

Supplementary Materials

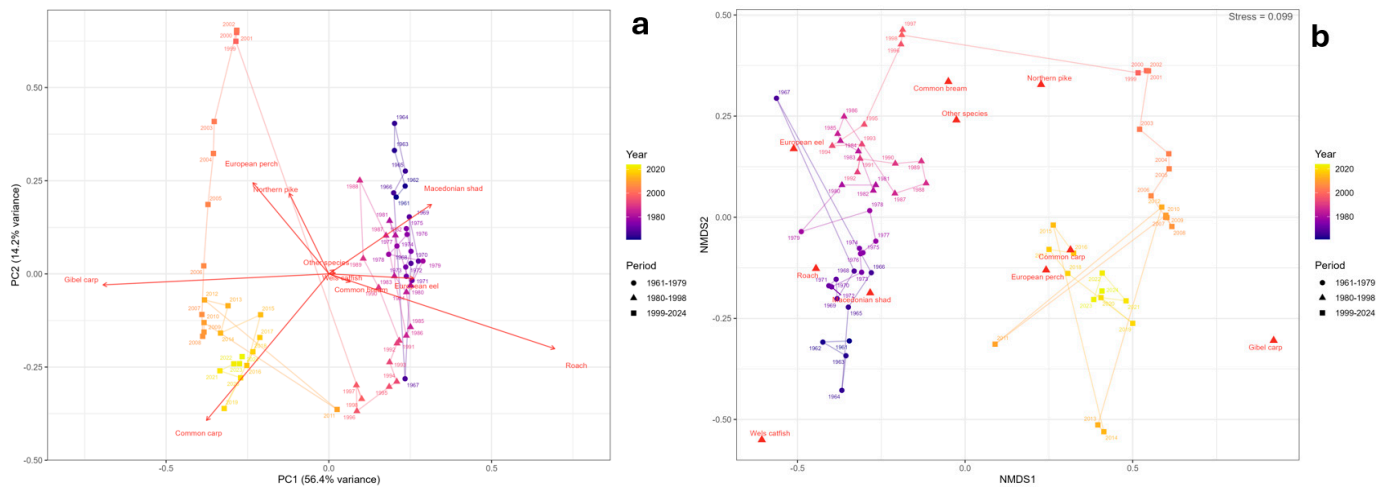


Figure S1. Multivariate reorganization of the Lake Volvi fish landings assemblage, 1961–2024. (a) PCA of Hellinger-transformed annual catch composition. (b) NMDS based on Bray–Curtis dissimilarity (stress = 0.0992). Points represent years and are colored by year or period; taxon scores identify compositional gradients.

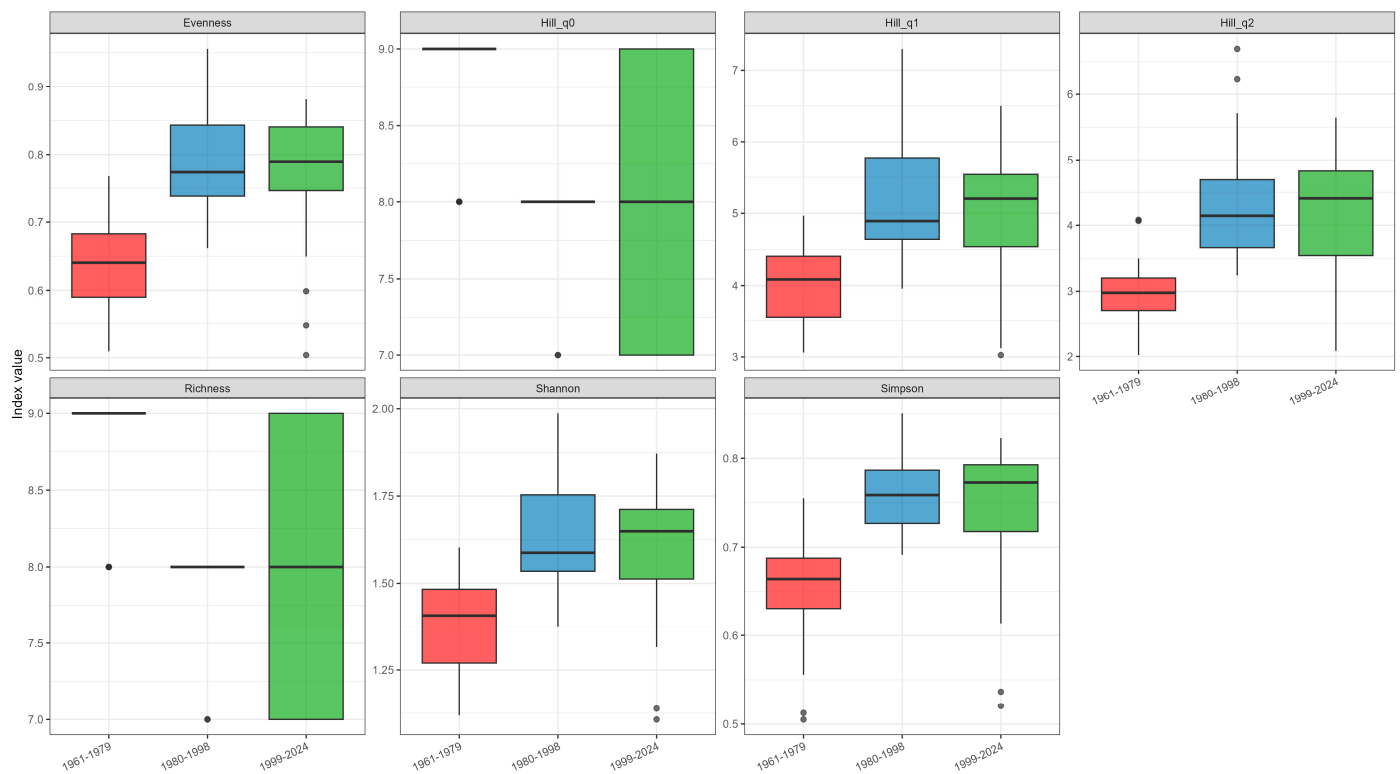


Figure S2. Temporal dynamics of fish landings diversity in Lake Volvi, 1961–2024. Period-stratified distributions of annual Shannon diversity, Simpson's index, richness, Pielou's evenness, and Hill numbers $q = 1$ and $q = 2$. Hill $q = 0$ is numerically identical to observed richness and is not plotted separately.

