Presentation to

Lake Okeechobee Technical Advisory Committee

W. Walker

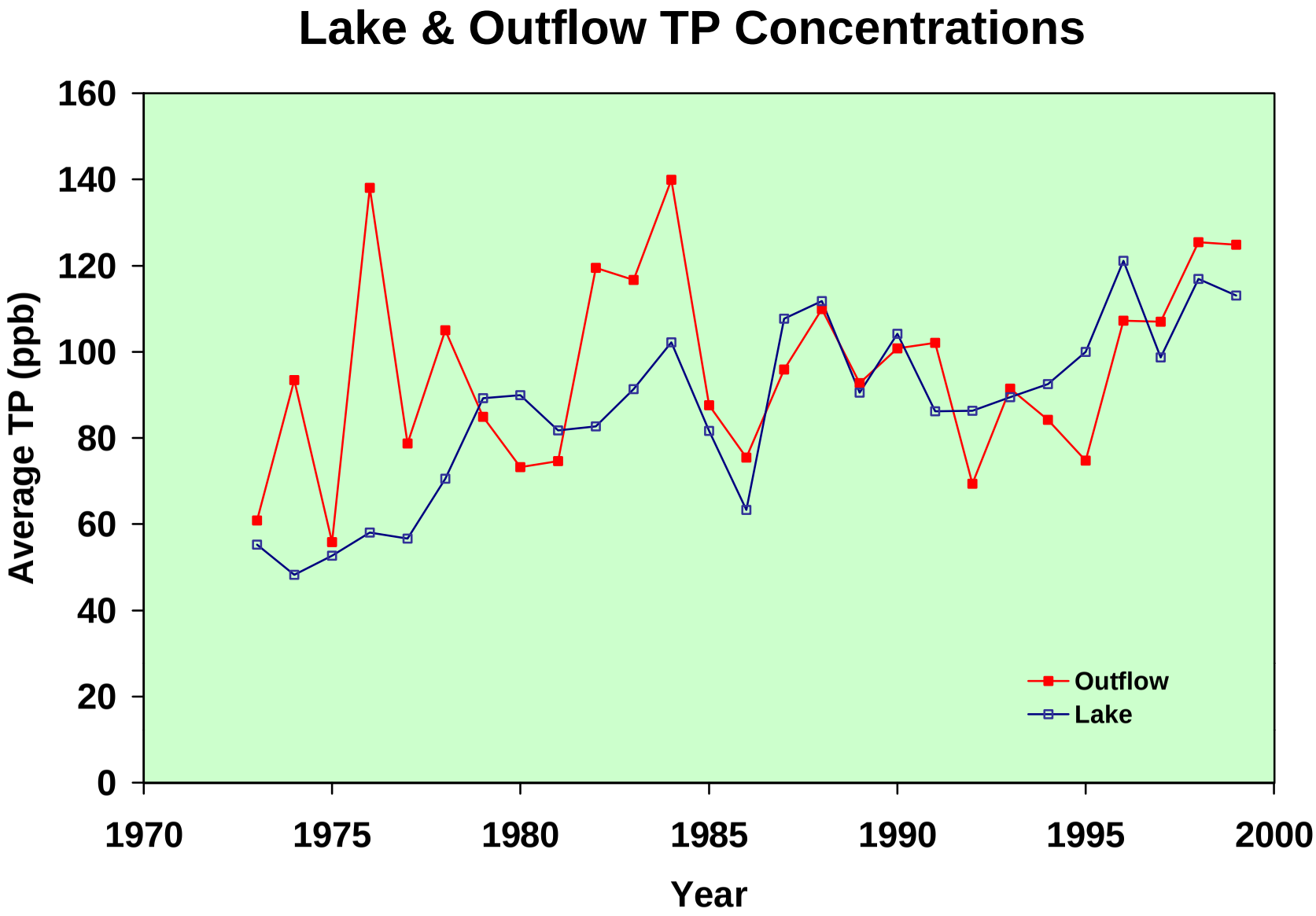
May 3, 2000

Lake Inflow & Outflow Data

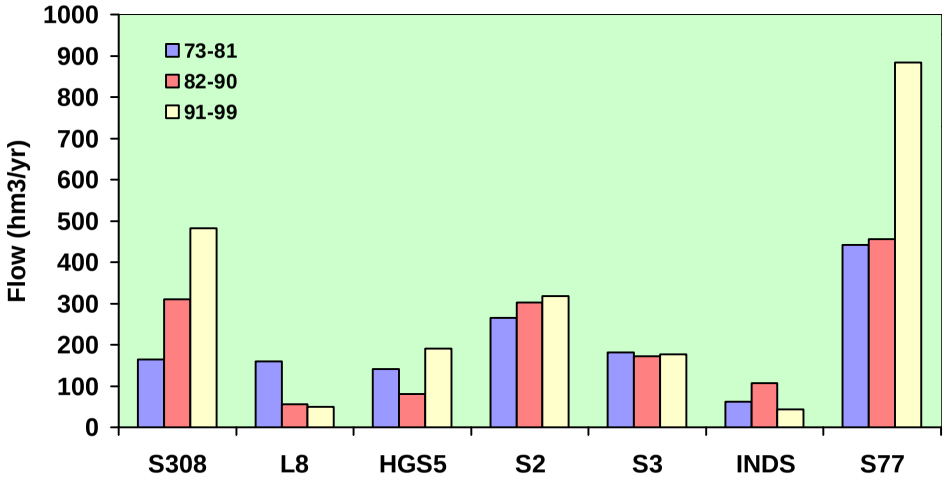
- **Outflow Concs. Vs. Lake Concs.**
- **Structure Flows & Loads**
- **Inflow & Outflow Conc. Trends**
- **Data Limitations**

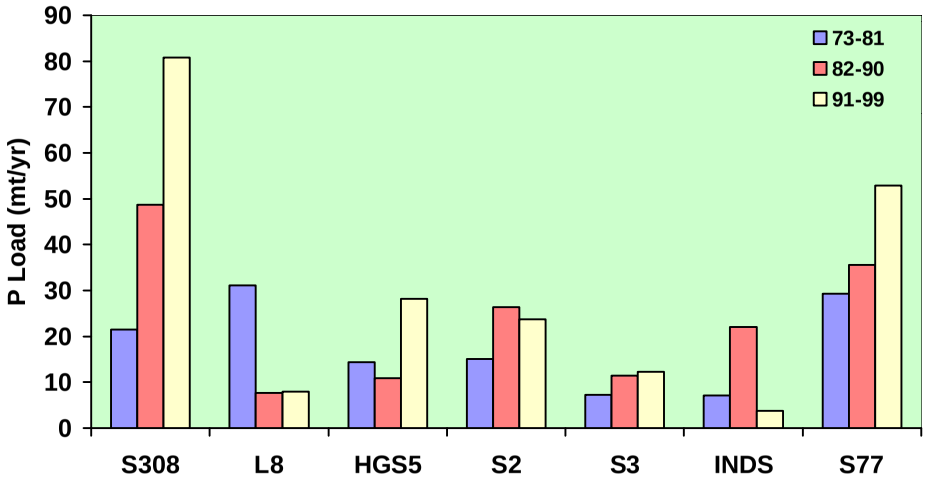
Refinements to P Mass Balance Model

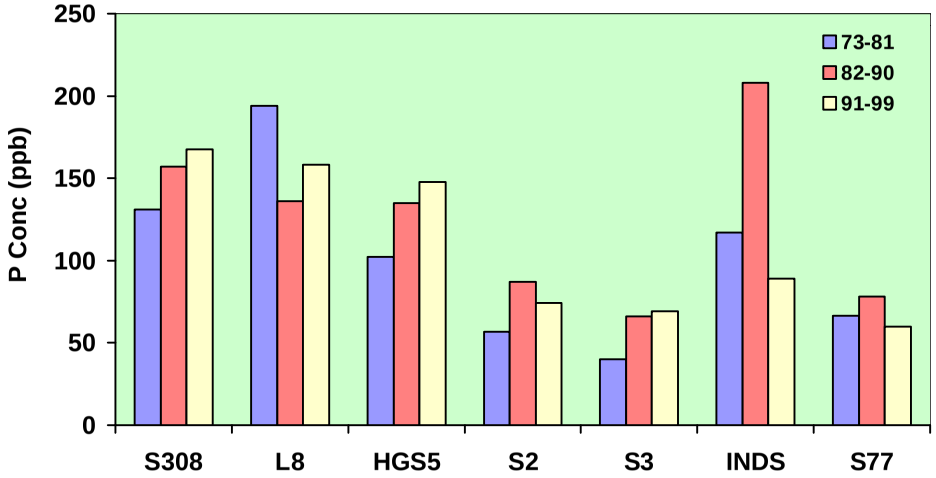
- **Addition of 1999 Data**
- **Settling Rate Estimation**
- **Net Inflow Estimation**


Lake & Outflow TP Concentrations
Average TP (ppb)
160
140
120
100
80
60
40
20
0
1970
1975
1980
1985
1990
1995
2000
Year
Outflow
Lake

