2009 Bainbridge Basin Marine Sediment Monitoring

Infaunal Community Data Summary

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Results and Statistical Summaries

Benthic infaunal results for the 2009 Bainbridge Basin survey.

Benthic infaunal species identified in the 2009 Bainbridge Basin survey.

Phylum Class Order Family	Taxononomy level reported	Authorship
Cnidaria		
Hydrozoa		
Hydroida		
Tubulariidae		
	Euphysa sp	
Campanulariidae		
	Obelia sp	
	Clytia sp	
Anthozoa		
Ceriantharia		
Cerianthidae		
	Pachycerianthus fimbriatus	McMurrich 1910
Pennatulacea		
Virgulariidae		
	Stylatula elongata	(Gabb 1862)
	Acanthoptilum gracile	(Gabb 1862)
Actiniaria		
Edwardsiidae		
	Edwardsia sp	
	Edwardsia juliae	Daly and Ljubenkov, 2008
Haloclavidae		
	Haloclavidae	
Platyhelminthes		
Turbellaria		
Polycladida		
Leptoplanidae		
	Leptoplanidae	
Rhabditophora		
Pseudocerotidae		
	Acanthozoon lepidum	
Nemertea		
	Nemertea	
Anopla		

Phylum Class Order Family	Taxononomy level reported	Authorship
Paleonemertea		
Tubulanidae		
	Tubulanus polymorphus	Renier 1804
Tubulanidae	*Tubulanus sp A*	
Carinomidae		
	Carinoma mutabilis	Griffin 1898
Heteronemertea		
Lineidae		
	Lineidae	
	Cerebratulus sp	
	Lineus sp	
	Micrura sp	
Enopla		
Hoplonemertea		
	Hoplonemertea	
Emplectonematidae		
	Paranemertes californica	Coe 1904
Prosorhochmidae		
	Oerstedia dorsalis	(Abildgaard 1806)
Amphiporidae		
	Amphiporus sp	
Tetrastemmatidae		
	Tetrastemma sp	
	Tetrastemma nigrifrons	Coe 1904
Annelida		
Polychaeta		
Aciculata		
Polynoidae		
	Polynoidae	Malmgren, 1867
	Eunoe senta	(MOORE, 1902)
	Gattyana ciliata	Moore, 1902
	Harmothoe sp	
	Harmothoe imbricata	(Linnaeus 1767)
	Lepidonotus spiculus	(Treadwell 1906)
	Hesperonoe sp	
	Hesperonoe complanata	(Johnson 1901)
	Hesperonoe laevis	Hartman 1961
	Lepidasthenia berkeleyae	Pettibone 1948
	Tenonia priops	(Hartman 1961)

Phylum Class Order Family	Taxononomy level reported	Authorship
	Malmgreniella sp	
	Malmgreniella bansei	Pettibone 1993
	Malmgreniella macginitiei	Pettibone 1993
	Malmgreniella liei	Pettibone 1993
	Grubeopolynoe tuta	(Grube, 1855)
Pholoidae		
	Pholoe sp	
	Pholoe minuta	(FABRICIUS)
	Pholoe sp N1	
Sigalionidae		
	Sthenelais berkeleyi	Pettibone 1971
	Sthenelais tertiaglabra	Moore 1910
Chrysopetalidae		
	Paleanotus bellis	(Johnson 1897)
Phyllodocidae		
	Phyllodoce groenlandica	Ørsted 1843
	Phyllodoce longipes	Kinberg 1866
	Eteone sp	
	Eteone californica	
	Eteone pacifica	Hartman 1936
	Eteone spilotus	Kravitz & Jones 1979
	Eteone leptotes	Blake 1992
	Eulalia quadrioculata	Moore 1906
	Eumida longicornuta	(Moore 1906)
	Phyllodoce hartmanae	Blake & Walton 1977
	Phyllodoce cuspidata	McCammon & Montagne 1979
	Sige montereyensis	
Hesionidae		
	Hesionidae	
	Microphthalmus sp	
	Micropodarke dubia	(Hessle 1925)
	Ophiodromus pugettensis	Johnson 1901
	Podarkeopsis glabrus	(Hartman 1961)
Pilargidae		
	Sigambra bassi	(Hartman 1945)
	Pilargis maculata	Hartman 1947
	Parandalia fauveli	(Berkeley & Berkeley 1941)
Syllidae		
	Proceraea cornuta	(Agassiz 1862)

Phylum Class Order Family	Taxononomy level reported	Authorship
	Typosyllis cornuta	(Rathke 1843)
	Typosyllis caeca	(Katzmann 1973)
	Eusyllis lamelligera	MARION & BOBRETZK
	Exogone dwisula	Kudenov & Harris 1995
	Exogone lourei	Berkeley & Berkeley 1938
	Sphaerosyllis sp N1	NAMIT 1997
	Odontosyllis phosphorea	Moore 1909
Nereididae		
	Alitta virens	
	Nereis procera	Ehlers 1868
	Platynereis bicanaliculata	(Baird 1863)
Nephtyidae		
	Nephtys sp	
	Nephtys caeca	(Fabricius 1780)
	Bipalponephtys cornuta	Berkeley & Berkeley 1945
	Nephtys ferruginea	Hartman 1940
	Nephtys caecoides	Hartman 1938
Sphaerodoridae		
	Sphaerodoropsis sphaerulifer	(Moore 1909)
Glyceridae		
	Glycera americana	Leidy 1855
	Glycera nana	Johnson 1901
Goniadidae		
	Goniadidae	
	Glycinde sp	
	Glycinde picta	Berkeley 1927
	Glycinde armigera	Moore 1911
	Goniada sp	
Onuphidae		
	Onuphidae	
	Onuphis sp	
	Onuphis iridescens	(Johnson 1901)
	Onuphis elegans	(Johnson 1901)
	Diopatra ornata	Moore 1911
Lumbrineridae		
	Lumbrineridae	
	Scoletoma luti	(Berkeley and Berkeley 1945)
	Lumbrineris cruzensis	Hartman 1944
	Lumbrineris californiensis	Hartman 1944

Phylum Class Order Family	Taxononomy level reported	Authorship
	Eranno bicirrata	(Treadwell 1922)
Oenonidae		
	Notocirrus californiensis	Hartman 1944
Dorvilleidae		
	Protodorvillea gracilis	(Hartman 1938)
	Dorvillea (Schistomeringos) annulata	(Moore 1906)
Orbiniidae		
	Scoloplos sp	
	Scoloplos acmeceps	Chamberlin 1919
	Phylo felix	Kinberg 1866
	Leitoscoloplos pugettensis	(Pettibone 1957)
Paraonidae		
	Aricidea (Allia) ramosa	Annenkova 1934
	Levinsenia gracilis	(Tauber 1879)
Cossuridae	*Cossura pygodactylata*	Jones 1956
Scalibregmatidae		
	Scalibregma californicum	Blake 2000
Opheliidae		
	Armandia brevis	(Moore 1906)
	Ophelina acuminata	Ørsted 1843
Capitellidae		
	Capitella capitata Cmplx	(Fabricius 1780)
	Heteromastus filobranchus	Berkeley & Berkeley 1932
	Notomastus sp	
	Notomastus tenuis	Moore 1909
	Notomastus latericeus	M. Sars 1851
	Notomastus hemipodus	Hartman 1945
	Mediomastus californiensis	Hartman 1944
Maldanidae		
	Maldane sarsi	Malmgren 1865
	Axiothella rubrocincta	(Johnson 1901)
	Praxillella sp	
	Praxillella gracilis	(M. Sars 1861)
	Praxillella pacifica	E. Berkeley 1929
	Euclymeninae	
	Rhodine bitorquata	Moore 1923
	Microclymene caudata	
	Euclymeninae sp A	

Phylum Class Order Family	Taxononomy level reported	Authorship
Canalipalpata		
Apistobranchidae		
	Apistobranchus tullbergi	Hartman 1965
Spionidae		
	Laonice sp	
	Laonice cirrata	(M. Sars 1851)
	Laonice pugettensis	
	Polydora limicola	Annenkova 1934
	Dipolydora socialis	(Schmarda 1861)
	Dipolydora brachycephala	Hartman 1936
	Dipolydora cardalia	(Berkeley 1927)
	Prionospio (Prionospio) steenstrupi	Malmgren 1867
	Prionospio (Minuspio) lighti	Maciolek 1985
	Prionospio (Minuspio) multibranchiata	E. Berkeley 1927
	Spio sp	
	Spio filicornis	(O. F. Müller 1766)
	Boccardia pugettensis	Blake 1979
	Spiophanes bombyx	(Claparède 1870)
	Spiophanes berkeleyorum	Pettibone 1962
	Paraprionospio alata	(Moore 1923)
	Boccardiella hamata	(Webster 1879)
Magelonidae		
	Magelona longicornis	Johnson 1901
Trochochaetidae		
	Trochochaeta multisetosa	(Ørsted 1844)
Chaetopteridae		
	Chaetopterus sp	
Chaetopteridae	*Phyllochaetopterus prolifica*	Potts 1914
	Spiochaetopterus pottsi	
	Mesochaetopterus sp	
Cirratulidae		
	Cirratulus sp	
	Caulleriella pacifica	Berkeley 1929
	Aphelochaeta sp	
	Monticellina sp	
	Aphelochaeta monilaris	(Hartman 1960)
	Aphelochaeta glandaria Cmplx	Blake 1996
	Aphelochaeta sp N5	

Phylum Class Order Family	Taxononomy level reported	Authorship
	Chaetozone sp	
	Chaetozone nr setosa	
	Chaetozone acuta	
	Chaetozone sp N2	
	Chaetozone sp N1	
	Monticellina serratiseta	(Banse & Hobson 1968)
Flabelligeridae		
	Flabelligera affinis	Sars 1829
	Pherusa plumosa	
Oweniidae		
	Owenia sp	
	Owenia fusiformis	Delle Chiaje 1841
	Galathowenia oculata	(Zaks 1923)
Pectinariidae		
	Pectinaria granulata	(Linnaeus 1767)
	Pectinaria californiensis	Hartman 1941
Ampharetidae		
	Ampharete sp	
	Ampharete acutifrons	(Grube 1860)
	Ampharete labrops	Hartman 1961
	Amphicteis mucronata	Moore 1923
	Melinna oculata	Hartman 1969
	Anobothrus gracilis	(Malmgren 1866)
	Asabellides sibirica	
Terebellidae		
	Terebellidae	
	Nicolea zostericola	(Ørsted 1844)
	Pista agassizi	
	Pista wui	Saphranova 1988
	Polycirrus sp	
	Polycirrus californicus	Moore 1909
	Polycirrus sp IV	
	Polycirrus sp V	sensu Banse 1980
	Polycirrus sp I	sensu Banse 1980
	Artacama coniferi	Moore 1905
	Lanassa sp	
	Lanassa nordenskioeldi	Malmgren 1866
	Lanassa venusta	(Malm 1874)
	Proclea graffi	(Langerhans 1884)

Phylum Class Order Family	Taxononomy level reported	Authorship
	Streblosoma bairdi	(Malmgren 1866)
	Amphitrite edwardsi	(Quatrefages 1865)
Trichobranchidae		
	Terebellides sp	
	Terebellides californica	Williams 1984
	Terebellides reishi	Williams 1984
Sabellidae		
	Chone sp	
	Chone gracilis	
	Euchone analis	
	Eudistylia sp	
	Eudistylia catharinae	Banse 1979
	Megalomma splendida	(Moore 1905)
	Myxicola infundibulum	(Renier 1804)
	Schizobranchia insignis	Bush 1905
Serpulidae		
	Circeis armoricana	Saint-Joseph, 1894
Oligochaeta		
	Oligochaeta	
Mollusca		
Gastropoda		
Archaeogastropoda		
Trochidae		
	Margarites pupillus	(Gould 1841)
	Lirularia lirulata	(Carpenter, 1864)
Mesogastropoda		
Lacunidae		
	Lacuna vincta	(Montagu, 1803)
Neotaenioglossa		
Rissoidae		
	Alvania compacta	Carpenter, 1864
Cerithiidae		
	Lirobittium sp	
Eulimidae	*Polygireulima rutila*	(Carpenter 1864)
Calyptraeidae	*Crepipatella dorsata*	(Broderip 1834)
Neogastropoda		
Columbellidae		
	Astyris gausapata	(Gould, 1850)
	Alia carinata	(Hinds 1844)

Phylum Class Order Family	Taxononomy level reported	Authorship
Nassariidae		
	Nassarius mendicus	(Gould 1849)
Conidae	*Kurtziella plumbea*	(Hinds 1843)
Conidae	*Kurtzia arteaga*	(Dall & Bartsch 1910)
Heterostropha		
Pyramidellidae		
	Turbonilla sp	
	Odostomia sp	
Cephalaspidea		
Cylichnidae		
	Acteocina eximia	(Baird 1863)
	Cylichna attonsa	Carpenter 1865
Retusidae		
	Sulcoretusa xystrum	(Dall 1919)
Nudibranchia		
Dotoidae		
	Doto columbiana	ODonoghue 1921
	Aeolidacea	
Polyplacophora		
	Polyplacophora	
Neoloricata		
Ischnochitonidae	*Lepidozona mertensii*	(Middendorff 1847)
Mopaliidae		
	Mopalia imporcata	Carpenter, 1864
Bivalvia		
Nuculoida		
Nuculidae		
	Acila castrensis	(Hinds 1843)
	Ennucula tenuis	(Montagu 1808)
Nuculanidae		
	Nuculana minuta	(Muller,1776)
Yoldiidae		
	Yoldia sp	
	Yoldia seminuda	Dall 1871
Mytiloida		
Mytilidae		
	Mytilidae	Rafinesque, 1815
	Solamen columbianum	(Dall 1897)
	Modiolus sp	