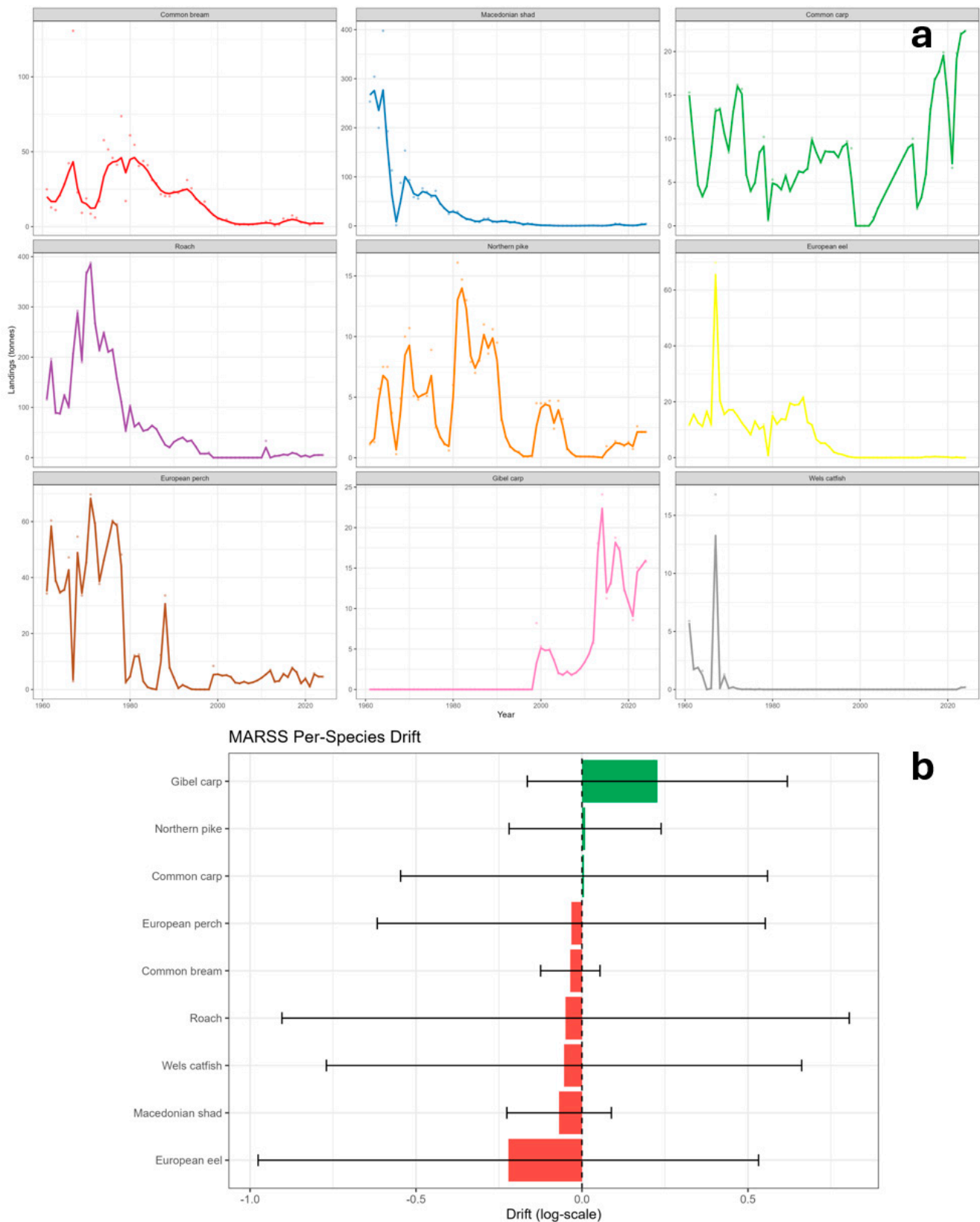


Figure S3. MARSS state estimates and species-specific drift for nine Lake Volvi taxa, 1961–2024. (a) Smoothed latent states versus observed annual landings. (b) Log-scale drift coefficients from the Q diagonal-and-unequal, R diagonal-and-equal specification (Table S5), with approximate 95% intervals. Positive values indicate increasing latent landing states and negative values indicate declining states; all intervals should be interpreted jointly with the non-significant approximate p-values in Table 8.

