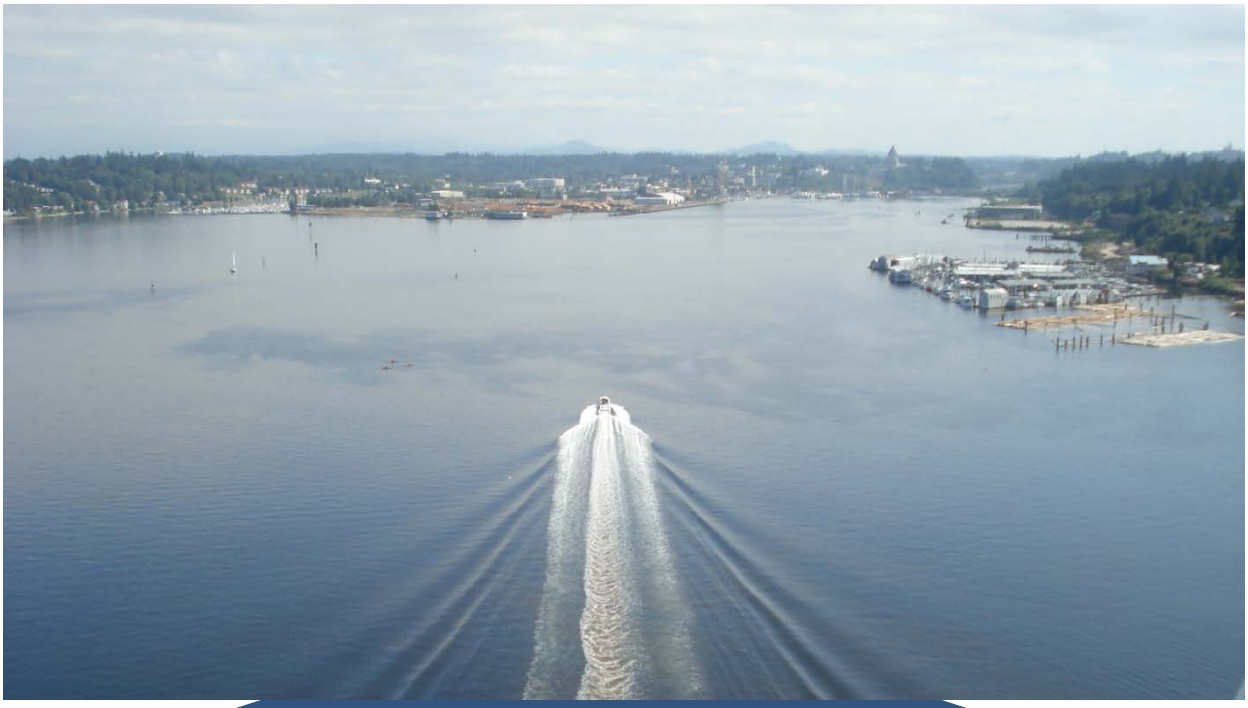
2011 Budd Inlet Marine Sediment Monitoring



Infaunal Community Data Summary

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Results and Statistical Summaries

Benthic infaunal results for the 2011 Budd Inlet survey.

Benthic infaunal species identified in the 2011 Budd Inlet survey.

Statistical Summaries of 9 Benthic Indices

Benthic infaunal indices calculated to characterize the infaunal invertebrate assemblages identified for the 2011 Budd Inlet survey.

Infaunal index	Definition	Calculation
Total Abundance	A measure of density equal to the total number of organisms per sample area	Sum of all organisms counted in each sample
Major Taxa Abundance (5 groups)	A measure of density equal to the total number of organisms in each major taxa group (Annelida, Mollusca, Echinodermata, Arthropoda, Miscellaneous Taxa) per sample area	Sum of all organisms counted in each major taxa group per sample
Taxa Richness	Total number of taxa (taxa = lowest level of identification for each organism) per sample area	Sum of all taxa identified in each sample
Pielou's Evenness (J') (Pielou, 1966, 1974)	Relates the observed diversity in benthic assemblages as a proportion of the maximum possible diversity for the data set (the equitability (evenness) of the distribution of individuals among species)	$J' = H'/\log S$, where $H' = -\sum_{i=1}^{S} p_i \log p_i$, where p_i = the proportion of the assemblage that belongs to the ith species ($p_i = n_i/N$, where n_i=the number of individuals in the ith species and N= total number of individuals) and S = the total number of species (H' is the Shannon-Wiener diversity index)
Swartz Dominance Index (SDI) (Swartz et al., 1985)	The minimum number of taxa whose combined abundance accounted for 75 percent of the total abundance in each sample	Sum of the minimum number of taxa whose combined abundance accounted for 75 percent of the total abundance in each sample

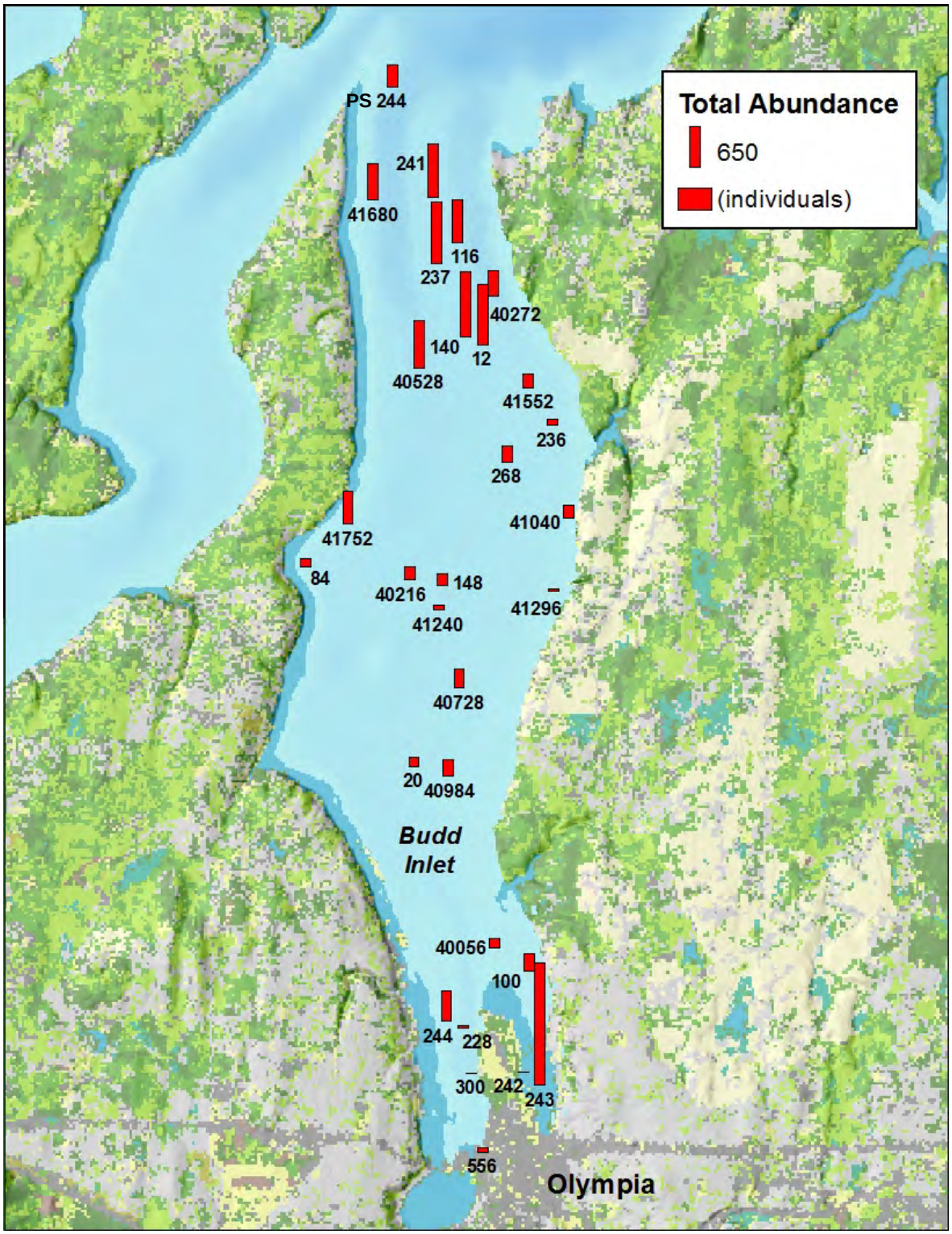
Total abundance, major taxa abundance, and major taxa percent abundance calculated for the 2011 Budd Inlet survey.

