

Appendix D

Annual Abundance Indices

APPENDIX D

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D.1 INTRODUCTION

Annual indices of abundance for 13 species of finfish are based on data from the Longitudinal River Survey (LRS), Fall Juvenile Survey (FJS) and Beach Seine Survey (BSS). This appendix documents the methods used to calculate these indices of abundance and presents the indices from 1974 through 2004.

For each of the 13 species, one or more sampling programs were selected to be the basis for the index of abundance. The selections considered when and where each species was expected to be present in the Hudson River based on life-history characteristics of each species in relation to the times and places that sampling gear is deployed by each program. The selections were also based on observed catch rates from each of the three sampling programs. The sampling programs on which the indices of abundance are based as well as the life stages and weeks selected for analysis are summarized in [Table D-1](#).

The statistical methods used to estimate the annual indices of abundance are described in the following section. Summaries of the indices of annual abundance for the 13 species are presented in [Figures D-1 through D-13](#) and [Tables D-2 through D-14](#).

D.2 METHODS

D.2.1 Beach Seine Survey

Indices of abundance using data from the BSS were calculated for juvenile striped bass, white perch, American shad, bluefish, and spottail shiner; for yearling white perch; and for yearling and older white catfish. Weeks 33 to 40 were selected as the only period consistently sampled in the BSS. The Beach Seine Survey Index of abundance (B) for each year and species is a measure of catch per haul and is calculated according to the following formula:

$$B = \frac{1}{n} \sum_{w=33}^{40} \left[\frac{\sum_{i=1}^{12} W_i \left(\frac{\sum_j C_{jiw}}{h_{iw}} \right)}{\sum_{i=1}^{12} W_i} \right] X_w,$$

where

- B = the BSS index for a species in a year;
- C_{jiw} = the count of a species in sample j , region i , and week w ;
- X_w = 1 if week w was sampled during the year, 0 otherwise;
- n = the number of weeks sampled in the year,
= $\sum_{w=33}^{40} X_w$;
- h_{iw} = the number of seine hauls in region i and week w ; and
- W_i = the number of beaches in the sampling design in river region i .

The above equation can be expressed in terms of a weighted average catch per haul (CPH) as follows:

$$B = \frac{1}{n} \sum_{w=33}^{40} \bar{Y}_w X_w = \frac{1}{n} \sum_{w=33}^{40} \left[\frac{\sum_{i=1}^{12} W_i \bar{Y}_{wi}}{\sum_{i=1}^{12} W_i} \right] X_w,$$

where

$$\begin{aligned} \bar{Y}_{wi} &= \text{the average CPH in week } w \text{ and region } i \text{ and} \\ \bar{Y}_w &= \text{the weighted average CPH in week } w. \end{aligned}$$

Because not all weeks within the period of week 33 to 40 were sampled by the BSS in each year, the variance of the BSS index in any year is calculated as a two-stage variance. The primary sampling unit in the first stage is weeks, and the design is assumed to be simple random sampling (i.e., weeks of sampling are construed to be a random sample of weeks within the period from week 33 through week 40). The sampling units in the second stage are regions, and the design is stratified random where regions are the statistical strata. The variance is calculated using a two-stage estimator based on equation 11.24 in Cochran (1977, p. 303):

$$\text{var}(B) = \frac{\left(1 - \frac{n}{N}\right)}{n} S_1^2 + \frac{1}{Nn} \sum_w S_{2,w}^2,$$

where

$$\begin{aligned} S_1^2 &= \text{the first stage variance (temporal, among weeks),} \\ S_{2,w}^2 &= \text{the second stage variance (spatial) in week } w, \text{ and} \\ N &= \text{the number of weeks (8) within the selected period, i.e., weeks 33} \\ &\quad \text{through 40.} \end{aligned}$$

The first stage variance component is estimated as:

$$S_1^2 = \frac{1}{n-1} \sum_{w=33}^{40} (\bar{Y}_w - B)^2.$$

The second stage variance component is estimated as:

$$S_{2,w}^2 = \frac{\sum_{i=1}^{12} W_i^2 \left[\frac{\sum_j \left(Ct_{jiw} - \frac{1}{h_{iw}} \sum_j Ct_{jiw} \right)^2}{(h_{iw})(h_{iw} - 1)} \right]}{\left(\sum_{i=1}^{12} W_i \right)^2}$$

Then:

$$\text{std. err.}(B) = (\text{var}(B))^{1/2}.$$

D.2.2 Fall Juvenile Survey

Indices of abundance using data from channel sampling by the FJS were calculated for juvenile blueback herring, alewife, bay anchovy, weakfish, and rainbow smelt for the years 1979 through 2004, the years that the channel was sampled. In addition, indices of abundance based on bottom sampling by the FJS were calculated for juvenile hogchoker. Weeks 33 to 40 were selected as the only period consistently sampled in the FJS for channel sampling and weeks 40 to 43 for bottom sampling. The Fall Juvenile Survey Index of abundance (F) for each year and species sampled in gear specific for either the channel or the bottom is a measure of average density and is calculated according to the following formula:

$$F_g = \frac{1}{n} \sum_{w=33}^{40} \left[\frac{\sum_{i=1}^{12} \sum_{s=1}^3 V_{is} \left(\frac{\sum_j Ct_{jiswg}}{\sum_j v_{jiswg}} \right)}{\sum_{i=1}^{12} \sum_{s=1}^3 V_{is}} \right] X_w,$$

where

- F_g = the FJS index (for gear g) for a species in a year;
- Ct_{jiswg} = the count of a species in sample j from gear g , region i , stratum s , and week w ;
- X_w = 1 if week w was sampled during the year, 0 otherwise;
- n = the number of weeks sampled in the year,
 $= \sum_{w=33}^{40} X_w$;
- v_{jiswg} = the volume of sample j from gear g in region i , stratum s , and week w ; and
- V_{isg} = the volume of stratum s , sampled by gear g , in river region i .

The above equation can be expressed in terms of weighted average sample densities as follows:

$$F_g = \frac{1}{n} \sum_{w=33}^{40} \bar{Y}_{wg} X_w = \frac{1}{n} \sum_{w=33}^{40} \left[\frac{\sum_{i=1}^{12} \sum_{s=1}^3 V_{si} \bar{Y}_{iswg}}{\sum_{i=1}^{12} \sum_{s=1}^3 V_{si}} \right] X_w,$$

where

- \bar{Y}_{iswg} = the average density of a species in samples from region i , stratum s , week w , and gear g and
 \bar{Y}_{wg} = the weighted average density of a species in samples from week w , and gear g .

Because not all weeks within the period of week 33 to 40 (or 40 to 43 for bottom sampling) were sampled by the FSS in each year, the variance of the FSS index of abundance in any year is calculated as the sum of two components. The primary unit in the first stage is weeks, and the design is assumed to be simple random sampling (i.e., weeks of sampling are construed to be a random sample of weeks within the period from week 33 through week 40 or from week 40 through week 43). The sampling units in the second stage are region-(habitat) strata, and the design is stratified random where region-(habitat) strata are the statistical strata. The variance is calculated using a two-stage estimator based on equation 11.24 in Cochran (1977, p. 303):

$$\text{var}(F_g) = \frac{\left(1 - \frac{n}{N}\right)}{n} S_{1,g}^2 + \frac{1}{Nn} \sum_w S_{2,gw}^2,$$

where

- $S_{1,g}^2$ = the first stage variance (temporal, among weeks),
 $S_{2,gw}^2$ = the second stage variance (spatial) in week w , and
 N = the number of weeks (8 or 4) within the selected period, i.e., weeks 33 through 40 or weeks 40 through 43.

The first stage variance component is calculated as:

$$S_{1,g}^2 = \frac{1}{n-1} \sum_{w=33}^{40} (\bar{Y}_{wg} - F_g)^2.$$

The second stage variance is calculated as:

$$S_{2, gw}^2 = \frac{\sum_{i=1}^{12} \sum_{s=1}^3 V_{isg}^2 \left[\frac{\left(h_{iswg} \sum_j (Ct_{jiswg} - \bar{C}t_{iswg})^2 \right)}{h_{iswg} - 1} \right]}{\left(\sum_{i=1}^{12} \sum_{s=1}^3 V_{isg} \right)^2},$$

where

V_{isg} = the total volume of (habitat) stratum, s , and region, i , sampled by gear g .

Then:

$$\text{std. err. } (F_g) = (\text{var}(F_g))^{1/2}.$$

D.2.3 Long River Survey

Indices of abundance using data from the LRS were calculated for striped bass, white perch, American shad, Atlantic tomcod and rainbow smelt. For striped bass, white perch and American shad, the indices are based on the egg, yolk-sac larvae (YSL), and post yolk-sac larvae (PYSL) life stages and the weeks selected depend on the period of abundance. For Atlantic tomcod the index was based on PYSL and juveniles combined over weeks 19 through 22 and for rainbow smelt the index was based on the juvenile life stage in weeks 20 through 27. The Long River Survey Index of abundance (L) for each year and species is a measure of average density and is calculated according to the following formula:

$$L = \sum_{w=firstwk}^{lastwk} \left[\frac{\sum_{i=1}^{12} \sum_{s=1}^5 V_{is} \left(\frac{\sum_j Ct_{jisw}}{\sum_j v_{jisw}} \right)}{\sum_{i=1}^{12} \sum_{s=1}^5 V_{is}} \right],$$

where

- L = the LRS index for any species in any year;
- Ct_{jisw} = the count of a species in sample j , region i , stratum s , and week w ;
- v_{jisw} = the volume of sample j from in region i , stratum s , and week w ;
- V_{is} = the volume of stratum s in river region i ;
- $firstwk$ = the first week included in the annual index of abundance:
 striped bass, American shad, and white perch egg, YSL, and PYSL -- the first week of the year in which the sum of weekly density estimates (from the initial week of sampling in the

year through the current week) exceeds 5% of the sum of densities over all weeks of sampling,
 Atlantic tomcod PYSL and juveniles combined -- week 19, and rainbow smelt juveniles -- week 20; and
lastwk = the last week included in the annual index of abundance:
 striped bass, American shad, and white perch egg, YSL, and PYSL -- *firstwk* +7;
 Atlantic tomcod PYSL and juveniles combined -- week 22; and rainbow smelt juveniles -- week 27.

The above equation can be expressed in terms of average sample density as follows:

$$L = \sum_{w=firstwk}^{lastwk} \bar{Y}_w = \sum_{w=firstwk}^{lastwk} \left[\frac{\sum_{i=1}^{12} \sum_{s=1}^5 V_{si} \bar{Y}_{isw}}{\sum_{i=1}^{12} \sum_{s=1}^5 V_{si}} \right],$$

where

\bar{Y}_{isw} = the average density of a species in samples from region *i*, stratum *s*, and week *w* [Note: for strata and regions that were not sampled, predicted densities (based on regression predictors and densities in adjacent strata) were used] and
 \bar{Y}_w = the weighted average density of a species in samples collected during week *w*.

