SWRCB POD workshop

presentation

by

The San Luis and Delta-Mendota Water Authority

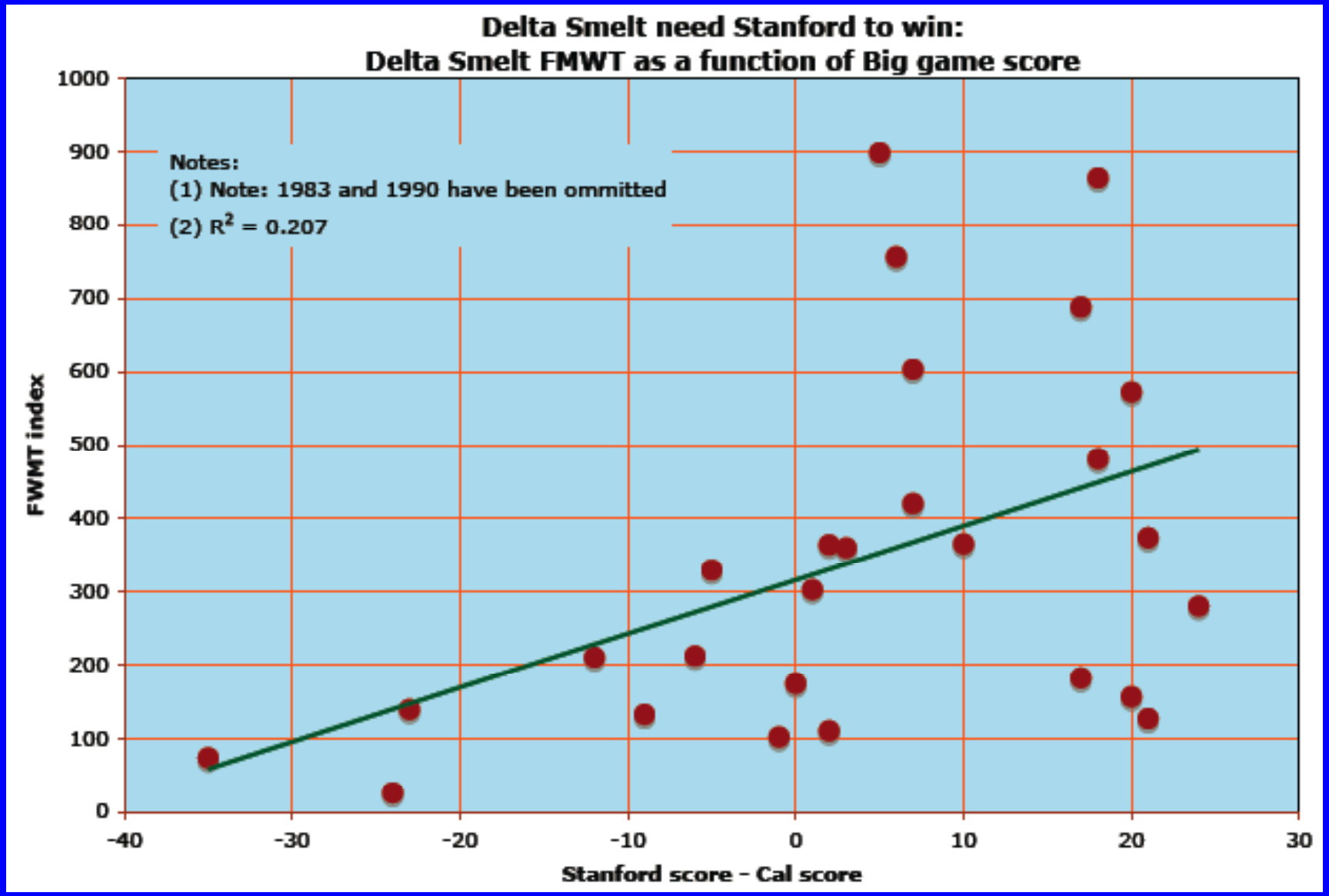
Dr. B. J. Miller, P.E.
Consulting Engineer

Conclusions

- Despite extensive analysis by many analysts, no evidence that exports have important effects on abundance of delta smelt
- No evidence supporting additional requirements on exports to protect delta smelt
- Considerable evidence that smelt decline caused by food limitation in Summer

