Something about sampling, statistical power, and bad things in fish

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Objectives

- Advice on sampling in 2006
- Frequency of future sampling
- Scenarios of improvement
- PCB, DDT, Hg
- Selected species

Approach

- Power analysis
- Partition variance
- Look for trends
- Simple, optimistic
- Nothing fancy
- Cohen, J. Statistical Power Analysis…rev. 1977

Raw Statatistics

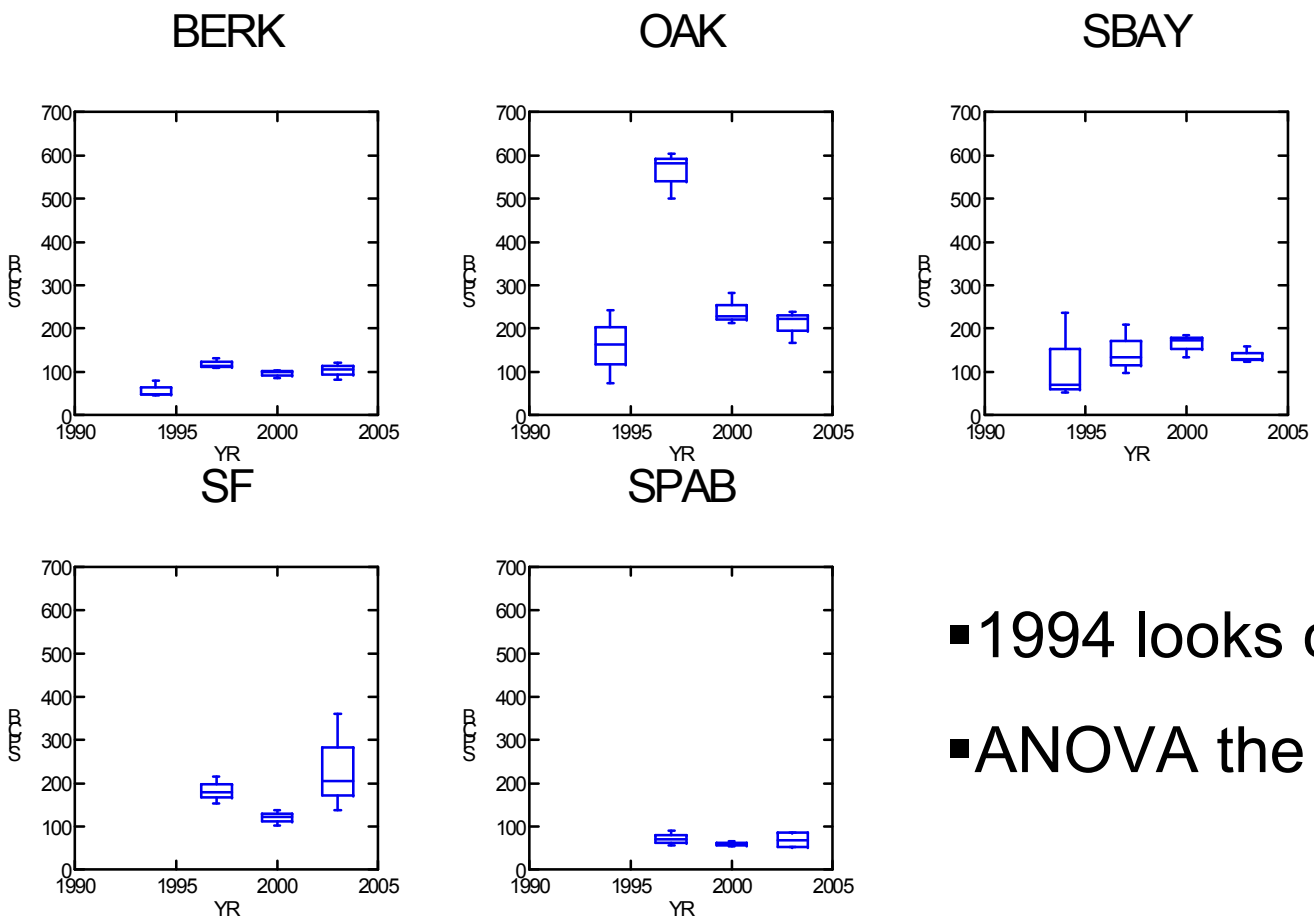
	SFEI sum (PCB)	
	SPERCH	WHT_CR
N of cases	61	78
Minimum	47	61
Maximum	603	690
Mean	162	229
Std Dev	117	101
C.V.	0.72	0.44
Effect Size (d) @ 20% change	0.28	0.45
n	60	60
d	.3	.45
Power of t-test @ α=.05, n, d	37%	68%

Screening value = 10 ng/g

SHINER PERCH # PCB SAMPLES

	1994	1997	2000	2003
Berkeley		3	3	3
Berkeley Pier	3			
Double Rock (Candlestick)	1			
Dumbarton Bridge	1			
Islais Creek	1			
Oakland		3	3	
Oakland Inner Har. (Fruitvale)	3			
Oakland Inner Harbor				3
Oakland Middle Harbor Pier	1			
Richmond Harbor	3			
S.F. Waterfront		3	3	
San Francisco Waterfront				3
San Leandro Bay			3	
San Mateo Bridge	1			
San Pablo Bay		3	3	2
South Bay				3
South Bay Bridges		3	3	

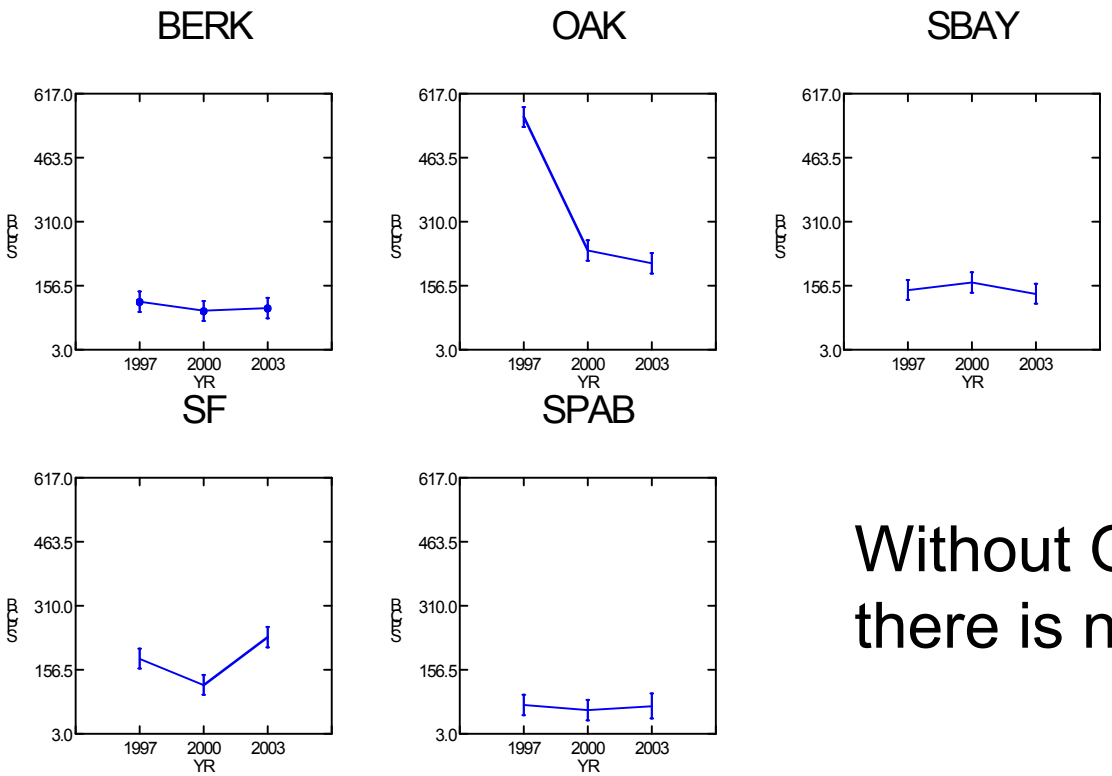
S. Perch PCBs by year/site



- 1994 looks odd
- ANOVA the rest

SPERCH PCB. yr, site, yr x site all sig. INTERACTION TERM:

Least Squares Means



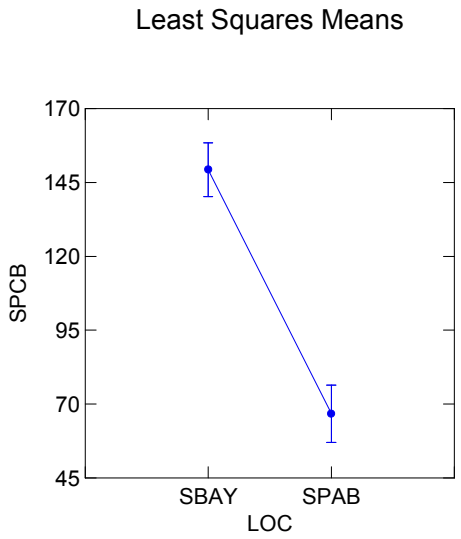
Without Oakland data, there is no time trend

S.PERCH 1997-2003 STAT SUMMARY

	BERK	OAK	SF	SPAB	SBAY
N of cases	9	9	9	8	9
Minimum	82	167	102	52	98
Maximum	132	603	360	91	209
Mean	106	337	179	67	149
Std Dev	16	173	78	15	35
C.V.	15%	51%	43%	22%	23%