Phylum Class Order Family	Taxononomy level reported	Authorship
Ostreoida		
Pectinidae		
	Chlamys hastata	(G. B. Sowerby II 1843)
Veneroida		
Lucinidae		
	Parvilucina tenuisculpta	(Carpenter 1864)
	Lucinoma annulatum	(Reeve 1850)
Thyasiridae		
	Axinopsida serricata	(Carpenter 1864)
Lasaeidae		
	Rochefortia tumida	(Carpenter 1864)
Cardiidae		
	Clinocardium sp	
	Clinocardium nuttallii	(Conrad 1837)
	Nemocardium centifilosum	(Carpenter 1864)
Mactridae		
	Mactridae	Lamarck,1809
	Mactromeris polynyma	(Stimpson,1860)
Solenidae		
	Solen sicarius	Gould 1850
Tellinidae		
	Macoma sp	
	Macoma calcarea	(Gmelin,1791)
	Macoma elimata	Dunnill & Coan,1968
	Macoma yoldiformis	Carpenter 1864
	Macoma carlottensis	Whiteaves 1880
	Macoma nasuta	(Conrad 1837)
	Macoma inquinata	(Deshayes,1855)
	Macoma golikovi	(Sowerby,1817)
	Tellina modesta	(Carpenter 1864)
Veneridae		
	Saxidomus giganteus	
	Compsomyax sp	
	Compsomyax subdiaphana	(Carpenter 1864)
	Nutricola lordi	(Baird,1863)
	Leukoma staminea	(Conrad 1837)
Myoida		
Myidae		
	Mya arenaria	Linnaeus 1758

Phylum Class Order Family	Taxononomy level reported	Authorship
Hiatellidae		
	Hiatella arctica	(Linnaeus 1767)
Pholadomyoida		
Pandoridae		
	Pandora sp	
	Pandora filosa	(Carpenter 1864)
Lyonsiidae		
	Lyonsia californica	Conrad 1837
Scaphopoda		
Gadilida		
Pulsellidae		
	Pulsellum salishorum	E. Marshall,1980
Arthropoda		
Pycnogonida		
Pantopoda		
Phoxichilidiidae		
	Phoxichilidium femoratum	(Rathke 1799)
Chelicerata		
Ostracoda		
Myodocopida		
Cylindroleberididae		
	Cylindroleberididae	Mueller, 1906
Crustacea		
Rutidermatidae		
	Rutiderma lomae	(Juday 1907)
Philomedidae		
	Euphilomedes carcharodonta	(Smith 1952)
	Euphilomedes producta	Poulsen 1962
Maxillopoda		
Calanoida		
Calaniidae		
	Calanus sp	
Maxillipoda		
Cyclopoida		
	Cyclopoida	
Siphonostomatoida		
Caligidae		
	Caligidae	Kabata, 1988
Arguloidea		

Phylum Class Order Family	Taxononomy level reported	Authorship
Argulidae		
	Argulus sp	
Cirripidea		
Thoracica		
	Balanomorpha	
Balanidae		
	Balanus sp	
	Balanus crenatus	Bruguière 1789
Malacostraca		
Leptostraca		
Nebaliidae		
	Nebalia sp	
Mysida		
Mysidae		
	Neomysis kadiakensis	Ortmann 1908
Cumacea		
Lampropidae		
	Lamprops augustinensis	
Leuconidae		
	Eudorella pacifica	Hart 1930
Diastylidae		
	Diastylis santamariensis	Watling & McCann 1997
Nannastacidae		
	Cumella californica	Watling & McCann 1997
Tanaidacea		
Pseudozeuxidae		
	Leptochelia dubia Cmplx	
Isopoda		
Gnathiidae		
	Araphura breviaria	Dojiri & Sieg 1997
Anthuridae		
	Haliophasma geminatum	Menzies & J. L. Barnard 1959
Idoteidae		
	Synidotea consolidata	Stimpson 1856
Amphipoda		
Ampeliscidae		
	Ampelisca hancocki	
	Ampelisca pugetica	Stimpson 1864
	Ampelisca lobata	Holmes 1908

Phylum Class Order Family	Taxononomy level reported	Authorship
	Byblis sp	
Ampithoidae		
	Ampithoe sp	
Aoridae		
	Aoroides inermis	Conlan & Bousfield 1982
	Aoroides exilis	Conlan & Bousfield 1982
Argissidae		
	Argissa hamatipes	(Norman 1869)
Corophiidae		
	Monocorophium acherusicum	(Costa 1857)
	Laticorophium baconi	(Shoemaker 1934)
	Ericthonius brasiliensis	(Dana 1853)
Dexaminidae		
	Guernea reduncans	(J. L. Barnard 1958)
Eusiridae		
	Accedomoera vagor	Barnard 1969
	Pontogeneia rostrata	Gurjanova 1938
Gammaridae		
	Maera sp	
Melitidae		
	Desdimelita desdichada	(J. L. Barnard 1962)
Isaeidae		
	Photis sp	
	Photis brevipes	Shoemaker 1942
	Protomedeia grandimana	Bruggen, 1906
	Protomedeia articulata Cmplx	J. L. Barnard 1962
	Gammaropsis thompsoni	(Walker 1898)
	Gammaropsis ellisi	Conlan 1983
	Cheirimedeia macrocarpa	
Ischyroceridae		
	Ischyrocerus sp	
Oedicerotidae		
	Americhelidium rectipalmum	Mills 1962
Lysianassidae		
	Hippomedon coecus	
	Lepidepecreum gurjanovae	Hurley 1963
	Orchomene pinguis	(Boeck 1861)
	Orchomene decipiens	(Hurley 1963)
Oedicerotidae		

Phylum Class Order Family	Taxononomy level reported	Authorship
	Westwoodilla tone	Jansen, 2002
	Deflexilodes similis	Bousfield and Chevier 1996
	Americhelidium shoemakeri	Mills 1962
Phoxocephalidae		
	Heterophoxus ellisi	Jarrett & Bousfield 1994
	Heterophoxus conlanae	Jarrett & Bousfield 1994
	Metaphoxus frequens	J. L. Barnard 1960
	Rhepoxynius pallidus	
	Rhepoxynius boreovariatus	Jarrett and Bousfield 1994
	Eobrolgus chumashi	Barnard & Barnard, 1981
Pleustidae		
	Pleusymtes sp	
	Pleusirus secorrus	J. L. Barnard 1969
	Thorlaksonius sp	
Podoceridae		
	Dyopedos sp	
Stenothoidae		
	Stenothoidae	Chevreux
Synopiidae		
	Tiron biocellata	J. L. Barnard 1962
	Hyperiidea	
Caprellidae		
	Caprella sp	
	Caprella mendax	Mayer 1903
	Caprella kennerlyi	
Decapoda		
	Caridea	Dana, 1852
Hippolytidae		
	Hippolytidae	Bate, 1888
	Spirontocaris ochotensis	(Brandt, 1851)
	Eualus sp	
	Heptacarpus sp	
	Heptacarpus sitchensis	(Brandt 1851)
	Heptacarpus brevirostris	(Dana 1852)
	Heptacarpus stimpsoni	Holthius 1947
Crangonidae		
	Crangonidae	Haworth, 1825
	Crangon sp	
	Crangon alaskensis	Lockington 1877

Phylum Class Order Family	Taxononomy level reported	Authorship
	Mesocrangon munitella	(Walker 1898)
	Anomura	
Callianassidae		
	Neotrypaea sp	
Paguridae		
	Paguridae	Latreille, 1803
	Pagurus sp	
	Pagurus caurinus	Hart, 1971
Porcellanidae		
	Porcellanidae	
	Brachyura	Latreille, 1803
Majidae		
	Pugettia gracilis	Dana, 1851
Cancridae		
	Cancer sp	
Cancridae		
	Cancer gracilis	Dana 1852
Pinnotheridae		
	Pinnotheridae	
Pinnotheridae		
	Pinnixa sp	
	Pinnixa schmitti	Rathbun 1918
	Pinnixa tubicola	Holmes 1894
	Pinnixa occidentalis Cmplx	#
Sipuncula		
Sipunculidea		
Golfingiformes		
Golfingiidae		
	Golfingiidae	
	Thysanocardia nigra	(Ikeda 1904)
Echiura		
Echiuridae		
Echiuroinea		
Echiuridae		
	Echiurus echiurus alaskanus	
Phoronida		
Phoronidae		

Phylum Class Order Family	Taxononomy level reported	Authorship
	Phoronopsis harmeri	
	Phoronis sp	
Ectoprocta		
Gymnolaemata		
Cheilostomata		
Hippothoidae		
	Celleporella hyalina	(Linnaeus 1767)
Brachiopoda		
Articulata		
Terebratulida		
Laqueidae		
	Terebratalia transversa	(G. B. Sowerby I 1846)
Echinodermata		
Stelleroidea		
Spinulosida		
Solasteridae		
	Crossaster papposus	(Linnaeus 1767)
Ophiurida		
	Ophiurida	Muller & Troschel, 1940
Amphiuridae		
	Amphiuridae	Ljungman, 1867
	Amphiodia sp	
	Amphiodia urtica/periercta	
	Amphipholis sp	
	Amphipholis squamata	(Delle Chiaje 1828)
	Amphiodia occidentalis	H. L. Clark 1935
Echinoidea		
	Echinoidea	Leske, 1778
Echinozoa		
Holothuroidea		
Dendrochirotida		
Cucumariidae		
	Pentamera sp	
	Pentamera pseudocalcigera	Deichmann 1938
	Pentamera populifera	(Stimpson 1857)
	Pentamera rigida	
Apodida		
Synaptidae		
	Leptosynapta sp	

Phylum Class Order Family	Taxononomy level reported	Authorship
Hemichordata		
Enteropneusta		
Ptychoderidae		
	Glossobalanus sp	
Chordata		
Ascidiacea		
Aplousobranchiata		
Clavelinidae		
Urochordata		
	Distaplia occidentalis	BANCROFT, 1899

Statistical Summaries of 9 Benthic Indices

Benthic infaunal indices calculated to characterize the infaunal invertebrate assemblages identified for the 2009 Bainbridge Basin 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 2009 Bainbridge Basin survey.

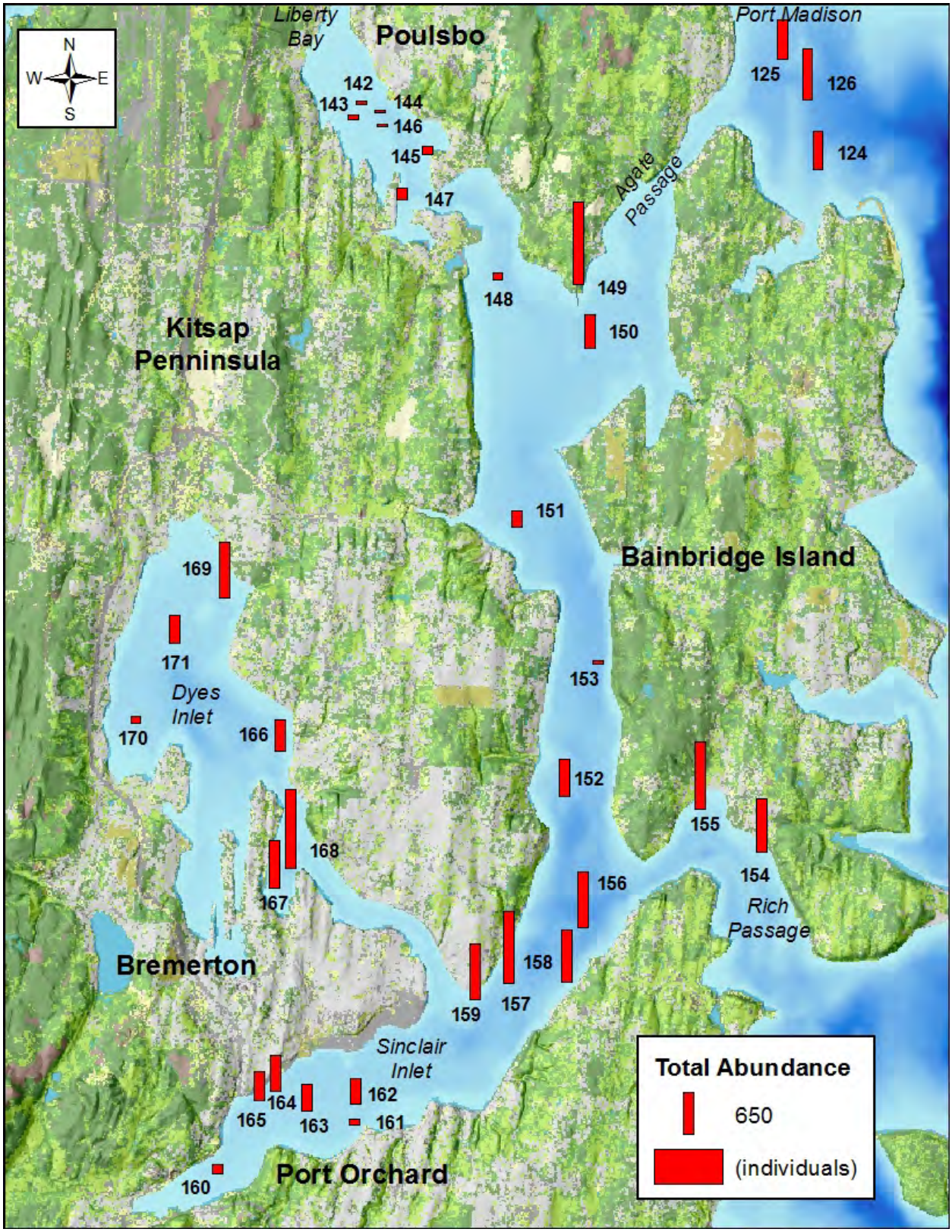
Station	Total abundance	Annelida	Annelida % of total abundance	Arthropoda	Arthropoda % of total abundance	Echino-dermata	Echinodermata % of total abundance	Mollusca	Mollusca % of total abundance	Misc. taxa	Misc. taxa % of total abundance
124	601	197	32.78	76	12.65	114	18.97	206	34.28	8	1.33
125	624	208	33.33	92	14.74	125	20.03	194	31.09	5	0.80
126	807	142	17.60	108	13.38	55	6.82	498	61.71	4	0.50
142	45	26	57.78	6	13.33	0	0.00	10	22.22	3	6.67
143	81	66	81.48	4	4.94	0	0.00	9	11.11	2	2.47
144	40	28	70.00	7	17.50	0	0.00	4	10.00	1	2.50
145	121	55	45.45	36	29.75	1	0.83	26	21.49	3	2.48
146	36	22	61.11	5	13.89	0	0.00	8	22.22	1	2.78
147	189	49	25.93	12	6.35	8	4.23	112	59.26	8	4.23
148	103	17	16.50	53	51.46	1	0.97	32	31.07	0	0.00
149	1305	485	37.16	264	20.23	10	0.77	521	39.92	25	1.92
150	540	217	40.19	56	10.37	187	34.63	63	11.67	17	3.15
151	270	107	39.63	52	19.26	94	34.81	11	4.07	6	2.22
152	586	110	18.77	11	1.88	24	4.10	437	74.57	4	0.68
153	53	30	56.60	4	7.55	0	0.00	18	33.96	1	1.89
154	846	335	39.60	219	25.89	3	0.35	259	30.61	30	3.55
155	1069	270	25.26	130	12.16	1	0.09	644	60.24	24	2.25
156	897	528	58.86	174	19.40	18	2.01	158	17.61	19	2.12
157	1148	462	40.24	88	7.67	46	4.01	530	46.17	22	1.92
158	839	225	26.82	220	26.22	31	3.69	349	41.60	14	1.67
159	870	369	42.41	201	23.10	52	5.98	230	26.44	18	2.07
160	147	142	96.60	1	0.68	0	0.00	3	2.04	1	0.68