Variance of the index was estimated using the following equation:

$$\text{var}(L) = \sum_{w=firstwk}^{lastwk} \left[\frac{\sum_s \sum_i V_{is}^2 \left(\frac{n_{si} \left(\sum_j (Ct_{jisw} - \bar{Ct}_{isw})^2 \right)}{n_{si} - 1} \right)}{\left(\sum_j v_{jisw} \right)^2} \right] \frac{1}{\left(\sum_s \sum_i V_{is} \right)^2},$$

where

V_{is} = the total volume in region *i* and stratum *s*.

Then:

$$\text{std. err.}(L) = (\text{var}(L))^{1/2}.$$

As indicated in Heimbuch et al. (1992), for indices based on LRS sampling, the volume of water between the beach and 10 ft deep was divided into two substrata: beach and shore. The beach stratum, defined from the beach to water five ft deep, corresponds with the shallow waters sampled in the BSS. The shore stratum, defined as water greater than five ft deep and less than 10 ft deep, is an unsampleable region. Densities in these substrata were estimated based on fixed ratios to the densities in adjacent strata.

D.3 LITERATURE CITED

Cochran, W.G. 1977. Sampling techniques, 3rd edition. Wiley, New York.

Heimbuch, D.G., D.J. Dunning, and J.R. Young. 1992. Post-Yolk-Sac Larvae Abundance as an Index of Year Class Strength of Striped Bass in the Hudson River, pages 376-391 *in* C. L. Smith (ed.) Estuarine Research in the 1980s. State University of New York Press. Albany.

Striped bass

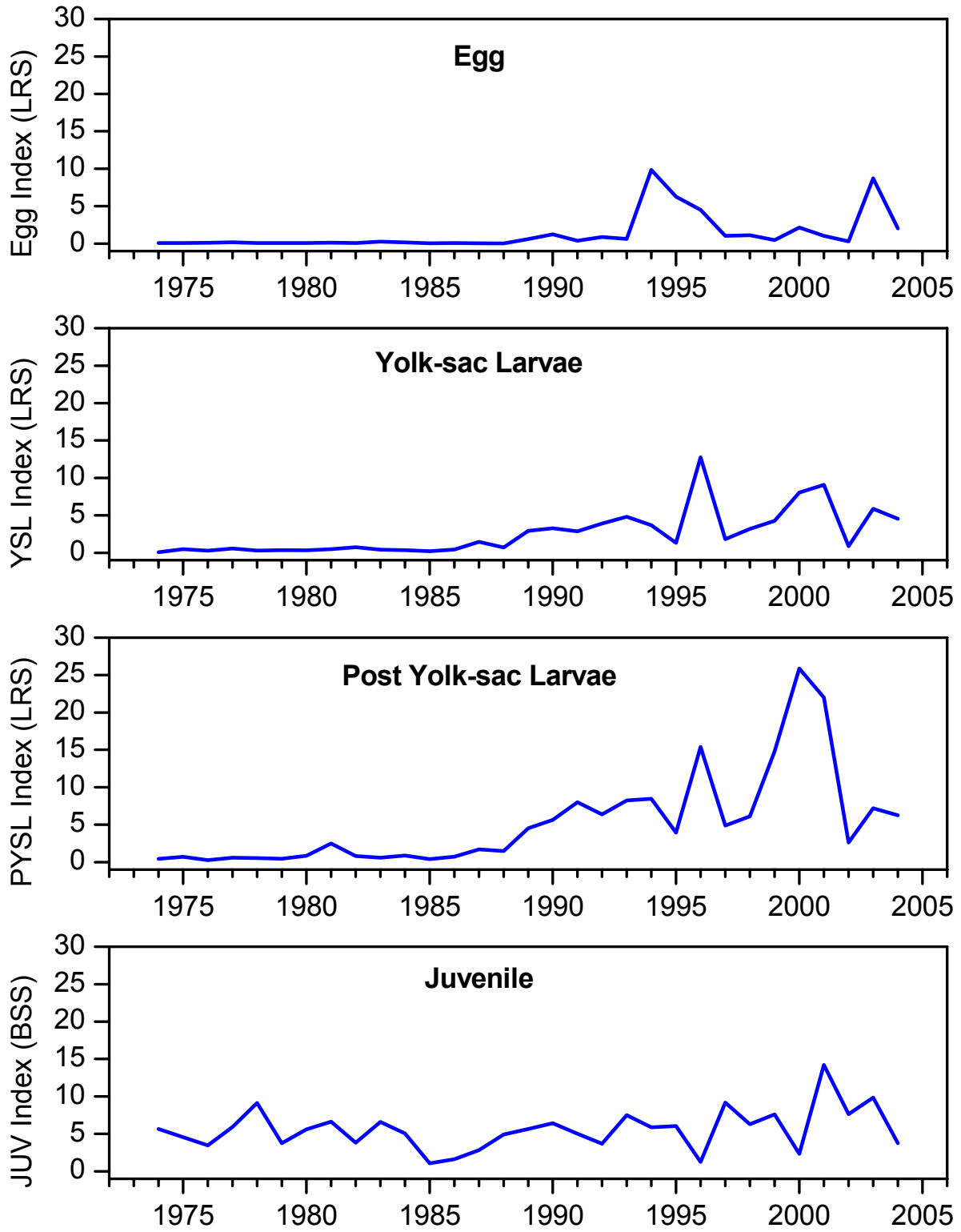


Figure D-1. Striped bass indices of annual abundance based on Long River Survey and Beach Seine Survey, 1974-2004

White perch

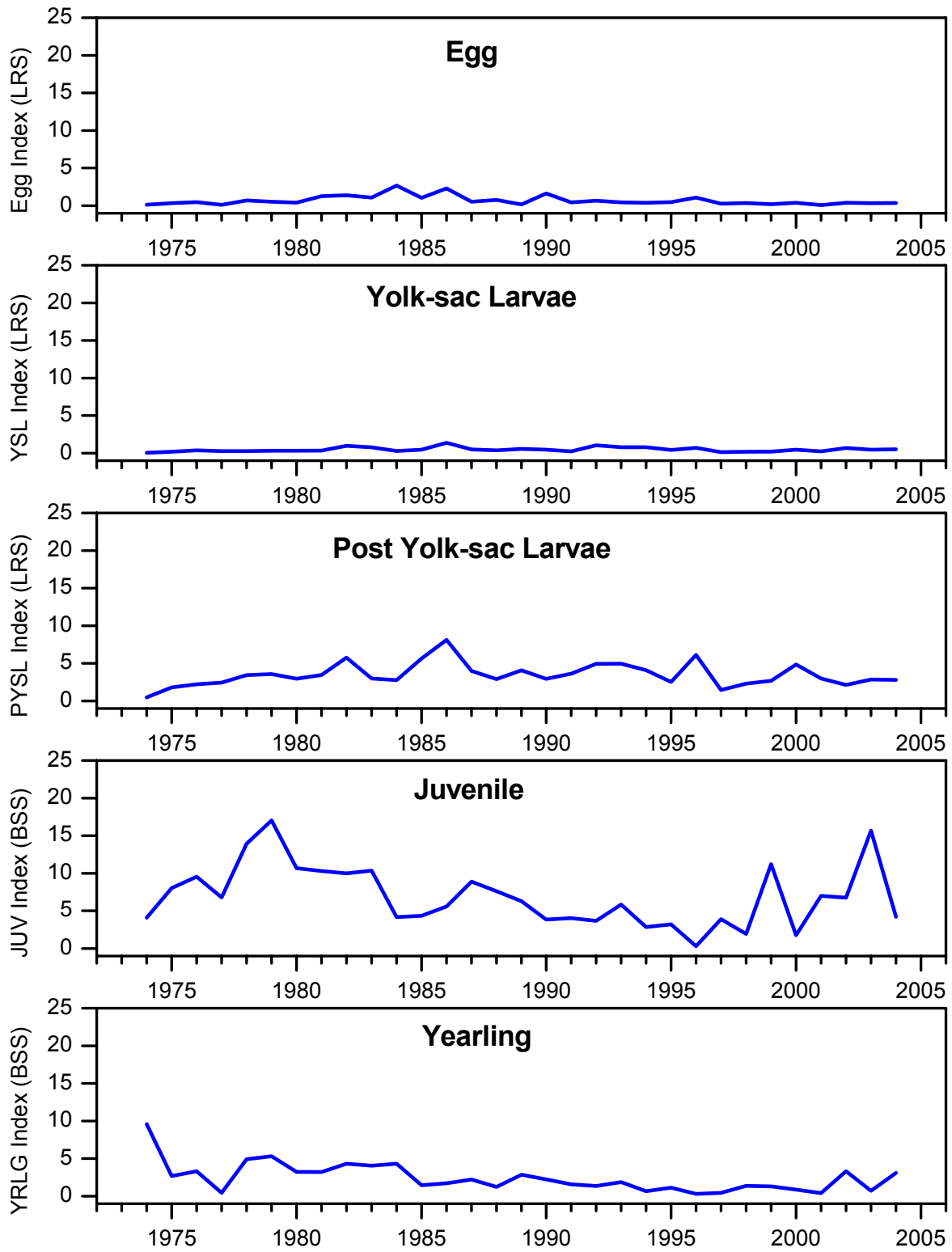


Figure D-2. White perch indices of annual abundance based on Long River Survey and Beach Seine Survey, 1974-2004

