Appendix A9. ADAPT Virtual Population Analysis

Catch at Age and Indices

Initial runs of ADAPT for the 2007 assessment used a combination of 62 age-specific and age aggregated fishery independent and fishery dependent indices under TOR 1 and 2. Model results indicated a significant increase in fishing mortality among 9-11 year old fish in the terminal year. The increases, particularly at age 10 from which increased from 0.5 in 2005 to 2.2 in 2006, were unrealistic and further evaluation of the chosen indices was warranted (Figure 1). Residual plots (Figure 2) showed systematic trends in residuals for some survey indices and suggests that the MD spawning stock indices for ages 3 to 9, the New York haul seine index for combined ages 9 to13, the CT trawl index and the DE trawl index should be removed from the updated analysis. Similarly, fishery dependent indices from MA commercial CPUE, MRFSS and CT recreational CPUE were also removed (the MA commercial indices failure to track strong year classes which provided additional justification for exclusion from analysis).

Model Configuration

The remaining 34 indices were used in the final run of ADAPT. Indices included the MD SSB index for ages 10-13+, NY Ocean Haul seine ages 3-8, NEFSC aggregated for ages 2-9, young-of-year (age 0) in Maryland, Virginia, New York and New Jersey, age 1 index for Maryland and Long Island, New York, DE spawning stock for ages 2-9, and aggregated for 10-13, and the NJ trawl index for ages 2-8 and aggregated for 9-13. The ADAPT run used the following input options: full F in terminal year was calculated using an averaging method; F at oldest true age for all years, including terminal year was calculated using Heincke's method and ages 8 through 11 were used to calculate the oldest true age. Plus group abundance was calculated using the backward method and the model assumed a flat topped partial recruitment. Natural mortality was fixed at M=0.15. In past assessments, an iterative re-weighting of the survey indices was applied to the model. Generally the result was an improvement in the CVs at age and the overall standard deviation. In the current model configuration, the CVs and standard deviation was better without re-weighting. Consequently the re-weighting is turned off and all indices given equal weighting.

Partial Recruitment Vector

A flat top partial recruitment vector was assumed for the ADAPT model. Initial PR values were calculated using the three year geometric mean fishing mortality for each age from the previous ADAPT model scaled to the highest value of F among all ages.

Bootstrap

The model was bootstrapped 1000 times to produce a distribution of F, SSB and abundance in the terminal year.

ADAPT Results

Tuning Indices

Plots of observed and predicted indices (Figure 3) and the residuals (Figure 4) for the 34 remaining indices suggested better fit with this model configuration.

Fishing Mortality

The 2006 average fishing mortality rate (F) for fully recruited ages 8 through 11 equaled 0.34 and was above the current target (0.30)(Table 1 and 2). This represents a decrease in F on fully recruited ages from that reported for 2003 (reported as F = 0.62 in 2004, SBSASC 2004). This may reflect the shift in model indices and a reduced in the retrospective effect on terminal year F. The 2003 value of F in the current run was 0.19. Fishing mortality in 2006 on ages 3-8, which are generally targeted in producer areas, was F = 0.15 (Table 2). Among the individual age groups, the highest value of F (0.46) was estimated for 9 year old fish (1997 year class) (Table 1). Estimates of age 8-11 F increased from 0.27 in 2005 to 0.34 in 2006 (Table 2). Bootstrap estimates of age 8-11 F, based on 1000 iterations, are presented in Figure 5; the distribution of Fs was characterized by a highly skewed distribution with values to 1.32.

Population Abundance (January 1)

Striped bass abundance increased steadily from 1982 through 1997 when it reached a level around 70 million fish (Table 3). Total abundance declined to 60 million fish in 2000, increased to 78 million fish in 2004 and has since declined to 61 million in 2007. The 2001 and 2003 cohort remained strong in 2007 and exceeded the size of the strong 1993 and 1996 year classes. Estimates of abundance obtained this year were higher than those reported in 2004 (SBSAC 2004). Bootstrap estimates for abundance at age are presented in Figure 6; the total abundance estimates followed near- normal distribution.

Abundance of striped bass age 8+ increased steadily from 1982 through 2004 to 5.6 million fish. It has since decreased to a 1 Jan 2007 estimate 6.1 million fish (Table 3).

Spawning Stock Biomass

Female spawning stock biomass (SSB) grew steadily from 1982 through 2002 when it peaked at about 36.7 thousand metric tons (Table 4). Female SSB has declined since then and was estimated at 29.8 thousand metric tons in 2006, assuming 1:1 male- female ratio. The estimated SSB remained above the threshold level of 1995. Bootstrap estimates for SSB are presented in Figure 7; the SSB estimates followed a near- normal distribution.

Retrospective Patterns

A retrospective analysis was conducted on the VPA results extending back to 2000 in order to determine trends in estimation of F, total abundance, female SSB and recruitment in the terminal year. The analysis revealed that average fishing mortality estimates for ages 8-11 were overestimated in 2000 but improved significantly in subsequent years (Figure 8). The terminal year estimate for 2005 was 0.28 compared to the 2005 estimate in the 2006 model of 0.27. There was limited bias in terminal year estimates of total abundance, recruitment or female SSB (Figure 8) which were all underestimated.

Sensitivity Runs

Natural mortality was changed to 1.0, 0.5, and 0.35 for ages 1, 2 and 3 respectively to determine the sensitivity to age specific values. As expected, the increase in M at age increased the estimates of population abundance for the corresponding ages.

Additional Estimates

Estimates of total and catch biomass are given in Tables 5 and 6.

Sources of Uncertainty

The ADAPT VPA abundance indices used this year's analysis were improved through a reasoned and objective evaluation process described in ASMFC 2004. The review reduced the number of indices and the number of indices at age, especially for fish age eight and older. This year's ADAPT VPA analysis was highly sensitive to the selection of indices, especially to those for the older ages. As the striped bass population abundance increased beginning in 1982, the indices produced a strong signal of trend. However, as abundance peaked and fluctuated around the recent level, the trends are less evident in the indices, as used by this model. There is clearly a need to develop additional fishery independent indices of abundance for older fish in the fished subset of the population.

ADAPT Summary

The striped bass population remains at high level of abundance due, in part, to strong incoming cohorts. The fully exploited population abundance (age 8+) has decreased since 2004, but remains above the abundance in 2000. Average fishing mortality for fully recruited ages (8-11) in 2006 was estimated at 0.35. The F estimate for 2003 was 0.19 which is much lower than the F for the same year (0.62) estimated in the 2004 assessment (SBSASC 2004). However, this difference is due primarily to the selection of tuning indices and the presence of a retrospective problem in the previous model. The 2006 fully recruited fishing mortality estimate is above the target of 0.3. However, the bootstrap distribution of F and suggests that the mean is not the appropriate metric and true F is likely less than 0.3. Spawning stock biomass has decreased from levels in 2002 but remains well above the 1995 threshold level.

Appendix A9 Tables

Table 1. Fishing mortality estimates from ADAPT model using reduced suite of indices.

	Fishing Mortality											
AGE	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.12	0.09	0.24	0.04	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01
3	0.38	0.29	0.37	0.06	0.04	0.02	0.02	0.03	0.03	0.04	0.03	0.03
4	0.37	0.52	0.20	0.07	0.10	0.04	0.03	0.04	0.08	0.07	0.06	0.07
5	0.28	0.44	0.29	0.20	0.11	0.06	0.10	0.06	0.14	0.09	0.07	0.11
6	0.19	0.28	0.25	0.32	0.15	0.07	0.12	0.12	0.12	0.11	0.08	0.10
7	0.33	0.26	0.20	0.33	0.23	0.08	0.16	0.07	0.17	0.09	0.08	0.08
8	0.59	0.08	0.09	0.27	0.29	0.10	0.20	0.11	0.13	0.19	0.08	0.12
9	0.67	0.17	0.05	0.16	0.21	0.11	0.31	0.12	0.14	0.15	0.19	0.13
10	0.71	0.43	0.18	0.10	0.19	0.10	0.13	0.12	0.11	0.22	0.16	0.38
11	0.20	0.73	0.13	0.11	0.13	0.07	0.15	0.09	0.23	0.29	0.12	0.20
12	0.64	0.14	0.08	0.20	0.25	0.10	0.21	0.11	0.13	0.18	0.12	0.16
13	0.64	0.14	0.08	0.20	0.25	0.10	0.21	0.11	0.13	0.18	0.12	0.16
8 - 11 F	0.54	0.35	0.11	0.16	0.21	0.09	0.20	0.11	0.15	0.21	0.14	0.21
3 - 8 F	0.35	0.31	0.23	0.21	0.15	0.06	0.10	0.07	0.11	0.10	0.07	0.08

1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.01	0.03	0.01	0.02	0.01	0.01	0.04	0.02	0.02	0.01	0.03	0.02	0.03
0.05	0.06	0.06	0.06	0.04	0.04	0.06	0.06	0.04	0.05	0.05	0.08	0.07
0.06	0.09	0.10	0.11	0.08	0.07	0.11	0.12	0.04	0.13	0.09	0.09	0.15
0.10	0.10	0.14	0.14	0.17	0.10	0.14	0.12	0.11	0.15	0.15	0.16	0.12
0.12	0.17	0.15	0.23	0.14	0.15	0.15	0.13	0.12	0.21	0.16	0.21	0.16
0.09	0.15	0.22	0.20	0.14	0.13	0.21	0.15	0.16	0.18	0.26	0.17	0.21
0.10	0.17	0.20	0.31	0.16	0.16	0.15	0.19	0.18	0.16	0.23	0.29	0.20
0.24	0.24	0.17	0.32	0.25	0.18	0.14	0.13	0.19	0.19	0.21	0.26	0.46
0.17	0.34	0.15	0.25	0.25	0.26	0.17	0.14	0.23	0.23	0.25	0.22	0.40
0.30	0.15	0.25	0.22	0.25	0.36	0.15	0.17	0.18	0.16	0.34	0.31	0.30
0.15	0.22	0.18	0.30	0.20	0.18	0.15	0.17	0.20	0.18	0.23	0.25	0.32
0.15	0.22	0.18	0.30	0.20	0.18	0.15	0.17	0.20	0.18	0.23	0.25	0.32
0.20	0.23	0.19	0.27	0.23	0.24	0.15	0.16	0.20	0.19	0.26	0.27	0.34
0.09	0.12	0.14	0.17	0.12	0.11	0.14	0.13	0.11	0.15	0.16	0.17	0.15

Table 2. Average fishing mortality for ages 8-11 estimated in ADAPT model.

Year	8-11 Average F	F wt'd by N	3 - 8 average F
1982	0.54	0.45	0.35
1983	0.35	0.20	0.31
1984	0.11	0.09	0.23
1985	0.16	0.20	0.21
1986	0.21	0.23	0.15
1987	0.09	0.10	0.06
1988	0.20	0.20	0.10
1989	0.11	0.11	0.07
1990	0.15	0.13	0.11
1991	0.21	0.19	0.10
1992	0.14	0.12	0.07
1993	0.21	0.17	0.08
1994	0.20	0.16	0.09
1995	0.23	0.21	0.12
1996	0.19	0.18	0.14
1997	0.27	0.29	0.17
1998	0.23	0.21	0.12
1999	0.24	0.20	0.11
2000	0.15	0.15	0.14
2001	0.16	0.17	0.13
2002	0.20	0.19	0.11
2003	0.19	0.18	0.15
2004	0.26	0.24	0.16
2005	0.27	0.26	0.17
2006	0.34	0.32	0.15

Table 3. Population abundance estimate (000s) from ADAPT model using reduced suite of indices.

1-Jan Population Numbers

AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	1547	3222	2432	3690	2816	4085	5476	5828	8703	9254	9690	12287
2	1003	1329	2770	2088	3175	2413	3515	4711	5015	7489	7964	8338
3	867	766	1042	1883	1730	2713	2067	2997	4021	4274	6378	6812
4	760	510	494	618	1526	1430	2300	1740	2505	3346	3544	5305
5	261	451	261	349	494	1190	1183	1921	1435	1983	2686	2875
6	122	170	250	169	246	379	962	919	1557	1075	1556	2148
7	93	87	110	167	105	183	303	738	703	1187	831	1238
8	41	58	58	78	104	72	145	223	592	509	937	657
9	26	19	46	45	51	67	56	102	173	447	361	744
10	22	11	14	38	33	36	52	35	78	130	330	257
11	66	10	6	10	29	24	28	39	27	61	89	243
12	31	46	4	5	8	22	19	20	31	18	39	68
13	36	112	147	61	49	142	55	91	121	146	151	128
Total	4873	6792	7633	9200	10366	12755	16160	19365	24960	29917	34558	41100
8+	222	256	275	237	274	363	355	510	1022	1311	1907	2097

1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
17353	16043	17701	16997	10063	11310	8842	14968	22700	8684	24413	11195	12938	6050
10575	14931	13805	15234	14626	8637	9727	7575	12854	19516	7448	20947	9618	11104
7112	8967	12449	11790	12842	12419	7334	8074	6375	10877	16563	6246	17605	8069
5691	5798	7282	10114	9590	10603	10300	5925	6549	5279	8918	13510	4987	14071
4263	4629	4568	5666	7806	7600	8525	7954	4546	5403	3989	6981	10612	3682
2208	3328	3609	3429	4242	5678	5947	6394	6075	3496	3995	2954	5123	8120
1677	1685	2412	2673	2346	3179	4212	4396	4855	4624	2451	2930	2062	3761
986	1318	1252	1667	1877	1760	2410	2937	3247	3558	3326	1623	2128	1442
504	768	953	884	1051	1370	1293	1784	2081	2332	2605	2269	1048	1500
564	341	519	694	554	705	989	964	1345	1474	1661	1826	1512	567
151	410	210	383	468	372	470	720	719	917	1005	1117	1261	875
171	96	304	141	265	315	224	349	524	517	670	615	704	801
112	78	125	119	384	318	235	338	674	599	709	679	757	917
51365	58394	65188	69791	66114	64266	60509	62380	72545	67275	77754	72893	70355	60959
2488	3011	3363	3888	4599	4840	5621	7092	8590	9397	9976	8129	7410	6102

Table 4. Female spawning biomass (000s MT) from ADAPT model using a reduced suite of indices.

	Female	Spawning	Stock	Biomass (000s mt)								
AGE	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	17.5	11.5	11.5	19.5	46	44.5	73	51.5	75	99.5	106	162	183.5
5	32.5	51	30	40	61	179	186	291	200.5	281.5	407.5	406.5	622
6	95.5	100	148	108.5	136	215	645.5	731	1127.5	621.5	1025.5	1445	1454.5
7	175	135	187	279.5	164.5	257.5	451.5	1441	1379.5	2139	1375.5	2184	2960.5
8	97	130.5	118	178.5	224.5	138	261.5	516.5	1479.5	1174.5	2194	1590.5	2381
9	61.5	53.5	130.5	131	130	166.5	128.5	256	483.5	1300	1056	2229.5	1508
10	82	36.5	45	125.5	99	99.5	135.5	111.5	221.5	359.5	1123	878	1919
11	337	38.5	24.5	40	104	76.5	97	131	100	210.5	328	998.5	614.5
12	152	230	20.5	21	33	90	79	88	130.5	67.5	199	327.5	809.5
13	223	586.5	856.5	396.5	292.5	877	339.5	573.5	713	970	995	875	668.5
Total	1,273	1,373	1,572	1,340	1,291	2,144	2,397	4,191	5,911	7,224	8,810	11,097	13,121

1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
210	243	362	250.5	263.5	246	154.5	161.5	121	199	276.5	101.5
701.5	739.5	882.5	1117	819	874	870.5	543	600	448.5	784	1196.5
2259.5	2694	2461	2579.5	2847	2895	3412.5	3401.5	1937	2202	1702.5	2968.5
3051.5	4825.5	5008	4048.5	4185	5457.5	6215.5	7466.5	6934	3680.5	4377	3068.5
3197	3395	4114	4172	3763	4392	5694	6777.5	7310	6691.5	3264.5	4316
2395	3094.5	2818	2868.5	3903.5	3628.5	4767.5	5342	6296.5	6822.5	5897	2667
1218.5	1988.5	2727.5	1769.5	2394	3219	3365.5	4335	4514.5	5081.5	5588	4546.5
1452	885.5	1704.5	1831	1334.5	1923.5	2691	2826.5	3440	3549	3931.5	4441
437	1241.5	638	1223.5	1279	1010.5	1466	2246.5	2232	2733	2454	2789
607.5	798	815	2124.5	1782.5	1492.5	1720	3624.5	3075.5	3531	3375.5	3739.5
15,530	19,905	21,531	21,985	22,571	25,139	30,357	36,725	36,461	34,939	31,651	29,834

Table 5. Biomass estimates (Jan. 1 000s MT) from ADAPT model using reduced suite of indices.

1-Jan Biomass (000s mt) AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	98	372	366	72	168	383	1038	395	205	1073	352	222	2438
2	530	355	960	799	587	792	1499	2389	1893	2032	3032	2299	2867
3	843	594	1005	1508	1523	2432	1902	3158	3911	4579	7002	6476	8060
4	944	623	610	1035	2445	2340	3844	2726	3962	5262	5592	8565	9684
5	541	861	499	658	995	2916	3035	4729	3284	4594	6634	6648	10151
6	455	480	708	523	644	1010	3050	3455	5329	2933	4826	6813	6874
7	426	327	450	682	397	613	1082	3427	3314	5094	3275	5197	7054
8	230	294	266	410	516	311	597	1167	3352	2676	4945	3598	5376
9	139	115	276	280	279	354	279	544	1030	2774	2262	4745	3246
10	185	80	96	266	212	211	288	237	470	773	2398	1917	4101
11	723	87	52	85	222	162	207	278	215	456	697	2141	1331
12	341	491	44	45	71	191	170	187	277	144	424	700	1727
13	499	1249	1815	850	630	1862	728	1218	1518	2076	2116	1868	1426
Total	5,954	5,928	7,146	7,213	8,688	13,578	17,719	23,911	28,762	34,466	43,554	51,189	64,335

1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
2320	1177	908	2583	7445	3228	1720	1219	478	4687	2149	2484	1162
6120	7485	4488	4628	5117	5680	2841	2863	5236	1353	5771	2650	2712
10676	12629	13124	11077	11481	7297	6337	4046	6056	11758	3289	9269	4741
11129	12887	19232	13260	13938	13068	8221	8517	6431	10551	14650	5408	15723
11454	12122	14466	18365	13369	14323	14239	8879	9847	7358	12877	19574	6792
10735	12771	11759	12214	13494	13728	16138	16081	9234	10451	8120	14085	21960
7312	11647	12069	9692	10008	13160	14903	17916	16670	8922	10512	7397	13560
7273	7742	9488	9482	8546	9968	12980	15428	16609	15311	7511	9844	6660
5156	6613	6112	6180	8349	7735	10153	11447	13485	14634	12714	5871	8409
2648	4244	5874	3812	5162	6879	7175	9325	9710	10946	12005	9941	3733
3097	1907	3661	3944	2906	4102	5750	6048	7347	7716	8523	9621	6693
939	2656	1381	2623	2737	2156	3132	4814	4778	5874	5290	6049	6925
1304	1707	1765	4556	3814	3185	3675	7767	6584	7590	7275	8111	9821
80,163	95,587	104,329	102,416	106,367	104,511	107,263	114,350	112,466	117,153	110,685	110,304	108,889

Table 6. Catch biomass estimates (000s MT) from ADAPT model using reduced suite of indices.