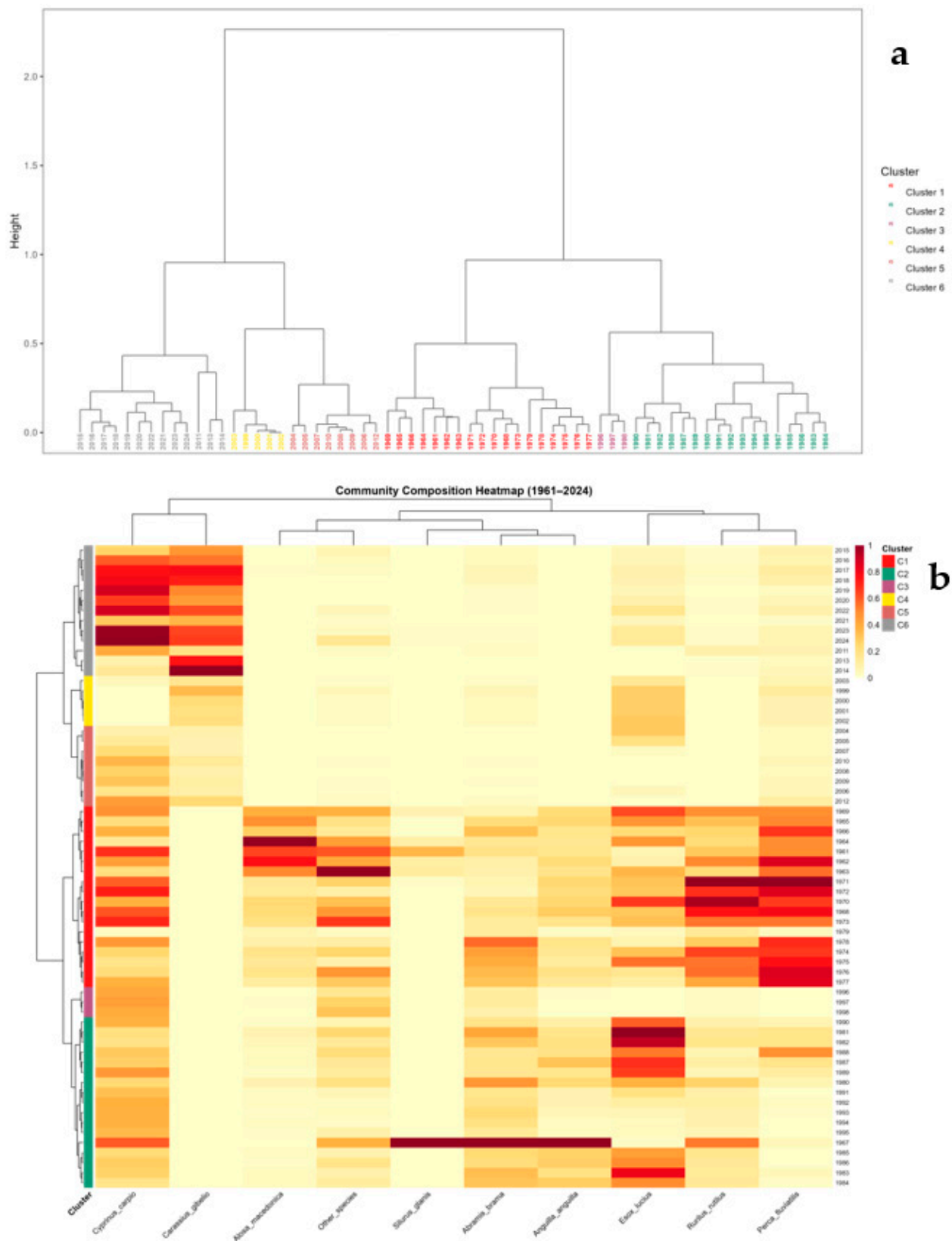


Figure S4. Hierarchical clustering and landings-composition heatmap for Lake Volvi, 1961–2024. (a) Ward's D2 dendrogram based on Bray–Curtis dissimilarity, colored by the six-cluster capped solution. (b) Year-by-taxon heatmap of min–max-scaled landings.