Atlantic tomcod

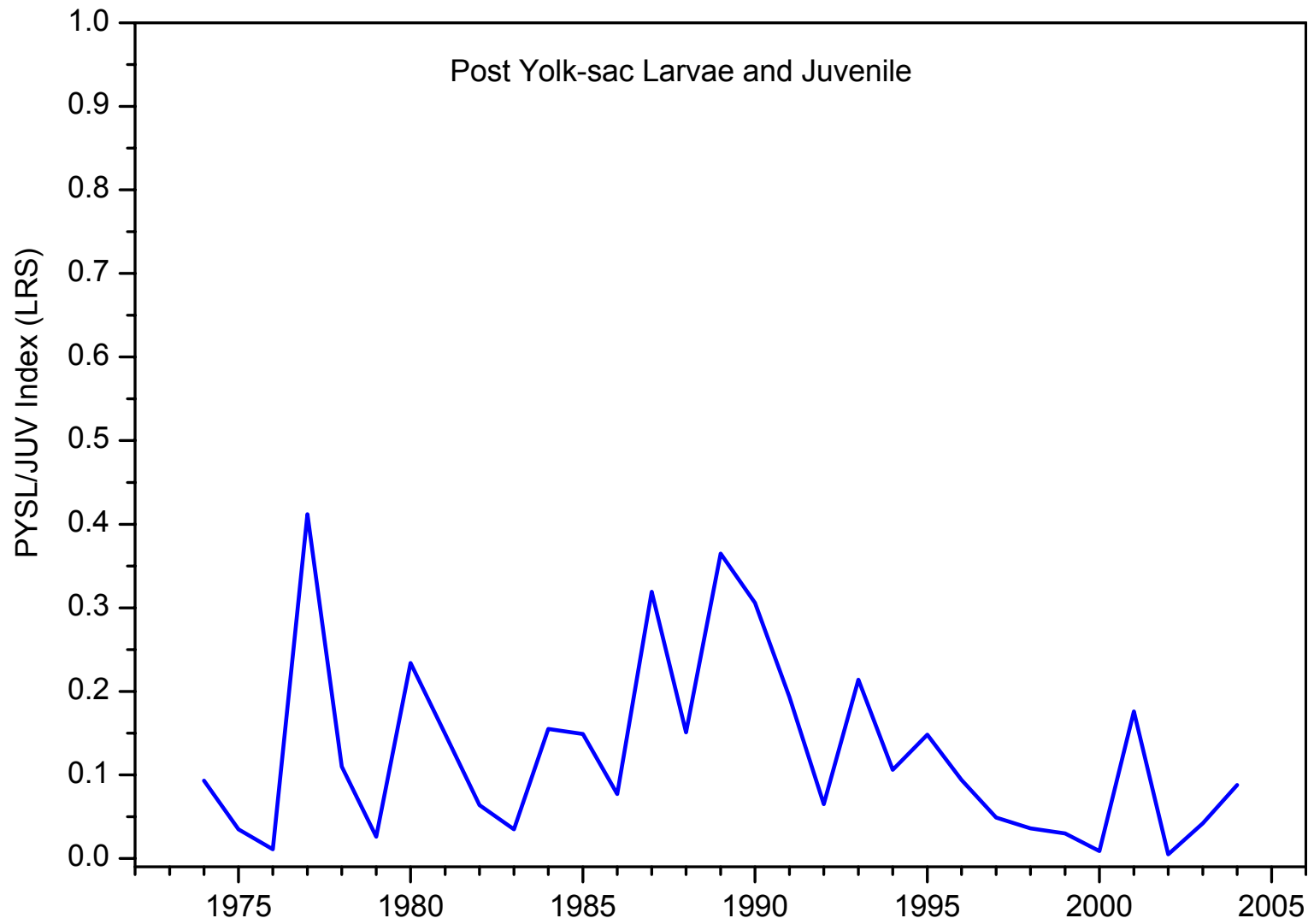


Figure D-3. Atlantic tomcod indices of annual abundance based on Long River Survey, 1974-2004

Bay anchovy

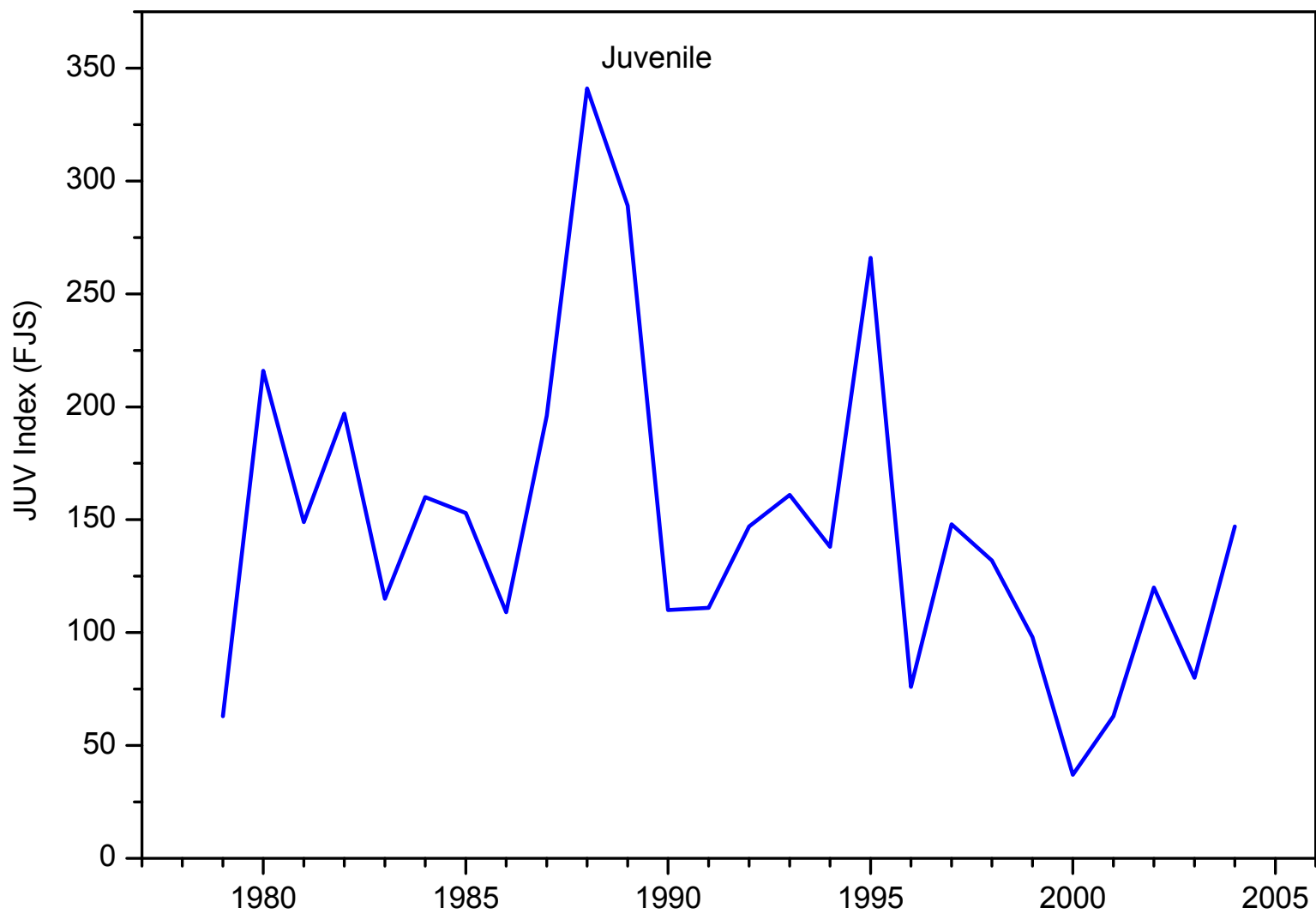


Figure D-4. Bay anchovy indices of annual abundance based on Fall Juvenile Survey, 1979-2004

American shad

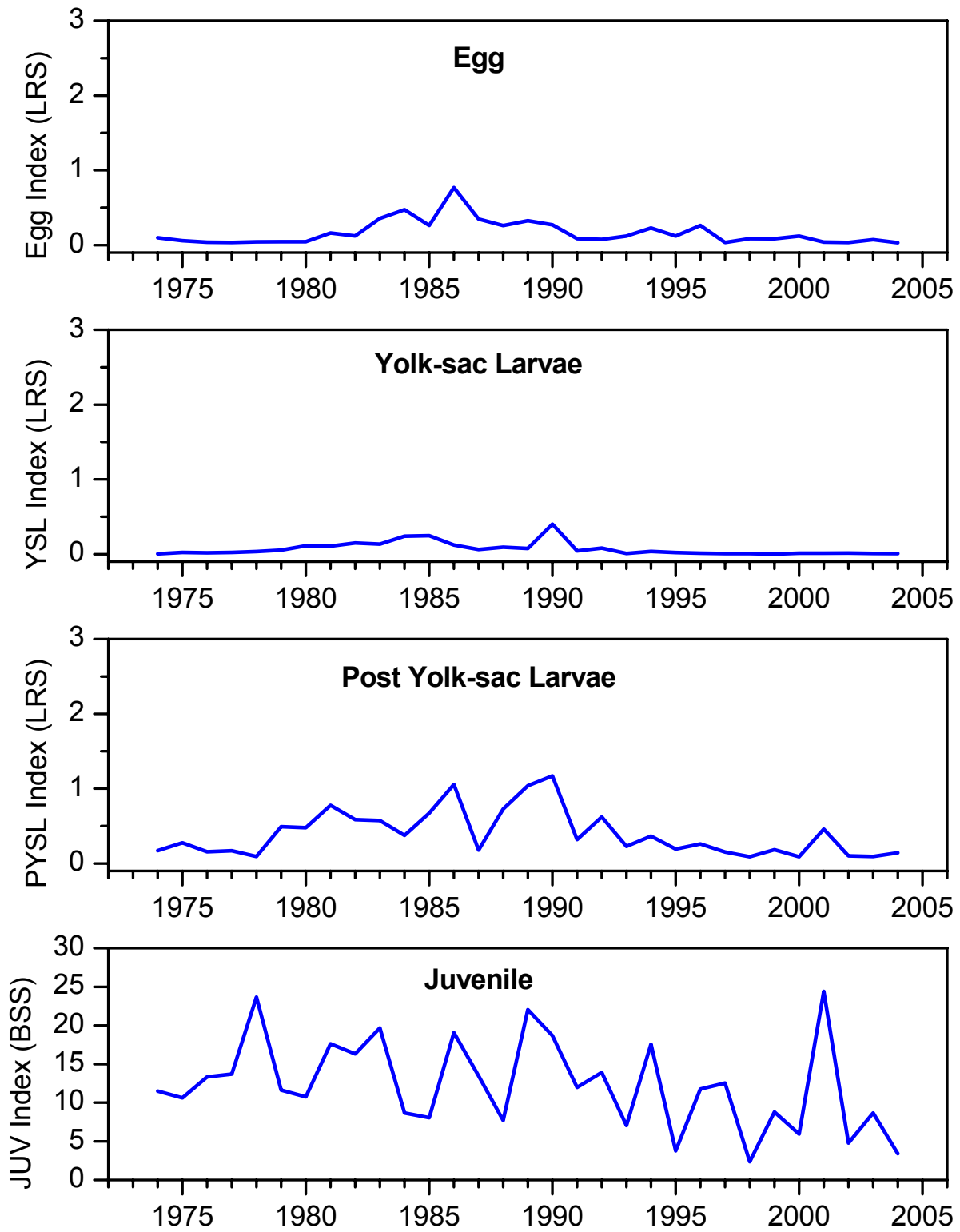


Figure D-5. American shad indices of annual abundance based on Long River Survey and Beach Seine Survey, 1974-2004