Catch AGE	Biomass 1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	-	1	1	-	2	-	1	-	-	-	-	-	1
2	68	61	326	44	12	8	28	30	41	67	32	53	153
3	280	168	512	109	81	53	46	97	142	187	262	243	589
4	340	265	133	67	319	108	125	152	385	453	365	651	642
5	141	356	161	129	122	168	334	321	407	424	498	799	1,048
6	72	129	175	155	100	73	394	432	633	321	402	664	813
7	117	70	93	214	81	48	178	245	511	439	306	416	669
8	97	22	27	94	121	31	115	131	405	468	393	411	538
9	73	17	14	43	50	35	73	63	118	380	406	581	679
10	92	30	16	25	32	19	33	33	44	150	365	610	610
11	119	44	6	9	26	12	32	29	38	134	91	392	350
12	153	58	4	9	15	20	34	19	32	23	51	100	238
13	221	151	137	143	129	170	127	119	173	317	222	255	186
Total	1,773	1,371	1,606	1,041	1,089	745	1,520	1,671	2,928	3,365	3,392	5,174	6,518

1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	-	-	10	5	14	5	3	3	16	2	4
303	104	181	141	97	177	59	62	152	59	215	79
636	955	710	582	466	459	484	238	480	677	420	771
994	1,508	2,389	1,145	934	1,428	1,047	381	839	1,050	1,636	766
1,123	1,754	1,926	2,531	1,227	1,999	1,841	981	1,558	1,260	2,001	2,049
1,788	2,119	2,387	1,507	1,833	2,181	2,277	2,073	1,932	1,712	1,596	1,894
1,154	2,826	2,068	1,315	1,182	2,894	2,388	2,811	2,900	2,179	1,656	1,454
1,207	1,490	2,108	1,500	1,202	1,597	2,430	2,739	2,573	3,317	2,043	1,738
1,118	1,068	1,504	1,470	1,347	1,147	1,313	2,068	2,286	2,731	2,927	2,240
803	634	1,289	800	1,165	1,047	936	1,971	2,048	2,410	2,237	3,225
404	396	696	738	908	580	894	1,000	1,088	2,215	2,197	2,490
170	468	348	446	474	315	413	845	761	1,140	1,141	1,590
237	260	424	777	589	419	524	1,284	1,032	1,430	1,521	2,117
9,939	13,581	16,031	12,964	11,430	14,255	14,612	16,457	17,653	20,195	19,591	20,417

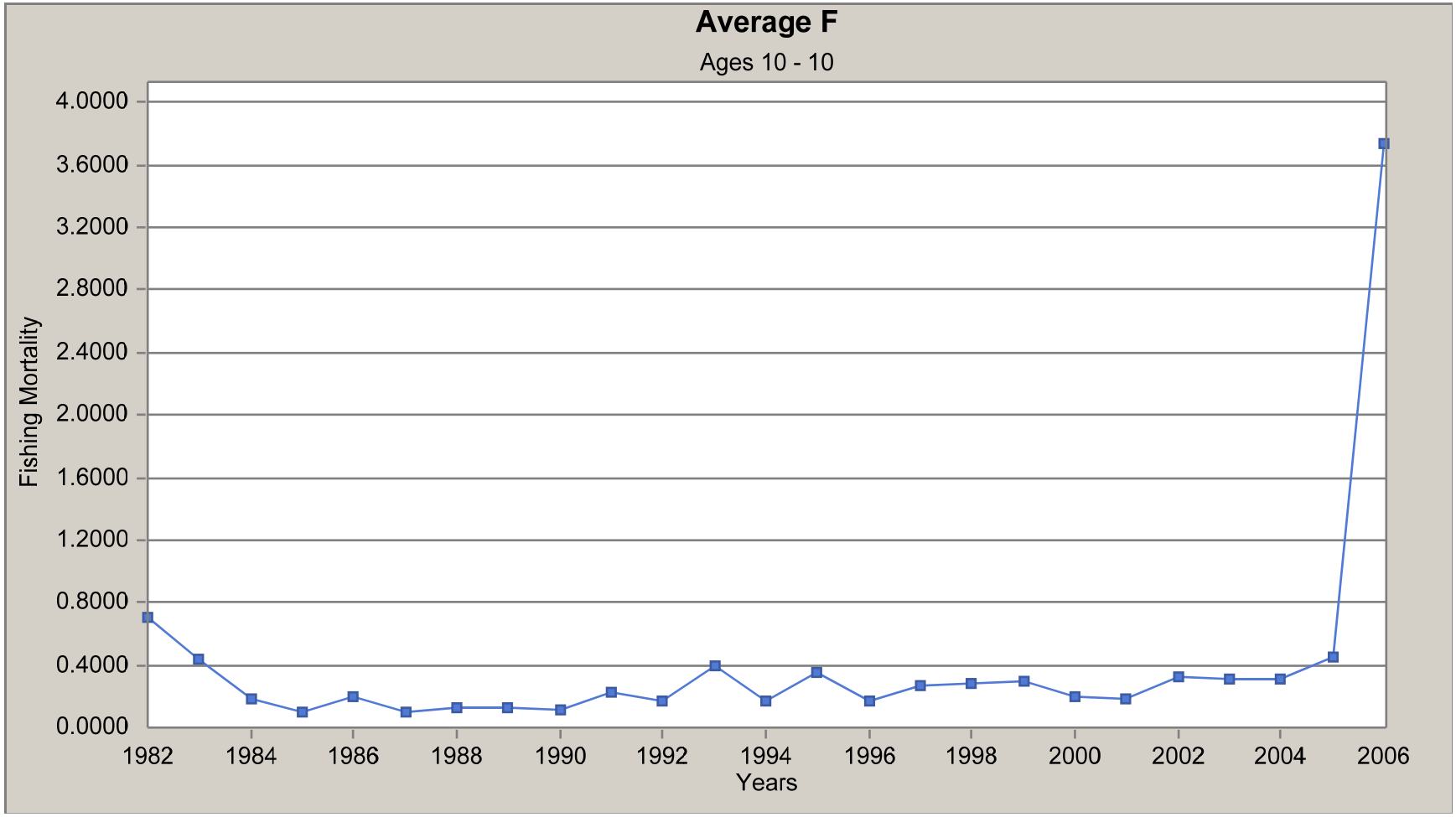


Figure 1. Age 10 fishing mortality from full ADAPT model with index selection comparable to previous assessment.

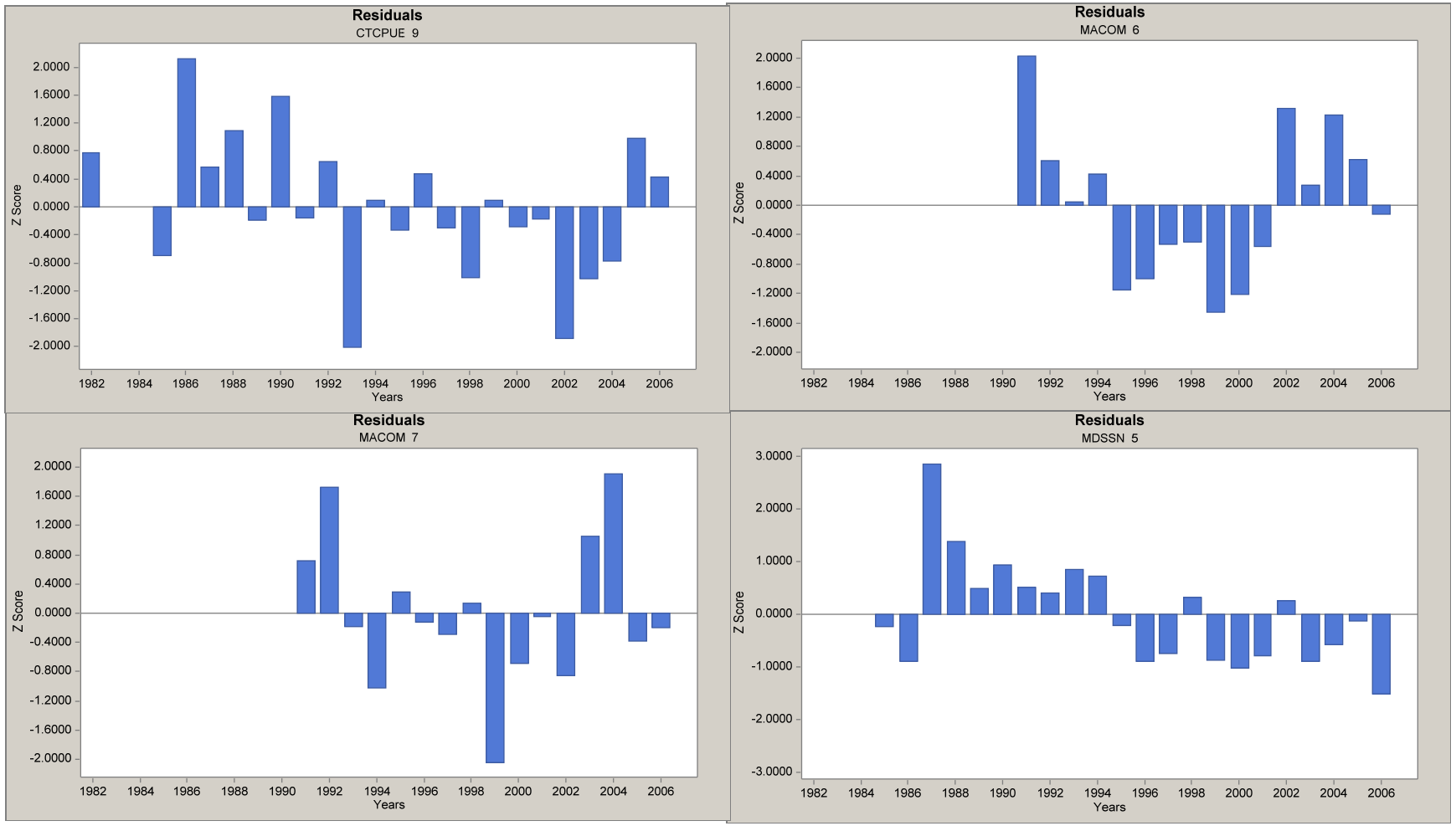


Figure 2. Residual plots from ADAPT model using index selection from previous assessment.

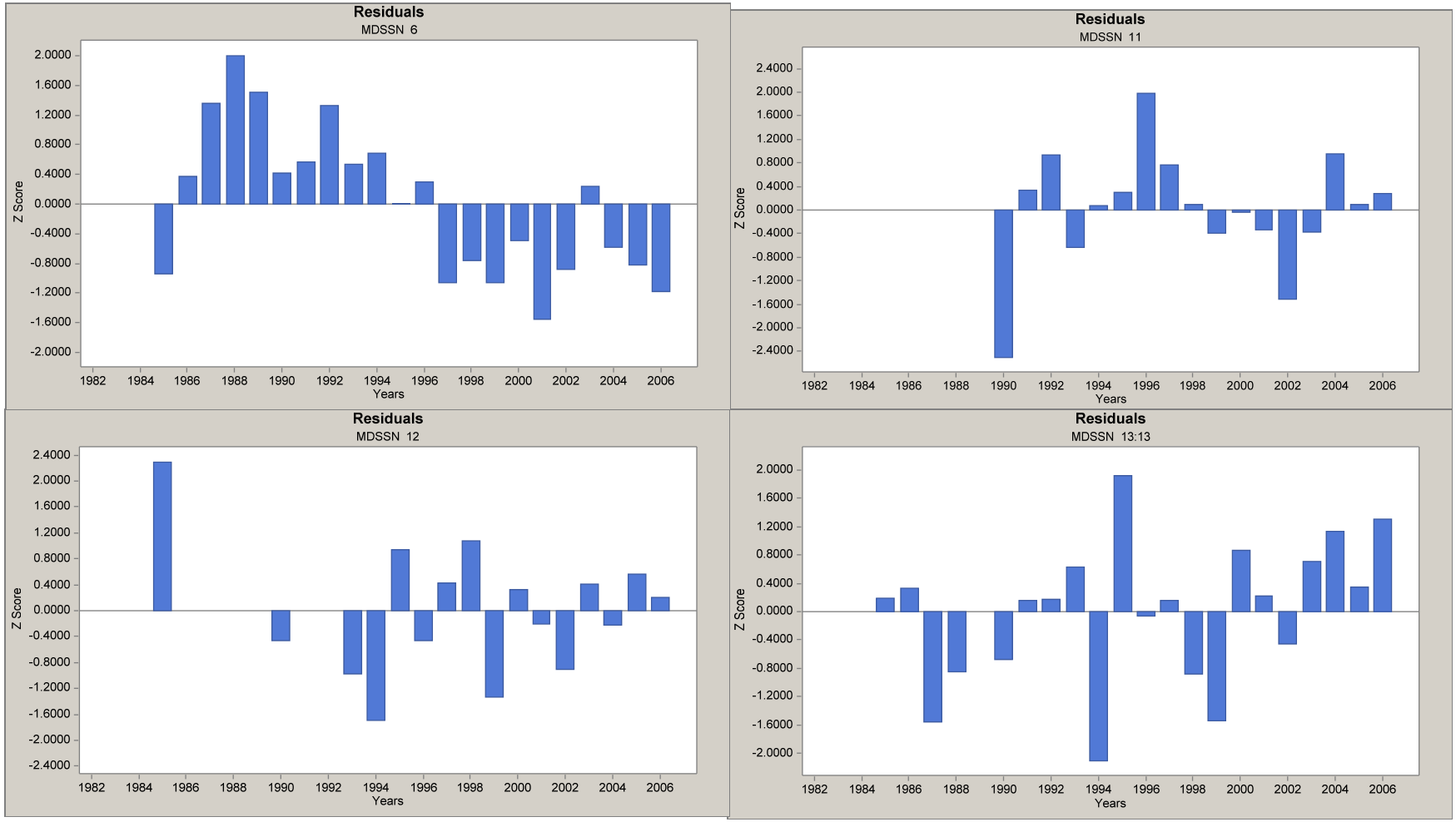


Figure 2 continued.

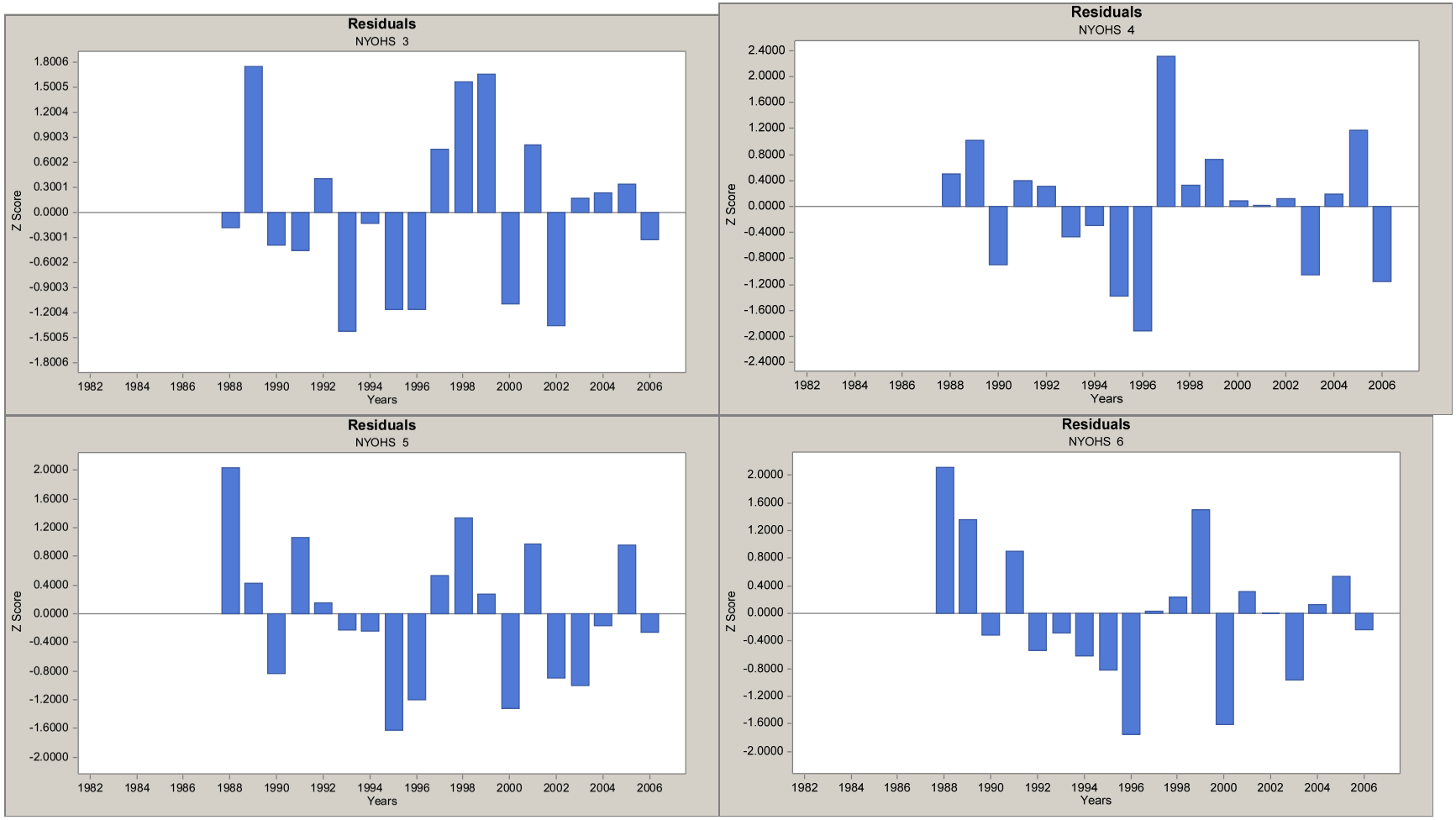
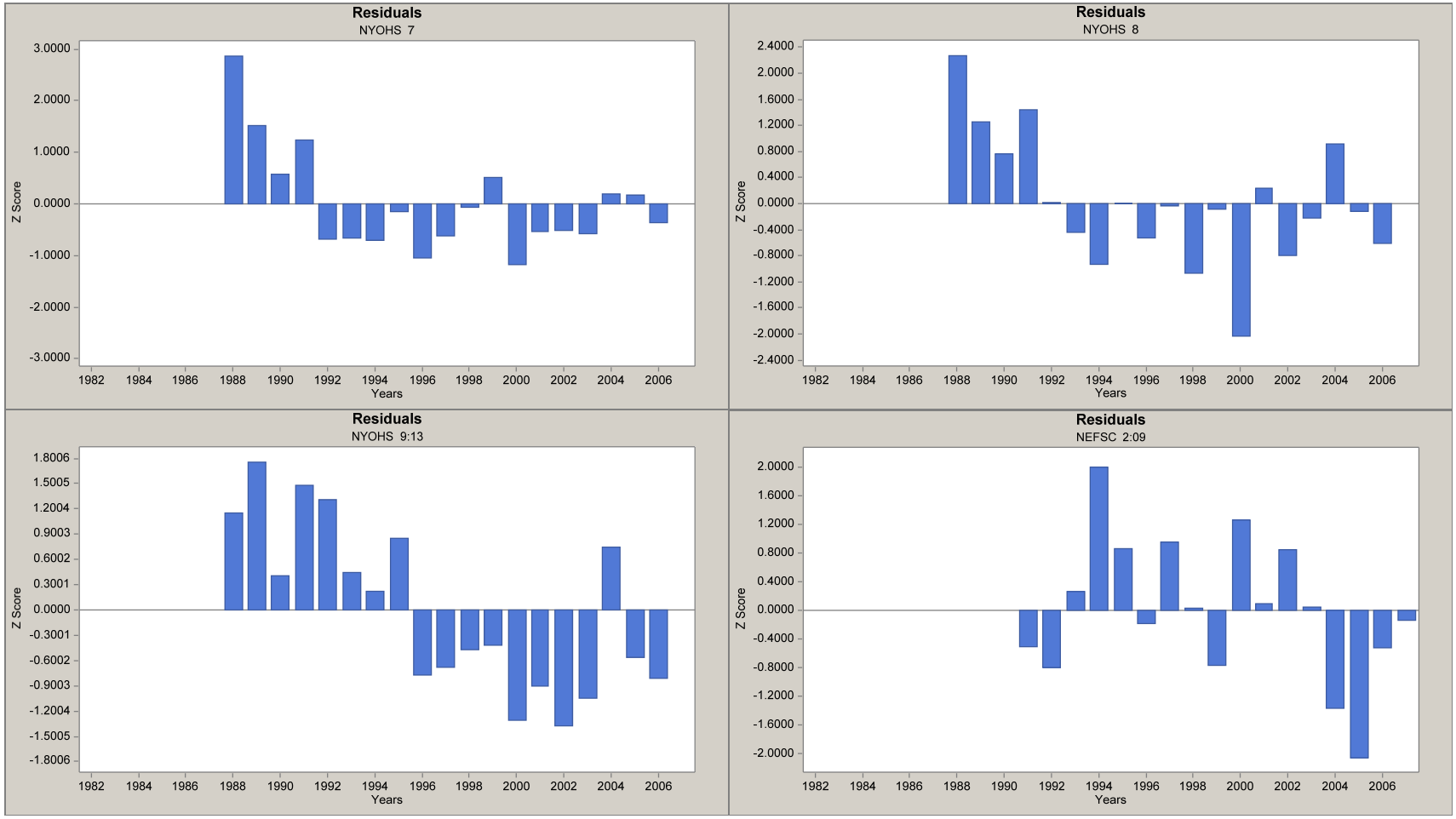


