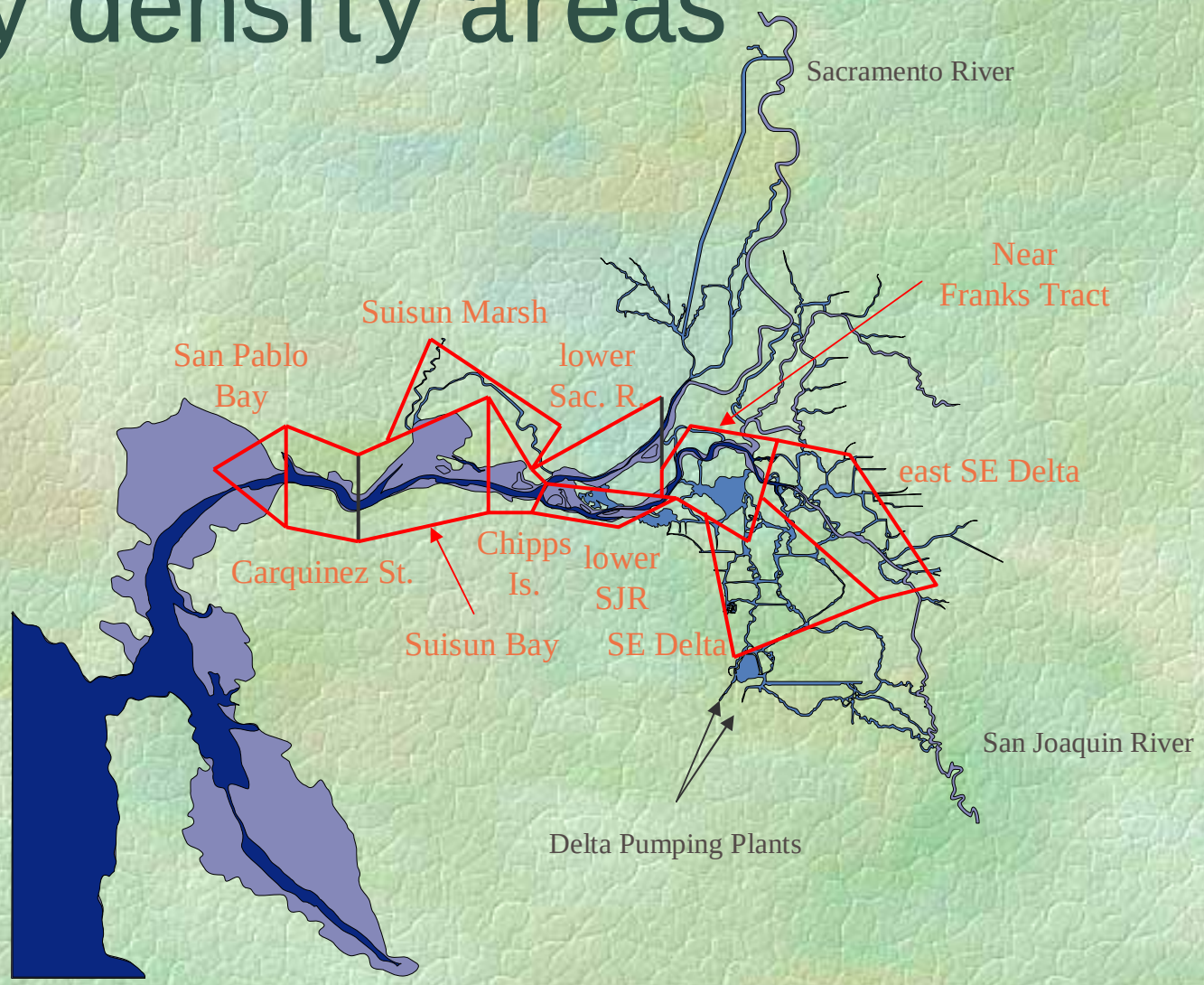
San Luis and Delta-Mendota Water Authority

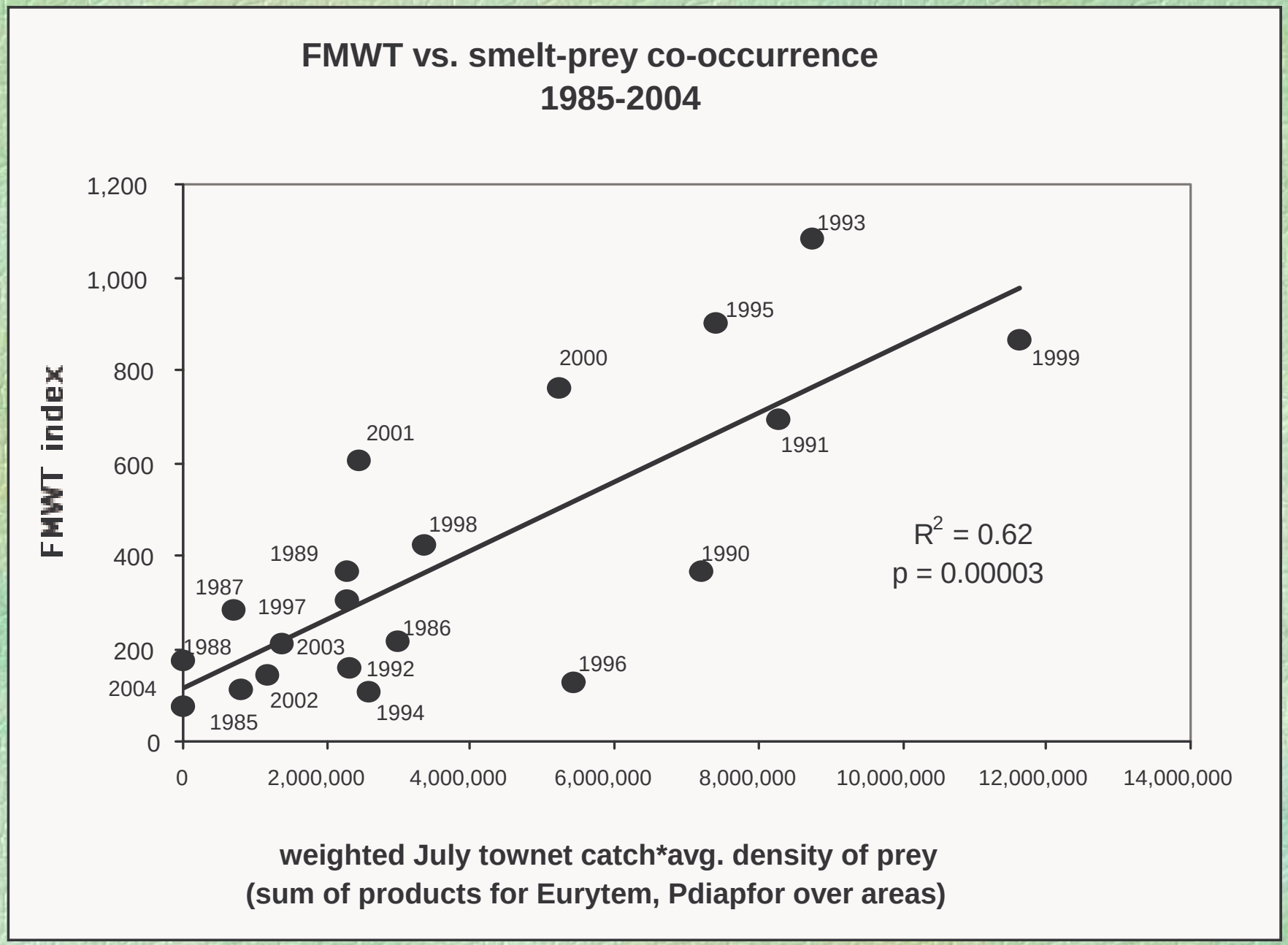
Delta smelt background

What controls the fall midwater trawl index of sub-adult delta smelt?

- No correlation between FMWT index of sub-adult abundance and STN index of juvenile abundance in smelt “post-decline” period (after 1980).???
- There is a correlation between the STN and previous FMWT, so these data are good enough to show a correlation between FMWT and previous STN if one existed.
- Bennett: Based on lab analyses of smelt from 1999 concludes that factor(s) in late summer controls sub-adult abundance in fall. Most likely food limitation.
- We compared smelt abundance and prey density in July for ten areas of smelt habitat.
- Found highly significant correlation of FMWT vs. sum over areas of product of smelt abundance and prey density.

Delta smelt abundance & prey density areas




FMWT vs. smelt-prey co-occurrence
1985-2004
FMWT index
1,200
1,000
800
600
400
200
0
0
2,000,000
4,000,000
6,000,000
8,000,000
10,000,000
12,000,000
14,000,000
1993
1995
1999
2000
1991
2001
1998
1989
1990
1987
1997
1986
1988
2003
1992
1996
2004
2002
1994
1985
R^2 = 0.62
p = 0.00003
weighted July townet catch*avg. density of prey
(sum of products for Eurytem, Pdiapfor over areas)

co-occurrence products, smelt abundance and prey density

year	San Pablo Bay	Carquinez St.	Suisun Bay	Suisun Marsh	Chipps Is.	Lower Sac. R.	Lower SJR	nr Franks Tract	E-SE Delta	SE Delta
1985	0	0	0	0	440,690	344,045	30,664	0	0	0
1986	0	0	450,941	14,533	1,242,206	1,267,601	21,035	0	0	0
1987	0	0	0	5,518	0	604,187	88,799	2,195	0	0
1988	0	0	0	0	0	0	0	0	0	0
1989	0	0	163,253	397,592	0	1,681,362	0	0	0	24,771
1990	0	0	63,145	0	51,242	6,110,920	964,590	0	0	0
1991	0	0	0	0	74,938	7,207,645	920,136	64,015	0	0
1992	0	0	11,392	0	504,997	1,485,621	314,314	0	0	0
1993	0	3,049	907,585	27,597	1,895,987	3,324,685	2,588,521	0	0	0
1994	0	0	11,070	5,630	29,798	2,490,736	0	0	27,957	0
1995	0	0	6,404,571	75,496	680,357	253,148	0	0	0	0
1996	0	0	112,081	1,436,198	643,081	1,538,178	1,688,019	0	0	0
1997	0	0	288,588	0	629,147	1,237,496	136,774	0	0	0
1998	0	18,940	1,956,598	1,021,038	70,601	82,325	188,754	0	0	0
1999	0	0	1,471,853	444,747	4,418,652	4,446,508	647,666	189,416	0	0
2000	0	0	157,713	405,110	676,491	3,629,136	340,656	0	0	0
2001	0	0	12,533	2,581	0	2,431,670	0	0	0	0
2002	0	0	10,244	0	44,512	993,401	136,284	0	0	0
2003	0	0	1,399	4,810	259,573	899,270	203,891	0	0	0
2004	0	0	0	0	0	0	0	0	0	0

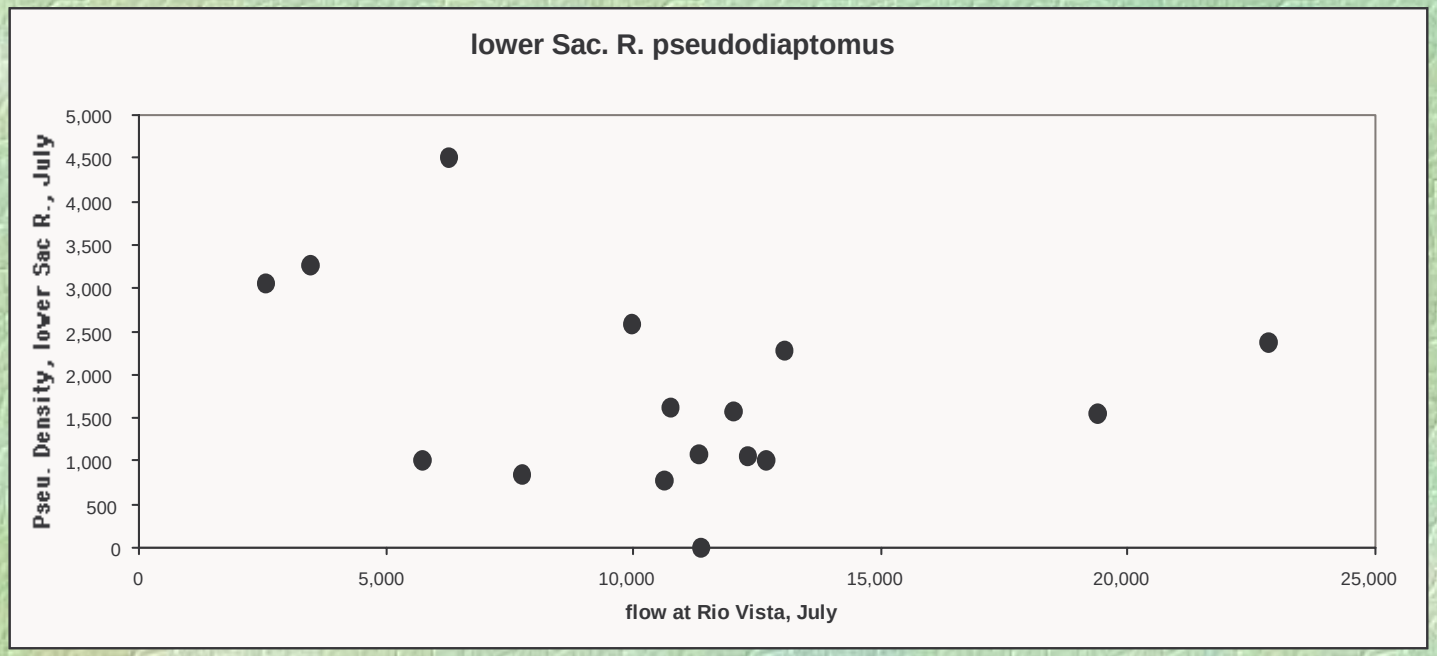
The sum of each year's products over these areas is the value on the x-axis of the previous graph.