Station	Total abundance	Annelida	Annelida % of total abundance	Arthropoda	Arthropoda % of total abundance	Echino-dermata	Echinodermata % of total abundance	Mollusca	Mollusca % of total abundance	Misc. taxa	Misc. taxa % of total abundance
PSUW012	948	364	38.4	182	19.2	364	38.4	34	3.6	4	0.4
PSUW020	148	112	75.7	28	18.9	0	0.0	6	4.1	2	1.4
PSUW084	129	71	55.0	13	10.1	0	0.0	45	34.9	0	0.0
PSUW100	282	199	70.6	32	11.3	15	5.3	23	8.2	13	4.6
PSUW116	687	133	19.4	197	28.7	305	44.4	11	1.6	41	6.0
PSUW140	1021	191	18.7	257	25.2	568	55.6	0	0.0	5	0.5
PSUW148	187	132	70.6	22	11.8	25	13.4	6	3.2	2	1.1
PSUW228	42	33	78.6	3	7.1	0	0.0	0	0.0	6	14.3
UWNO236	102	51	50.0	18	17.6	1	1.0	32	31.4	0	0.0
UWNO237	979	232	23.7	225	23.0	512	52.3	5	0.5	5	0.5
UWNO241	857	240	28.0	185	21.6	415	48.4	3	0.4	14	1.6
UWNO242	3	0	0.0	1	33.3	0	0.0	2	66.7	0	0.0
UWNO243	1953	1643	84.1	25	1.3	0	0.0	274	14.0	11	0.6
PSUW244	336	211	62.8	40	11.9	2	0.6	68	20.2	15	4.5
UWNO244	474	413	87.1	34	7.2	1	0.2	21	4.4	5	1.1
PSUW268	267	116	43.4	54	20.2	86	32.2	9	3.4	2	0.7
PSUW300	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
PSUW556	81	43	53.1	14	17.3	0	0.0	17	21.0	7	8.6
UW40056	141	113	80.1	7	5.0	4	2.8	14	9.9	3	2.1
UW40216	207	183	88.4	5	2.4	2	1.0	15	7.2	2	1.0
UW40272	402	68	16.9	245	60.9	71	17.7	13	3.2	5	1.2
UW40528	762	252	33.1	190	24.9	298	39.1	8	1.0	14	1.8

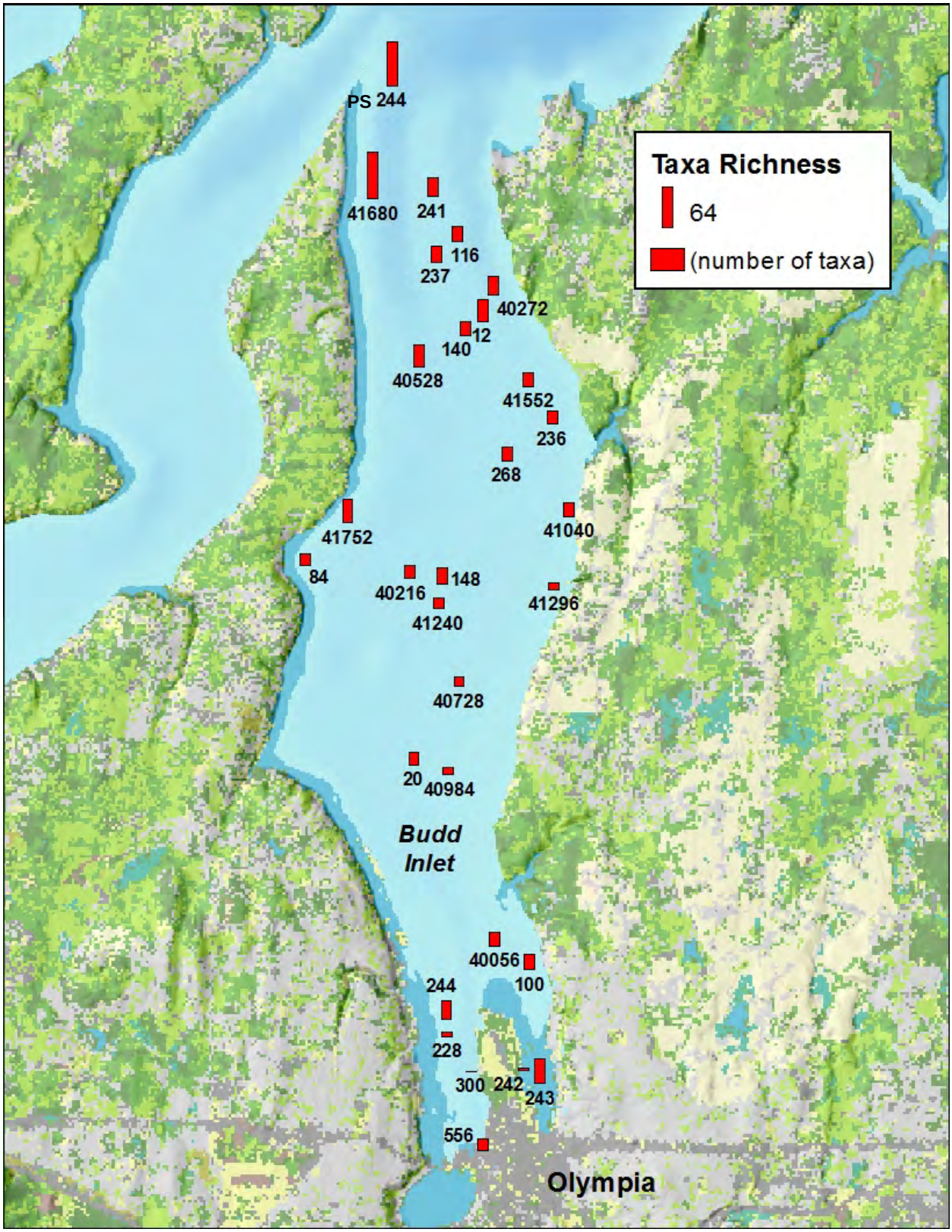
Station	Total abundance	Annelida	Annelida % of total abundance	Arthropoda	Arthropoda % of total abundance	Echino-dermata	Echinodermata % of total abundance	Mollusca	Mollusca % of total abundance	Misc. taxa	Misc. taxa % of total abundance
UW40728	308	279	90.6	14	4.5	0	0.0	15	4.9	0	0.0
UW40984	262	249	95.0	11	4.2	0	0.0	0	0.0	2	0.8
UW41040	204	96	47.1	66	32.4	0	0.0	38	18.6	4	2.0
UW41240	80	59	73.8	0	0.0	0	0.0	17	21.3	4	5.0
UW41296	32	15	46.9	4	12.5	0	0.0	8	25.0	5	15.6
UW41552	222	38	17.1	155	69.8	0	0.0	28	12.6	1	0.5
UW41680	577	366	63.4	34	5.9	96	16.6	63	10.9	18	3.1
UW41752	520	244	46.9	136	26.2	113	21.7	14	2.7	13	2.5
Mean	407.1	204.9	52.0	73.2	17.8	95.9	13.0	26.3	11.2	6.8	2.7
Median	264.5	132.5	51.5	30	14.9	1.5	0.8	14	4.7	4.5	1.2
Min	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Max	1953	1643	95.0	257	69.8	568	55.6	274	66.7	41	15.6
Range	1953	1643	95.0	257	69.8	568	55.6	274	66.7	41	15.6

Total abundance, taxa richness, Pielou's evenness, and Swartz Dominance Index calculated for the 2011 Budd Inlet survey.

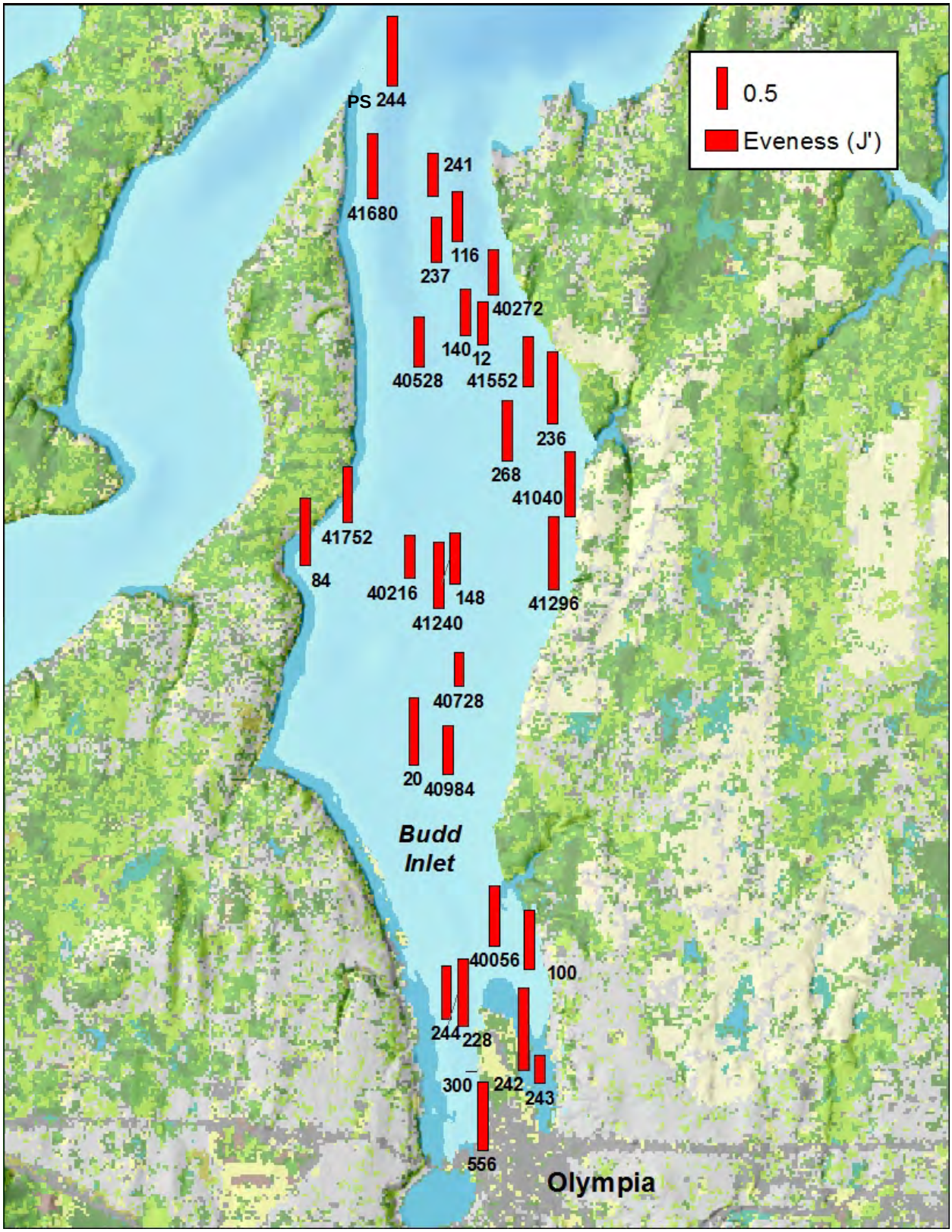
Station	Total abundance	Taxa richness	Pielou's evenness (J')	Swartz Dominance Index
PSUW012	948	35	0.52	3
PSUW020	148	19	0.81	7
PSUW084	129	18	0.82	7
PSUW100	282	25	0.73	6
PSUW116	687	23	0.61	4
PSUW140	1021	21	0.55	3
PSUW148	187	25	0.62	4
PSUW228	42	7	0.83	3
UWNO236	102	21	0.88	9
UWNO237	979	25	0.55	3
UWNO241	857	30	0.53	3
UWNO242	3	3	1.00	3
UWNO243	1953	39	0.34	2
PSUW244	336	69	0.85	20
UWNO244	474	28	0.65	6
PSUW268	267	22	0.73	5
PSUW300	0	0		
PSUW556	81	18	0.84	7
UW40056	141	22	0.73	6
UW40216	207	21	0.53	3
UW40272	402	29	0.54	4
UW40528	762	34	0.60	4
UW40728	308	16	0.42	2
UW40984	262	12	0.60	3
UW41040	204	22	0.80	6
UW41240	80	17	0.81	6
UW41296	32	11	0.89	5
UW41552	222	22	0.60	4
UW41680	577	72	0.80	17
UW41752	520	36	0.69	7
Mean	407.1	24.7	0.7	5.6
Median	264.5	22.0	0.7	4.0
Min	0.0	0.0	0.3	2.0
Max	1953.0	72.0	1.0	20.0
Range	1953.0	72.0	0.7	18.0