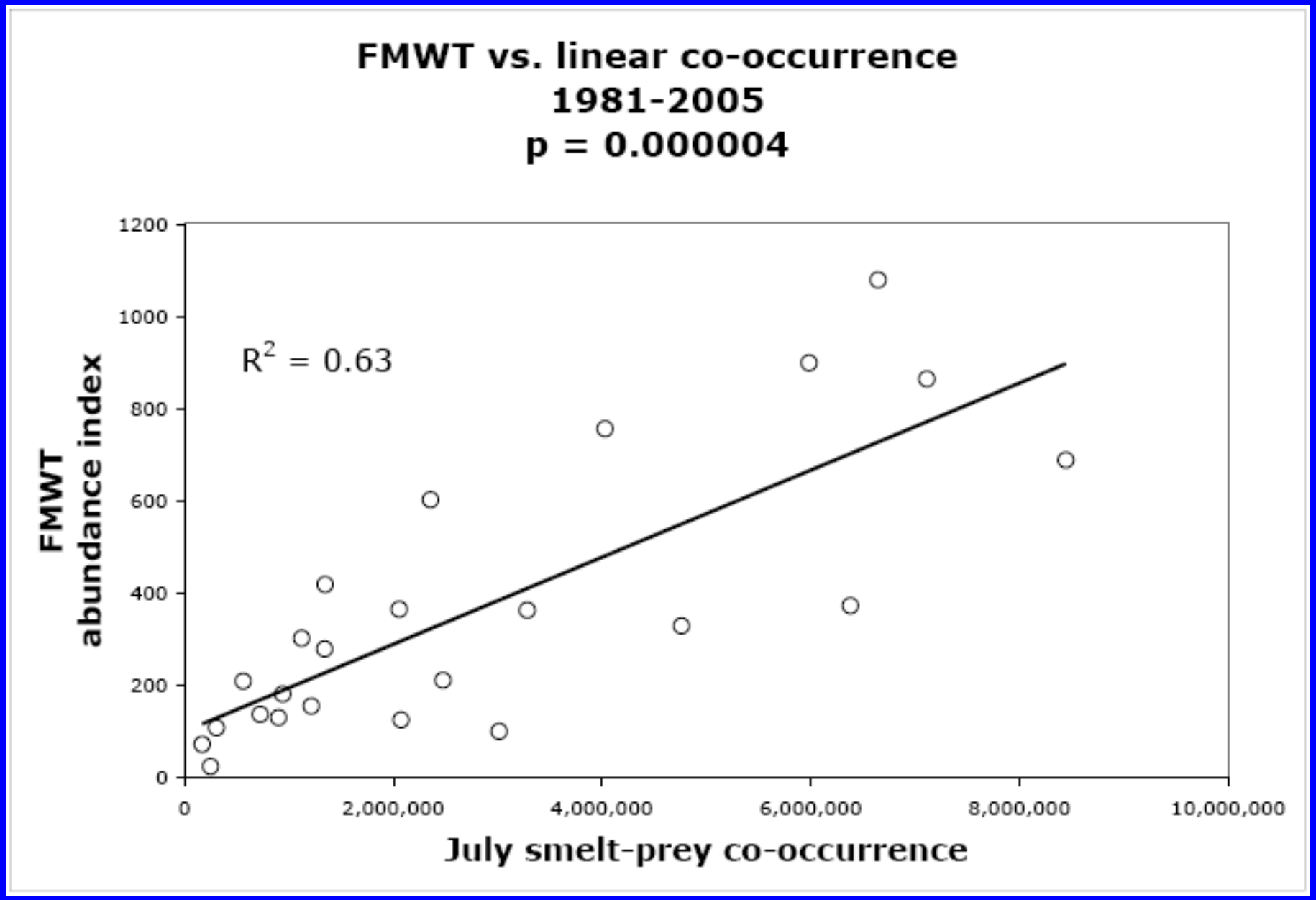
A word about correlations

- Correlation does not necessarily mean cause and effect
- However, if there is good reason to suspect cause and effect, correlation can indicate so
- Lack of correlation means either:
  - Incomplete analysis
  - No cause and effect (good analysis, no correlation)
- So, if strongly believe cause and effect and conduct a careful, comprehensive analysis and find no correlation, then no cause and effect, especially if there is a plausible explanation for no cause and effect


Delta Smelt need Stanford to win:
Delta Smelt FMWT as a function of Big game score
Notes:
(1) Note: 1983 and 1990 have been ommitted
(2) R2 = 0.207
FWMT index
1000
900
800
700
600
500
400
300
200
100
0
-40
-30
-20
-10
0
10
20
30
Stanford score - Cal score

A word about correlations

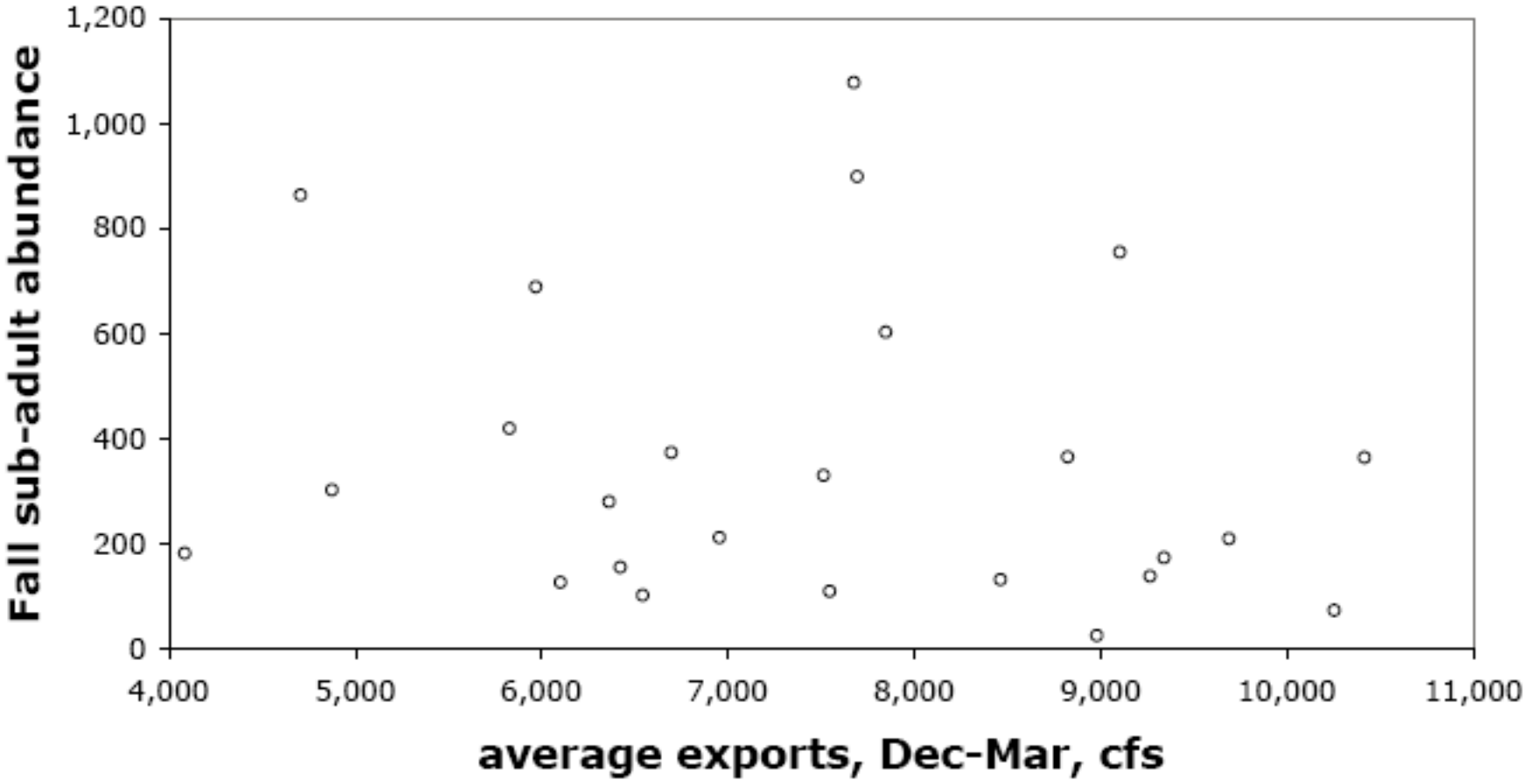
- Correlation does not necessarily mean cause and effect
- However, if there is good reason to suspect cause and effect, correlation can indicate so
- Lack of correlation means either:
  - Wrong analysis
  - No cause and effect (good search, no correlation
- So, if strongly believe cause and effect and conduct a good search and find no correlation, then no cause and effect, especially if there is a plausible explanation for no cause and effect