Simplify and simulate

	SPAB	SBAY
n	8	9
Min	52	98
Max	91	209
Mean	67	149
Std Dev	15	35
C.V.	22%	23%

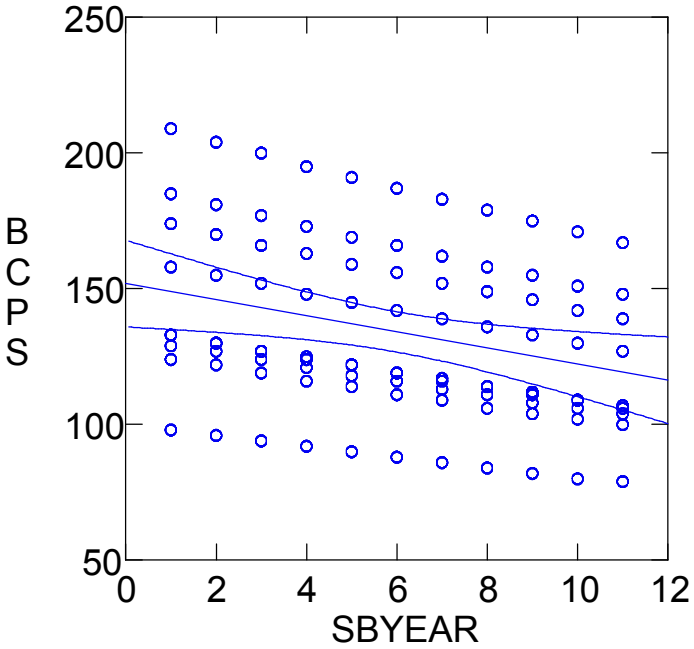


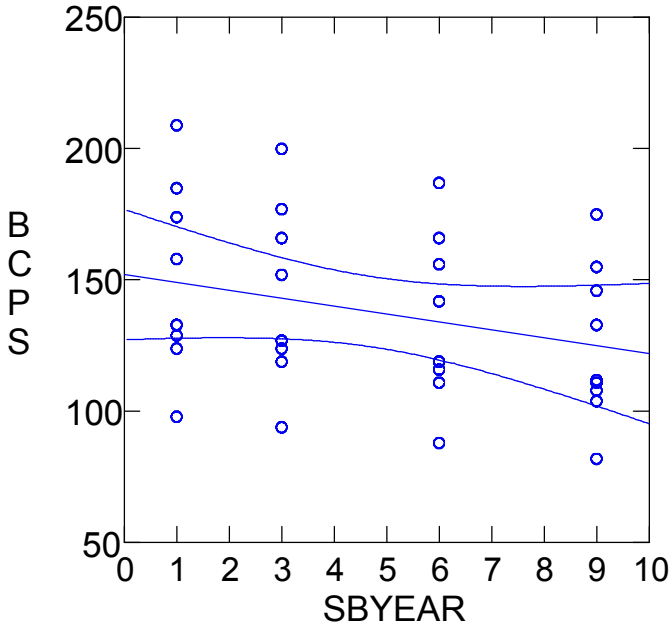
Std. dev. (resid)=24%

Suggested scenario:

- ANCOVA with station as a factor and year a cofactor, 20% decrease over 10 years
- Model as regression of South Bay through time

CONCEPTUAL MODEL



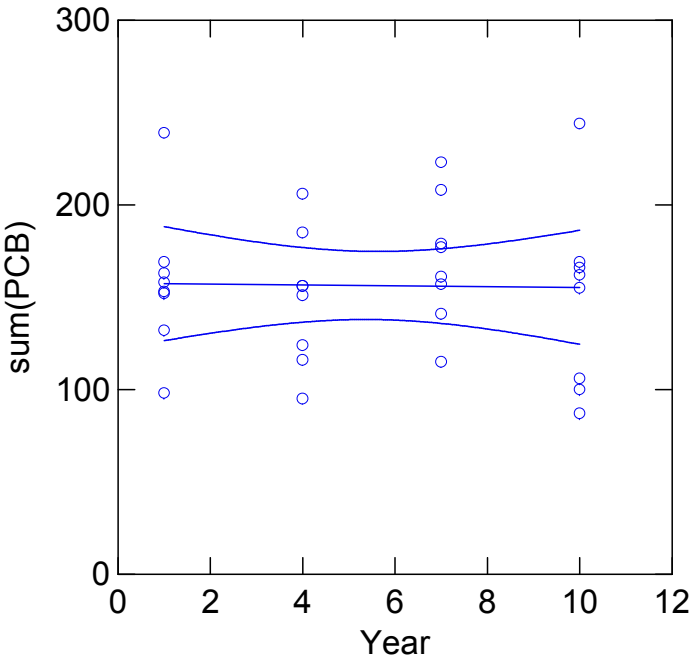


1000 Random numbers

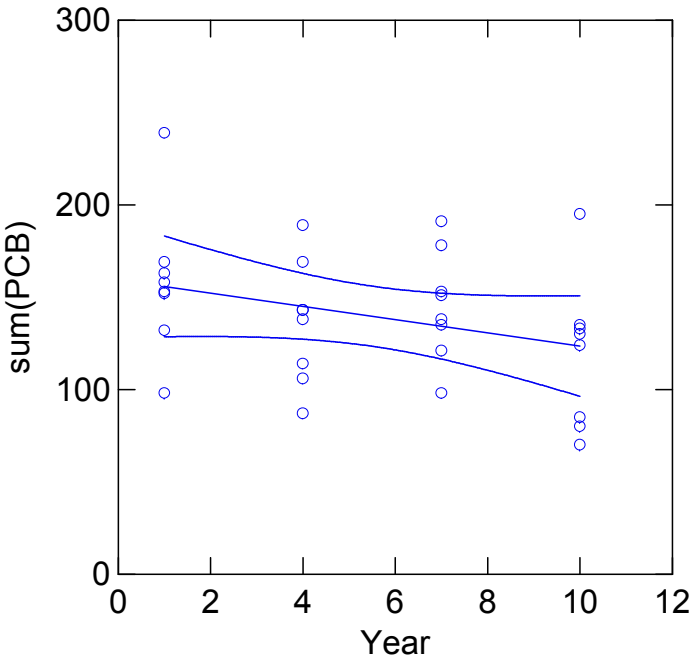
- Log-normally distributed
- Mean=150
- S.d.=36
- Samples of 8 with replacement
- Simulated effects = 0 or 20%/10 yr
- Followed by power tables (Cohen 1977)