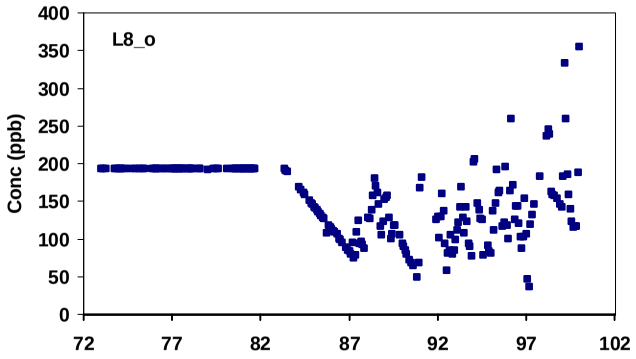
Lake Okeechobee Outflows by Structure

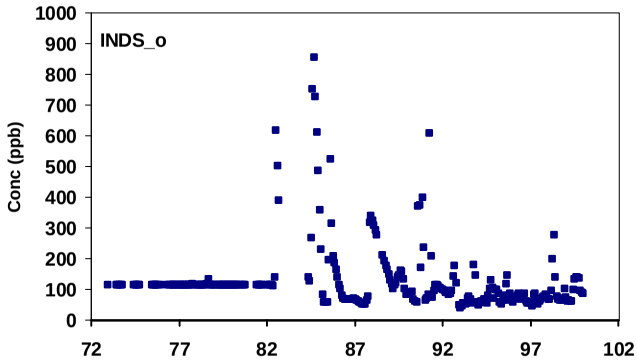


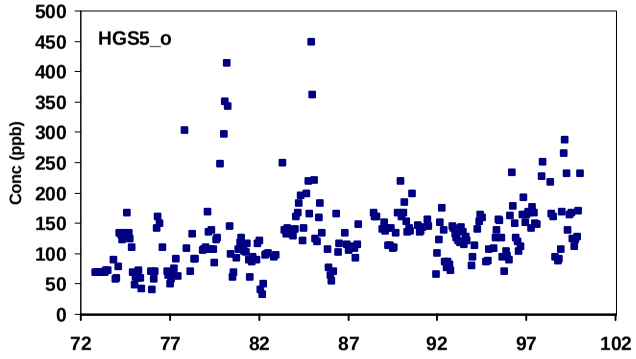


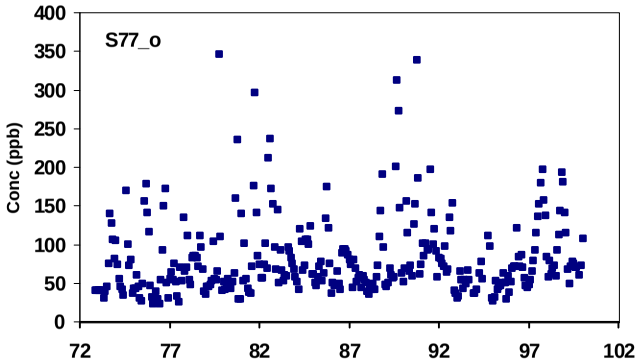


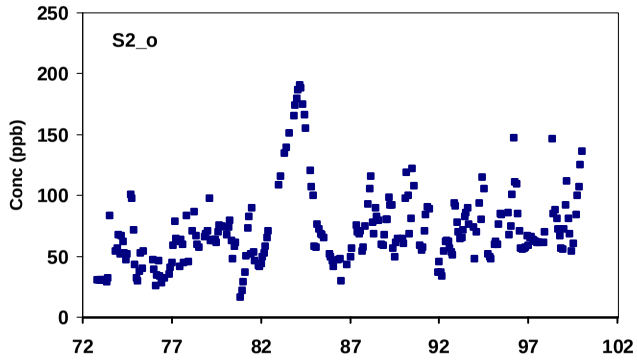
Monthly Flow-Weighted Mean Total P Concentrations at Lake Outflow Stations

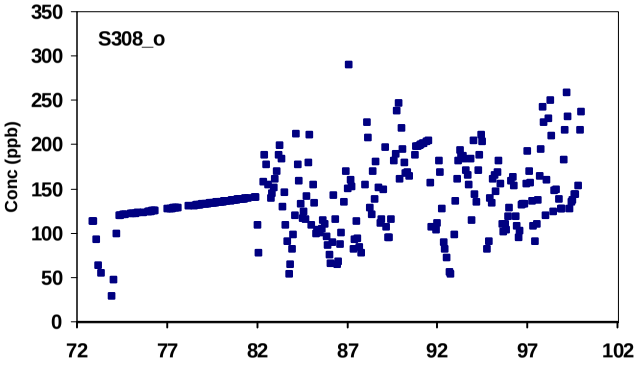


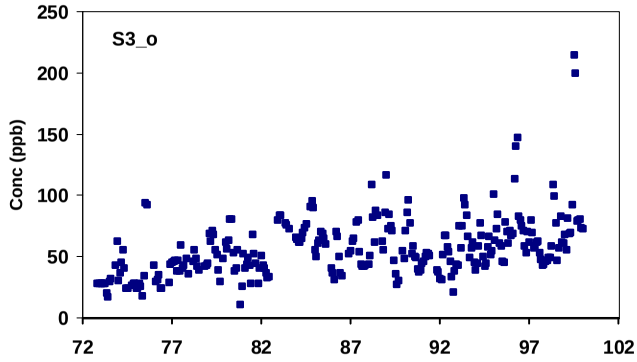


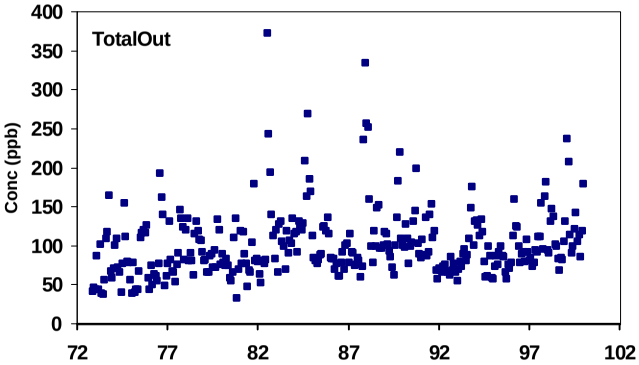












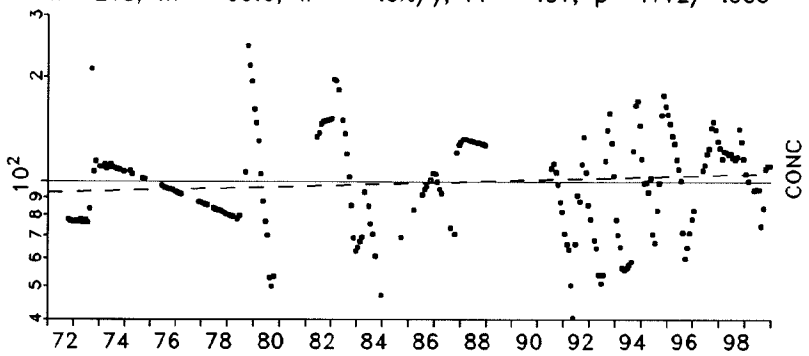
Lake Okeechobee Inflows & Outflows by Structure
Average Values, 1973-1999

Structure	Flow hm3/yr	%	Load kg/yr	%	Conc ppb	Trend %/yr	p	
Inflows								
S131	7.9	0.3%	856.8	0.2%	108	0.5	0.383	
S71	195.9	7.3%	42822.1	9.3%	219	-1.9	0.005	**
S129	14.4	0.5%	2025.7	0.4%	141	-2.1	0.036	**
S72	49.0	1.8%	9901.7	2.2%	202	0.0	1.000	
S127	21.9	0.8%	7049.8	1.5%	323	-4.5	0.000	**
S84	183.1	6.9%	11661.3	2.5%	64	-0.9	0.234	
S65E	1292.4	48.4%	125131.4	27.2%	97	1.3	0.044	**
S154	33.4	1.2%	22728.5	4.9%	681	5.0	0.004	**
S133	27.3	1.0%	7612.8	1.7%	279	-3.3	0.000	**
S191	137.7	5.2%	106096.2	23.1%	770	-3.0	0.000	**
S135	25.0	0.9%	2629.5	0.6%	105	-0.3	0.614	
S308	71.7	2.7%	10752.9	2.3%	150	3.0	0.001	**
L8	63.0	2.4%	6180.3	1.3%	98	0.0	0.703	
C10	10.2	0.4%	3868.7	0.8%	379	4.5	0.000	**
C12A	9.0	0.3%	1461.0	0.3%	163	-5.3	0.000	**
C12	15.9	0.6%	2603.9	0.6%	164	0.0	0.876	
S2	122.2	4.6%	22428.6	4.9%	184	1.5	0.032	**
C4A	7.2	0.3%	703.4	0.2%	98	-0.1	0.772	
S3	46.1	1.7%	8134.6	1.8%	177	1.5	0.333	
S236	11.6	0.4%	1108.2	0.2%	96	-1.1	0.105	
INDS	16.8	0.6%	4156.2	0.9%	248	-10.4	0.000	**
S4	33.3	1.2%	7345.0	1.6%	221	2.7	0.070	*
FECR	227.5	8.5%	45533.9	9.9%	200	0.0	0.990	
L61W	10.5	0.4%	878.0	0.2%	84	0.0	0.058	*
L61E	6.9	0.3%	1182.8	0.3%	172	0.0	0.001	**
L60W	0.4	0.0%	64.1	0.0%	156	-0.1	0.003	**
L60E	1.2	0.0%	159.8	0.0%	132	0.0	0.198	
L59W	8.1	0.3%	1066.9	0.2%	131	0.0	0.097	*
L59E	6.3	0.2%	1927.1	0.4%	308	0.0	0.003	**
NIC	3.3	0.1%	199.7	0.0%	60	0.0	0.001	**
S77	6.7	0.2%	1046.1	0.2%	157	6.6	0.155	
HGS5	4.9	0.2%	879.9	0.2%	179	-5.3	0.271	
TotalIn	2670.5	100.0%	460196.9	100.0%	172	-0.7	0.214	
Outflows								
S308_o	331.2	18.9%	49961.0	30.5%	151	1.7	0.002	**
L8_o	92.3	5.3%	15303.5	9.4%	166	-1.5	0.017	**
HGS5_o	144.8	8.3%	16358.0	10.0%	113	2.5	0.000	**
S2_o	310.1	17.7%	21613.3	13.2%	70	2.0	0.002	**
S3_o	184.9	10.5%	10257.2	6.3%	55	2.7	0.000	**
INDS_o	72.9	4.2%	11319.8	6.9%	155	-1.8	0.008	**
S77_o	617.5	35.2%	38769.8	23.7%	63	1.3	0.040	**
TotalOut	1753.6	100.0%	163582.6	100.0%	93	1.1	0.013	**

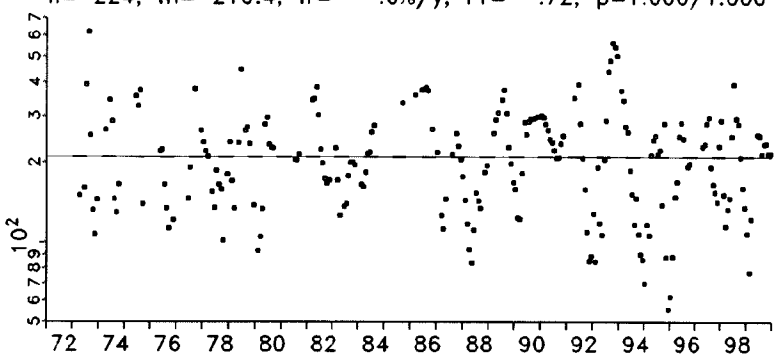
p - significance level, seasonal kendall test on monthly flow-wtd mean concs.