Alewife

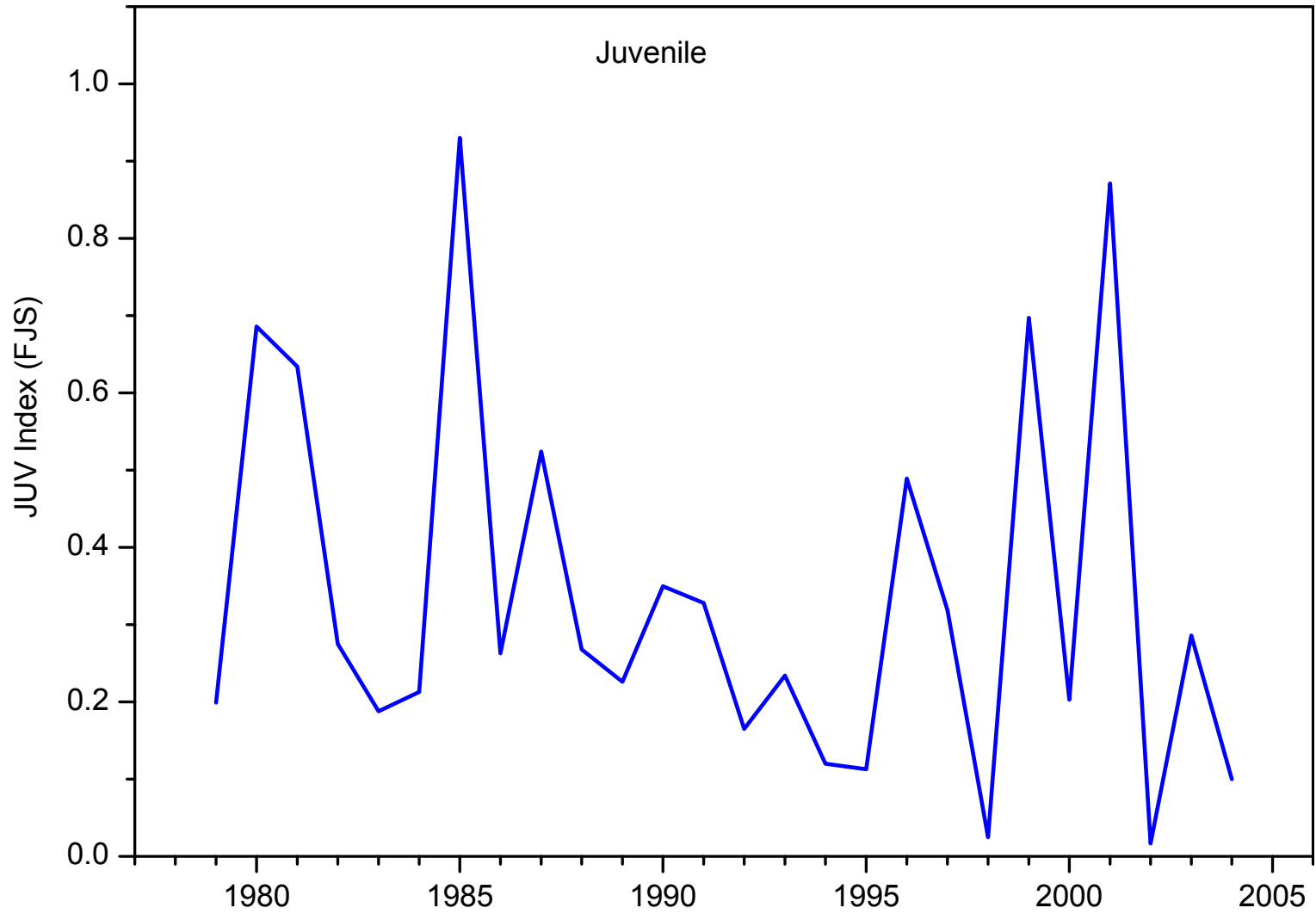


Figure D-6. Alewife indices of annual abundance based on Fall Juvenile Survey, 1979-2004

Blueback herring

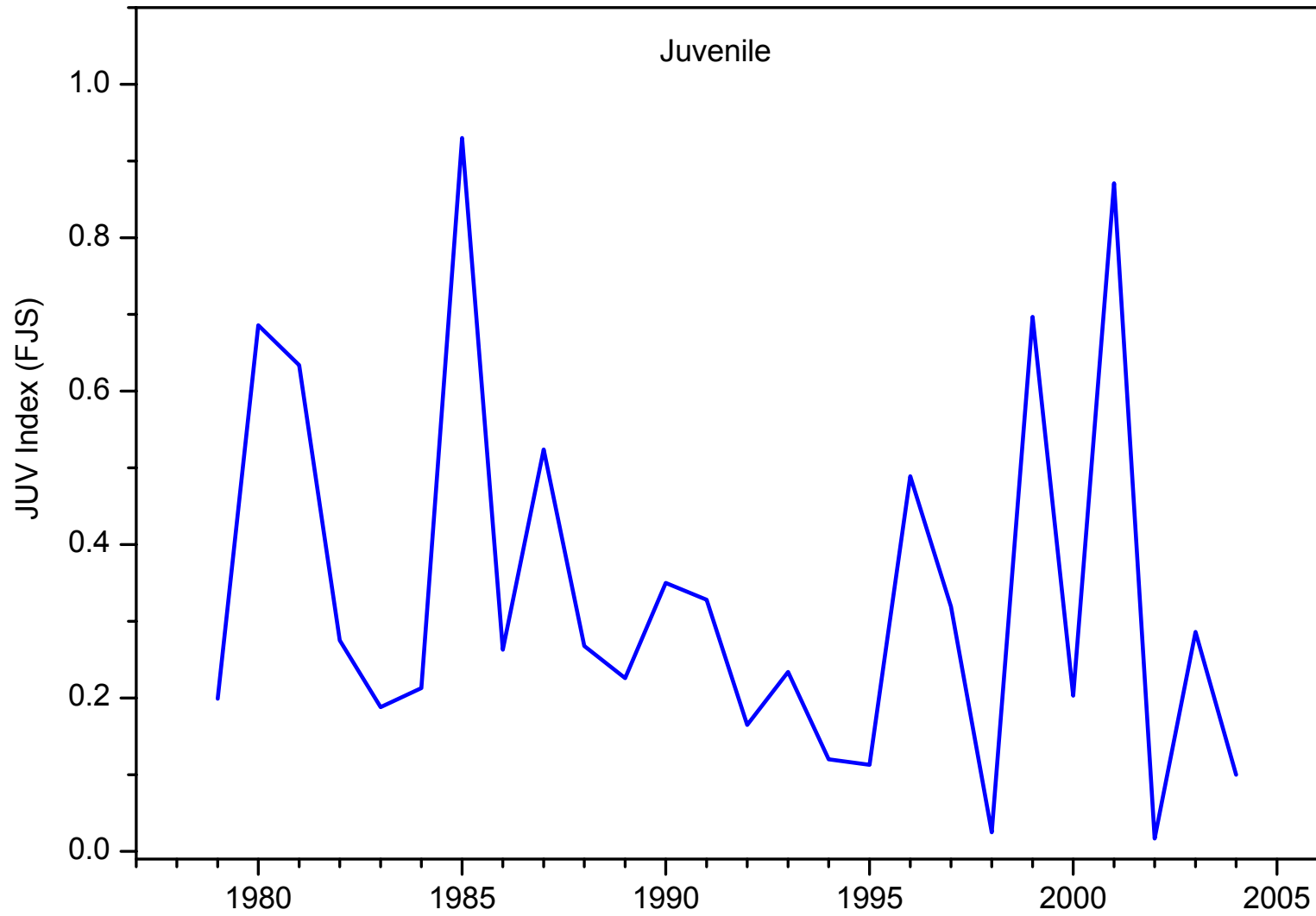


Figure D-7. Blueback herring indices of annual abundance based on Fall Juvenile Survey, 1979-2004

Rainbow smelt

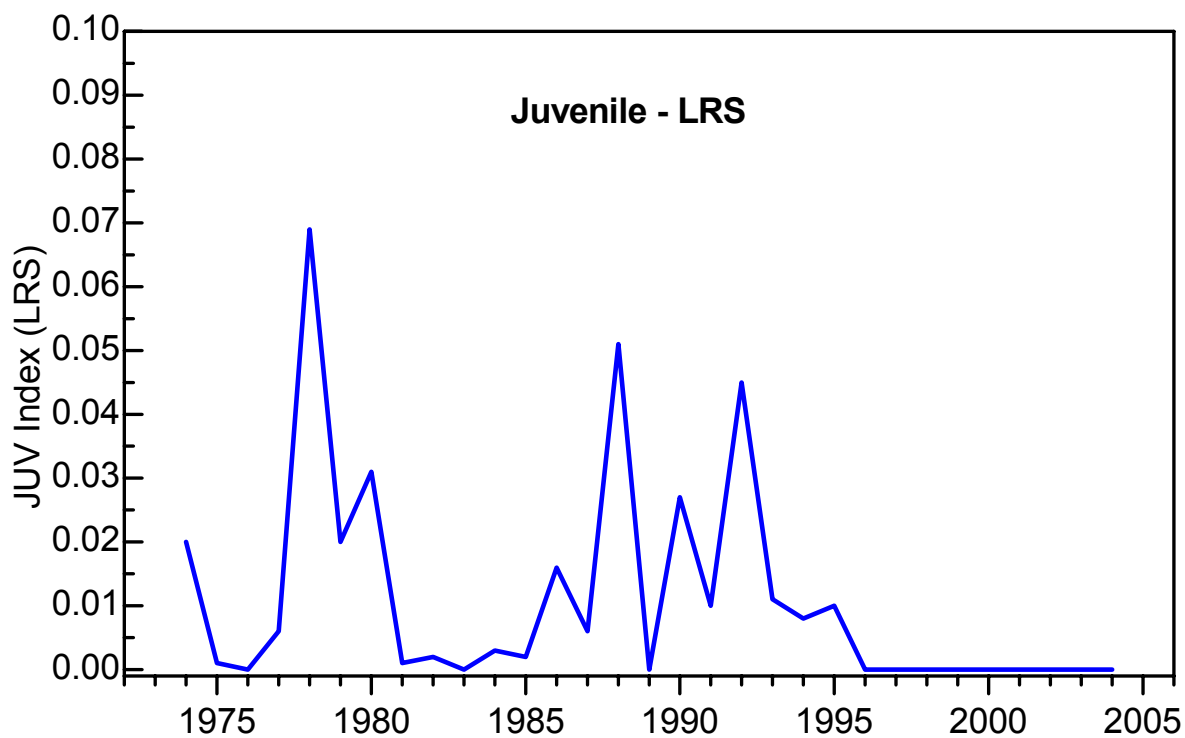
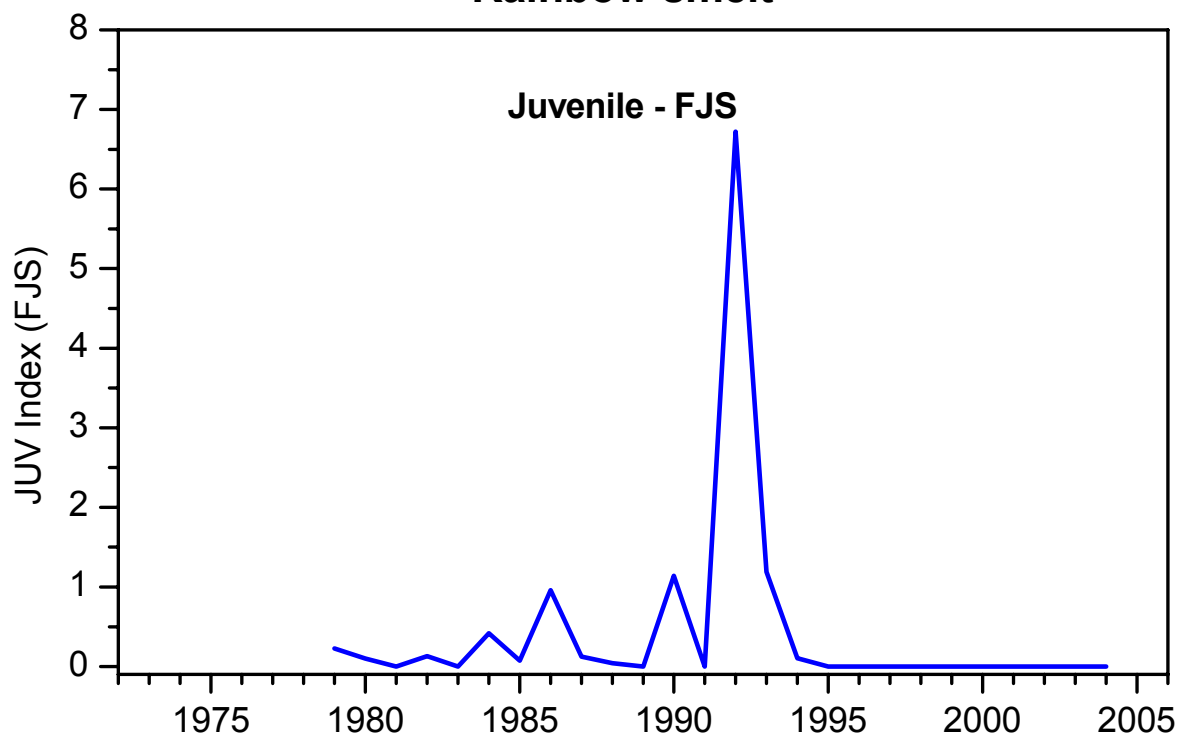