r=-.33, p=.067

Perch simulation 1, effect=0

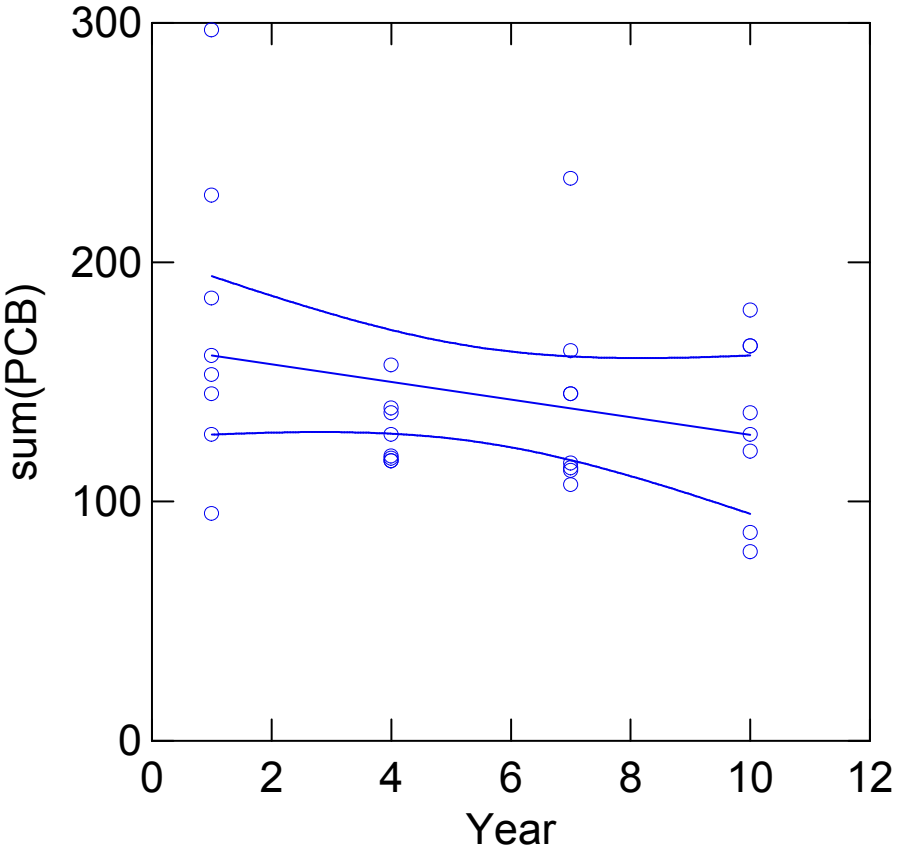


Perch simulation 1, effect=20%



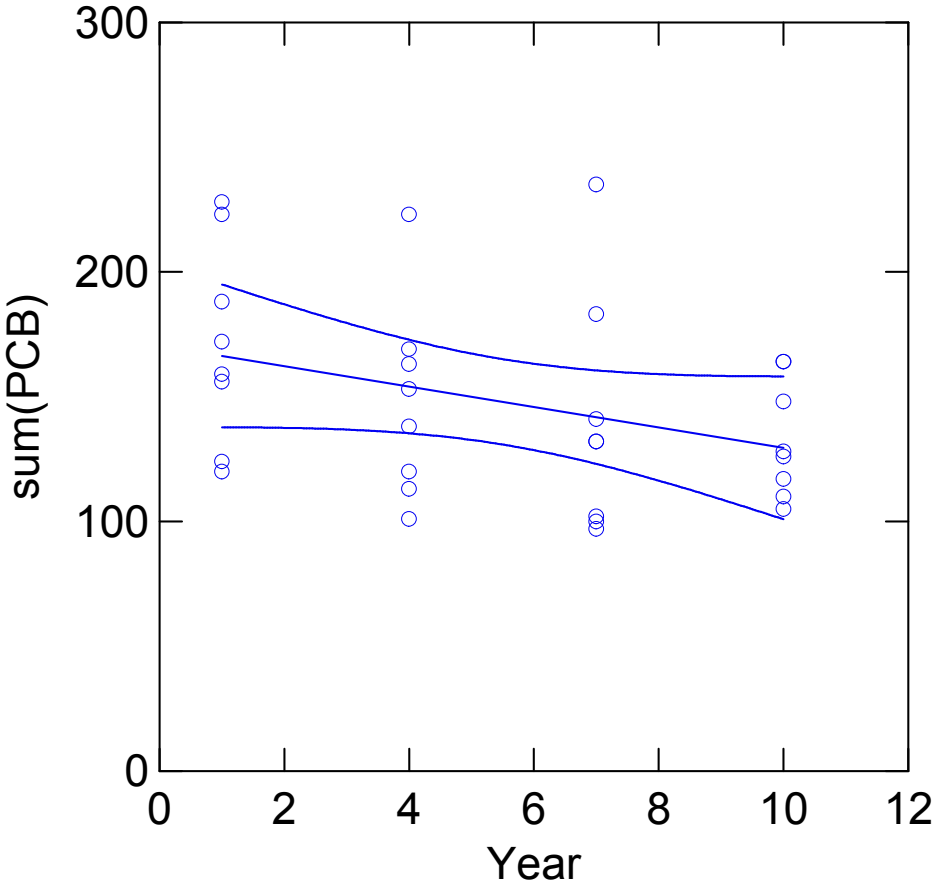
r=-.28, p=.118

Perch simulation 2, effect=20%



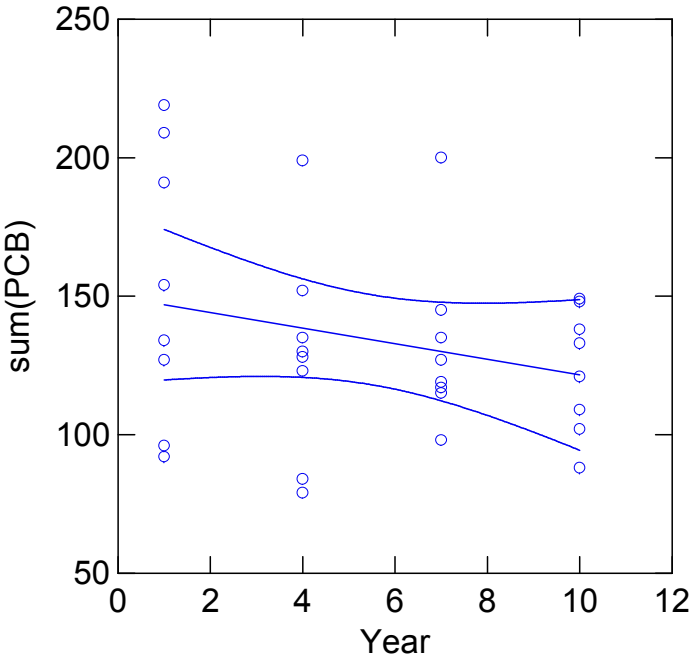
r=-.35, p=.048

Perch simulation 3, effect=0 !