Lake Okeechobee Inflow & Outflow TP Conc. (ppb) 1973–1999

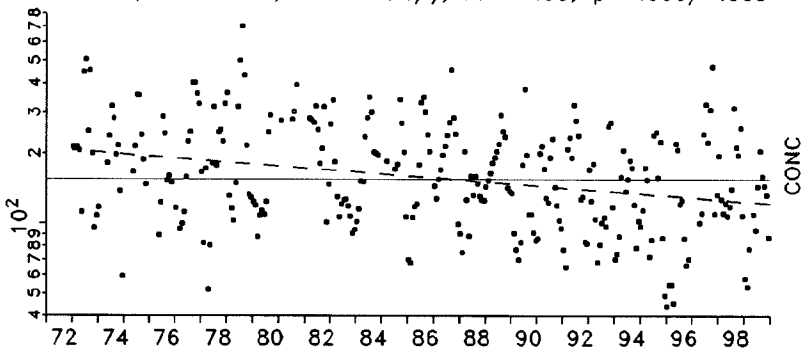
S131
n= 218, m= 99.6, tr= .5%/y, r1= .81, p= .112/ .383



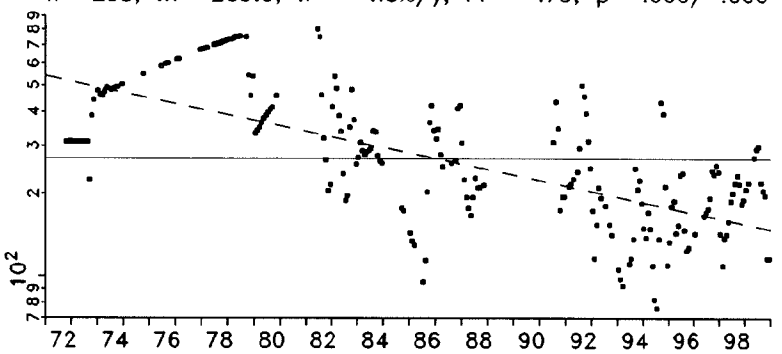
S72
n= 224, m= 210.4, tr= .0%/y, r1= .72, p=1.000/1.000



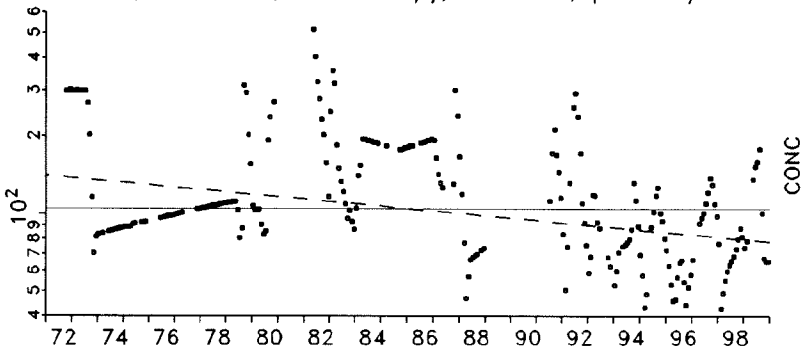
S71
n= 285, m= 154.9, tr= -1.9%/y, r1= .55, p= .000/ .005



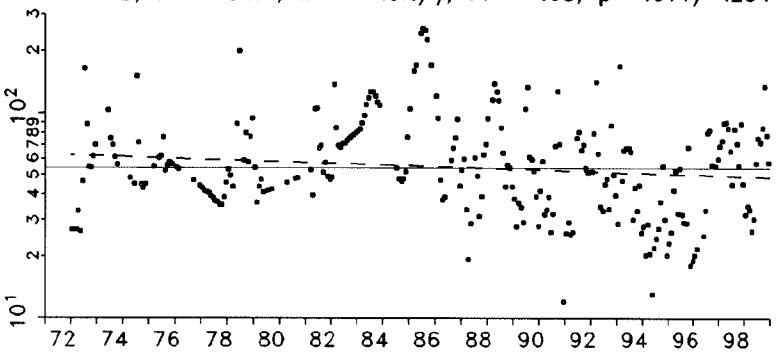
S127
n= 208, m= 269.0, tr= -4.5%/y, r1= .79, p= .000/ .000



S129
n= 234, m= 104.2, tr= -2.1%/y, r1= .86, p= .000/ .036

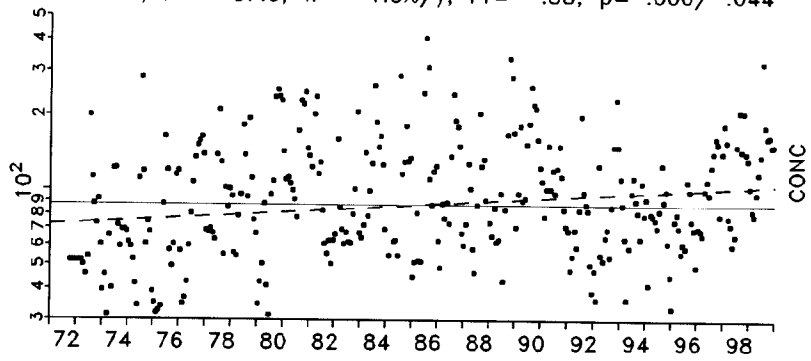


S84
n= 262, m= 54.1, tr= -.9%/y, r1= .68, p= .011/ .234

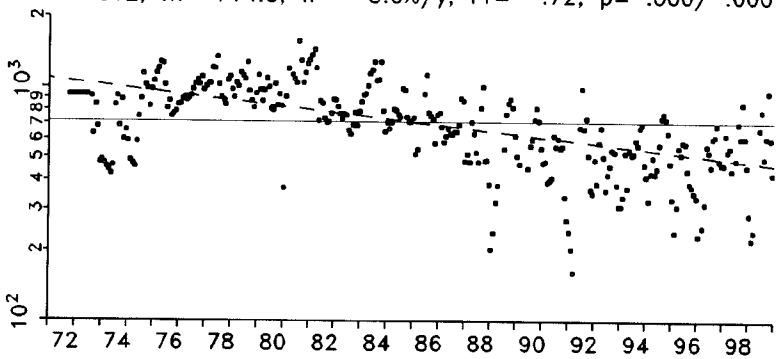


Lake Okeechobee Inflow & Outflow TP Conc. (ppb) 1973–1999

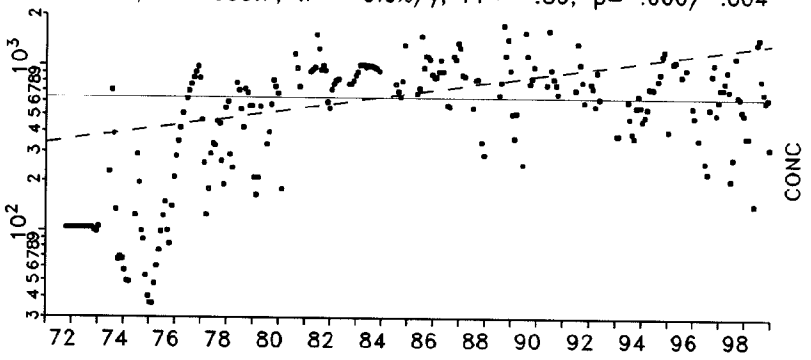
S65E
n= 324, m= 87.5, tr= 1.3%/y, r1= .58, p= .000/ .044



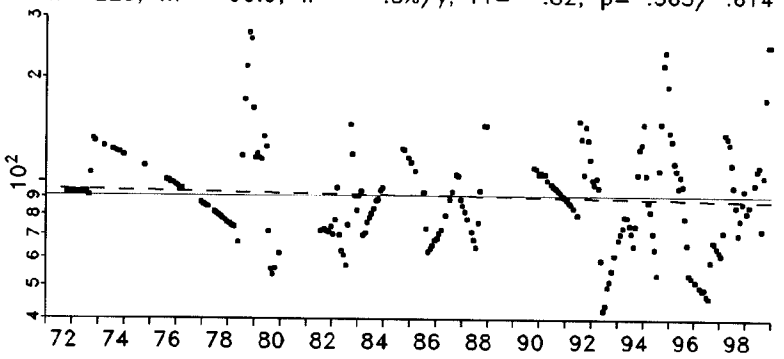
S191
n= 312, m= 714.8, tr= -3.0%/y, r1= .72, p= .000/ .000



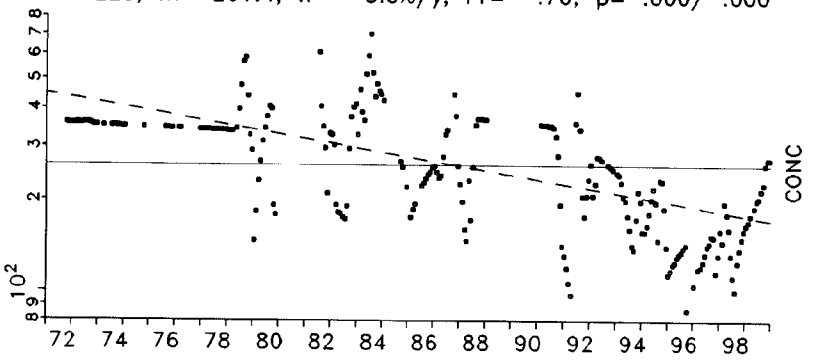
S154
n= 239, m= 635.7, tr= 5.0%/y, r1= .80, p= .000/ .004



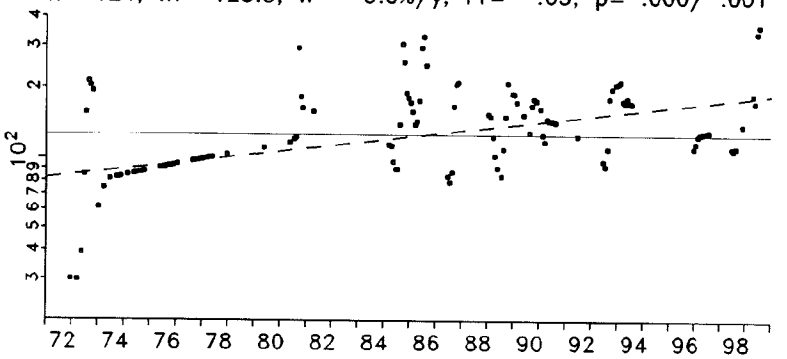
S135
n= 225, m= 90.9, tr= -.3%/y, r1= .82, p= .365/ .614