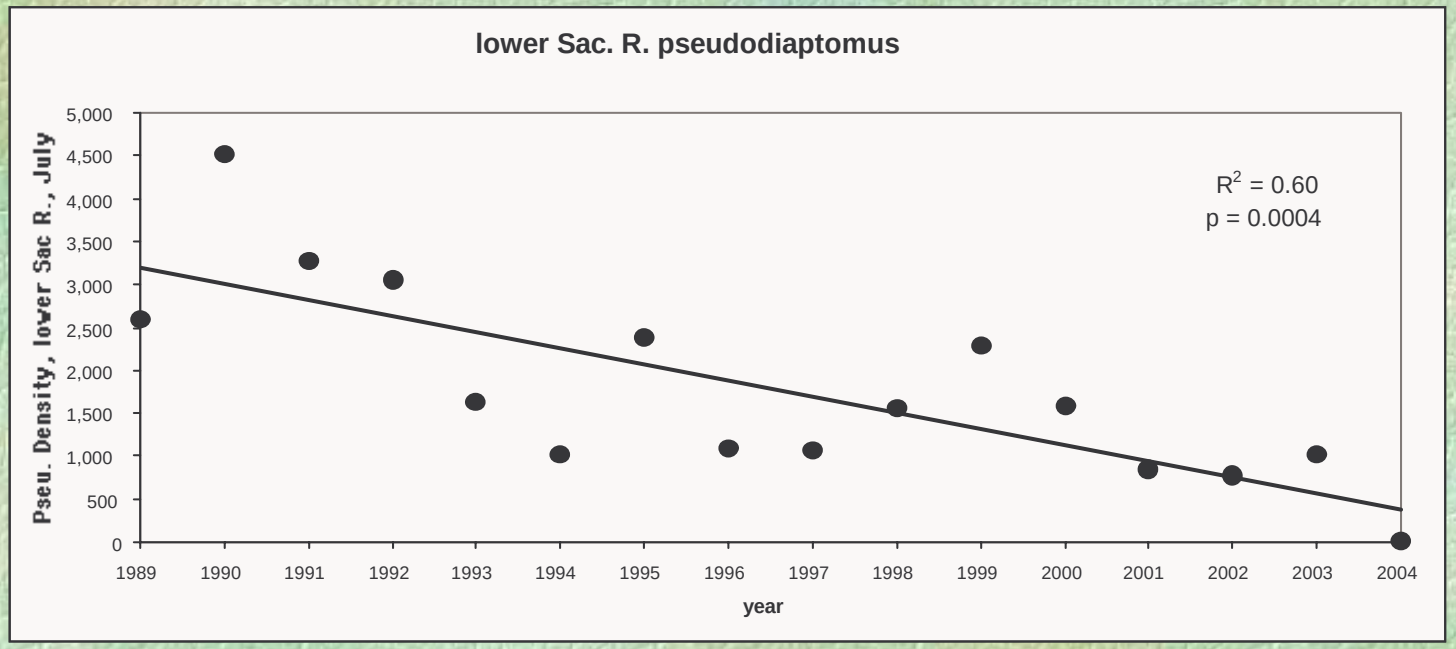
Conclusions

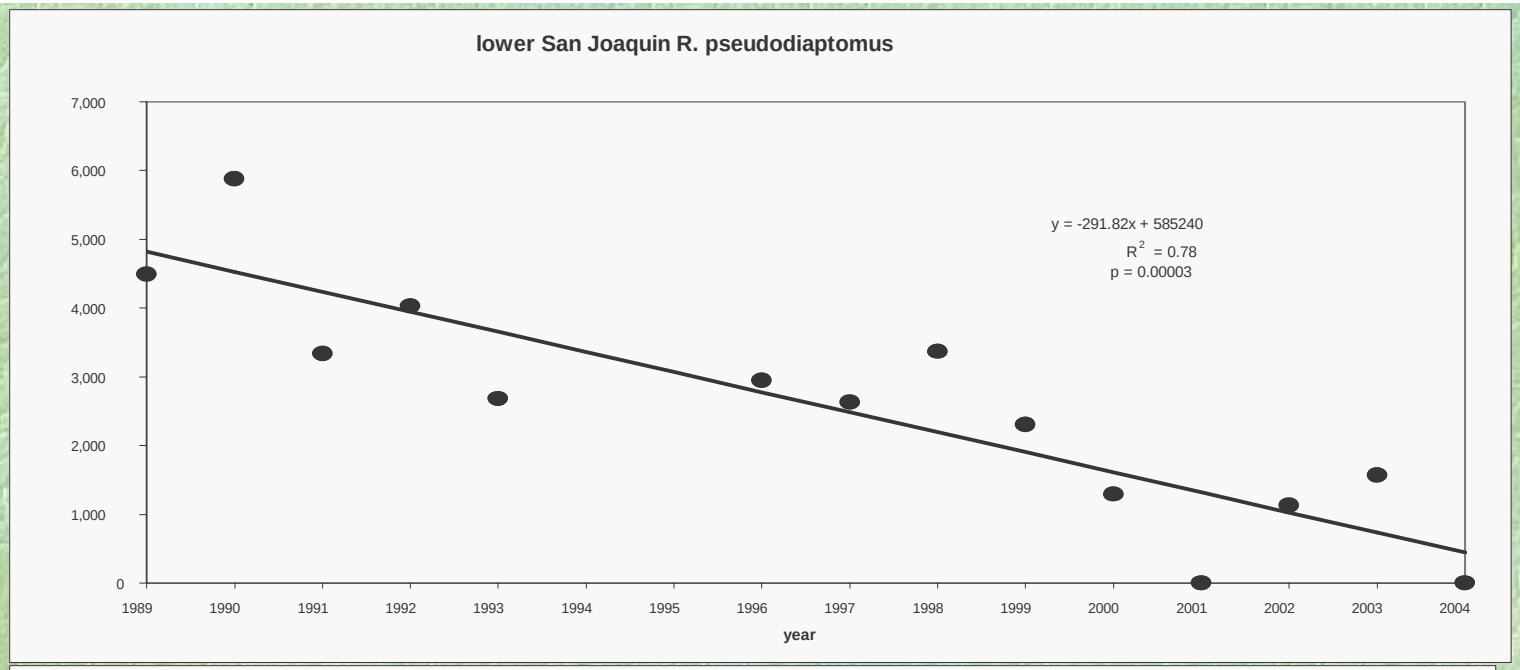
- There is a highly significant correlation (R2=0.62, p=0.00003) between FMWT and the July co-occurrence of smelt and prey.
- The primary area of co-occurrence in July is the lower Sacramento River and, in some years, nearby areas.
- Areas near the export pumps are not areas of significant co-occurrence of smelt and prey in July.
- If export entrainment is affecting FMWT, must be affecting smelt and/or prey that end up in co-occurrence areas in July.

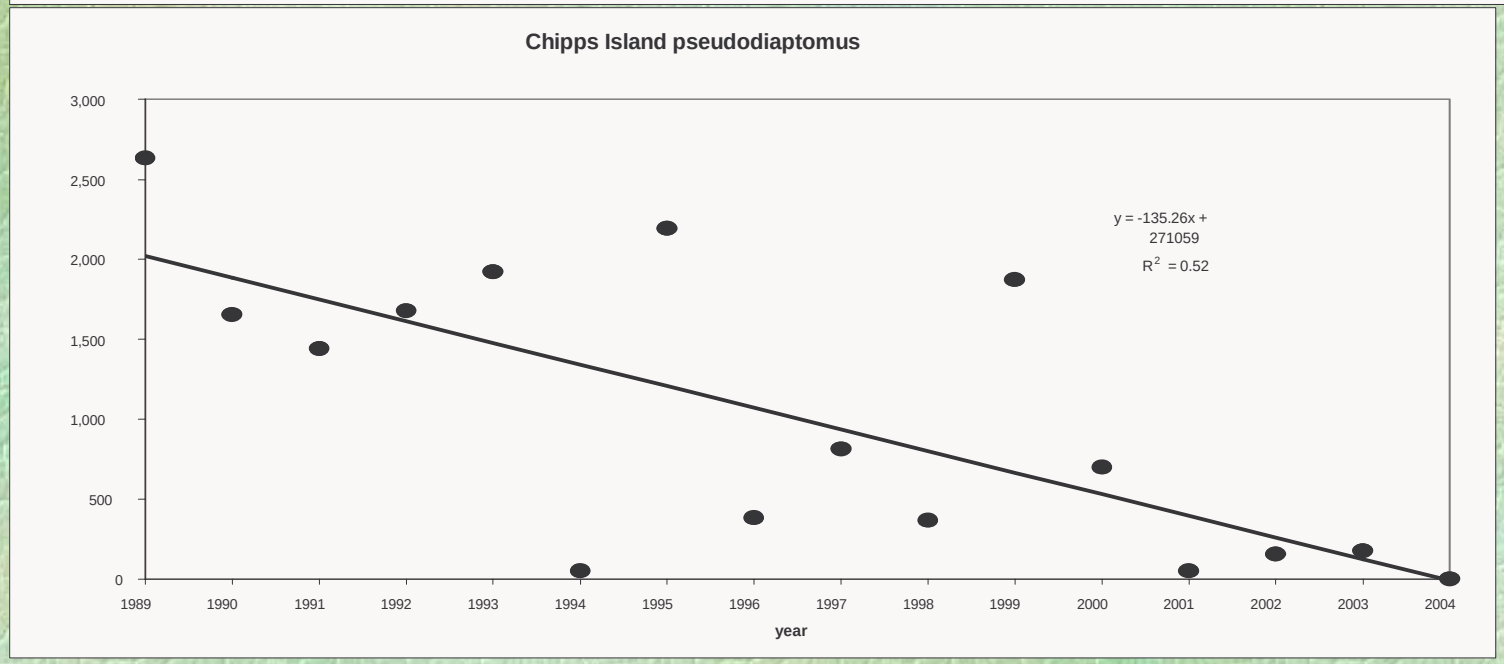
The key questions:

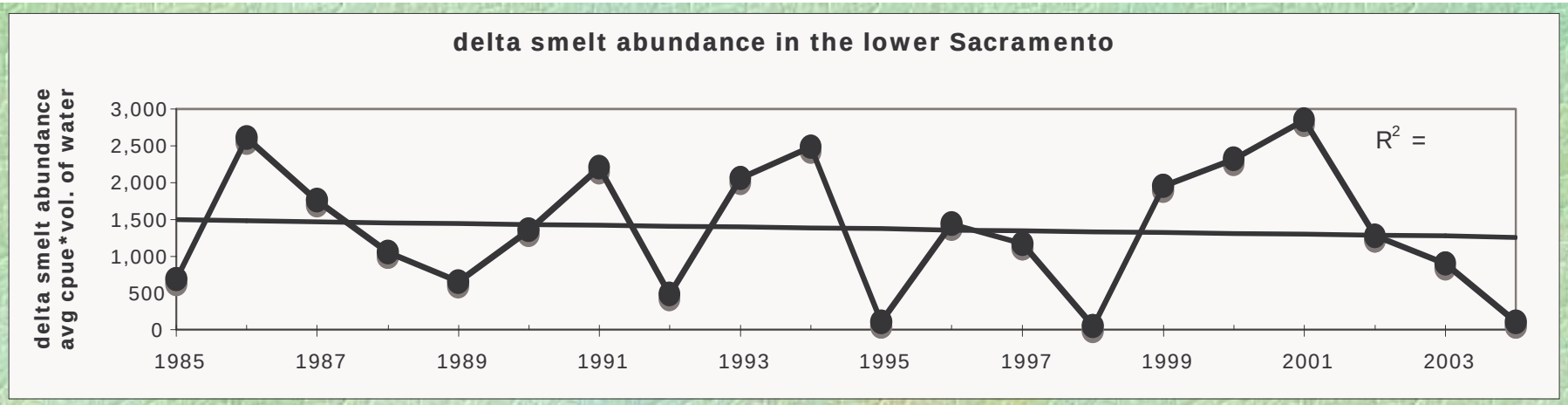
- Where do smelt in the high co-occurrence areas in the late summer come from? Export effect?
- What factors affect prey (pseudodiaptomus) density in the high co-occurrence areas in the late summer?