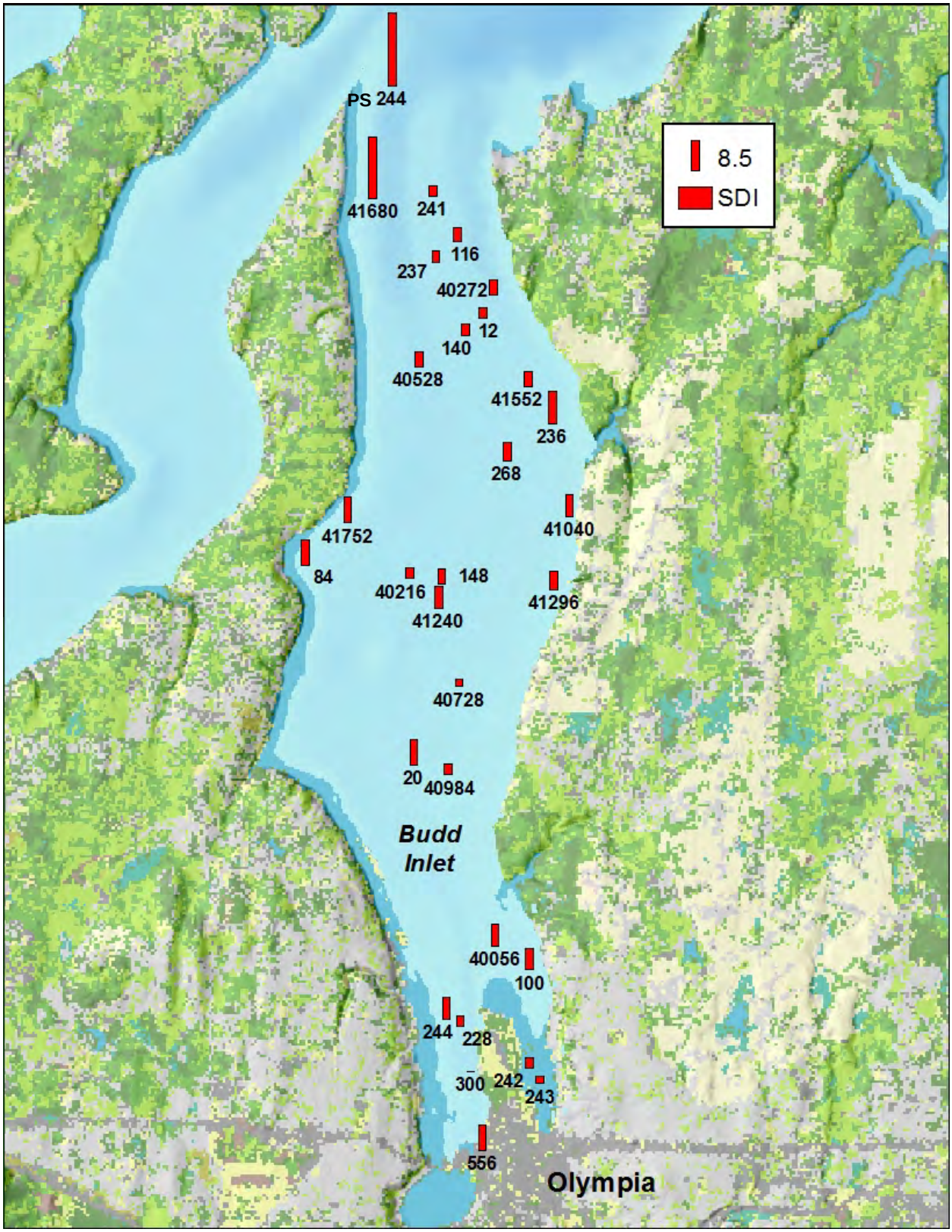
Spatial patterns in total benthic invertebrate abundance in the 2011 Budd Inlet survey. *The numbers on the map are the station identifications.*



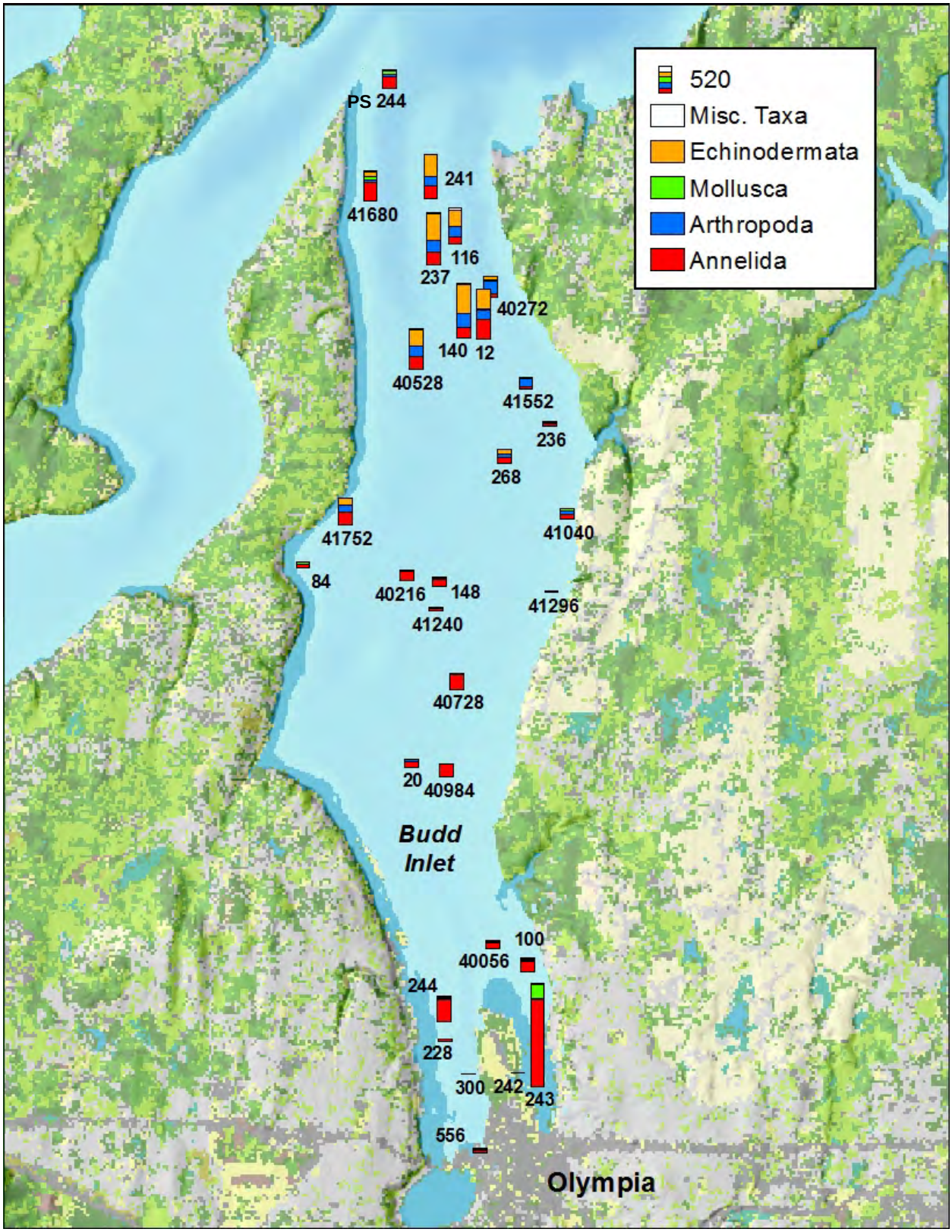
Spatial patterns in taxa richness in the 2011 Budd Inlet survey.
The numbers on the map are the station identifications.