S133
n= 228, m= 261.4, tr= -3.3%/y, r1= .76, p= .000/ .000

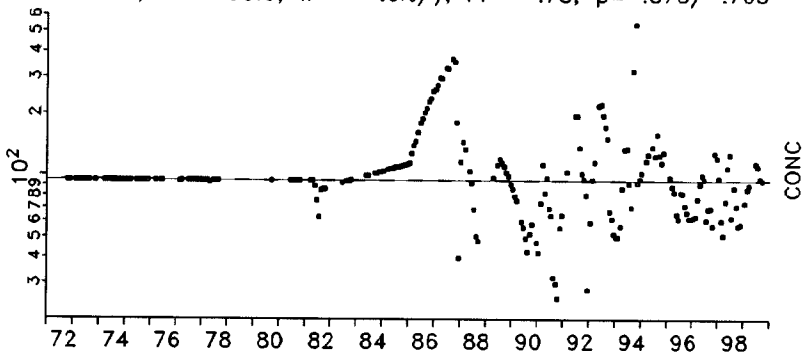


S308
n= 124, m= 125.5, tr= 3.0%/y, r1= .63, p= .000/ .001

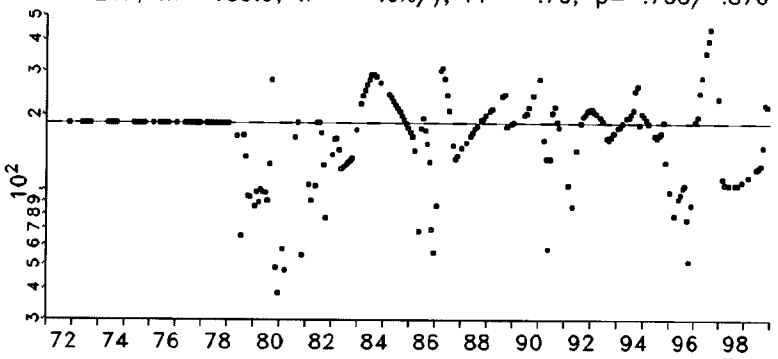


Lake Okeechobee Inflow & Outflow TP Conc. (ppb) 1973–1999

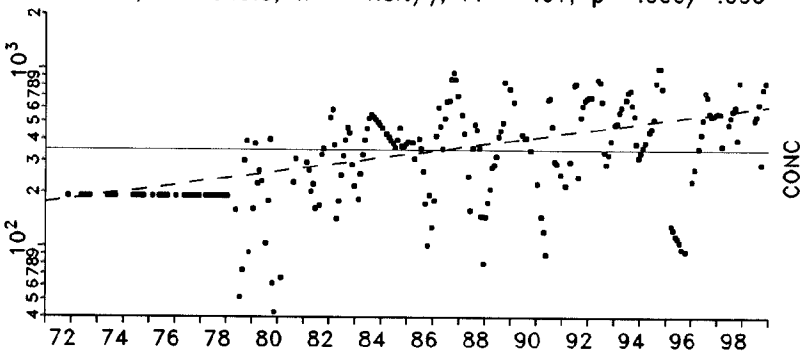
L8
n= 218, m= 95.0, tr= .0%/y, r1= .78, p= .375/ .703



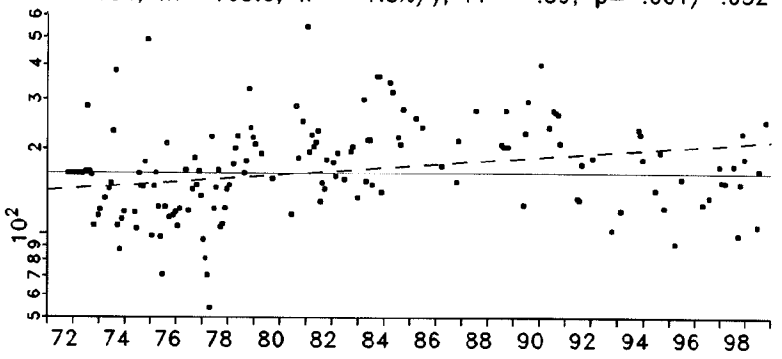
C12
n= 217, m= 185.9, tr= .0%/y, r1= .70, p= .738/ .876



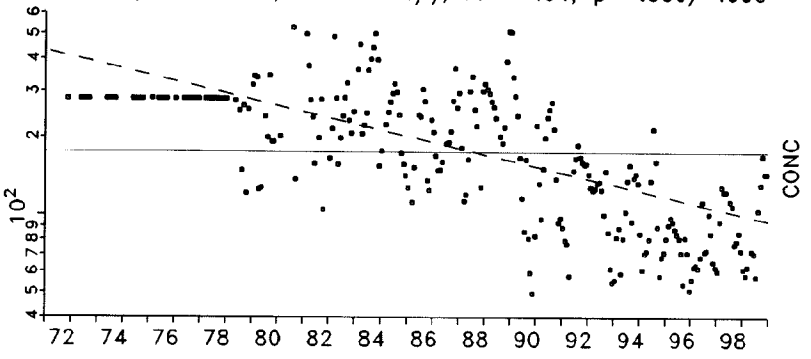
C10
n= 232, m= 349.8, tr= 4.5%/y, r1= .61, p= .000/ .000



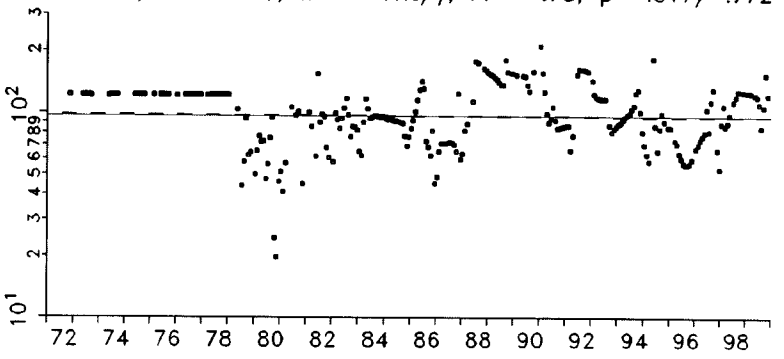
S2
n= 154, m= 163.6, tr= 1.5%/y, r1= .39, p= .001/ .032



C12A
n= 262, m= 175.1, tr= -5.3%/y, r1= .64, p= .000/ .000



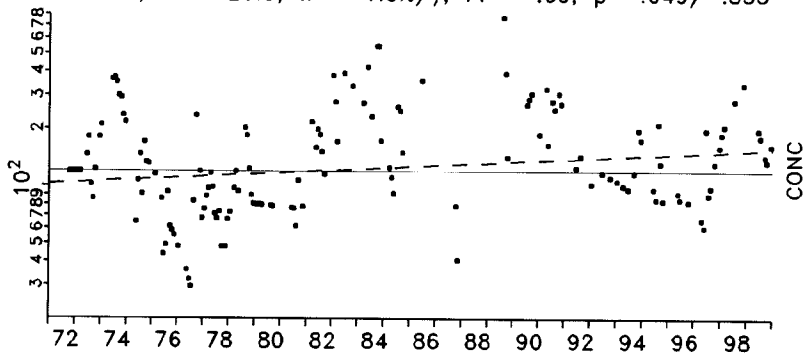
C4A
n= 255, m= 96.5, tr= -.1%/y, r1= .73, p= .517/ .772