Figure 2 continued.



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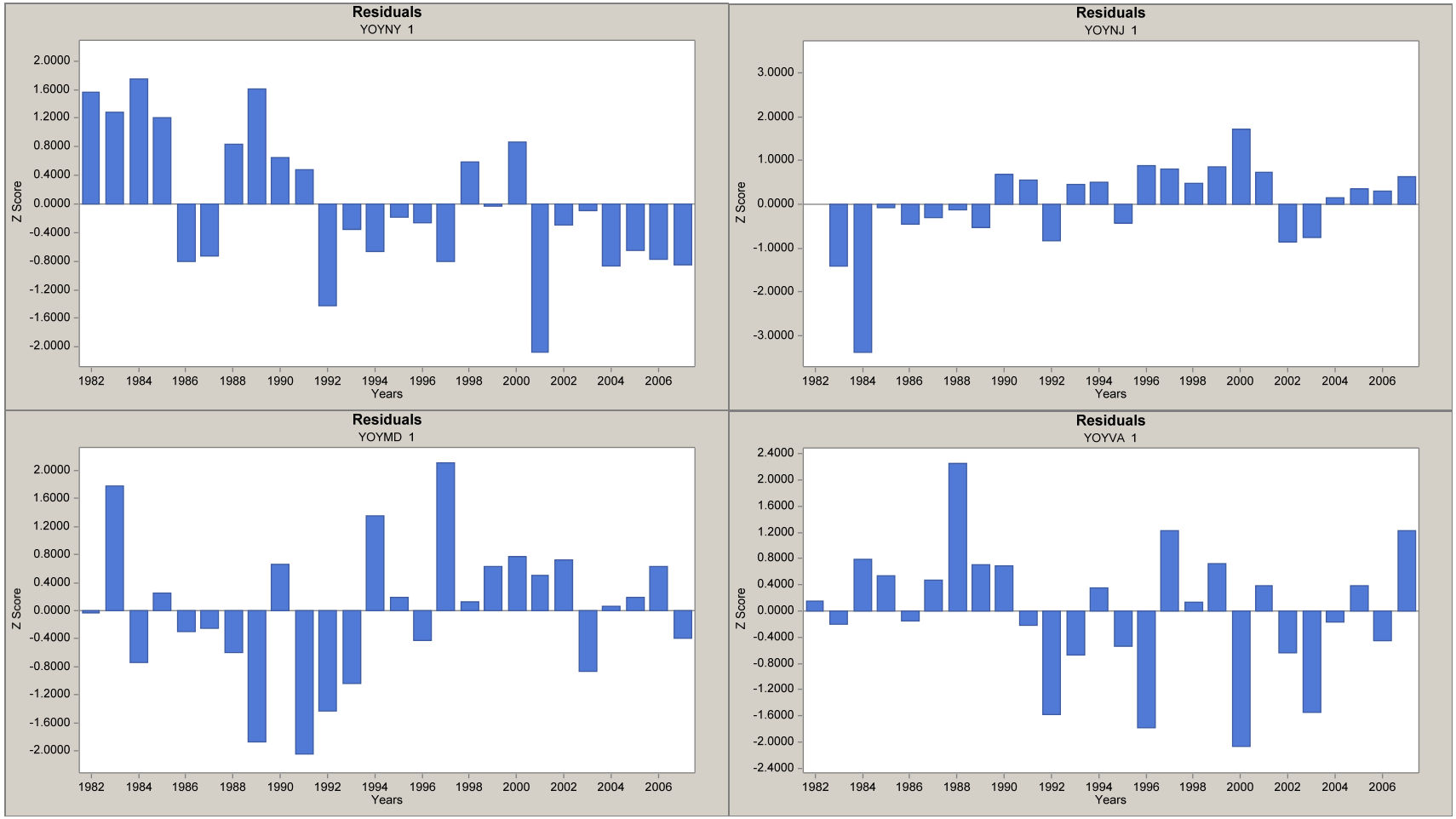
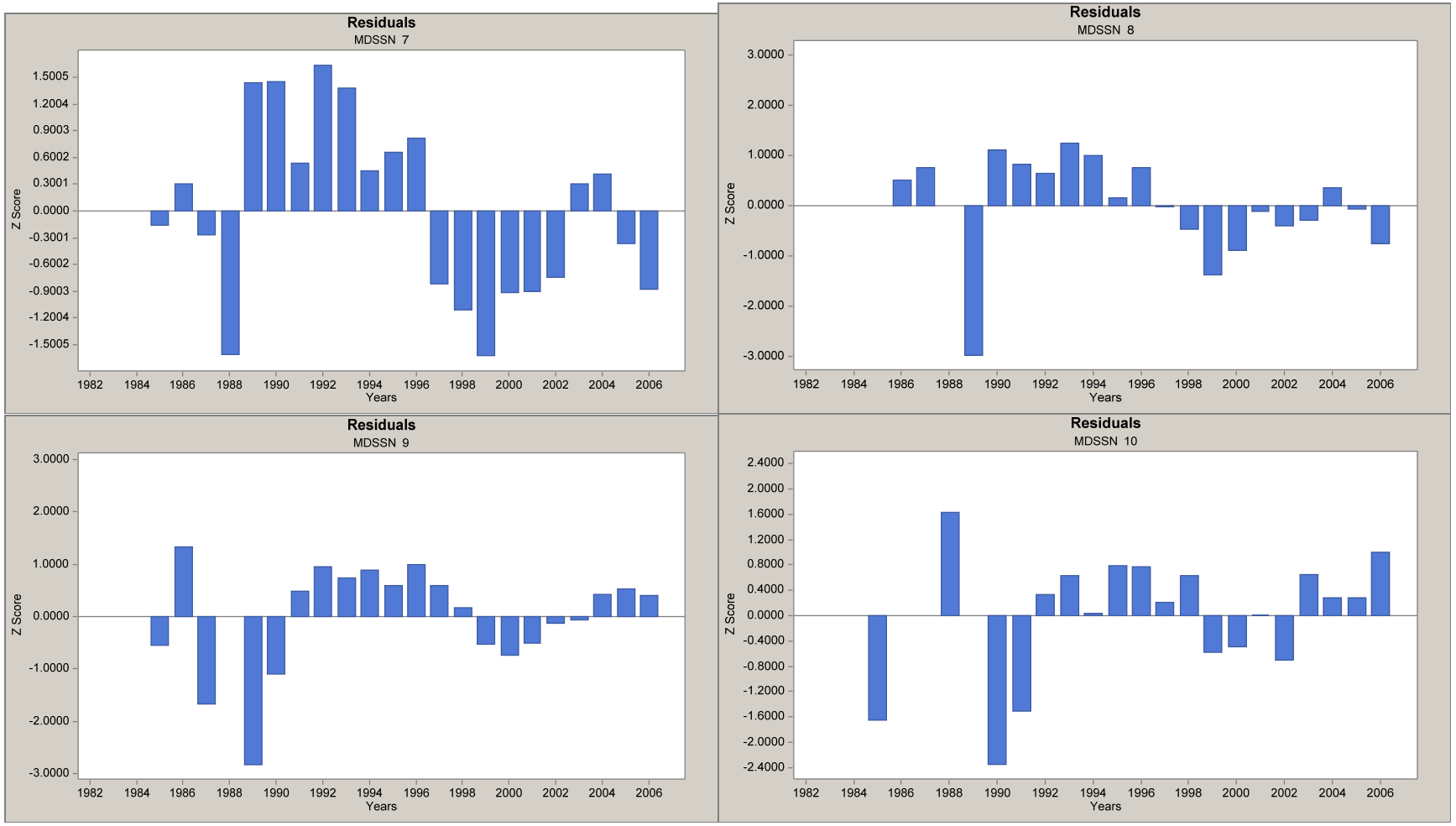


Figure 2 continued.

Figure 2 continued.



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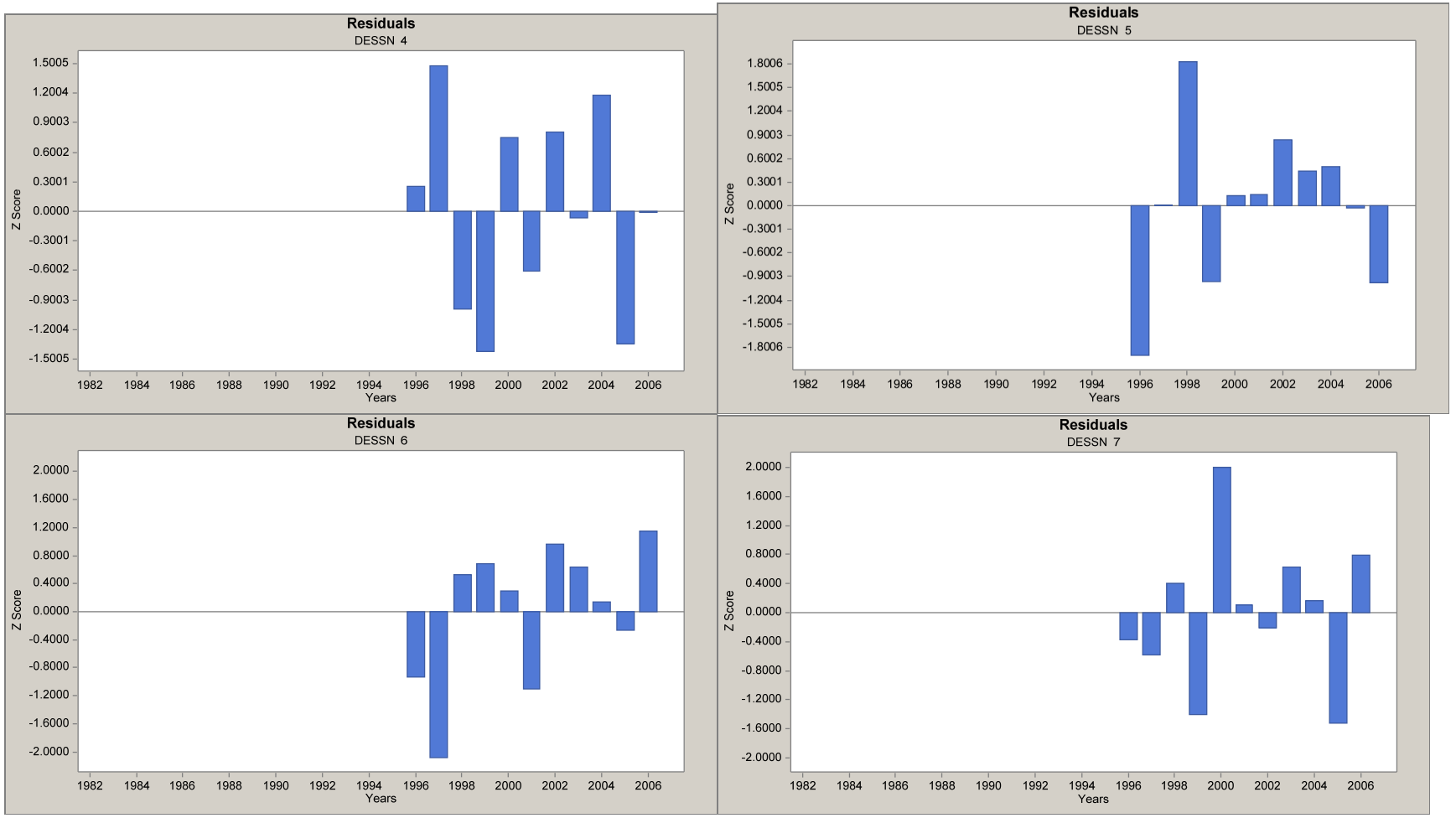

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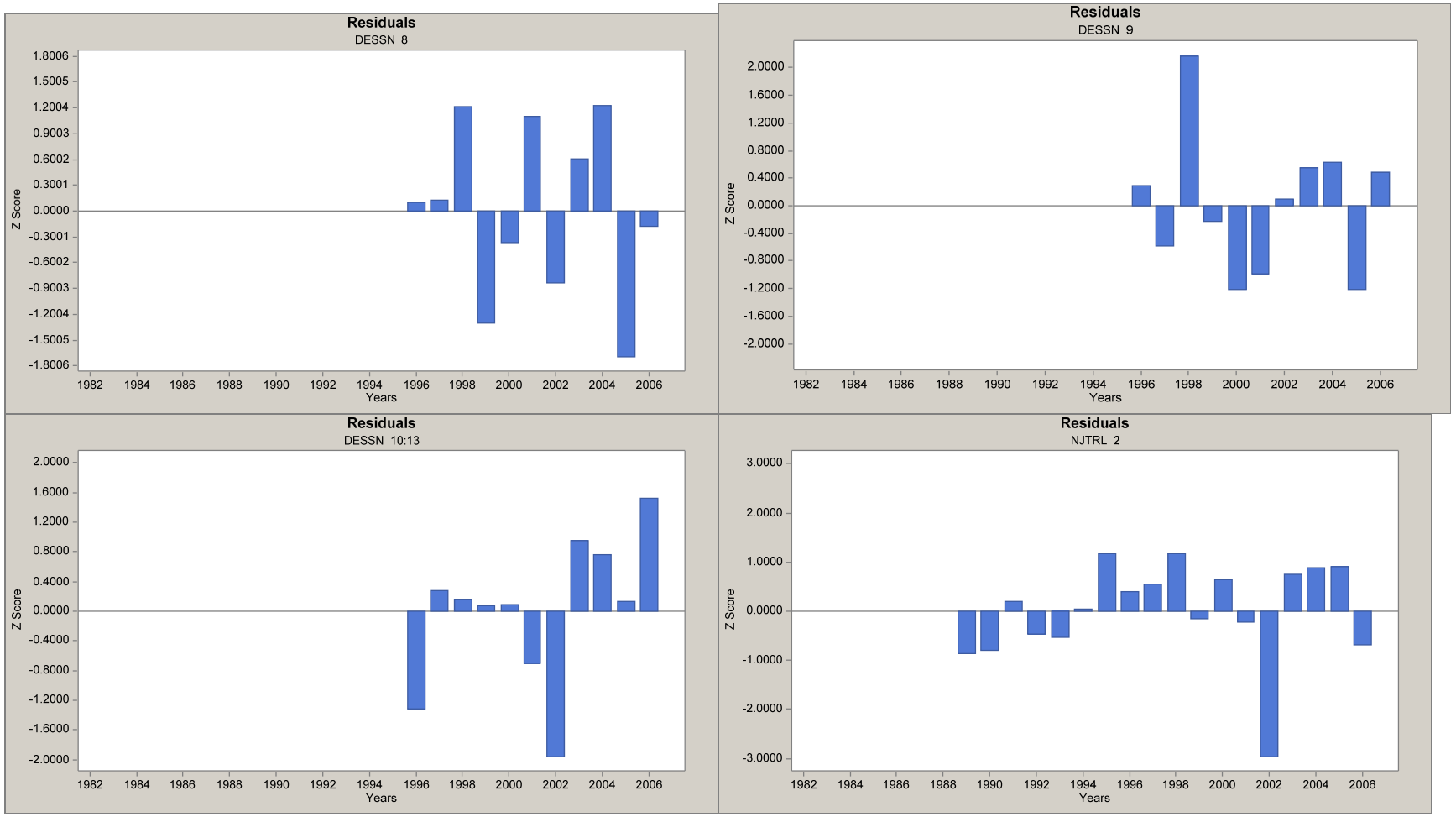