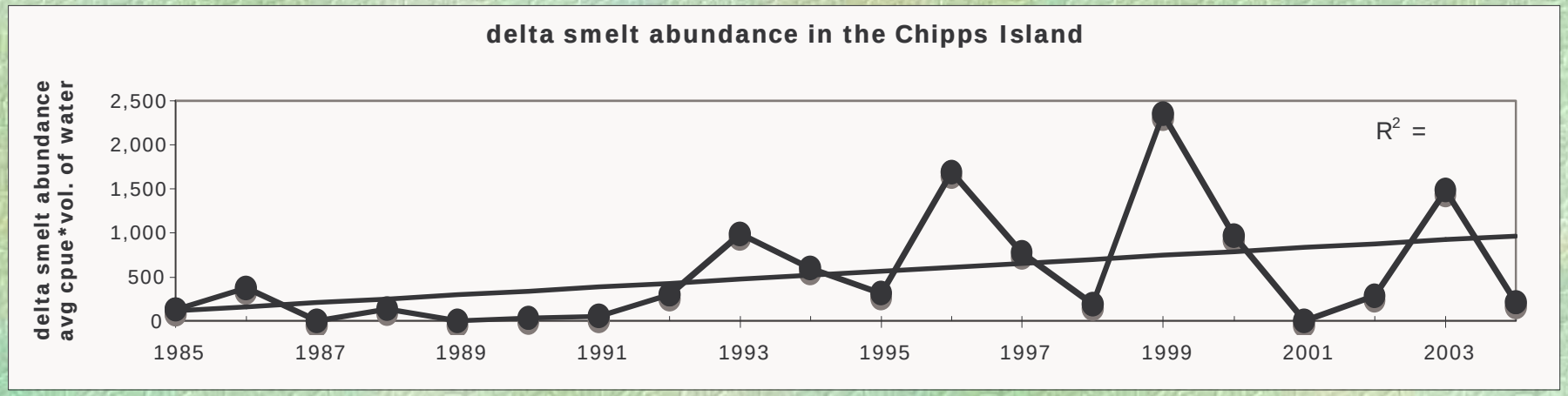

lower Sac. R. pseudodiaptomus
Pseu. Density, lower Sac R., July
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
5,000
10,000
15,000
20,000
25,000
flow at Rio Vista, July

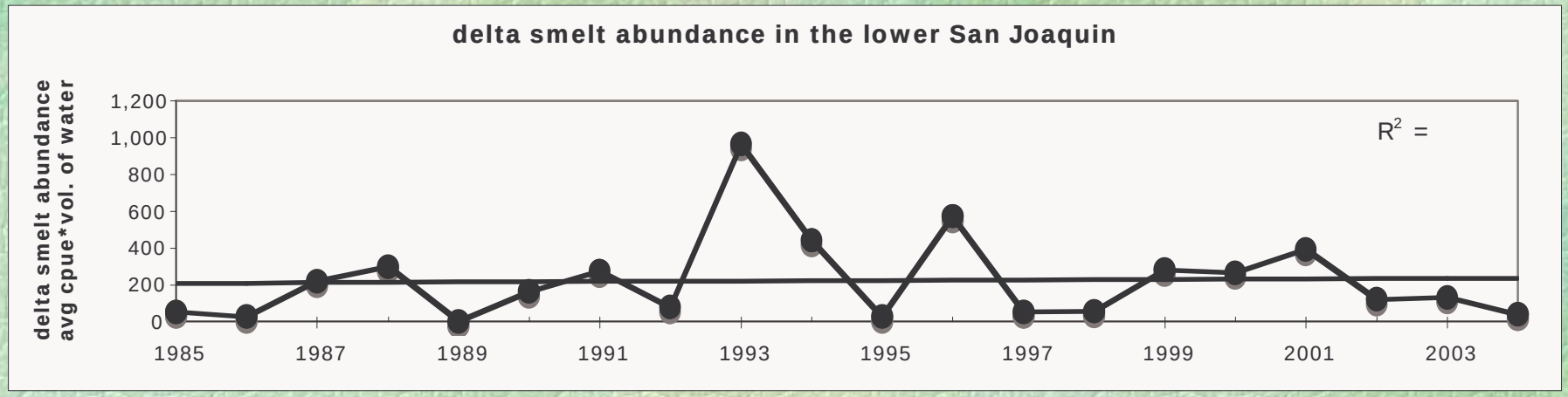

lower Sac. R. pseudodiaptomus
Pseu. Density, lower Sac R., July
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
R2 = 0.60
p = 0.0004
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
year


lower San Joaquin R. pseudodiaptomus
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
year
y = -291.82x + 585240
R2 = 0.78
p = 0.00003


Chipps Island pseudodiaptomus
3,000
2,500
2,000
1,500
1,000
500
0
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
year
y = -135.26x + 271059
R2 = 0.52


delta smelt abundance in the lower Sacramento
delta smelt abundance
avg cpue*vol. of water
3,000
2,500
2,000
1,500
1,000
500
0
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
R2 =


delta smelt abundance in the Chipps Island
delta smelt abundance
avg cpue*vol. of water
2,500
2,000
1,500
1,000
500
0
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
R2 =


delta smelt abundance in the lower San Joaquin
delta smelt abundance
avg cpue*vol. of water
1,200
1,000
800
600
400
200
0
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
R2 =

Conclusions:

- Water project operations are not affecting psuedodiaptomus (prey) abundance in July by affecting flows in the lower Sacramento River.
- Pseudodiaptomus densities in the lower Sac. R. have shown a marked decline over the last 20 years.???

explanation

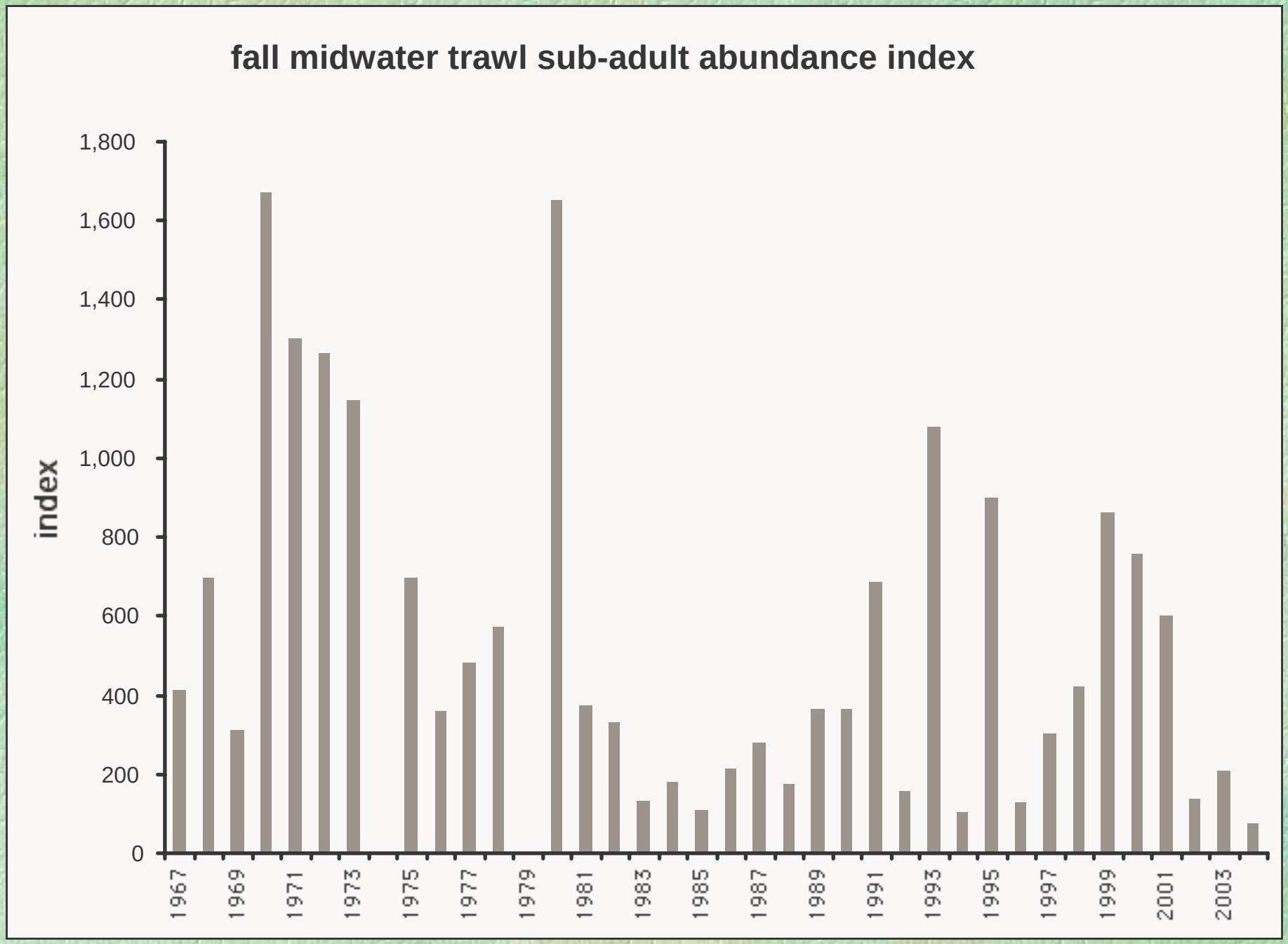
- Smelt that co-occur with prey in July must have co-occurred with prey as larvae and juveniles AND THEN ended up in/near lower Sac. R. in late summer.
- Year-to-year variations in this co-occurrence and in migration would explain lack of relationship between exports and juvenile abundance.

Next steps

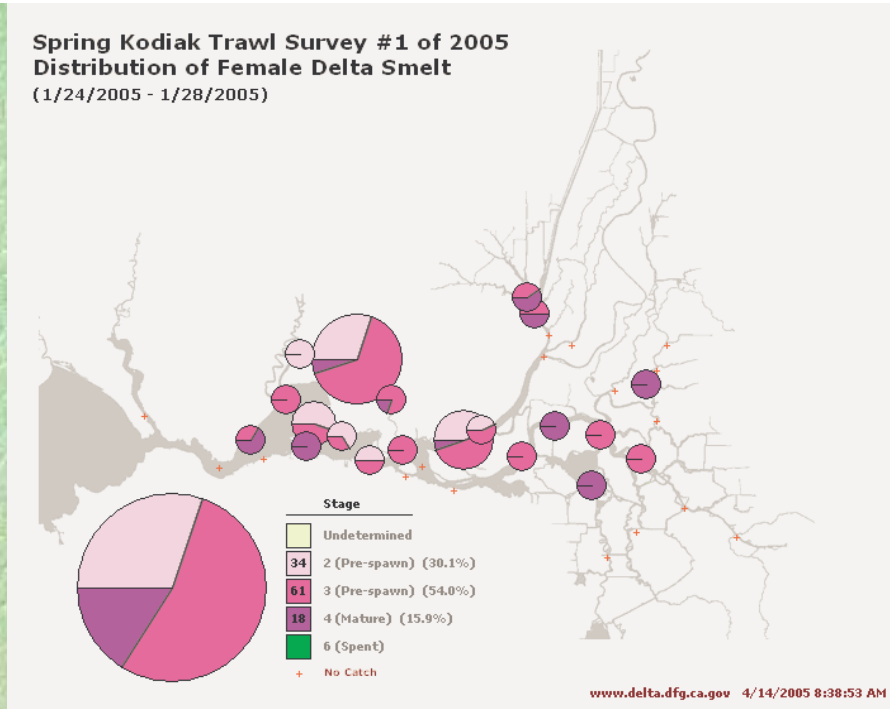
- Bennett lab analysis of origin of smelt in high co-occurrence areas in July
- Analysis of smelt abundance and co-occurrence with prey before July
- Identification of factors affecting prey abundance in areas of co-occurrence