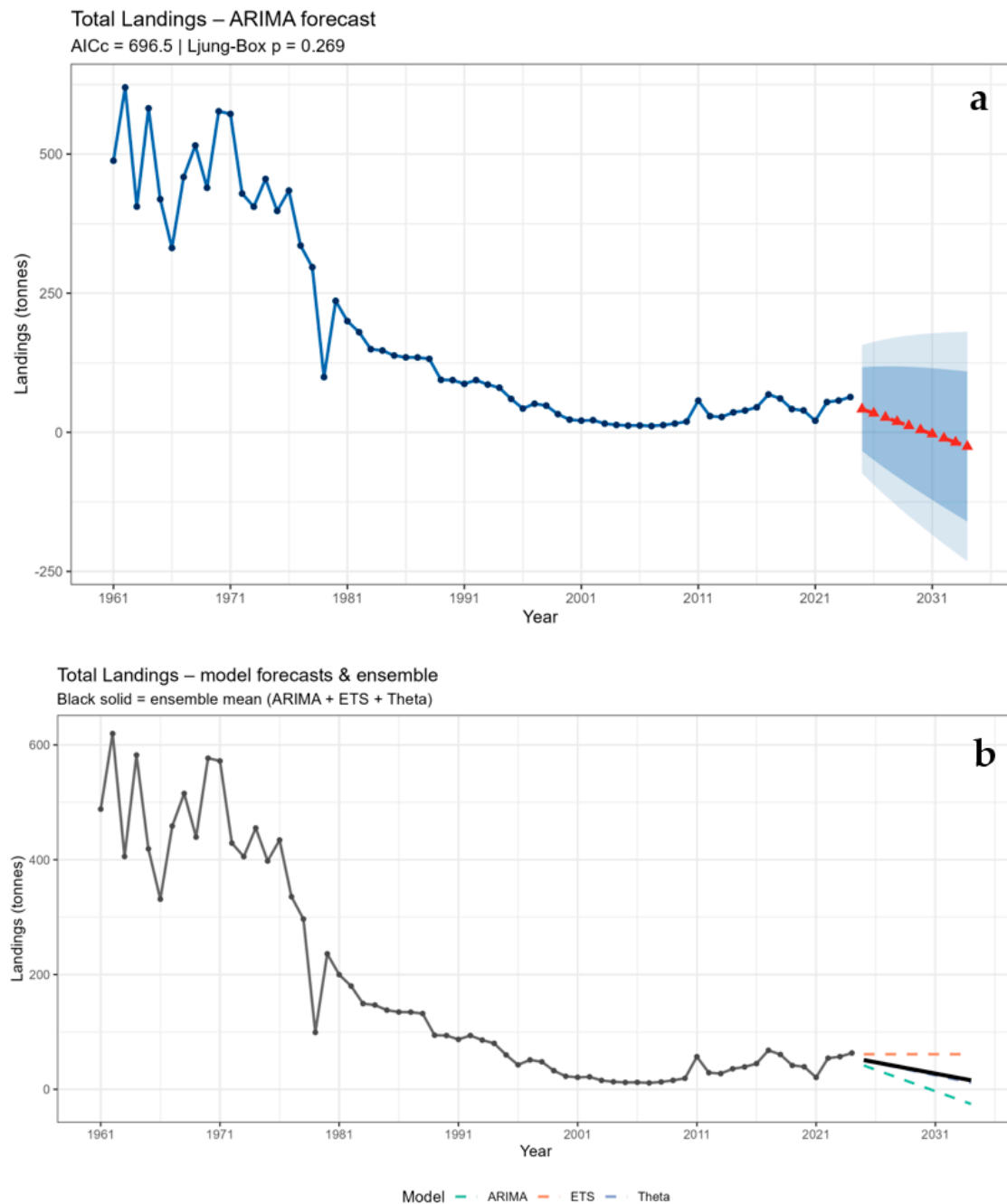


Figure S5. Forecast performance and ten-year projections of Lake Volvi fish landings, 2025–2034. (a) ARIMA forecast for total landings with 80% and 95% prediction intervals; the point forecast falls below zero before the end of the horizon, which is inadmissible as a catch. (b) Component and ensemble forecasts for total landings. The complete cross-validated model comparison for all nine series is given in Table S3 and the fitted ARIMA specifications in Table S5. Projections are scenario envelopes conditional on the historical landings process, not predictions of future yield.

Table S1. Annual diversity indices for the Lake Volvi landings assemblage, 1961–2024. Columns give year, descriptive period, Shannon diversity (H'), Simpson diversity ($1 - D$), observed category richness (S), Pielou's evenness (J'), and Hill numbers of orders $q = 0$, 1 and 2. Indices were computed from the ten-column landings matrix, which includes the aggregate "Other species" category; $q = 0$ and S therefore index recorded categories, not biological species richness.

Year	Shannon	Simpson	Richness	Evenness	Period	Hill_q0	Hill_q1	Hill_q2
1961	1.4411	0.6625	9	0.6559	1961-1979	9	4.2252	2.9630
1962	1.3082	0.6469	9	0.5954	1961-1979	9	3.6996	2.8323
1963	1.4846	0.6876	9	0.6756	1961-1979	9	4.4130	3.2012

1964	1.1191	0.5050	9	0.5093	1961-1979	9	3.0621	2.0202
1965	1.4348	0.6843	8	0.6900	1961-1979	8	4.1987	3.1671
1966	1.6027	0.7551	9	0.7294	1961-1979	9	4.9666	4.0834
1967	1.3979	0.6877	9	0.6362	1961-1979	9	4.0467	3.2024
1968	1.3908	0.6329	9	0.6330	1961-1979	9	4.0182	2.7238
1969	1.4394	0.6816	9	0.6551	1961-1979	9	4.2180	3.1408
1970	1.2247	0.5556	9	0.5574	1961-1979	9	3.4032	2.2505
1971	1.1312	0.5123	9	0.5148	1961-1979	9	3.0995	2.0505
1972	1.2312	0.5720	9	0.5603	1961-1979	9	3.4253	2.3363
1973	1.4823	0.6718	9	0.6746	1961-1979	9	4.4029	3.0468
1974	1.3919	0.6480	9	0.6335	1961-1979	9	4.0226	2.8405
1975	1.4074	0.6642	9	0.6406	1961-1979	9	4.0855	2.9782
1976	1.4837	0.6917	8	0.7135	1961-1979	8	4.4093	3.2435
1977	1.5397	0.7141	9	0.7008	1961-1979	9	4.6634	3.4973
1978	1.5955	0.7541	8	0.7673	1961-1979	8	4.9306	4.0663
1979	1.2154	0.6289	8	0.5845	1961-1979	8	3.3717	2.6950
1980	1.5321	0.7144	8	0.7368	1980-1998	8	4.6281	3.5016
1981	1.7803	0.7941	8	0.8561	1980-1998	8	5.9314	4.8564
1982	1.7270	0.7711	8	0.8305	1980-1998	8	5.6235	4.3681
1983	1.6718	0.7617	8	0.8040	1980-1998	8	5.3217	4.1967
1984	1.6048	0.7485	8	0.7717	1980-1998	8	4.9769	3.9769
1985	1.5107	0.7076	8	0.7265	1980-1998	8	4.5301	3.4198
1986	1.6077	0.7419	8	0.7731	1980-1998	8	4.9912	3.8745
1987	1.8993	0.8249	8	0.9134	1980-1998	8	6.6814	5.7118
1988	1.9445	0.8398	8	0.9351	1980-1998	8	6.9899	6.2409
1989	1.9868	0.8506	8	0.9555	1980-1998	8	7.2925	6.6917
1990	1.7939	0.7935	8	0.8627	1980-1998	8	6.0130	4.8423
1991	1.5743	0.7320	8	0.7571	1980-1998	8	4.8276	3.7314
1992	1.5373	0.7216	8	0.7393	1980-1998	8	4.6520	3.5918
1993	1.4752	0.7093	8	0.7094	1980-1998	8	4.3717	3.4398
1994	1.3761	0.6915	8	0.6618	1980-1998	8	3.9593	3.2414
1995	1.5300	0.7395	8	0.7358	1980-1998	8	4.6181	3.8382
1996	1.5641	0.7587	8	0.7522	1980-1998	8	4.7784	4.1438
1997	1.5877	0.7758	7	0.8159	1980-1998	7	4.8925	4.4601
1998	1.5757	0.7798	7	0.8097	1980-1998	7	4.8340	4.5415
1999	1.6410	0.7873	7	0.8433	1999-2024	7	5.1603	4.7019
2000	1.6514	0.7933	7	0.8487	1999-2024	7	5.2145	4.8369
2001	1.6499	0.7932	7	0.8479	1999-2024	7	5.2067	4.8357
2002	1.6486	0.7931	7	0.8472	1999-2024	7	5.1999	4.8332
2003	1.7319	0.7986	8	0.8329	1999-2024	8	5.6513	4.9657
2004	1.6783	0.7816	7	0.8625	1999-2024	7	5.3563	4.5789
2005	1.7150	0.8007	7	0.8813	1999-2024	7	5.5564	5.0168
2006	1.6763	0.7823	8	0.8061	1999-2024	8	5.3458	4.5926
2007	1.5304	0.7239	7	0.7864	1999-2024	7	4.6198	3.6213
2008	1.4545	0.7051	7	0.7475	1999-2024	7	4.2823	3.3909
2009	1.4756	0.7156	8	0.7096	1999-2024	8	4.3735	3.5159
2010	1.5066	0.7324	8	0.7245	1999-2024	8	4.5112	3.7376
2011	1.3155	0.6142	9	0.5987	1999-2024	9	3.7267	2.5918
2012	1.5620	0.7608	8	0.7512	1999-2024	8	4.7684	4.1806
2013	1.1383	0.5365	8	0.5474	1999-2024	8	3.1216	2.1573
2014	1.1071	0.5202	9	0.5039	1999-2024	9	3.0257	2.0840
2015	1.8716	0.8228	9	0.8518	1999-2024	9	6.4988	5.6445
2016	1.7684	0.7899	9	0.8048	1999-2024	9	5.8614	4.7596
2017	1.8253	0.8117	9	0.8308	1999-2024	9	6.2050	5.3095
2018	1.7425	0.7916	9	0.7931	1999-2024	9	5.7118	4.7974

