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Covariance Among Survey Indices of Abundance at Age

by

Antonio Vazquez and Santiago Cerviño

Instituto de Investigaciones Marinas
Eduardo Cabello 6, Vigo, Spain

Introduction

Survey indices of abundance at age are currently calculated from a large set of catch results, length frequencies and age-length keys. Those results are commonly used to tuning sequential population analysis of the fish stocks. Their covariance, if can not be ignored, may determine the adequate of the fit test in the tuning process.

Material and methods

The EU bottom-trawl survey of Flemish Cap (Vazquez 1997) was used as source data. The survey series starting in 1988 can be considered a good example of a survey. Surveys are made according to most common NAFO specifications. Abundance at age indices are calculated for most common species: cod, American plaice, redfish (3 species) and Greenland halibut, all of then aged by otoliths reading at each survey. The zone is divided in 19 strata and both catches and length sampling are evaluated according to them, but strata are not taken into account for otolith sampling.

Covariance of abundance at age indices were calculated analytically and by bootstrap. For bootstrap, the random selection process was applied to catches on each strata, length distribution of each selected haul and otoliths age frequency at each length class.

Results

Covariance matrices of survey indices of abundance at age calculated by bootstrap for cod, as a representative of all other species, in 1988 to 1997 surveys are presented in table 1.

The contribution of catches, length distribution and otoliths frequencies to the covariance of survey indices of abundance at age was explored in cod in 1997 survey. The bootstrap was repeated three times excluding in each case the sampling on one of the cited variables. Results are presented in table 2. Most of the variance in abundant year-classes proceed from catch variability. For scarce year-classes both frequencies and catch variability have the highest effect. Otoliths seems to have no effect at age 12, but only one length-class has otoliths of that age.

The analytical approach requires a shorter computer time than the bootstrap method. The similarity of the results from both cases was judged by the correlation coefficient between the corresponding elements of the covariance matrix being different from zero (table 3).

Discussion

The relationship between abundance at age and survey catches, length distribution and otoliths frequencies is not lineal: there is a systematic cross product among those variables. Consequently, the analytical estimation of the covariance is only a approximation. But covariance calculated by bootstrap are also a sampling estimation of its parametric value. So there is not reason to prefer one or another. In fact, the observed covariance could be substituted by a predetermined matrix (Lewis and Odell 1971).

But the covariance among survey indices of abundance at age is a consequence of the sampling procedure, it is not a population parameter. This covariance refers to abundance estimates at the same survey, not to the possible dependence between age groups among years produced by a stock recruitment relationship. So, there is no base for a generalise unique covariance matrix that could substitute the observed ones.

According to precautionary approach system to assess fisheries, the errors of both parameters and results of mathematical model in use are important, so important as the mean. But not only mean and variance characterise a set of results, but their covariance. For survey indices of abundance at age we concluded that covariance are high, so much high as not to be rejected.

If survey indices of abundance at age are incorporated to a bootstrap process to estimate some other population variable, covariance must be taken into account. A simple method to produce stochastic frequency distributions with a predetermined mean F and covariance Σ could be to transform Σ to their eigen-value equivalent:

$\Sigma = M \cdot E \cdot M^{-1}$ E = eigen-value diagonal matrix
M = eigen-vectors matrix

This transformation is always possible because Σ is a positive defined matrix. The diagonal square matrix E contain the variances of same independent variables Z that reproduce the previous F values when linearly transformed by M:

$$F = M \cdot Z$$

The mean of this stochastic and independent variables Z are calculated from the above expression applied to the means:

$$\{Z \text{ means}\} = M^{-1} \cdot F$$

Distribution of survey indices of abundance at age is quite close to normal, according to the bootstrap results (Table 2). So, the Z variables must be also normal distributed.

References

Lewis, T.O. and P.L. Odell - 1971. Estimation in linear models. Prentice-Hall, London, 193 pp.

Vazquez, A.- 1997. Results from bottom trawl survey of Flemish Cap in July 1996. *NAFO SCR Doc.* 97/28.

Table 1 - Original and bootstrap survey estimates of abundance at age. Semi-matrices of typified covariance among bootstrap results. Survey year are indicated on each set. Ages are indicated in the headings. Cod. 10000 cycles.