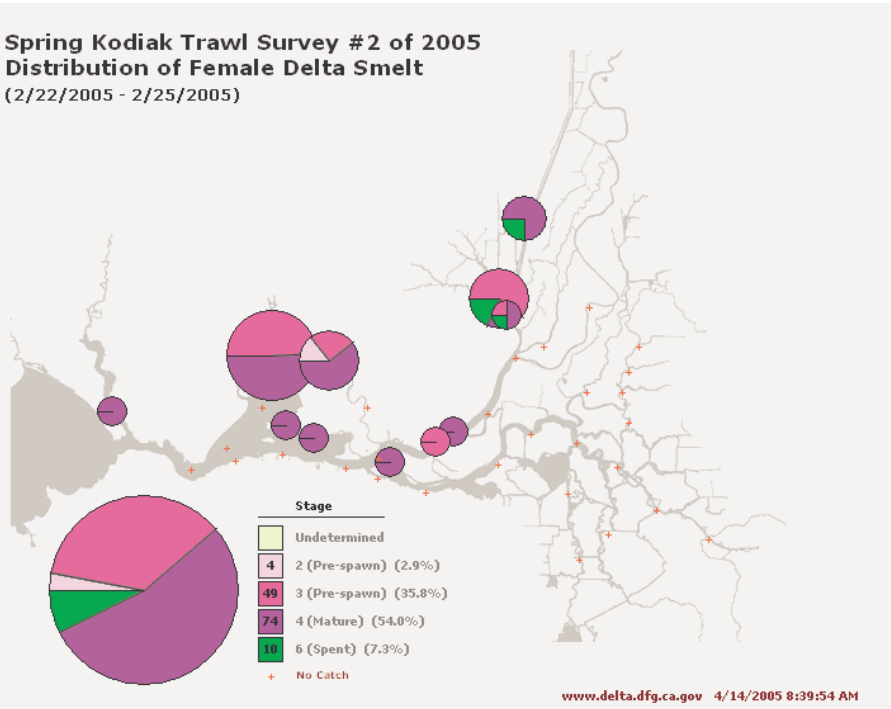
Delta smelt: this year Conclusions:

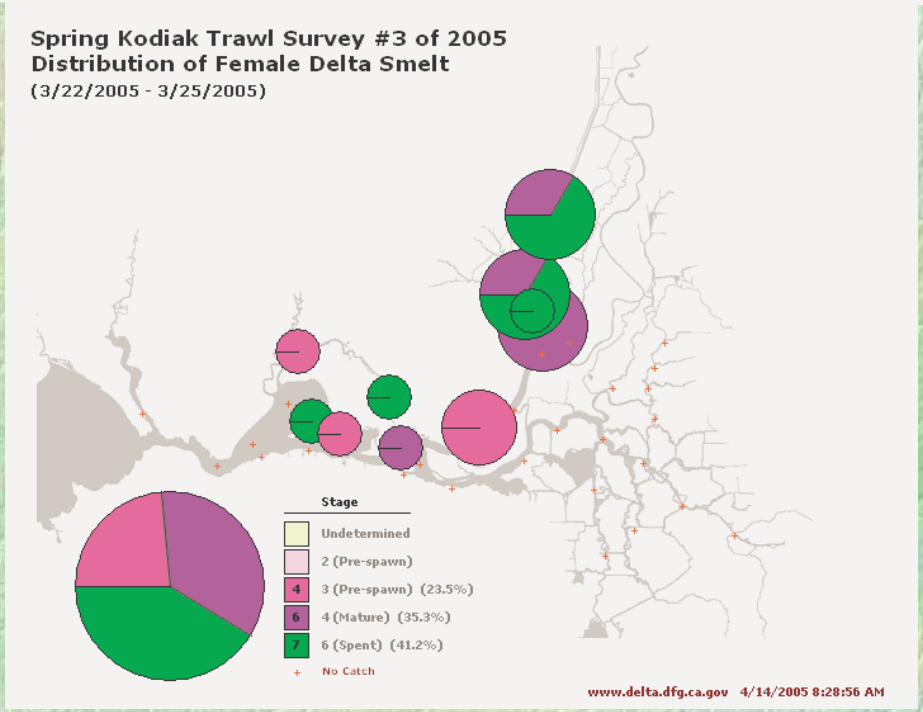
- Distribution of spawning adults and PTM runs: essentially no chance of entrainment, regardless of export rate
- Application of past analysis to this year's situation: exports could be at least 5,000 cfs


fall midwater trawl sub-adult abundance index
index
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003

Adult distribution and PTM runs


Spring Kodiak Trawl Survey #1 of 2005
Distribution of Female Delta Smelt
(1/24/2005 - 1/28/2005)
Stage
Undetermined
34 2 (Pre-spawn) (30.1%)
61 3 (Pre-spawn) (54.0%)
18 4 (Mature) (15.9%)
6 (Spent)
No Catch
www.delta.dfg.ca.gov 4/14/2005 8:38:53 AM

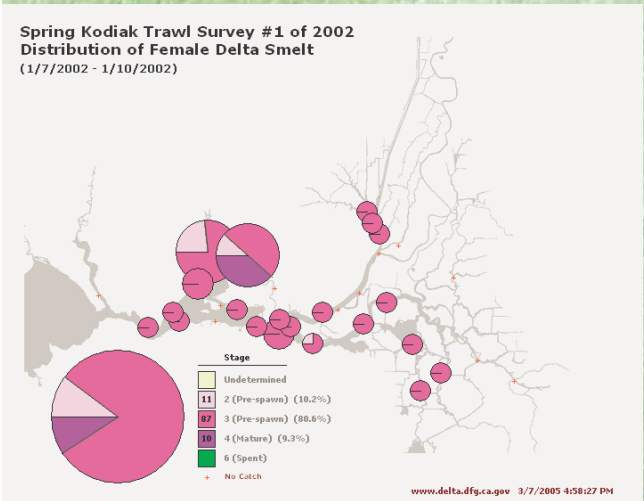

Spring Kodiak Trawl Survey #2 of 2005
Distribution of Female Delta Smelt
(2/22/2005 - 2/25/2005)
Stage
Undetermined
4 2 (Pre-spawn) (2.9%)
49 3 (Pre-spawn) (35.8%)
74 4 (Mature) (54.0%)
10 6 (Spent) (7.3%)
No Catch
www.delta.dfg.ca.gov 4/14/2005 8:39:54 AM

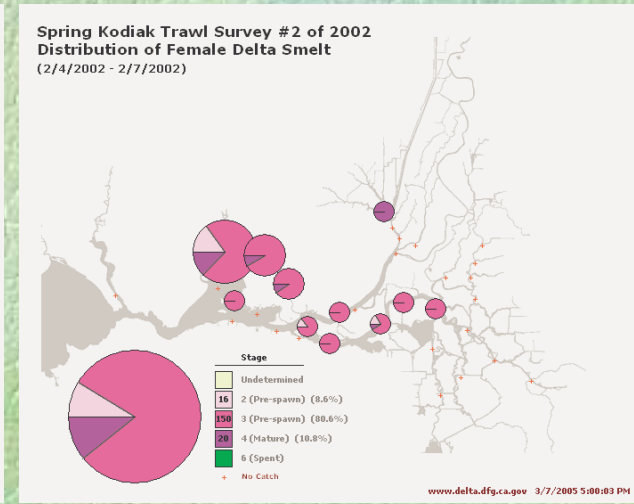

Spring Kodiak Trawl Survey #3 of 2005
Distribution of Female Delta Smelt
(3/22/2005 - 3/25/2005)
Stage
Undetermined
2 (Pre-spawn)
4 3 (Pre-spawn) (23.5%)
6 4 (Mature) (35.3%)
7 6 (Spent) (41.2%)
No Catch
www.delta.dfg.ca.gov 4/14/2005 8:28:56 AM

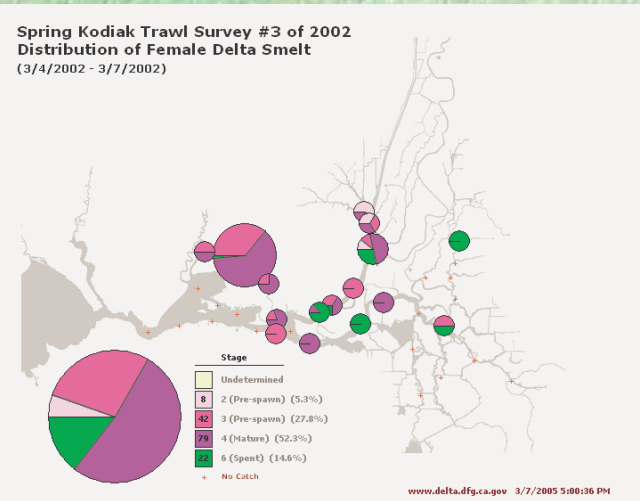
Conclusions:

- Adult smelt are spawning in and downstream of the lower Sacramento River and in the Cache Slough area.
- No spawning adults have been found near the export pumps.

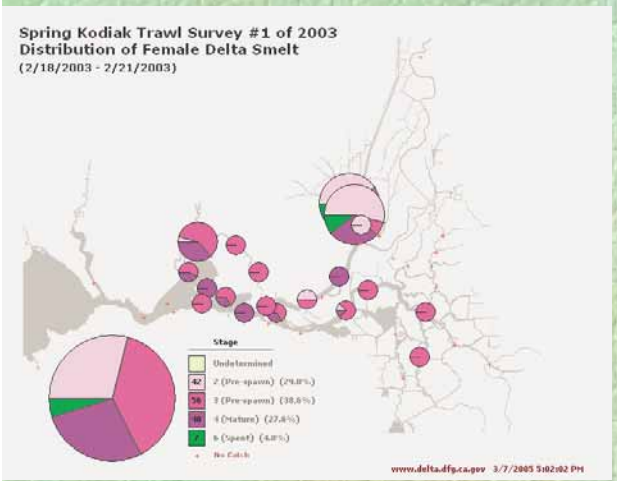
female delta smelt distribution and maturity 2002

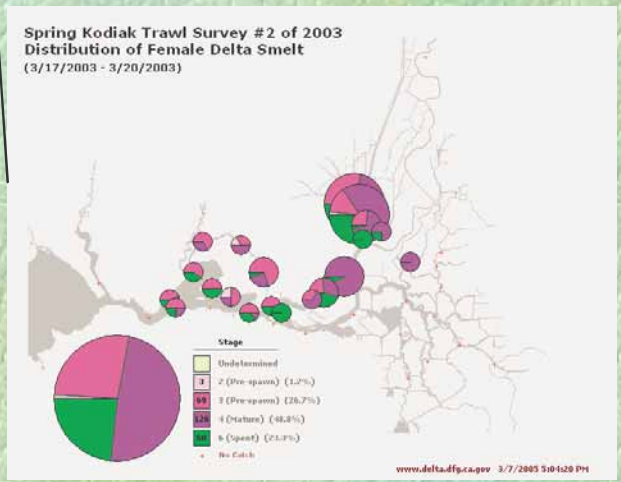


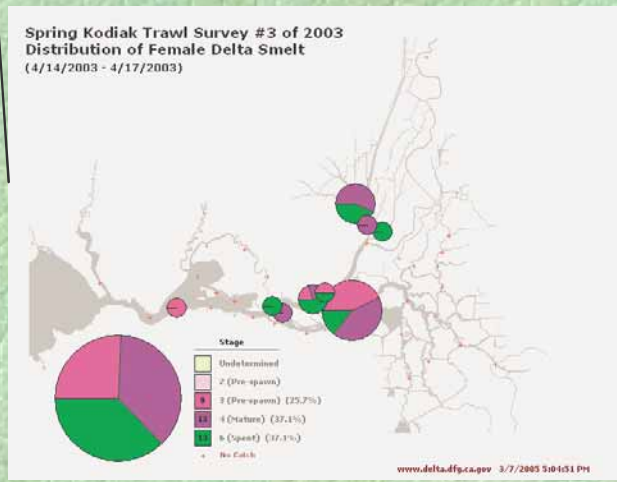


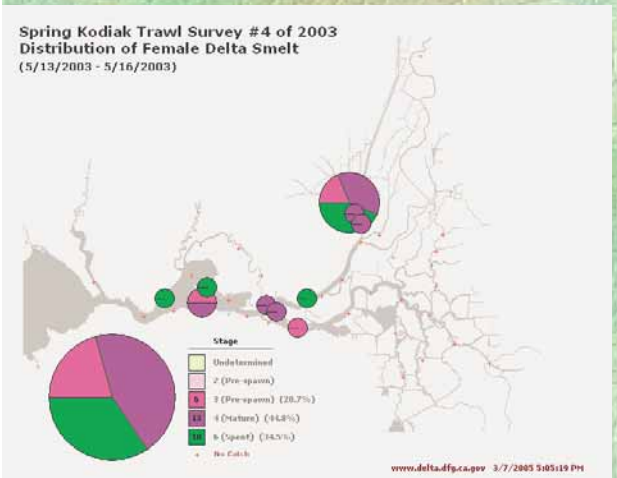


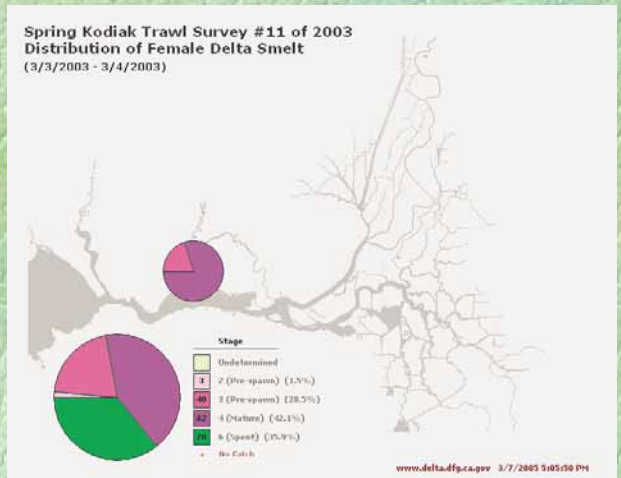
female delta smelt distribution and maturity 2003