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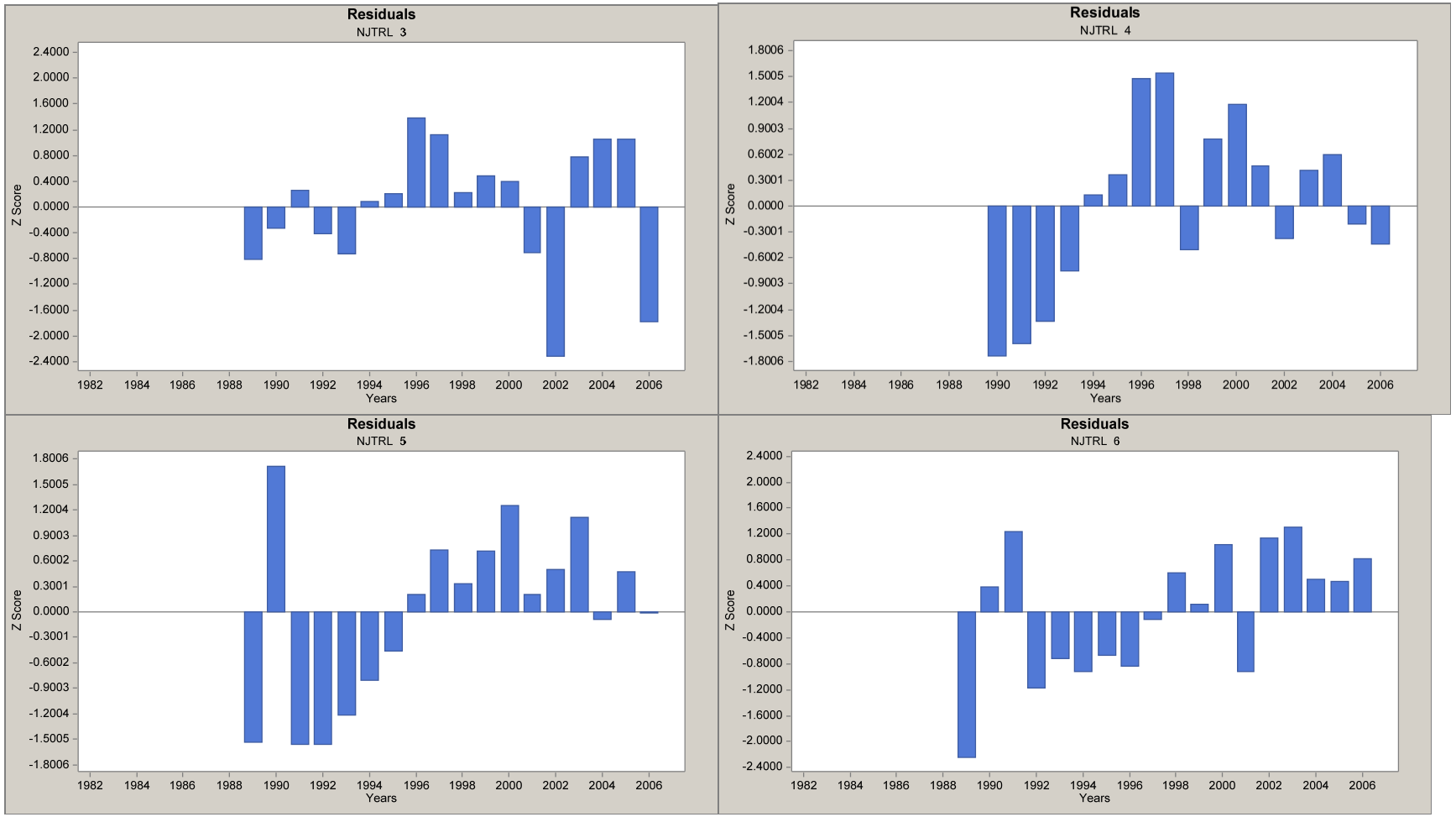

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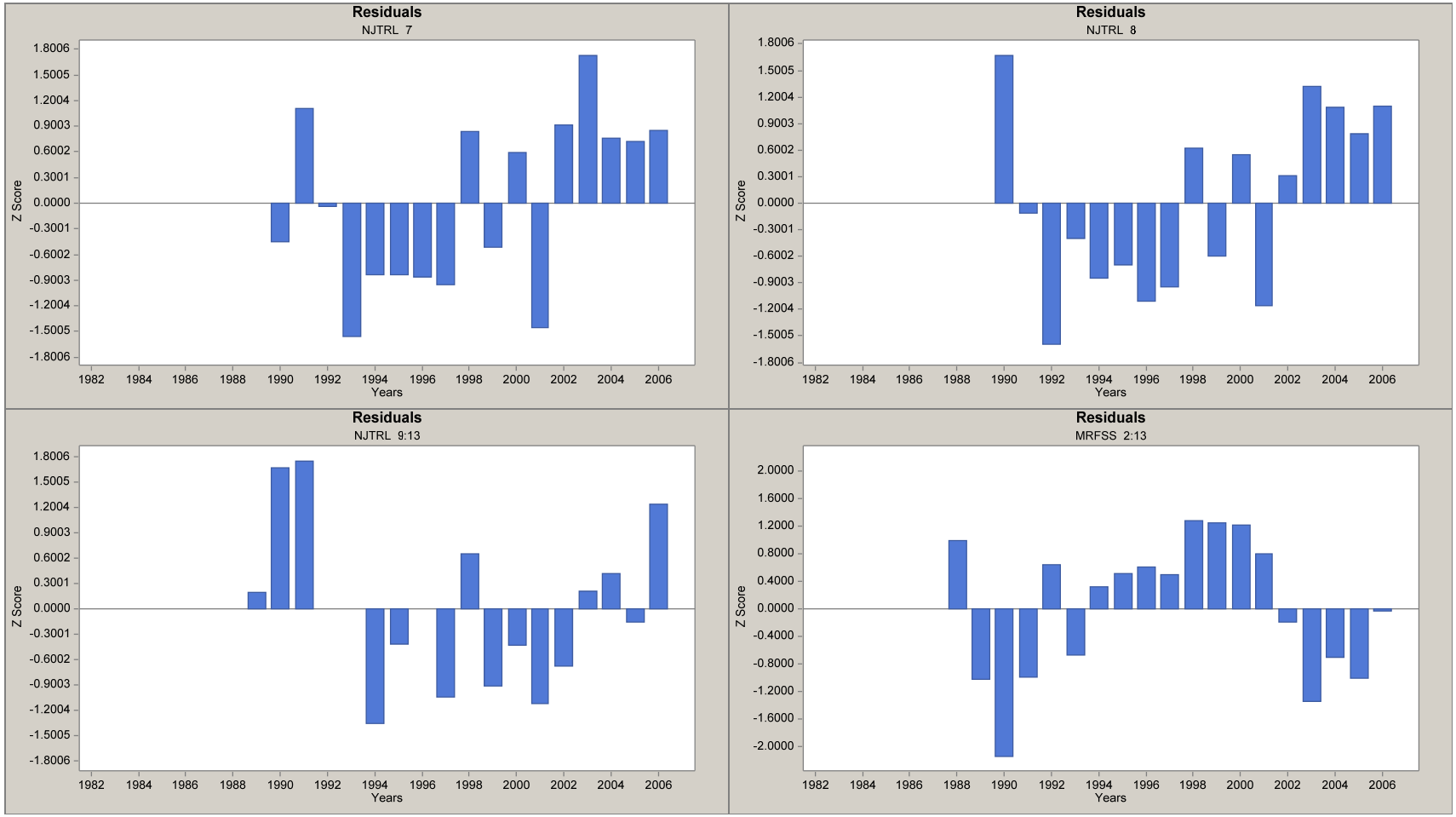

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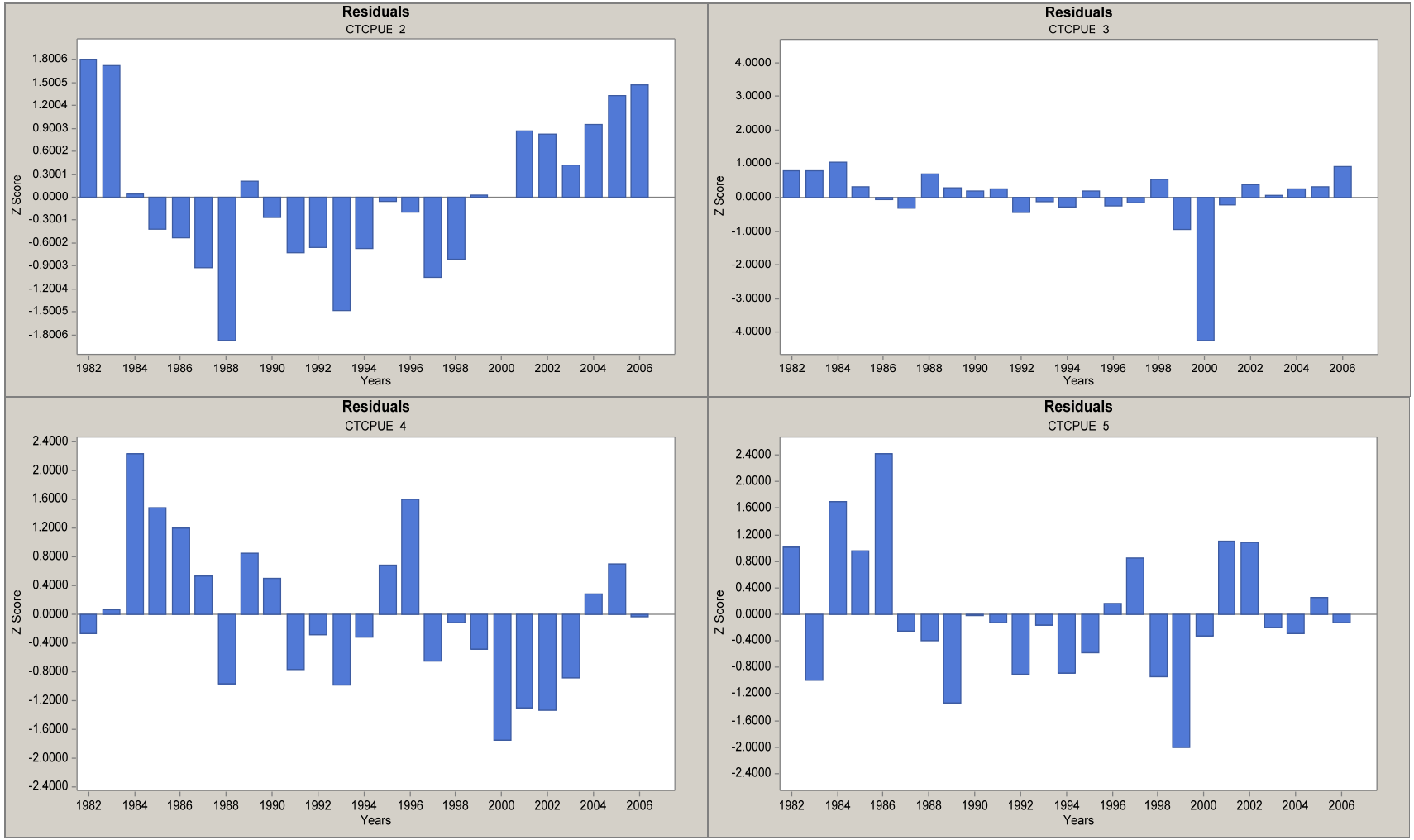

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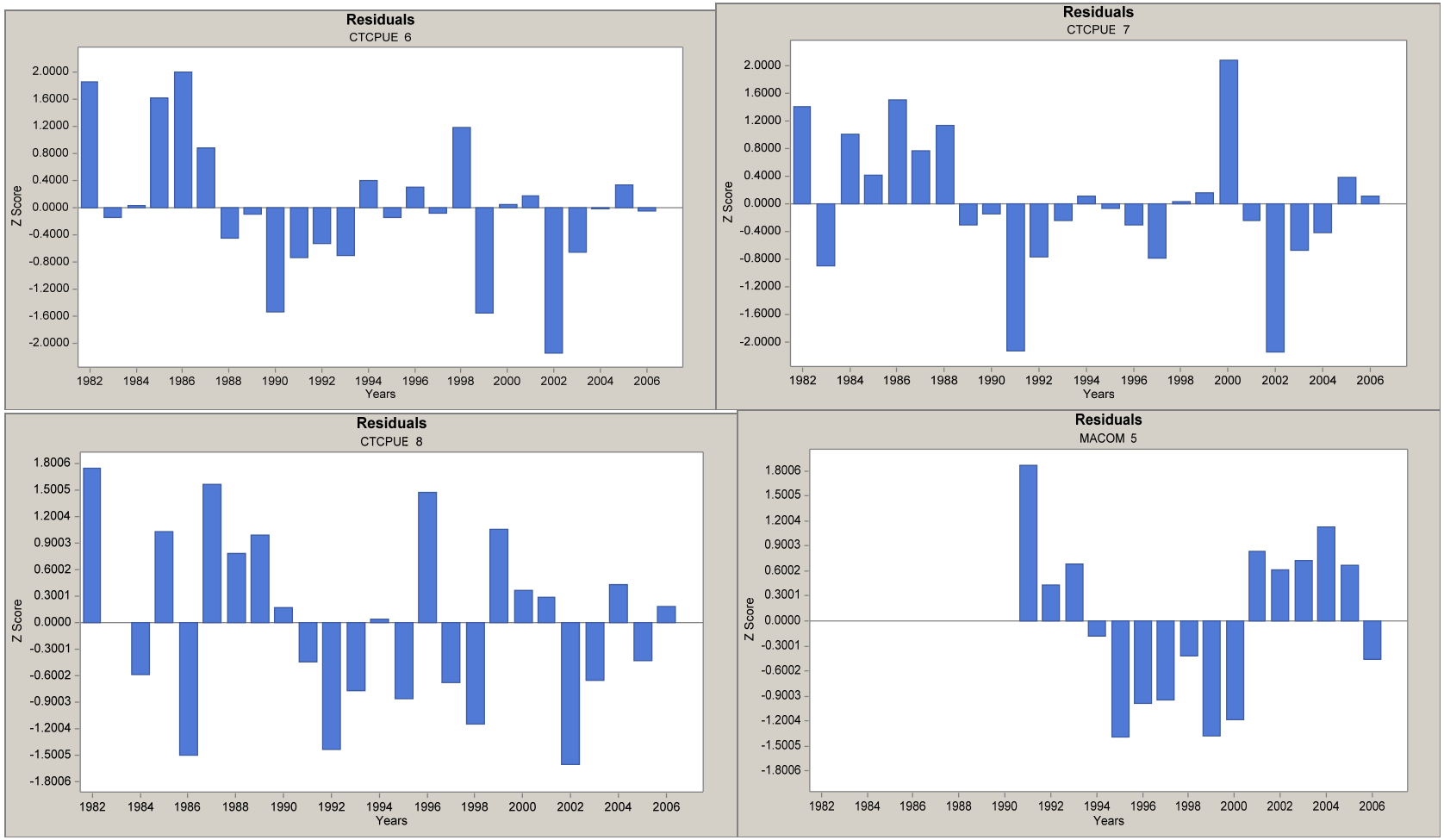

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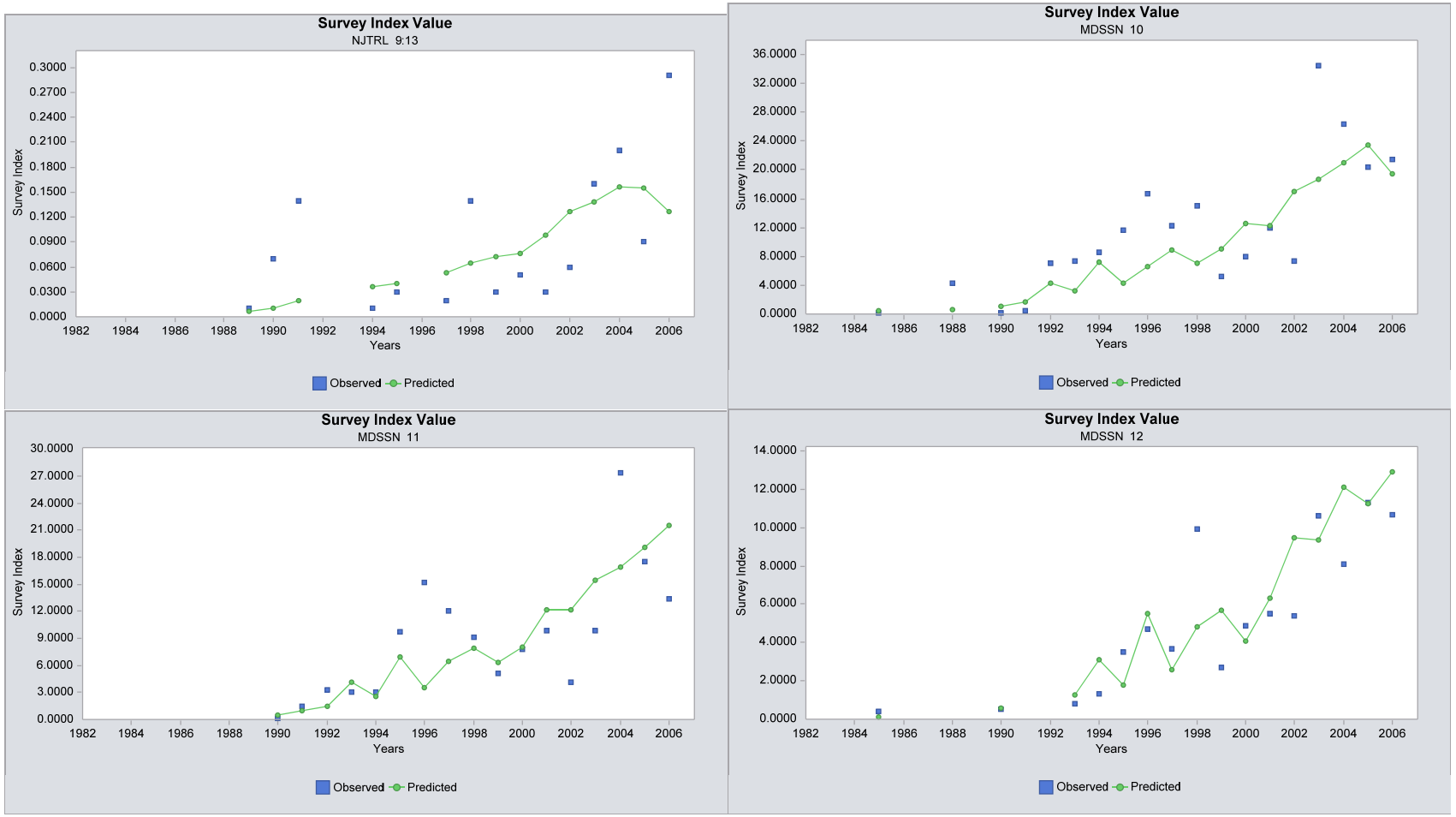
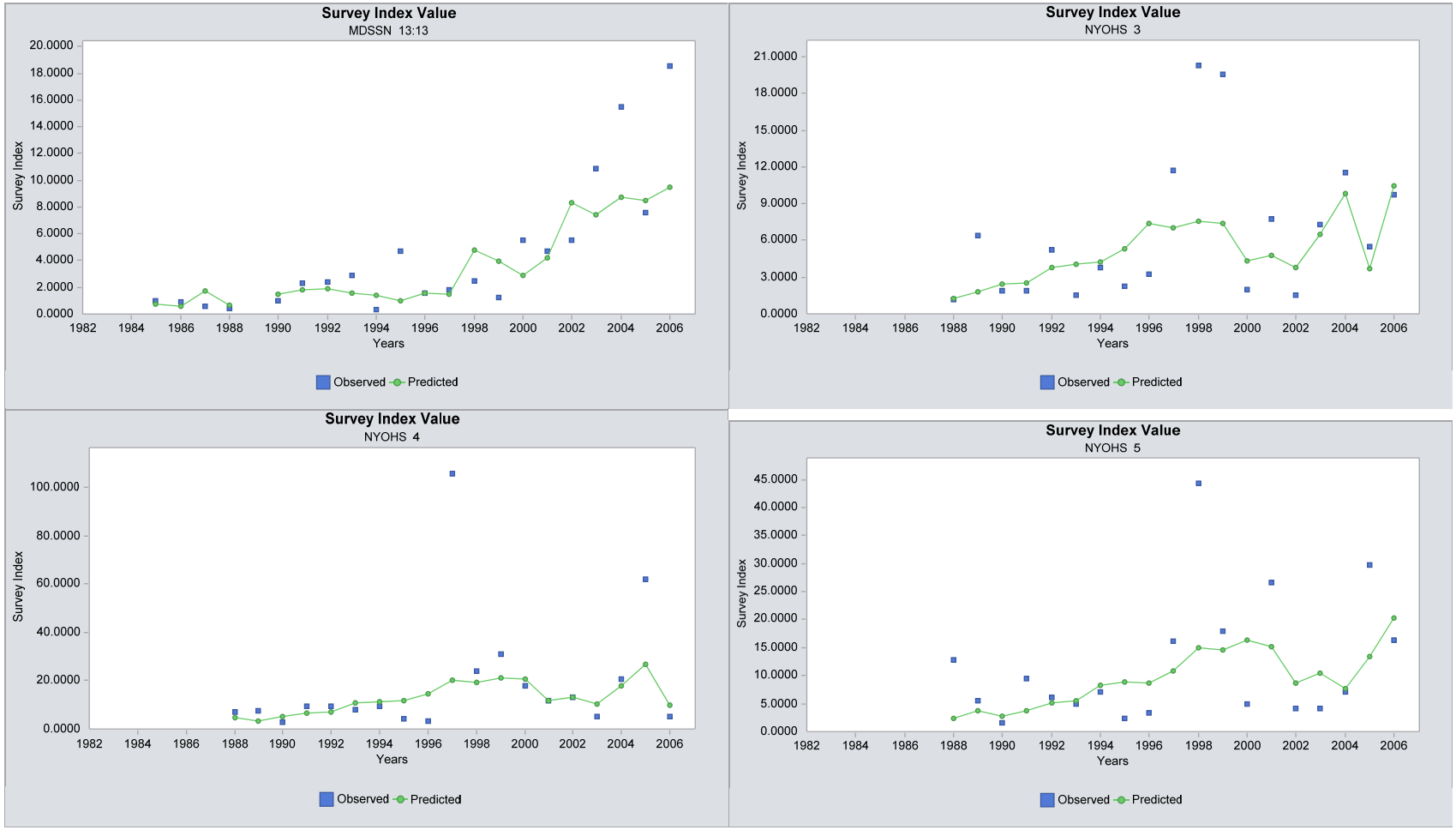