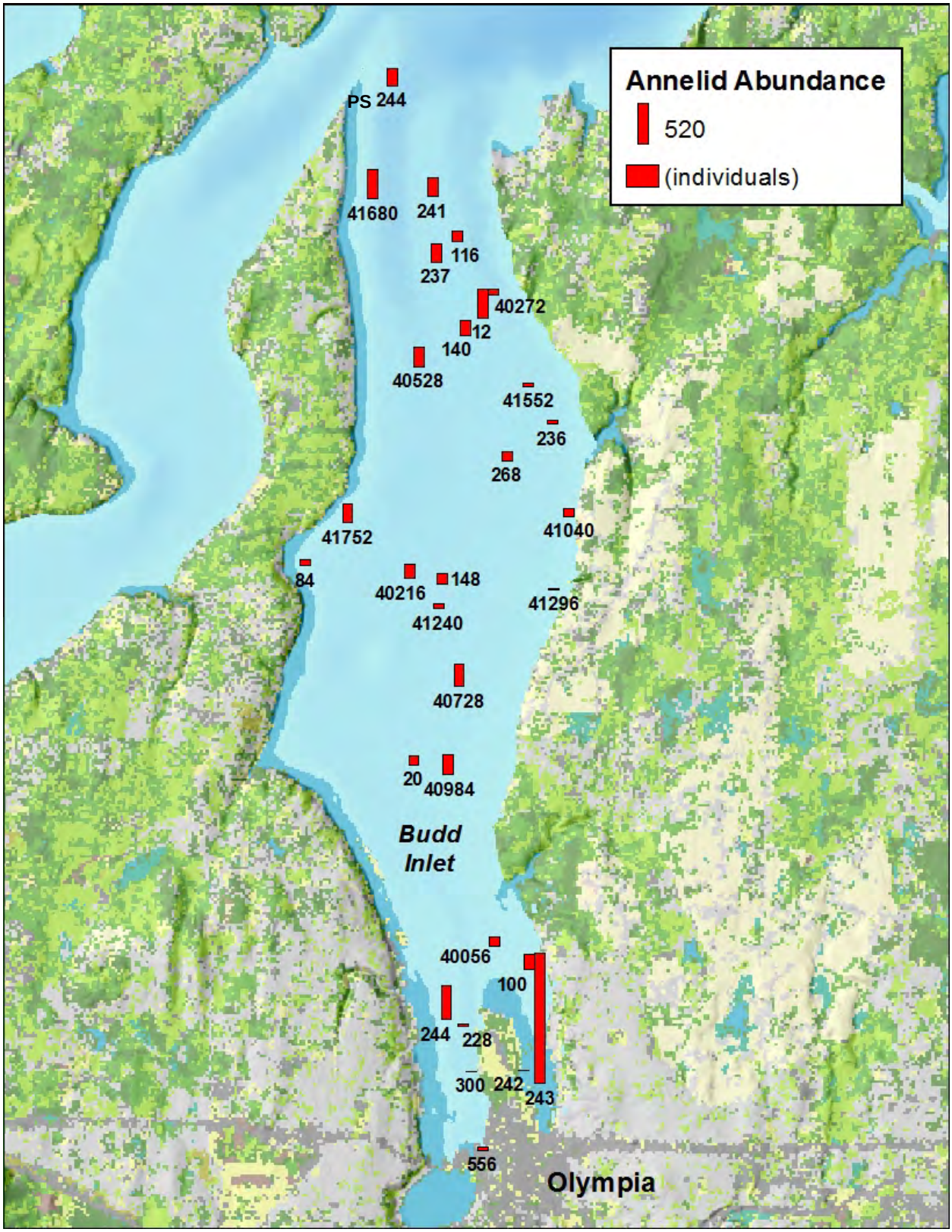
Spatial patterns in Pielou's Evenness (J') in the 2011 Budd Inlet survey.
The numbers on the map are the station identifications.



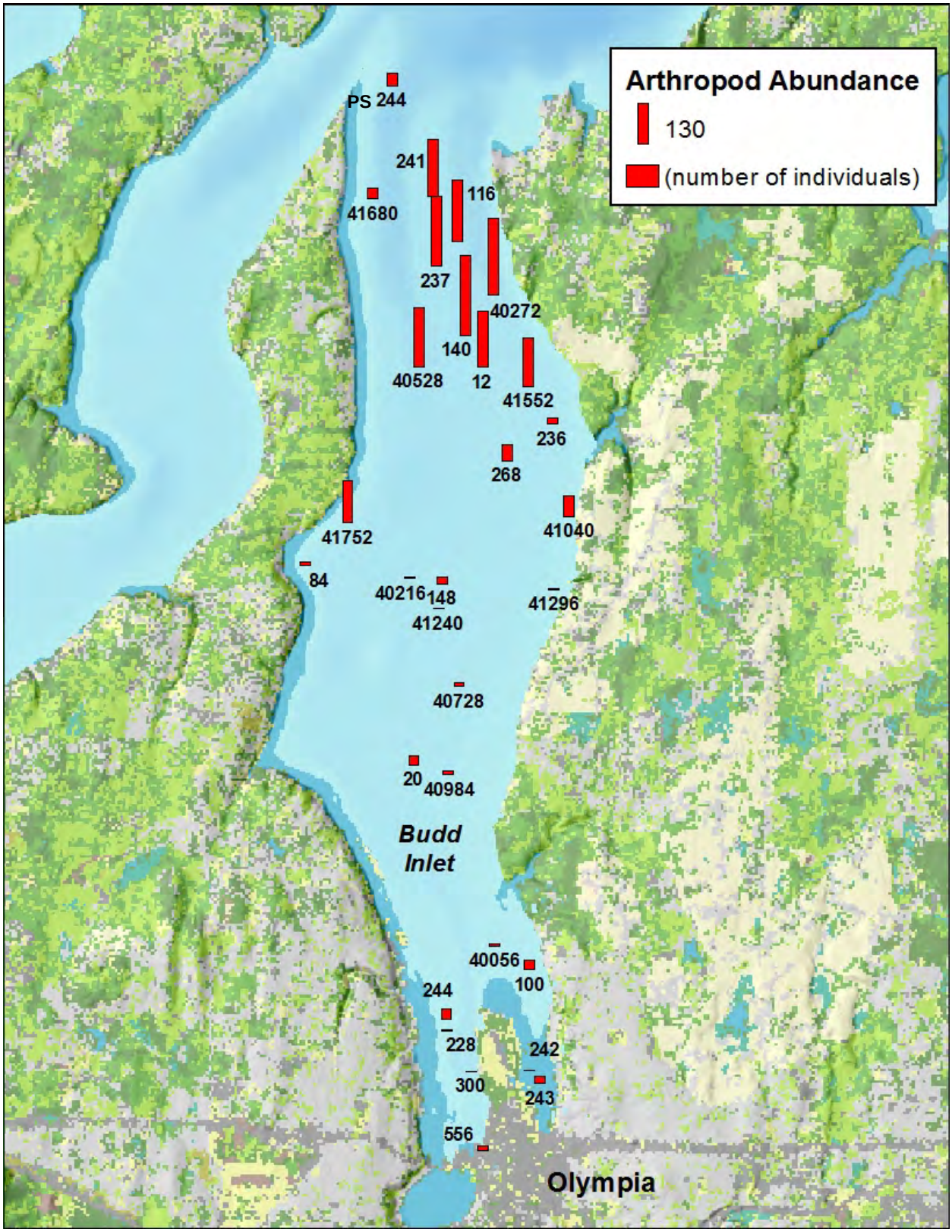
Spatial patterns in Swartz Dominance Index in the 2011 Budd Inlet survey.
The numbers on the map are the station identifications.