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
161	87	84	96.55	1	1.15	0	0.00	1	1.15	1	1.15
162	392	187	47.70	105	26.79	54	13.78	38	9.69	8	2.04
163	421	305	72.45	67	15.91	11	2.61	36	8.55	2	0.48
164	560	251	44.82	206	36.79	14	2.50	79	14.11	10	1.79
165	473	206	43.55	148	31.29	46	9.73	64	13.53	9	1.90
166	492	279	56.71	83	16.87	2	0.41	117	23.78	11	2.24
167	759	498	65.61	112	14.76	24	3.16	114	15.02	11	1.45
168	1256	1030	82.01	169	13.46	0	0.00	55	4.38	2	0.16
169	871	595	68.31	93	10.68	6	0.69	154	17.68	23	2.64
170	106	47	44.34	30	28.30	10	9.43	19	17.92	0	0.00
171	436	191	43.81	99	22.71	108	24.77	19	4.36	19	4.36
Mean	517.27	235.24	49.39	88.85	17.31	31.67	6.34	152.06	24.96	9.45	2.00
Median	492.00	197.00	44.34	83.00	14.76	10.00	2.50	64.00	21.49	8.00	1.92
Min	36.00	17.00	16.50	1.00	0.68	0.00	0.00	1.00	1.15	0.00	0.00
Max	1305.00	1030.00	96.60	264.00	51.46	187.00	34.81	644.00	74.57	30.00	6.67
Range	1269.00	1013.00	80.09	263.00	50.78	187.00	34.81	643.00	73.42	30.00	6.67

Total abundance, taxa richness, Pielou's evenness, and Swartz Dominance Index calculated for the 2009 Bainbridge Basin survey.

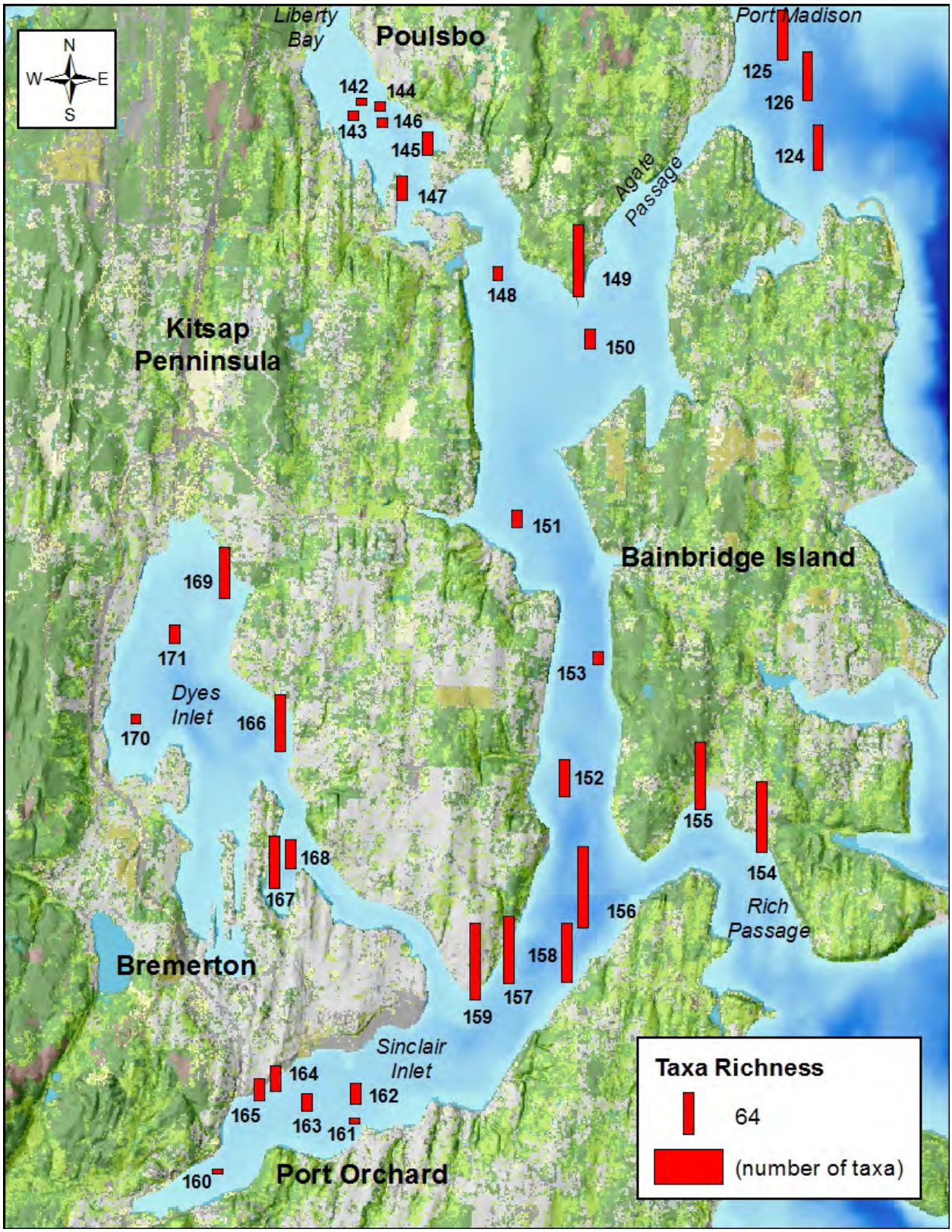
Station	Location	Total abundance	Taxa richness	Pielou's evenness (J')	Swartz Dominance Index
124	Port Madison	601	71	0.79	15
125	Port Madison	624	78	0.79	16
126	Port Madison	807	76	0.70	12
142	Liberty Bay	45	11	0.95	7
143	Liberty Bay	81	15	0.76	5
144	Liberty Bay	40	15	0.88	7
145	Liberty Bay	121	36	0.85	14
146	Liberty Bay	36	14	0.89	6
147	Liberty Bay	189	39	0.86	13
148	Southeast of Keyport	103	22	0.65	5
149	North Port Orchard Pt.Bolin	1305	112	0.71	18
150	North Port Orchard	540	32	0.68	5
151	North Port Orchard E. of Brownsville	270	28	0.76	7
152	Port Orchard Illahee	586	57	0.67	9
153	Port Orchard	53	20	0.83	7
154	Rich Pass Pleasant Beach	846	111	0.85	31
155	Rich Pass Lynwood Center	1069	105	0.70	16
156	South Port Orchard	897	128	0.78	27
157	South Port Orchard East Bremerton	1148	105	0.74	17
158	South Port Orchard	839	94	0.67	13
159	South Port Orchard Pt.Herron	870	118	0.80	25
160	Sinclair Inlet	147	8	0.36	1
161	Sinclair Inlet	87	8	0.50	2
162	Sinclair Inlet	392	32	0.74	7
163	Sinclair Inlet	421	27	0.73	7
164	Sinclair Inlet	560	39	0.68	7
165	Sinclair Inlet	473	35	0.76	9
166	Dyes Inlet Tracyton	492	89	0.83	24
167	Phinney Bay	759	82	0.76	15
168	Phinney Bay	1256	45	0.34	2
169	Dyes Inlet SE of Silverdale	871	79	0.79	16
170	Dyes Inlet North Chico Bay	106	14	0.78	5
171	Dyes Inlet	436	29	0.70	5

Station	Location	Total abundance	Taxa richness	Pielou's evenness (J')	Swartz Dominance Index
	Mean	517.27	53.76	0.74	11.36
	Median	492.00	39.00	0.76	9.00
	Min	36.00	8.00	0.34	1.00
	Max	1305.00	128.00	0.95	31.00
	Range	1269.00	120.00	0.61	30.00

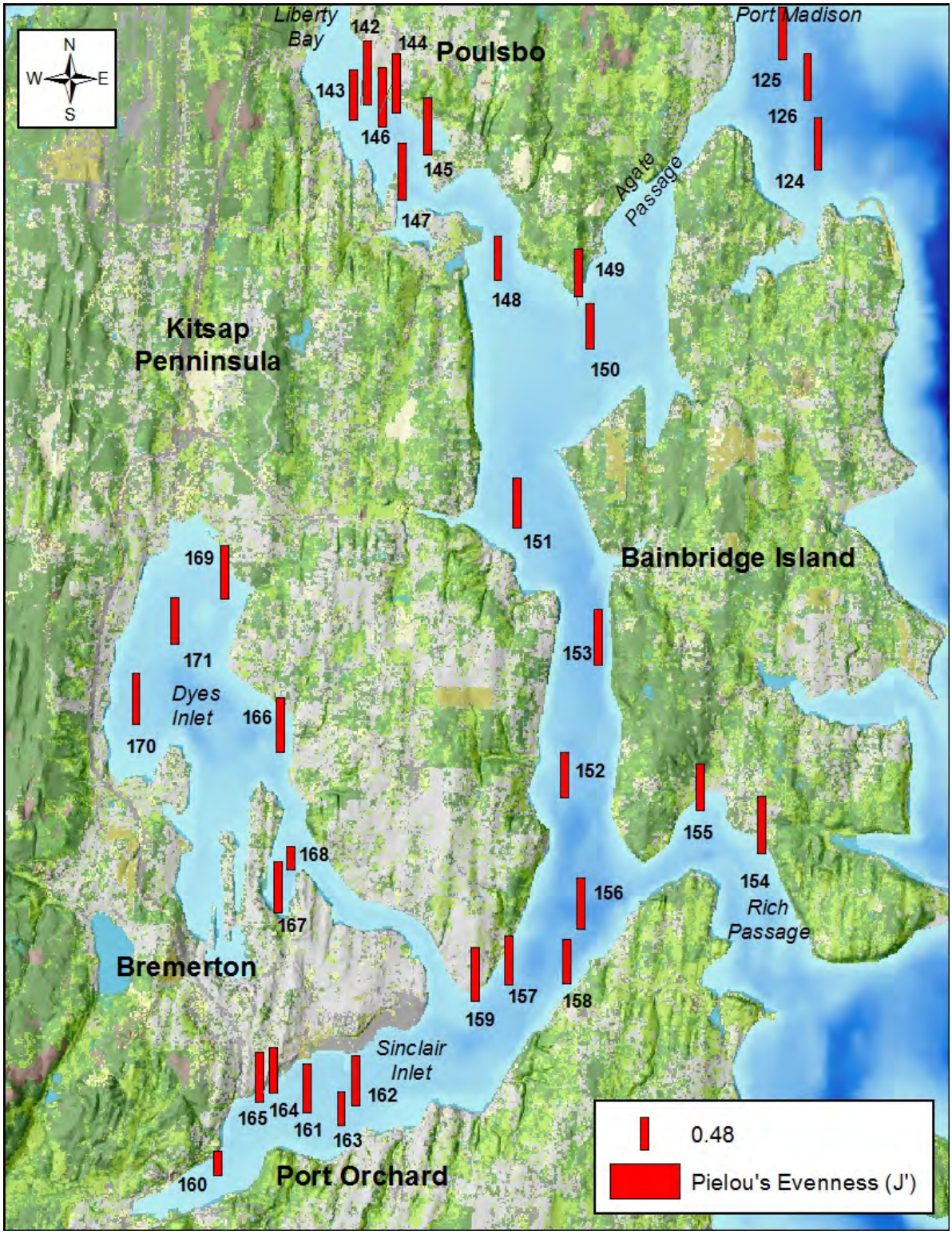


Spatial patterns in total benthic invertebrate abundance in the 2009 Bainbridge Basin survey.

The numbers on the map are the station identifications.