2019	1.4272	0.6755	9	0.6495	1999-2024	9	4.1668	3.0814
2020	1.6390	0.7558	9	0.7459	1999-2024	9	5.1501	4.0955
2021	1.5526	0.7148	8	0.7466	1999-2024	8	4.7236	3.5061
2022	1.7025	0.7640	9	0.7748	1999-2024	9	5.4877	4.2374
2023	1.6841	0.7550	9	0.7665	1999-2024	9	5.3878	4.0824
2024	1.7734	0.7829	9	0.8071	1999-2024	9	5.8907	4.6069

Table S2. Cross-correlations among the nine named Lake Volvi landing series, 1961–2024, for the 30 of 36 taxon pairs whose correlation exceeded the approximate 95% reference bound of ± 0.245 ($n = 64$) at one or more lags between -10 and $+10$ years. The six pairs that did not exceed the bound are listed in the note below the table.

Species pair	Maximum CCF	Best lag (yr)	Leading taxon	Lags $ r > 0.245$
Roach vs European perch	+0.848	−1	Roach (leads 1 yr)	20
Macedonian shad vs Roach	+0.826	−6	Macedonian shad (leads 6 yr)	15
Common bream vs European eel	+0.780	0	Synchronous	20
European eel vs Wels catfish	+0.738	0	Synchronous	3
Macedonian shad vs European eel	+0.717	−3	Macedonian shad (leads 3 yr)	14
Roach vs European eel	+0.685	+3	European eel (leads 3 yr)	21
Macedonian shad vs European perch	+0.673	−7	Macedonian shad (leads 7 yr)	15
Common bream vs European perch	+0.671	+5	European perch (leads 5 yr)	12
Common bream vs Roach	+0.636	+5	Roach (leads 5 yr)	17
Macedonian shad vs Wels catfish	+0.591	−3	Macedonian shad (leads 3 yr)	8
Common bream vs Wels catfish	+0.581	0	Synchronous	1
Roach vs Northern pike	+0.575	−10	Roach (leads 10 yr)	14
Northern pike vs European perch	+0.574	+10	European perch (leads 10 yr)	7
Common bream vs Macedonian shad	+0.564	+3	Macedonian shad (leads 3 yr)	7
European eel vs European perch	+0.558	−4	European eel (leads 4 yr)	21
Common bream vs Northern pike	+0.538	−7	Common bream (leads 7 yr)	19
Northern pike vs European eel	+0.538	+2	European eel (leads 2 yr)	14
Northern pike vs Gibel carp	−0.523	−6	Northern pike (leads 6 yr)	18
Common carp vs Gibel carp	+0.501	+5	Gibel carp (leads 5 yr)	12
Roach vs Wels catfish	+0.498	+4	Wels catfish (leads 4 yr)	9
Roach vs Gibel carp	−0.475	−10	Roach (leads 10 yr)	17
Common bream vs Gibel carp	−0.466	−10	Common bream (leads 10 yr)	17
European eel vs Gibel carp	−0.461	−8	European eel (leads 8 yr)	17
European perch vs Wels catfish	+0.444	+10	Wels catfish (leads 10 yr)	10
European perch vs Gibel carp	−0.428	−9	European perch (leads 9 yr)	13
Macedonian shad vs Northern pike	+0.350	−8	Macedonian shad (leads 8 yr)	6
Macedonian shad vs Gibel carp	−0.349	−10	Macedonian shad (leads 10 yr)	12
Common carp vs European perch	+0.289	−4	Common carp (leads 4 yr)	2
Common carp vs Northern pike	−0.283	+10	Northern pike (leads 10 yr)	3
Common bream vs Common carp	−0.278	−9	Common bream (leads 9 yr)	3

Table S3. Cross-validated forecast accuracy for total landings and eight named Lake Volvi taxa. Rolling-origin cross-validation with a ten-year initial training window and a five-year horizon; RMSE and MAE in tonnes. Rows are ordered by RMSE within each series.