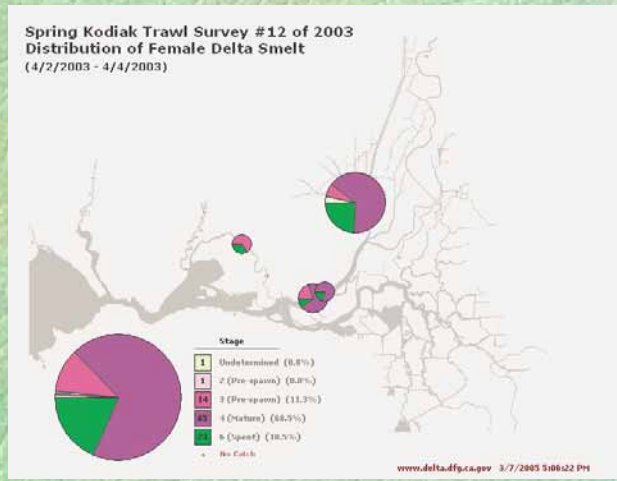




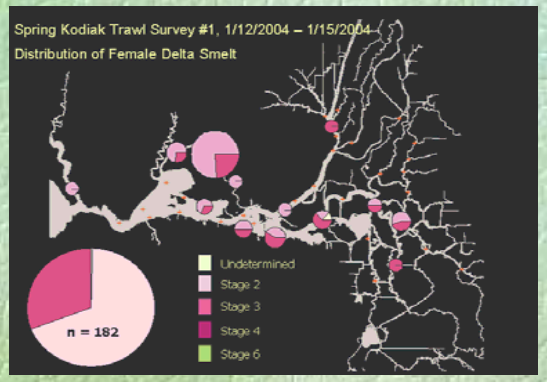


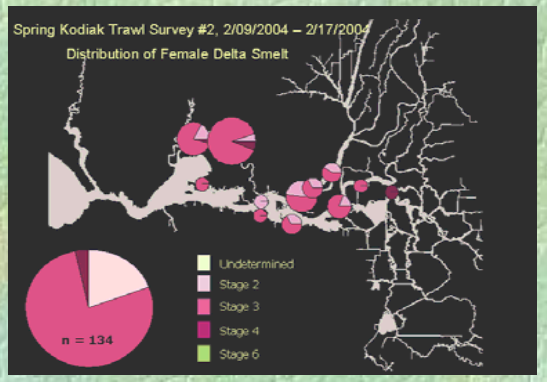


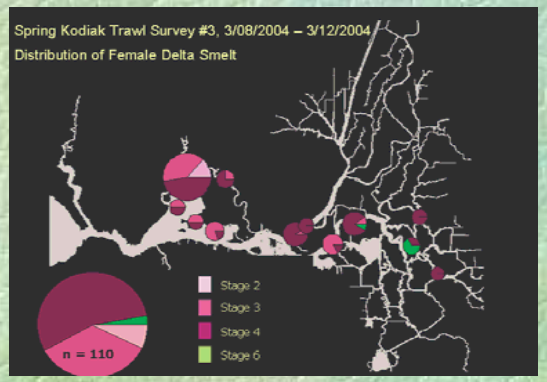


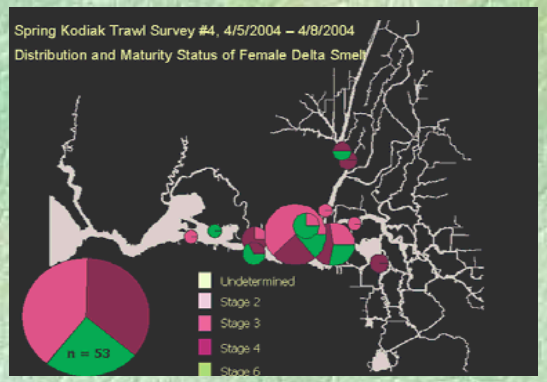


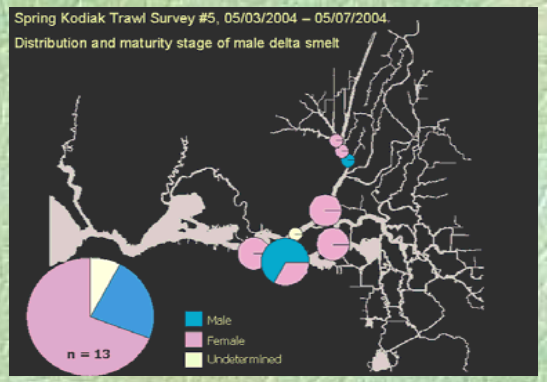
female delta smelt distribution and maturity 2004









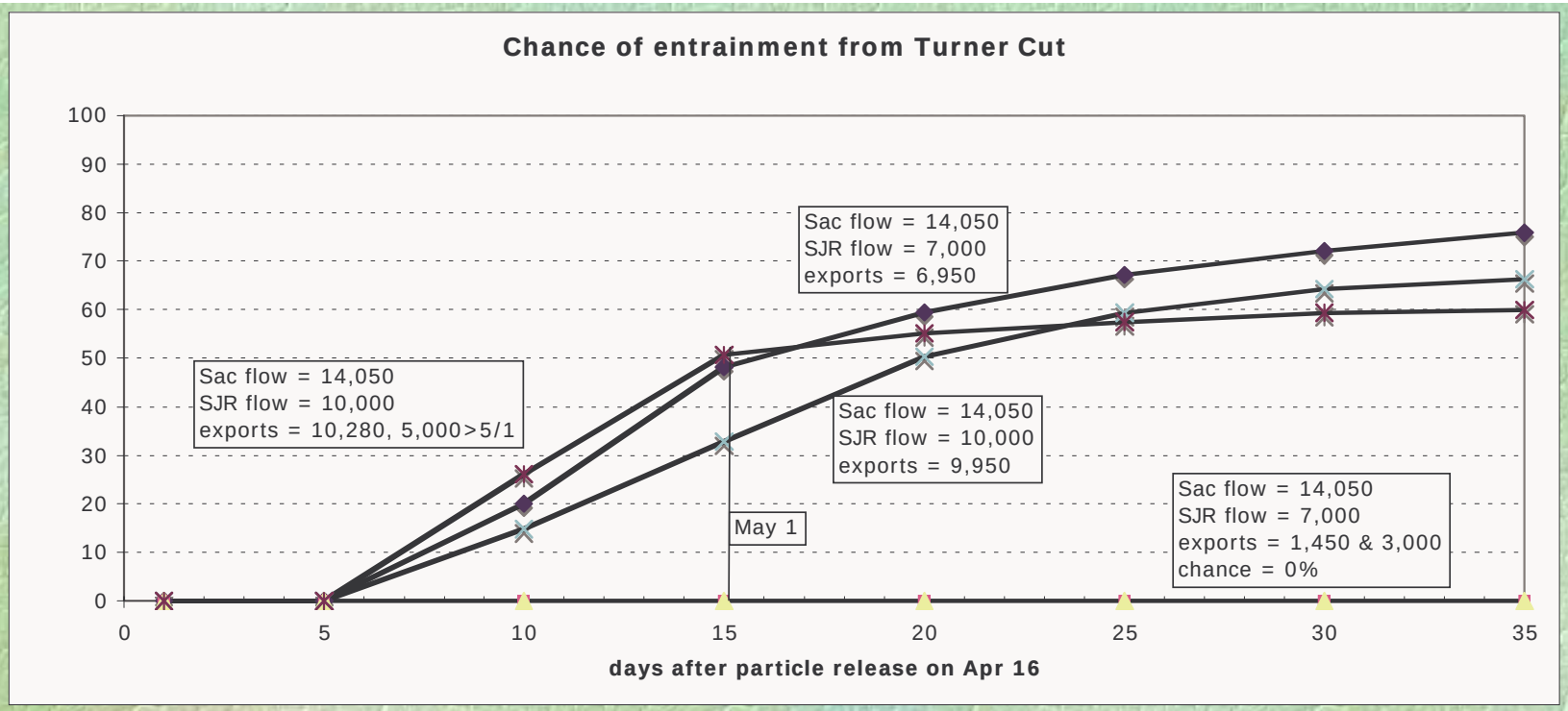


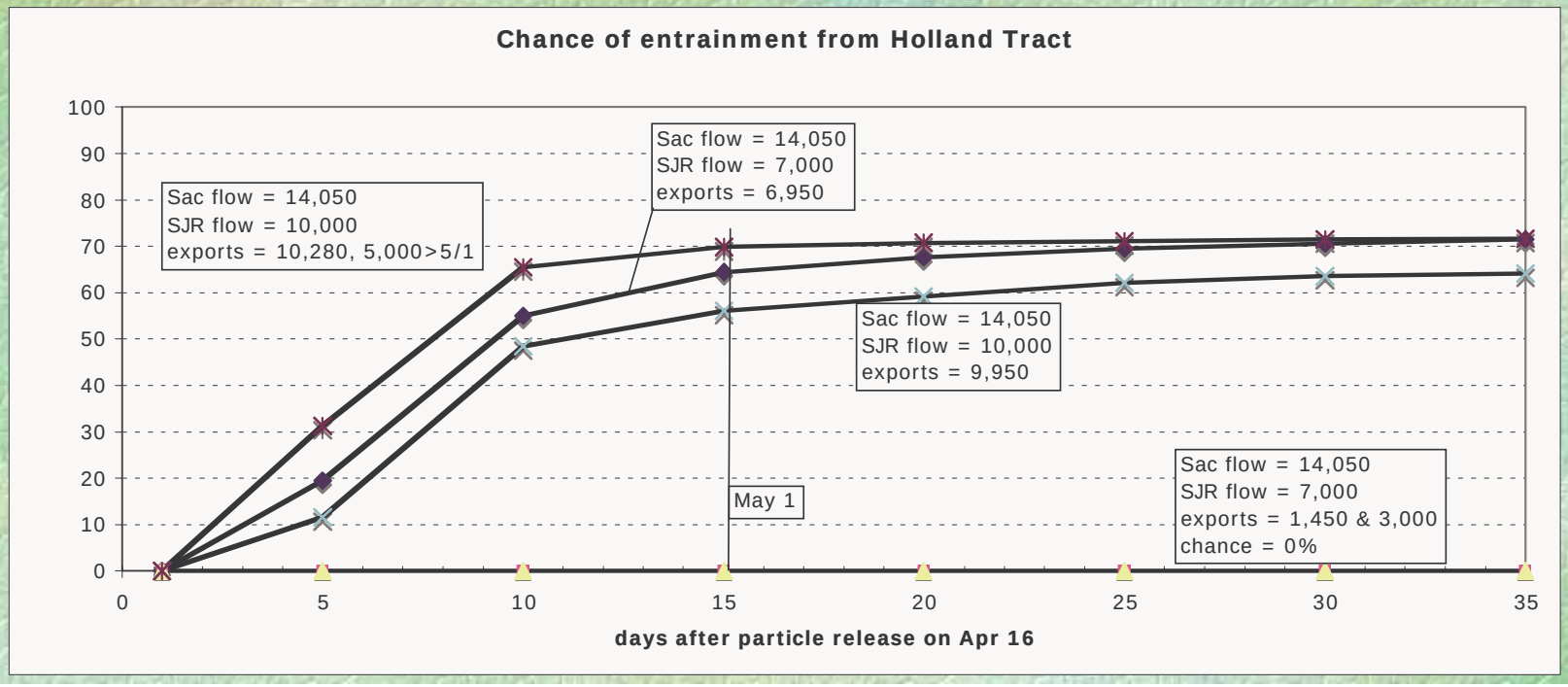
Conclusions:

