Supporting Information

Belanger et al. 10.1073/pnas.1212381109
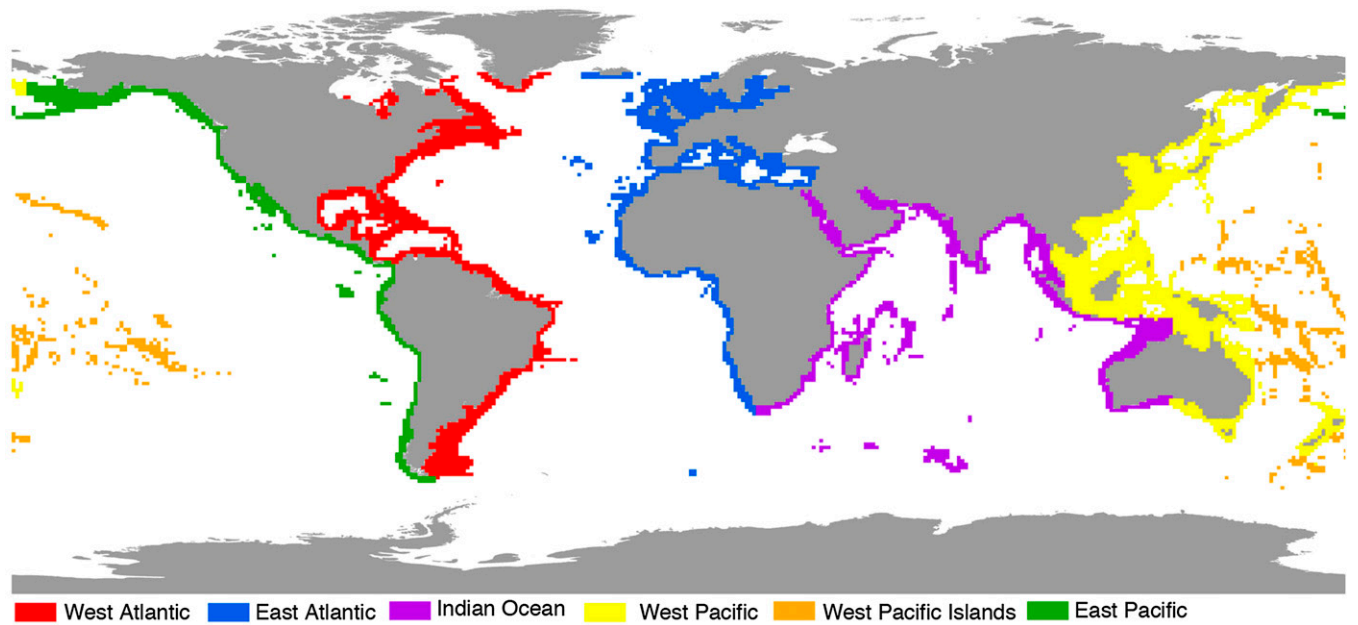

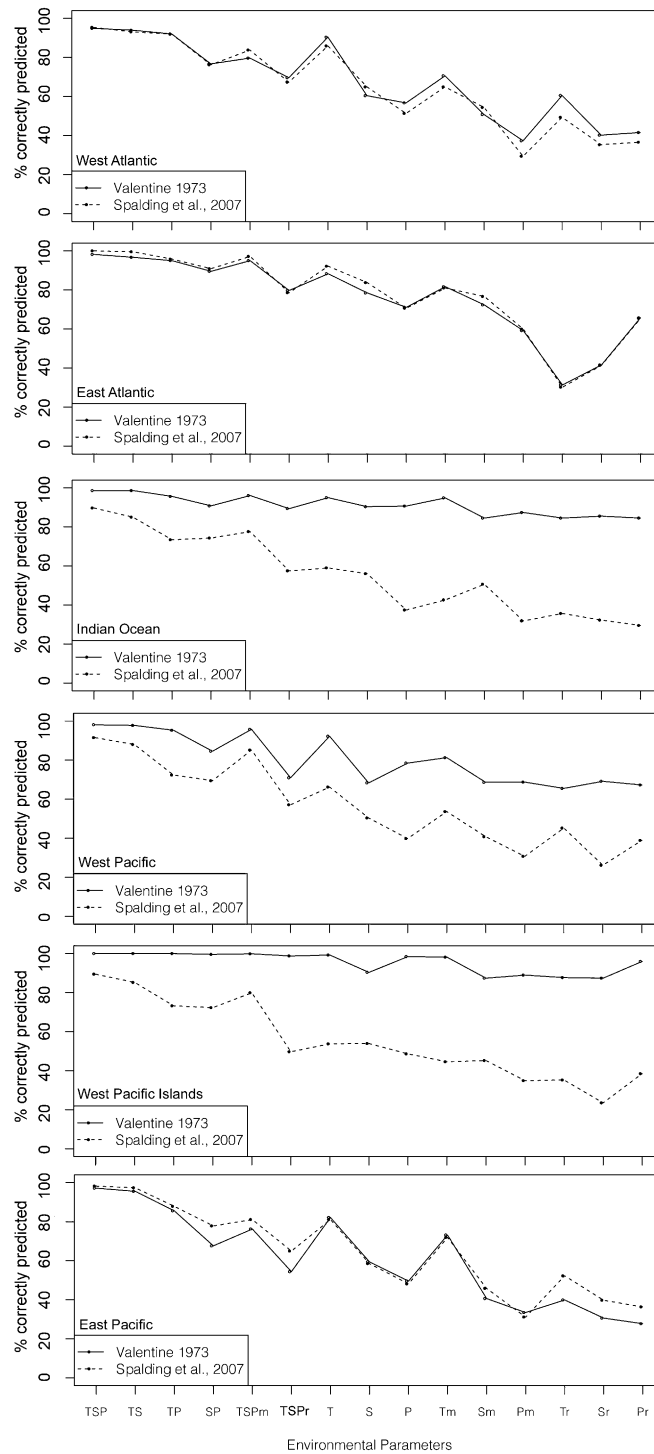**Fig. S1.** Map of coastline assignments used for analysis.

Fig. S2. Proportion of grid cells correctly predicted with nested multinomial logistic regressions where nested sets of oceanographic variables are used to predict biogeographic units membership at the coastline-scale for two biogeographic schemes. T, temperature; S, salinity; *P*, net primary productivity; m, mean annual values only; r, seasonal ranges only. Both mean annual values and seasonal ranges are used as predictors unless otherwise specified.

Table S1. Results from multinomial logistic regressions at the basin scale for combinations of temperature, salinity, and productivity

Region	Oceanographic variables	Spalding et al. (6)		Valentine (1)	
		AIC	% correct	AIC	% correct
Atlantic Basin	TSP	1574.2541	86.11	1554.5174	86.78
	TS	1919.0188	81.79	2019.5277	81.63
	TP	2310.6245	79.45	2077.5940	81.63