Lake Okeechobee Inflow & Outflow TP Conc. (ppb) 1973–1999

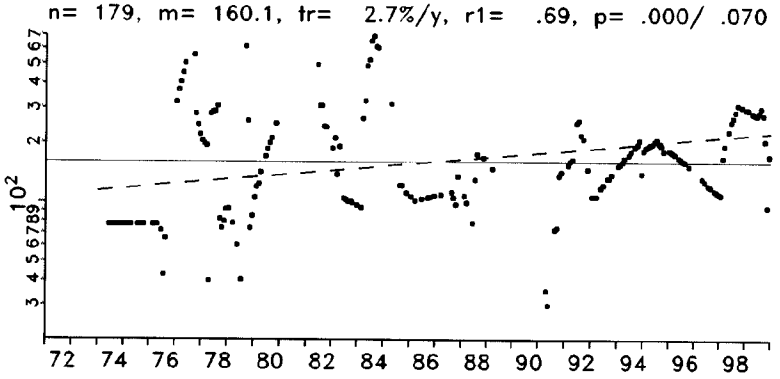
S3

n= 145, m= 120.3, tr= 1.5%/y, r1= .60, p= .049/ .333



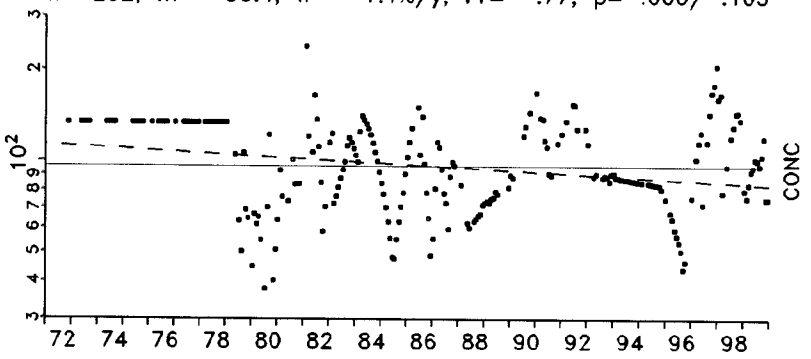
S4

n= 179, m= 160.1, tr= 2.7%/y, r1= .69, p= .000/ .070



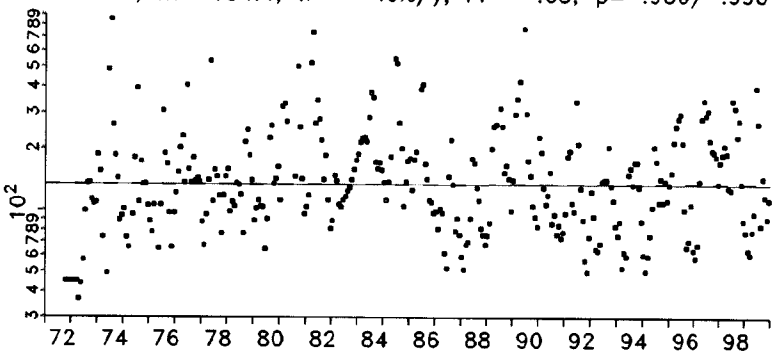
S236

n= 232, m= 96.4, tr= -1.1%/y, r1= .77, p= .000/ .105



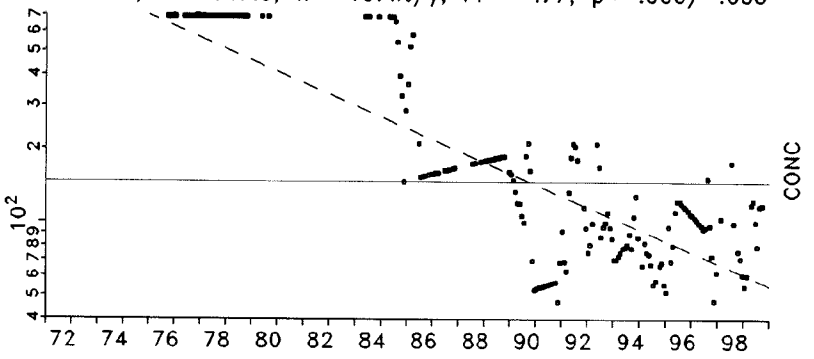
FECR

n= 317, m= 134.4, tr= .0%/y, r1= .65, p= .980/ .990



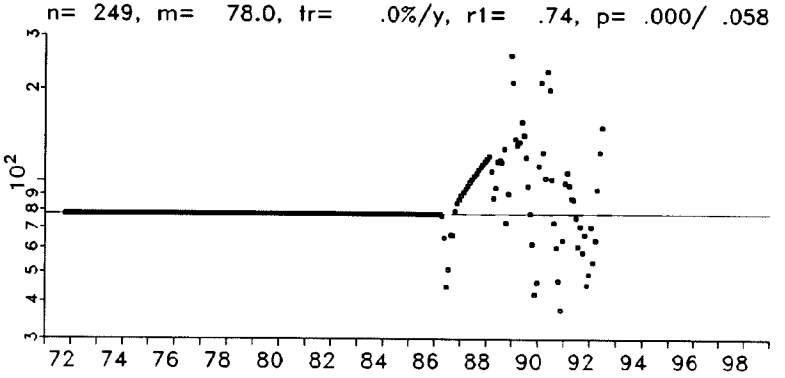
INDS

n= 183, m= 147.0, tr=-10.4%/y, r1= .77, p= .000/ .000



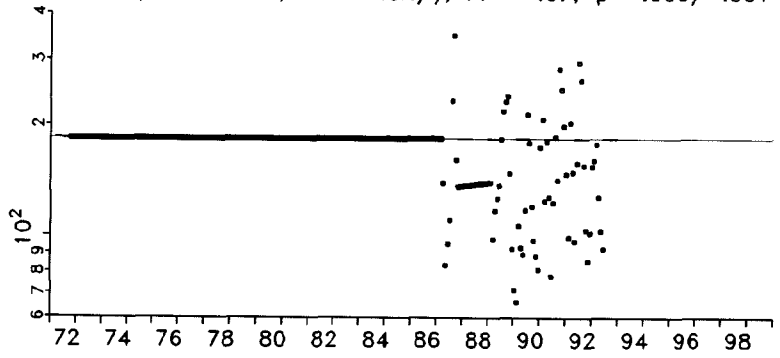
L61W

n= 249, m= 78.0, tr= .0%/y, r1= .74, p= .000/ .058

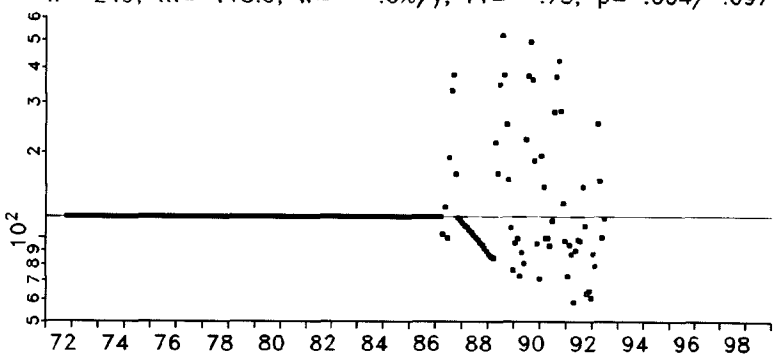


Lake Okeechobee Inflow & Outflow TP Conc. (ppb) 1973–1999

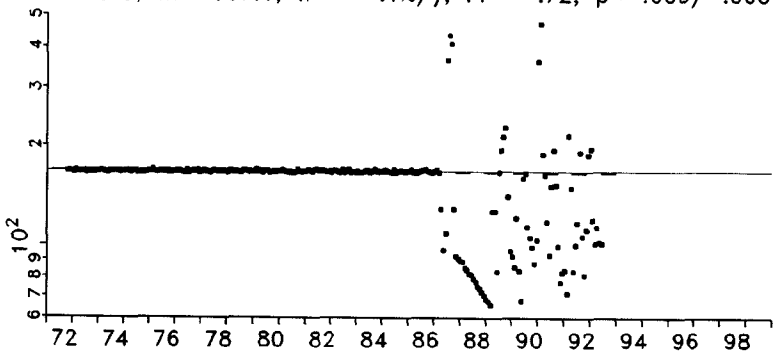
L61E
n= 249, m= 183.9, tr= .0%/y, r1= .67, p= .000/ .001



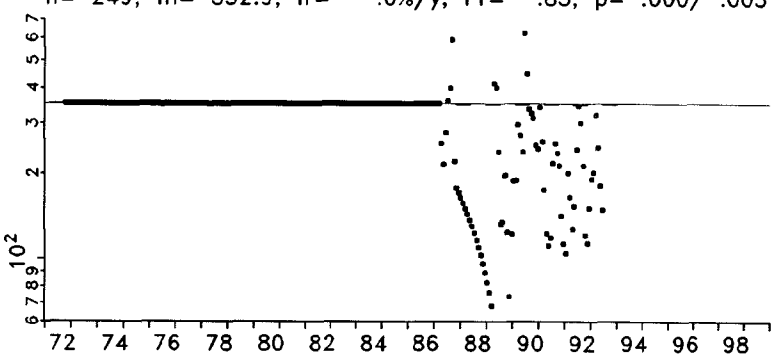
L59W
n= 249, m= 118.0, tr= .0%/y, r1= .73, p= .004/ .097



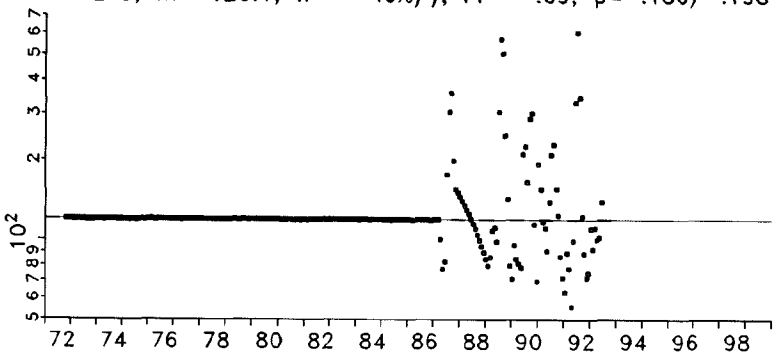
L60W
n= 249, m= 167.1, tr= -.1%/y, r1= .72, p= .000/ .003



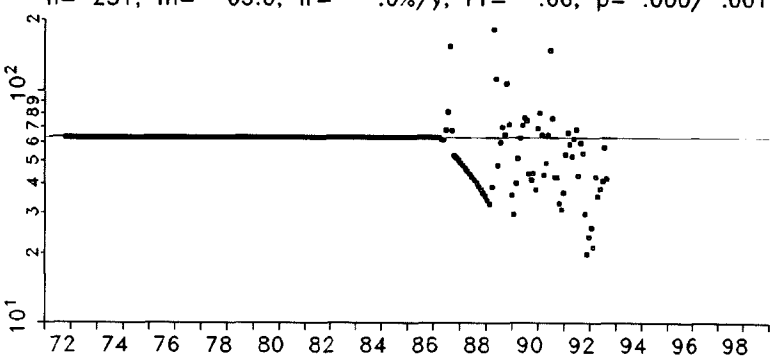
L59E
n= 249, m= 352.9, tr= .0%/y, r1= .85, p= .000/ .003



L60E
n= 249, m= 120.1, tr= .0%/y, r1= .69, p= .186/ .198



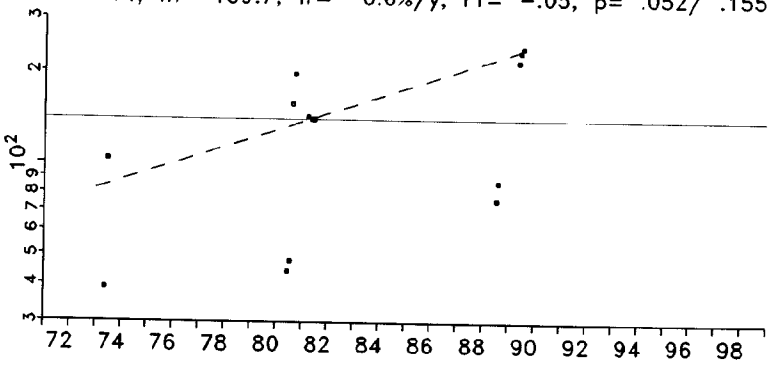
NIC
n= 251, m= 63.0, tr= .0%/y, r1= .66, p= .000/ .001