1988

	age:	original	-- bootstrap -- mean	s.d.	g1-skew	g2-kurtosis
1	E 1 -	4575.838	4566.084	1367.781	0.412	-0.028
2	E 2 -	72615.319	72690.732	11126.367	0.274	0.001
3	E 3 -	40564.492	40548.877	5479.898	0.230	0.008
4	E 4 -	10665.445	10644.275	2101.092	0.407	0.060
5	E 5 -	1230.387	1220.041	366.650	0.438	-0.026
6	E 6 -	191.284	191.411	59.876	0.623	0.645
7	E 7 -	223.101	223.000	71.328	0.625	0.624
8	E 8 -	67.769	67.497	36.354	0.895	1.253

R1\R2:	1	2	3	4	5	6	7	8
1:	1.0000							
2:	0.6429	1.0000						
3:	0.1719	0.3427	1.0000					
4:	0.0651	0.1274	0.7631	1.0000				
5:	0.0257	0.0880	0.1472	0.3486	1.0000			
6:	0.0032	0.0435	0.0361	0.1411	0.5525	1.0000		
7:	-0.0038	0.0171	0.0112	0.0641	0.2757	0.3226	1.0000	
8:	-0.0054	-0.0079	-0.0169	-0.0085	-0.0104	0.0649	0.2642	1.0000

1989

	age:	original	-- bootstrap -- mean	s.d.	g1-skew	g2-kurtosis
1	E 1 -	20801.375	20925.411	3130.301	0.246	0.052
2	E 2 -	11005.923	11038.913	1824.871	0.359	0.188
3	E 3 -	83782.610	83801.758	11624.756	0.202	-0.027
4	E 4 -	47775.581	47773.529	5506.633	0.156	0.028
5	E 5 -	17769.781	17763.840	2560.460	0.269	0.038
6	E 6 -	1262.461	1257.565	234.250	0.513	0.456
7	E 7 -	157.153	156.609	51.021	0.543	0.425
8	E 8 -	140.356	140.132	68.505	0.533	0.242
9	E 9 -	7.770	7.784	9.132	1.919	5.543
10	E 10 -	6.143	6.087	8.508	1.685	3.232

matriz de covarianzas

R1\R2:	1	2	3	4	5	6	7	8	9	10
1:	1.0000									
2:	0.7642	1.0000								
3:	0.3383	0.4307	1.0000							
4:	0.0339	0.0722	0.5434	1.0000						
5:	-0.0134	0.0089	0.1735	0.7120	1.0000					
6:	-0.0164	-0.0138	0.0347	0.3924	0.6342	1.0000				
7:	-0.0368	-0.0220	-0.0445	0.0076	0.0247	0.0981	1.0000			
8:	-0.0209	-0.0162	-0.0689	-0.0844	-0.0568	0.0374	0.3628	1.0000		
9:	-0.0202	-0.0342	-0.0506	-0.0484	-0.0365	0.0103	0.1848	0.3277	1.0000	
10:	0.0198	0.0228	-0.0042	-0.0654	-0.0914	-0.0329	0.0736	0.3443	0.2049	1.0000

1990

	age:	original	-- bootstrap -- mean	s.d.	g1-skew	g2-kurtosis
1	E 1 -	2492.493	2495.805	516.709	0.412	0.067
2	E 2 -	11937.121	11961.665	1500.295	0.203	0.075
3	E 3 -	4755.455	4757.382	646.426	0.232	0.045
4	E 4 -	15469.092	15477.697	2414.394	0.137	-0.092
5	E 5 -	14659.768	14652.402	2104.119	0.220	0.009
6	E 6 -	4297.835	4291.827	600.494	0.345	0.279
7	E 7 -	349.687	348.241	88.520	0.547	0.573
8	E 8 -	159.125	158.311	63.221	0.849	1.055
9	E 9 -	87.962	87.828	45.432	0.996	1.550
10	E 10 -	29.072	29.166	21.868	1.428	3.305

R1\R2:	1	2	3	4	5	6	7	8	9	10
1:	1.0000									
2:	0.2698	1.0000								
3:	0.0807	0.5396	1.0000							
4:	-0.0215	0.1337	0.5732	1.0000						
5:	-0.0391	0.0603	0.0843	0.4982	1.0000					
6:	-0.0523	-0.0052	0.0197	0.2925	0.6908	1.0000				
7:	-0.0459	-0.0518	0.0313	0.2442	0.4270	0.6278	1.0000			
8:	-0.0706	-0.0685	0.0137	0.1919	0.4094	0.5728	0.5563	1.0000		
9:	-0.0334	-0.0637	0.0076	0.1836	0.3540	0.4814	0.4949	0.5879	1.0000	
10:	-0.0199	-0.0142	0.0171	0.1346	0.2500	0.3683	0.3714	0.4277	0.4436	1.0000