	SP	4028.2070	64.72	4119.2604	65.87
	Mean	2889.1195	74.19	2872.6364	72.32
	Range	5018.7010	55.20	5084.2548	56.56
	T	3253.0357	64.98	2995.8055	69.77
	S	5462.3780	44.80	5998.9693	47.92
	P	6853.6874	37.36	6642.2616	39.85
	Tm	4450.0939	58.06	4085.2605	61.19
	Sm	6520.2745	38.76	7195.8872	36.06
	Pm	8553.6308	20.71	8453.4566	20.92
	Tr	7274.3786	29.66	7183.0434	33.61
	Sr	8494.1120	18.31	8668.4117	22.89
	Pr	7897.0784	31.48	7886.0499	35.12
Pacific Basin	TSP	4950.5760	80.20	2874.1524	89.00
	TS	6827.1300	70.98	3233.8184	87.95
	TP	9671.5030	58.65	3453.5118	86.75
	SP	10274.8327	56.98	6522.6356	74.31
	Mean	8423.5462	63.40	4312.6558	82.70
	Range	14514.1439	38.74	8245.1403	65.90
	T	13370.2547	42.43	4096.7124	82.92
	S	15326.5947	35.46	8133.6998	67.95
	P	18190.9774	24.52	8470.1694	70.17
	Tm	16832.9861	26.74	5643.4275	75.76
	Sm	17668.5572	27.55	9607.9787	63.34
	Pm	21137.3089	18.11	10377.8202	65.40
	Tr	19529.4645	25.27	9779.9474	63.82
	Sr	22653.6593	12.36	9891.5673	65.40
	Pr	20505.8611	18.94	10009.5586	63.98