Lake Okeechobee Inflow & Outflow TP Conc. (ppb) 1973–1999

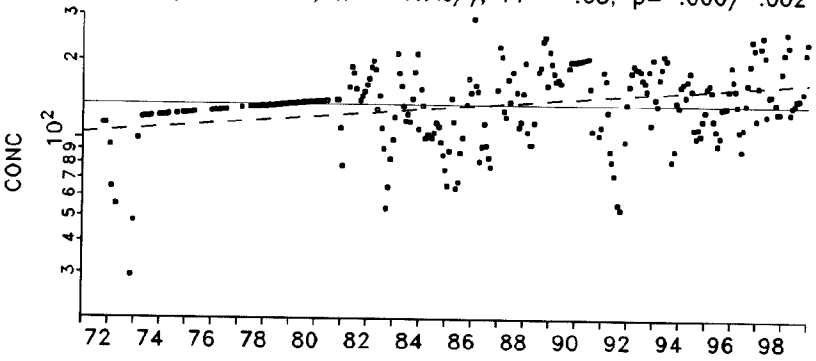
S77

n= 14, m= 139.7, tr= 6.6%/y, r1= -.05, p= .052/ .155



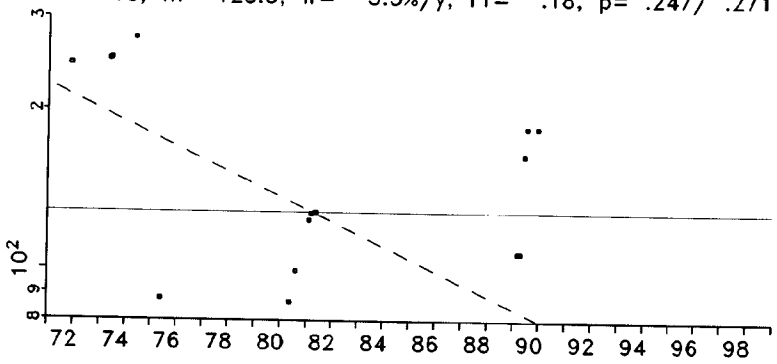
S308 o

n= 264, m= 135.4, tr= 1.7%/y, r1= .68, p= .000/ .002



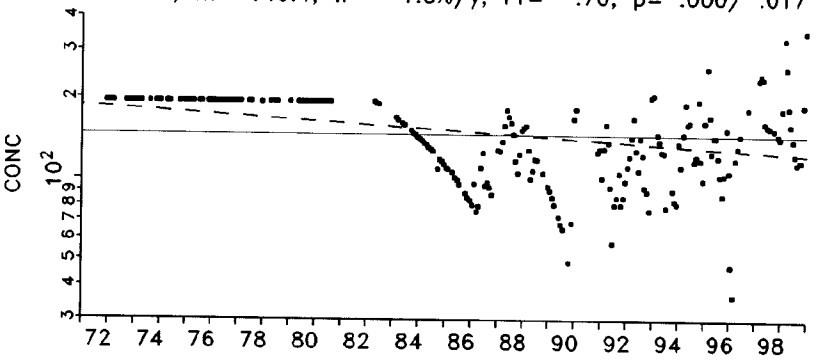
HGS5

n= 15, m= 128.5, tr= -5.3%/y, r1= .18, p= .247/ .271



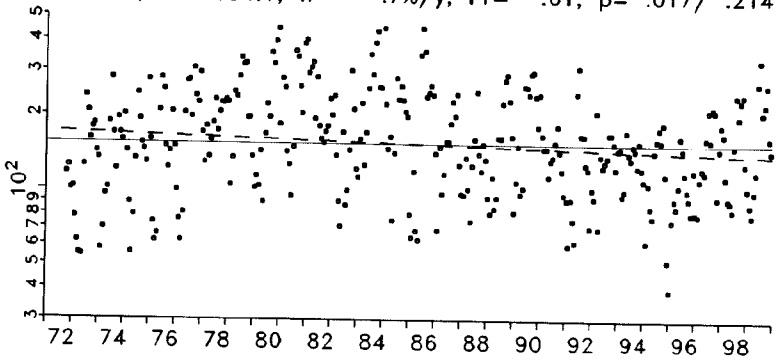
L8 o

n= 215, m= 146.4, tr= -1.5%/y, r1= .70, p= .000/ .017



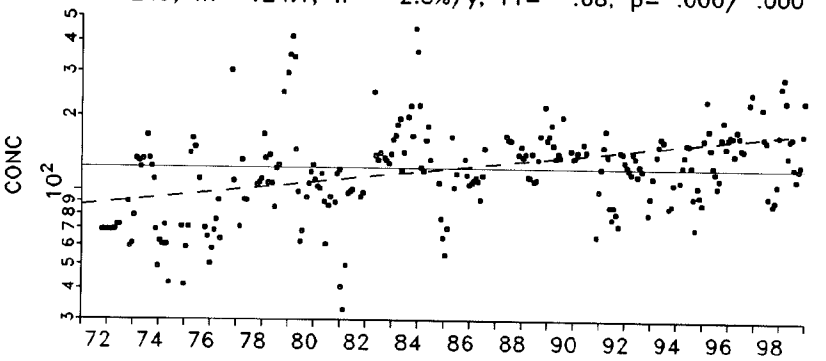
TotalIn

n= 327, m= 154.1, tr= -.7%/y, r1= .61, p= .017/ .214



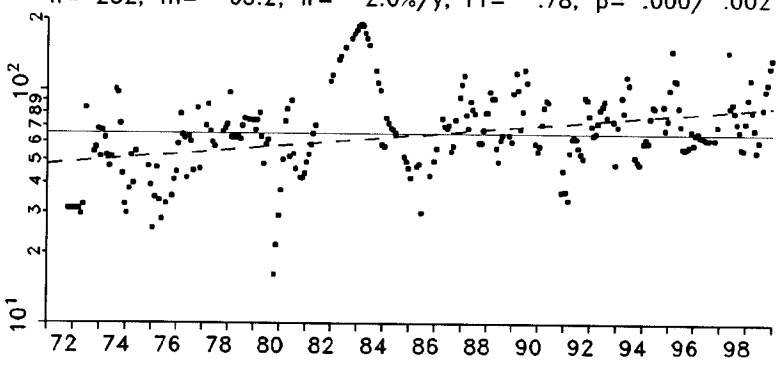
HGS5 o

n= 249, m= 124.1, tr= 2.5%/y, r1= .68, p= .000/ .000

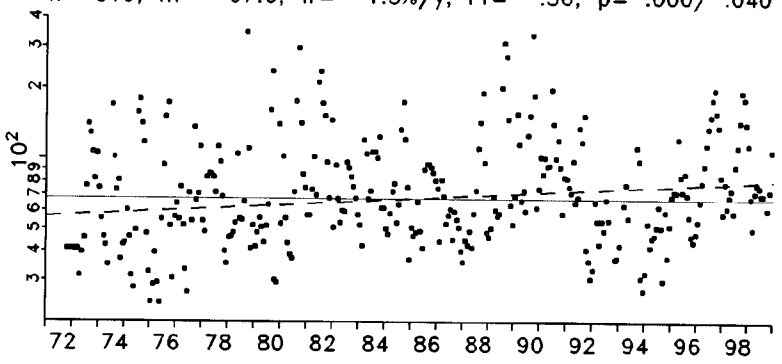


Lake Okeechobee Inflow & Outflow TP Conc. (ppb) 1973–1999

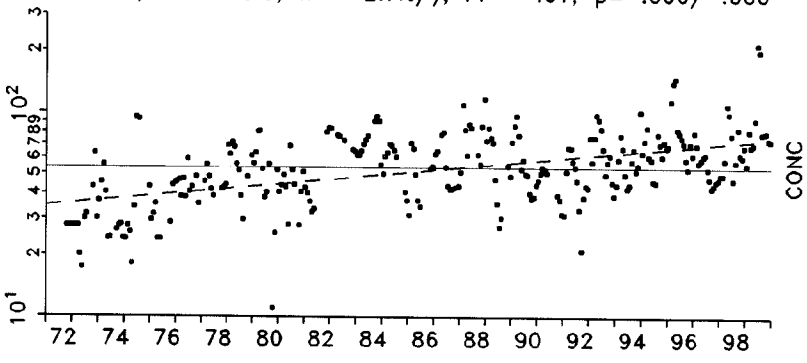
S2 o
n= 252, m= 65.2, tr= 2.0%/y, r1= .78, p= .000/ .002



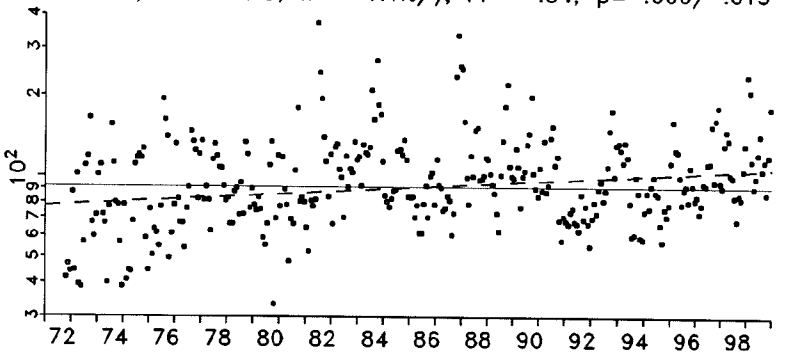
S77 o
n= 319, m= 67.6, tr= 1.3%/y, r1= .56, p= .000/ .040



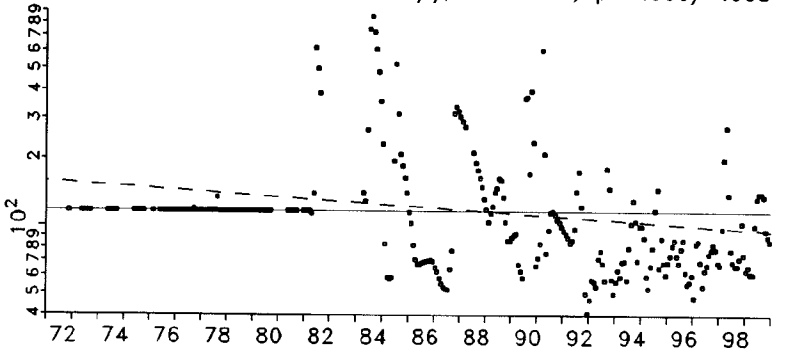
S3 o
n= 275, m= 53.5, tr= 2.7%/y, r1= .61, p= .000/ .000