1991

	age:	original	-- bootstrap -- mean	s.d.	g1-skew	g2-kurtosis
1	E 1 -	137814.327	138283.697	46425.110	0.642	0.513
2	E 2 -	25599.926	25642.255	4805.501	0.440	0.459
3	E 3 -	15381.471	15423.825	3244.016	0.426	0.041
4	E 4 -	1928.084	1923.831	368.425	0.336	0.065
5	E 5 -	6282.889	6264.770	1554.843	0.411	0.049
6	E 6 -	1674.060	1671.220	386.169	0.573	0.192
7	E 7 -	295.683	295.748	69.051	0.401	0.188
8	E 8 -	70.929	71.703	30.676	0.609	0.528
9	E 9 -	35.173	35.591	20.221	0.854	1.176
10	E 10 -	6.825	6.962	8.505	1.797	4.454
11	E 11 -	13.408	13.666	12.220	1.174	1.695

R1\R2:	1	2	3	4	5	6	7	8	9	10	11
1:	1.0000										
2:	0.8193	1.0000									
3:	0.1700	0.3109	1.0000								
4:	0.2354	0.3617	0.5843	1.0000							
5:	0.1739	0.3008	0.2543	0.7197	1.0000						
6:	0.1818	0.3153	0.1527	0.5588	0.8295	1.0000					
7:	0.0525	0.1321	0.0771	0.2421	0.3576	0.4498	1.0000				
8:	0.0631	0.1229	0.1070	0.2370	0.3013	0.2920	0.1286	1.0000			
9:	0.0160	0.0095	-0.0253	-0.0192	-0.0064	0.0357	0.1021	0.0038	1.0000		
10:	0.0067	0.0088	-0.0078	-0.0127	-0.0099	-0.0110	0.0018	-0.0099	-0.0060	1.0000	
11:	-0.0002	-0.0006	-0.0097	0.0030	-0.0078	0.0002	-0.0100	-0.0069	-0.0170	-0.1012	1.0000

1992

	age:	original	-- bootstrap --			
			mean	s.d.	g1-skew	g2-kurtosis
1	E 1 -	71190.315	71126.274	14081.352	0.196	0.046
2	E 2 -	37060.414	36935.282	9551.080	0.320	0.141
3	E 3 -	4748.080	4732.430	1548.665	0.468	0.183
4	E 4 -	2032.756	2018.070	837.018	0.534	-0.076
5	E 5 -	332.324	330.345	169.438	0.824	0.740
6	E 6 -	1255.095	1248.347	445.544	0.545	-0.017
7	E 7 -	222.254	221.993	79.568	0.727	0.845
8	E 8 -	11.867	11.608	11.864	1.424	2.505
9	E 9 -	0.000	0.000	0.000	0.000	0.000
10	E 10 -	0.000	0.000	0.000	0.000	0.000
11	E 11 -	6.927	6.914	9.653	1.790	4.220

R1\R2:	1	2	3	4	5	6	7	8	11
1:	1.0000								
2:	0.5863	1.0000							
3:	0.2931	0.8706	1.0000						
4:	-0.0637	0.0390	0.1408	1.0000					
5:	-0.0820	-0.0610	0.0275	0.8767	1.0000				
6:	-0.0742	-0.0667	0.0051	0.9097	0.8520	1.0000			
7:	0.0080	0.0234	0.0283	0.6144	0.5739	0.6714	1.0000		
8:	-0.0263	-0.0372	-0.0359	0.0020	-0.0022	0.0393	0.0827	1.0000	
11:	0.0003	-0.0142	-0.0217	-0.0037	-0.0044	0.0265	0.0792	0.4027	1.0000

1993

	age:	original	-- bootstrap --			
			mean	s.d.	g1-skew	g2-kurtosis
1	E 1 -	4363.741	4314.332	1981.631	0.318	-0.326
2	E 2 -	132236.917	133395.485	55080.125	0.471	0.184
3	E 3 -	28402.879	28291.195	6739.274	0.378	0.097
4	E 4 -	1009.924	1006.825	308.945	0.562	0.306
5	E 5 -	1269.207	1261.763	483.517	0.586	0.151
6	E 6 -	168.118	167.580	76.528	0.948	1.346
7	E 7 -	491.165	490.104	137.816	0.532	0.349
8	E 8 -	99.975	100.586	37.162	0.607	0.573