FMWT vs. linear co-occurrence
1981-2005
p = 0.000004
FMWT abundance index
July smelt-prey co-occurrence
R2 = 0.63
0
200
400
600
800
1000
1200
0
2,000,000
4,000,000
6,000,000
8,000,000
10,000,000

A word about correlations

- Correlation does not necessarily mean cause and effect
- However, if there is good reason to suspect cause and effect, correlation can indicate so
- Lack of correlation means either:
  - Wrong analysis
  - No cause and effect (good search, no correlation)
- So, if strongly believe cause and effect and conduct a good search and find no correlation, then no cause and effect, especially if there is a plausible explanation for no cause and effect

Fall delta smelt abundance vs. preceding Dec-Mar exports 1981-2005



A word about correlations

- Correlation does not necessarily mean cause and effect
- However, if there is good reason to suspect cause and effect, correlation can indicate so
- Lack of correlation means either:
  - Wrong analysis
  - No cause and effect (good search, no correlation
- So, if strongly believe cause and effect and conduct a good search and find no correlation, then no cause and effect, especially if there is a plausible explanation for no cause and effect

POD = Pelagic Organism Decline

- Initial idea - recent ecosystem-wide decline of pelagic (open water) organisms in the Bay/Delta system beginning in 2000

Second look at POD

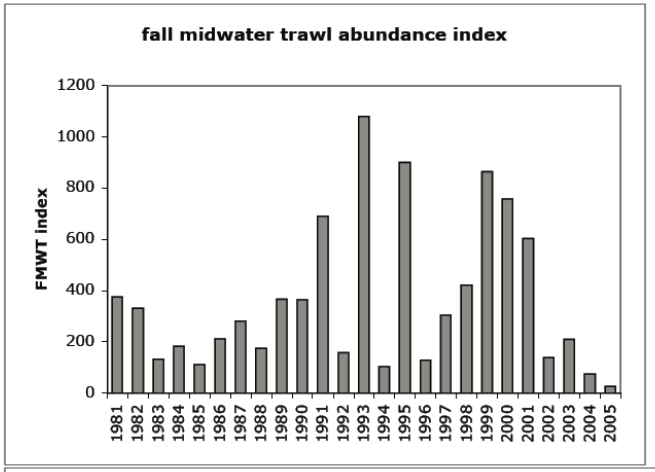
- No evidence of recent system-wide decline in phytoplankton and bacteria at the base of the pelagic food web
- Initial impressions of system-wide decline in zooplankton based on incorrect data
- Bay Survey data for San Francisco Bay fish did not show general declines

Current status of POD

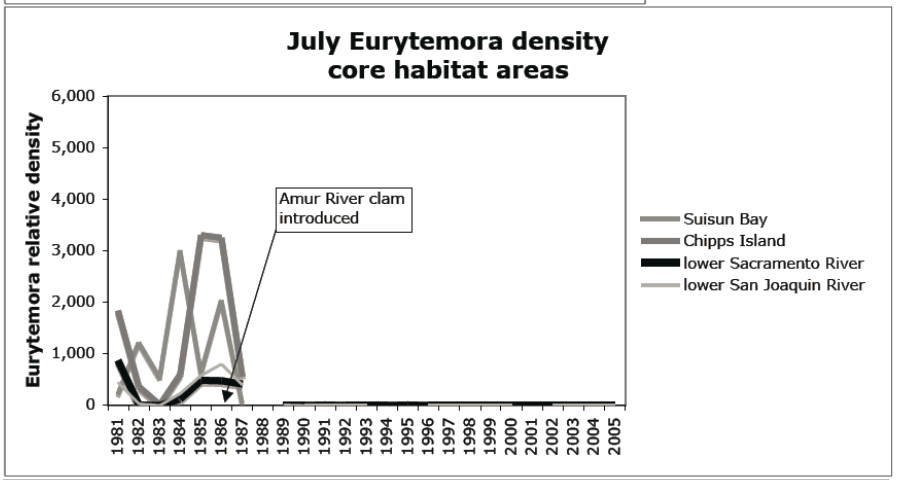
- declining abundance of four fish species in the Fall Midwater Trawl (FMWT) survey:
  - delta smelt
  - juvenile striped bass
  - longfin smelt
  - threadfin shad

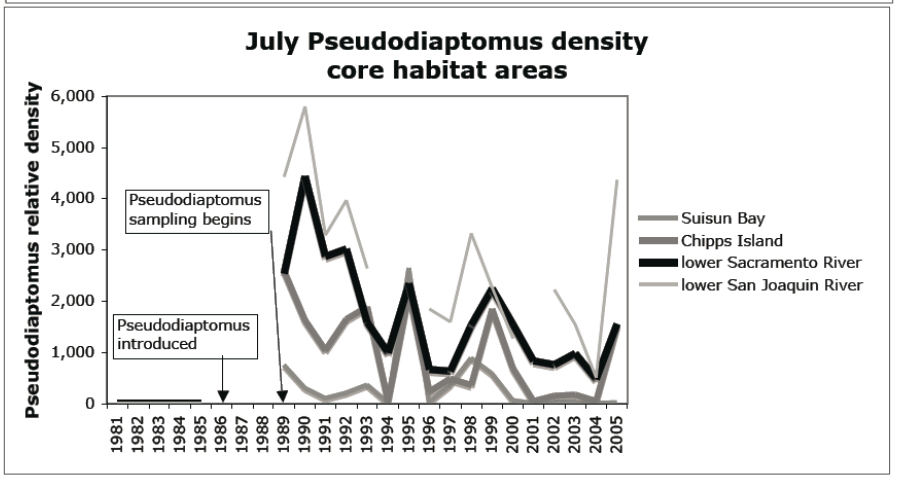
Delta smelt

- Listed as threatened under ESA
- Should be main focus of POD effort
- Abundance of zooplankton food *Eurytemora* and *Pseudodiaptomus* has declined in core delta smelt summer habitat near Sacramento/San Joaquin confluence



time trends
July prey density
core habitat area





Longfin smelt

- range far downstream from FMWT survey area, into the open ocean
- some indication of abundance increase in the Bay Survey downstream from the FMWT
- declines in FMWT may represent a shift in population distribution of longfin rather than decline in total population