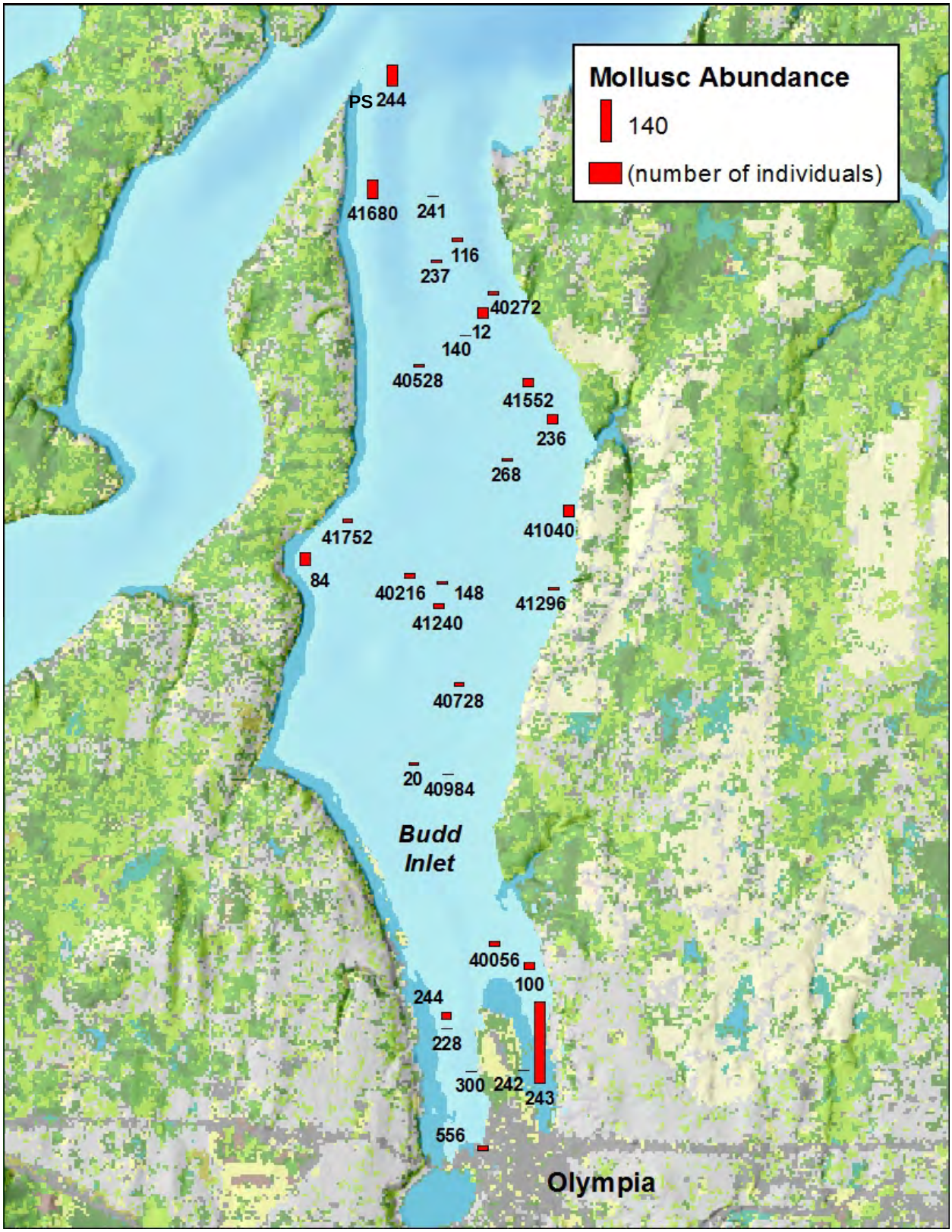
Spatial patterns in major taxa relative abundance (percent) in the 2011 Budd Inlet survey. *The numbers on the map are the station identifications.*



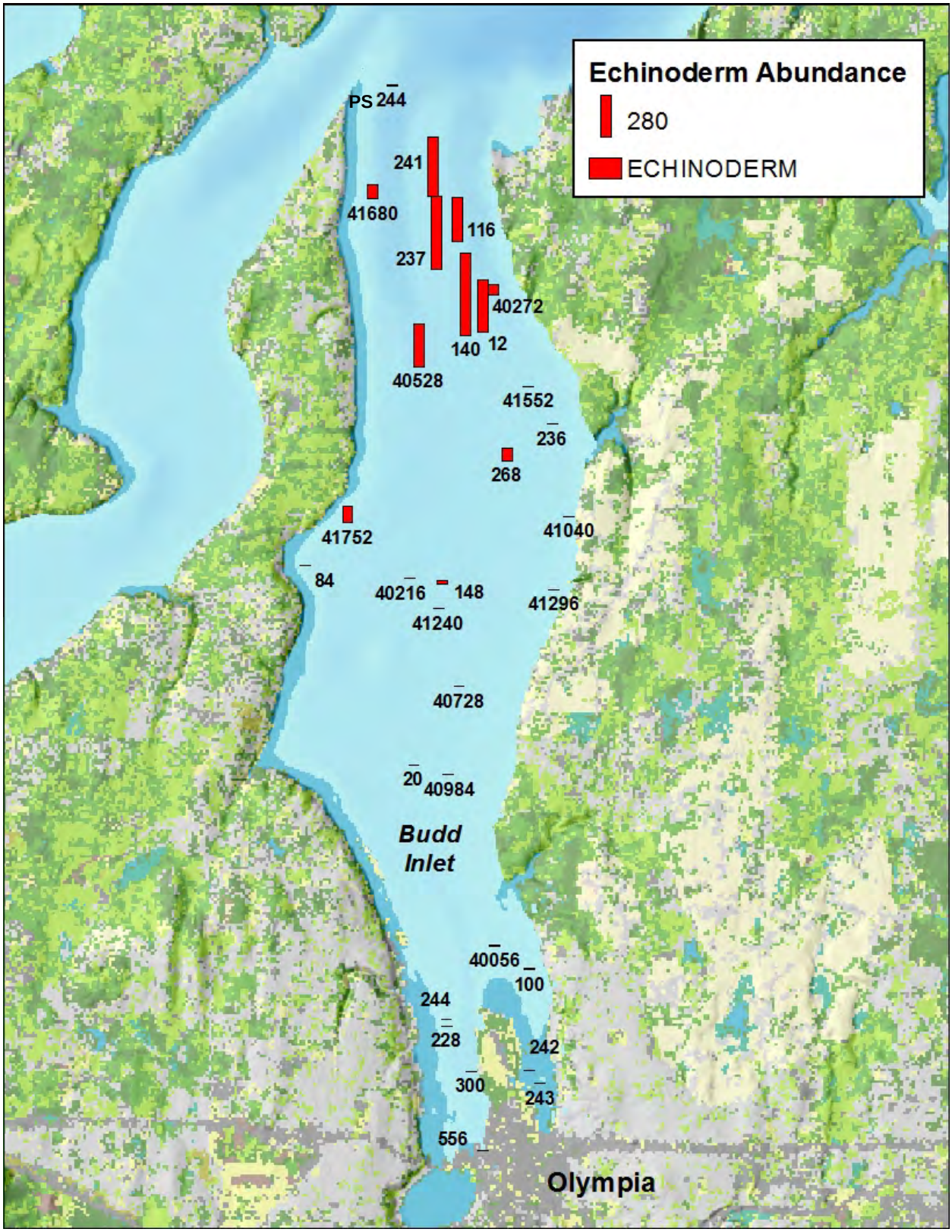
Spatial patterns in annelid abundance in the 2011 Budd Inlet survey.
The numbers on the map are the station identifications.



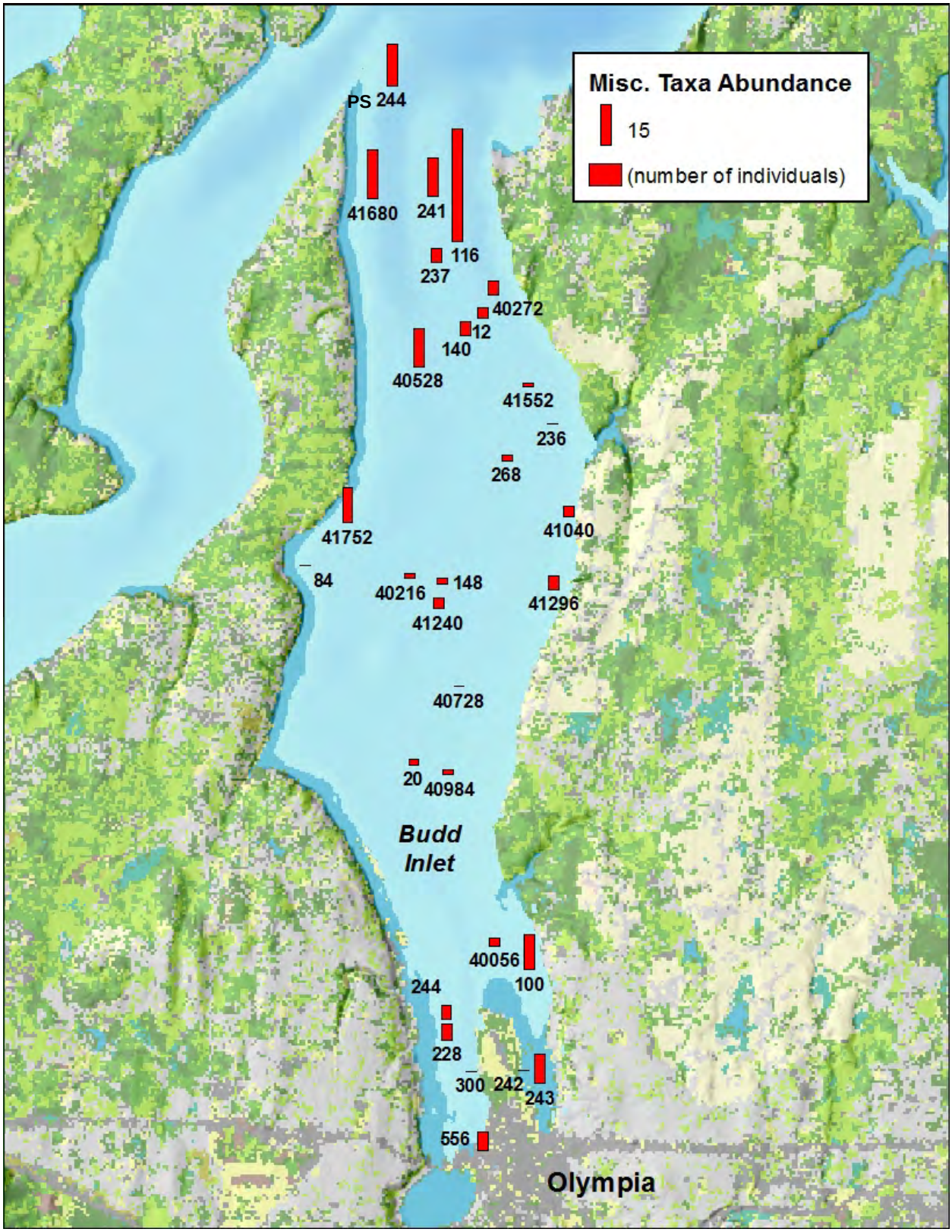
Spatial patterns in arthropod abundance in the 2011 Budd Inlet survey.
The numbers on the map are the station identifications.



Spatial patterns in mollusc abundance in the 2011 Budd Inlet survey.
The numbers on the map are the station identifications.