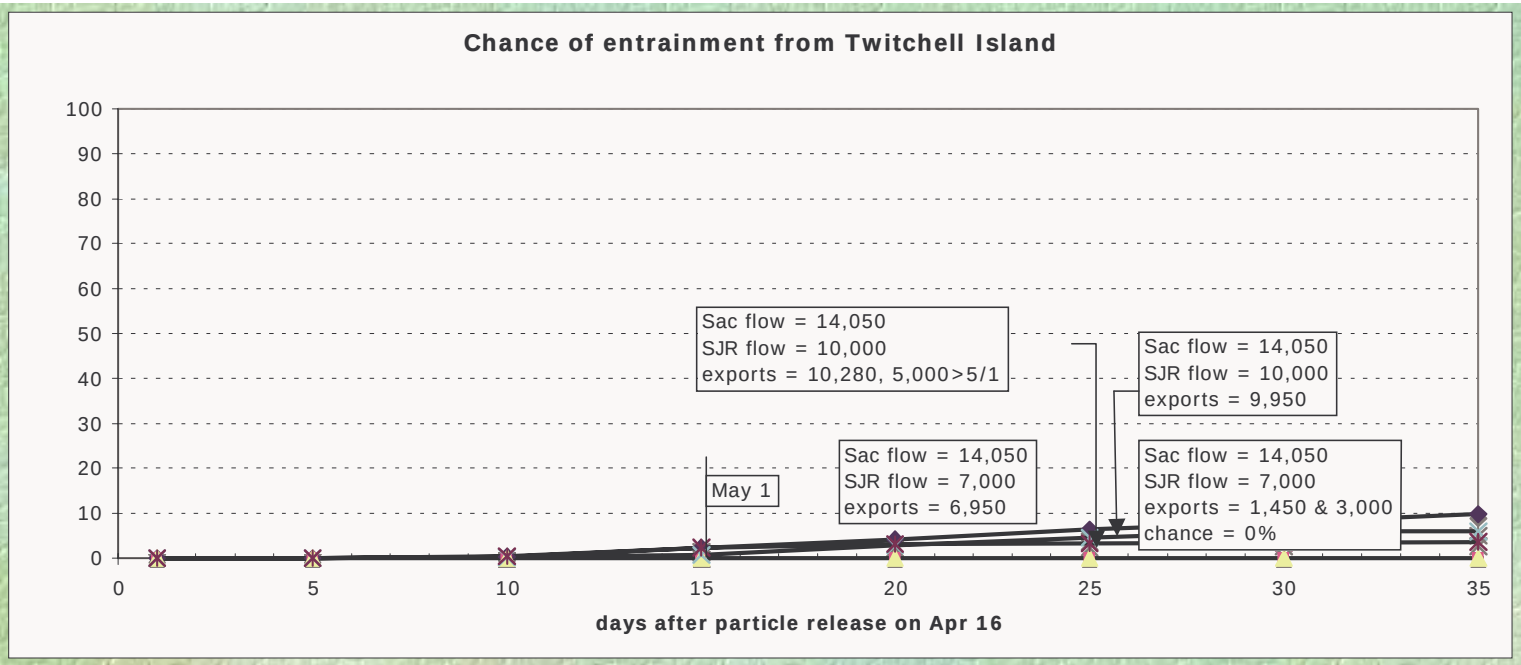
- Past year's adult Kodiak surveys indicate that spawning adults are not likely to occur closer to the export pumps than they are now.
- High flows on the San Joaquin River make subsequent occurrence near the pumps even less likely this year.

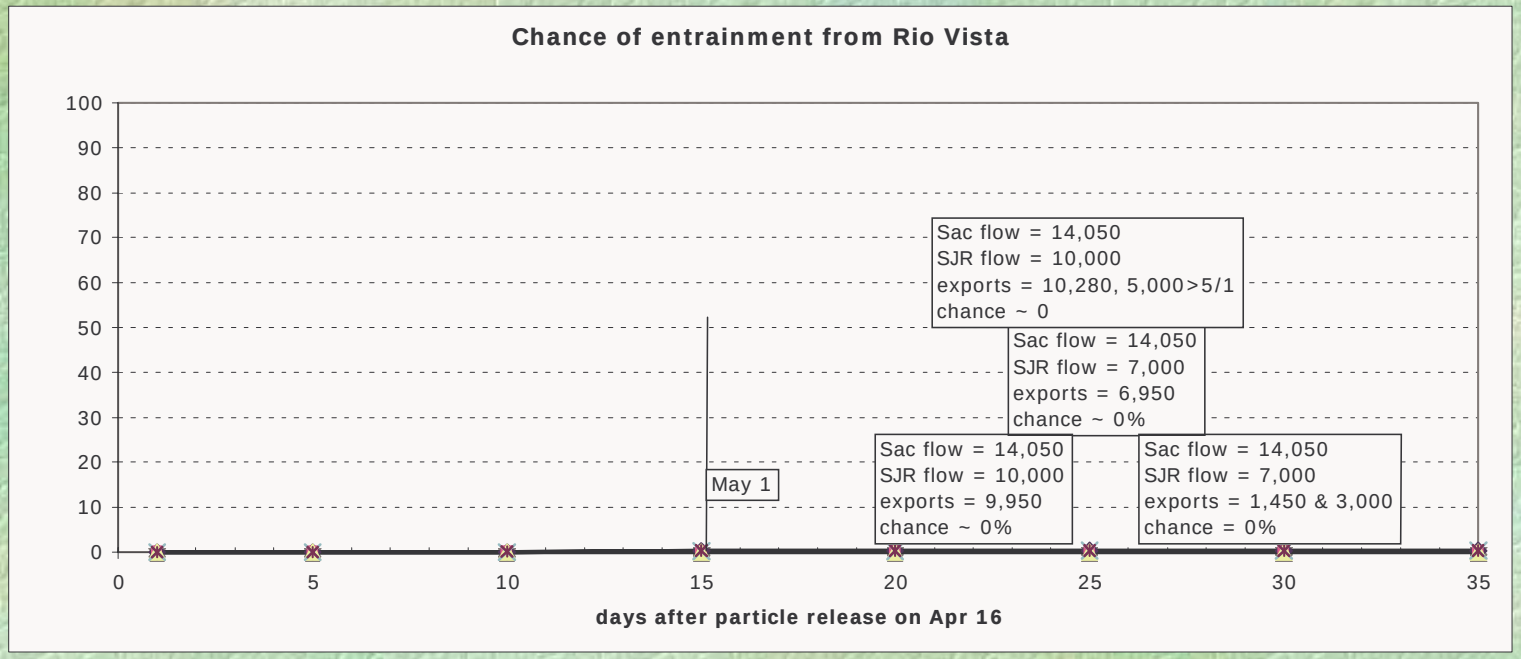
This year's particle tracking model runs

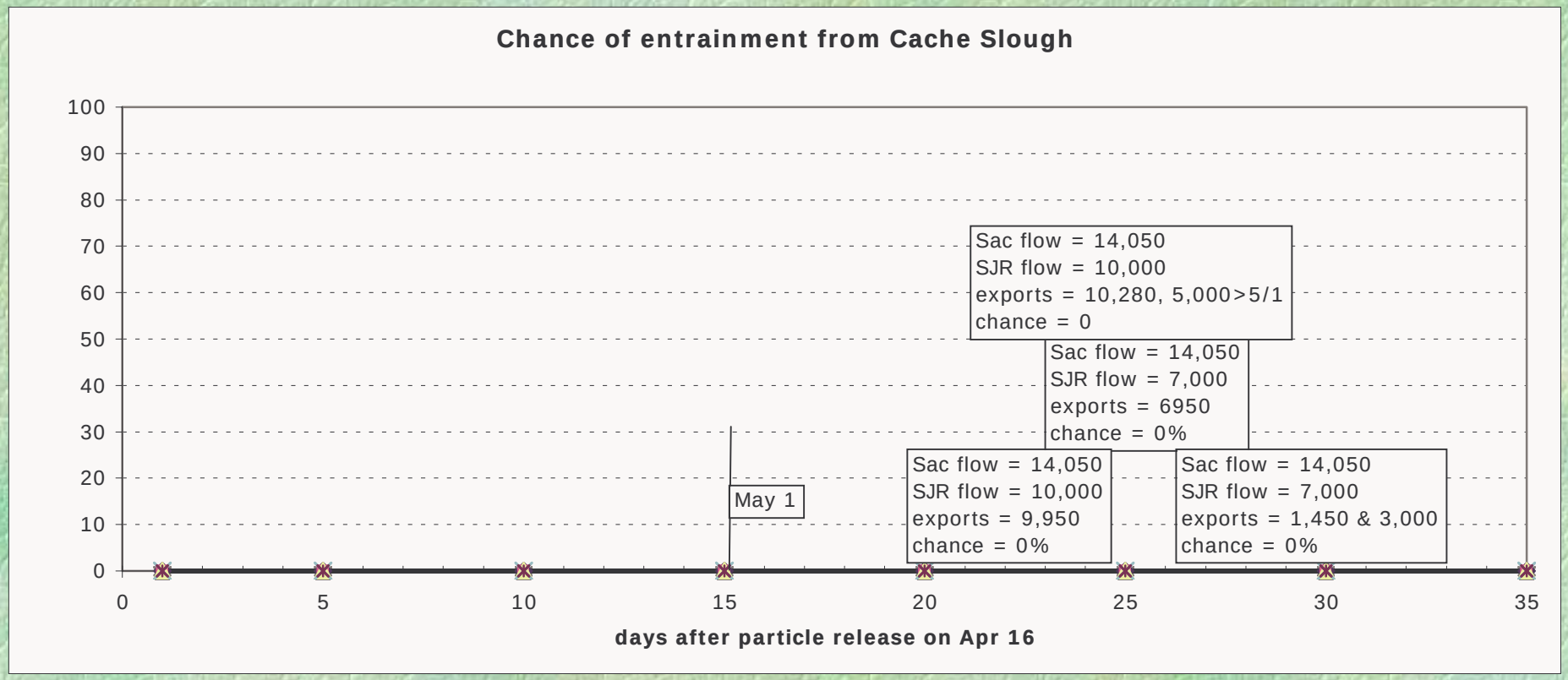
- Results from these runs are plotted on the following graphs.
- Each graph shows the chance of being entrained at the export pumps after a certain number of days from a particular location.
- May 1, this year's likely start date for the VAMP experiment is shown on each graph.