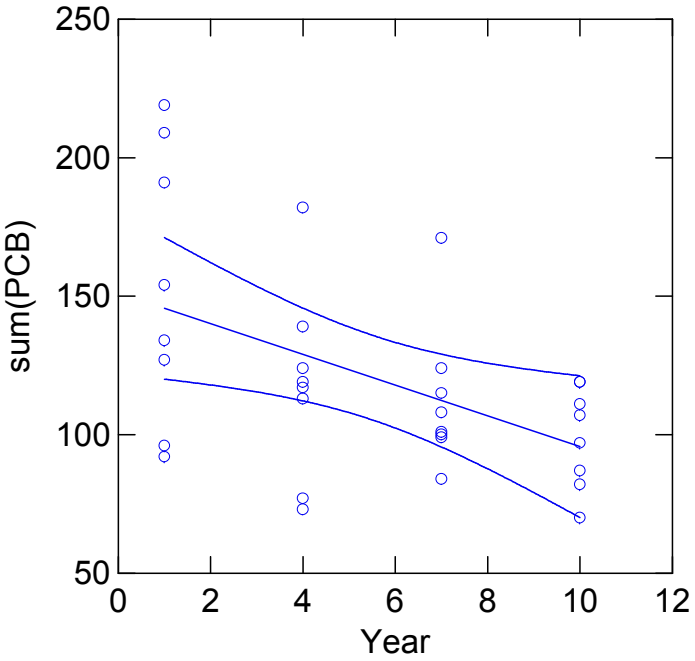


r=-.5, p<.01

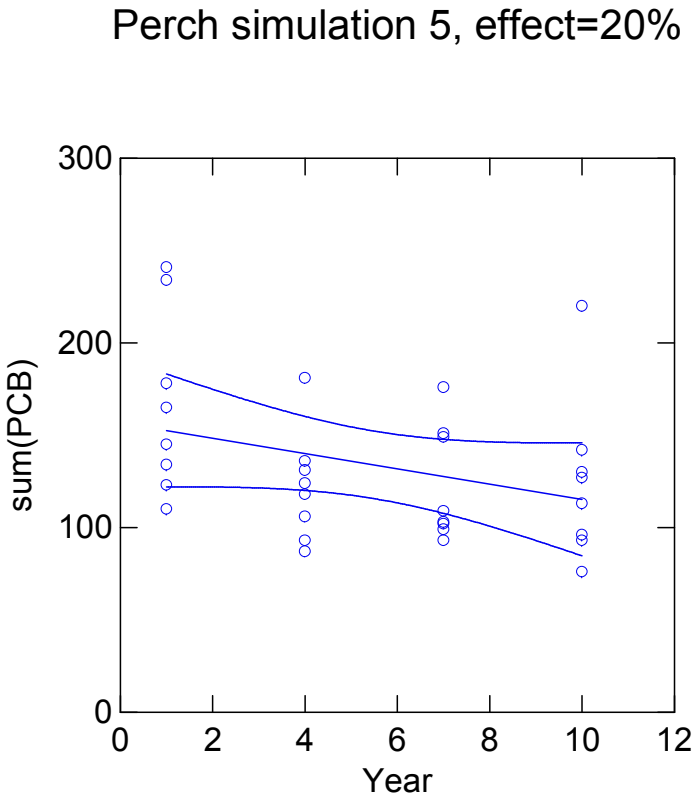
Perch simulation 4, effect=0



Perch simulation 4, effect=20%



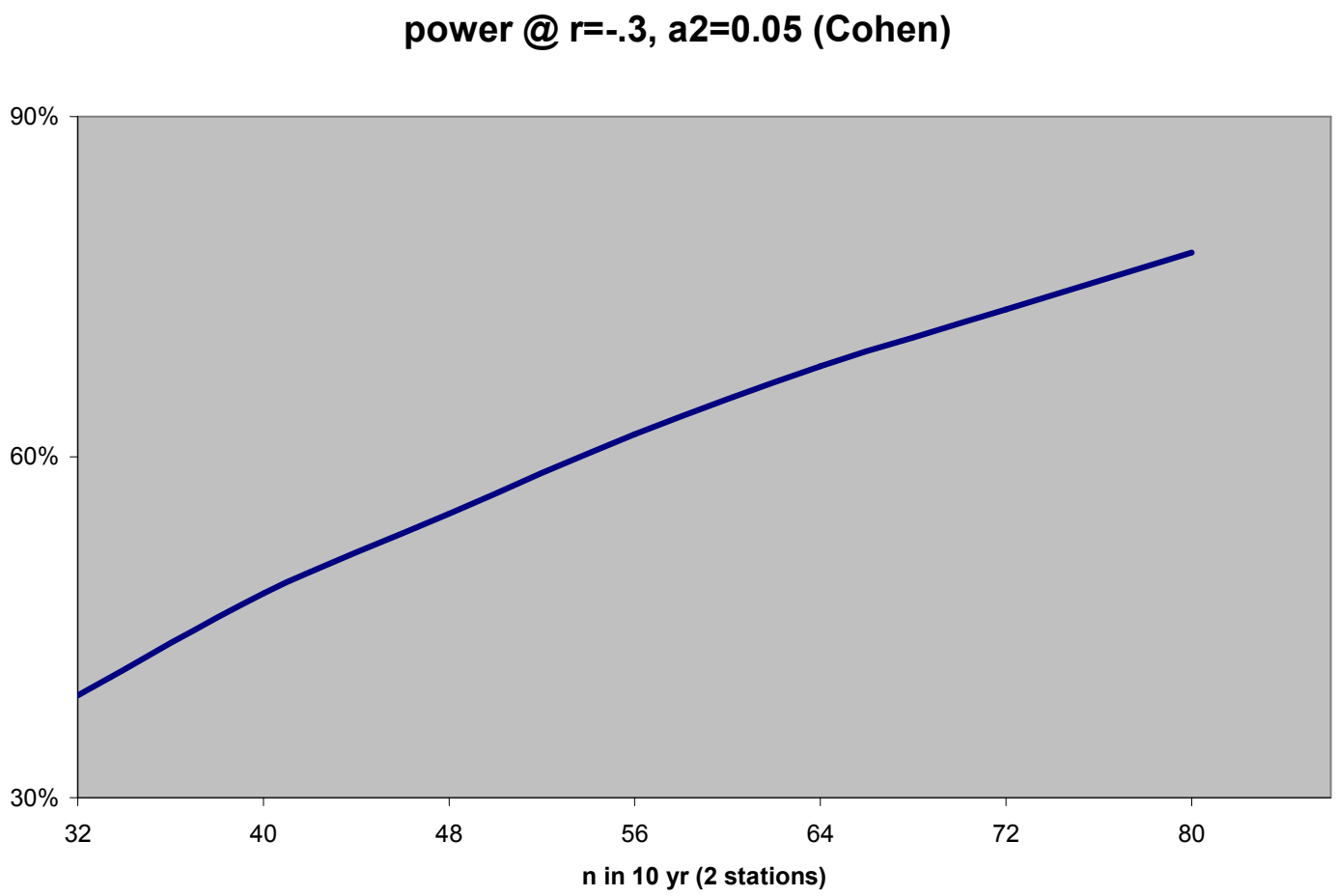
r=-.34, p=.06



Simulation Summary

- 1/5 False positive
- ¾ False negative
- Power ~ 40% (2/5)
- 2-tailed tests

From Cohen's power tables

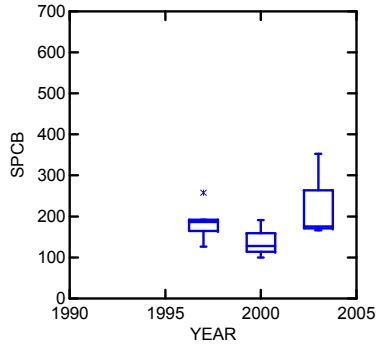


Simpler still

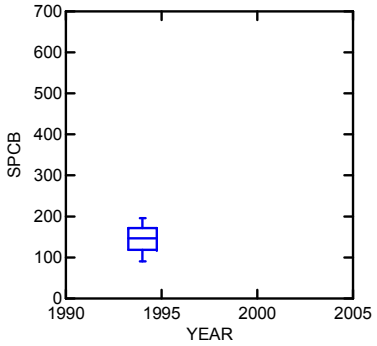
- One-factor ANOVA after some time
  - Var. accounted for by site = 56%
- Modeled as *t*-test for 20% change with adjusted C.V.=31%
- power~80%@**n**=25
- Assumes replication @ same 5 sites
- Alternatively, bank **n** and go for small Conf. interval (testing is secondary)
- ESTIMATION is the GOAL

PCB in White croaker

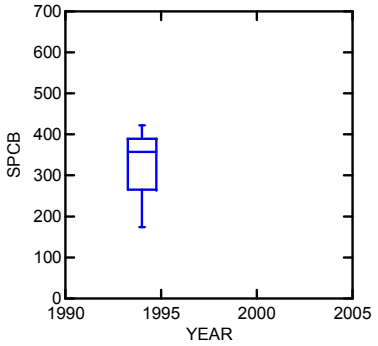
BERK



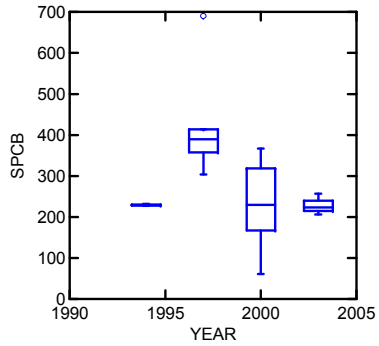
ISCR



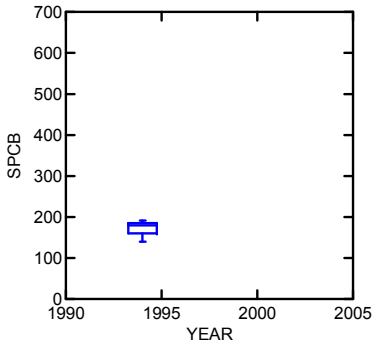
MAIS



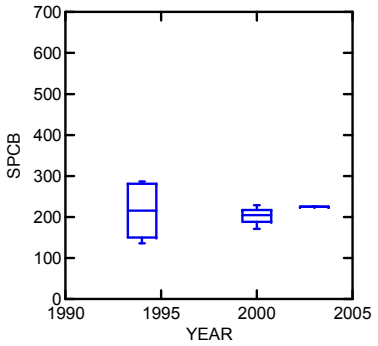
OAK



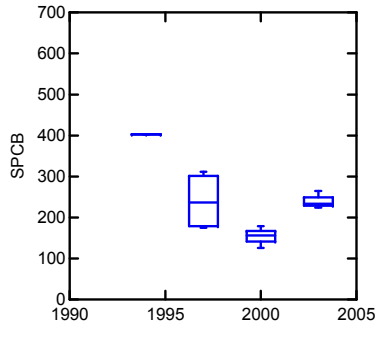
PM



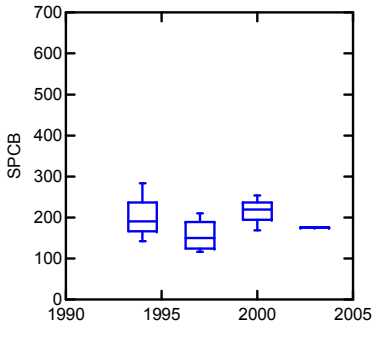
SBAY



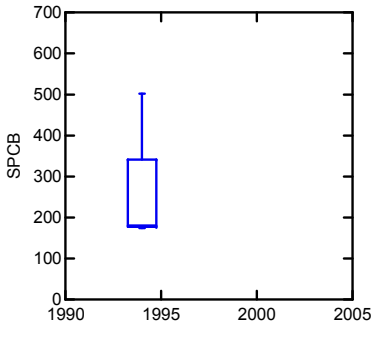
SF



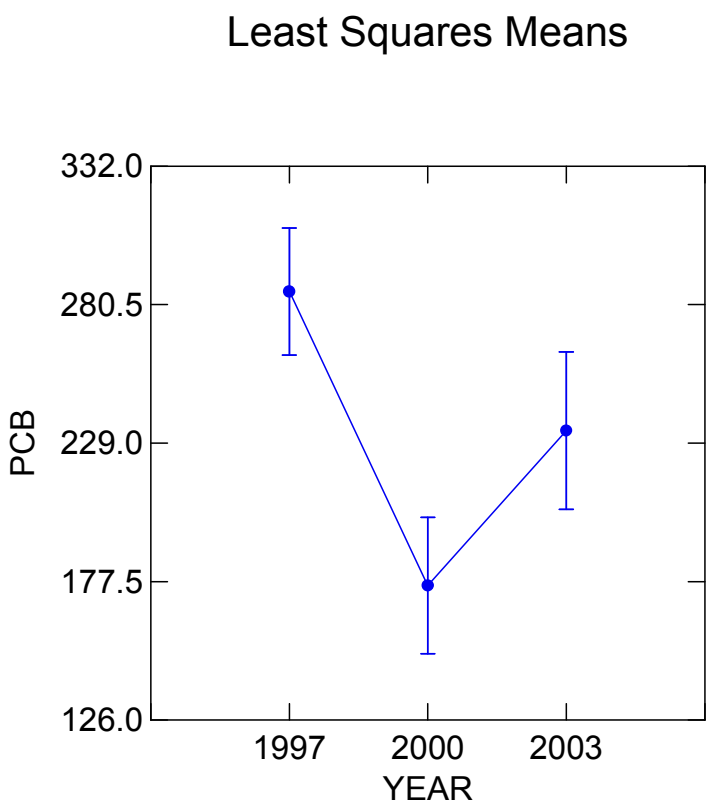
SPAB



STICK



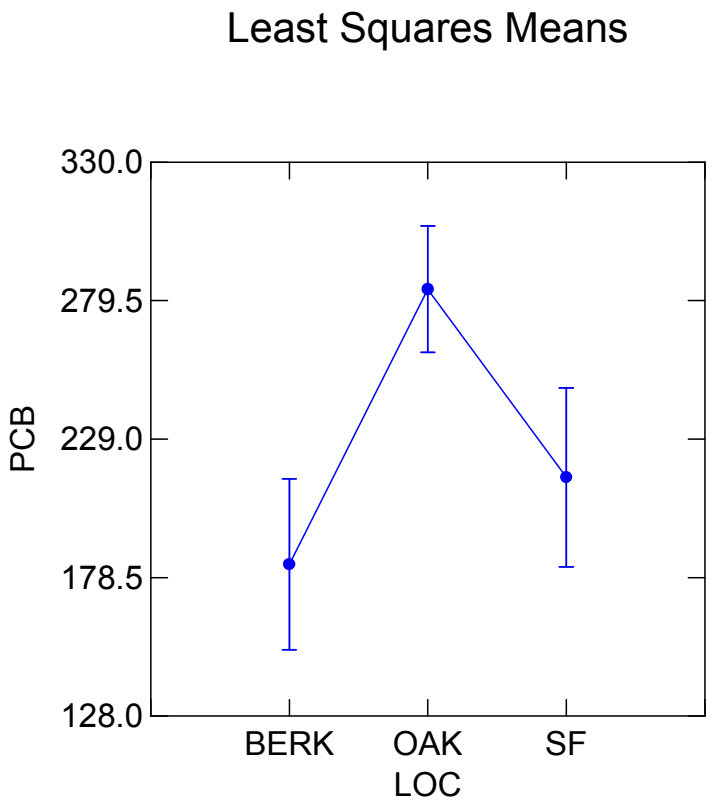
PCB in White croaker



ANOVA

Source	Sum-of-Squares	df	Mean-Square	F-ratio	p
LOC$	88120	2	44060	5.70	0.008
YEAR	76842	2	38421	4.97	0.013
LOC$*YEAR	70204	4	17551	2.27	0.083
Error	247393	32	7731		