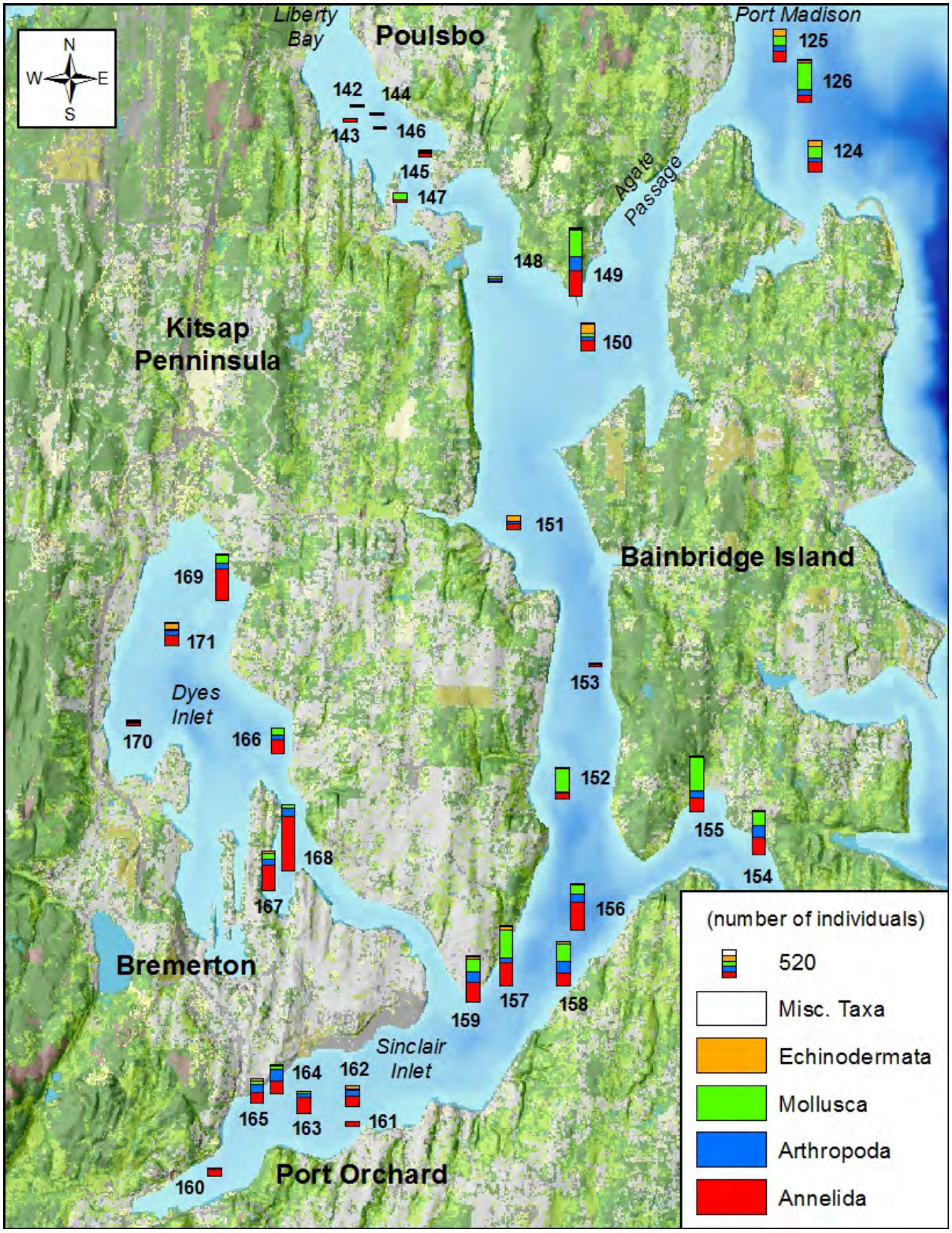
Spatial patterns in taxa richness in the 2009 Bainbridge Basin survey.
The numbers on the map are the station identifications.



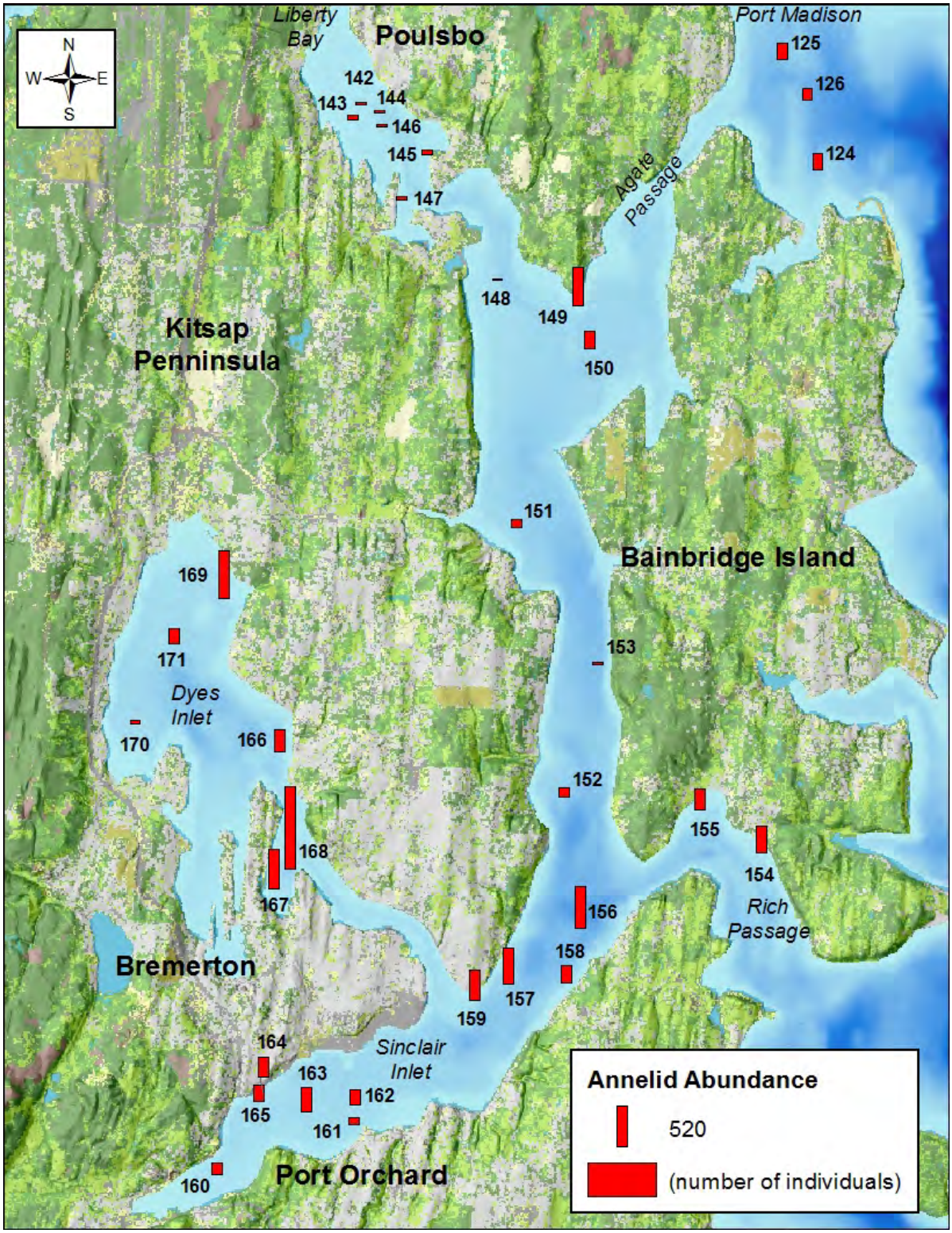
Spatial patterns in Pielou's Evenness (J') in the 2009 Bainbridge Basin survey.

The numbers on the map are the station identifications.

Spatial patterns in Swartz Dominance Index in the 2009 Bainbridge Basin survey.
The numbers on the map are the station identifications.

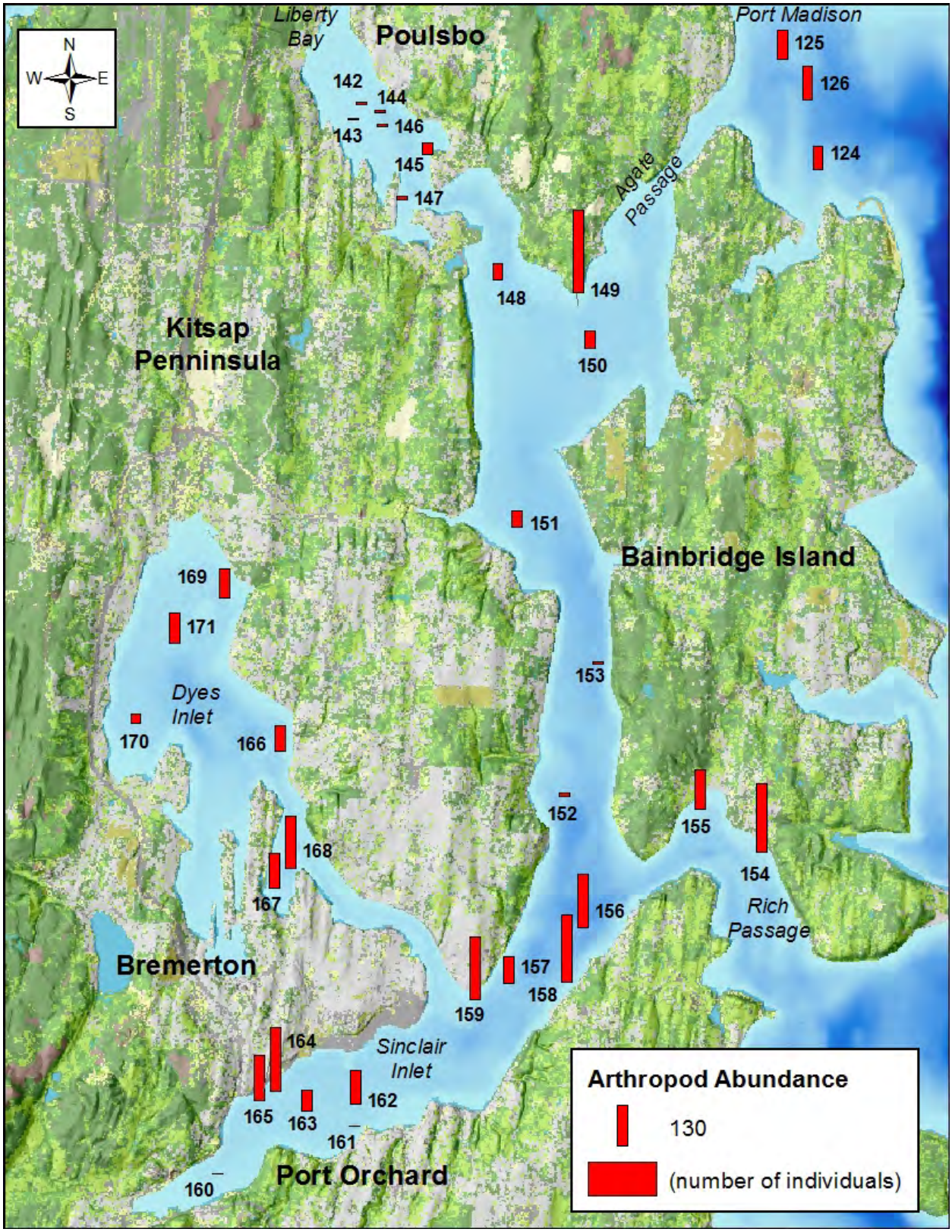


Spatial patterns in major taxa relative abundance (percent) in the 2009 Bainbridge Basin survey.
The numbers on the map are the station identifications.

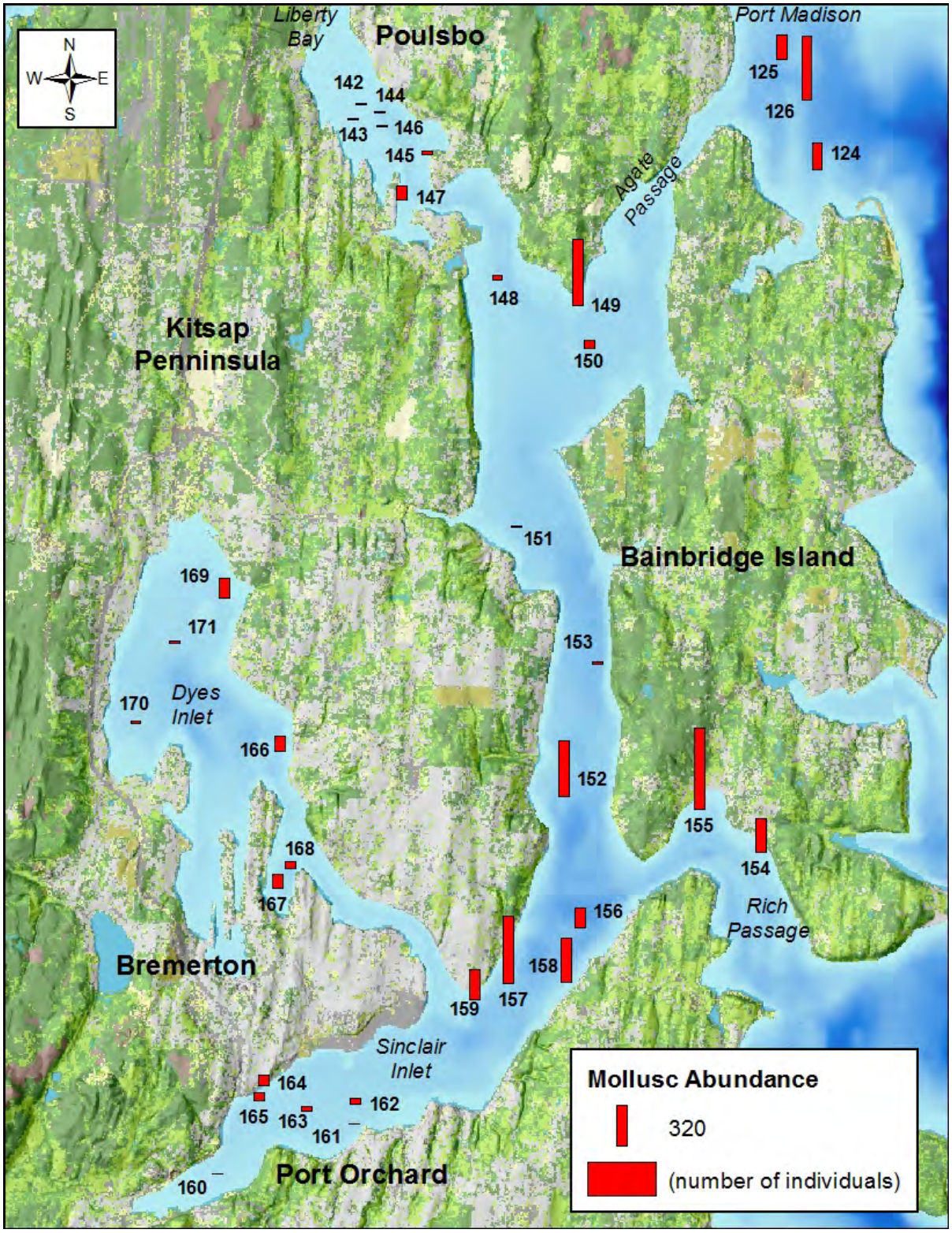


Spatial patterns in annelid abundance in the 2009 Bainbridge Basin survey.