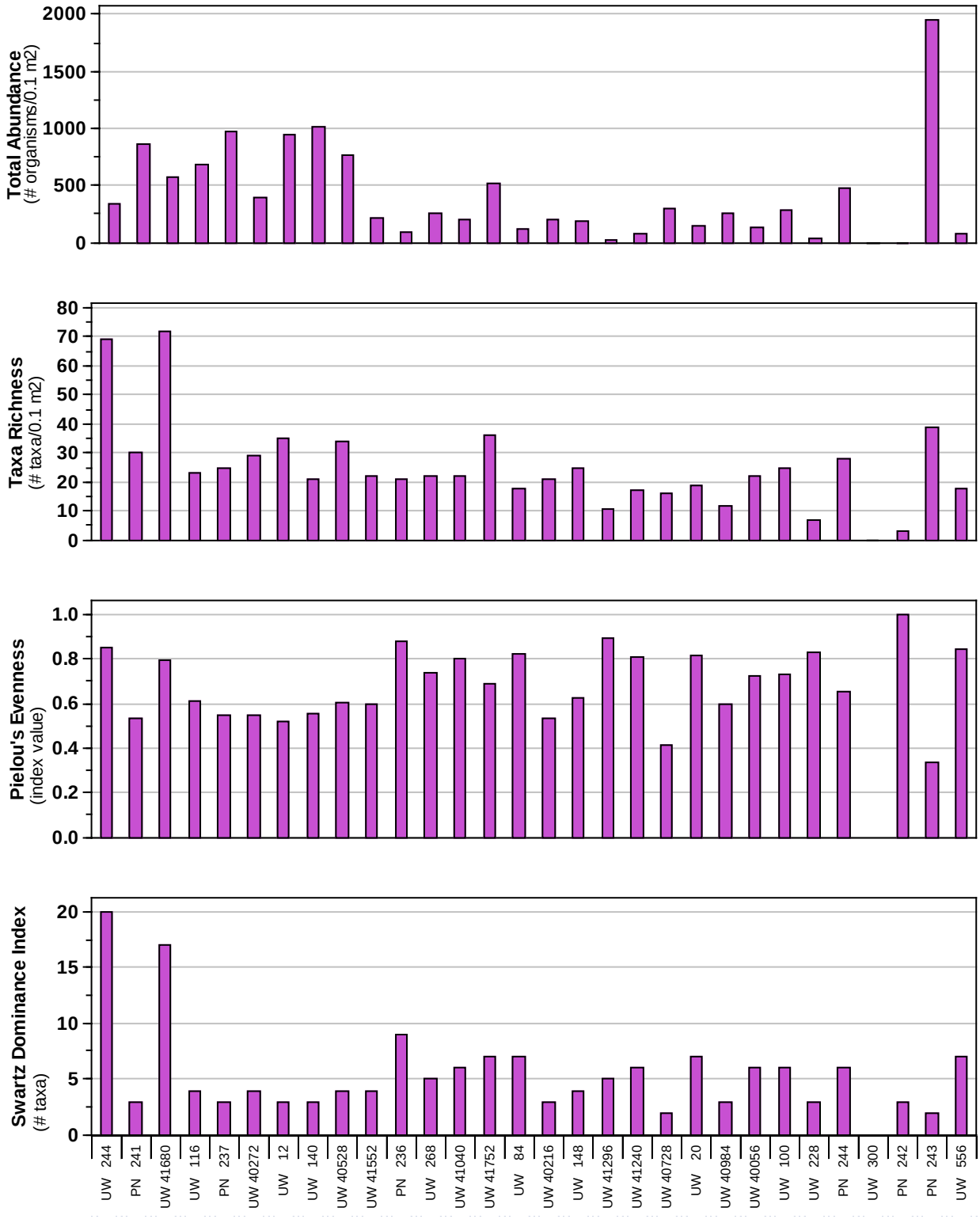
Spatial patterns in echinoderm abundance in the 2011 Budd Inlet survey.
The numbers on the map are the station identifications.

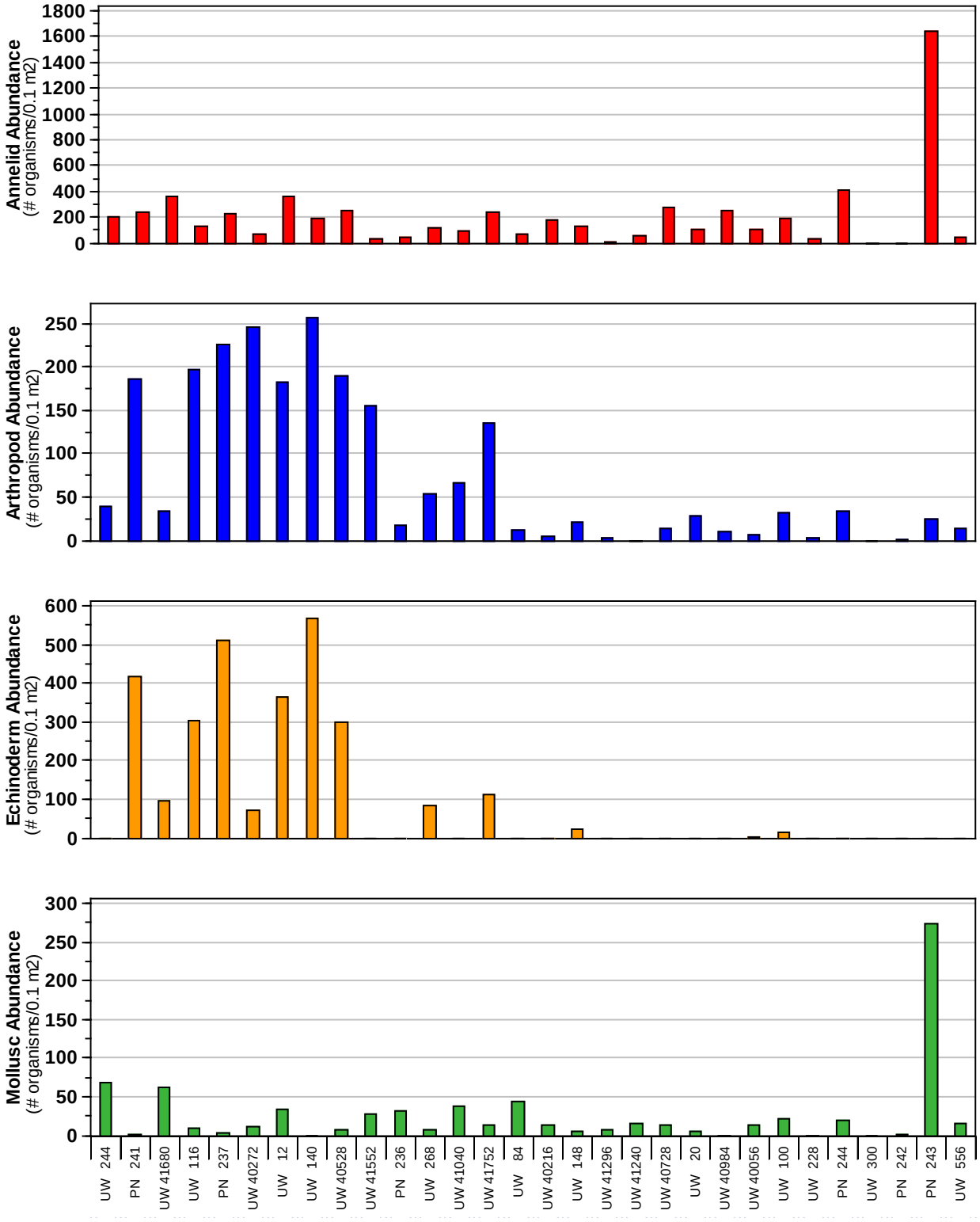


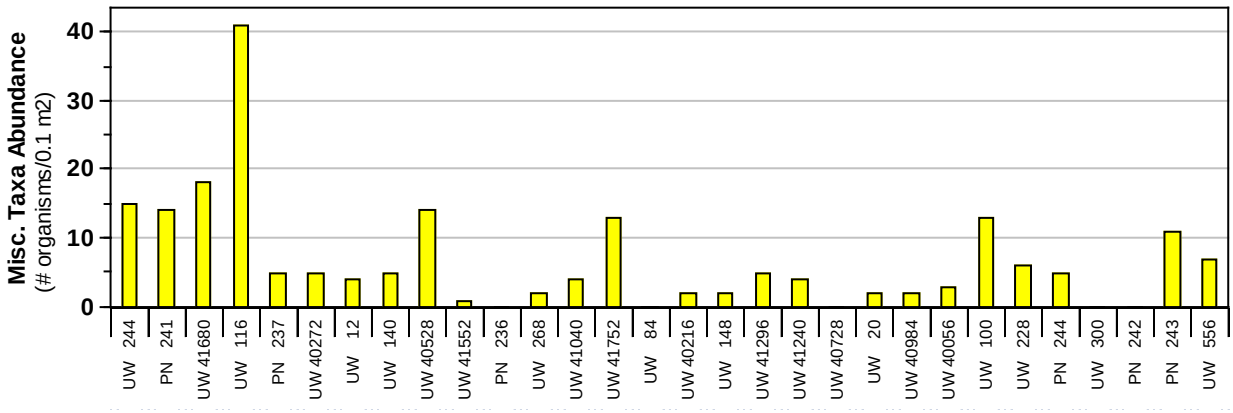
Spatial patterns in miscellaneous taxa abundance in the 2011 Budd Inlet survey.

The numbers on the map are the station identifications.