Species	Model	RMSE	MAE	MASE
Macedonian shad	Ensemble	7.96	5.46	0.292
Macedonian shad	Naive	10.19	5.45	0.292
Macedonian shad	ARIMA	10.31	5.65	0.302
Macedonian shad	ETS	11.77	6.37	0.341
Macedonian shad	Theta	14.61	11.58	0.62
Macedonian shad	RWdrift	26.14	21.36	1.143
Macedonian shad	Mean	73.04	69.74	3.731
Common bream	Ensemble	13.88	10.27	1.09
Common bream	Naive	14.4	8.86	0.94
Common bream	ETS	14.93	9.78	1.038
Common bream	ARIMA	15.52	11.73	1.245
Common bream	Theta	15.53	11.88	1.261
Common bream	RWdrift	16.13	9.71	1.03
Common bream	Mean	20.47	18.98	2.014
Common carp	Ensemble	5.37	3.9	1.523
Common carp	Naive	5.41	3.93	1.536
Common carp	ETS	5.43	3.93	1.535
Common carp	Theta	5.61	4.14	1.616
Common carp	RWdrift	5.73	4.39	1.712
Common carp	ARIMA	5.92	4.47	1.744
Common carp	Mean	5.92	4.46	1.74
European eel	Naive	4.48	2.49	0.717
European eel	RWdrift	4.83	2.85	0.818
European eel	ETS	5.6	3.53	1.015
European eel	Ensemble	5.64	3.69	1.06
European eel	Theta	5.93	4.25	1.222
European eel	ARIMA	6.46	4.2	1.206
European eel	Mean	9.76	9.08	2.609
Gibel carp	Theta	4.58	2.32	1.924
Gibel carp	Naive	4.6	2.35	1.946
Gibel carp	ARIMA	4.63	2.35	1.945
Gibel carp	RWdrift	4.68	2.42	2.006
Gibel carp	Ensemble	4.96	2.43	2.013
Gibel carp	ETS	6.16	2.72	2.249
Gibel carp	Mean	6.97	3.97	3.289
European perch	Naive	14.46	7.74	1.029
European perch	Ensemble	15.26	8.94	1.19
European perch	Theta	15.74	8.89	1.183
European perch	ETS	15.78	9.46	1.259
European perch	ARIMA	16.15	9.73	1.294
European perch	RWdrift	16.21	9.04	1.202
European perch	Mean	23.24	21.1	2.808
Northern pike	Ensemble	3.84	2.72	1.629
Northern pike	ARIMA	3.95	3.05	1.828
Northern pike	ETS	4.21	2.71	1.626
Northern pike	Theta	4.21	2.85	1.711
Northern pike	Naive	4.26	2.73	1.64
Northern pike	Mean	4.4	3.82	2.291
Northern pike	RWdrift	4.65	2.99	1.794
Roach	Naive	42.15	21.47	0.896
Roach	ETS	44.23	23.37	0.975

Roach	Ensemble	48.77	26.84	1.12
Roach	ARIMA	52.15	30.18	1.259
Roach	Theta	55.45	28.92	1.206
Roach	RWdrift	55.55	27.51	1.148
Roach	Mean	101.84	97.39	4.063
Total Landings	Naive	64.7	37.23	0.969
Total Landings	RWdrift	66.12	42.87	1.115
Total Landings	Theta	69.57	39.14	1.018
Total Landings	Ensemble	78.35	45.19	1.176
Total Landings	ETS	79.58	43.72	1.138
Total Landings	ARIMA	91.96	62.67	1.631
Total Landings	Mean	219.42	210.05	5.466

Table S4. Terminal-year (2022) B/B_{MSY} and F/F_{MSY} with 95% credible limits from a single CMSY2 reference fit, for the eight successfully assessed Lake Volvi series. Point estimates differ from the replicate medians in Table 4 because cmsy2() is not reproducible under a fixed seed; the two sets are not directly commensurable, and these limits describe one representative solution rather than replicate-based intervals. Wels catfish F/F_{MSY} is undefined because terminal catch in 2022 was zero. Roach and European perch are omitted (no viable solution).

Species	B/B_{MSY} (95% CL)	F/F_{MSY} (95% CL)
Common bream	0.076 (0.026–0.184)	6.29 (2.59–18.59)
Macedonian shad	0.071 (0.025–0.192)	0.345 (0.128–0.999)
Common carp	1.010 (0.478–1.195)	1.66 (1.40–3.50)
Northern pike	0.197 (0.027–0.564)	5.64 (1.97–41.03)
European eel	0.089 (0.022–0.193)	1.11 (0.51–4.51)
Gibel carp	0.941 (0.441–1.191)	1.12 (0.89–2.39)
Wels catfish	0.072 (0.030–0.184)	undefined
Other species	0.109 (0.022–0.355)	3.21 (0.99–15.97)

Table S5. ARIMA specifications for total landings and eight named Lake Volvi taxa, 1961–2024, with ten-year projections. Orders were chosen by exhaustive search under AICc. Ljung–Box p-values test residual autocorrelation at lag 10. The 2034 point forecast for total landings is negative and therefore inadmissible as a catch.