Juvenile striped bass

- Striped bass are introduced predators on native species
- Juvenile striped bass abundance does not correlate with adult abundance
- So, significance of juvenile bass decline is unclear

Threadfin shad

- Introduced species ranging far upstream from FMWT survey area
- However, recent declines in FMWT survey area suggest unknown changes in Delta ecosystem

DFG fish surveys

- Fall Midwater Trawl (FMWT) survey, Sept - Dec, 1967 - present
- Summer Townet (STN) survey, June-Aug, 1959 - present
- 20 mm survey, Mar-Apr to June-Aug, 1995 - present
- Kodiak trawl survey, Jan-May, 2002 - present
- Zooplankton survey, 1972 - present

Export-centered view of POD

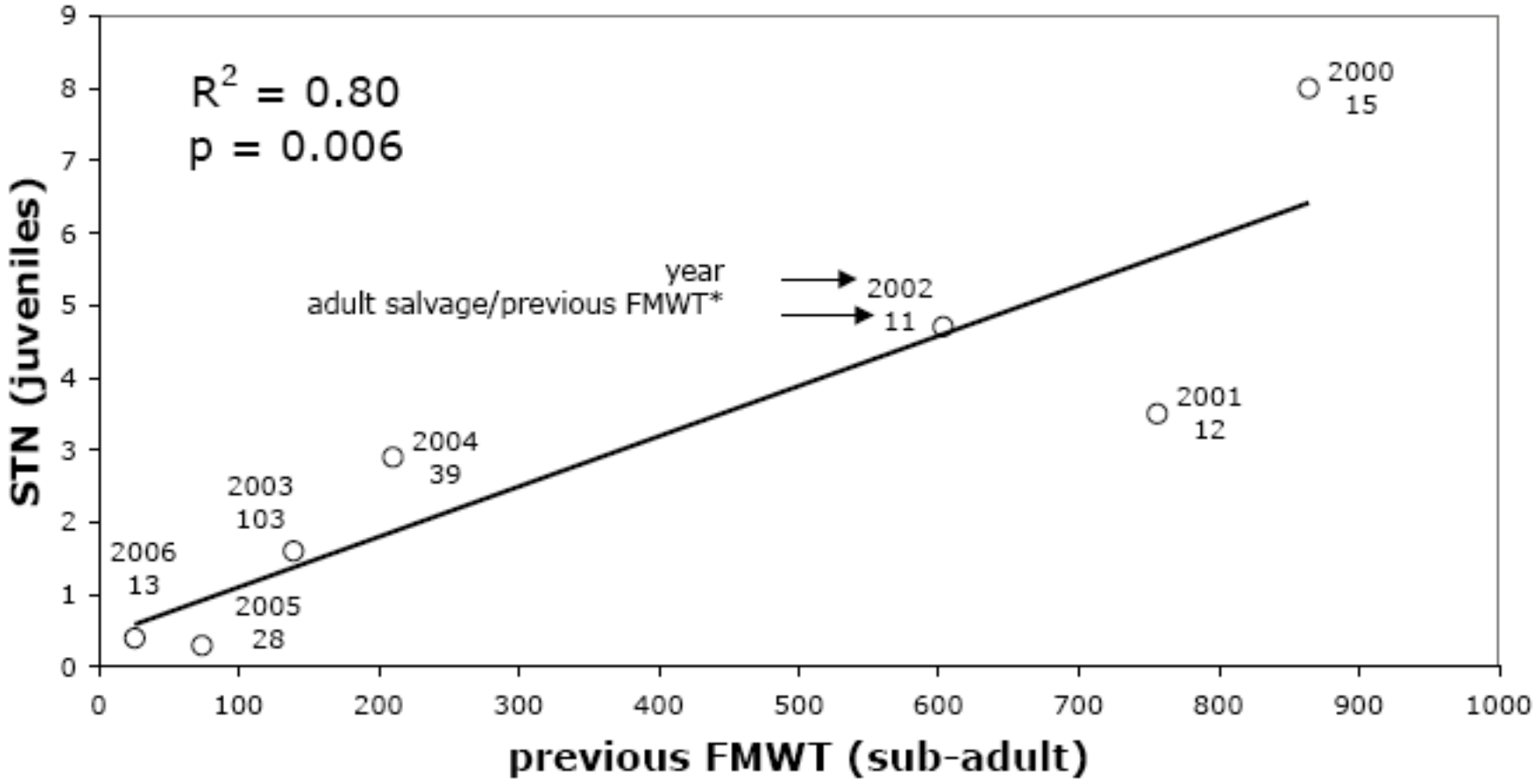
- If exports are a major factor in fish declines, correlations with exports should be obvious from the data.
- In contrast, there are no strong and reliable correlations between exports and fish abundance*
- Chotkowski and Manly** found "statistically significant but unimportant" effects of exports on fish abundance

*Manly report on analyses at 2005 EWA Workshop
**Chotkowski at 2006 CalFed Science Conference