TotalOut
n= 327, m= 91.3, tr= 1.1%/y, r1= .54, p= .000/ .013



INDS o
n= 267, m= 117.0, tr= -1.8%/y, r1= .75, p= .000/ .008



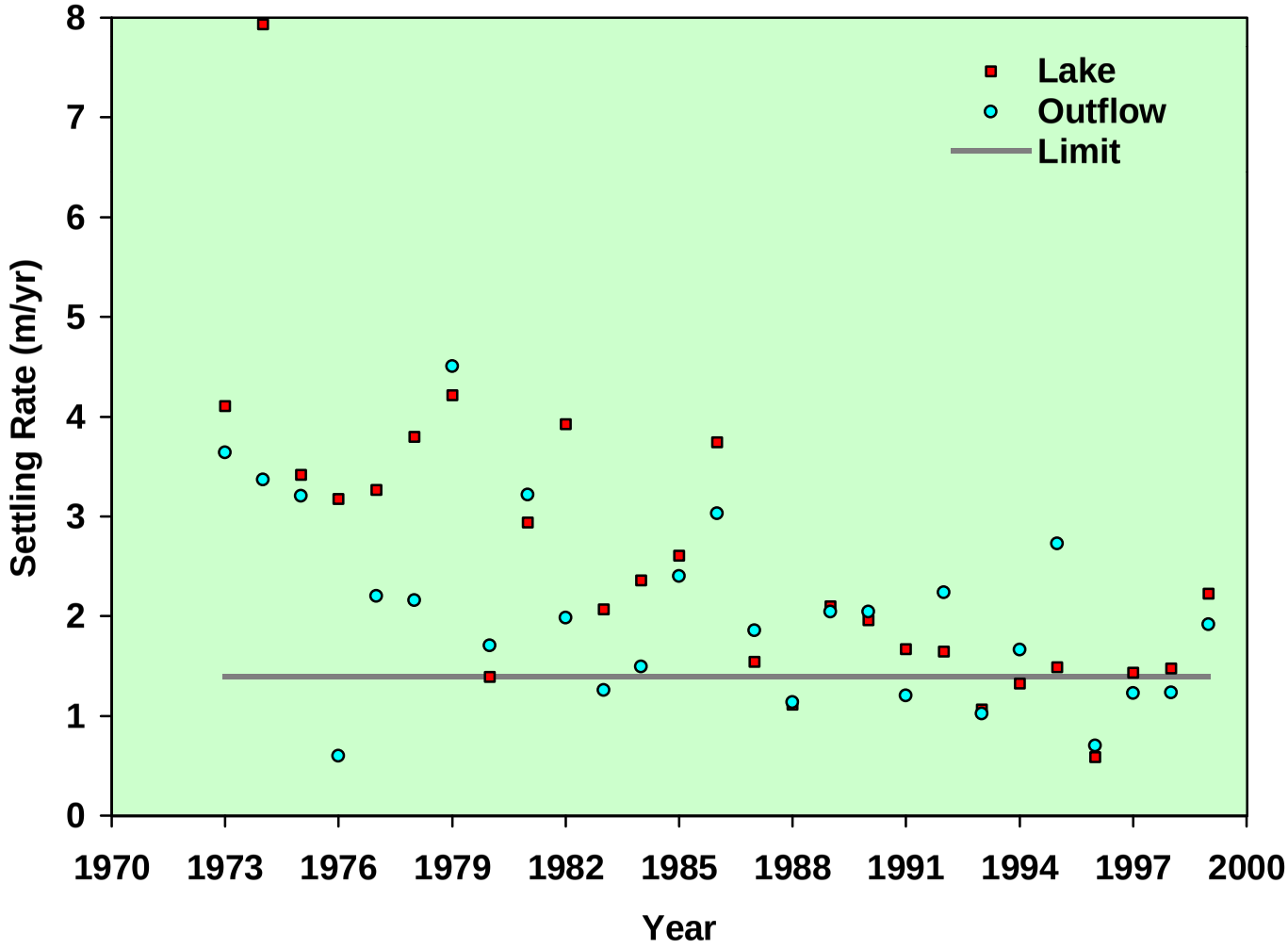
Revised TMDL Calculations for Lake Okeechobee

W. Walker, LOTAC, May 2, 2000

TMDL = Qnet Ctarget + Knet Area Ctarget

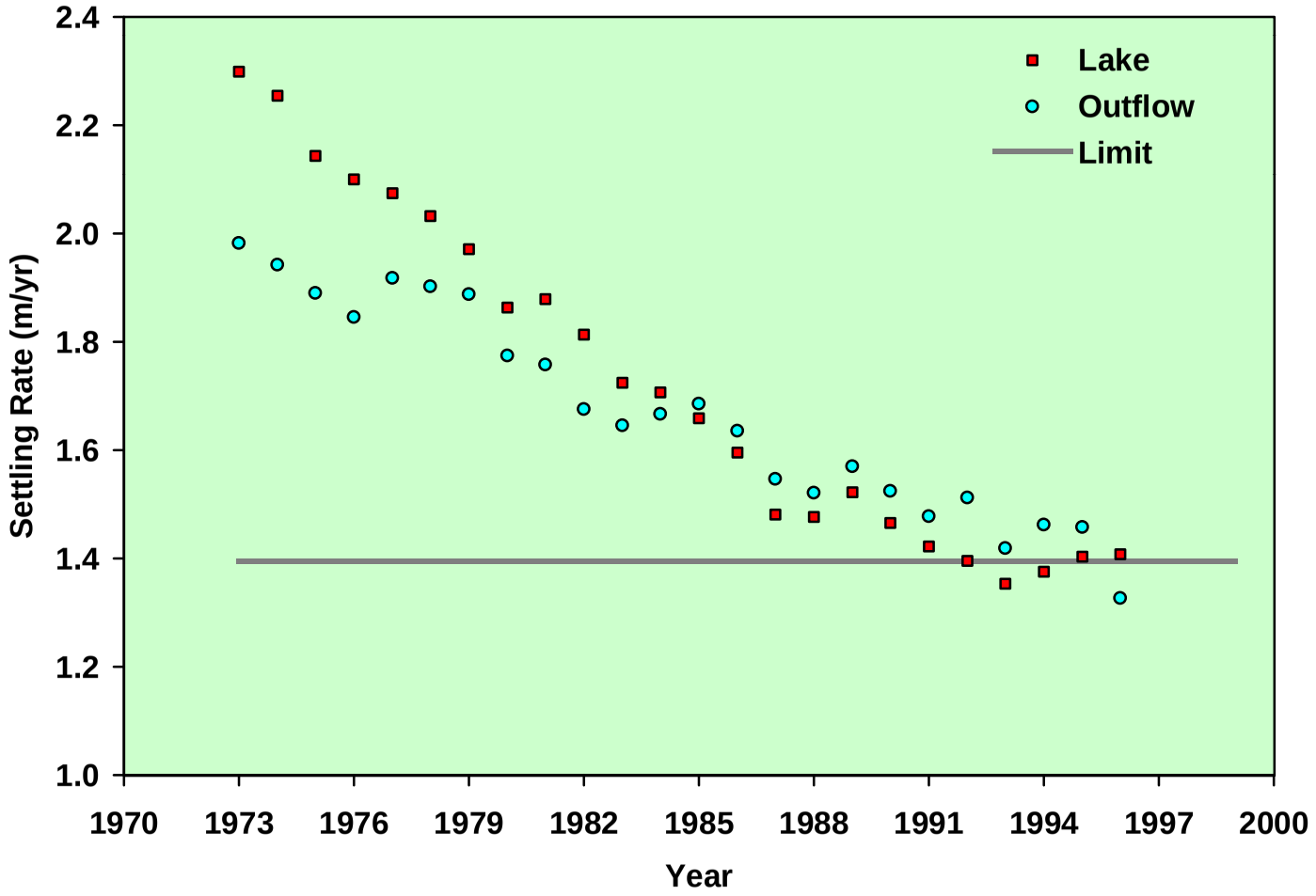
Target Conc (ppb)			
	April	40	LOTAC consensus
	Revised	40	" "
Area (km2)			
	April	1730	1973-1998 Mean
	Revised	1733	1973-1999 Mean
Rainfall P Load (mg/m2-yr)			
	April	20	assumed
	Revised	18	LOTAC consensus
Settling Rate (m/yr)			
	April	1.22	1994-1998 mean
	Revised	1.40	1992-1999 mean (~steady state ?)
Net Inflow (hm3/yr)			
	April	1751	1973-1998 mean
	Revised	1945	1965-1995 mean for Restudy Alt-D13R
TMDL (mtons/yr)			
	April	154	mass-balance model
	Revised	175	"
Watershed Inflow Volume (hm3/yr)			
	April	2564	1973-1998 mean
	Revised	2541	1965-1995 mean for Restudy Alt-D13R
Watershed Inflow Conc (ppb)			
	April	47	mass-balance model
	Revised	57	"

Yearly Settling Rates



Limit = Average Net Settling Rate from 1992 thru 1999 = 1.40 m/yr

Cumulative Settling Rates



Average Net Settling Rates from Year N through 1999, where 1999 - N >= 3
Each Point Based upon at Least 4 Years of Data
Limit = Average Net Settling Rate from 1992 thru 1999 = 1.40 m/yr

Lake Mass Balance Data

Yearly Balances

Year	Surf L mt/y	Atm L mt/yr	Total L mt/yr	Qin E9m3	Qout E9m3	Sto Inc E9m3	Qnet E9m3	Area km2	Zmn m	Lake P ppb	Outfl P ppb	K Lake m/yr	K Outfl m/yr
1973	434.4	29.8	464.2	3.01	0.76	0.84	1.60	1656	2.4	55.2	60.8	4.11	3.64
1974	737.3	30.4	767.6	3.63	2.27	0.26	2.53	1686	2.5	48.3	93.5	7.93	3.37
1975	297.0	29.9	327.0	1.89	1.08	-0.56	0.53	1664	2.4	52.7	55.8	3.41	3.20
1976	403.0	30.2	433.2	2.40	1.88	0.25	2.14	1678	2.4	58.1	138.0	3.17	0.60
1977	332.6	30.3	362.9	1.61	0.76	0.15	0.91	1686	2.5	56.6	78.7	3.26	2.20
1978	608.1	32.7	640.7	3.24	0.83	1.36	2.19	1814	2.9	70.6	105.0	3.80	2.16
1979	900.9	32.9	933.8	3.66	2.41	0.35	2.76	1826	3.0	89.3	84.9	4.22	4.51
1980	193.8	32.6	226.3	1.22	1.79	-2.00	-0.20	1809	2.9	89.9	73.3	1.50	1.82
1981	324.0	26.2	350.3	1.01	0.94	-1.34	-0.40	1458	2.2	81.7	74.7	3.21	3.49
1982	814.6	29.1	843.7	3.86	0.71	3.15	3.86	1616	2.7	82.7	119.5	3.92	1.98
1983	594.6	33.1	627.8	3.70	3.33	-0.27	3.06	1842	3.1	91.3	116.6	2.07	1.26
1984	569.0	33.1	602.1	2.38	2.35	-0.80	1.56	1838	3.0	102.2	139.9	2.36	1.49
1985	371.0	30.1	401.0	1.58	1.30	-0.73	0.56	1670	2.5	81.6	87.6	2.60	2.40
1986	457.0	31.4	488.5	1.81	0.72	0.46	1.18	1747	2.6	63.3	75.4	3.74	3.03
1987	460.3	32.0	492.4	2.74	1.06	0.77	1.83	1781	2.7	107.7	95.9	1.54	1.86
1988	260.2	32.9	293.1	1.86	1.51	-0.92	0.59	1825	2.9	111.7	109.9	1.11	1.14
1989	314.9	28.2	343.1	1.59	1.60	-1.10	0.50	1565	2.3	90.5	92.7	2.10	2.04
1990	360.6	26.8	387.4	1.67	0.77	0.03	0.80	1490	2.2	104.2	100.8	1.96	2.04
1991	409.8	30.6	440.4	2.71	0.39	1.89	2.28	1699	2.6	86.1	102.0	1.67	1.20
1992	353.5	32.8	386.3	2.05	1.52	-0.04	1.48	1824	2.9	86.3	69.4	1.64	2.24
1993	258.2	32.1	290.2	1.99	2.33	-0.99	1.35	1781	2.7	89.4	91.5	1.07	1.02
1994	539.3	32.2	571.5	3.89	1.93	1.88	3.81	1790	2.8	92.5	84.2	1.32	1.66
1995	642.7	33.2	675.8	4.35	4.69	-0.68	4.02	1842	3.1	100.0	74.8	1.49	2.73
1996	160.9	32.7	193.6	1.57	1.72	-1.19	0.53	1819	2.8	121.1	107.2	0.59	0.70
1997	427.4	31.3	458.7	2.82	0.73	1.42	2.15	1741	2.6	98.7	106.9	1.43	1.23
1998	739.5	32.9	772.4	4.46	4.16	-0.25	3.91	1830	3.1	117.0	125.4	1.47	1.23
1999	626.1	32.5	658.6	2.66	1.85	-0.03	1.81	1805	2.9	113.0	124.8	2.23	1.92