R1\R2:	1	2	3	4	5	6	7	8
1:	1.0000							
2:	0.0926	1.0000						
3:	0.0002	0.4712	1.0000					
4:	-0.0291	0.1001	0.6561	1.0000				
5:	-0.0046	0.0113	0.4739	0.7789	1.0000			
6:	-0.0039	0.0092	0.3899	0.6387	0.7599	1.0000		
7:	-0.0038	-0.0045	0.3487	0.5826	0.7036	0.6112	1.0000	
8:	0.0118	-0.0075	0.0639	0.0945	0.0813	0.0873	0.1556	1.0000

1994

	age:	original	-- bootstrap -- mean	s.d.	g1-skew	g2-kurtosis
1	E 1 -	3146.662	3148.488	679.133	0.470	0.626
2	E 2 -	3835.296	3837.021	1514.697	0.472	-0.218
3	E 3 -	24599.176	24426.775	7415.098	0.332	0.026
4	E 4 -	4561.952	4534.088	1297.102	0.502	0.206
5	E 5 -	119.820	118.682	46.998	0.813	1.090
6	E 6 -	65.799	65.101	29.757	0.763	0.892
7	E 7 -	6.721	6.673	7.971	1.859	5.100
8	E 8 -	117.619	117.086	41.844	0.506	0.373
9	E 9 -	0.000	0.000	0.000	0.000	0.000
10	E 10 -	6.648	6.558	9.148	1.736	3.852

R1\R2:	1	2	3	4	5	6	7	8	10
1:	1.0000								
2:	0.1994	1.0000							
3:	0.1176	0.3988	1.0000						
4:	0.5244	0.2953	0.6983	1.0000					
5:	0.3297	0.1394	0.3234	0.4972	1.0000				
6:	0.0743	0.0036	0.0257	0.1314	0.1855	1.0000			
7:	0.0072	-0.0008	-0.0126	0.0380	0.0434	0.1412	1.0000		
8:	-0.0084	-0.0260	-0.0170	0.0370	0.0811	0.1282	0.0335	1.0000	
10:	0.0245	-0.0281	-0.0153	-0.0259	-0.0257	-0.0223	-0.0337	-0.0499	1.0000

1995

	age:	original	-- bootstrap -- mean	s.d.	g1-skew	g2-kurtosis
1	E 1 -	1546.368	1541.749	372.024	0.298	0.094
2	E 2 -	11364.684	11333.111	5010.611	0.636	0.232
3	E 3 -	1237.865	1233.568	295.060	0.483	0.424
4	E 4 -	3595.478	3580.445	745.744	0.319	-0.067
5	E 5 -	884.979	886.947	208.495	0.262	-0.017
6	E 6 -	33.095	33.279	17.950	0.857	1.386
7	E 7 -	24.647	24.687	16.323	0.899	1.205
8	E 8 -	0.000	0.000	0.000	0.000	0.000
9	E 9 -	23.411	23.331	16.104	1.030	1.436
10	E 10 -	6.659	6.727	8.467	1.440	2.415

R1\R2:	1	2	3	4	5	6	7	9	10
1:	1.0000								
2:	0.4562	1.0000							
3:	0.2671	0.7439	1.0000						
4:	-0.0358	0.1004	0.5201	1.0000					
5:	-0.0277	0.0247	0.2473	0.6752	1.0000				
6:	0.0076	0.0168	0.0679	0.1733	0.2057	1.0000			
7:	0.0673	-0.0106	-0.0294	-0.0477	-0.0234	-0.0011	1.0000		
9:	-0.0090	0.0166	0.0504	0.0999	0.1357	0.0755	-0.0737	1.0000	
10:	0.0083	-0.0107	-0.0151	-0.0225	-0.0135	-0.0031	0.0083	0.0165	1.0000

1996

	age:	original	bootstrap mean	bootstrap s.d.	g1-skew	g2-kurtosis
1	E 1 -	38.750	38.002	21.665	0.716	0.733
2	E 2 -	2964.419	2954.438	389.907	0.154	0.044
3	E 3 -	6130.610	6139.239	1268.063	0.284	0.022
4	E 4 -	819.668	819.828	171.354	0.429	0.200
5	E 5 -	2246.864	2244.909	381.455	0.269	0.039
6	E 6 -	187.408	187.876	48.123	0.418	0.217
7	E 7 -	8.399	8.154	10.301	1.468	2.578
8	E 8 -	6.232	6.311	8.653	1.599	2.785