Series	Order	AICc	Ljung–Box p	2025 forecast (t)	2034 forecast (t)
Total landings	ARIMA(0,1,1)	696.5	0.269	41.6	–25.6
Common bream	ARIMA(1,1,1)	551.3	0.819	2.9	3.1
Macedonian shad	ARIMA(5,1,0)	629.6	0.108	4.2	8.0
Common carp	ARIMA(1,0,1)	354.3	0.852	19.0	9.2
Roach	ARIMA(2,1,2)	649.9	0.130	6.3	6.6
Northern pike	ARIMA(0,1,4)	300.2	0.585	2.0	1.9
European eel	ARIMA(0,1,1)	449.9	0.963	0.1	0.1
European perch	ARIMA(0,1,1)	500.2	0.054	4.5	4.5
Gibel carp	ARIMA(2,1,0)	310.4	0.642	15.7	15.6

Table S6. Sensitivity of Lake Volvi results to exclusion of the 1999–2012 reporting interval. (a) Mann–Kendall trend tests for total and taxon-specific landings and for the seven annual diversity indices; (b) multivariate tests of the three a priori periods. The full dataset comprises 64 years (1961–2024) and the censored dataset 50 years.

(a) Mann–Kendall trend tests							
Series/index	τ (full)	p (full)	Classification (full)	τ (excl.)	p (excl.)	Classification (excl.)	Change
<i>Total and taxon-specific landings</i>							
Total landings	−0.682	<0.001	Decreasing	−0.799	<0.001	Decreasing	No
Common bream	−0.538	<0.001	Decreasing	−0.436	<0.001	Decreasing	No
Macedonian shad	−0.708	<0.001	Decreasing	−0.785	<0.001	Decreasing	No
Common carp	0.089	0.305	No trend	0.222	0.024	Increasing	Yes
Roach	−0.635	<0.001	Decreasing	−0.730	<0.001	Decreasing	No
Northern pike	−0.336	<0.001	Decreasing	−0.249	0.011	Decreasing	No
European eel	−0.609	<0.001	Decreasing	−0.589	<0.001	Decreasing	No
European perch	−0.320	<0.001	Decreasing	−0.410	<0.001	Decreasing	No
Gibel carp	0.692	<0.001	Increasing	0.553	<0.001	Increasing	No
Wels catfish	−0.478	<0.001	Decreasing	−0.513	<0.001	Decreasing	No
Other species	−0.593	<0.001	Decreasing	−0.560	<0.001	Decreasing	No
<i>Diversity indices</i>							
Shannon H'	0.291	<0.001	Increasing	0.336	<0.001	Increasing	No
Simpson 1 – D	0.309	<0.001	Increasing	0.370	<0.001	Increasing	No
Category richness	−0.188	0.059	No trend	−0.169	0.148	No trend	No
Pielou's evenness J'	0.268	0.002	Increasing	0.339	<0.001	Increasing	No
Hill q = 0	−0.188	0.059	No trend	−0.169	0.148	No trend	No
Hill q = 1	0.291	<0.001	Increasing	0.336	<0.001	Increasing	No
Hill q = 2	0.309	<0.001	Increasing	0.370	<0.001	Increasing	No
(b) Multivariate tests of period structure							
Dataset	Years	PERMANOVA R ²	PERMANOVA p	PERMDISP F	PERMDISP p		
Full dataset (1961–2024)	64	0.656	0.001	4.789	0.011		
Excluding 1999–2012	50	0.685	0.001	0.360	0.721		

τ , Kendall's rank correlation coefficient. p-values are from the classical (uncorrected) Mann–Kendall test in both columns; the Hamed and Rao variance correction applied to the primary results in Table 2 was not re-applied to the censored series, so the two columns are directly comparable to each other but not to the corrected p-values of Table 2. Hill numbers q = 0, 1 and 2 are monotone transformations of category richness, Shannon H' and Simpson 1 – D respectively, so their rank correlations are identical to those quantities by construction. “Change” indicates whether the trend classification differs between the full and censored datasets. PERMANOVA and PERMDISP were computed on Hellinger-transformed landings with 999 permutations. CMSY2 and the forecasting models were not refitted on the censored series (Section 2.1).

Table S7. Sensitivity of CMSY2 terminal stock status to the choice of terminal year, Lake Volvi. Each converged series was refitted twelve times with the catch history truncated at 2022 and at 2024; values are replicate medians. “Overfished” denotes the overfished-and-overfishing quadrant ($B/B_{MSY} < 1$, $F/F_{MSY} > 1$). Terminal catches are in tonnes and are shown because terminal F is computed as terminal catch divided by terminal biomass; seven of the ten categories carry identical values in 2023 and 2024, so 2024 falls inside a block of carried-forward reporting. Roach and European perch returned no viable r - k trajectory at either terminal year.

Series	Catch 2022 (t)	B/B_{msy} 2022	F/F_{msy} 2022	Status 2022	Catch 2024 (t)	B/B_{msy} 2024	F/F_{msy} 2024	Status 2024	Status changed?
Common bream	2.654	0.089 (0.056–0.108)	4.78 (3.24–11.9)	Overfished	2.266	0.084 (0.066–0.115)	4.61 (2.44–7.41)	Overfished	No
Macedonian shad	1.116	0.063 (0.059–0.068)	0.445 (0.388–0.534)	Recovering	3.952	0.066 (0.055–0.077)	1.42 (1.08–2.05)	Overfished	YES
Common carp	19.813	1.01 (0.992–1.02)	1.65 (1.63–1.69)	Overfishing	22.381	1.38 (1.37–1.39)	0.971 (0.949–0.983)	Sustainable	YES
Northern pike	2.594	0.191 (0.183–0.215)	6.06 (4.79–6.49)	Overfished	2.13	0.152 (0.139–0.164)	7.73 (6.82–9.43)	Overfished	No
European eel	0.231	0.090 (0.086–0.094)	1.07 (0.998–1.18)	Overfished	0	0.089 (0.086–0.093)	— (undefined)	Depleted (indet. F)	YES
Gibel carp	15.049	0.953 (0.937–0.970)	1.1 (1.08–1.13)	Overfished	15.778	1.49 (1.49–1.5)	0.602 (0.594–0.608)	Sustainable	YES
Wels catfish	0	0.077 (0.073–0.080)	— (undefined)	Depleted (indet. F)	0.192	0.076 (0.070–0.079)	5.82 (5.28–6.94)	Overfished	YES
Other species	2.072	0.116 (0.093–0.158)	3.38 (2.39–5.69)	Overfished	6.794	0.128 (0.076–0.223)	9.83 (3.03–32.1)	Overfished	No
Roach	—	—	—	Indeterminate	—	—	—	Indeterminate	No
European perch	—	—	—	Indeterminate	—	—	—	Indeterminate	No