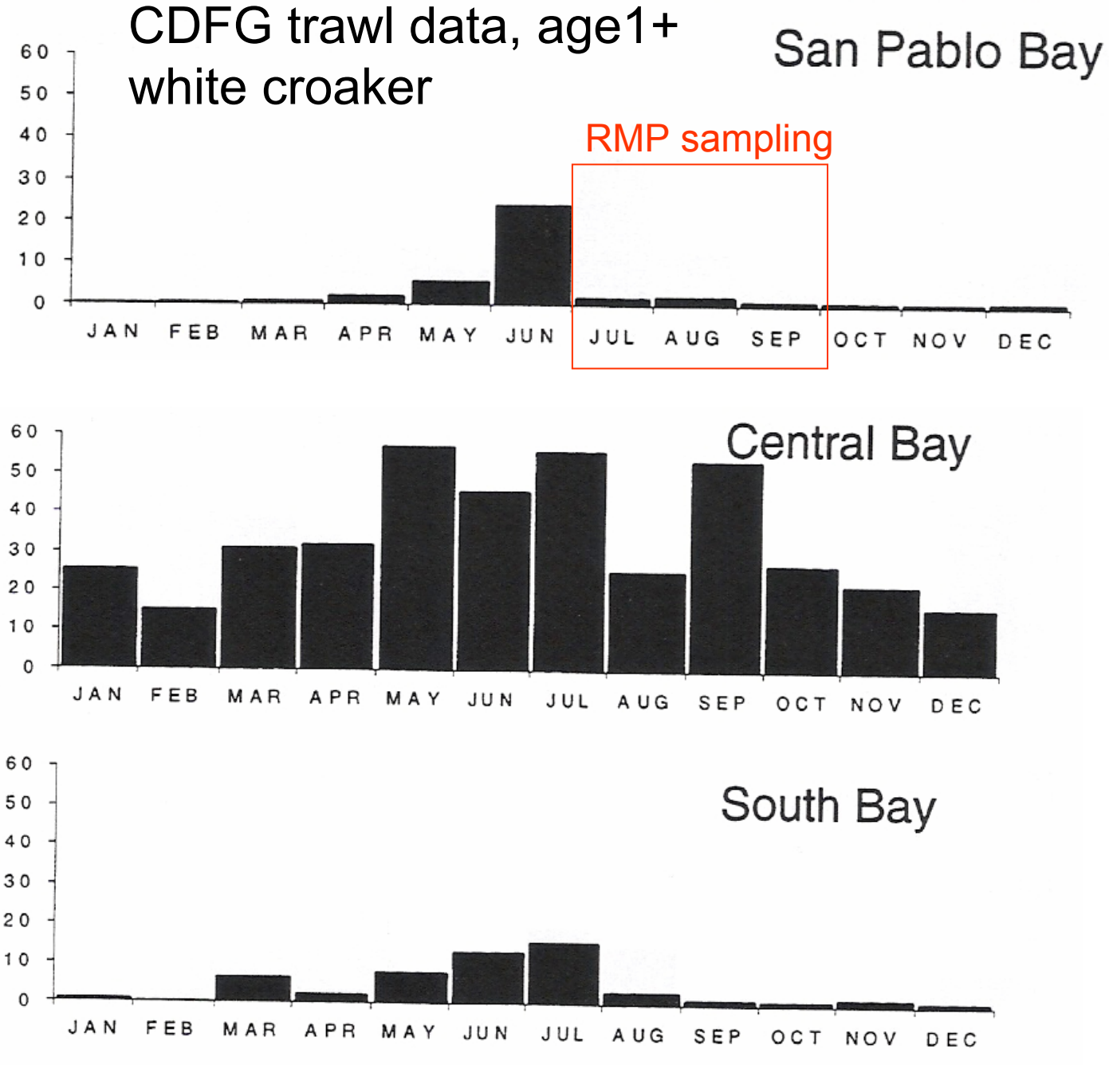
PCB in White croaker



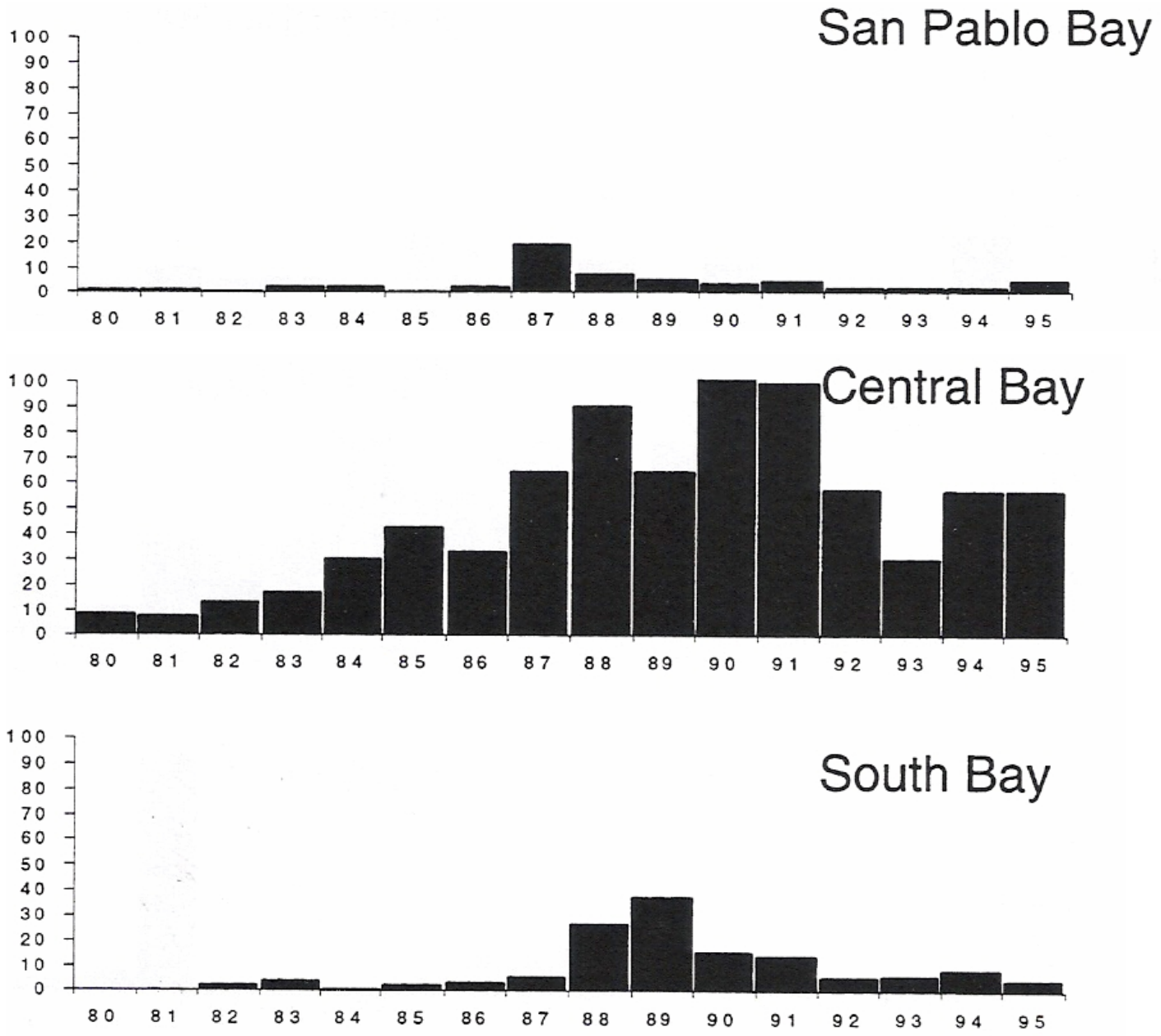
ANCOVA

Source	Sum-of-Squares	df	Mean-Square	F-ratio	p
LOC$	79496	2	39748	3.73	0.033
YEAR	27704	1	27704	2.60	0.115
Error	394004	37	10649		

CDFG trawl data, age1+ white croaker



CDFG age 1+ white croaker CPUE by year



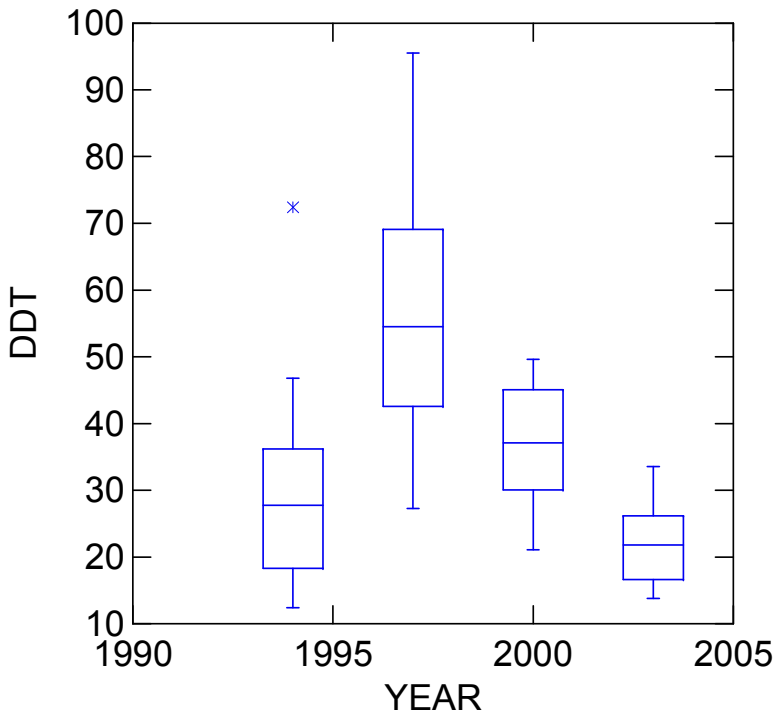
Power analysis, PCB in croaker

- Only 15% of variance “accounted for” by site
- Adjusted c.v = 38%
- Power ~80% to see 20% change @ n=40
- No hurry to sample

DDT in Shiner perch

SPERCH	DDT
N of cases	61
Minimum	12.4
Maximum	95.5
Mean	37.1
Std Dev	19.4
C.V.	52%