Chance of entrainment from Turner Cut
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
days after particle release on Apr 16
Sac flow = 14,050
SJR flow = 7,000
exports = 6,950
Sac flow = 14,050
SJR flow = 10,000
exports = 10,280, 5,000>5/1
Sac flow = 14,050
SJR flow = 10,000
exports = 9,950
May 1
Sac flow = 14,050
SJR flow = 7,000
exports = 1,450 & 3,000
chance = 0%


Chance of entrainment from Holland Tract
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
days after particle release on Apr 16
Sac flow = 14,050
SJR flow = 7,000
exports = 6,950
Sac flow = 14,050
SJR flow = 10,000
exports = 10,280, 5,000>5/1
Sac flow = 14,050
SJR flow = 10,000
exports = 9,950
May 1
Sac flow = 14,050
SJR flow = 7,000
exports = 1,450 & 3,000
chance = 0%


Chance of entrainment from Twitchell Island
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
days after particle release on Apr 16
May 1
Sac flow = 14,050
SJR flow = 10,000
exports = 10,280, 5,000>5/1
Sac flow = 14,050
SJR flow = 10,000
exports = 9,950
Sac flow = 14,050
SJR flow = 7,000
exports = 6,950
Sac flow = 14,050
SJR flow = 7,000
exports = 1,450 & 3,000
chance = 0%


Chance of entrainment from Rio Vista
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
days after particle release on Apr 16
May 1
Sac flow = 14,050
SJR flow = 10,000
exports = 10,280, 5,000>5/1
chance ~ 0
Sac flow = 14,050
SJR flow = 7,000
exports = 6,950
chance ~ 0%
Sac flow = 14,050
SJR flow = 10,000
exports = 9,950
chance ~ 0%
Sac flow = 14,050
SJR flow = 7,000
exports = 1,450 & 3,000
chance = 0%


Chance of entrainment from Cache Slough
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
days after particle release on Apr 16
May 1
Sac flow = 14,050
SJR flow = 10,000
exports = 10,280, 5,000>5/1
chance = 0
Sac flow = 14,050
SJR flow = 7,000
exports = 6950
chance = 0%
Sac flow = 14,050
SJR flow = 10,000
exports = 9,950
chance = 0%
Sac flow = 14,050
SJR flow = 7,000
exports = 1,450 & 3,000
chance = 0%

Conclusions:

- Essentially all smelt spawned west of Twitchell Island
- Past year's data indicate adults don't migrate upstream
- PTM runs indicate:
  - Almost no chance of entrainment from Twitchell
  - No chance of entrainment from locations where most spawning is occurring
  - Regardless of export rates and river flows

Application of past analysis

Estimating % juvenile entrainment

- Used data from 20 mm surveys, 1995-2004
- Estimated distribution of smelt from 20 mm surveys
- Estimated entrainment from PTM data
- Accounted for fraction hatched using temp

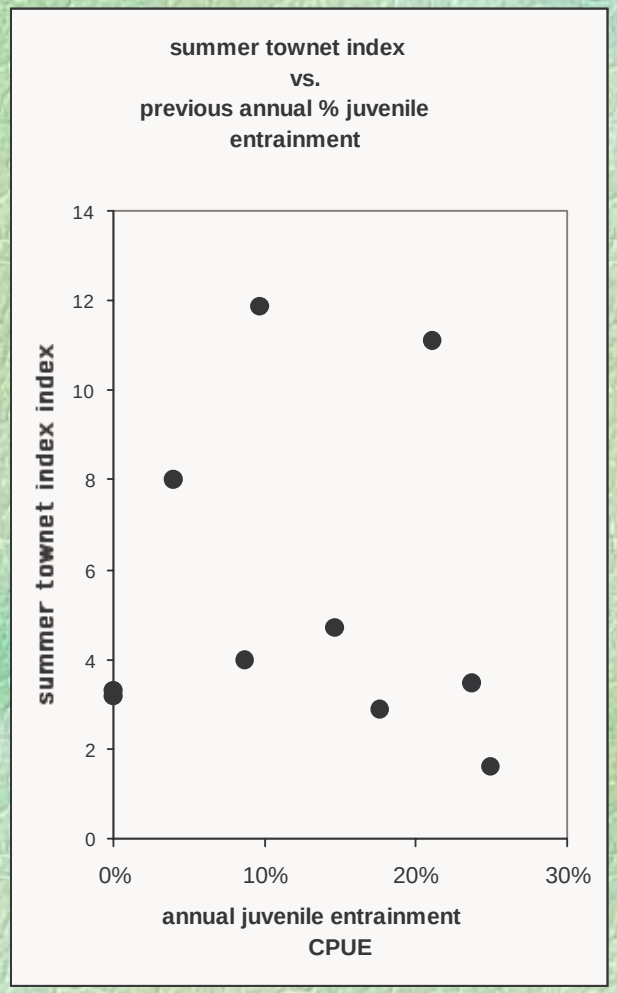
annual juvenile delta smelt entrainment

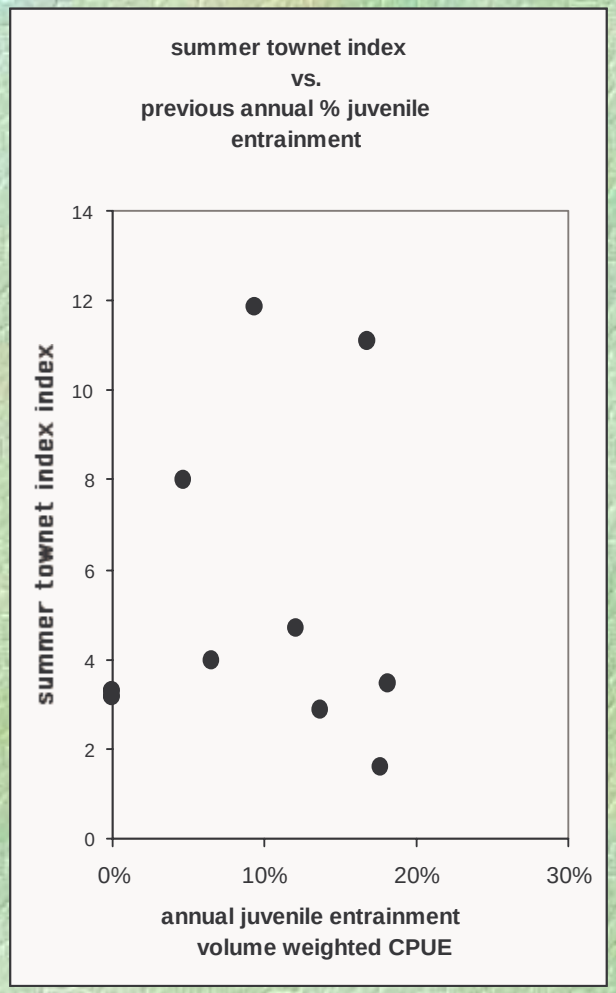
year	% population entrained		
	avg cpue	avg cpue*vol wtg factor	avg cpue* area wtg factor
1995	0%	0%	0%
1996	21%	17%	18%
1997	9%	7%	6%
1998	0%	0%	0%
1999	10%	9%	9%
2000	4%	5%	5%
2001	24%	18%	17%
2002	15%	12%	13%
2003	25%	18%	17%
2004	18%	14%	15%

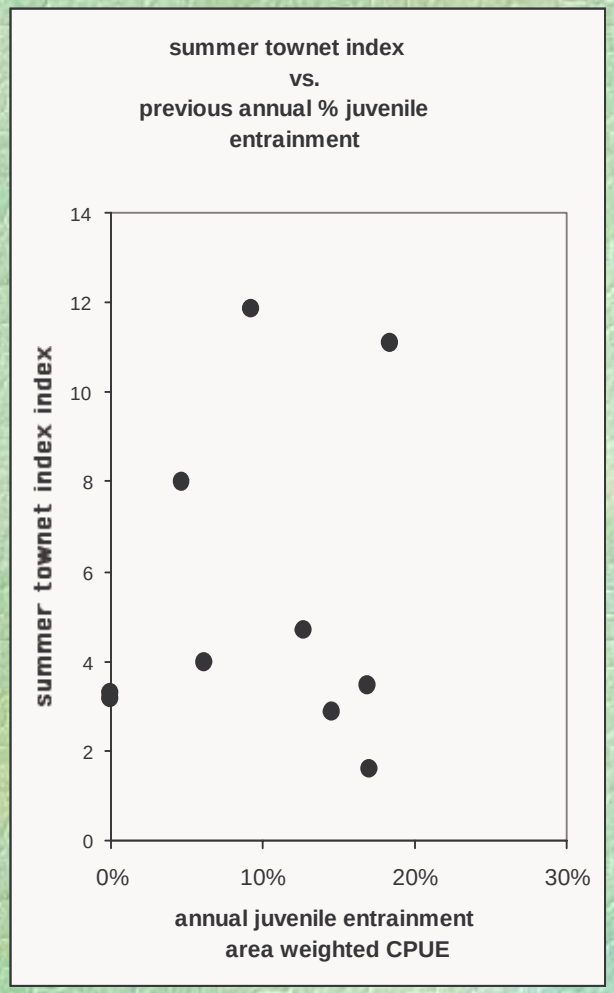
Does % juvenile entrainment affect subsequent abundance?

- No apparent relationship with subsequent juvenile abundance (summer townet survey)
- No apparent relationship with subsequent sub-adult abundance (fall midwater trawl survey)
- Suggest that target % juvenile entrainment should be 20% or less.

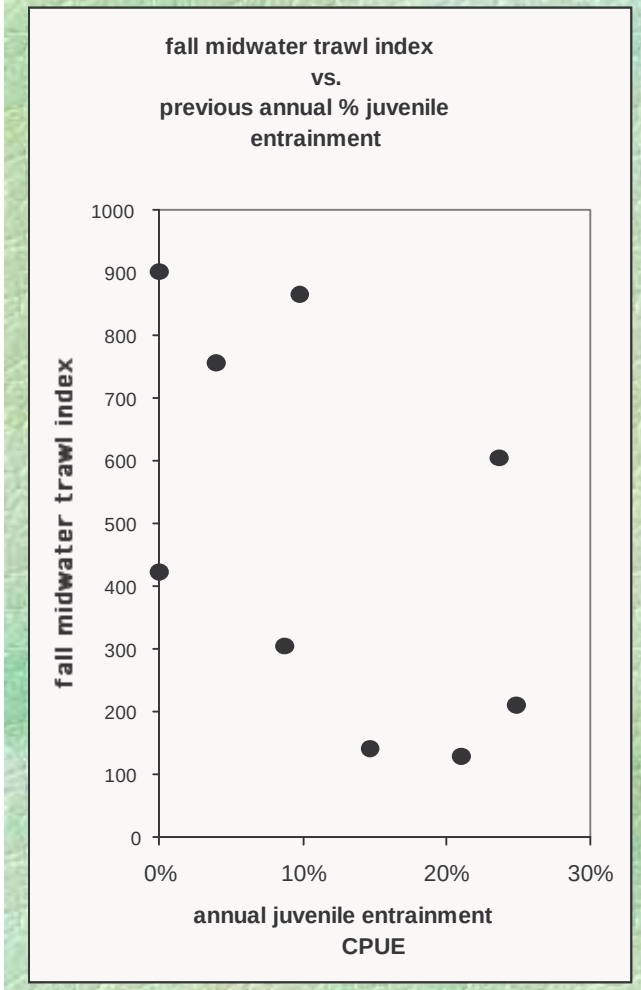
These three graphs differ only as to whether and how the catch per unit effort at each station in the 20 mm survey data are weighted by station water volume or water surface area.

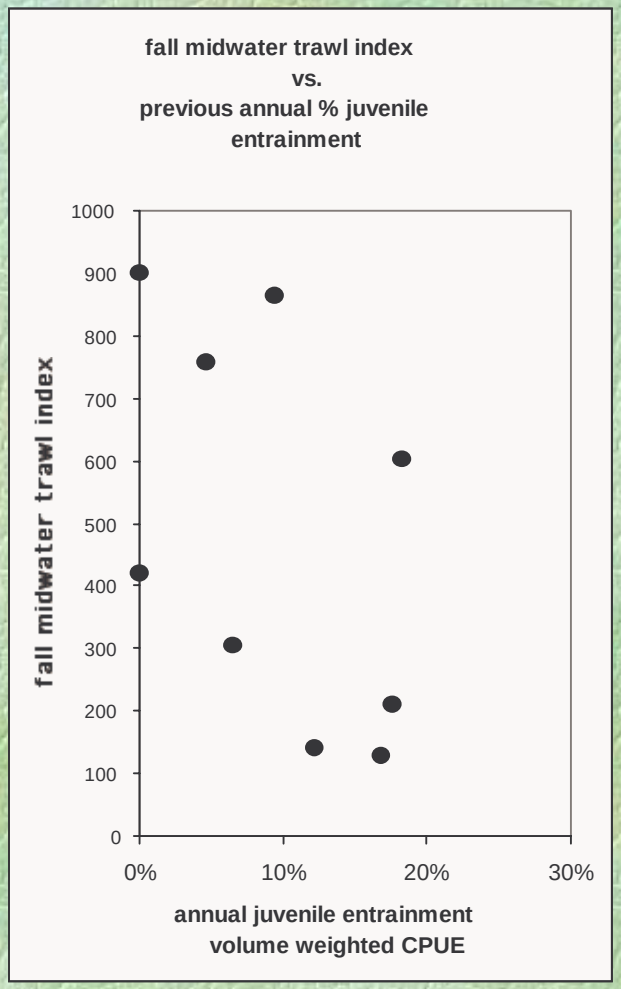


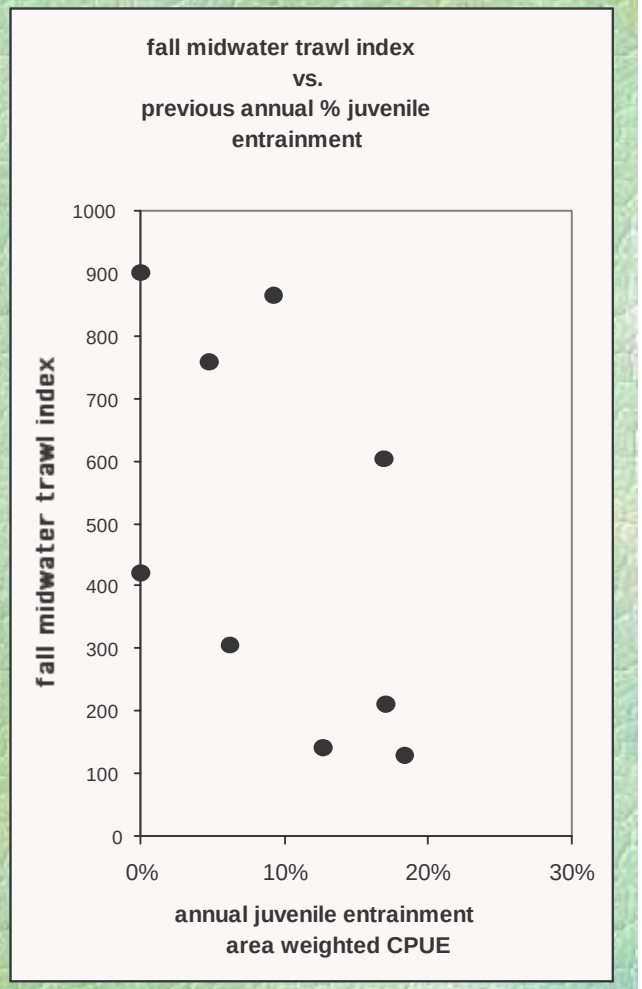




These three graphs differ only as to whether and how the catch per unit effort at each station in the 20 mm survey data are weighted by station water volume or water surface area.