The numbers on the map are the station identifications.

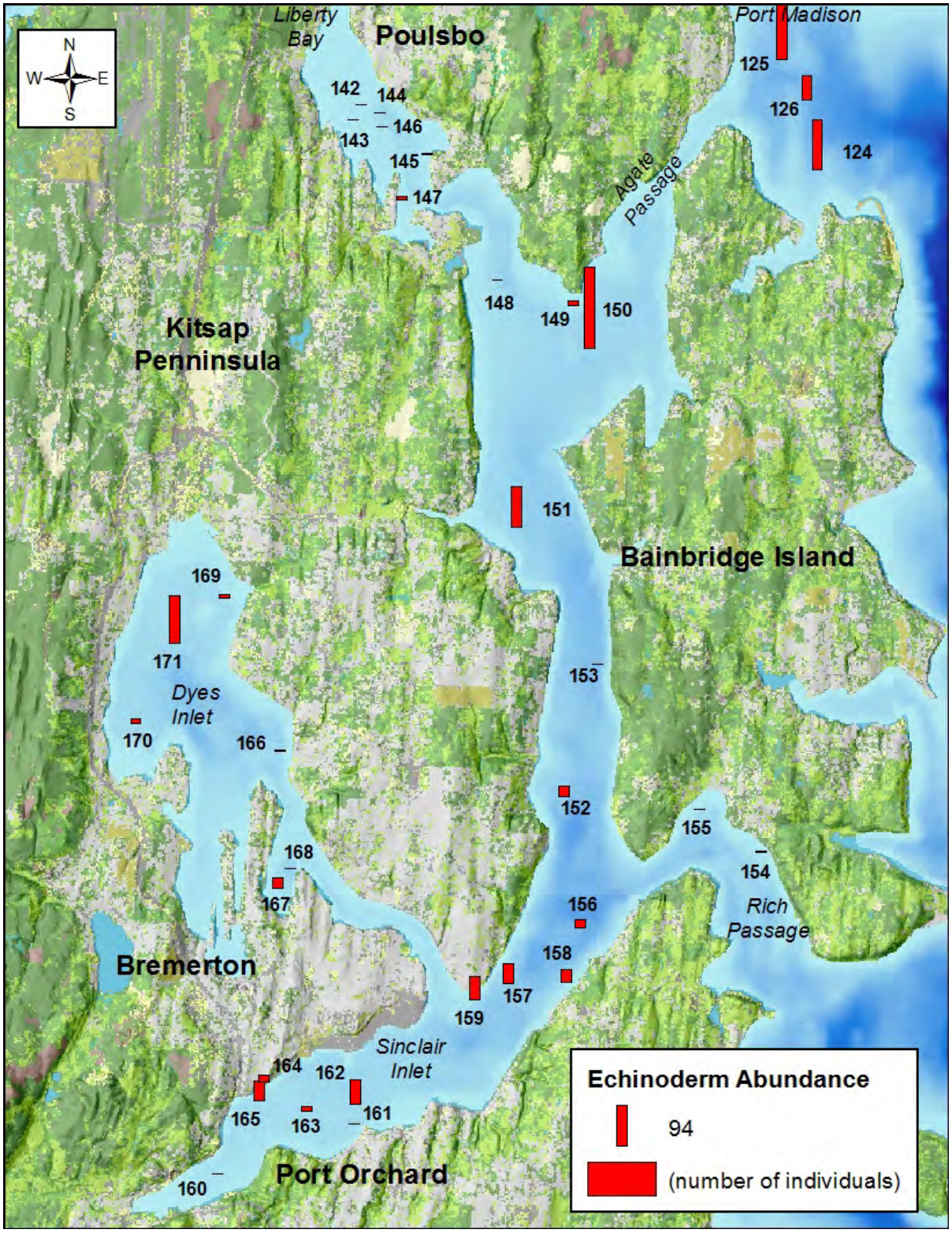


Spatial patterns in arthropod abundance in the 2009 Bainbridge Basin survey.
The numbers on the map are the station identifications.



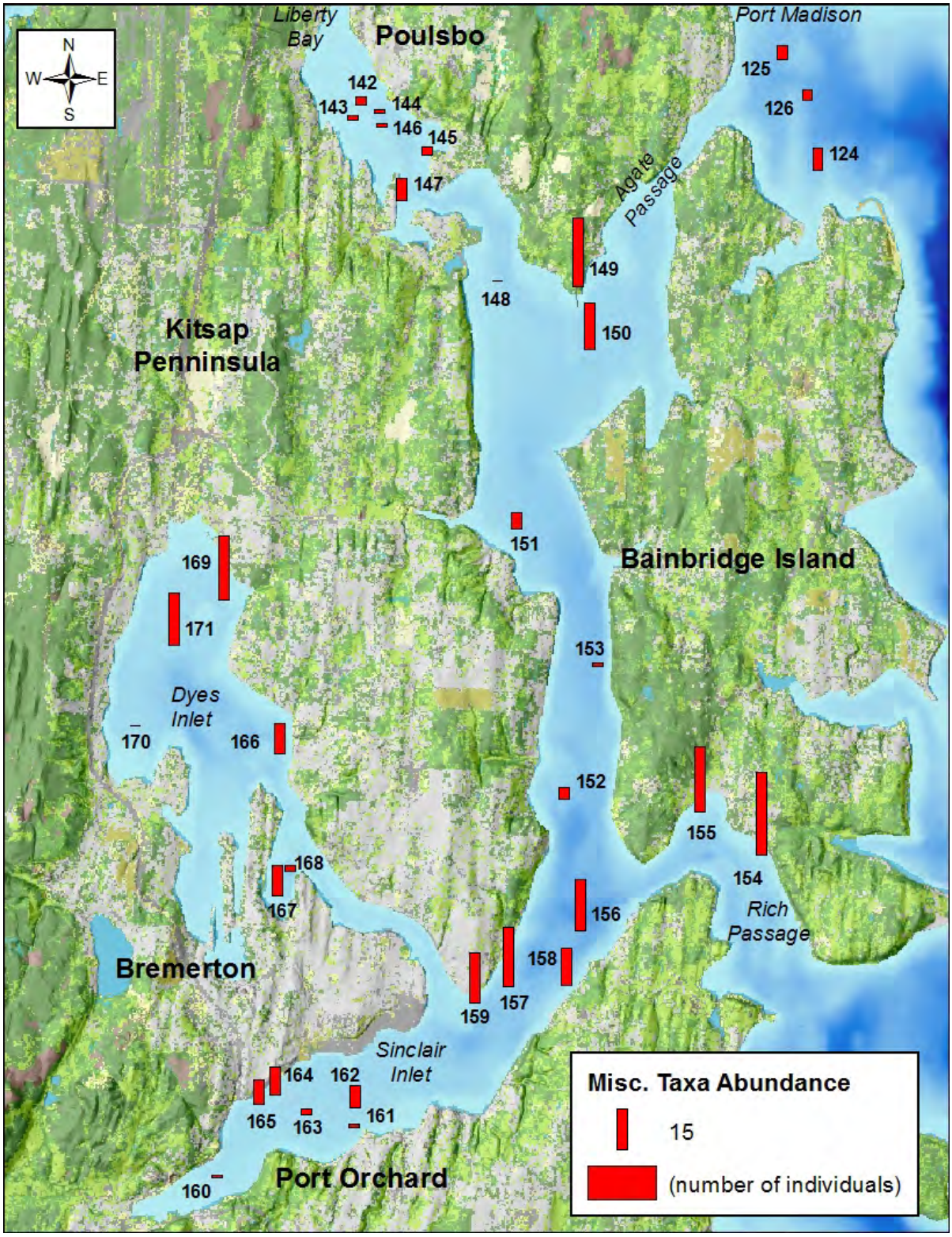
Spatial patterns in mollusc abundance in the 2009 Bainbridge Basin survey.

The numbers on the map are the station identifications.



Spatial patterns in echinoderm abundance in 2009 Bainbridge Basin survey.

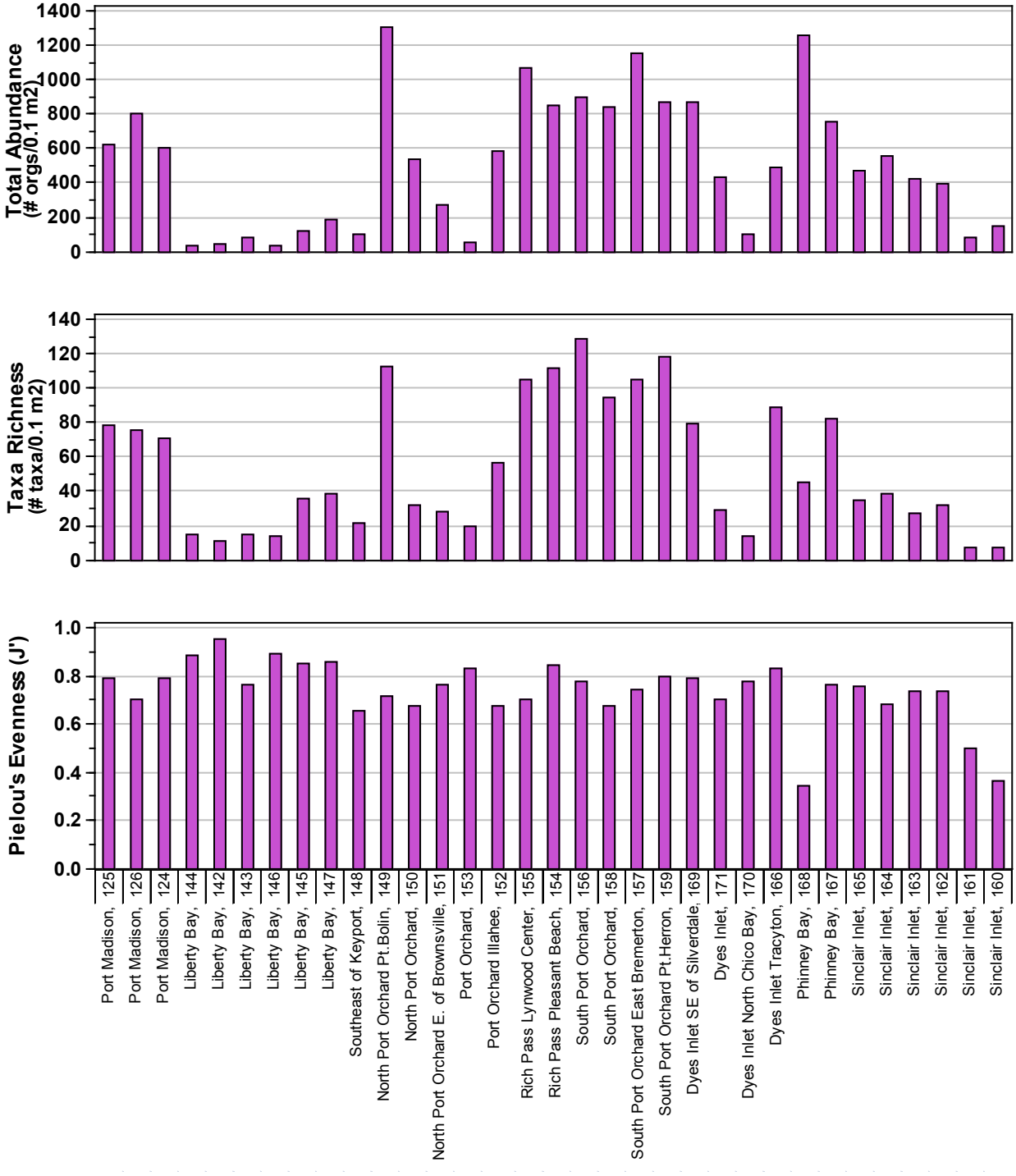
The numbers on the map are the station identifications.