Unmodified abbreviations signify combined annual mean and seasonal range; m and r signify annual mean or seasonal range alone, respectively. TSP, temperature, salinity, and productivity; AIC, Akaike information criterion.

Table S2. Results from multinomial logistic regressions at the coastline scale for combinations of temperature, salinity, and productivity

Oceanographic variables	East Pacific % correct	East Pacific AIC	West Pacific Islands % correct	West Pacific Islands AIC	West Pacific % correct	West Pacific AIC	Indian Ocean % correct	Indian Ocean AIC	East Atlantic % correct	East Atlantic AIC	West Atlantic % correct	West Atlantic AIC
Spalding biogeographic scheme												
TSP	98.21	129.4221	89.41	543.0267	91.48	943.3720	89.66	802.3963	100.00	98.0001	95.40	369.4630
TS	97.32	136.0872	85.20	640.4002	87.99	1167.9600	84.93	1072.2375	99.54	96.5202	93.10	462.6210
TP	87.84	381.9150	73.21	1086.9563	72.37	2278.2423	73.38	1504.0063	95.79	278.4827	91.95	545.7276
SP	77.82	677.8696	72.27	1028.6839	69.48	2744.6094	74.26	1614.6819	90.89	624.7677	76.25	1648.8195
Mean	81.04	545.1232	79.91	746.0326	85.18	1304.6531	77.56	1287.4154	97.15	229.9975	83.81	1052.5928
Range	64.94	1118.6570	49.69	1725.3948	57.14	3606.1079	57.43	2328.2095	78.59	1241.1131	67.34	1888.1514
T	81.04	514.3560	53.74	1545.6950	66.20	2857.3405	58.97	2208.7251	92.14	379.2801	85.92	721.0794
S	58.50	1056.3590	53.89	1594.5792	50.37	4016.4624	56.00	2264.3980	83.71	927.0010	64.94	2288.6199
P	48.12	1369.7961	48.60	1800.8348	39.84	5434.0121	37.40	3502.4659	70.62	1649.2970	51.34	2725.8336
Tm	71.91	747.9727	44.55	1717.8045	53.66	3731.3913	42.57	3067.9530	80.98	815.0344	64.94	1576.4913
Sm	45.80	1542.1934	45.17	1858.2543	40.78	4727.7421	50.61	2726.5602	76.65	1246.1797	54.41	2915.8247
Pm	31.13	1836.2629	34.89	2283.5388	30.72	6598.5547	31.79	4017.9138	59.91	2238.9964	29.41	3742.7940
Tr	52.24	1464.1014	35.20	2312.7968	45.20	4758.8200	35.64	3567.7446	30.18	2223.1635	49.33	2571.8793
Sr	39.71	1804.2198	23.52	2760.9495	26.16	6546.0420	32.23	3869.2800	41.34	2447.5293	35.34	3505.6058
Pr	36.31	1788.3689	38.47	2222.9836	38.90	5986.0386	29.48	4064.4912	65.38	1987.9158	36.59	3399.5545
Valentine biogeographic scheme												
TSP	99.46	123.6955	100.00	56.0002	98.57	124.2388	98.12	206.1705	98.18	150.0794	94.92	418.0608
TS	97.67	156.0741	100.00	41.6876	98.57	122.2391	97.79	216.9852	96.70	193.7719	93.97	475.8171
TP	88.37	358.0478	100.00	42.4404	95.60	204.2373	95.31	427.4692	94.99	258.6252	92.05	533.4627
SP	71.56	820.9125	99.53	66.5420	90.76	479.0003	84.57	1307.2501	89.52	556.6310	76.72	1649.7534
Mean	82.11	507.9120	99.84	38.8196	96.04	219.8138	95.77	326.9835	94.99	276.5889	79.69	1101.2957
Range	55.81	1545.4198	98.75	84.4317	89.33	567.0904	70.96	2387.8227	79.73	1195.0348	69.64	1935.9592
T	85.15	412.0605	99.22	53.4258	94.94	241.0578	92.22	647.7484	88.27	486.5286	90.42	630.8623
S	60.47	1152.8282	90.34	427.3278	90.32	556.4764	68.34	2232.0852	78.47	992.0194	60.44	2687.8897
P	51.70	1506.1099	98.44	96.7516	90.65	654.2027	78.47	2353.1800	71.07	1606.9679	56.70	2514.8156
Tm	76.74	613.0932	98.13	84.3949	94.83	236.5041	81.29	1398.9948	81.66	868.9825	70.59	1341.4671
Sm	41.32	1704.7456	87.38	559.5594	84.49	1075.5462	68.61	2378.7077	72.32	1322.2342	50.77	3395.5260
Pm	33.81	1951.9892	88.94	448.6964	87.35	841.4309	68.75	3307.4376	59.11	2175.1007	37.36	3654.5939
Tr	43.29	1869.0942	87.69	523.6450	84.49	1050.2493	65.53	2865.7792	31.32	2210.9549	60.54	2455.8221
Sr	31.84	1915.1965	87.38	565.5770	85.48	761.2677	69.15	2986.9512	41.57	2462.5062	40.23	3676.5885
Pr	30.23	2005.7643	95.95	149.7016	84.49	1053.8006	67.27	3130.0102	65.72	1964.9854	41.57	3358.8725