Figure 3. Observed vs. predicted indices from ADAPT model with reduced suite of indices



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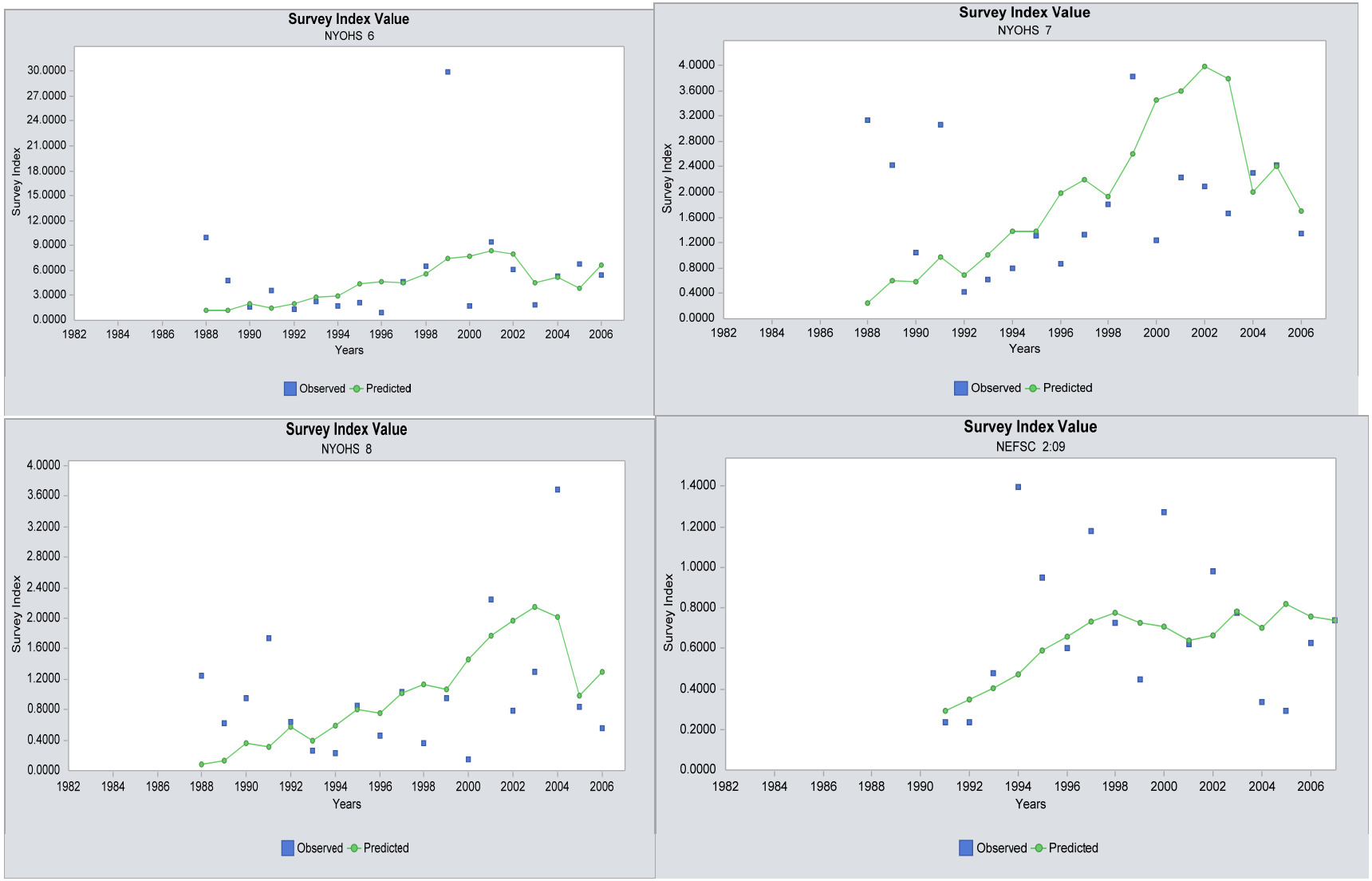
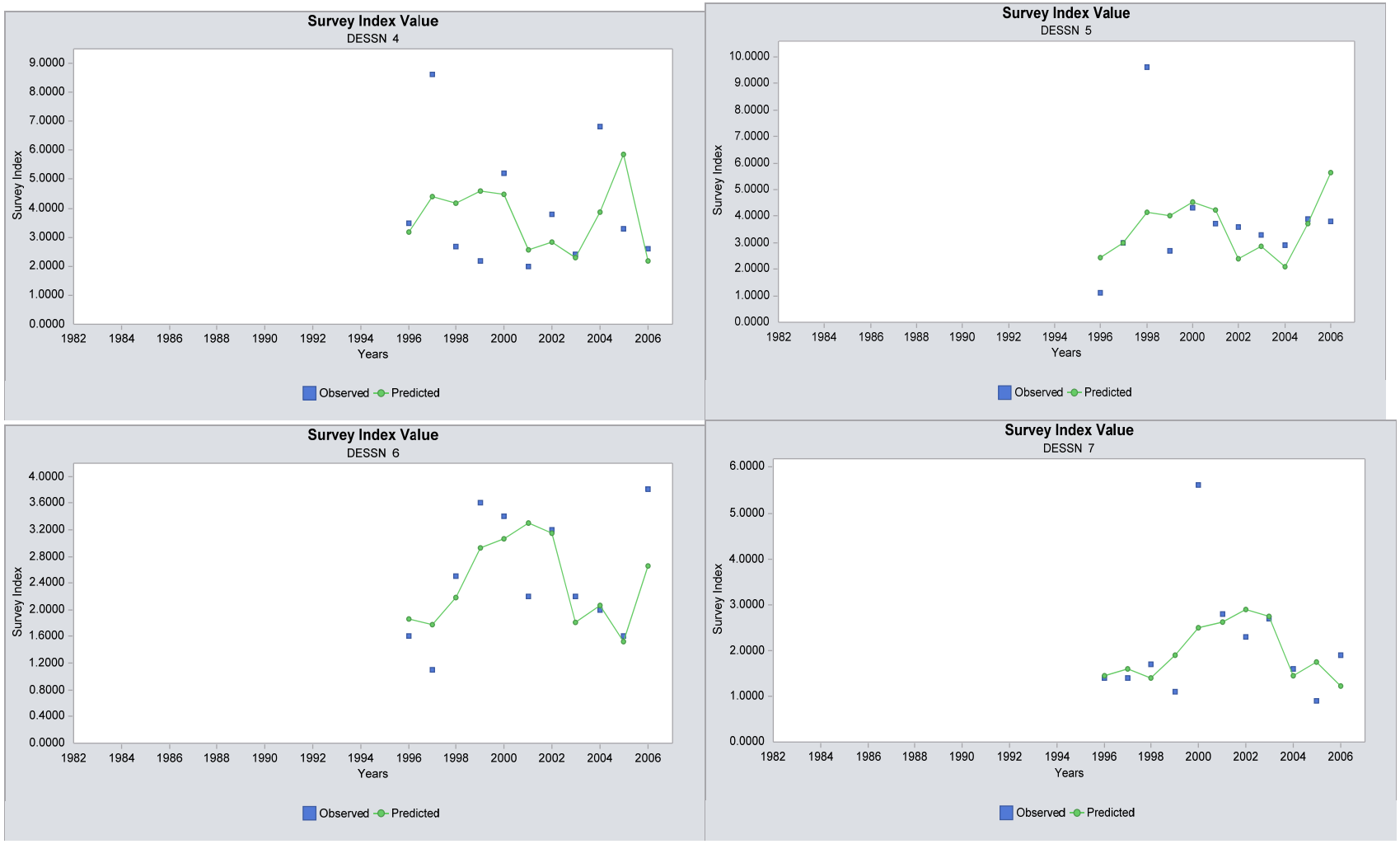


Figure 3 continued.

Figure 3 continued.

Figure 3 continued.



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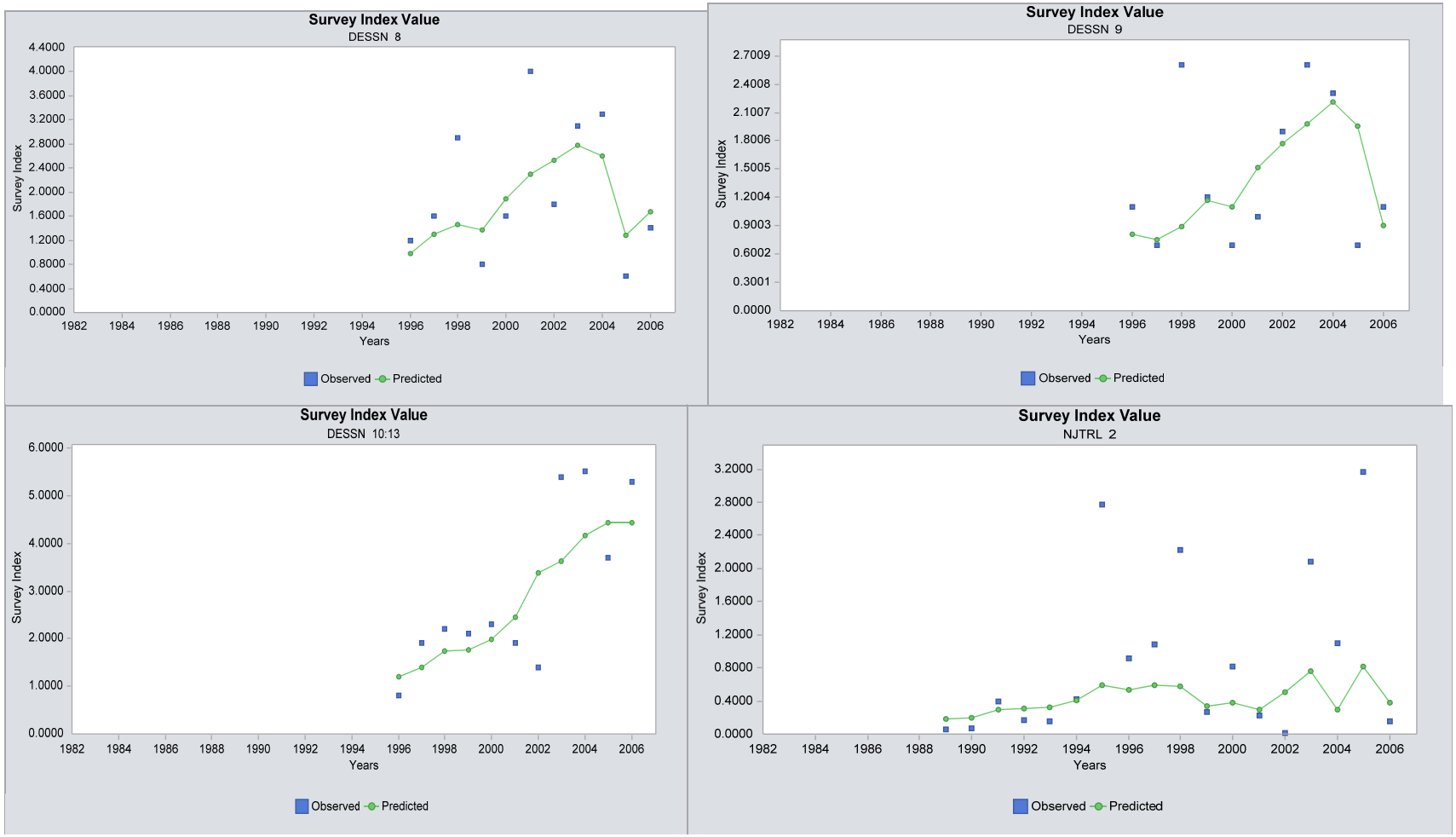

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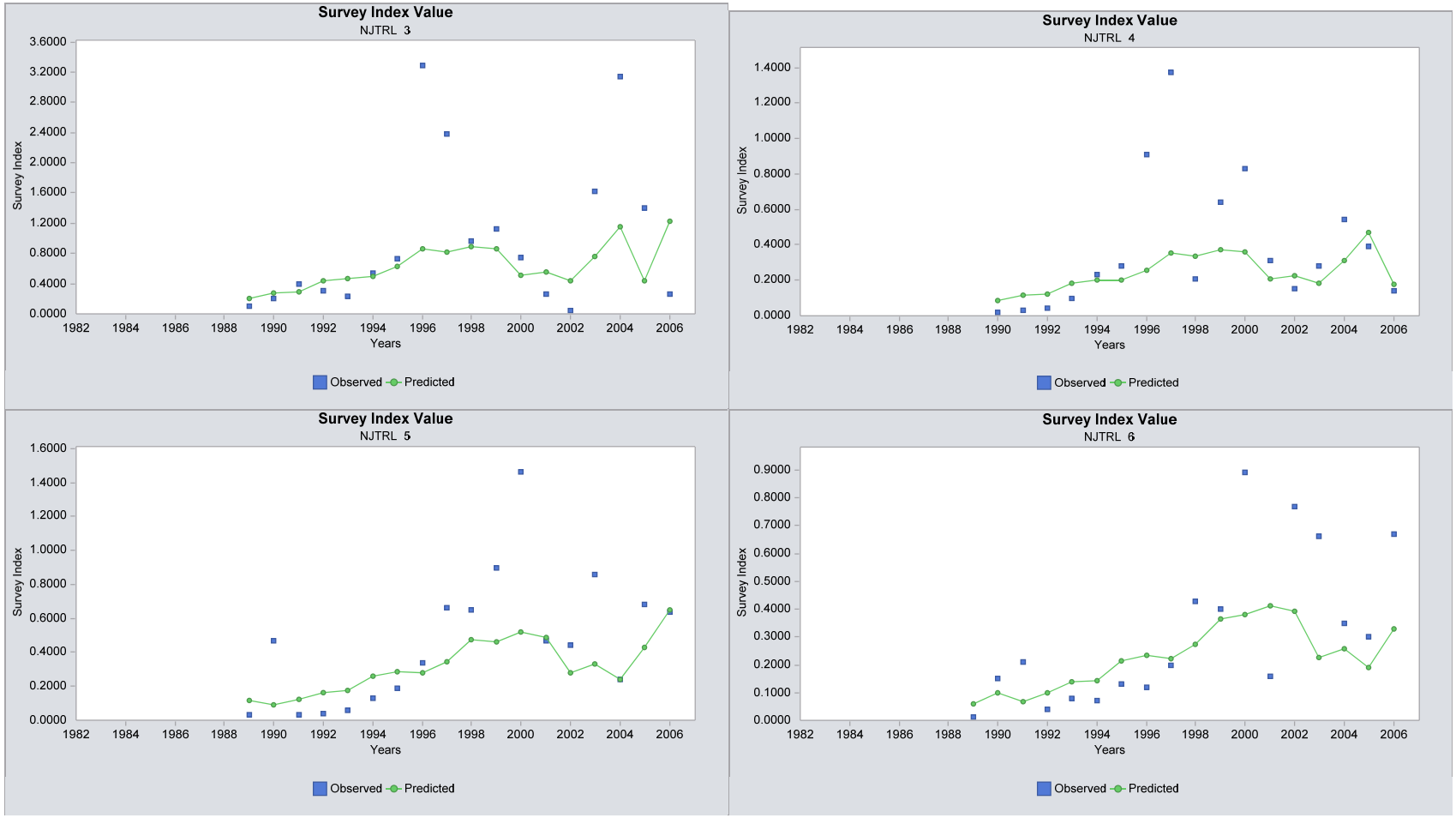