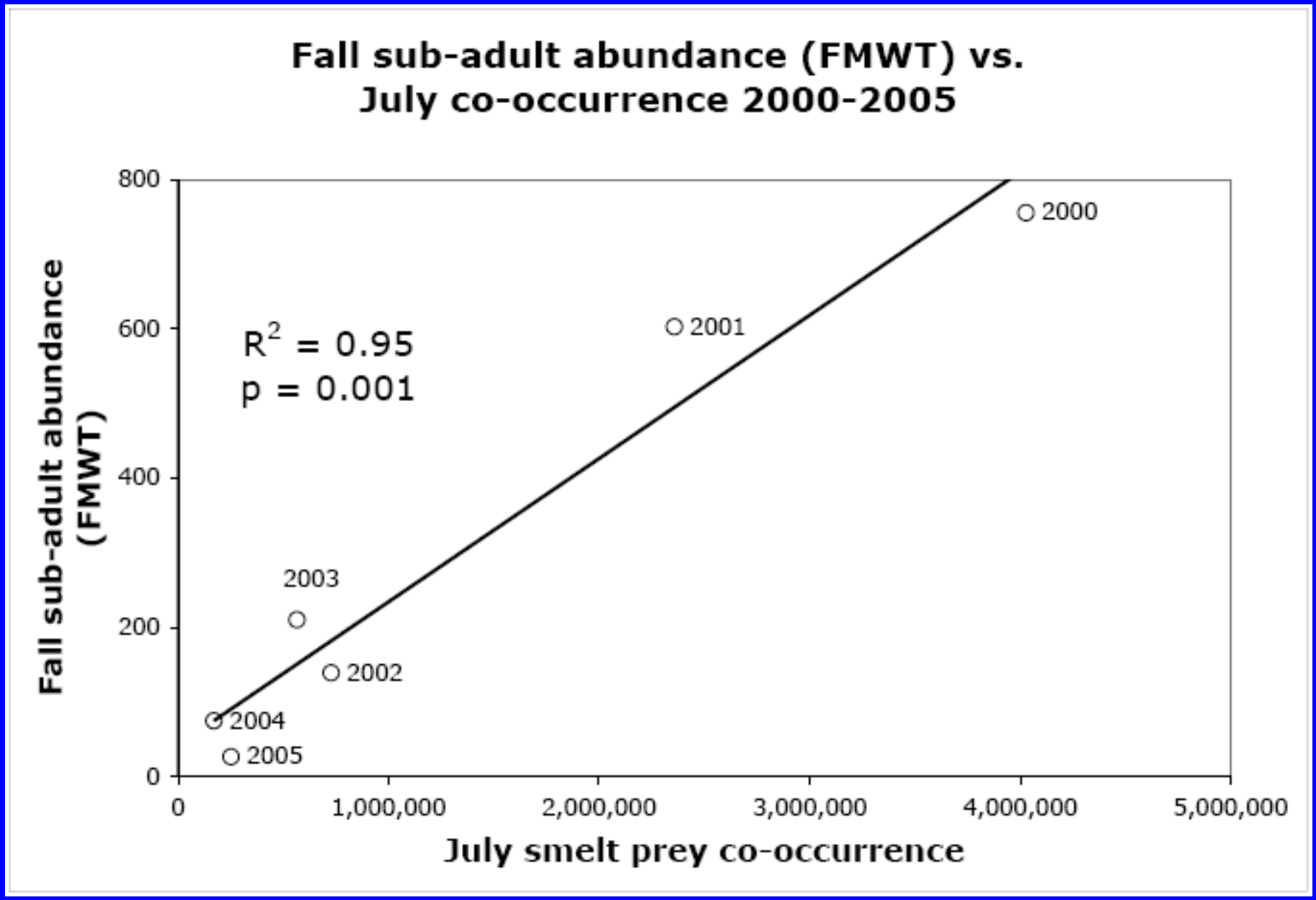
Delta smelt life-cycle abundance in POD years 2000-2006

- Delta smelt life-cycle abundance in 2000-2006 can be explained *without reference to export effects*
- Previous year's FMWT abundance accounts for 80% of the variation in STN ($p = 0.006$)
- Linear co-occurrence of STN delta smelt and *Pseudodiaptomus* in summer accounts for 95% of 2000-2005 FMWT ($p = 0.001$)

Summer juvenile abundance (STN) vs. previous Fall sub-adult abundance (FMWT)



*measure of % adults entrained at export pumps, if entrainment at pumps important, would expect years with high ratio to be above the line


Fall sub-adult abundance (FMWT) vs.
July co-occurrence 2000-2005
Fall sub-adult abundance (FMWT)
July smelt prey co-occurrence
800
600
400
200
0
0
1,000,000
2,000,000
3,000,000
4,000,000
5,000,000
R2 = 0.95
p = 0.001
2000
2001
2003
2002
2004
2005

Implications

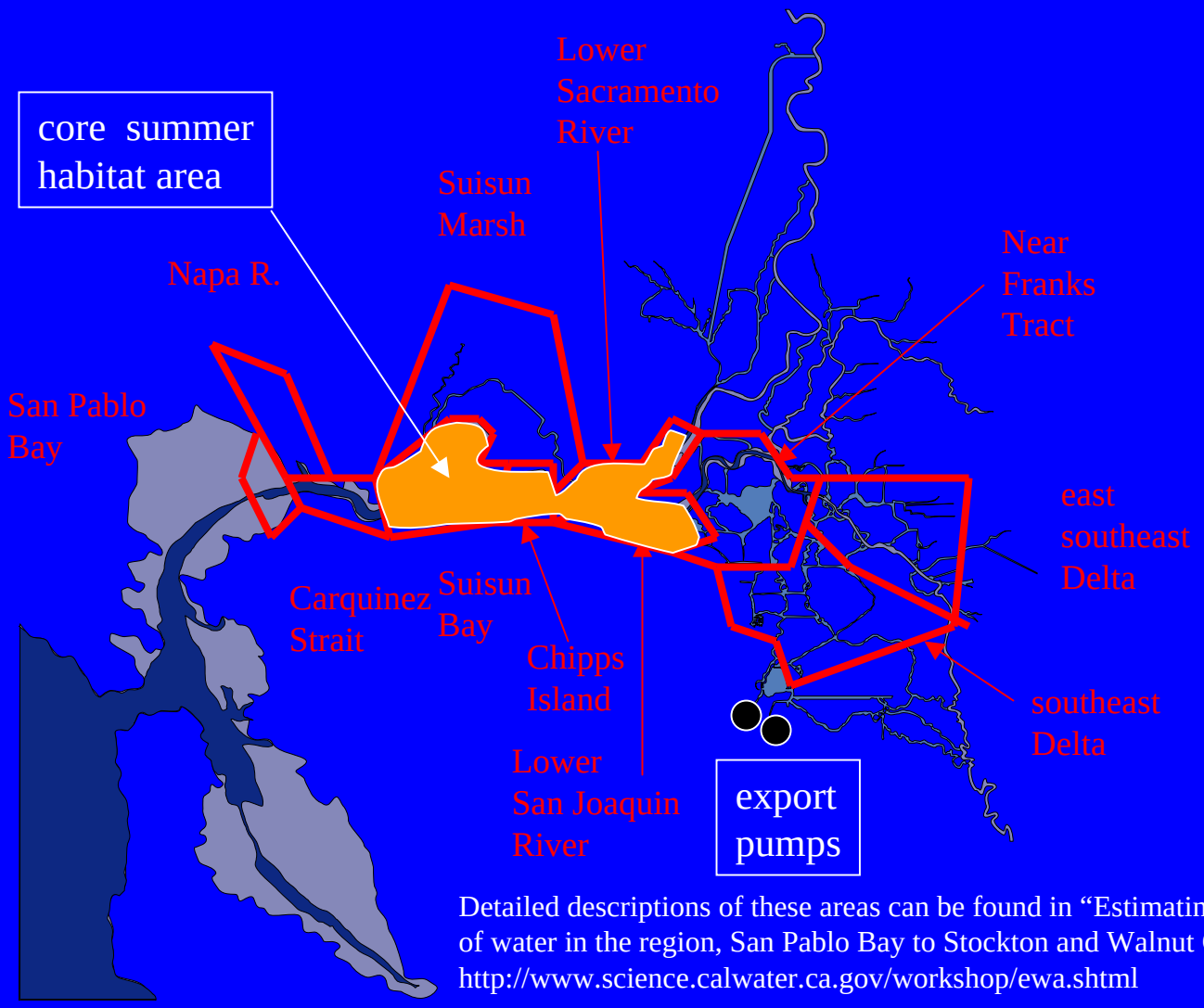
- FMWT abundance of delta smelt in POD years 2000 - 2006 is largely explained by previous year's abundance of pre-spawning delta smelt and July food availability
- Even high adult entrainment does not show effects from Fall to subsequent Summer
- Sharp contrast with continued POD emphasis (contrary to all analyses) on exports as a major factor in low smelt abundance in POD years