Unmodified abbreviations signify combined annual mean and seasonal range; m and r signify annual mean or seasonal range alone, respectively. AIC, Akaike information criterion; TSP, temperature, salinity, and productivity.

Table S3. Percentage improvement in biogeographic units prediction accuracy by temperature, salinity, and productivity over the expectation by chance

Region	% correct by chance Spalding	% correct by chance Valentine	% correct using TSP Spalding	% correct using TSP Valentine	Improvement over chance Spalding	Improvement over chance Valentine
Atlantic Basin	10.49	11.80	86.11	86.78	75.62	74.98
East Atlantic	27.16	27.08	95.40	94.92	68.24	67.84
West Atlantic	16.29	20.96	100.00	98.18	83.71	77.22
Pacific Basin	4.05	44.04	80.20	89.00	76.15	44.96
Indian Ocean	9.46	72.22	89.66	98.57	80.20	26.35
West Pacific	12.25	49.72	91.48	98.12	79.23	48.40
West Pacific Islands	12.50	77.10	89.41	100.00	76.91	22.90
East Pacific	19.85	17.12	98.21	97.14	78.36	80.02

Table S4. Goodness-of-fit of the multinomial logistic regressions and the effect of temperature, salinity, and productivity on predicting biogeographic unit (BU) membership