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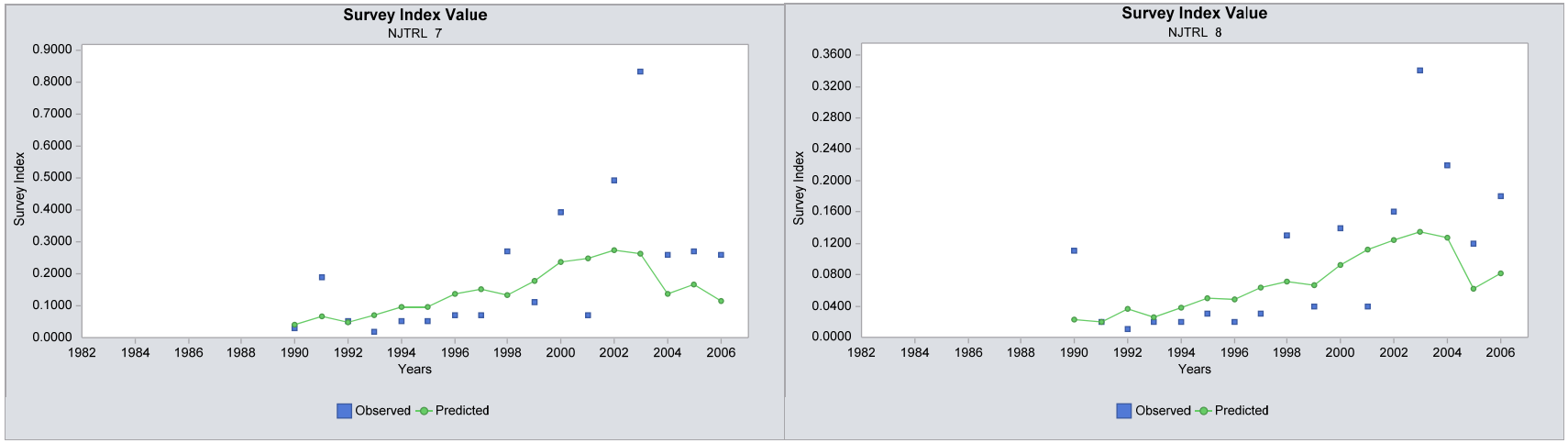

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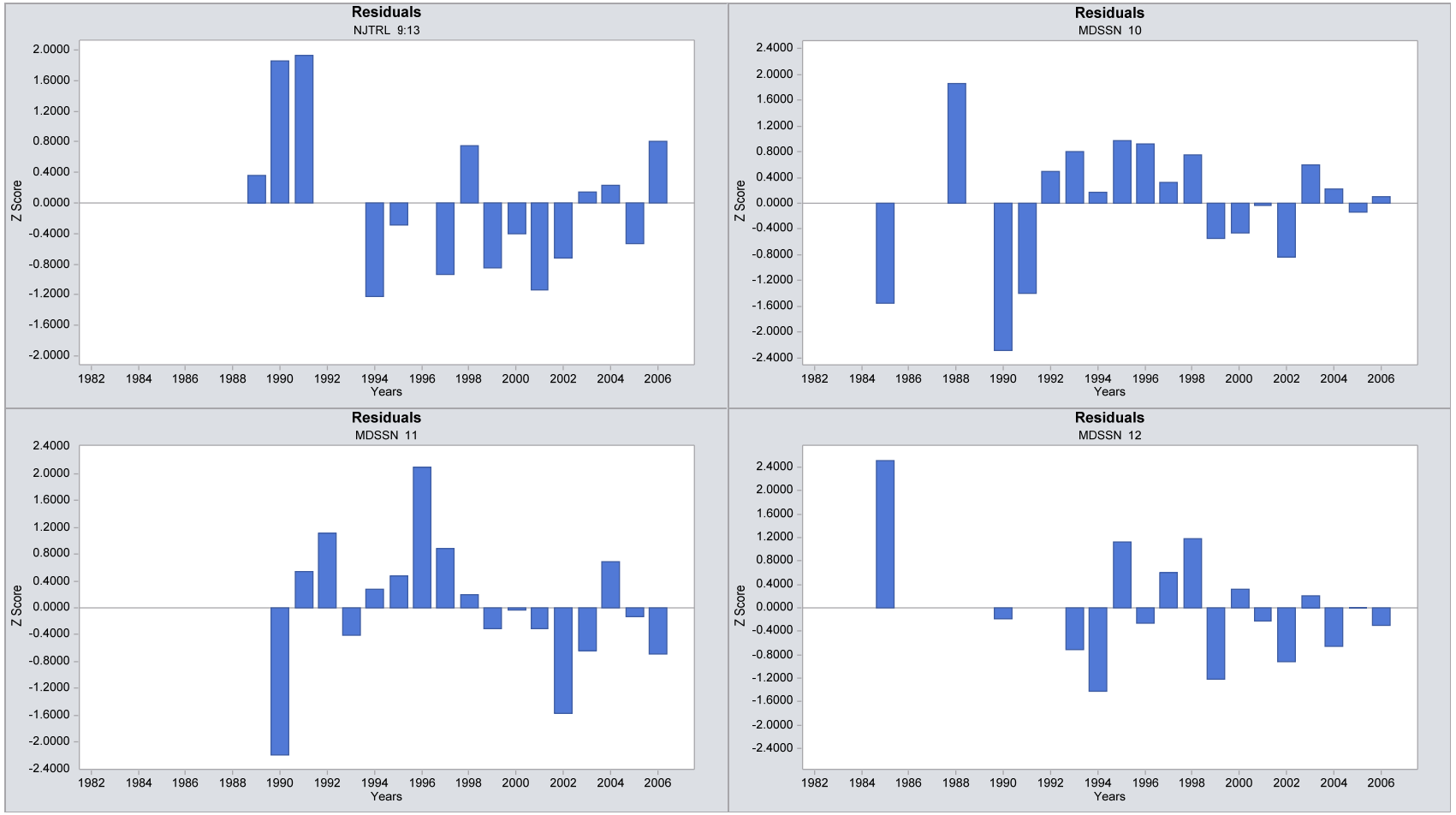
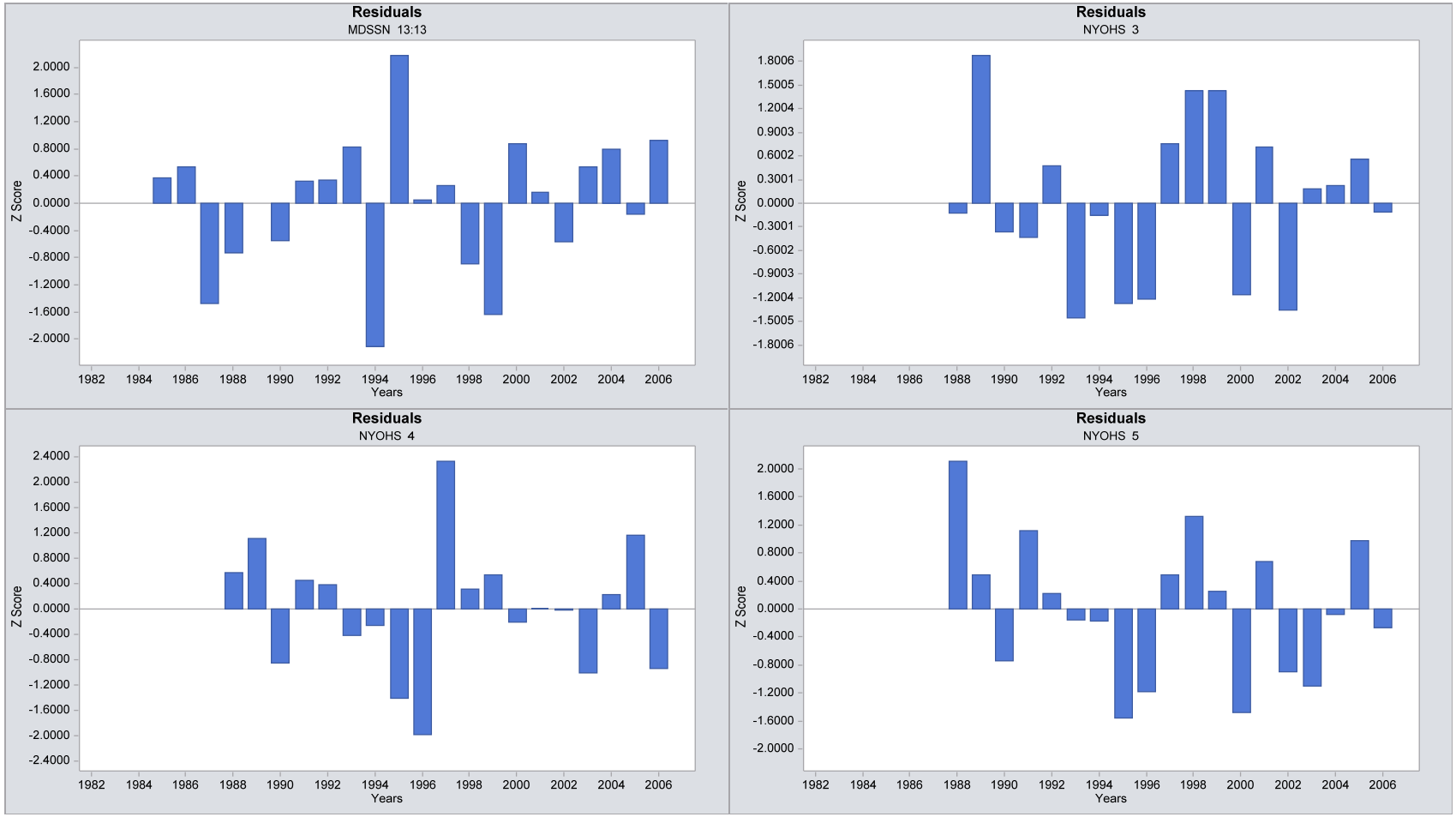


Figure 4. Residual plots from ADAPT model using reduced suite of indices.



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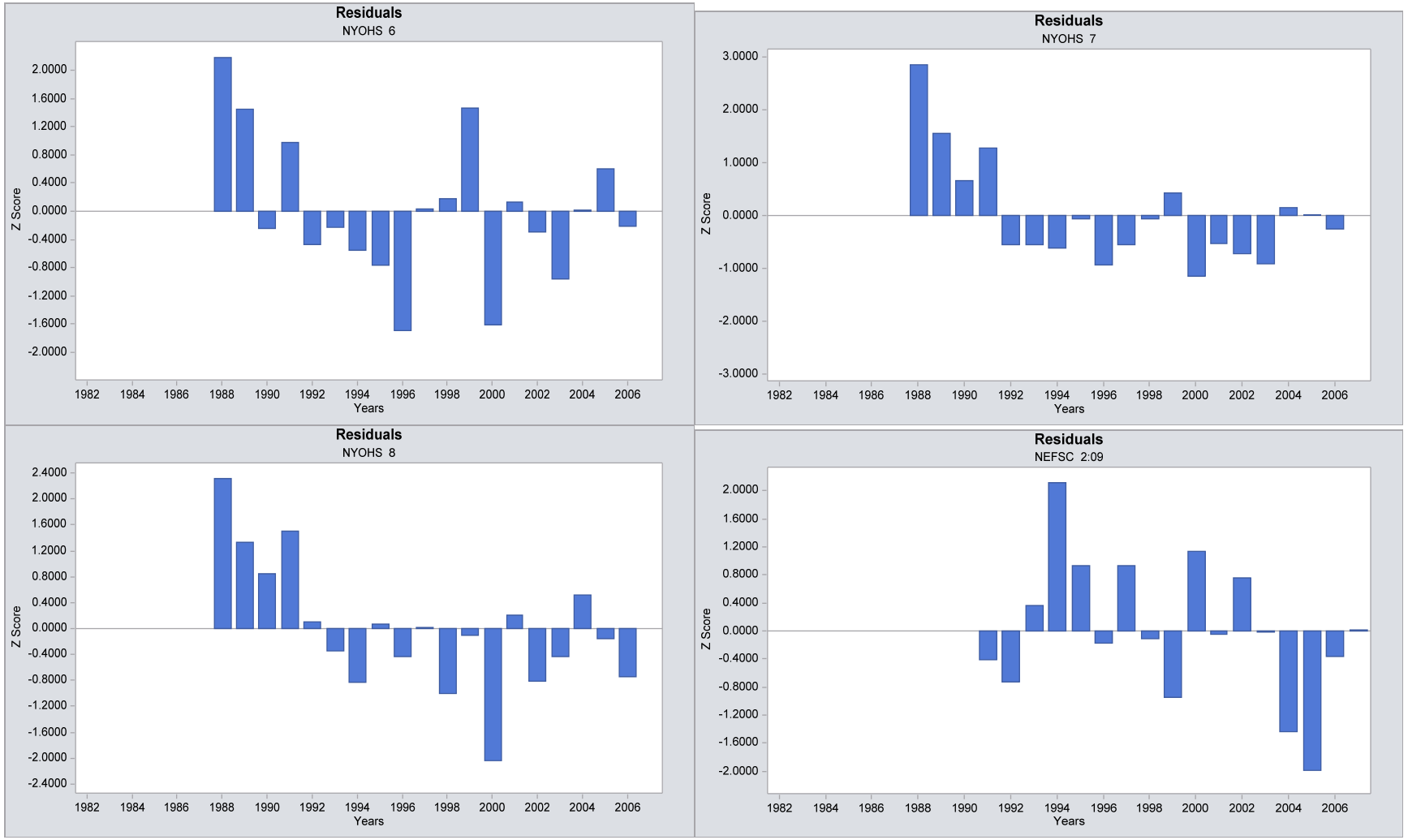

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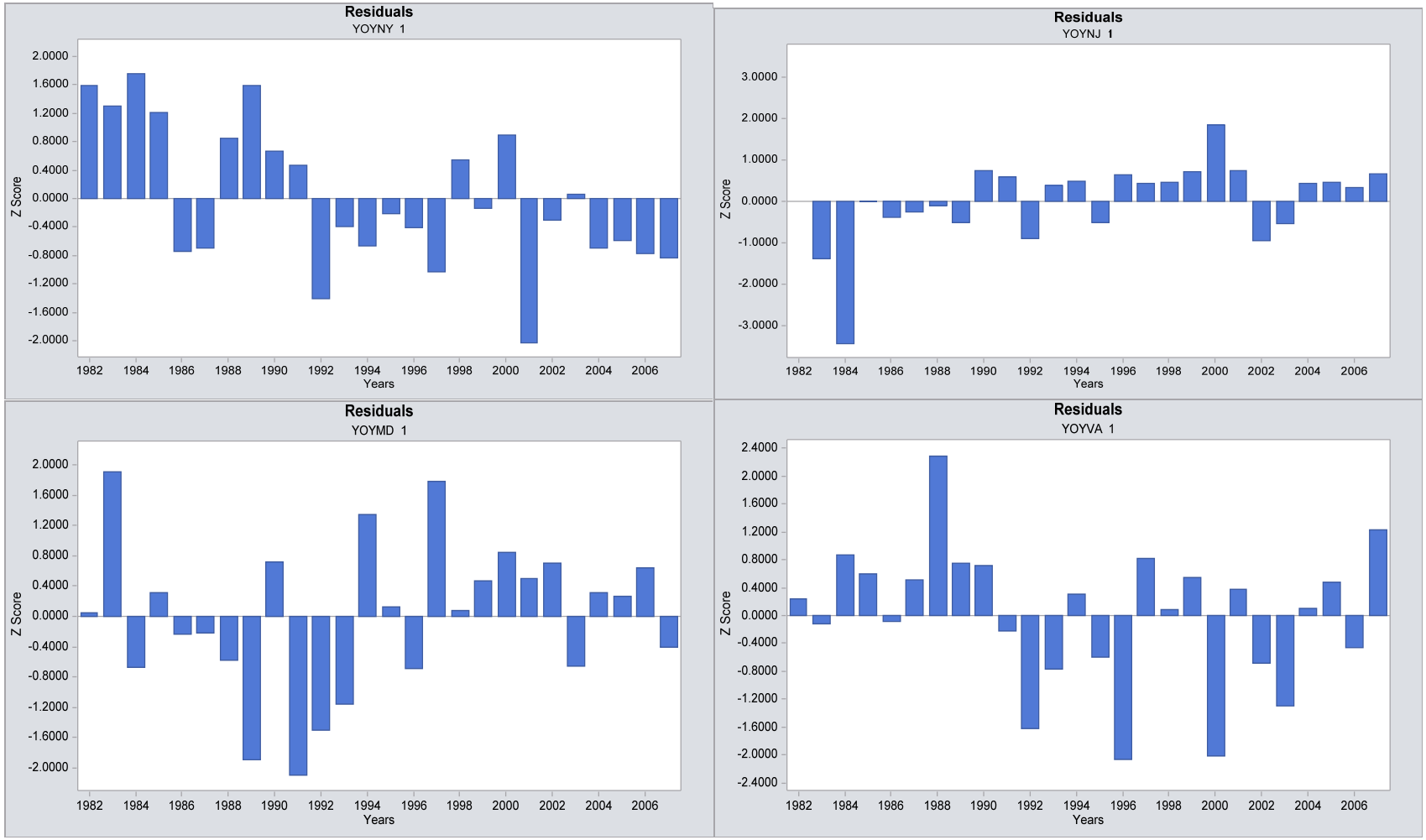

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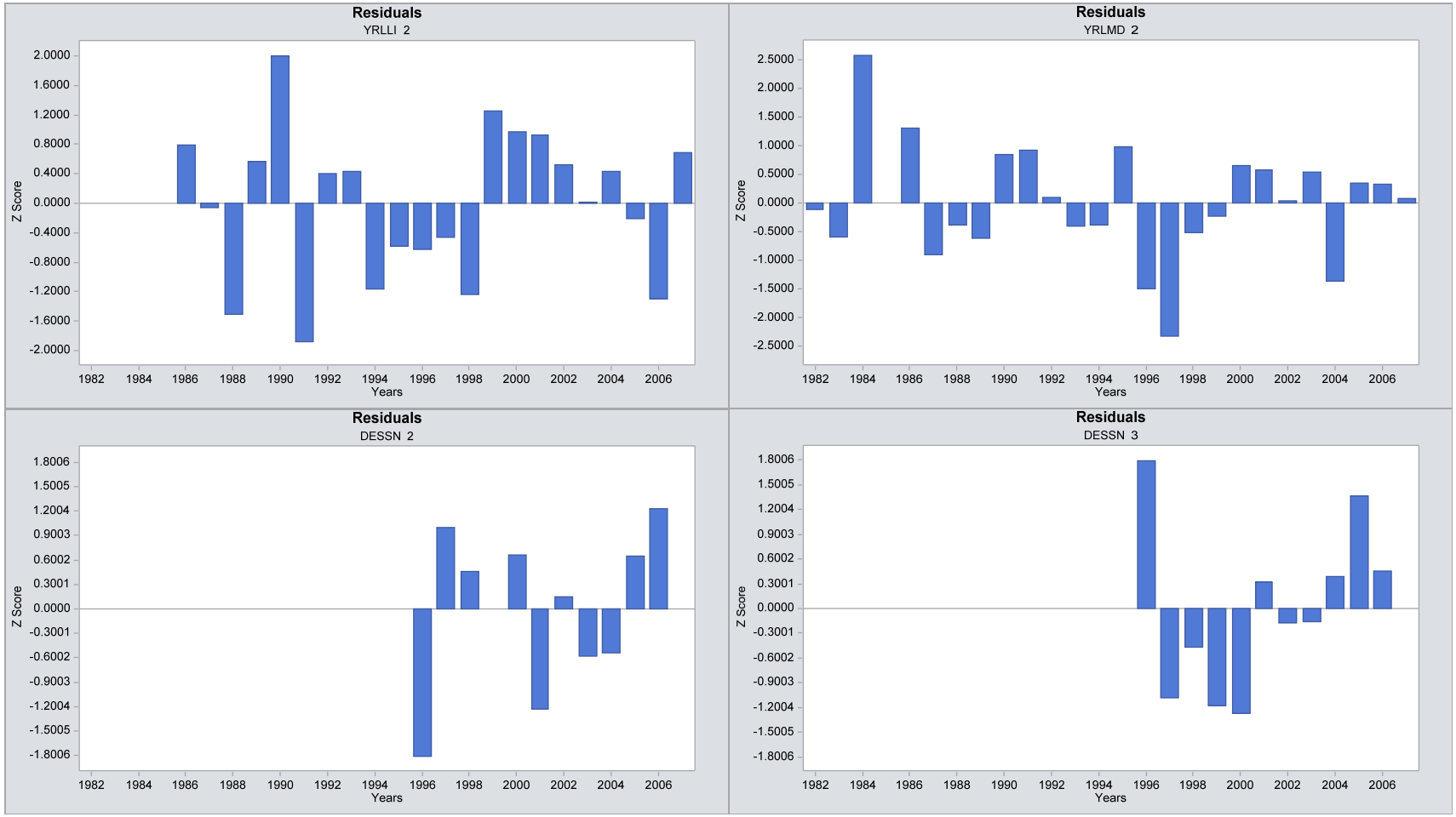