Table S8. MARSS taxon-specific drift estimates for Lake Volvi, 1961–2024. Model: B = identity, U unequal, Z = identity, A = zero, Q diagonal and unequal, R diagonal and equal (AICc = 2,372.5; selected by AICc from four variance structures). Drift is on the $\log(x + 0.01)$ scale; annual change is $[\exp(\text{drift}) - 1] \times 100$. ns, not significant at $\alpha = 0.05$. No drift coefficient was resolved individually; only the sign and relative ranking are interpretable.

Taxon	Drift	SE	p (approx.)	Sig.	Annual change (%)
Common bream	−0.03513	0.04568	0.442	ns	−3.45
Macedonian shad	−0.06888	0.08038	0.392	ns	−6.66
Common carp	+0.00633	0.28199	0.982	ns	+0.64
Roach	−0.04931	0.43600	0.910	ns	−4.81
Northern pike	+0.00944	0.11685	0.936	ns	+0.95
European eel	−0.22183	0.38458	0.564	ns	−19.89
European perch	−0.03232	0.29824	0.914	ns	−3.18
Gibel carp	+0.22704	0.19989	0.256	ns	+25.49
Wels catfish	−0.05403	0.36527	0.882	ns	−5.26



Table S9. Stationarity tests for total and taxon-specific landings in Lake Volvi, 1961–2024. ADF, Augmented Dickey–Fuller (H_0 : unit root); KPSS, Kwiatkowski–Phillips–Schmidt–Shin (H_0 : level stationarity). p-values reported as 0.01 or 0.10 are at the boundary of the tabulated range. † Both nulls rejected; the two tests disagree and the series is reported as conflicting rather than trend-stationary.

Series	ADF statistic	ADF p	KPSS statistic	KPSS p	Joint interpretation
Total	−1.125	0.911	1.396	<0.01	Non-stationary
Common bream	−4.198	<0.01	1.041	<0.01	Conflicting †
Macedonian shad	−14.063	<0.01	0.987	<0.01	Conflicting †
Common carp	−1.315	0.853	0.277	>0.10	Inconclusive
Roach	−2.713	0.286	1.119	<0.01	Non-stationary
Northern pike	−2.858	0.227	0.665	0.017	Non-stationary
European eel	−3.338	0.074	1.197	<0.01	Non-stationary
European perch	−2.123	0.525	1.102	<0.01	Non-stationary
Gibel carp	−2.011	0.571	1.154	<0.01	Non-stationary
Wels catfish	−3.658	0.036	0.585	0.024	Conflicting †
Other species	−4.048	0.013	1.272	<0.01	Conflicting †

Table S10. Selection of the number of breakpoints in the segmented regression of total Lake Volvi landings on year, 1961–2024.

Breakpoints	AIC	BIC	Adjusted R ²	Estimated breakpoint years
0	1655.99	1662.46	0.728	—
1	1592.4	1603.2	0.902	1995
2	1578.96	1594.07	0.923	1971, 1986
3	1560.17	1579.6	0.944	1976, 1979, 2002
4	1555.54	1579.29	0.949	1966, 1970, 1982, 2003

Models with a fixed number of breakpoints were fitted with bootstrap restarting (50 replicates) to reduce sensitivity to starting values. BIC decreases by 14.47 units from two to three breakpoints and by a further 0.31 from three to four, so three and four breakpoints are not distinguishable and three is retained as the more parsimonious. Davies’ test for a non-constant slope, evaluated against the single-line model, gave $p = 1.007 \times 10^{-13}$. The model reported in Section 3.2 was obtained by BIC search over the same candidate set using `selgmented()`, which places the three breakpoints at 1973, 1980 and 2002; the two three-breakpoint solutions select the same number of breaks but differ slightly in their locations, and only the `selgmented()` solution yields segments that all meet the five-observation minimum length applied to the Bai–Perron analysis.

Table S11. Sensitivity of Lake Volvi compositional, diversity, trend and clustering results to exclusion of the anomalous year 1967. Full series $n = 64$, censored series $n = 63$. Sheets give (a) PERMANOVA, PERMDISP, NMDS stress and a Procrustes test of the reduced ordination; (b) Mann–Kendall trends for the seven diversity indices; (c) Mann–Kendall trends for total and taxon-specific landings; (d) k-means clustering summary statistics; (e) cluster composition; (f) year-by-year cluster membership under both scenarios and under hierarchical clustering. No catch-only assessment was refitted, so stock-status results are unaffected.

Scenario	N years	Permanova R ²	Permanova p	Permdisp F	Permdisp p	NMDS stress	Procrustes corr	Procrustes p
Full dataset	64	0.6557	0.001	4.7888	0.011	0.0992		
Exclude 1967	63	0.6699	0.001	6.7712	0.002	0.0983	0.9999	0.001