Region	Likelihood-ratio statistic		McFadden's R^2		Maximum likelihood R^2		Maximum likelihood Craig and Uhler R^2	
	Spalding	Valentine	Spalding	Valentine	Spalding	Valentine	Spalding	Valentine
East Atlantic	3780.44	3544.67	0.93	0.92	0.97	0.97	0.99	0.99
West Atlantic	2651.00	2562.21	1.00	0.97	0.95	0.95	1.00	1.00
Indian Ocean	4100.06	1005.55	0.88	0.92	0.99	0.67	0.99	0.96
West Pacific	6473.60	3170.69	0.90	0.96	0.99	0.88	1.00	0.99
West Pacific Islands	2457.21	650.19	0.88	0.99	0.98	0.64	0.99	0.99
East Pacific	1976.99	2031.10	0.98	0.96	0.97	0.97	1.00	1.00

All likelihood-ratio statistics are significant ($P << 0.001$; χ^2 test, df = 6).

Table S5. Variance inflation factors (VIF) for the *z*-score–transformed oceanographic variables (temperature, salinity, and productivity) used as predictors in multinomial logistic regressions

Variable	Mean annual temperature	Seasonal range temperature	Mean annual salinity	Seasonal range salinity	Mean annual productivity	Seasonal range productivity
VIF	1.62	1.64	2.21	1.29	3.13	4.76

Table S6. χ^2 tests comparing the proportion of misclassified grid cells with respect to proximity to biogeographic unit (BU) boundaries and sea floor depth for the two biogeographic schemes

	Classified correctly	Misclassified	% correct	χ^2 statistic	P value
Spalding biogeographic scheme					
Proximity to BU boundary					
Within 1°	542	132	80.42		
Outside 1°	4,624	225	95.36	216.1219	$P << 0.001$
Within 2°	1,148	200	85.16		
Outside 2°	4,018	157	96.24	204.943	$P << 0.001$
Within 3°	1,732	251	87.34		
Outside 3°	3,434	106	97.01	194.7066	$P << 0.001$
Depth of sea floor					
Shallower than or equal to 20 m	1,932	100	95.08		
Deeper than 20 m	3,234	257	92.64	12.4347	$P < 0.001$
Shallower than or equal to 50 m	2,479	126	95.16		
Deeper than 50 m	2,687	231	92.08	21.0817	$P < 0.001$
Shallower than or equal to 100 m	2,886	150	95.06		
Deeper than 100 m	2,280	207	91.68	25.3152	$P < 0.001$
Valentine biogeographic scheme					
Proximity to BU boundary					
Within 1°	245	53	82.21		
Outside 1°	5,146	79	98.49	313.0876	$P << 0.001$
Within 2°	565	83	87.19		
Outside 2°	4,826	49	98.99	336.5482	$P << 0.001$
Within 3°	888	103	89.61		
Outside 3°	4,503	29	99.36	327.4437	$P << 0.001$
Depth of sea floor					
Shallower than or equal to 20 m	1,979	53	97.39		
Deeper than 20 m	3,412	79	97.74	0.5168	$P = 0.4722$
Shallower than or equal to 50 m	2,543	62	97.62		
Deeper than 50 m	2,848	70	97.60	0.0018	$P = 0.9662$
Shallower than or equal to 100 m	2,967	69	97.73		
Deeper than 100 m	2,424	63	97.47	0.2937	$P = 0.5879$

Three distance thresholds (1°, 2°, or 3°) are tested for the effect of grid-cell proximity to BU boundaries. Significant values indicate proportionally more misclassification in grid cells near BU boundaries. Three depth thresholds (20, 50, and 100 m) were tested for the effect of sea floor depth. Significant values indicate proportionally more misclassification in grid cells near BU boundaries. In the Valentine scheme, there is no significant difference in misclassification with depth.