Benthic invertebrate measures calculated for sediment samples collected in the 2011 Budd Inlet survey.




Annelid Abundance
(# organisms/0.1 m2)
1800
1600
1400
1200
1000
800
600
400
200
0
Arthropod Abundance
(# organisms/0.1 m2)
250
200
150
100
50
0
Echinoderm Abundance
(# organisms/0.1 m2)
600
500
400
300
200
100
0
Mollusc Abundance
(# organisms/0.1 m2)
300
250
200
150
100
50
0
UW 244
PN 241
UW 41680
UW 116
PN 237
UW 40272
UW 12
UW 140
UW 40528
UW 41552
PN 236
UW 268
UW 41040
UW 41752
UW 84
UW 40216
UW 148
UW 41296
UW 41240
UW 40728
UW 20
UW 40984
UW 40056
UW 100
UW 228
PN 244
UW 300
PN 242
PN 243
UW 556


Misc. Taxa Abundance
(# organisms/0.1 m2)
40
30
20
10
0
UW 244
PN 241
UW 41680
UW 116
PN 237
UW 40272
UW 12
UW 140
UW 40528
UW 41552
PN 236
UW 268
UW 41040
UW 41752
UW 84
UW 40216
UW 148
UW 41296
UW 41240
UW 40728
UW 20
UW 40984
UW 40056
UW 100
UW 228
PN 244
UW 300
PN 242
PN 243
UW 556

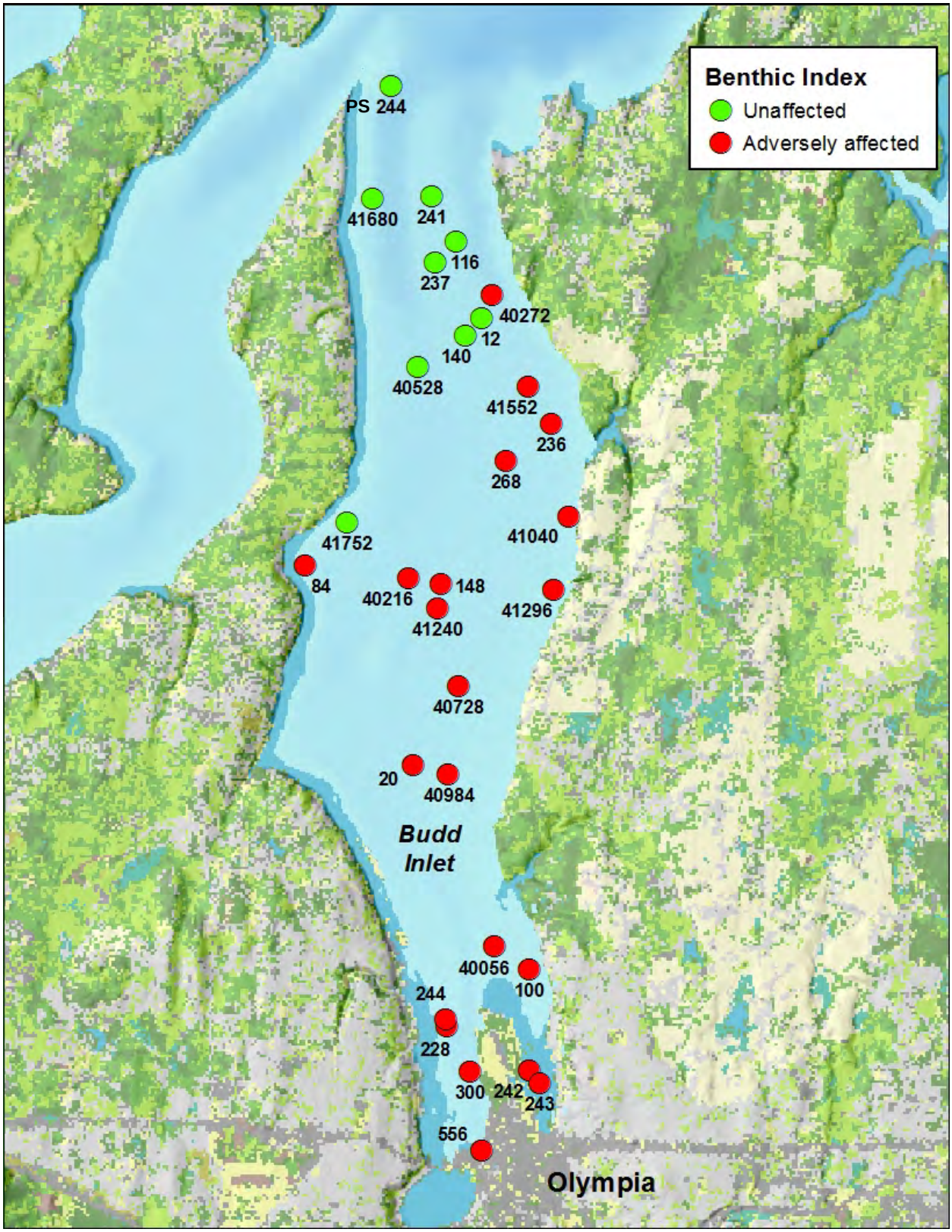
Adversely Affected Benthic Communities

Samples from the 2011 Budd Inlet survey with adversely affected benthos and associated station weights. Each station represents 0.58 km^2 with a total study area of 17.35 km^2.

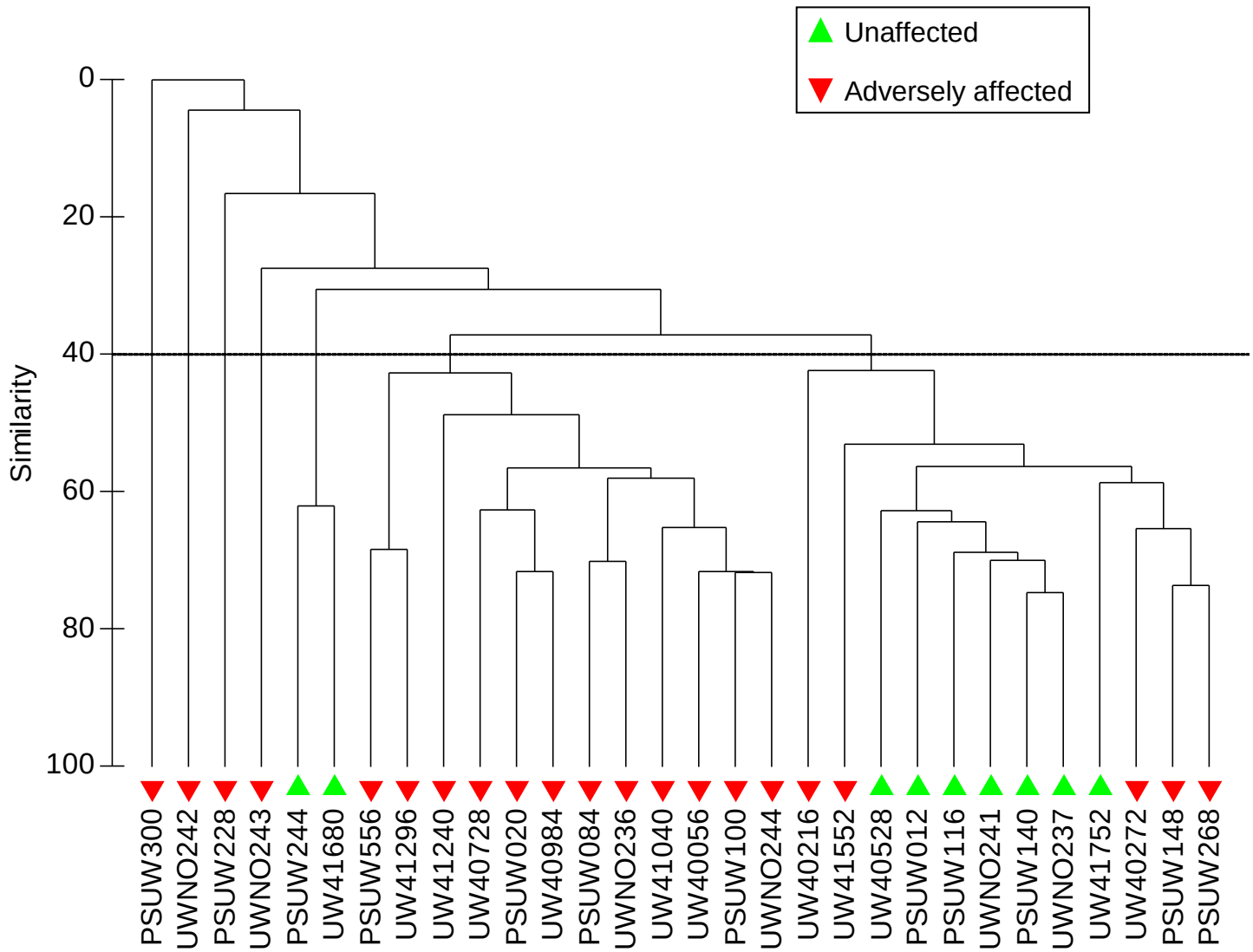
Sample	Location	km^2
PSUW020	Budd Inlet	0.58
PSUW084	Budd Inlet	0.58
PSUW100	Budd Inlet	0.58
PSUW148	Budd Inlet	0.58
PSUW228	Budd Inlet	0.58
UWNO236	Budd Inlet	0.58
UWNO242	Budd Inlet	0.58
UWNO243	Budd Inlet	0.58
UWNO244	Port of Olympia	0.58
PSUW268	Budd Inlet	0.58
PSUW300	Budd Inlet	0.58
PSUW556	Budd Inlet	0.58
UW40056	Budd Inlet	0.58
UW40216	Budd Inlet	0.58
UW40272	Budd Inlet	0.58
UW40728	Budd Inlet	0.58
UW40984	Budd Inlet	0.58
UW41040	Budd Inlet	0.58
UW41240	Budd Inlet	0.58
UW41296	Budd Inlet	0.58
UW41552	Budd Inlet	0.58
	Total	12.18

Mean and median benthic indices at stations with adversely affected and unaffected benthos in the 2011 Budd Inlet survey.