Delta smelt and their food

Delta smelt: core summer habitat

- In summer, Summer Townet surveys find more than 95% of delta smelt in the core habitat areas highlighted on the next slide
- The core habitat, at and immediately downstream of the Sacramento-San Joaquin confluence, is more than 30 river miles from the export pumps

co-occurrence areas



Detailed descriptions of these areas can be found in “Estimating area and volumes of water in the region, San Pablo Bay to Stockton and Walnut Grove,” Miller WJ, http://www.science.calwater.ca.gov/workshop/ewa.shtml

July smelt abundance and co-occurrence

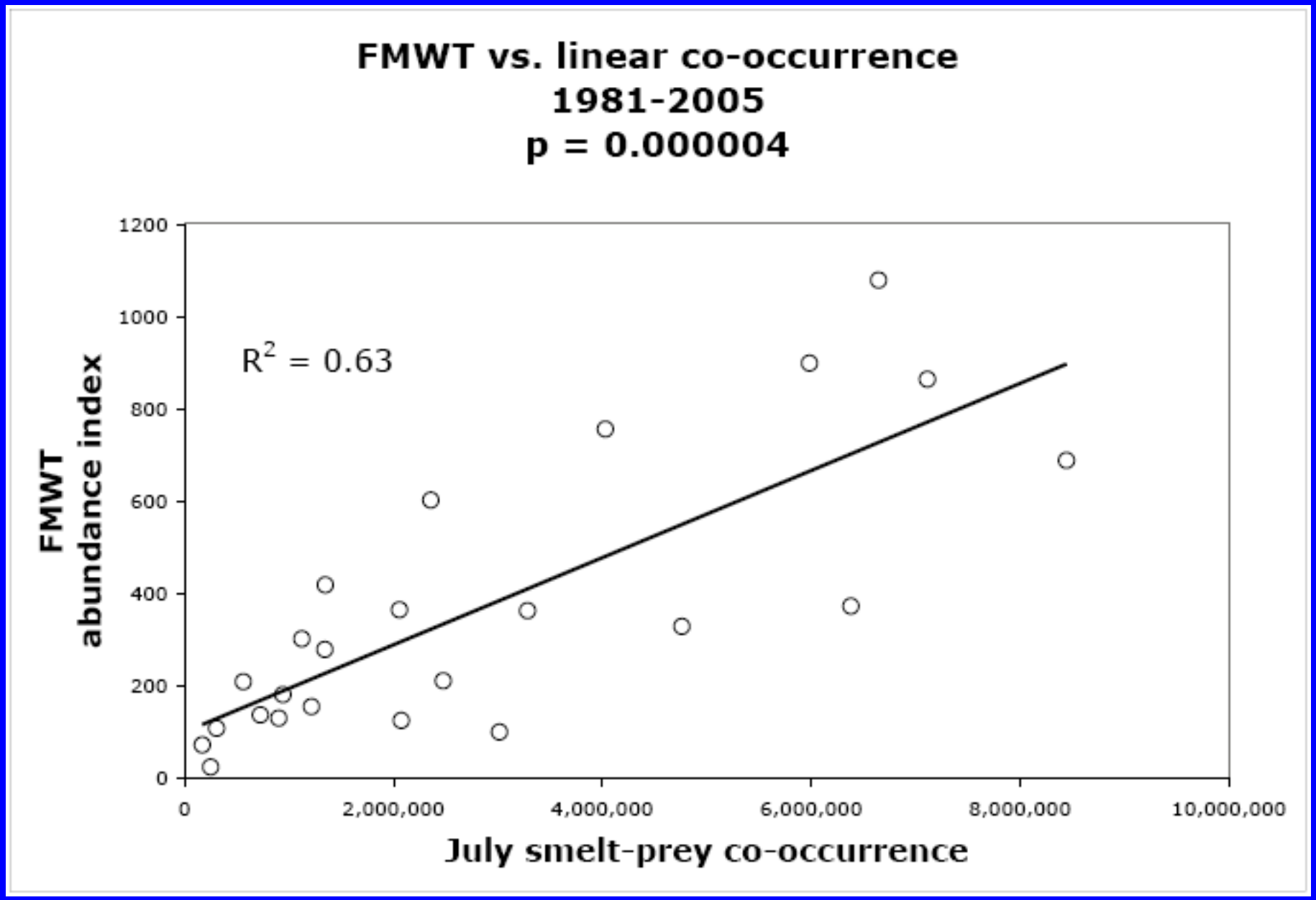
- Relative July smelt abundance in each sub-area estimated as (relative Summer Townet smelt density) x (sub-area volume)
- Two ways to estimate July delta smelt-prey co-occurrence in core habitat