R1\R2:	1	2	3	4	5	6	7	8
1:	1.0000							
2:	0.2805	1.0000						
3:	0.0258	0.2900	1.0000					
4:	-0.0028	0.2565	0.7727	1.0000				
5:	-0.0473	0.2002	0.4975	0.6578	1.0000			
6:	-0.0456	0.0263	0.0043	0.0949	0.3153	1.0000		
7:	0.0040	0.0197	0.0110	0.0085	-0.0041	-0.0232	1.0000	
8:	-0.0212	-0.0309	-0.0580	0.0064	0.0239	0.2143	-0.0122	1.0000

1997

	age:	original	bootstrap mean	bootstrap s.d.	g1-skew	g2-kurtosis
1	E 1 -	39.381	38.968	23.480	0.779	0.879
2	E 2 -	139.299	138.989	52.241	0.511	0.281
3	E 3 -	3145.538	3146.073	779.592	0.579	0.147
4	E 4 -	4360.145	4360.583	819.497	0.501	0.181
5	E 5 -	357.895	357.550	72.169	0.455	0.329
6	E 6 -	901.809	901.966	129.189	0.251	0.117
7	E 7 -	20.019	19.908	12.199	0.827	1.126
8	E 8 -	0.000	0.000	0.000	0.000	0.000
9	E 9 -	0.000	0.000	0.000	0.000	0.000
10	E 10 -	0.000	0.000	0.000	0.000	0.000
11	E 11 -	0.000	0.000	0.000	0.000	0.000
12	E 12 -	6.426	6.584	8.920	1.612	3.133

R1\R2:	1	2	3	4	5	6	7	12
1:	1.0000							
2:	0.3049	1.0000						
3:	0.0827	0.5016	1.0000					
4:	0.0682	0.4137	0.8945	1.0000				
5:	0.0532	0.2332	0.5388	0.6424	1.0000			
6:	0.0682	0.0963	0.2186	0.3287	0.3524	1.0000		
7:	0.0081	0.0235	0.0499	0.0693	0.0558	0.1269	1.0000	
12:	-0.0011	0.0007	-0.0078	-0.0122	0.0231	-0.0011	-0.0092	1.0000

Table 2 - Original and bootstrap estimates of cod abundance at age in 1997 survey. 10000 cycles. The variable cited was excluded from the bootstrap in each case.

no variable excluded

	age:	original	bootstrap mean	bootstrap s.d.	g1-skew	g2-kurtosis
1	E 1 -	39.381	38.968	23.480	0.779	0.879
2	E 2 -	139.299	138.989	52.241	0.511	0.281
3	E 3 -	3145.538	3146.073	779.592	0.579	0.147
4	E 4 -	4360.145	4360.583	819.497	0.501	0.181
5	E 5 -	357.895	357.550	72.169	0.455	0.329
6	E 6 -	901.809	901.966	129.189	0.251	0.117
7	E 7 -	20.019	19.908	12.199	0.827	1.126
8	E 8 -	0.000	0.000	0.000	0.000	0.000
9	E 9 -	0.000	0.000	0.000	0.000	0.000
10	E 10 -	0.000	0.000	0.000	0.000	0.000
11	E 11 -	0.000	0.000	0.000	0.000	0.000
12	E 12 -	6.426	6.584	8.920	1.612	3.133

R1\R2:	1	2	3	4	5	6	7	12
1:	1.0000							
2:	0.3049	1.0000						
3:	0.0827	0.5016	1.0000					
4:	0.0682	0.4137	0.8945	1.0000				
5:	0.0532	0.2332	0.5388	0.6424	1.0000			
6:	0.0682	0.0963	0.2186	0.3287	0.3524	1.0000		
7:	0.0081	0.0235	0.0499	0.0693	0.0558	0.1269	1.0000	
12:	-0.0011	0.0007	-0.0078	-0.0122	0.0231	-0.0011	-0.0092	1.0000

length frequencies excluded

	age:	original	bootstrap mean	bootstrap s.d.	g1-skew	g2-kurtosis
1	E 1 -	39.381	39.667	15.791	0.272	0.014
2	E 2 -	139.299	139.970	44.339	0.469	0.384
3	E 3 -	3145.538	3150.780	790.774	0.655	0.382
4	E 4 -	4360.145	4365.633	817.948	0.539	0.237
5	E 5 -	357.895	358.232	69.796	0.431	0.240
6	E 6 -	901.809	904.184	113.911	0.228	0.054
7	E 7 -	20.019	20.179	11.900	0.720	0.824
8	E 8 -	0.000	0.000	0.000	0.000	0.000
9	E 9 -	0.000	0.000	0.000	0.000	0.000
10	E 10 -	-0.000	0.000	0.000	0.000	0.000
11	E 11 -	0.000	0.000	0.000	0.000	0.000
12	E 12 -	6.426	6.339	5.768	0.612	0.054