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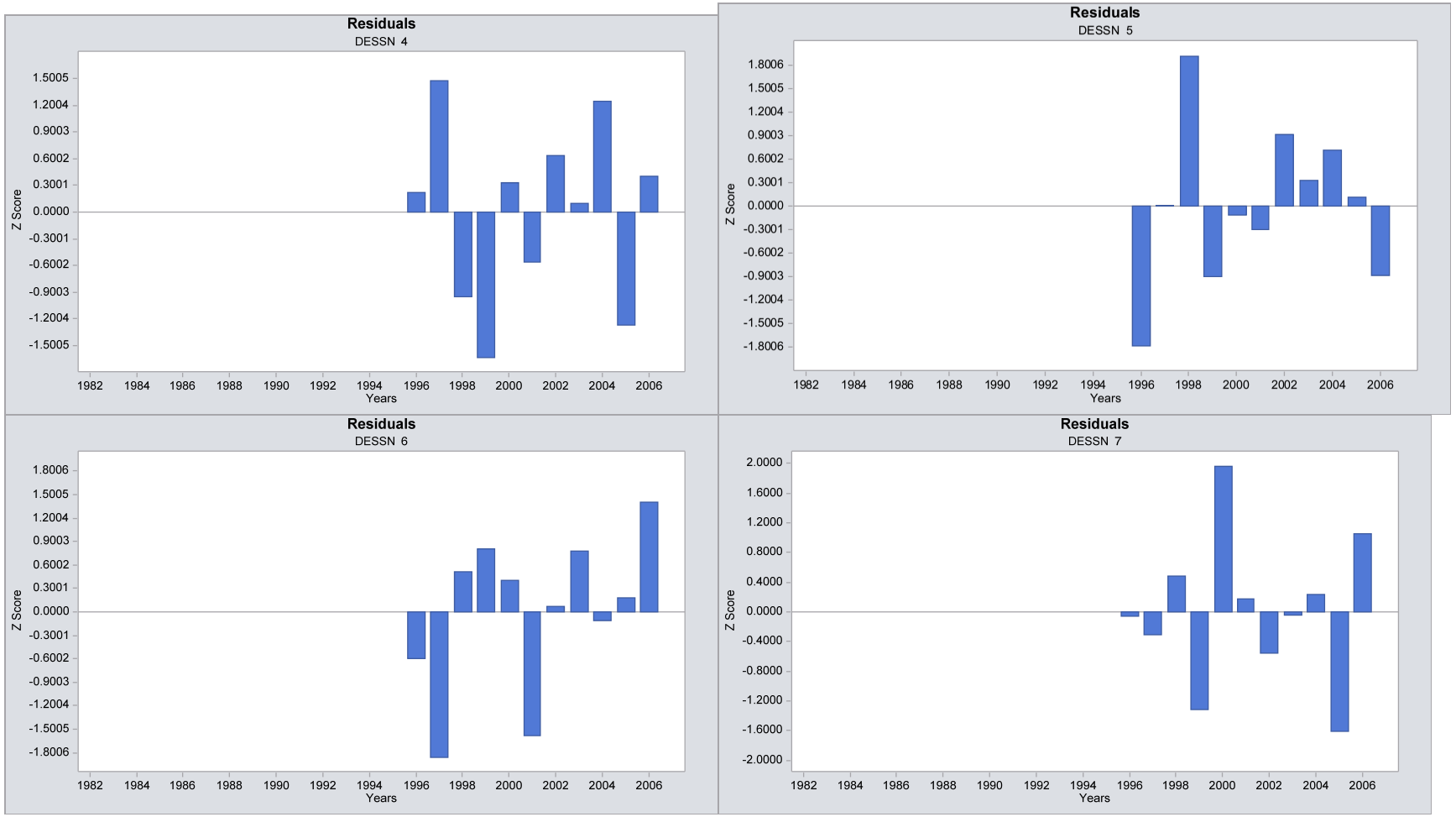

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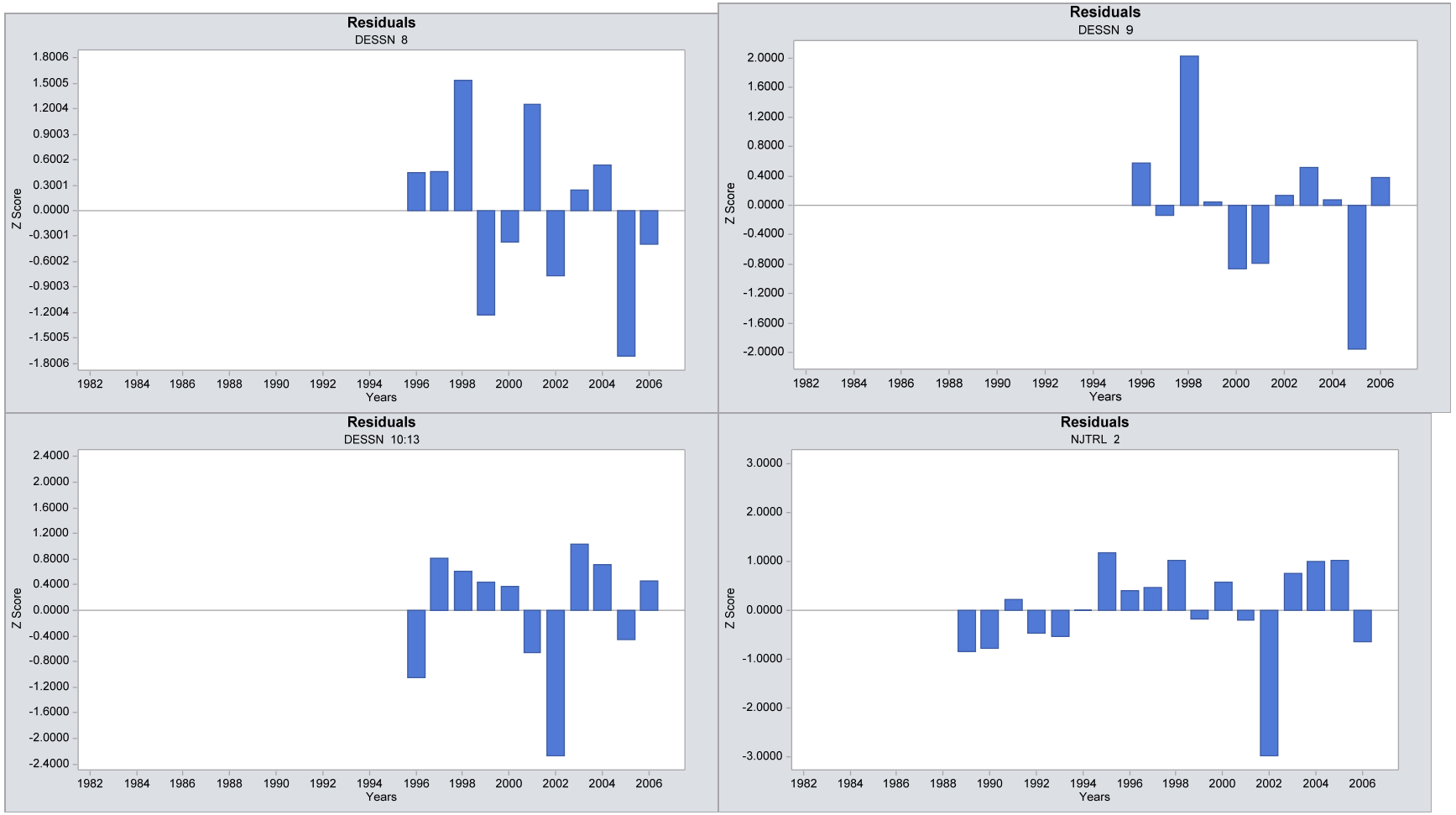

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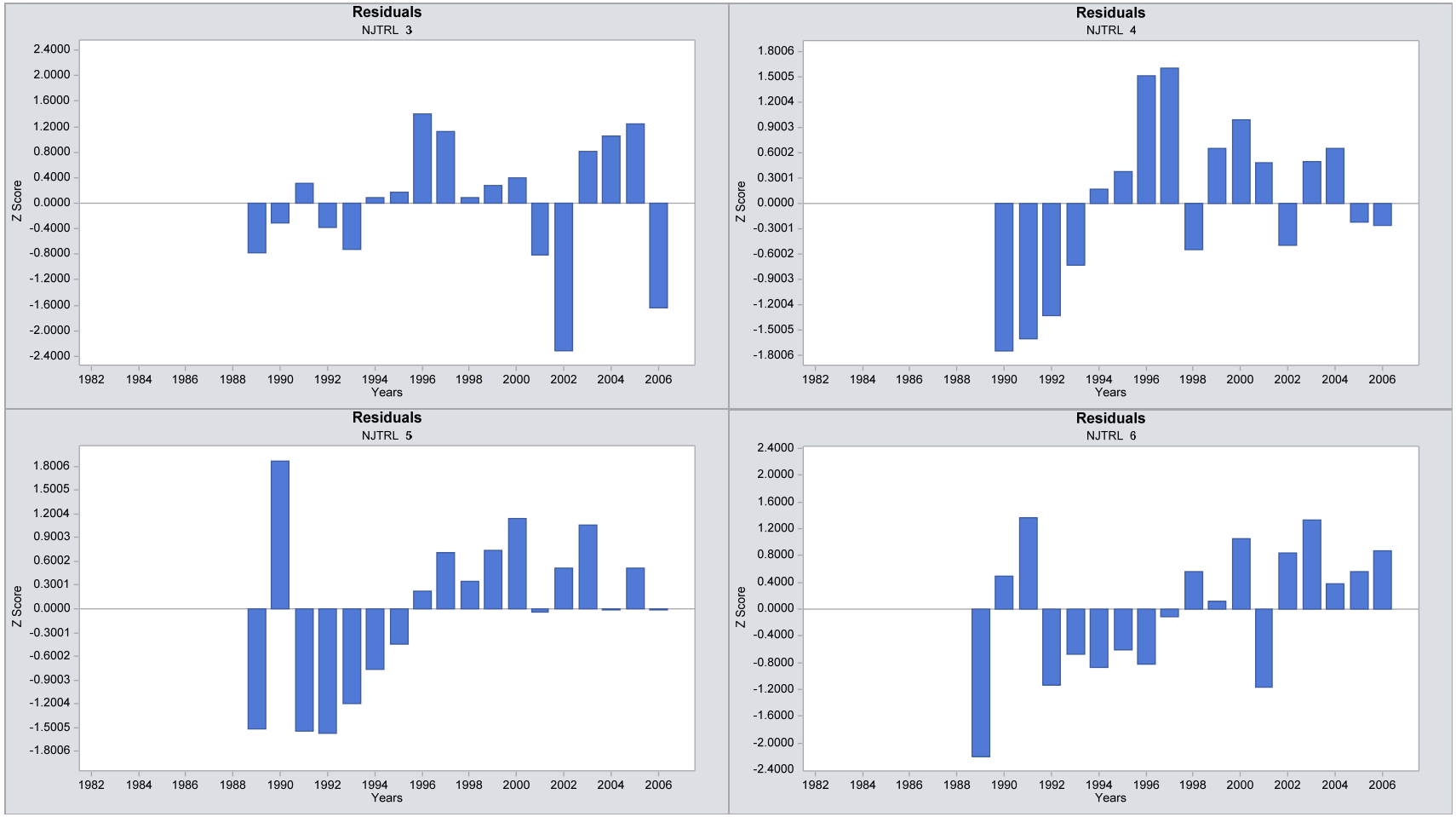

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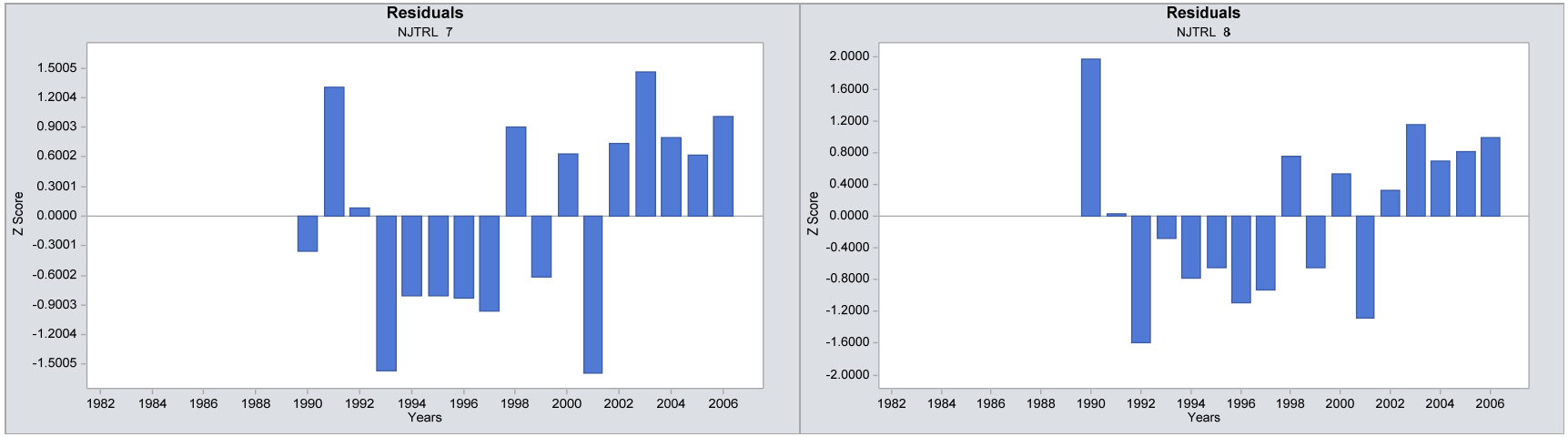

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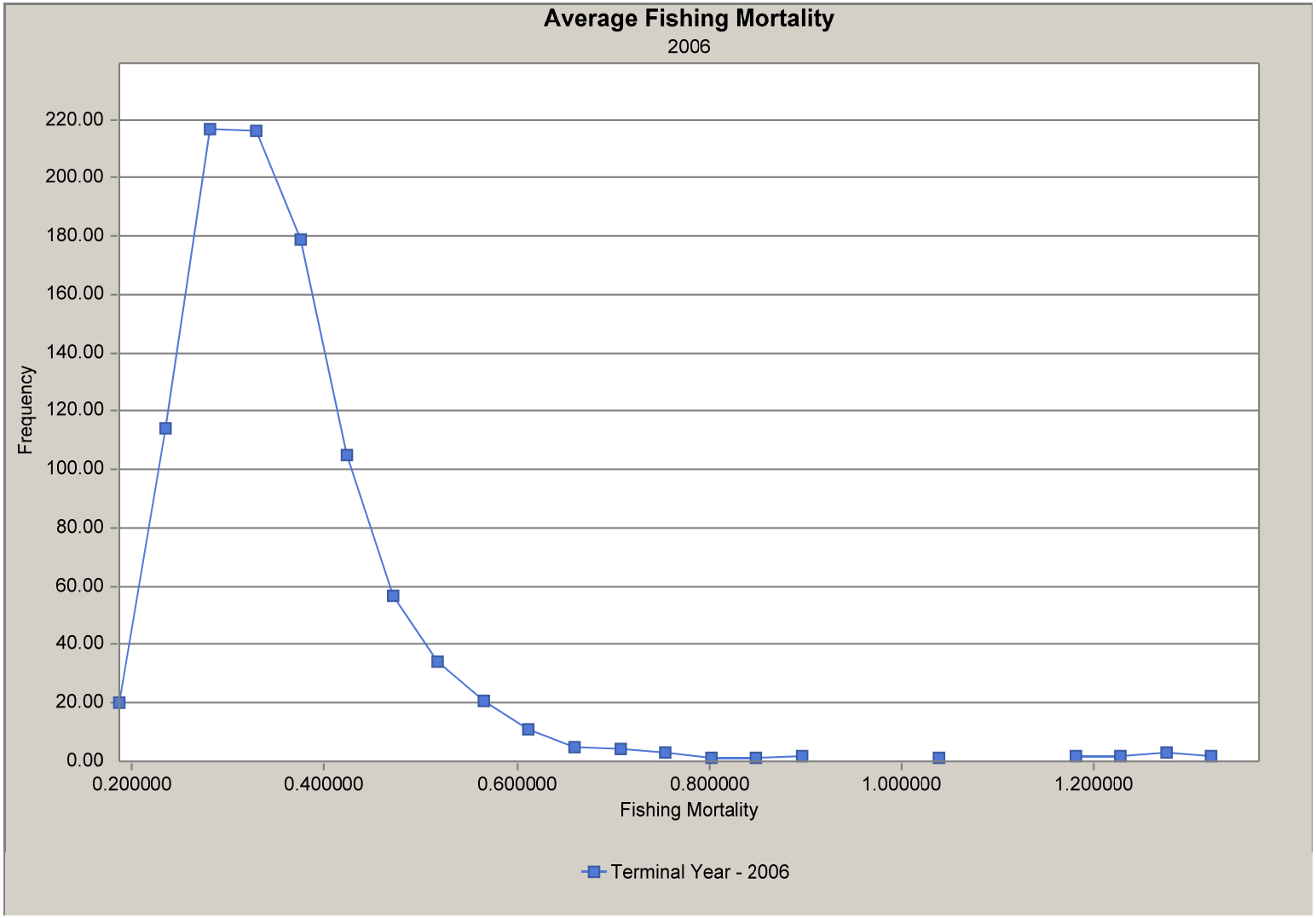


Figure 5. Bootstrap plot of fishing mortality from ADAPT model using reduced suite of indices