Linear co-occurrence estimate

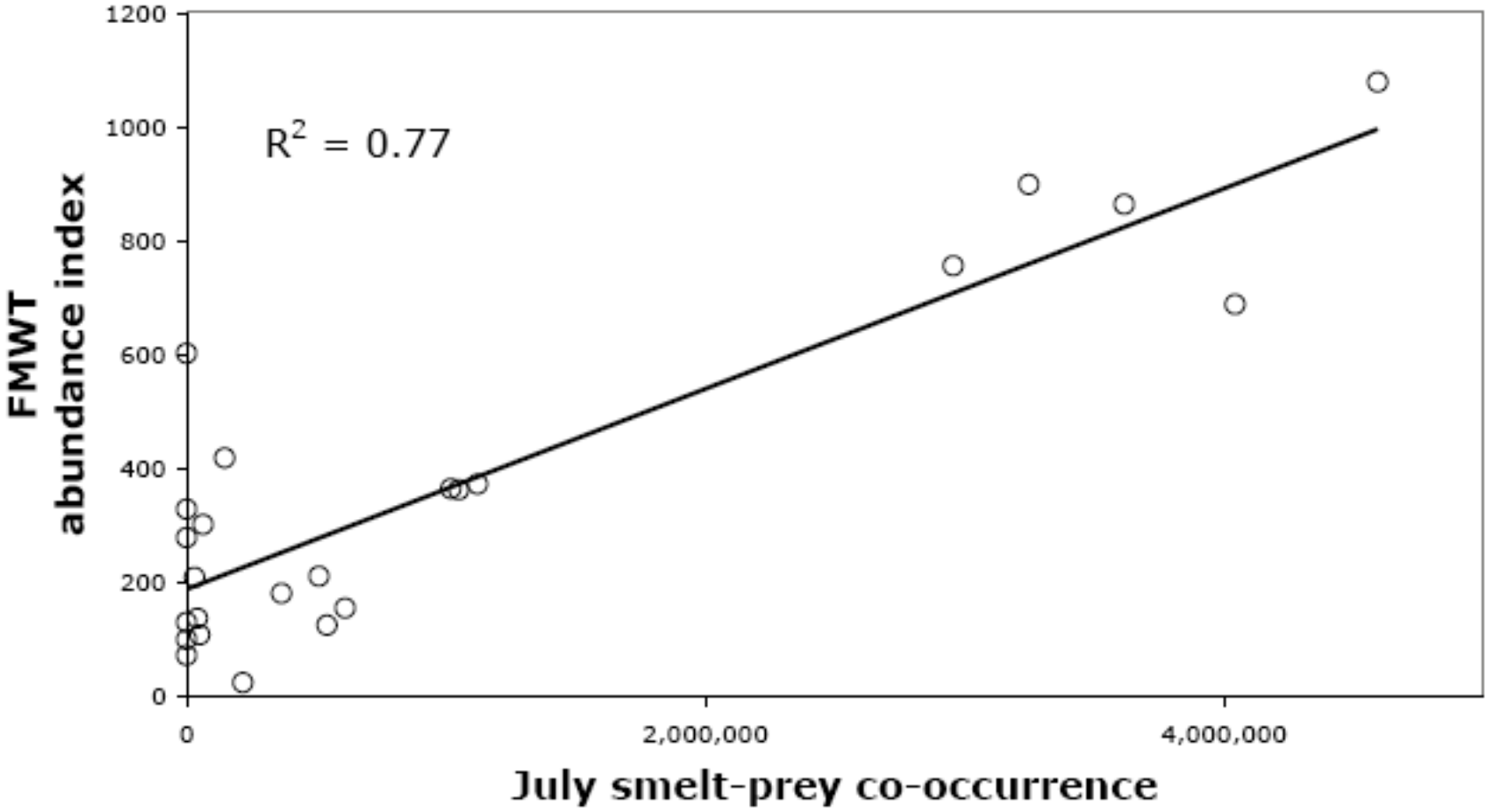
- Assume co-occurrence proportional to prey density = assuming smelt never encounter excess food
- Implies same co-occurrence (on average) when many juveniles compete for sparse food as when few juveniles encounter much food

Threshold co-occurrence estimate

- Delta smelt are stressed in recent years, when average 1981-2005 core habitat relative prey density ~1,250/m^3
- Assume no co-occurrence in sub-areas with average prey density <1,250/m^3, co-occurrence = smelt abundance in sub-areas with higher prey density
- Basically assumes delta smelt only find subsistence rations, on average, when prey density >~1,250/m^3


FMWT vs. linear co-occurrence
1981-2005
p = 0.000004
FMWT abundance index
July smelt-prey co-occurrence
R2 = 0.63
0
200
400
600
800
1000
1200
0
2,000,000
4,000,000
6,000,000
8,000,000
10,000,000

FMWT vs. threshold co-occurrence
1981-2005
p = 0.00000002



Implications

- These are the best available correlations of delta smelt FMWT abundance with any environmental variables
- They imply that crucial FMWT abundance of pre-spawning delta smelt is largely determined by July food availability in their core summer habitat more than 30 miles from the export pumps

A word about correlations

- Correlation does not necessarily mean cause and effect
- However, if there is good reason to suspect cause and effect, correlation can indicate so
- Lack of correlation means either:
  - Wrong analysis
  - No cause and effect (good search, no correlation
- So, if strongly believe cause and effect and conduct a good search and find no correlation, then no cause and effect, especially if there is a plausible explanation for no cause and effect

The plausible explanation for no important effect of exports (or entrainment) on subsequent spawning delta smelt abundance

- Exports entrain some delta smelt
- Must be an effect on subsequent abundance*
- But, dominant effect is prey in summer (co-occurrence analysis shows this)
- Export effect is unimportant relative to subsequent co-occurrence in July*

*Chotkowski and Manly at 2006 CalFed Science Conference

Considering 1972 - 2005

- Average July 1972 – 2005 core habitat relative delta smelt density = $5/m^3$
- Before 1981, relative smelt density in lower Sacramento River > $100/m^3$ in several years when FMWT not proportionally high
- Suggests density dependence before 1981
- Accounting for density dependence produces good correlation for 1972-2005

Implication

- Taking account of density dependence, the central role of July core habitat food availability in determining FMWT pre-spawning abundance of delta smelt is apparent all the way back to 1972 when zooplankton survey data first became available

Other important analyses

No export effects on FMWT

- Miller and Manly found no evidence of export effects on FMWT abundance even in years when delta smelt were close to the pumps*

*Miller presentation at 2006 CalFed Science conference and Manly review of that analysis