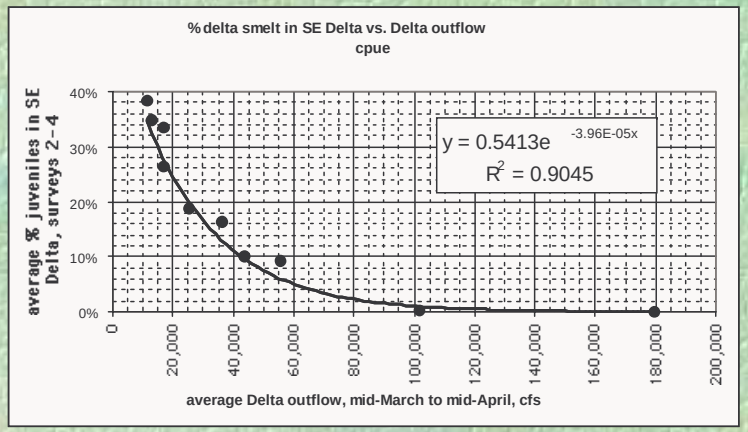


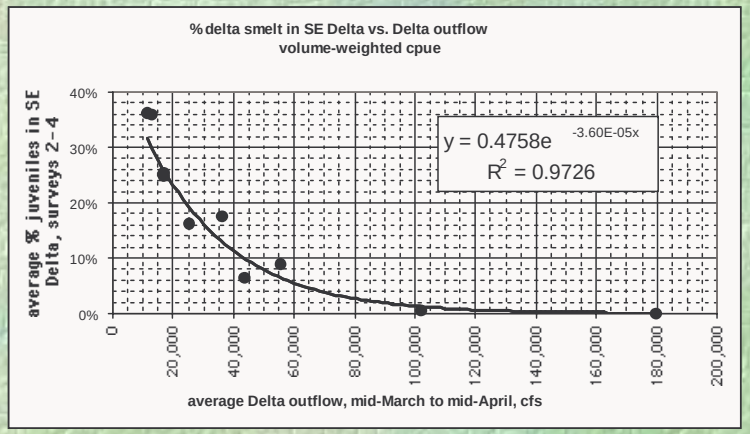


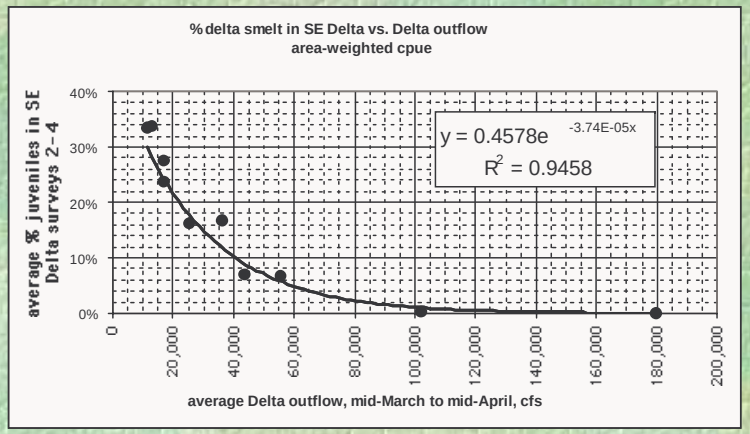
Predicting % juvenile entrainment

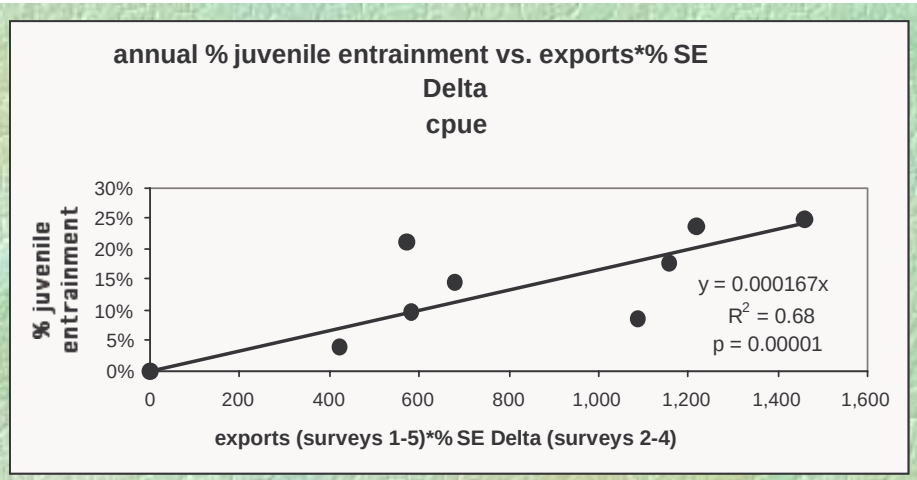
- % juvenile entrainment depends on two factors:
  - % of juveniles near the export pumps
  - Export rate
- % juveniles near pumps depends on Delta outflow
- % juvenile entrainment depends on product of % near pumps and export rate

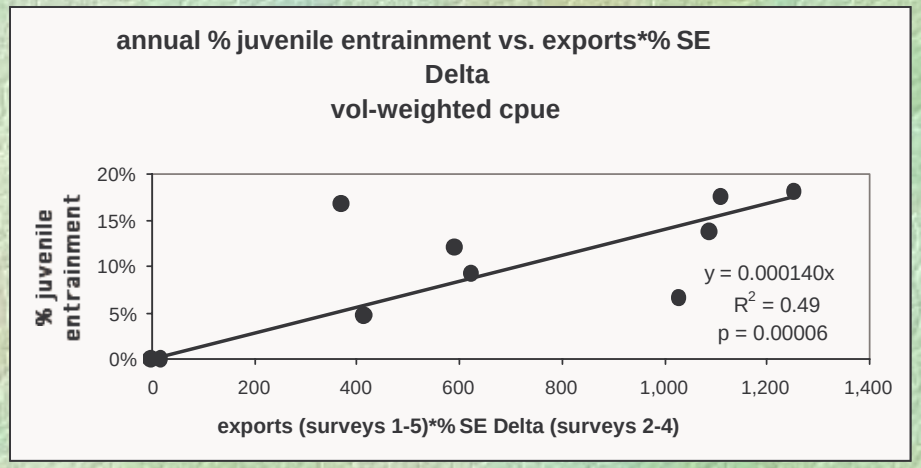
Percentage of total delta smelt in the southeastern Delta vs. export rate

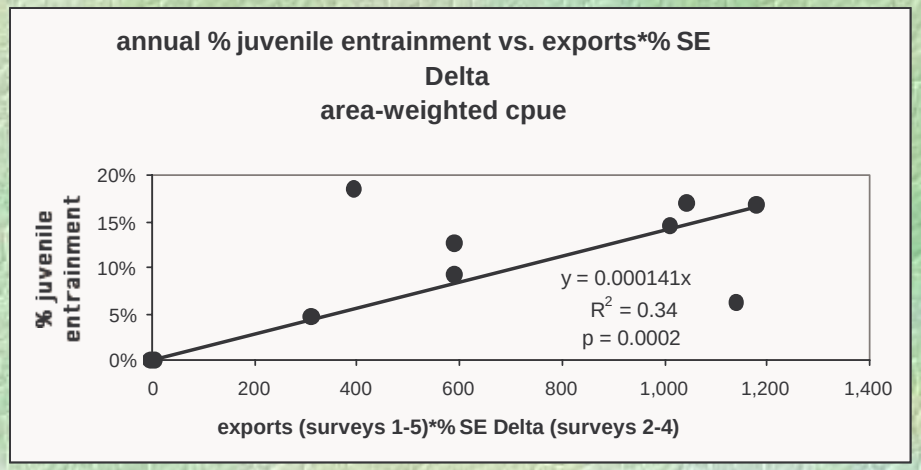







annual % juvenile entrainment vs. exports*% SE Delta
cpue
% juvenile entrainment
30%
25%
20%
15%
10%
5%
0%
0
200
400
600
800
1,000
1,200
1,400
1,600
y = 0.000167x
R2 = 0.68
p = 0.00001
exports (surveys 1-5)*% SE Delta (surveys 2-4)


annual % juvenile entrainment vs. exports*% SE Delta
vol-weighted cpue
% juvenile entrainment
20%
15%
10%
5%
0%
0
200
400
600
800
1,000
1,200
1,400
y = 0.000140x
R2 = 0.49
p = 0.00006
exports (surveys 1-5)*% SE Delta (surveys 2-4)


annual % juvenile entrainment vs. exports*% SE Delta
area-weighted cpue
% juvenile entrainment
20%
15%
10%
5%
0%
0
200
400
600
800
1,000
1,200
1,400
y = 0.000141x
R2 = 0.34
p = 0.0002
exports (surveys 1-5)*% SE Delta (surveys 2-4)

Current data

- Delta outflow: 3/15 to 4/13 = 38,827 cfs average
- % smelt southeast Delta = 12% (conservative because of relatively high SJR flows)
- Target exports for 1st five surveys depends on target % juvenile entrainment (recall, no correlation between % entrained and either STN or FMWT)

Target exports for Apr-May

target % juvenile entrainment	target export rate cfs
5%	2,500
10%	5,000
15%	7,500
20%	10,000

Delta smelt conclusion:

- By two methods, export rates before and during VAMP could be at least 5,000 cfs without any measurable effect on juvenile or sub-adult smelt populations.

Salmon and VAMP exports

- Higher exports during VAMP (even higher than 3,000 cfs) has two benefits:
  - More likely to show export effect if such an effect exists
  - Probably improves smolt survival

Background

- No correlation between export rate and smolt survival has been found in VAMP experiments
- Correlation between flow and survival has been shown
- Use of the ratio of flow to exports is misleading
- Survival in SJR is 15% or less, 30% for fish entrained at Tracy, ? for un-entrained smolts in Old River.

The ratio of flow to exports

- Has been used for years
- Survival vs. flow correlation drives the survival vs. ratio correlation
- The ratio of flow to any factor unrelated to survival would likely produce a correlation between survival and the ratio.
- Flow and exports can and should be separated; if so, no export effect found yet

Exports and smolt survival

- No effect found yet
- Two possibilities
  - There is no measurable effect
  - There is an effect, but it cannot be detected because exports are always so low.

The VAMP experiment

- Supposed to be an adaptive management experiment
- Already have a relationship between survival and river flow
- Need higher export experiment to see if export effect can be detected
- Do not need a high flow-low export experiment unless you believe in the ratio

Entrainment at Tracy is good for smolts

- SJR survival 15% or less
- Tracy PP survival is about 30%, assuming:
  - 15% pre-screen predation
  - 70% screening efficiency
  - 50% trucking/handling loss
- Therefore, unless un-entrained Old River smolt survival is substantially less than 15%, high pumping and entrainment at Tracy PP will improve survival
- Banks: pre-screen predation is too high.

General conclusion

- Export rates in the pre-VAMP and VAMP periods could be at least 5,000 cfs
- No significant effect on smelt
- Probable benefits for smolts (Tracy, not Banks)
- Produces valuable VAMP data