Table S7. Results from multinomial logistic regressions at the coastline level for combinations of environmental variables

Region	West Atlantic AIC	% correct	East Atlantic AIC	% correct	Indian Ocean AIC	% correct	West Pacific AIC	% correct	West Pacific Islands AIC	% correct	East Pacific AIC	% correct
Spalding biogeographic scheme												
TSONP	210.0002	100.00	210.0002	100.00	480.0002	100.00	540.0034	100.00	360.0001	100.00	210.0001	100.00
TSON	182.0001	100.00	182.0002	100.00	416.0001	100.00	531.0357	98.80	312.0001	100.00	182.0001	100.00
TSO	188.2927	97.54	98.0002	100.00	549.6126	89.58	700.7716	89.08	492.8153	89.34	121.0844	97.79
TSN	154.0137	100.00	154.0001	100.00	425.1023	97.44	608.5806	96.40	356.7030	97.63	154.0002	100.00
TSP	173.5382	97.54	98.0001	100.00	429.0200	94.15	634.8296	92.47	502.8801	89.17	113.3298	98.74
TON	172.9079	99.57	154.0002	100.00	519.6652	94.15	922.8670	88.32	465.2104	96.45	154.0001	100.00
TOP	255.4465	96.09	99.6271	100.00	547.7375	89.76	1234.5580	74.56	929.7474	75.30	159.3552	96.21
TNP	173.1042	99.13	154.0001	100.00	382.8483	98.90	901.0330	89.08	285.3134	99.32	154.0000	100.00
TS	208.5642	95.95	70.0004	100.00	632.3840	86.84	791.8093	86.24	584.6978	84.77	111.1418	96.85
TO	352.0529	92.04	179.8994	95.95	919.5690	74.59	1586.8344	67.69	1274.0108	62.44	213.7364	91.48
TN	171.0120	98.70	126.0001	100.00	609.4069	88.85	1126.6378	84.17	529.6888	92.22	126.0002	100.00
TP	295.2918	93.92	154.4425	96.96	748.2859	78.43	1424.8349	71.62	1018.6807	72.59	162.3835	94.64
T	407.9318	89.44	208.2372	93.72	1225.0221	60.15	1849.5477	64.96	1450.2972	52.79	284.6784	82.65
S	1317.5382	70.04	530.1380	84.82	1290.8198	60.88	2482.2654	49.13	1406.7393	54.31	576.7219	61.20
N	841.2034	80.61	565.2425	84.82	1465.7977	64.17	1904.9076	67.90	1075.4100	73.94	223.7113	92.43
O	809.8129	79.74	256.3962	92.71	1598.1539	53.56	2099.6529	55.79	1607.7885	43.15	391.4764	73.82
P	1621.5088	62.52	953.9071	68.62	1880.2138	42.60	3388.4342	36.79	1634.2959	49.41	749.2408	50.47
Valentine biogeographic scheme												
TSONP	240.0002	100.00	150.0002	100.00	90.0002	100.00	180.0001	100.00	90.0002	100.00	210.0001	100.00
TSON	208.0002	100.00	130.0001	100.00	78.0002	100.00	156.0001	100.00	78.0001	100.00	182.0001	100.00
TSO	187.1492	97.83	129.1102	98.18	42.0002	100.00	85.7955	100.00	42.0002	100.00	104.4690	99.00
TSN	176.0001	100.00	110.0001	100.00	66.0001	100.00	132.0001	100.00	66.0002	100.00	154.0002	100.00
TSP	237.5460	96.67	102.3551	98.99	57.3841	99.63	125.9436	99.02	42.0002	100.00	98.0002	100.00
TON	176.0001	100.00	110.0001	100.00	86.3306	99.27	132.0002	100.00	66.0002	100.00	154.0002	100.00
TOP	184.5819	97.83	124.3652	97.77	82.1000	97.99	125.4996	99.34	42.0002	100.00	123.4235	98.00
TNP	176.0002	100.00	110.0002	100.00	66.0014	100.00	132.0002	100.00	66.0002	100.00	154.0001	100.00
TS	240.4446	95.66	122.8495	97.17	50.0358	99.27	132.7752	98.14	30.7640	100.00	105.0760	98.00
TO	241.0551	95.66	226.3560	92.51	86.0032	97.26	181.7345	97.93	30.0008	100.00	145.3042	93.00
TN	144.0001	100.00	135.6083	98.58	79.7823	98.72	125.3002	99.34	54.0001	100.00	126.0001	100.00
TP	239.1273	95.37	129.4160	96.36	86.7303	97.44	192.1835	97.16	31.5758	100.00	148.2403	96.00
T	373.0334	91.61	253.6596	89.68	122.8313	96.34	308.8324	93.89	47.4162	99.15	207.7020	87.00
S	1588.5481	64.40	558.5582	81.17	297.8086	91.22	1195.0286	76.53	351.1043	91.03	599.7627	64.00
O	680.0072	80.75	297.3890	89.88	121.2182	96.16	461.0094	90.72	55.3802	98.31	303.8774	82.00
N	672.2541	88.28	596.1660	80.57	235.7785	93.24	631.5262	90.17	253.0103	95.26	297.8504	89.00
P	1574.1922	63.10	915.3737	69.84	347.3264	91.41	1252.5992	82.31	44.6224	98.98	797.9237	60.00