matriz de covarianzas

R1\R2:	1	2	3	4	5	6	7	12
1:	1.0000							
2:	0.5928	1.0000						
3:	0.1720	0.6110	1.0000					
4:	0.1530	0.5153	0.9211	1.0000				
5:	0.1131	0.3161	0.5771	0.6569	1.0000			
6:	0.1270	0.1198	0.2431	0.3896	0.3889	1.0000		
7:	0.0317	0.0497	0.0621	0.0780	0.0551	0.1124	1.0000	
12:	-0.0001	-0.0146	-0.0293	-0.0212	0.0450	0.0314	-0.0184	1.0000

catches excluded

	age:	original	bootstrap mean	bootstrap s.d.	g1-skew	g2-kurtosis
1	E 1 -	39.381	39.089	15.737	0.364	0.071
2	E 2 -	139.299	139.091	30.462	0.256	0.056
3	E 3 -	3145.538	3145.451	109.924	0.070	-0.054
4	E 4 -	4360.145	4361.654	118.466	-0.047	0.015
5	E 5 -	357.895	358.416	47.227	0.157	-0.089
6	E 6 -	901.809	900.532	66.268	0.079	-0.055
7	E 7 -	20.019	19.854	11.558	0.634	0.530
8	E 8 -	0.000	0.000	0.000	0.000	0.000
9	E 9 -	0.000	0.000	0.000	0.000	0.000
10	E 10 -	0.000	0.000	0.000	0.000	0.000
11	E 11 -	0.000	0.000	0.000	0.000	0.000
12	E 12 -	6.426	6.424	5.777	0.710	0.174

matriz de covarianzas

R1\R2:	1	2	3	4	5	6	7	12
1:	1.0000							
2:	-0.0379	1.0000						
3:	-0.0611	-0.1414	1.0000					
4:	-0.0512	-0.1002	-0.7350	1.0000				
5:	-0.0020	-0.0086	-0.1332	-0.2137	1.0000			
6:	-0.0241	-0.0298	-0.1678	-0.3482	-0.0984	1.0000		
7:	-0.0107	-0.0093	-0.0075	-0.0474	-0.0243	-0.0518	1.0000	
12:	0.0028	0.0039	-0.0159	-0.0176	-0.0295	-0.0083	-0.0147	1.0000

otoliths excluded

	age:	original	bootstrap mean	bootstrap s.d.	g1-skew	g2-kurtosis
1	E 1 -	39.381	39.640	23.549	0.848	1.272
2	E 2 -	139.299	140.061	49.164	0.491	0.416
3	E 3 -	3145.538	3146.114	779.117	0.598	0.246
4	E 4 -	4360.145	4363.270	814.103	0.501	0.165
5	E 5 -	357.895	358.233	56.421	0.370	0.227
6	E 6 -	901.809	903.070	125.001	0.242	0.039
7	E 7 -	20.019	19.995	3.340	0.287	0.155
8	E 8 -	0.000	0.000	0.000	0.000	0.000
9	E 9 -	0.000	0.000	0.000	0.000	0.000
10	E 10 -	0.000	0.000	0.000	0.000	0.000
11	E 11 -	0.000	0.000	0.000	0.000	0.000
12	E 12 -	6.426	6.626	9.115	1.794	4.662

matriz de covarianzas

R1\R2:	1	2	3	4	5	6	7	12
1:	1.0000							
2:	0.3526	1.0000						
3:	0.1255	0.5413	1.0000					
4:	0.1069	0.4360	0.9150	1.0000				
5:	0.0952	0.3245	0.7074	0.8659	1.0000			
6:	0.0815	0.1030	0.2212	0.3519	0.5511	1.0000		
7:	0.0705	0.1187	0.2161	0.2851	0.3752	0.7483	1.0000	
12:	0.0147	0.0013	0.0033	0.0077	0.0426	0.0201	-0.0004	1.0000

Table 3 - Correlation coefficients between typified covariance of survey estimates of abundance at age calculated by both analytical and bootstrap methods.

1988:	0.987
1989:	0.923
1990:	0.798
1991:	1.000
1992:	0.945
1993:	0.998
1994:	0.975
1995:	0.992
1996:	0.971
1997:	0.999