Cumulative Balances - Average from Year N to 1999, 1999 - N >= 3 Years

Year	Surf L mt/y	Atm L mt/yr	Total L mt/yr	Qin E9m3	Qout E9m3	Sto Inc E9m3	Qnet E9m3	Area km2	Zmn m	Lake P ppb	Outfl P ppb	K Lake m/yr	K Outfl m/yr
1973	466.3	31.2	497.5	2.57	1.68	0.07	1.753	1733	2.7	86.7	95.9	2.30	1.98
1974	467.5	31.2	498.8	2.55	1.72	0.04	1.759	1736	2.7	87.9	97.2	2.25	1.94
1975	456.8	31.3	488.0	2.51	1.70	0.03	1.728	1738	2.7	89.5	97.4	2.14	1.89
1976	463.4	31.3	494.7	2.53	1.72	0.06	1.778	1741	2.7	91.1	99.1	2.10	1.85
1977	466.0	31.4	497.4	2.54	1.71	0.05	1.762	1743	2.7	92.5	97.4	2.07	1.92
1978	472.1	31.4	503.5	2.58	1.76	0.04	1.801	1746	2.7	94.1	98.3	2.03	1.90
1979	465.6	31.4	497.0	2.55	1.80	-0.02	1.783	1743	2.7	95.2	98.0	1.97	1.89
1980	443.9	31.3	475.2	2.50	1.77	-0.04	1.734	1738	2.7	95.5	98.6	1.86	1.77
1981	457.0	31.2	488.3	2.56	1.77	0.07	1.836	1735	2.7	95.8	100.0	1.88	1.76
1982	464.4	31.5	495.9	2.65	1.82	0.14	1.960	1750	2.7	96.6	101.4	1.81	1.68
1983	443.8	31.6	475.5	2.58	1.88	-0.03	1.848	1758	2.7	97.4	100.3	1.72	1.65
1984	434.4	31.6	466.0	2.51	1.79	-0.02	1.772	1753	2.7	97.8	99.3	1.71	1.67
1985	425.4	31.4	456.9	2.52	1.75	0.03	1.786	1747	2.7	97.5	96.6	1.66	1.69
1986	429.3	31.5	460.9	2.58	1.78	0.09	1.874	1753	2.7	98.7	97.2	1.60	1.64
1987	427.2	31.6	458.7	2.64	1.87	0.06	1.927	1753	2.7	101.4	98.9	1.48	1.55
1988	424.4	31.5	455.9	2.63	1.93	0.00	1.935	1751	2.7	100.9	99.1	1.48	1.52
1989	439.4	31.4	470.7	2.70	1.97	0.09	2.058	1744	2.7	99.9	98.2	1.52	1.57
1990	451.8	31.7	483.5	2.82	2.01	0.20	2.213	1762	2.8	100.8	98.7	1.47	1.52
1991	461.9	32.3	494.2	2.94	2.15	0.22	2.370	1792	2.8	100.5	98.5	1.42	1.48
1992	468.4	32.5	500.9	2.97	2.37	0.02	2.382	1804	2.8	102.2	98.0	1.40	1.51
1993	484.9	32.4	517.3	3.11	2.49	0.02	2.511	1801	2.8	104.5	102.1	1.35	1.42
1994	522.6	32.5	555.1	3.29	2.51	0.19	2.704	1804	2.9	107.0	103.9	1.38	1.46
1995	519.3	32.5	551.8	3.17	2.63	-0.15	2.483	1807	2.9	109.9	107.8	1.40	1.46
1996	488.5	32.4	520.8	2.88	2.11	-0.01	2.100	1799	2.8	112.4	116.1	1.41	1.33

"Mean (31 year) Annual Lake Okeechobee Inflows/Outflows in 1,000 acft"

	95BSR	50BSR	AD13R	2010	2015
Inflows					
Rainfall	1683.70(42.1%)	1683.70(42.6%)	1683.70(39.9%)	1683.70(43.4%)	1683.70(40.5%)
MDS_Positive	949.00(23.7%)	949.00(24.0%)	949.00(22.5%)	949.00(24.5%)	949.00(22.8%)
Kissimmee_Inflows	979.60(24.5%)	931.90(23.6%)	931.90(22.1%)	931.90(24.0%)	931.90(22.4%)
TaylorCrk_Inflows	126.20(3.2%)	126.20(3.2%)	23.44(0.6%)	20.95(0.5%)	15.71(0.4%)
TayCrkRes_Inflows	0.00(0.0%)	0.00(0.0%)	93.18(2.2%)	86.66(2.2%)	106.97(2.6%)
ASR_To_LOK	0.00(0.0%)	0.00(0.0%)	135.90(3.2%)	0.00(0.0%)	48.34(1.2%)
Stlucie_Backflows	81.81(2.0%)	99.02(2.5%)	92.85(2.2%)	88.24(2.3%)	92.03(2.2%)
Caloos_Backflows	13.89(0.3%)	28.37(0.7%)	5.70(0.1%)	13.26(0.3%)	9.23(0.2%)
Eaa_Back_Pumping	46.13(1.2%)	32.57(0.8%)	0.83(0.0%)	1.82(0.0%)	0.29(0.0%)
C43_Reservoir	0.00(0.0%)	0.00(0.0%)	152.77(3.6%)	0.00(0.0%)	172.59(4.1%)
North_Storage	0.00(0.0%)	0.00(0.0%)	50.97(1.2%)	0.00(0.0%)	49.09(1.2%)
L8_Backflows	53.91(1.3%)	13.78(0.3%)	4.45(0.1%)	13.77(0.4%)	9.87(0.2%)
S309_Backflows	0.00(0.0%)	48.66(1.2%)	65.08(1.5%)	53.72(1.4%)	56.10(1.3%)
Other_Inflows	63.24(1.6%)	35.96(0.9%)	34.69(0.8%)	35.22(0.9%)	34.13(0.8%)
Total	3997.48(100.0%)	3949.17(100.0%)	4224.46(100.0%)	3878.24(100.0%)	4158.95(100.0%)
Outflows					
ET	2360.70(59.5%)	2329.70(59.4%)	2382.40(56.9%)	2339.70(60.9%)	2354.50(57.1%)
MDS_Negative	280.50(7.1%)	280.50(7.2%)	280.50(6.7%)	280.50(7.3%)	280.50(6.8%)
StLucie_Regulatory	126.00(3.2%)	87.78(2.2%)	10.76(0.3%)	30.70(0.8%)	21.62(0.5%)
StLucie_Ag_Dmds	23.13(0.6%)	18.93(0.5%)	24.89(0.6%)	20.36(0.5%)	22.68(0.5%)
StLuci_Estuary_Min	0.00(0.0%)	0.00(0.0%)	19.09(0.5%)	5.85(0.2%)	5.17(0.1%)
Caloos_Regulatory	289.78(7.3%)	206.09(5.3%)	13.00(0.3%)	77.42(2.0%)	54.25(1.3%)
Caloos_Ag_Dmds	70.74(1.8%)	89.99(2.3%)	36.73(0.9%)	40.87(1.1%)	48.88(1.2%)
Caloos_Estuary_Min	0.00(0.0%)	0.00(0.0%)	21.67(0.5%)	3.15(0.1%)	4.42(0.1%)
Reg_to_EAA_Storage	0.00(0.0%)	0.00(0.0%)	278.75(6.7%)	289.14(7.5%)	350.85(8.5%)
Regulatory_to_Wcas	61.57(1.6%)	110.52(2.8%)	101.33(2.4%)	81.72(2.1%)	69.23(1.7%)
Exc_Wat_StLuc_Res	0.00(0.0%)	0.00(0.0%)	0.00(0.0%)	0.00(0.0%)	0.00(0.0%)
Exc_Wat_Caloo_Res	0.00(0.0%)	0.00(0.0%)	19.13(0.5%)	14.07(0.4%)	37.03(0.9%)
Water_Supp_to_EAA	377.09(9.5%)	329.33(8.4%)	174.44(4.2%)	176.44(4.6%)	171.13(4.1%)
Water_Supp_to_LEC	39.75(1.0%)	117.52(3.0%)	68.00(1.6%)	105.64(2.7%)	96.51(2.3%)
Water_Supp_Glades	165.00(4.2%)	161.56(4.1%)	148.82(3.6%)	181.53(4.7%)	193.81(4.7%)
Water_Supp_to_STAs	0.00(0.0%)	3.53(0.1%)	3.32(0.1%)	2.78(0.1%)	3.13(0.1%)
L8_Basin_Ag_Dmds	20.22(0.5%)	0.64(0.0%)	0.73(0.0%)	0.53(0.0%)	0.66(0.0%)
North_Storage	0.00(0.0%)	0.00(0.0%)	126.71(3.0%)	0.00(0.0%)	110.47(2.7%)
LOK_To_ASR	0.00(0.0%)	0.00(0.0%)	263.13(6.3%)	0.00(0.0%)	98.50(2.4%)
Other_Outflows	155.47(3.9%)	184.61(4.7%)	210.61(5.0%)	193.13(5.0%)	201.53(4.9%)
Total	3969.95(100.0%)	3920.71(100.0%)	4183.99(100.0%)	3843.54(100.0%)	4124.87(100.0%)
SW_Storage_Change	25.00(0.6%)	26.10(0.7%)	37.70(0.9%)	32.10(0.8%)	31.20(0.8%)
RESIDUAL	2.53(0.1%)	2.36(0.1%)	2.77(0.1%)	2.60(0.1%)	2.88(0.1%)