Environmental variables include: temperature (T), salinity (S), dissolved oxygen concentration (O), nutrient concentrations (N, including phosphate, nitrate, and silicate), and net primary productivity (P). Both means and seasonal ranges are used for each variable. Percentage correct is the percent of grid cells classified into the correct biogeographic unit. AIC, Akaike information criterion.

Table S8. Mantel correlations between bivalve composition and mean annual values and seasonal ranges in temperature, salinity, and net primary productivity

Region	Pearson		Spearman	
	Mantel *r*	*P* value	Mantel *r*	*P* value
Jaccard dissimilarity				
Northwestern Atlantic	0.4001	0.001	0.5041	0.001
Southwestern Atlantic	0.4577	0.001	0.6502	0.001
Northeastern Atlantic	0.3852	0.001	0.4793	0.001
Southeastern Atlantic	0.4981	0.001	0.4982	0.001
Indian Ocean	0.2559	0.001	0.2864	0.001
Northwestern Pacific	0.432	0.001	0.564	0.001
Southwestern Pacific	0.4319	0.001	0.522	0.001
North West Pacific Islands	0.5622	0.001	0.5767	0.001
South West Pacific Islands	0.6765	0.001	0.7399	0.001
Northeastern Pacific	0.5523	0.001	0.6365	0.001
Southeastern Pacific	0.5491	0.001	0.5538	0.001
Simpson dissimilarity				
Northwestern Atlantic	0.3962	0.001	0.5347	0.001
Southwestern Atlantic	0.434	0.001	0.6645	0.001
Northeastern Atlantic	0.383	0.001	0.4898	0.001
Southeastern Atlantic	0.3141	0.001	0.354	0.001
Indian Ocean	0.3136	0.001	0.3484	0.001
Northwestern Pacific	0.3754	0.001	0.5632	0.001
Southwestern Pacific	0.4446	0.001	0.543	0.001
North West Pacific Islands	0.7651	0.001	0.703	0.001
South West Pacific Islands	0.6982	0.001	0.766	0.001
Northeastern Pacific	0.5165	0.001	0.6205	0.001
Southeastern Pacific	0.5348	0.001	0.5353	0.001

P values were estimated after 1,000 iterations.

Dataset S1. The 1° grid-cell identifiers and environmental data

Dataset S1

Dataset S2. Jaccard-distance matrix of bivalve assemblage data at the 1° grid-cell resolution for the Atlantic Basin

Dataset S2

Dataset S3. Simpson-distance matrix of bivalve assemblage data at the 1° grid-cell resolution for the Atlantic Basin

Dataset S3

Dataset S4. Jaccard-distance matrix of bivalve assemblage data at the 1° grid-cell resolution for the Pacific Basin

Dataset S4

Dataset S5. Simpson-distance matrix bivalve assemblage data at the 1° grid-cell resolution for the Pacific Basin

Dataset S5