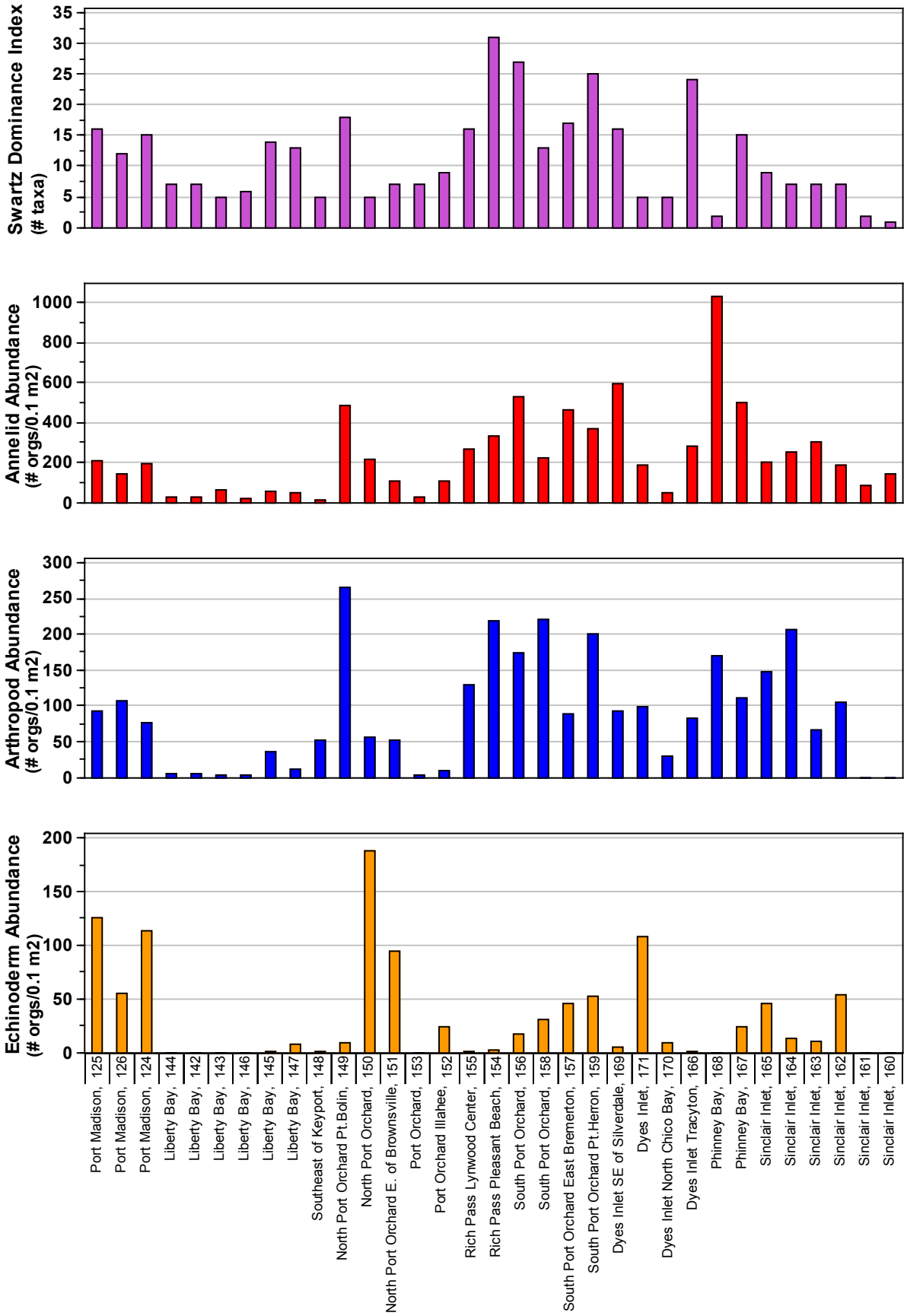


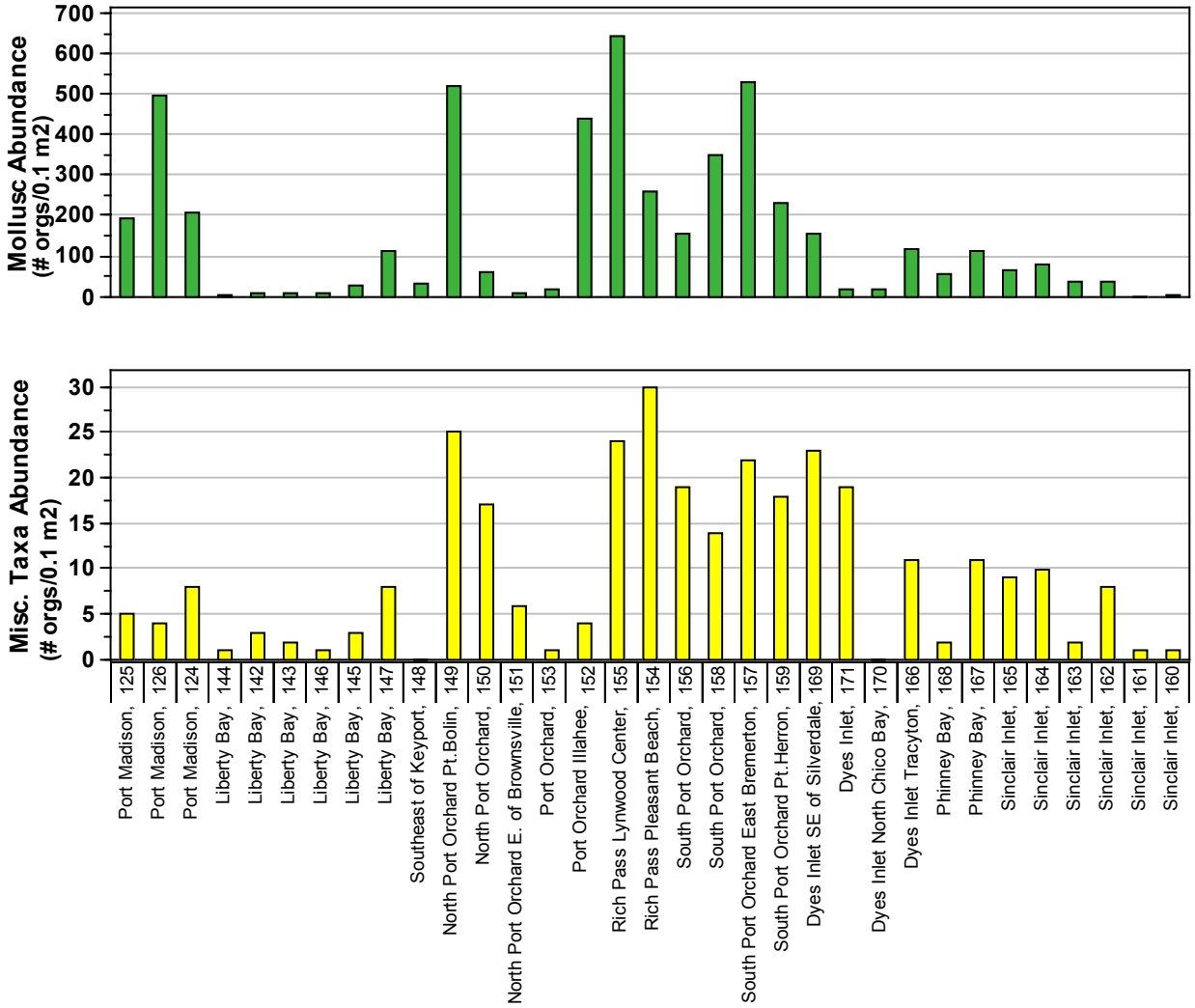
Spatial patterns in miscellaneous taxa abundance in the 2009 Bainbridge Basin survey.

The numbers on the map are the station identifications.

Benthic invertebrate measures calculated for sediment samples collected in the 2009 Bainbridge Basin survey. Stations are ordered approximately north to south.




Swartz Dominance Index (# taxa)
Annelid Abundance (# orgs/0.1 m2)
Arthropod Abundance (# orgs/0.1 m2)
Echinoderm Abundance (# orgs/0.1 m2)
Port Madison, 125
Port Madison, 126
Port Madison, 124
Liberty Bay, 144
Liberty Bay, 142
Liberty Bay, 143
Liberty Bay, 146
Liberty Bay, 145
Liberty Bay, 147
Southeast of Keyport, 148
North Port Orchard Pt.Bolin, 149
North Port Orchard, 150
North Port Orchard E. of Brownsville, 151
Port Orchard, 153
Port Orchard Illahee, 152
Rich Pass Lynwood Center, 155
Rich Pass Pleasant Beach, 154
South Port Orchard, 156
South Port Orchard, 158
South Port Orchard East Bremerton, 157
South Port Orchard Pt.Herron, 159
Dyes Inlet SE of Silverdale, 169
Dyes Inlet, 171
Dyes Inlet North Chico Bay, 170
Dyes Inlet Tracyton, 166
Phinney Bay, 168
Phinney Bay, 167
Sinclair Inlet, 165
Sinclair Inlet, 164
Sinclair Inlet, 163
Sinclair Inlet, 162
Sinclair Inlet, 161
Sinclair Inlet, 160


Mollusc Abundance
(# orgs/0.1 m2)
700
600
500
400
300
200
100
0
Misc. Taxa Abundance
(# orgs/0.1 m2)
30
25
20
15
10
5
0
Port Madison, 125
Port Madison, 126
Port Madison, 124
Liberty Bay, 144
Liberty Bay, 142
Liberty Bay, 143
Liberty Bay, 146
Liberty Bay, 145
Liberty Bay, 147
Southeast of Keyport, 148
North Port Orchard Pt.Bolin, 149
North Port Orchard, 150
North Port Orchard E. of Brownsville, 151
Port Orchard, 153
Port Orchard Illahee, 152
Rich Pass Lynwood Center, 155
Rich Pass Pleasant Beach, 154
South Port Orchard, 156
South Port Orchard, 158
South Port Orchard East Bremerton, 157
South Port Orchard Pt.Herron, 159
Dyes Inlet SE of Silverdale, 169
Dyes Inlet, 171
Dyes Inlet North Chico Bay, 170
Dyes Inlet Tracyton, 166
Phinney Bay, 168
Phinney Bay, 167
Sinclair Inlet, 165
Sinclair Inlet, 164
Sinclair Inlet, 163
Sinclair Inlet, 162
Sinclair Inlet, 161
Sinclair Inlet, 160

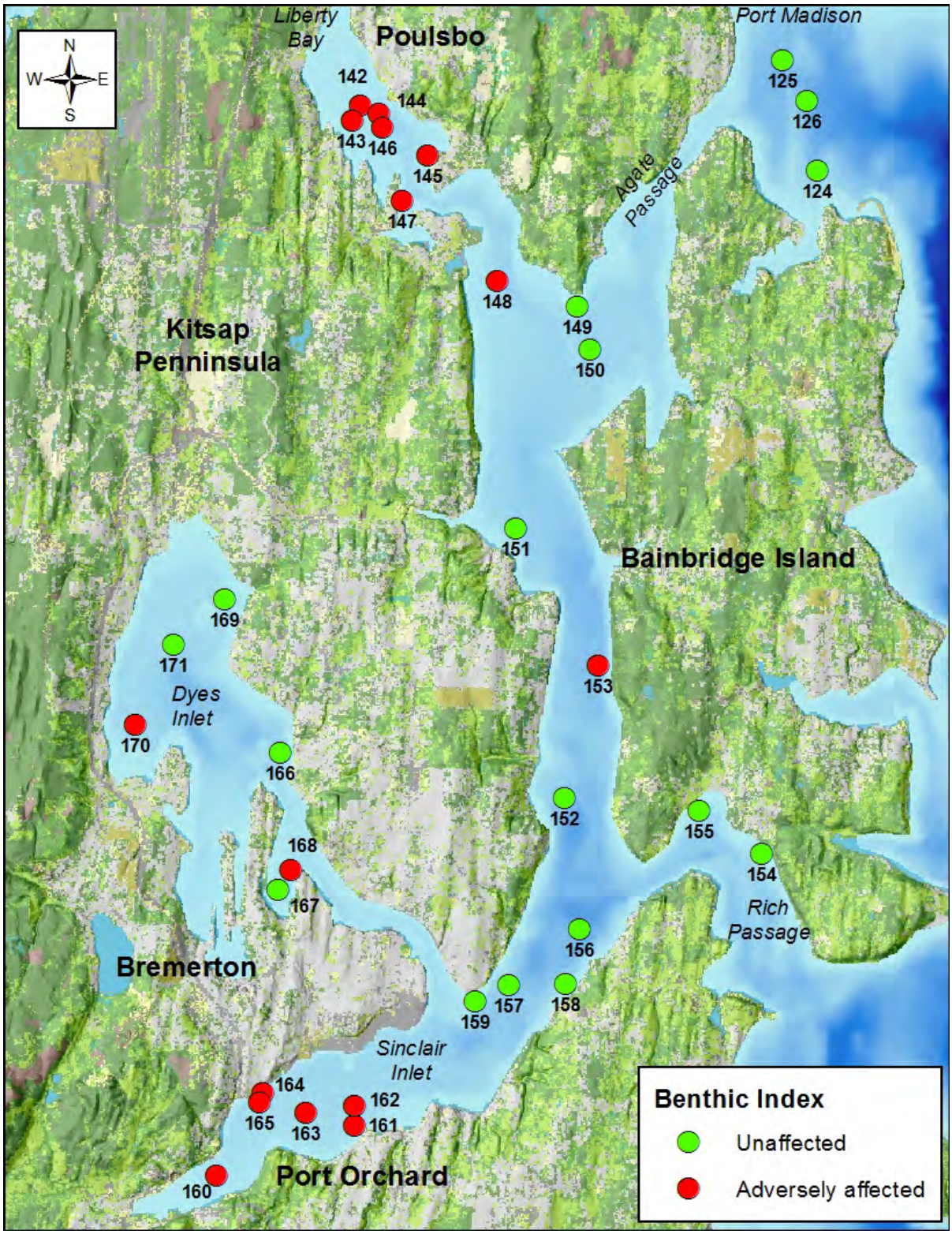
Adversely Affected Benthic Communities

Samples from the 2009 Bainbridge Basin survey with adversely affected benthos and associated station weights. Total sampling area = 81.85 km^2.