Benthic index	Adversely affected benthos		Unaffected benthos	
	Mean	Median	Mean	Median
Number of stations	21		9	
Total abundance (# orgs/0.1 m^2)	263	187	743	762
Taxa richness (# taxa/0.1 m^2)	19	21	38	34
Pielou's Evenness (J')	0.71	0.73	0.63	0.60
Swartz' Dominance Index (# taxa)	5	5	7	4
Annelid abundance	186	96	248	240
Arthropod abundance	36	14	161	185
Mollusc abundance	28	15	23	11
Echinoderm abundance	10	0	297	305
Abundance of miscellaneous taxa	4	2	14	14

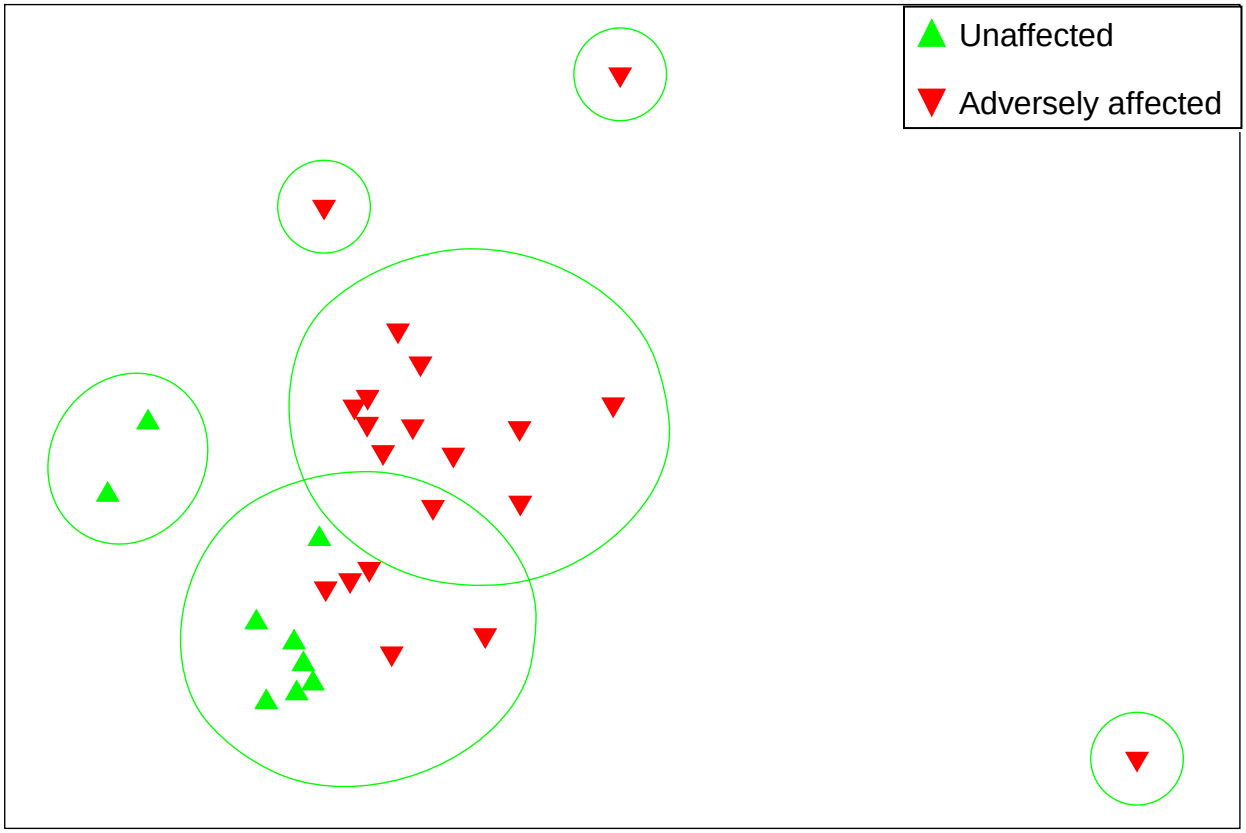


Spatial patterns in adversely affected benthic invertebrate assemblages in the 2011 Budd Inlet survey. *The numbers on the map are the station identifications.*



Cluster dendrogram of benthic invertebrate assemblages in the 2011 Budd Inlet survey, indicating adversely affected and unaffected assemblages (Bray-Curtis similarities of 4th-root-transformed abundances, all species). The dendrogram is sliced at 40% similarity.

Station PSUW300 had no macrobenthos (i.e., benthic invertebrates large enough to be found with a 1-mm mesh sieve).



Nonmetric multidimensional scaling (MDS) diagram indicating relative similarities of adversely affected and unaffected benthic invertebrate assemblages in the 2011 Budd Inlet Urban Waters sediment survey (Bray-Curtis similarities of 4th-root-transformed abundances, all species; 2D stress=0.13). The ellipses indicate assemblages with 40% or greater similarity, from the cluster dendrogram in the previous figure. The closer the symbols are in the diagram, the more similar their assemblages are.

Station PSUW300, which had no macrobenthos, is not shown in this MDS diagram.

Comparison to the Region

Incidence and spatial extent of adversely affected benthos for the urban embayment, the region it is nested in and all of Puget Sound.

Monitoring Region	Year(s) sampled	Numbers of Samples	Percent of Stations with Adversely Affected Benthos	Percent of Area with Adversely Affected Benthos
Budd Inlet	2011	30	70.0	70.0
South Sound	1999	42	42.9	38.2
	2011	55	44.5	33.8
All of Puget Sound	1997-2003	381	39.4	34.5

Data Quality Control Narrative

Infauna sediment sample sorting quality assurance and quality control for the 2011 Budd Inlet survey.

StationID	Sample Date	Sorted by	QA/QC Sorter	QA/QC Percent sorted	QA/QC Pass/Fail
PSUW012	6/3/2011	S. Weeks	S. Weakland	100%	Fail/Resort
PSUW020	6/2/2011	S. Weeks	S. Weakland	25%	Pass
PSUW084	6/2/2011	S. Weeks	S. Weakland	25%	Pass
PSUW100	6/7/2011	S. Weeks	S. Weakland	25%	Pass
PSUW116	6/21/2011	S. Weeks	S. Weakland	100%	Fail/Resort
PSUW140	6/3/2011	S. Weeks	S. Weakland	25%	Pass
PSUW148	6/7/2011	S. Weeks	S. Weakland	100%	Fail/Resort
PSUW228	6/2/2011	S. Weeks	S. Weakland	25%	Pass
PSUW244	6/21/2011	S. Weeks	S. Weakland	100%	Fail/Resort
PSUW268	6/3/2011	S. Weeks	S. Weakland	25%	Pass
PSUW300	6/1/2011	S. Weeks	S. Weakland	25%	Pass
PSUW556	6/7/2011	S. Weeks	S. Weakland	25%	Pass
UW40056	6/6/2011	S. Weeks	S. Weakland	25%	Pass
UW40216	6/2/2011	S. Weeks	S. Weakland	25%	Pass
UW40272	6/6/2011	S. Weeks	S. Weakland	100%	Fail/Resort
UW40528	6/1/2011	S. Weeks	S. Weakland	100%	Fail/Resort
UW40728	6/3/2011	S. Weeks	S. Weakland	25%	Pass
UW40984	6/6/2011	S. Weeks	S. Weakland	25%	Pass
UW41040	6/3/2011	S. Weeks	S. Weakland	25%	Pass
UW41240	6/6/2011	S. Weeks	S. Weakland	25%	Pass
UW41296	6/3/2011	S. Weeks	S. Weakland	25%	Pass
UW41552	6/1/2011	S. Weeks	S. Weakland	25%	Pass
UW41680	6/6/2011	S. Weeks	S. Weakland	25%	Pass
UW41752	6/6/2011	S. Weeks	S. Weakland	25%	Pass
UWNO236	6/1/2011	S. Weeks	S. Weakland	25%	Pass
UWNO237	6/7/2011	S. Weeks	S. Weakland	25%	Pass
UWNO241	6/7/2011	S. Weeks	S. Weakland	25%	Pass
UWNO242	6/1/2011	S. Weeks	S. Weakland	25%	Pass
UWNO243	6/2/2011	S. Weeks	S. Weakland	100%	Fail/Resort
UWNO244	6/2/2011	S. Weeks	S. Weakland	25%	Pass

Infauna sediment sample taxonomy quality assurance and quality control for the 2011 Budd Inlet survey.

	Crustacea	Misc. Taxa	Echinodermata	Annelida	Mollusca
Primary Taxonomist	Jeffery Cordell	Steven Hulsman	Steven Hulsman	Gene Ruff	Susan Weeks
QA Taxonomist		Scott McKuen	Scott McKuen	Kathy Welch	Allan Fukuyama
Number of Bulk Samples QAed	0	1	1	1	1
Identifications confirmed	NA	100%	100%	100%	100%
Identifications changed (includes species-level changes)	NA	0	0	0	0
Species-level changes	NA	0	0	0	0
Number of Voucher Specimens QAed	0	0	0	3	0
Voucher Specimens confirmed	NA	NA	NA	3	NA