Figure D-8. Rainbow smelt indices of annual abundance based on Fall Juvenile Survey, 1979-2004, and Long River Survey, 1974-2004

Hogchoker

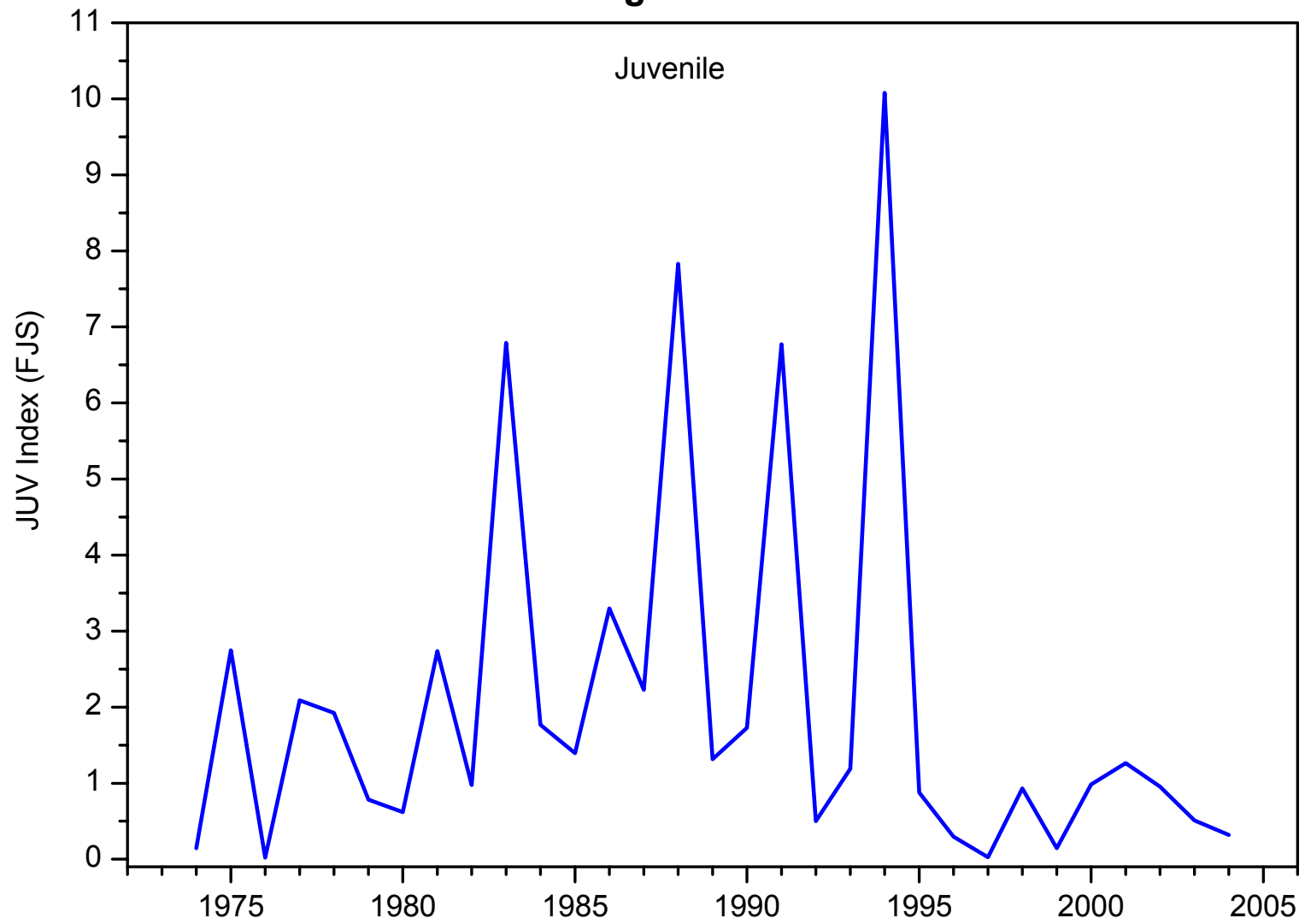


Figure D-9. Hogchoker indices of annual abundance based on Fall Juvenile Survey, 1974-2004

Spottail shiner

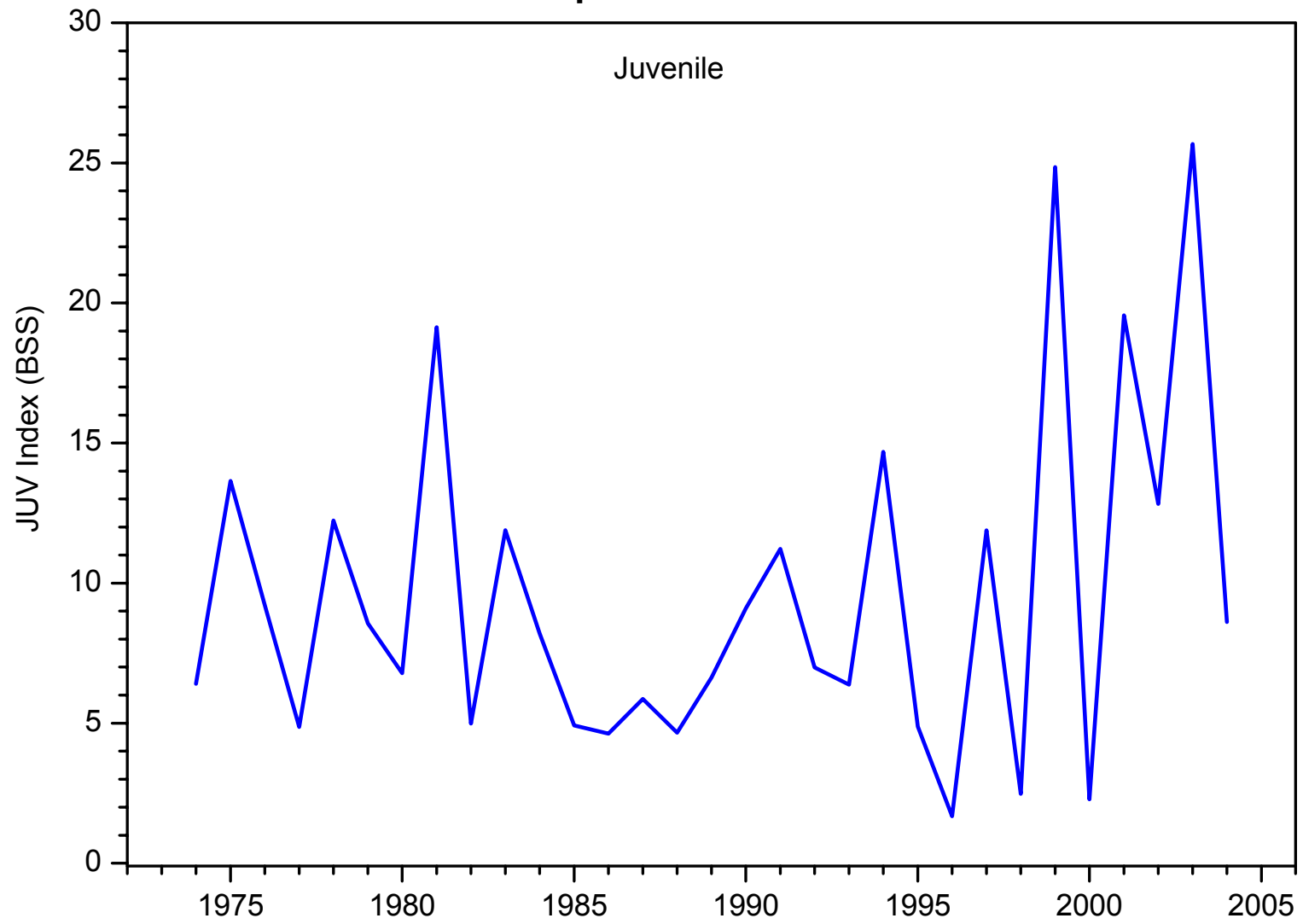


Figure D-10. Spottail shiner indices of annual abundance based on Beach Seine Survey, 1974-2004