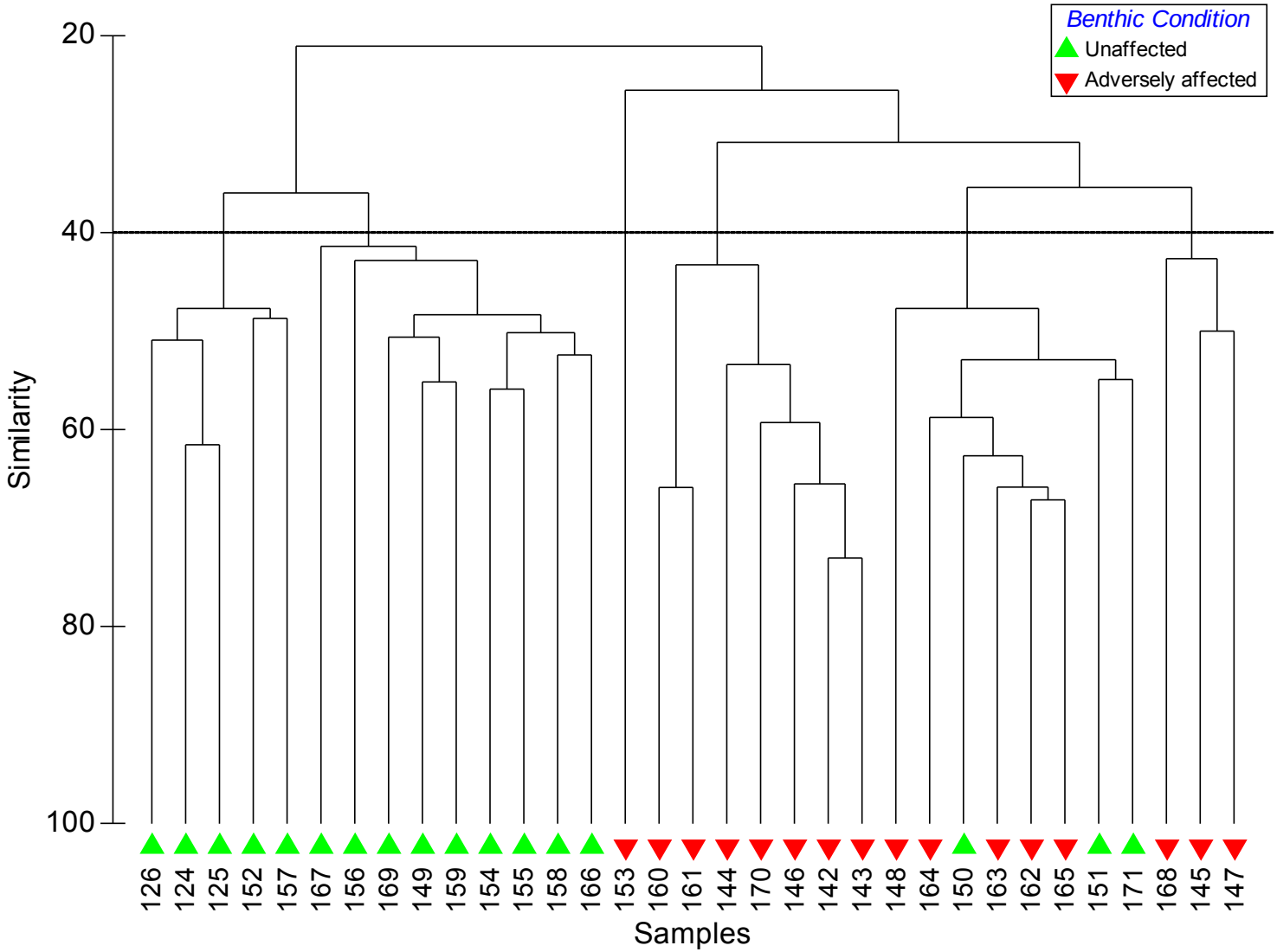
Sample	Location	km^2
142	Liberty Bay	0.62
143	Liberty Bay	0.62
144	Liberty Bay	0.62
145	Liberty Bay	0.99
146	Liberty Bay	0.99
147	Liberty Bay	0.99
148	Southeast of Keyport	4.32
153	Port Orchard	3.40
160	Sinclair Inlet	1.00
161	Sinclair Inlet	1.00
162	Sinclair Inlet	1.00
163	Sinclair Inlet	1.13
164	Sinclair Inlet	1.13
165	Sinclair Inlet	1.13
168	Phinney Bay	1.06
170	Dyes Inlet North Chico Bay	3.89
	Total	23.89

Mean and median benthic indices at stations with adversely affected and unaffected benthos in the 2009 Bainbridge Basin survey.

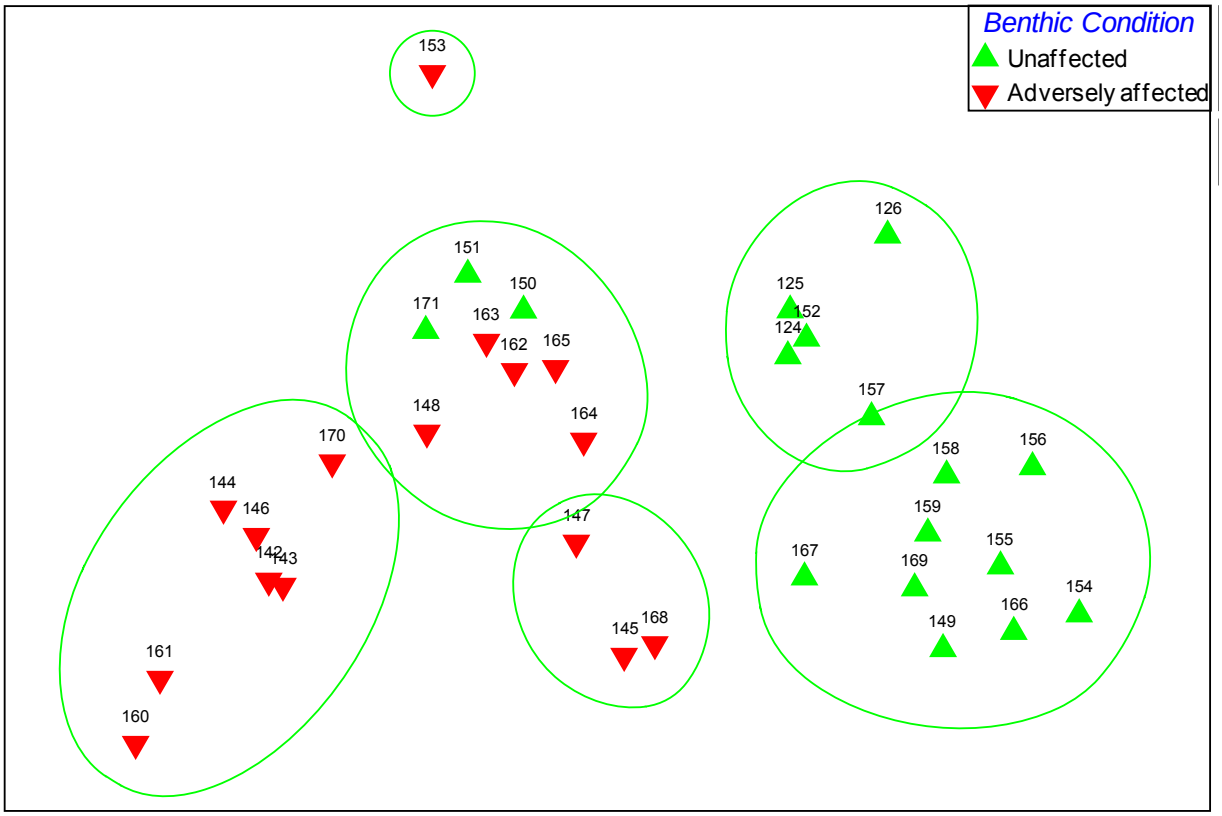
Benthic index	Adversely affected benthos		Unaffected benthos	
	Mean	Median	Mean	Median
Number of stations	16		17	
Total abundance (# orgs/0.1 m^2)	256.88	13.50	762.4	807.00
Taxa richness (# taxa/0.1 m^2)	23.75	21.00	82.00	82.00
Pielou's Evenness (J')	0.72	0.76	0.75	0.76
Swartz' Dominance Index (# taxa)	6.50	7.00	15.94	16.00
Annelid abundance	159.06	60.50	306.90	270.00
Arthropod abundance	53.38	21.00	122.20	99.00
Mollusc abundance	32.13	22.50	264.90	206.00
Echinoderm abundance	9.06	0.50	52.94	31.00
Abundance of misc. taxa	3.25	2.00	15.29	17.00



Spatial patterns in adversely affected benthic invertebrate assemblages in the 2009 Bainbridge Basin survey.
The numbers on the map are the station identifications.



Cluster dendrogram of benthic invertebrate assemblages in the 2009 Bainbridge Basin survey, indicating adversely affected and unaffected assemblages (Bray-Curtis similarities of 4th-root-transformed abundances, all species). The dendrogram is sliced at 40% similarity.



Nonmetric multidimensional scaling (MDS) diagram indicating relative similarities of adversely affected and unaffected benthic invertebrate assemblages in the 2009 Bainbridge Basin sediment survey (Bray-Curtis similarities of 4th-root-transformed abundances, all species; 2D stress=0.11). The closer the symbols are in the diagram, the more similar their assemblages are. Ellipses indicate 40% similarity.

Comparison with 1998

Summary of statistical comparisons of 1998 PSAMP/NOAA and 2009 Urban Waters Initiative measures of benthic invertebrate abundance and diversity.

↓ = decrease; ↑ = increase; -- = no change; ? indicates 0.05 < p-value ≤ 0.10.

Benthic invertebrate measure	Results of Unweighted Comparisons[1]	Results of Weighted (CDF) Comparisons[2]
Total Abundance	↓	--
Taxa Richness	↓	?, mixed
Pielou's Evenness	↑	--
Swartz' Dominance	--	--
SDI Standardized by Richness	--	--
Annelid Abundance	↓	↓
Arthropod Abundance	↓	↓
Echinoderm Abundance	↓	--
Mollusc Abundance	--	--
Abundance of Misc. Taxa	↓	--
Overall condition of assemblage	**Result of Unweighted Comparison[3]**	**Result of Weighted Comparison[4]**
Adversely affected	↑	↑
Unaffected	↓	↓

[1] Paired Wilcoxon signed rank test, $\alpha = 0.05$

[2] Wald F test, $\alpha = 0.05$

[3] Likelihood ratio test, $\alpha = 0.05$

[4] Olsen et al. (in prep.), $\alpha = 0.05$

Graphical summaries and spatial patterns of measures of benthic invertebrate abundance and diversity in sediments collected from the 2009 Urban Waters Initiative study. Comparisons to 1998 results from the PSAMP/NOAA survey are included.

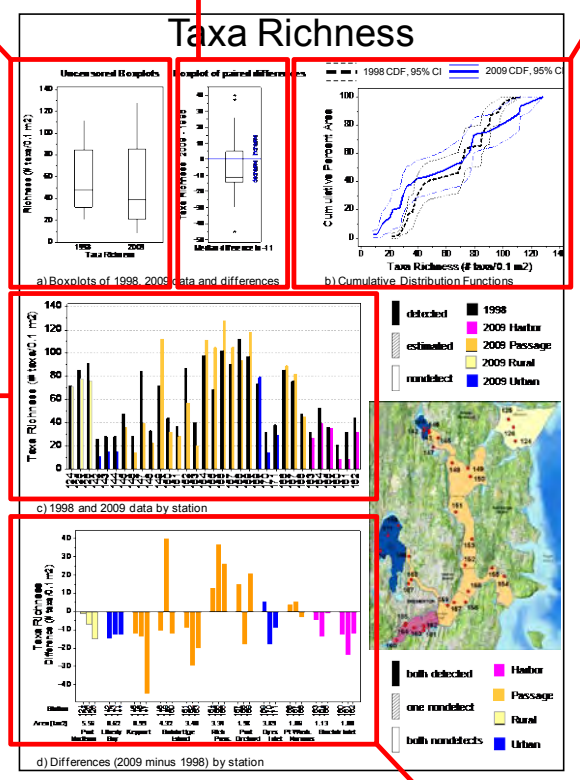
Elements of Graphical Summaries

The graphical summaries in this appendix display the following information for each parameter.

Boxplots
Boxplots of data for each year for that parameter.

Boxplot of differences
2009 minus 1998 by station:
positive = increase,
negative = decrease.
Median difference indicated.

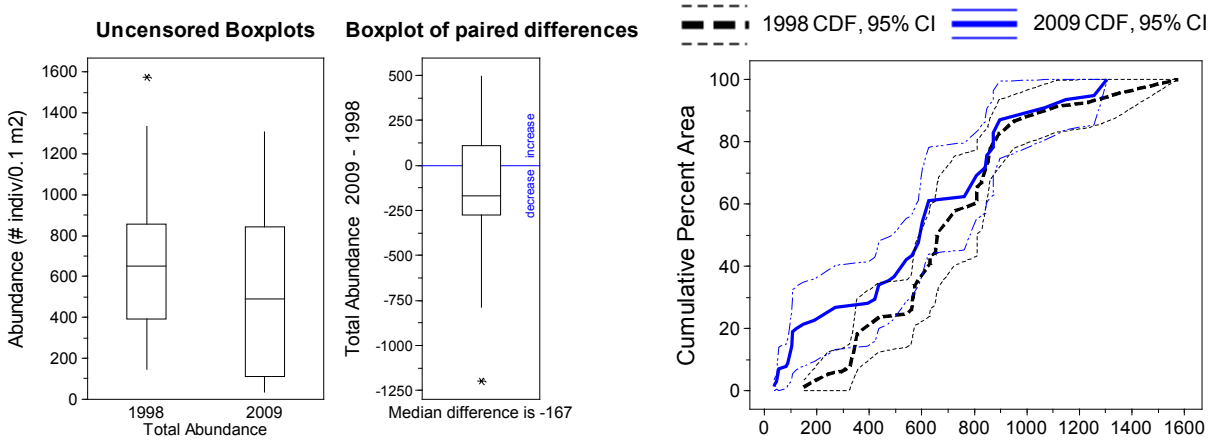
CDF comparisons
Cumulative Distribution Function (CDF) = % of area summed cumulatively for increasing values of parameter.
Also shown are confidence intervals (CI) for estimated % area.