S. perch DDT by yr.



Screening value = 100 ng/g

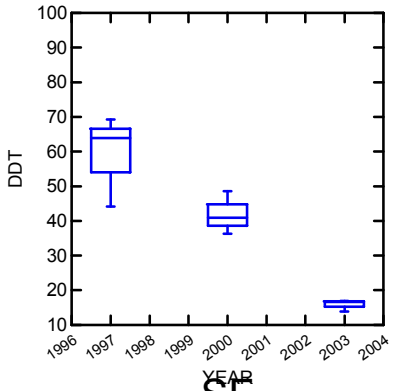
Select perch DDT data

Shiner perch DDT # samples by site and year

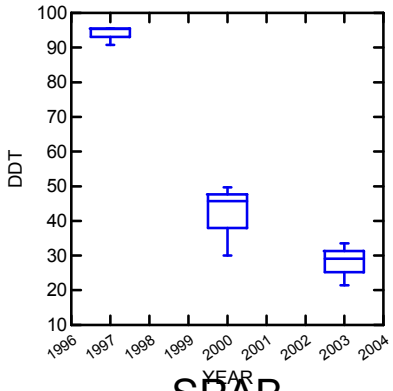
site	1994	1997	2000	2003
BERK	3	**3**	**3**	**3**
ISCR	1			
OAK	4	**3**	**3**	**3**
RICH	3			
SBAY	2	**3**	**3**	**3**
SF		**3**	**3**	**3**
SLB			3	
SPAB		**3**	**3**	**2**
STICK	1			

DDT in Shiner perch

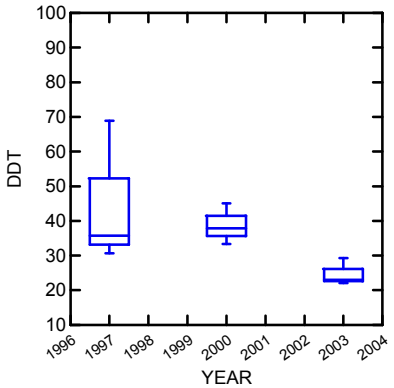
BERK



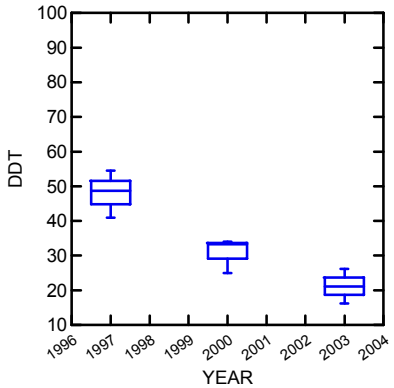
OAK



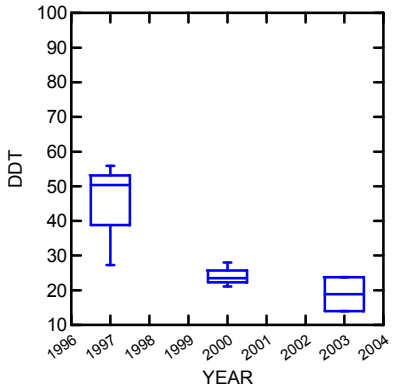
SBAY



SF



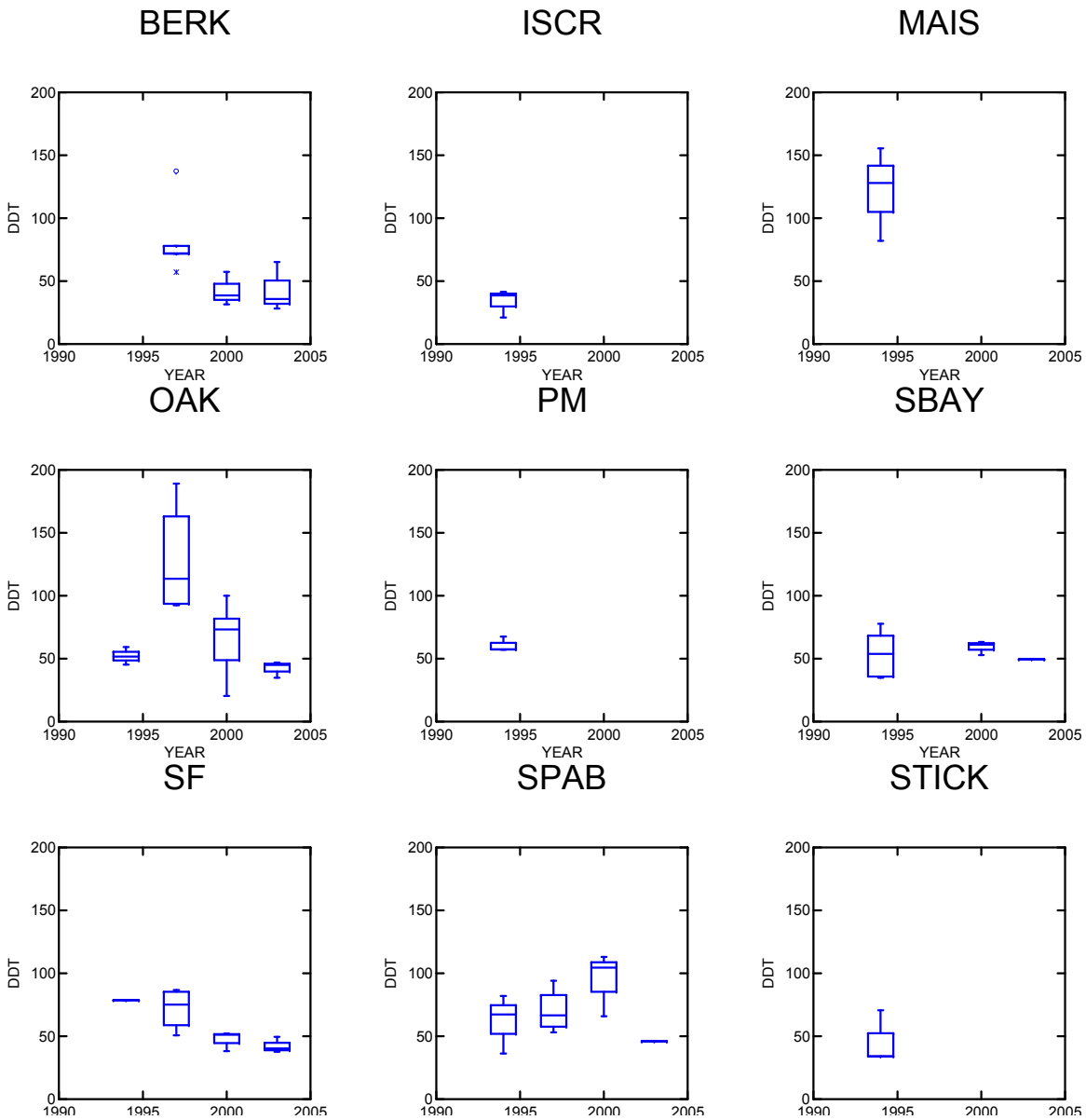
SPAB



ANCOVA

- Yr and loc sig (p≤.001)
- Yr is 53% of var.
- s.d.(resid)~29% of est
- 2003 mean~24⊕3

DDT in White croaker



Overall c.v.=48%

Low power for 20% change

Power to see 50% change good @ n=40

Sampling?

ANCOVA DDT in white croaker

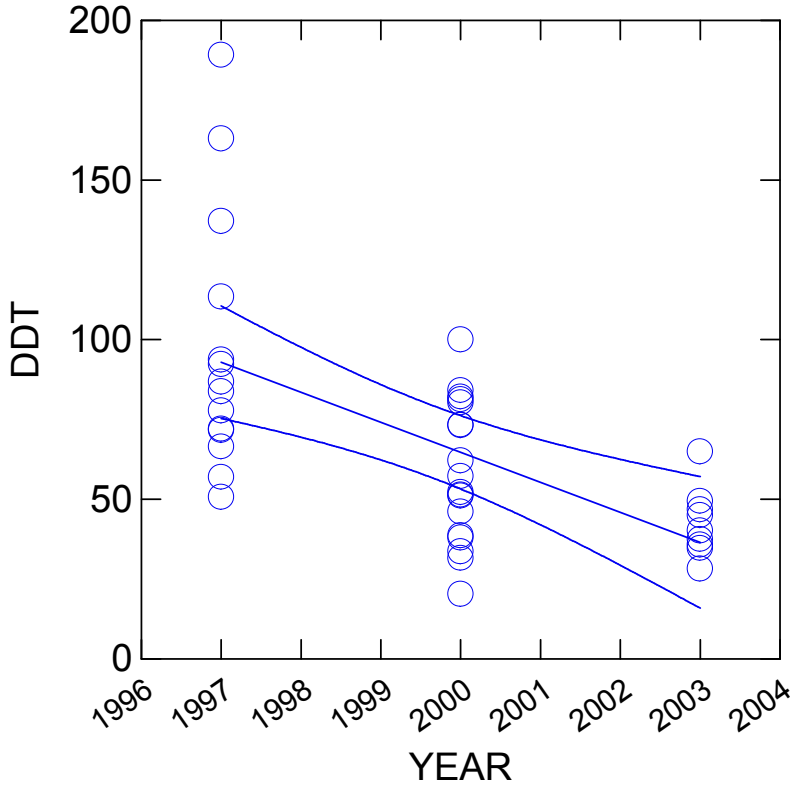
LOC$ (3 levels)
BERK, OAK, SF

Dep Var: DDT N: 41 Multiple R: 0.672 Squared multiple R: 0.452

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	p
LOC$	4582	2	2291	3.12	0.056
YEAR	18224	1	18224	24.83	<.001
Error	27161	37	734		