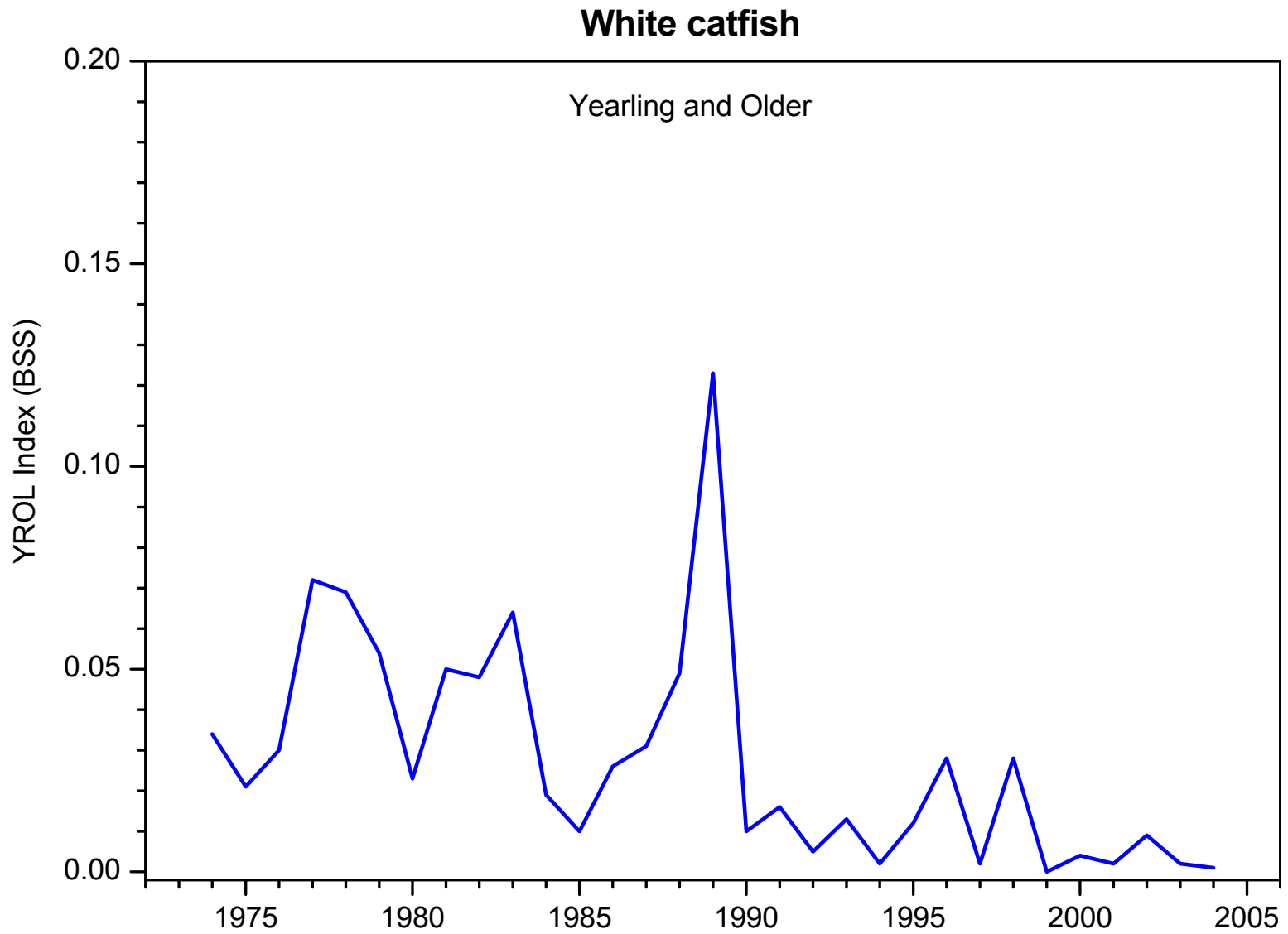


Figure D-11. White catfish indices of annual abundance based on Beach Seine Survey, 1974-2004

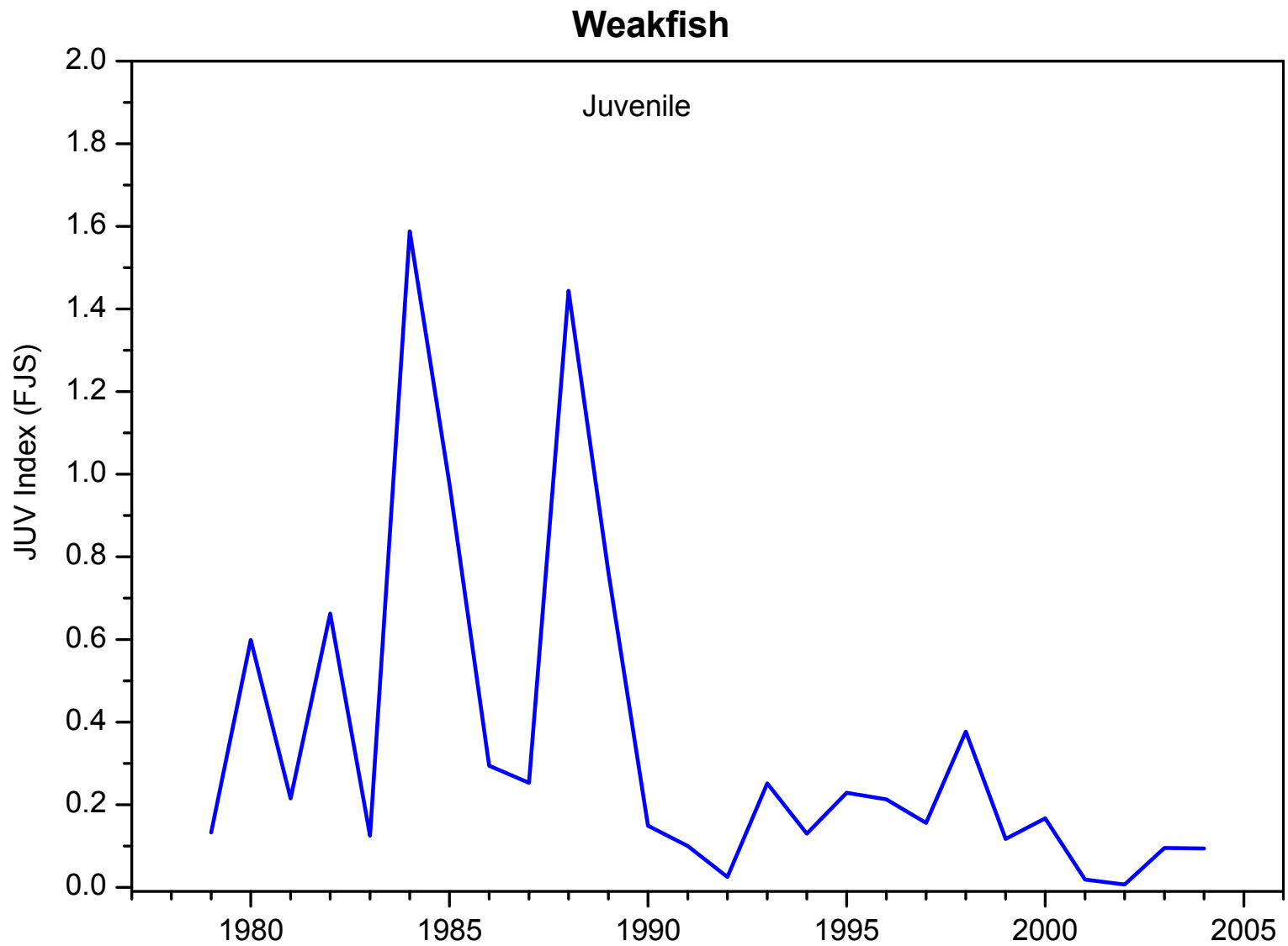


Figure D-12. Weakfish indices of annual abundance based on Fall Juvenile Survey, 1979-2004

Bluefish

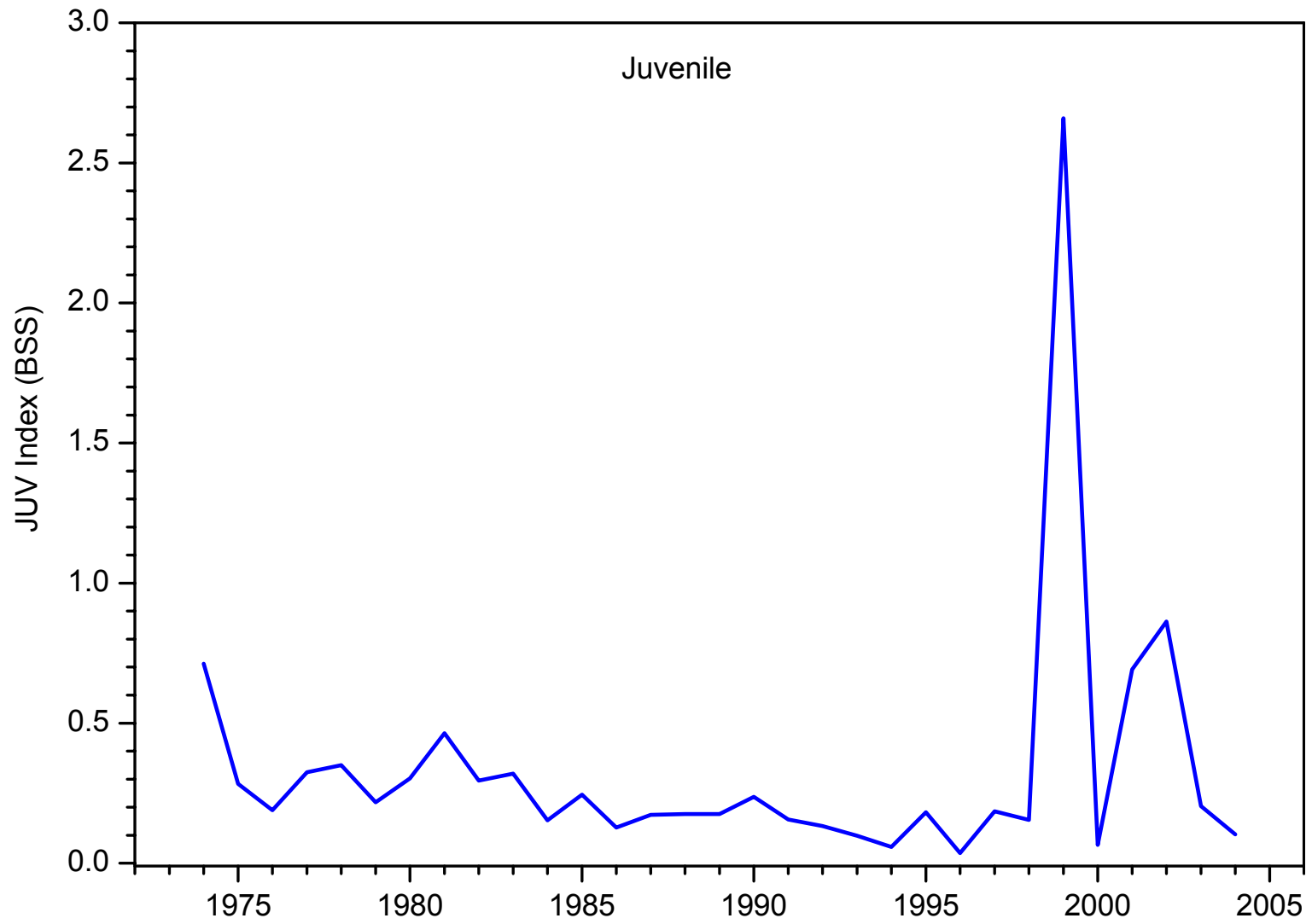


Figure D-13. Bluefish indices of annual abundance based on Beach Seine Survey, 1974-2004