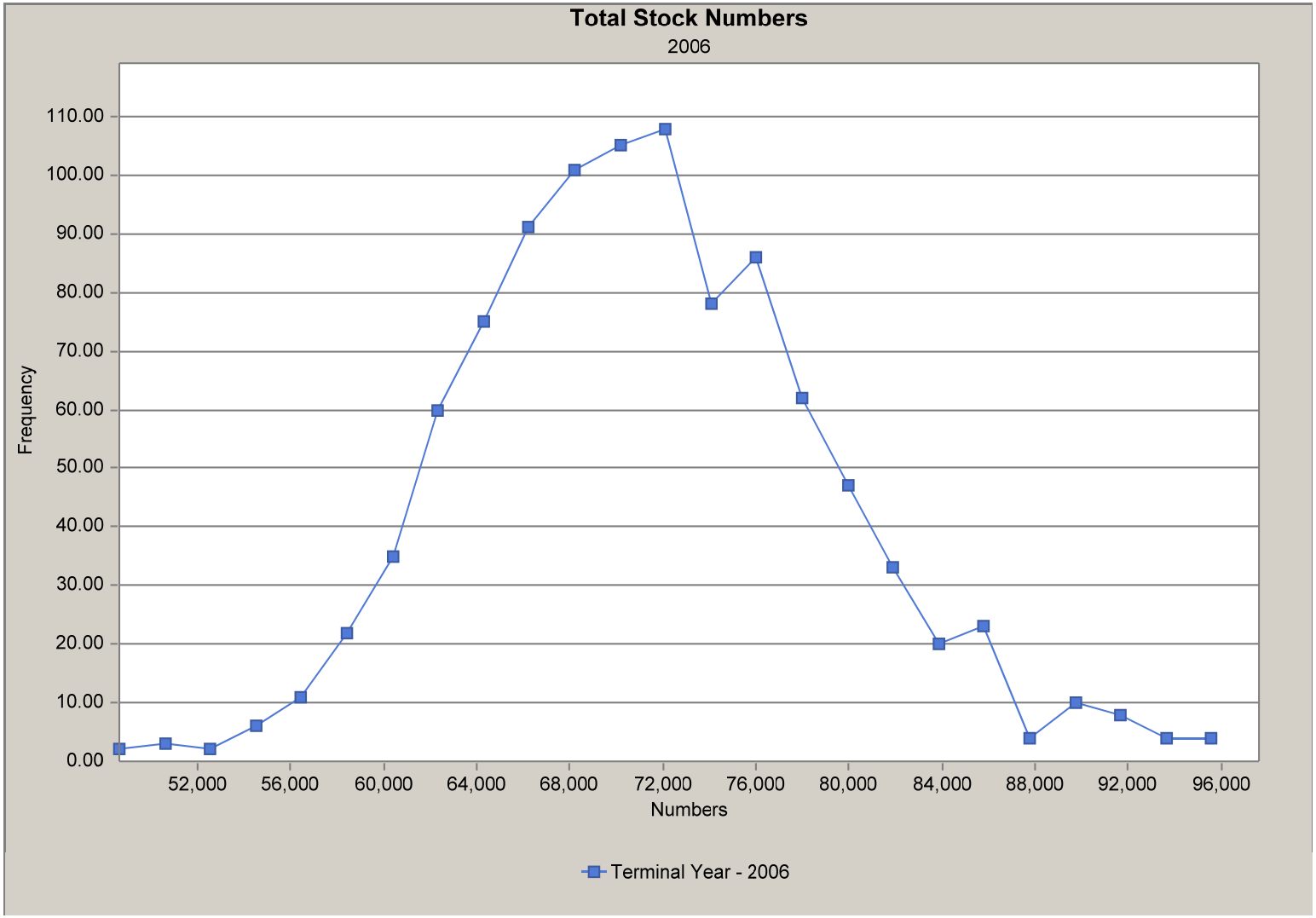


Figure 6. Bootstrap plot of stock numbers from ADAPT model using reduced suite of indices.

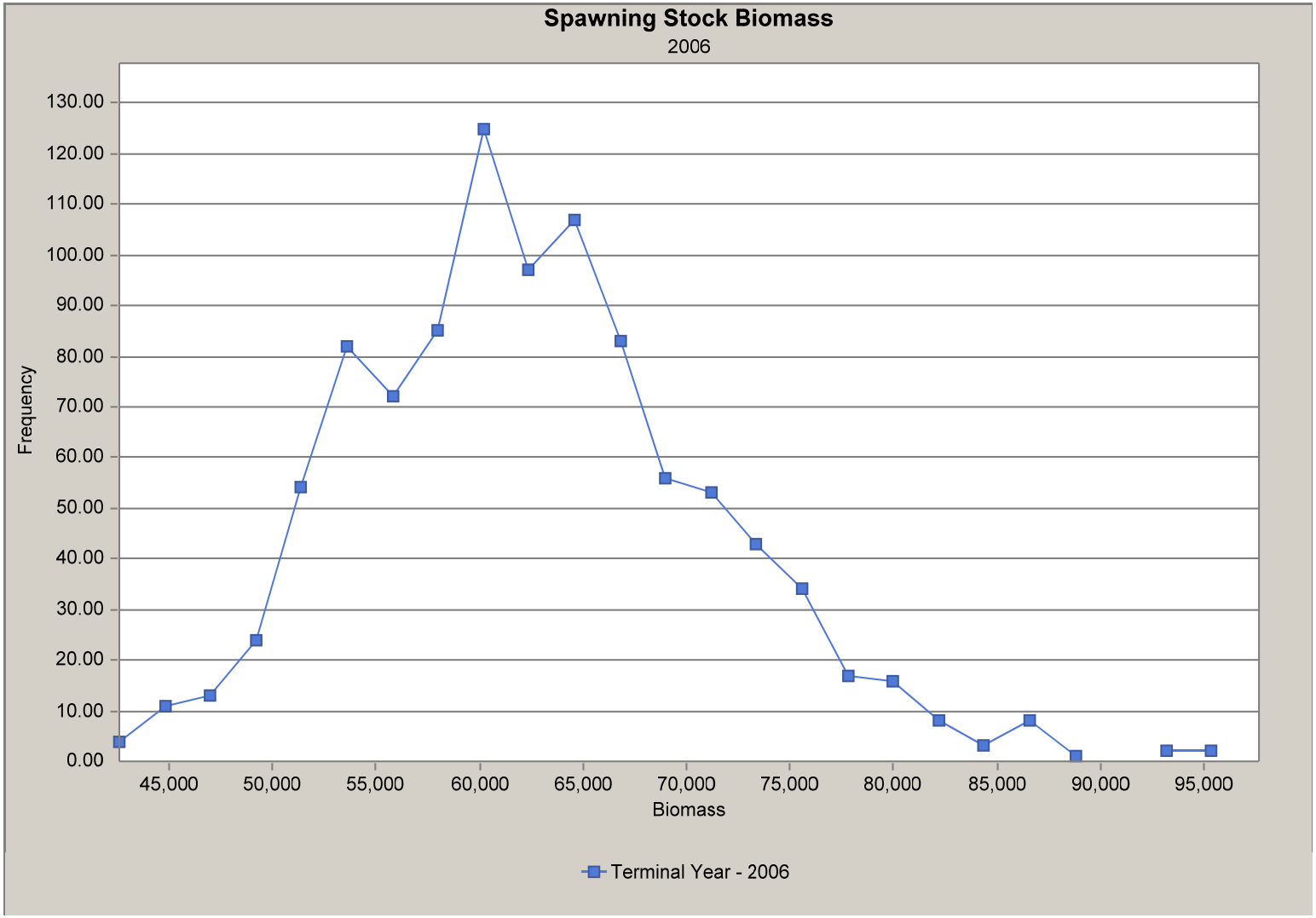
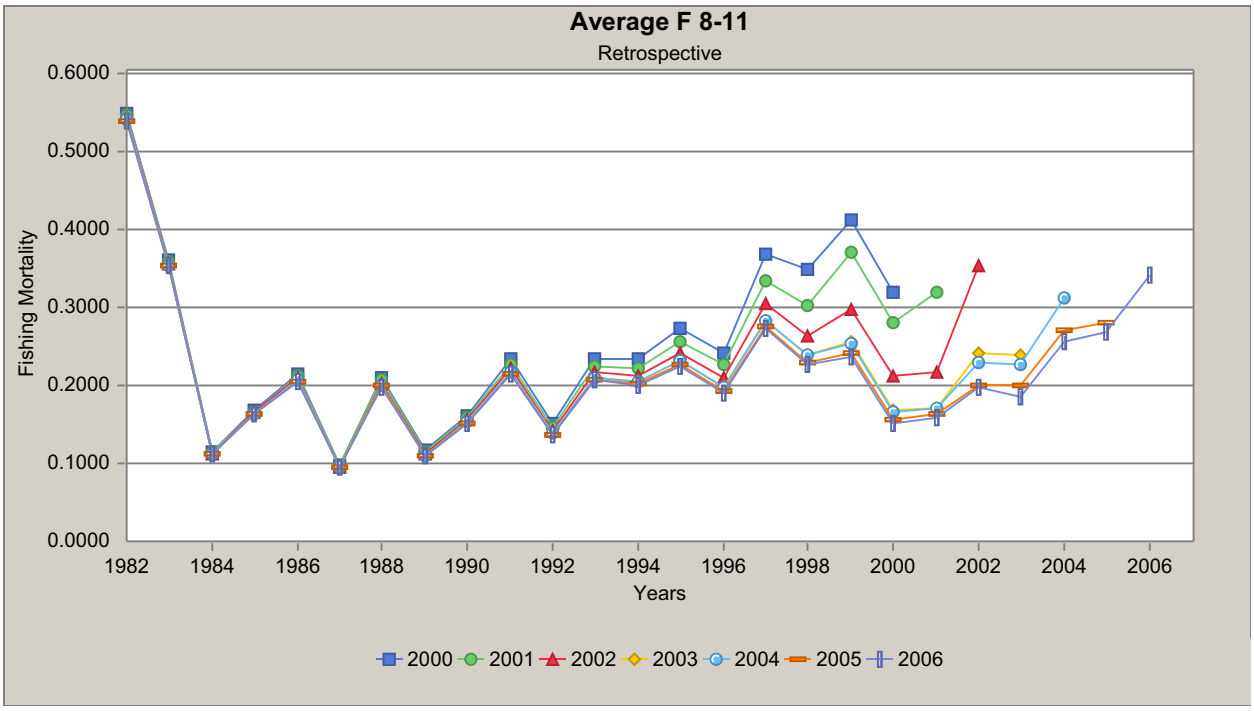


Figure 7. Bootstrap plot of spawning stock biomass from ADAPT model using reduced suite of indices.



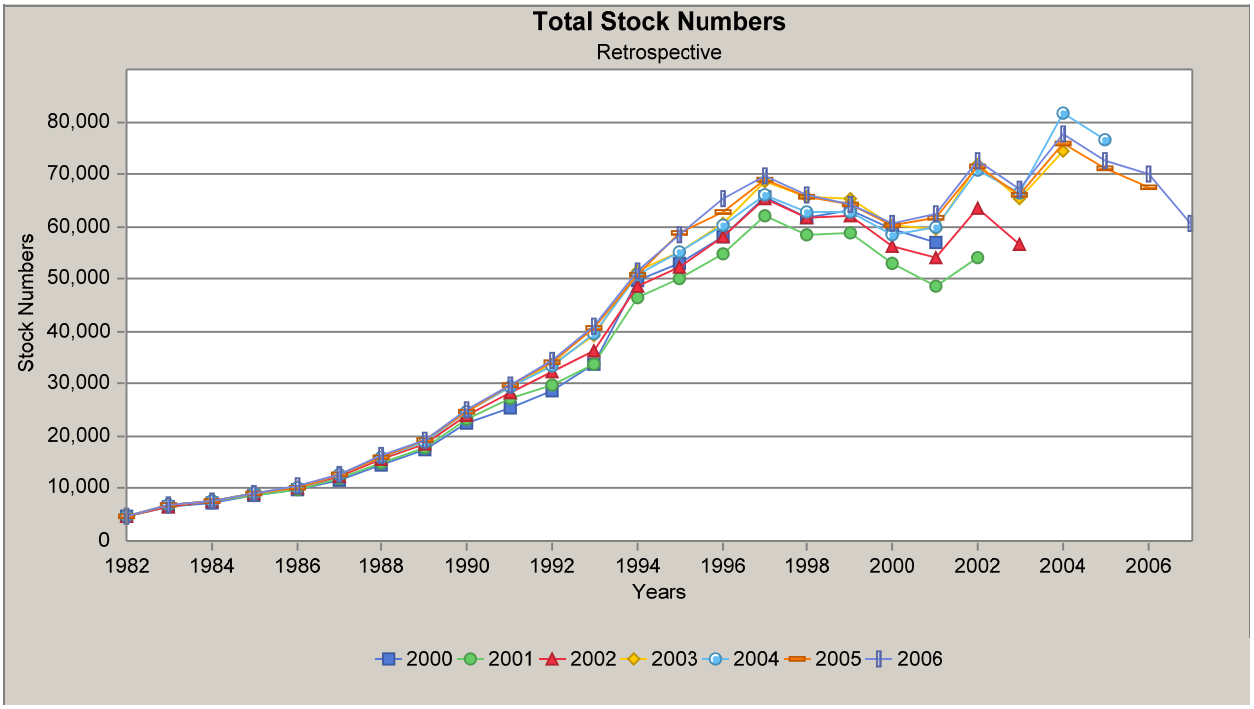
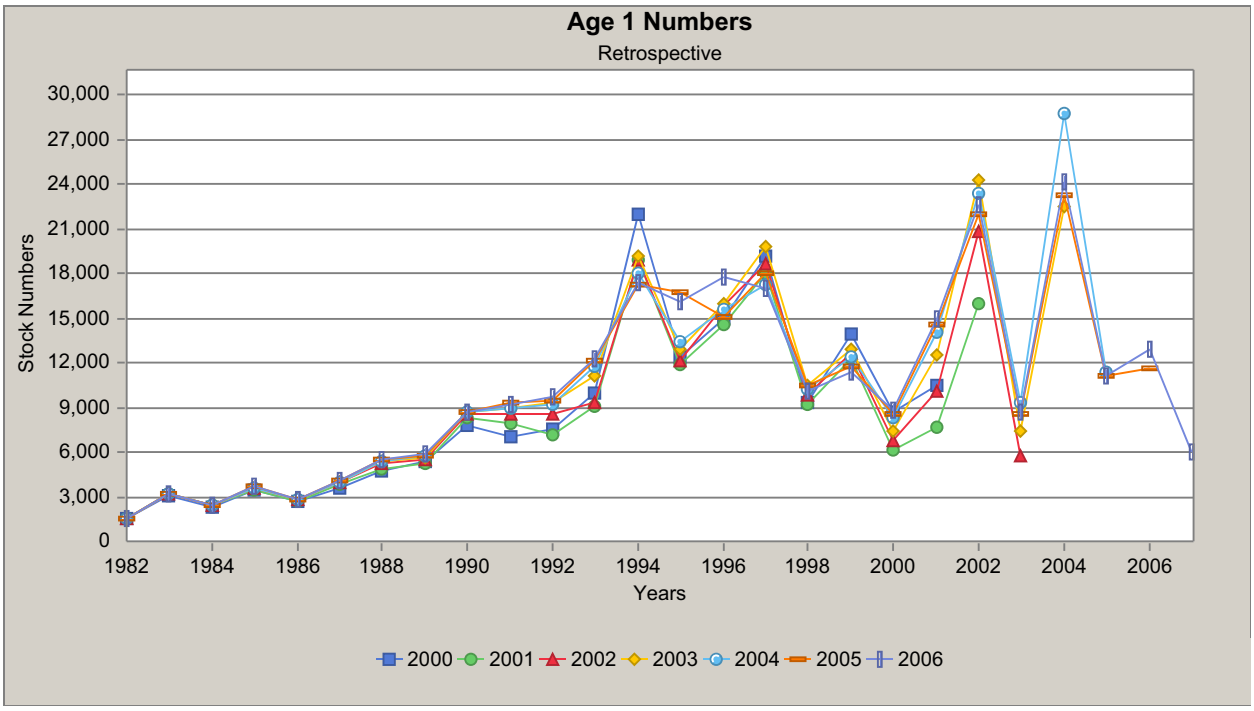


Figure 8. Retrospective plot of average fishing mortality and total stock abundance from ADAPT model using reduced suite of indices



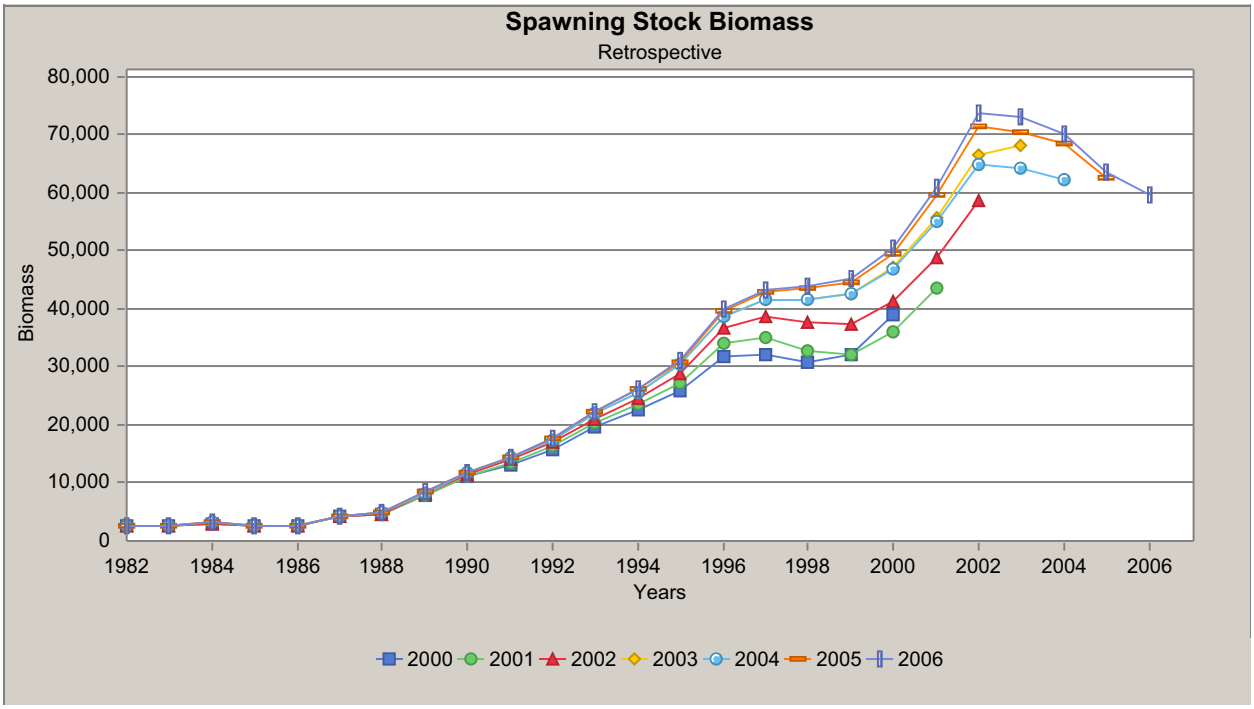


Figure 8 continued.