“Power analysis” DDT in croaker



r=-.6

Trend probably not linear

S. Palbo different?

Screening value = 100 ng/g

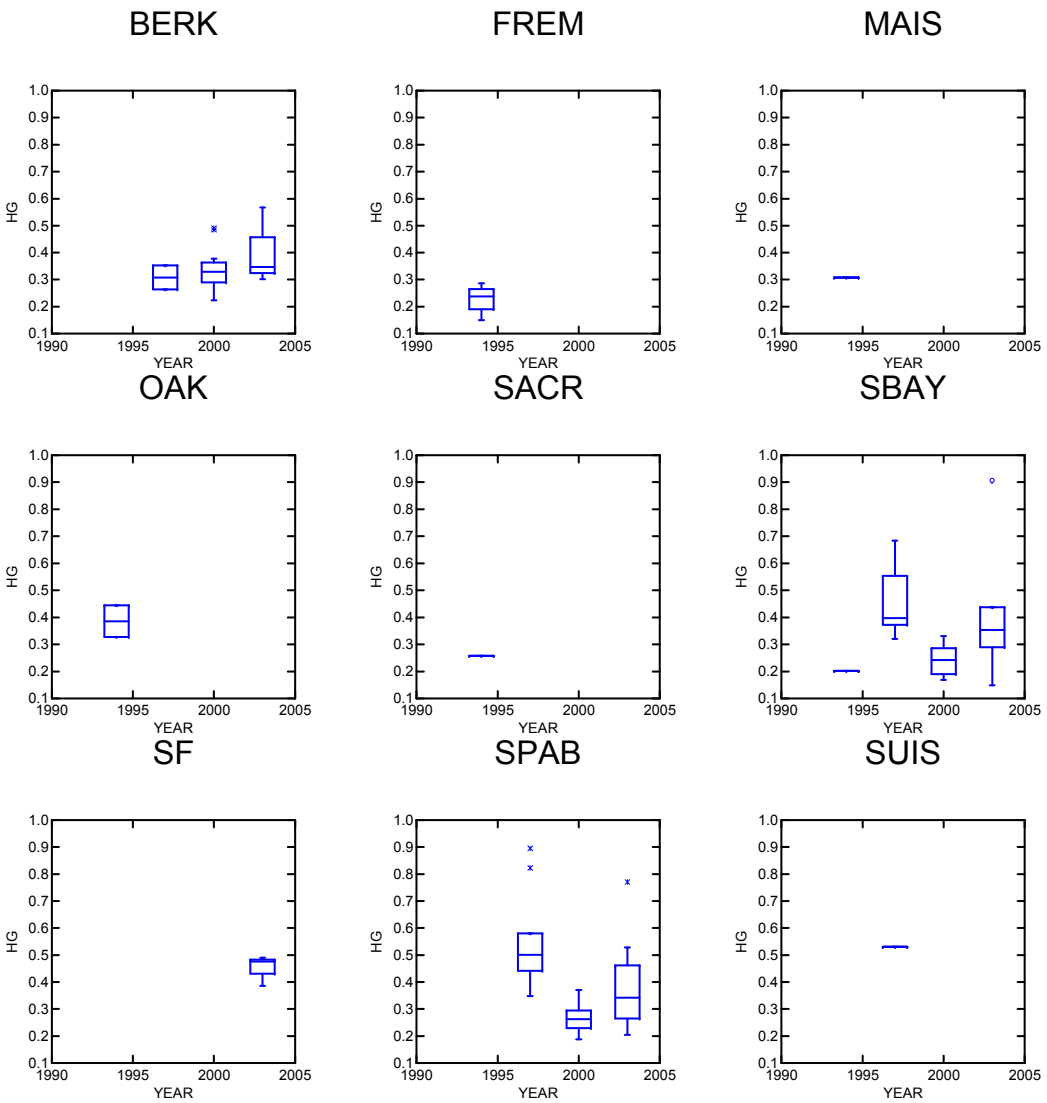
Scientific interest?

Mercury

	STBA	WHCR	LESH
N of cases	88	65	60
Mean	0.37	0.21	0.90
Std Dev	0.16	0.08	0.30
C.V.	0.43	0.41	0.33

Screening value = 0.2 µg/g

Hg in Striper



Mult. Regr. Hg in Striper

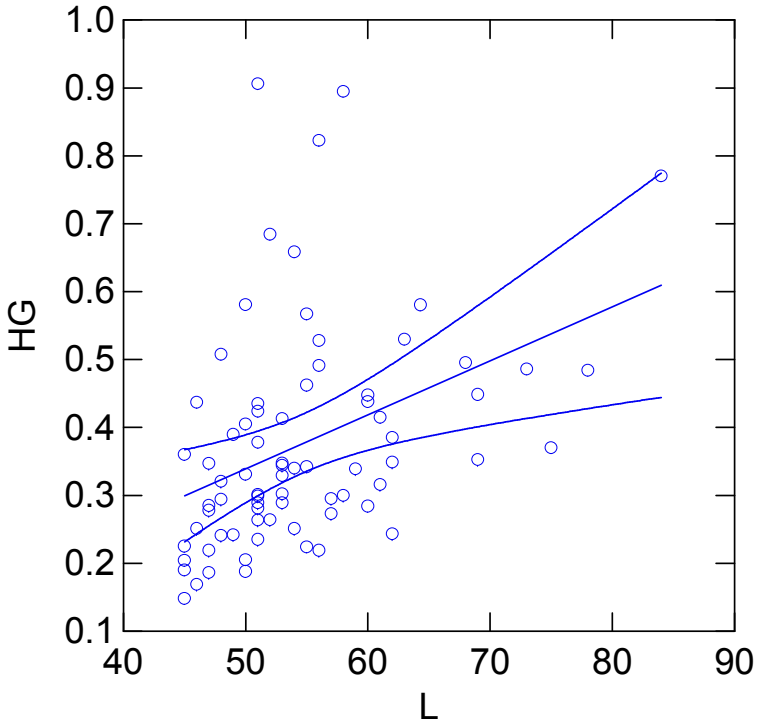
Adjusted squared multiple R: 0.177 Standard error of estimate: 0.147

Effect	Coefficient	Std Error	Std Coef	t	p(2 Tail)
CONSTANT	29.647	15.023	0	1.973	0.052
YEAR	-0.015	0.008	-0.209	-1.977	0.052
L	0.008	0.002	0.38	3.599	0.001

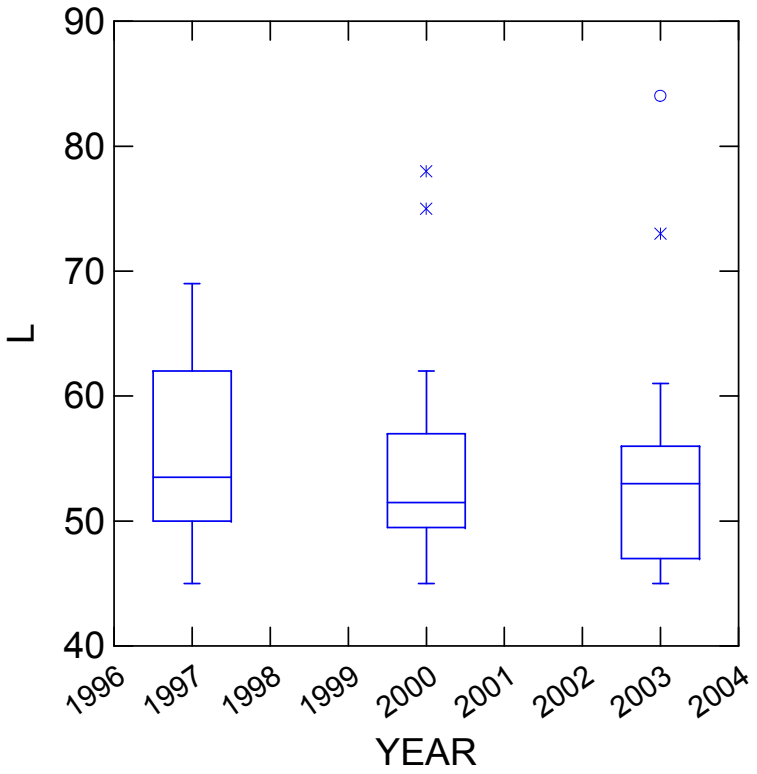
Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	p
Regression	0.388	2	0.194	8.933	<.001
Residual	1.563	72	0.022		