Table D-1 Parameters for Indices of Annual Abundance Based on Data from the Beach Seine Survey (BSS), Fall Juvenile Survey (FJS), and Longitudinal River Survey (LRS)

Species	Life Stage	Weeks Used in Sampling Program		
		BSS	FJS	LRS
Striped bass	Egg, YSL, and PYSL			Variable ¹
Striped bass	Juvenile	33-40		
White perch	Egg, YSL, and PYSL			Variable ¹
White perch	Juvenile and Yearling	33-40		
Atlantic tomcod	PYSL and Juvenile combined			19-22
Bay anchovy	Juvenile		33-40 (Channel)	
American shad	Egg, YSL, and PYSL			Variable ¹
American shad	Juvenile	33-40		
Alewife	Juvenile		33-40 (Channel)	
Blueback herring	Juvenile		33-40 (Channel)	
Rainbow smelt	Juvenile		33-40 (Channel)	20-27
Hogchoker	Juvenile		40-43 (Bottom)	
Spottail shiner	Juvenile	33-40		
White catfish	Yearling and older	33-40		
Weakfish	Juvenile		33-40 (Channel)	
Bluefish	Juvenile	33-40		

¹ 7 weeks beginning with the first week in which 5% of annual total is achieved

Table D-2 Striped Bass Indices of Annual Abundance Based on Long River Survey and Beach Seine Survey, 1974-2004

	Long River Survey						Beach Seine Survey	
	Egg		Yolk-Sac Larvae		Post Yolk-Sac Larvae		Juvenile	
	Index	Std. Err.	Index	Std. Err.	Index	Std. Err.	Index	Std. Err.
1974	0.062	0.044	0.080	0.018	0.424	0.033	5.652	0.869
1975	0.076	0.012	0.487	0.031	0.694	0.044	4.557	0.301
1976	0.097	0.011	0.253	0.014	0.265	0.017	3.445	0.392
1977	0.195	0.022	0.566	0.029	0.605	0.036	5.919	0.411
1978	0.077	0.010	0.306	0.019	0.538	0.038	9.115	1.884
1979	0.075	0.008	0.359	0.022	0.468	0.032	3.760	0.756
1980	0.072	0.009	0.319	0.024	0.833	0.062	5.605	0.829
1981	0.137	0.015	0.486	0.055	2.482	0.116	6.611	0.912
1982	0.073	0.007	0.745	0.078	0.825	0.061	3.826	0.539
1983	0.276	0.189	0.391	0.026	0.589	0.033	6.580	1.249
1984	0.152	0.019	0.358	0.030	0.867	0.096	5.059	1.008
1985	0.050	0.005	0.202	0.017	0.405	0.033	1.069	0.237
1986	0.060	0.008	0.421	0.032	0.721	0.036	1.618	0.388
1987	0.059	0.007	1.449	0.085	1.697	0.066	12.823	2.245
1988	0.024	0.008	0.706	0.068	1.481	0.139	4.912	0.607
1989	0.588	0.269	2.941	0.277	4.540	0.344	5.665	0.897
1990	1.219	0.182	3.271	0.295	5.642	0.535	6.415	0.703
1991	0.363	0.064	2.855	0.257	8.005	0.770	5.032	1.070
1992	0.874	0.154	3.884	0.219	6.380	0.426	3.678	0.581
1993	0.633	0.122	4.812	0.969	8.247	0.727	7.496	1.626
1994	9.825	1.869	3.678	0.526	8.454	0.795	5.880	1.056
1995	6.266	1.010	1.305	0.199	3.942	0.389	6.043	0.903
1996	4.497	0.649	12.743	1.796	15.404	1.465	1.252	0.330
1997	1.029	0.185	1.795	0.296	4.887	0.745	9.185	0.829
1998	1.131	0.343	3.173	0.548	6.133	0.490	6.287	0.709
1999	0.460	0.087	4.265	0.393	14.788	1.343	7.621	1.486
2000	2.144	0.194	8.061	0.817	25.886	2.823	2.320	0.691
2001	1.030	0.235	9.057	0.748	21.999	1.364	14.215	1.551
2002	0.291	0.042	0.879	0.054	2.625	0.151	7.649	0.860
2003	8.721	4.871	5.889	0.634	7.185	0.718	9.834	1.554
2004	2.018	0.402	4.534	0.372	6.254	0.352	3.752	0.822

Table D-3 White Perch Indices of Annual Abundance Based on Long River Survey and Beach Seine Survey, 1974-2004

	Long River Survey						Beach Seine Survey			
	Egg		Yolk-Sac Larvae		Post Yolk-Sac Larvae		Juvenile		Yearling	
	Index	Std. Err.	Index	Std. Err.	Index	Std. Err.	Index	Std. Err.	Index	Std. Err.
1974	0.122	0.049	0.040	0.010	0.464	0.037	4.091	0.556	9.57	2.24
1975	0.335	0.095	0.198	0.016	1.783	0.147	8.040	1.954	2.68	1.41
1976	0.480	0.092	0.388	0.015	2.214	0.239	9.537	1.341	3.31	0.43
1977	0.112	0.019	0.264	0.014	2.431	0.128	6.782	1.114	0.45	0.07
1978	0.687	0.083	0.261	0.021	3.438	0.195	13.934	2.838	4.92	2.37
1979	0.533	0.070	0.336	0.017	3.571	0.103	17.033	2.747	5.31	1.63
1980	0.411	0.038	0.328	0.015	2.954	0.110	10.682	2.306	3.24	0.94
1981	1.282	0.080	0.360	0.032	3.467	0.174	10.297	1.291	3.22	0.62
1982	1.374	0.158	0.986	0.050	5.757	0.221	9.995	1.139	4.31	0.80
1983	1.089	0.084	0.776	0.040	2.977	0.101	10.363	2.016	4.08	1.60
1984	2.691	0.659	0.310	0.015	2.754	0.119	4.175	0.684	4.31	1.11
1985	1.036	0.117	0.463	0.040	5.640	0.214	4.353	1.076	1.47	0.53
1986	2.306	0.338	1.375	0.080	8.106	0.378	5.597	1.129	1.71	0.43
1987	0.528	0.063	0.483	0.022	3.974	0.119	8.880	1.678	2.21	0.26
1988	0.781	0.104	0.381	0.037	2.905	0.147	7.606	1.296	1.23	0.25
1989	0.171	0.014	0.568	0.051	4.057	0.374	6.281	1.715	2.84	0.51
1990	1.633	0.350	0.460	0.034	2.919	0.261	3.844	0.416	2.25	0.59
1991	0.443	0.059	0.241	0.017	3.637	0.236	4.033	0.754	1.57	0.43
1992	0.665	0.062	1.052	0.062	4.921	0.202	3.677	0.645	1.34	0.18
1993	0.431	0.060	0.792	0.044	4.958	0.185	5.842	0.949	1.89	0.55
1994	0.378	0.035	0.812	0.043	4.106	0.173	2.837	0.581	0.65	0.19
1995	0.454	0.070	0.427	0.020	2.506	0.108	3.209	0.484	1.14	0.34
1996	1.071	0.134	0.721	0.051	6.123	0.269	0.309	0.125	0.29	0.10
1997	0.265	0.047	0.127	0.005	1.461	0.075	3.912	0.558	0.45	0.07
1998	0.370	0.056	0.192	0.014	2.300	0.142	1.930	0.486	1.39	0.29
1999	0.192	0.026	0.210	0.017	2.696	0.152	11.218	2.992	1.29	0.43
2000	0.396	0.030	0.480	0.027	4.841	0.504	1.766	0.391	0.89	0.29
2001	0.091	0.010	0.253	0.017	2.997	0.237	6.997	0.817	0.42	0.13
2002	0.397	0.037	0.677	0.027	2.125	0.147	6.766	1.038	3.33	0.87
2003	0.329	0.034	0.478	0.023	2.845	0.171	15.671	3.697	0.71	0.13
2004	0.355	0.036	0.526	0.036	2.782	0.127	4.203	0.985	3.10	1.03

Table D-4 Atlantic Tomcod Indices of Annual Abundance Based on Long River Survey, 1974-2004

	Long River Survey	
	Post Yolk-Sac Larvae and Juvenile	
	Index	Std. Err.
1974	0.093	0.016
1975	0.035	0.009
1976	0.011	0.003
1977	0.412	0.267
1978	0.110	0.031
1979	0.026	0.006
1980	0.234	0.078
1981	0.149	0.037
1982	0.064	0.024
1983	0.035	0.012
1984	0.155	0.070
1985	0.149	0.027
1986	0.077	0.010
1987	0.319	0.049
1988	0.151	0.034
1989	0.365	0.089
1990	0.306	0.135
1991	0.193	0.029
1992	0.065	0.021
1993	0.214	0.061
1994	0.106	0.022
1995	0.148	0.024
1996	0.094	0.014
1997	0.049	0.011
1998	0.036	0.008
1999	0.030	0.007
2000	0.009	0.002
2001	0.176	0.029
2002	0.005	0.001
2003	0.042	0.006
2004	0.088	0.012

Table D-5 Bay Anchovy Indices of Annual Abundance Based on Fall Juvenile Survey, 1979-2004

	Fall Juvenile Survey	
	Juvenile	
	Index	Std. Err.
1979	63	10
1980	216	53
1981	149	24
1982	197	25
1983	115	32
1984	160	33
1985	153	16
1986	109	16
1987	196	42
1988	341	51
1989	289	40
1990	110	12
1991	111	8
1992	147	35
1993	161	20
1994	138	33
1995	266	44
1996	76	20
1997	148	27
1998	132	20
1999	98	25
2000	37	4
2001	63	10
2002	120	16
2003	80	7
2004	147	48

Table D-6 American Shad Indices of Annual Abundance Based on Long River Survey and Beach Seine Survey, 1974-2004