No salvage effects on FMWT

- No correlation between salvage (entrainment) of delta smelt and subsequent FMWT abundance*
- No basis for suggestion that high salvage resulted in low FMWT abundance in POD years

*Manly review of analyses at 2005 EWA Workshop

High 2003 entrainment

- Assuming high mortality of delta smelt in Clifton Court Forebay, USGS estimated high percentage entrainment of adult delta smelt in 2003*
- Nevertheless, there is no evidence of any connection between entrainment and FMWT abundance

*Pete Smith presentation at 2006 CalFed Science conference

Pre-VAMP entrainment

- Bennett suggested smelt abundance might be affected by pre-VAMP (mid-April to mid-May) entrainment of larvae that would otherwise grow to be larger more fecund fish
- No evidence of adult size decline after 1990
- No evidence of correlation between adult size and subsequent delta smelt abundance; in fact, slight increase in adult size in POD years

Effect of Old/Middle River flow

- Correlations found between Old and Middle River flows and adult salvage
- Relevant to take at export pumps, but no population-level effect on overall delta smelt abundance

Salvage: % east of Franks Tract

- % of Kodiak Trawl abundance east of Franks Tract correlates with monthly salvage*
- % of adult delta smelt east of Franks Tract averages around 0%
- Suggests adult entrainment governed by the location of a very small % of adults

*Manly review of analyses at 2005 EWA Workshop

Effects of turbidity on delta smelt

- Water clarity affects survival of larvae and early juvenile (20-25 mm) delta smelt
- Catch of delta smelt related to turbidity
- Salvage of adult smelt coincides with turbid water near export pumps
- Delta waters becoming less turbid (invasive plants and clams?)
- Lower catch of delta smelt in southeast Delta explained by clearer water

What should we focus on?

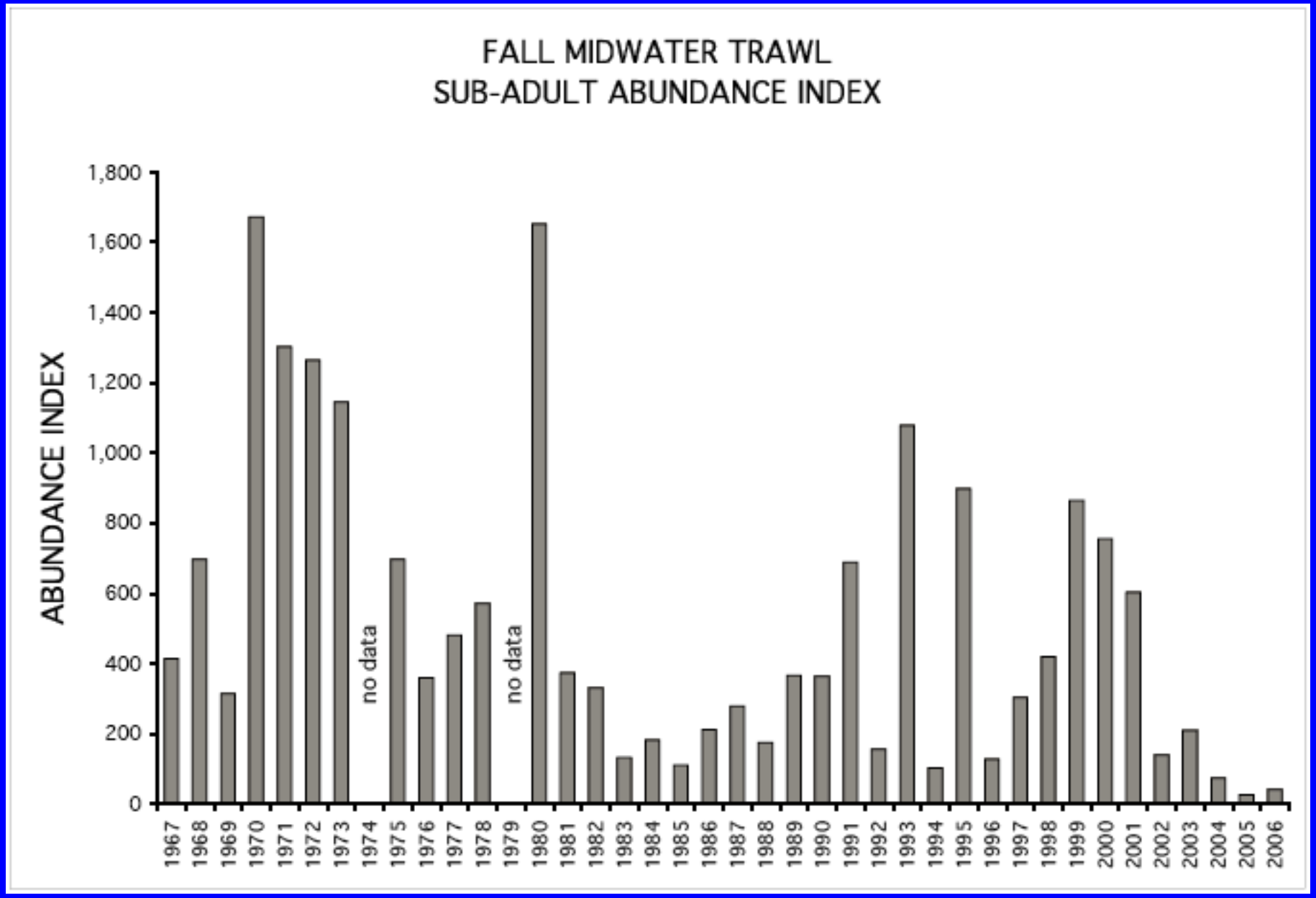
- Causes of Pseudodiaptomus decline in core habitat in the summer
- Much closer study of effects of factors *other than exports* on fish
  - Toxics
  - Invasive species
  - Discharges and diversions in core habitat

If the problem with delta smelt is food near confluence in Summer, what to do?

- Confirm that it is food
- If food subsidized from upstream
  - Check for export effect
  - Check for nutrient effects upstream
- If food affected by Amur River clam
  - Can clam be controlled with salinity?
- Can food be added using habitat?
- Don’t forget turbidity, especially for early life stages

Export actions

- Current requirements prevent unusually large delta smelt entrainment events
- Lack of evidence of export or entrainment effects on delta smelt abundance does not support additional export requirements


FALL MIDWATER TRAWL
SUB-ADULT ABUNDANCE INDEX
ABUNDANCE INDEX
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
no data
no data
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006