Length as factor in Striper Hg



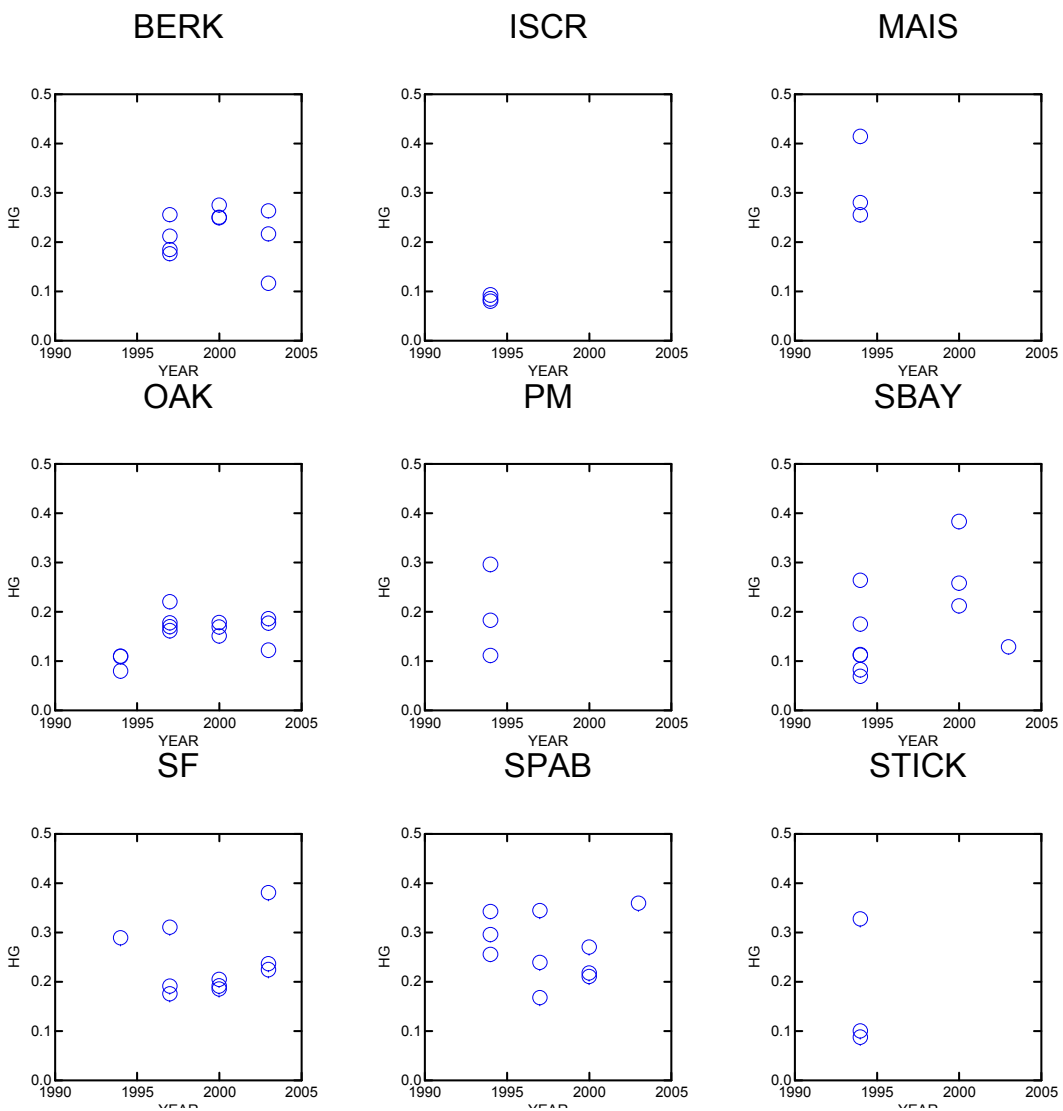
r^2=.15



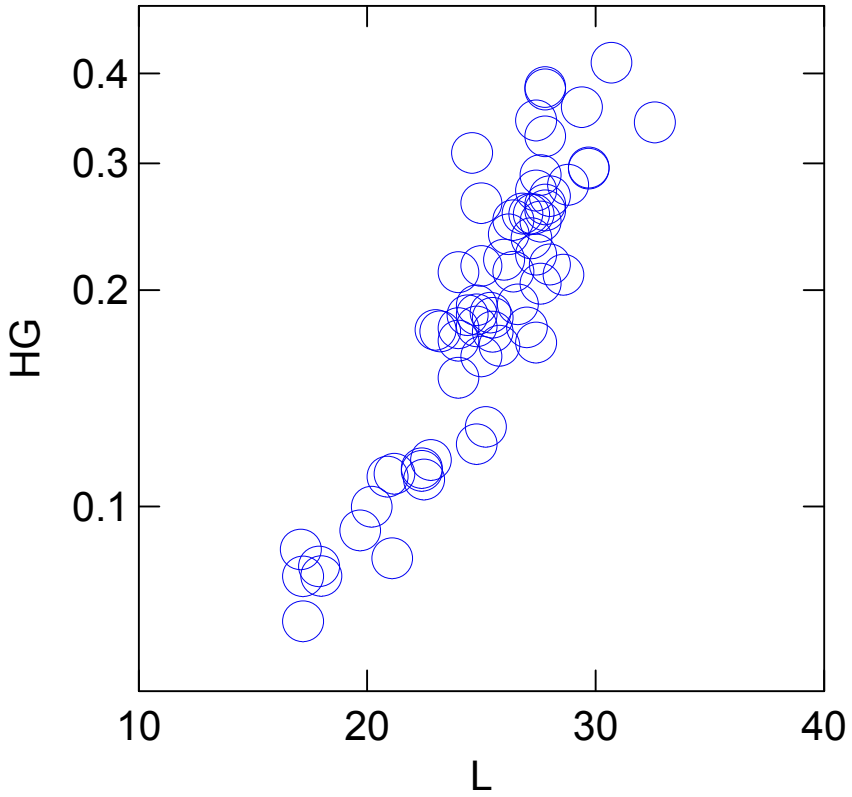
STBA Hg
Power analysis

- Efffects = 20%, 50% in 50 years
- Adjust for size
- C.V.= 43% x .85❼37%
- Cohen's d = .54, 1.35
- Power @ n=88: >99%
  - ♌80% @ n=40
- Worthwhile sampling in 20 years
- Does not matter where

Hg in White croaker



CROAKER Hg vs. length



Croaker Log(Hg) ANCOVA

Dep Var: LHG N: 29 Multiple R: 0.801 Squared multiple R: 0.642

Source	Sum-of-Squares	df	Mean-Square	F-ratio	p
YEAR	0.014	2	0.007	1.115	0.348
LOC$	0.051	2	0.026	3.954	0.037
YEAR*LOC$	0.023	4	0.006	0.907	0.480
L	0.065	1	0.065	10.105	0.005
Error	0.123	19	0.006		

Croaker Hg power analysis

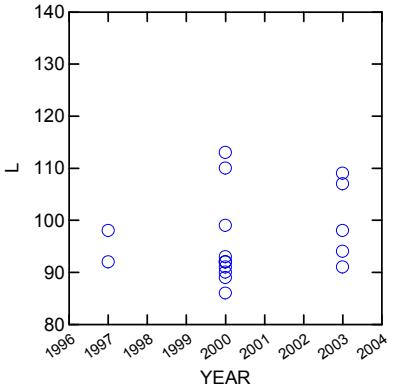
- C.V. = 41%
- Use log-linear function to correct for L
- Using ANOVA, resid. err.~36%
- Effective c.v.~15%
- Power to see 20%, 50% reduction

  >99%@ **n**>12
- 5% reduction, power good @ n>100

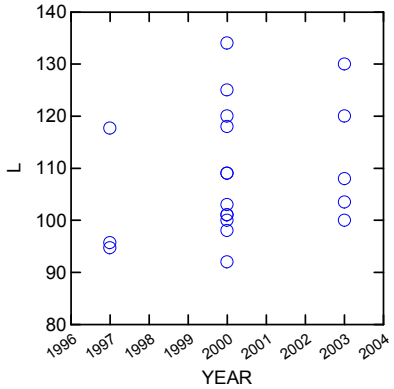
  Increase **n** now, then Get a piggy bank
- Get your fish (reps @ sites)

Hg in Leopard shark

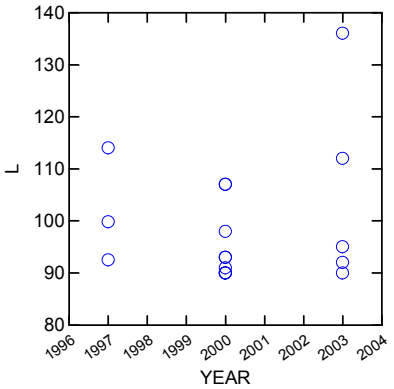
BERK



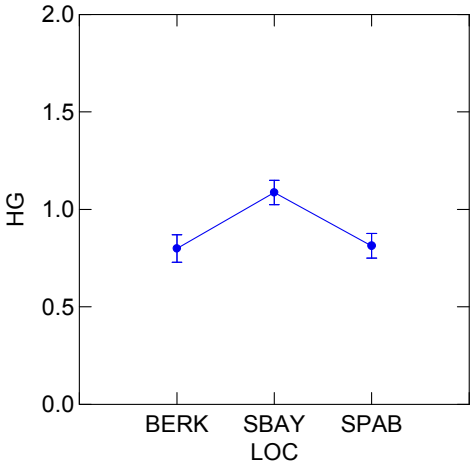
SBAY



SPAB

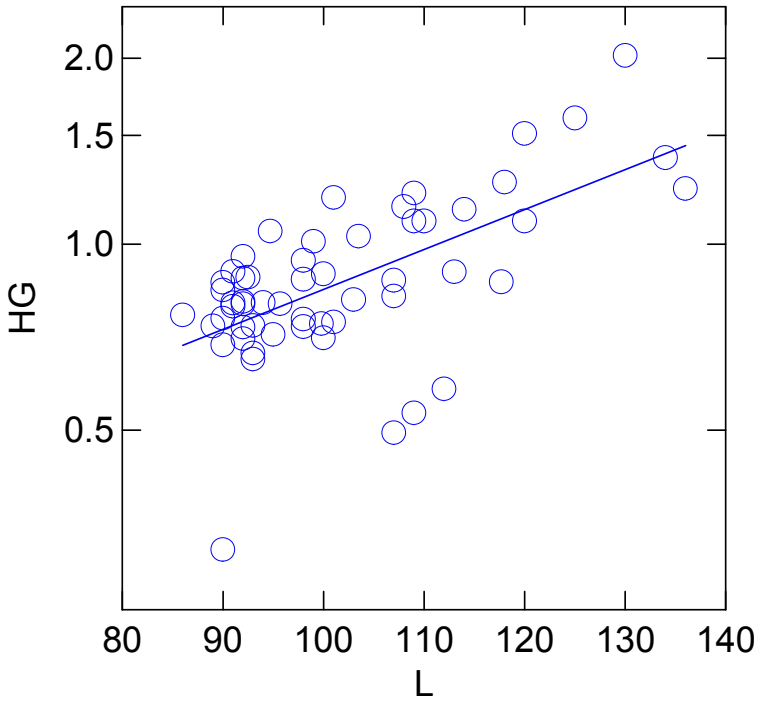


Least Squares Means



- Year is not significant (ANOVA)
- More big fish in So. Bay sample

Hg vs L in Leopard shark



Dep Var: HG N: 55 Multiple R: 0.745 R^2= 0.556

Source	Sum-of-Squares	df	Mean-Square	F-ratio	p
LOC$	0.388	2	0.194	5.122	0.009
L	1.064	1	1.064	28.094	<.001
Error	1.931	51	0.038		

Power analysis, Hg in Leopard shark

- >half of variance accounted for
- Effective c.v.~ 14%
- No trend over 6 years
- Power good as in white croaker
- Realistic to see 5% improvement
  - Increase **n** now for future comparison
  - Maintain spatial coverage with replicates
  - Then bank sample size and wait 10 years

Summary

	Trend?	2006 sample	Future sample
PCB	None	no	Consider hiatus
DDT	❽ s.perch ~❽ w.croak	?	Confirm trend?
Hg	None	Increase **n** in whcr, stba	5-10 yr, 100 whcr, lesh 10-20 yr, 88 stba