	Long River Survey						Beach Seine Survey	
	Egg		Yolk-Sac Larvae		Post Yolk-Sac Larvae		Juvenile	
	Index	Std. Err.	Index	Std. Err.	Index	Std. Err.	Index	Std. Err.
1974	0.097	0.031	0.004	0.001	0.171	0.065	11.499	0.825
1975	0.060	0.016	0.025	0.004	0.276	0.176	10.630	1.431
1976	0.037	0.009	0.017	0.002	0.155	0.049	13.325	0.869
1977	0.036	0.004	0.024	0.002	0.170	0.033	13.702	1.388
1978	0.044	0.008	0.034	0.003	0.092	0.031	23.671	2.658
1979	0.045	0.007	0.053	0.006	0.492	0.069	11.645	1.741
1980	0.046	0.009	0.111	0.012	0.479	0.216	10.747	2.464
1981	0.161	0.075	0.106	0.012	0.777	0.309	17.615	2.167
1982	0.123	0.041	0.149	0.016	0.586	0.120	16.312	1.919
1983	0.356	0.114	0.134	0.015	0.573	0.092	19.679	3.887
1984	0.472	0.112	0.240	0.019	0.376	0.168	8.686	1.839
1985	0.262	0.039	0.247	0.041	0.672	0.165	8.078	1.297
1986	0.770	0.325	0.122	0.015	1.054	0.150	19.060	3.735
1987	0.349	0.077	0.063	0.007	0.177	0.077	13.473	2.275
1988	0.259	0.051	0.093	0.030	0.729	0.344	7.717	1.010
1989	0.327	0.063	0.075	0.010	1.040	0.794	22.052	2.414
1990	0.270	0.062	0.400	0.053	1.170	0.733	18.674	1.742
1991	0.086	0.016	0.042	0.008	0.319	0.115	11.966	3.155
1992	0.075	0.021	0.082	0.011	0.622	0.213	13.923	1.051
1993	0.120	0.031	0.011	0.002	0.228	0.116	7.065	0.869
1994	0.227	0.036	0.038	0.005	0.366	0.126	17.557	3.276
1995	0.121	0.030	0.021	0.003	0.191	0.060	3.786	0.433
1996	0.262	0.042	0.012	0.003	0.260	0.061	11.773	1.928
1997	0.036	0.005	0.008	0.001	0.153	0.033	12.537	2.036
1998	0.086	0.012	0.008	0.001	0.089	0.028	2.361	0.415
1999	0.085	0.018	0.003	0.001	0.184	0.066	8.813	2.441
2000	0.119	0.015	0.013	0.002	0.090	0.026	5.925	0.930
2001	0.039	0.012	0.014	0.004	0.459	0.182	24.402	1.827
2002	0.034	0.004	0.016	0.003	0.100	0.037	4.792	0.468
2003	0.072	0.019	0.011	0.001	0.093	0.025	8.686	1.204
2004	0.033	0.008	0.008	0.001	0.141	0.062	3.397	0.613

Table D-7 Alewife Indices of Annual Abundance Based on Fall Juvenile Survey, 1979-2004

	Fall Juvenile Survey	
	Juvenile	
	Index	Std. Err.
1979	0.199	0.077
1980	0.686	0.353
1981	0.634	0.214
1982	0.275	0.084
1983	0.188	0.067
1984	0.213	0.125
1985	0.930	0.407
1986	0.263	0.079
1987	0.524	0.268
1988	0.268	0.129
1989	0.226	0.068
1990	0.350	0.137
1991	0.328	0.115
1992	0.165	0.084
1993	0.234	0.083
1994	0.120	0.062
1995	0.113	0.034
1996	0.489	0.146
1997	0.319	0.101
1998	0.025	0.015
1999	0.697	0.173
2000	0.203	0.077
2001	0.871	0.720
2002	0.017	0.014
2003	0.286	0.117
2004	0.100	0.039

Table D-8 Blueback Herring Indices of Annual Abundance Based on Fall Juvenile Survey, 1979-2004

	Fall Juvenile Survey	
	Juvenile	
	Index	Std. Err.
1979	3.695	0.746
1980	2.606	0.753
1981	21.197	5.861
1982	10.331	2.061
1983	6.082	1.073
1984	20.385	3.673
1985	17.424	4.584
1986	6.482	1.383
1987	25.608	12.357
1988	26.693	4.297
1989	16.825	5.408
1990	29.688	10.639
1991	12.648	4.469
1992	15.523	3.874
1993	7.717	1.594
1994	5.765	1.899
1995	1.266	0.417
1996	50.160	15.888
1997	7.301	1.428
1998	0.032	0.029
1999	2.073	0.783
2000	2.677	1.163
2001	5.845	4.998
2002	0.797	0.546
2003	5.920	1.891
2004	1.523	0.347

Table D-9 Rainbow Smelt Indices of Annual Abundance Based on Fall Juvenile Survey, 1979-2004, and Long River Survey, 1974-2004

	Fall Juvenile Survey		Long River Survey	
	Juvenile		Juvenile	
	Index	Std. Err.	Index	Std. Err.
1974			0.020	0.004
1975			0.001	0.000
1976			0.000	0.000
1977			0.006	0.002
1978			0.069	0.006
1979	0.226	0.092	0.020	0.003
1980	0.099	0.088	0.031	0.002
1981	0.000	0.000	0.001	0.000
1982	0.129	0.055	0.002	0.000
1983	0.000	0.000	0.000	0.000
1984	0.419	0.165	0.003	0.000
1985	0.074	0.057	0.002	0.000
1986	0.959	0.165	0.016	0.001
1987	0.122	0.065	0.006	0.001
1988	0.041	0.027	0.051	0.008
1989	0.000	0.000	0.000	0.000
1990	1.140	0.340	0.027	0.002
1991	0.000	0.000	0.010	0.003
1992	6.721	2.340	0.045	0.005
1993	1.190	0.563	0.011	0.003
1994	0.104	0.104	0.008	0.002
1995	0.000	0.000	0.010	0.002
1996	0.000	0.000	0.000	0.000
1997	0.000	0.000	0.000	0.000
1998	0.000	0.000	0.000	0.000
1999	0.000	0.000	0.000	0.000
2000	0.000	0.000	0.000	0.000
2001	0.000	0.000	0.000	0.000
2002	0.000	0.000	0.000	0.000
2003	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000

Table D-10 Hogchoker Indices of Annual Abundance Based on Fall Juvenile Survey, 1974-2004

	Fall Juvenile Survey	
	Juvenile	
	Index	Std. Err.
1974	0.147	0.033
1975	2.748	1.910
1976	0.021	0.017
1977	2.089	1.393
1978	1.925	0.806
1979	0.786	0.172
1980	0.620	0.183
1981	2.735	0.775
1982	0.975	--
1983	6.789	4.522
1984	1.767	0.428
1985	1.396	0.257
1986	3.298	1.587
1987	2.227	0.568
1988	7.832	0.914
1989	1.318	0.406
1990	1.728	1.024
1991	6.772	4.728
1992	0.502	0.234
1993	1.189	0.308
1994	10.079	1.418
1995	0.878	0.333
1996	0.295	0.066
1997	0.026	0.026
1998	0.932	0.129
1999	0.145	0.136
2000	0.983	0.363
2001	1.264	0.426
2002	0.956	0.346
2003	0.511	0.508
2004	0.319	0.079

Table D-11 Spottail Shiner Indices of Annual Abundance Based on Beach Seine Survey, 1974-2004

	Beach Seine Survey	
	Juvenile	
	Index	Std. Err.
1974	6.406	1.419
1975	13.648	3.194
1976	9.211	1.452
1977	4.860	1.112
1978	12.232	1.725
1979	8.562	1.357
1980	6.785	1.281
1981	19.134	3.977
1982	4.991	0.815
1983	11.890	3.007
1984	8.202	1.942
1985	4.916	0.780
1986	4.629	1.165
1987	5.868	1.403
1988	4.663	0.722
1989	6.626	1.472
1990	9.098	1.505
1991	11.223	1.880
1992	6.987	1.066
1993	6.379	0.797
1994	14.684	2.022
1995	4.875	0.696
1996	1.681	0.632
1997	11.880	1.742
1998	2.478	0.568
1999	24.848	5.432
2000	2.287	0.634
2001	19.556	4.314
2002	12.833	1.847
2003	25.669	4.877
2004	8.613	1.323

Table D-12 White Catfish Indices of Annual Abundance Based on Beach Seine Survey, 1974-2004

	Beach Seine Survey	
	Yearling and Older	
	Index	Std. Err.
1974	0.034	0.020
1975	0.021	0.011
1976	0.030	0.010
1977	0.072	0.022
1978	0.069	0.030
1979	0.054	0.028
1980	0.023	0.008
1981	0.050	0.029
1982	0.048	0.026
1983	0.064	0.044
1984	0.019	0.006
1985	0.010	0.005
1986	0.026	0.012
1987	0.031	0.015
1988	0.049	0.018
1989	0.123	0.056
1990	0.010	0.005
1991	0.016	0.008
1992	0.005	0.003
1993	0.013	0.009
1994	0.002	0.002
1995	0.012	0.008
1996	0.028	0.016
1997	0.002	0.001
1998	0.028	0.022
1999	0.000	0.000
2000	0.004	0.003
2001	0.002	0.002
2002	0.009	0.008
2003	0.002	0.001
2004	0.001	0.001

Table D-13 Weakfish Indices of Annual Abundance Based on Fall Juvenile Survey, 1979-2004

	Fall Juvenile Survey	
	Juvenile	
	Index	Std. Err.
1979	0.133	0.070
1980	0.599	0.284
1981	0.215	0.125
1982	0.663	0.306
1983	0.125	0.088
1984	1.588	0.633
1985	0.977	0.481
1986	0.294	0.105
1987	0.253	0.180
1988	1.444	0.599
1989	0.763	0.248
1990	0.149	0.090
1991	0.100	0.061
1992	0.025	0.017
1993	0.252	0.149
1994	0.130	0.058
1995	0.229	0.128
1996	0.213	0.160
1997	0.156	0.053
1998	0.377	0.277
1999	0.117	0.047
2000	0.167	0.115
2001	0.019	0.009
2002	0.007	0.007
2003	0.095	0.049
2004	0.094	0.062

Table D-14 Bluefish Indices of Annual Abundance Based on Beach Seine Survey, 1974-2004

	Beach Seine Survey	
	Juvenile	
	Index	Std. Err.
1974	0.712	0.210
1975	0.283	0.074
1976	0.189	0.028
1977	0.325	0.097
1978	0.350	0.075
1979	0.217	0.054
1980	0.303	0.053
1981	0.464	0.119
1982	0.295	0.059
1983	0.320	0.101
1984	0.153	0.034
1985	0.245	0.068
1986	0.127	0.054
1987	0.173	0.049
1988	0.176	0.027
1989	0.176	0.043
1990	0.237	0.053
1991	0.156	0.043
1992	0.133	0.050
1993	0.098	0.033
1994	0.058	0.017
1995	0.182	0.043
1996	0.036	0.012
1997	0.185	0.028
1998	0.155	0.026
1999	2.660	1.116
2000	0.065	0.027
2001	0.692	0.242
2002	0.863	0.300
2003	0.204	0.073
2004	0.103	0.037