Raw data by station and year, ordered approximately north to south

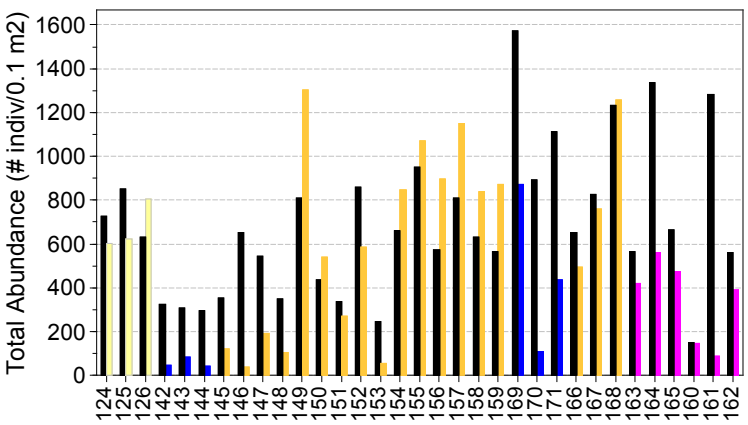
Differences (2009 minus 1998) by station, ordered approximately north to south
Paired differences: *negative = decrease, positive = increase.*

Total Abundance

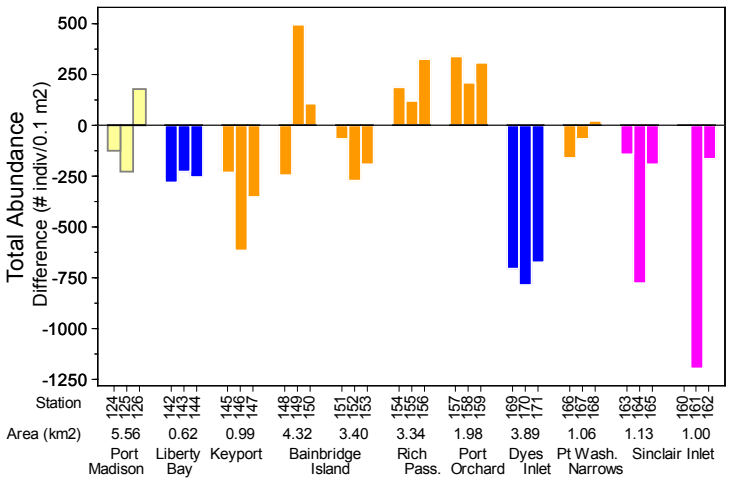


a) Boxplots of 1998, 2009 data and differences

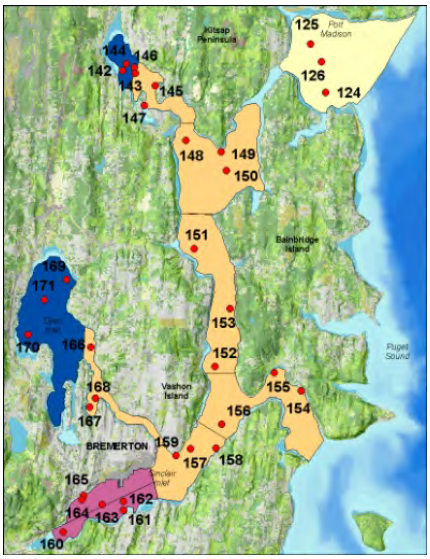
b) Cumulative Distribution Functions



c) 1998 and 2009 data by station



d) Differences (2009 minus 1998) by station



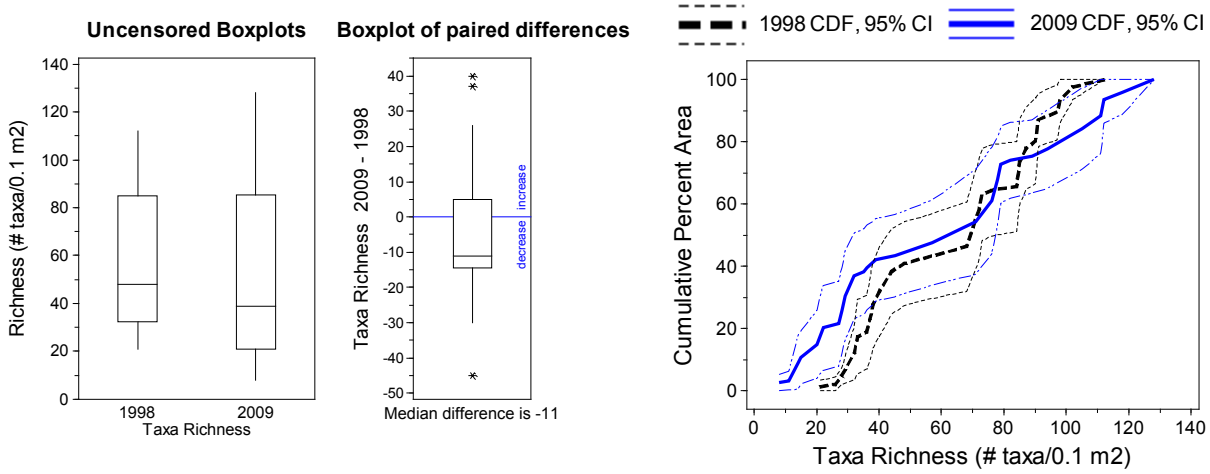
detected
estimated
nondetect

1998
2009 Harbor
2009 Passage
2009 Rural
2009 Urban

both detected
one nondetect
both nondetects

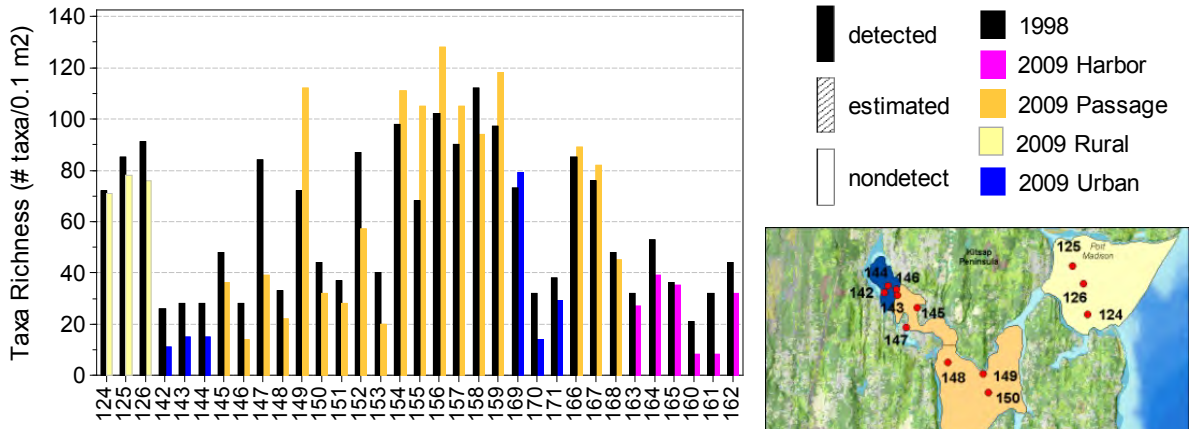
Harbor
Passage
Rural
Urban

Taxa Richness

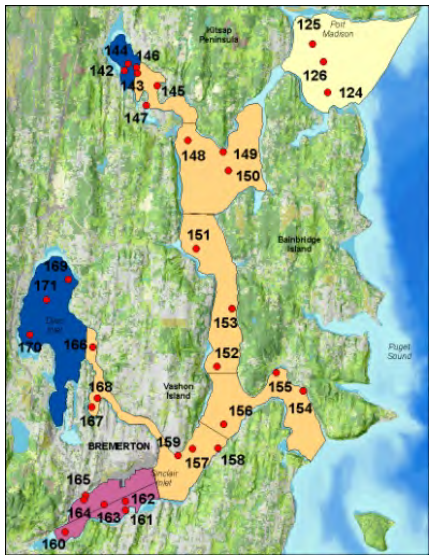


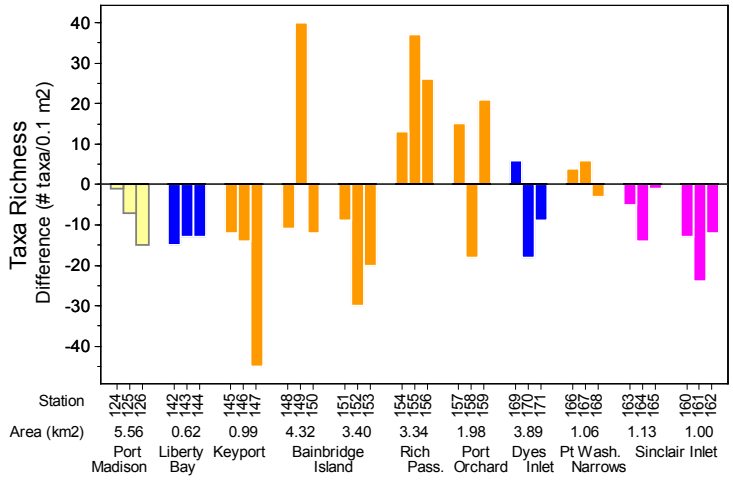
a) Boxplots of 1998, 2009 data and differences

b) Cumulative Distribution Functions



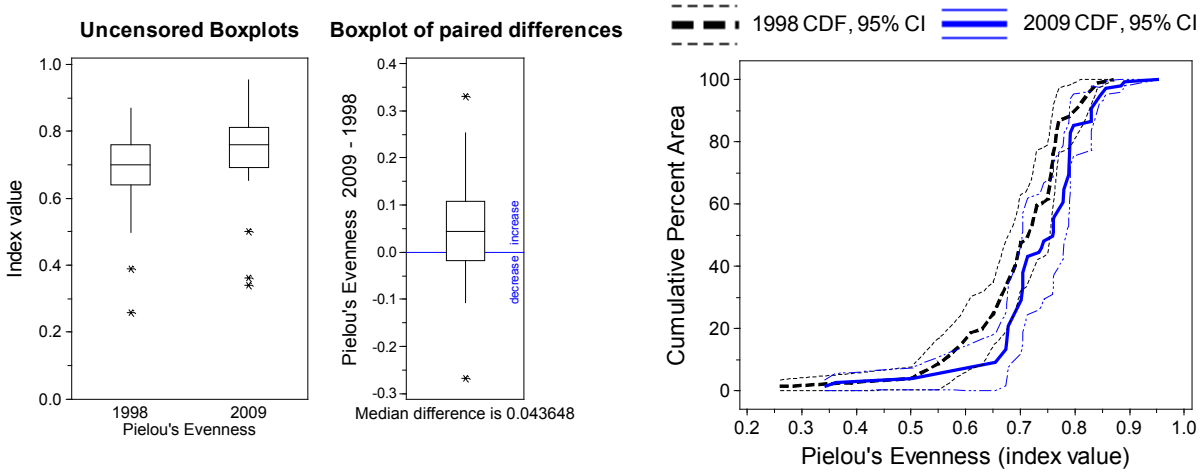
c) 1998 and 2009 data by station





d) Differences (2009 minus 1998) by station

Pielou's Evenness



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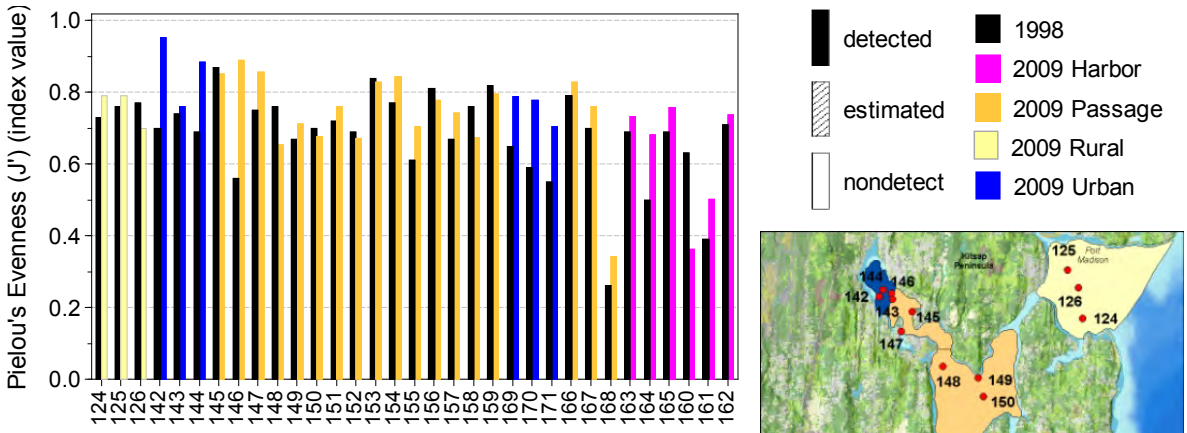
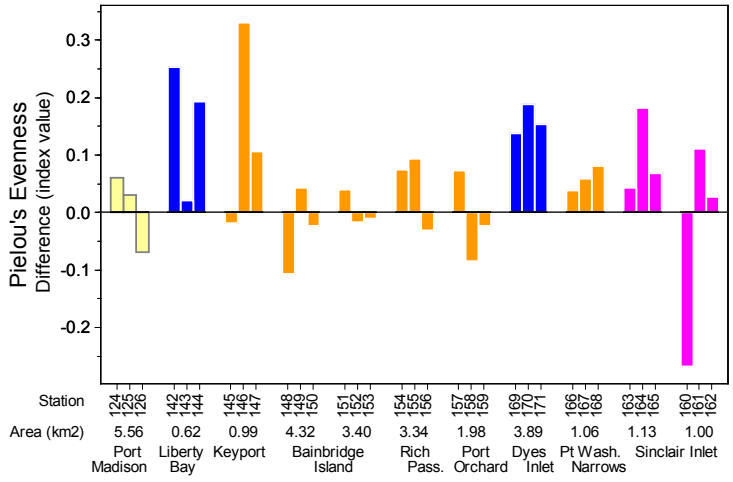
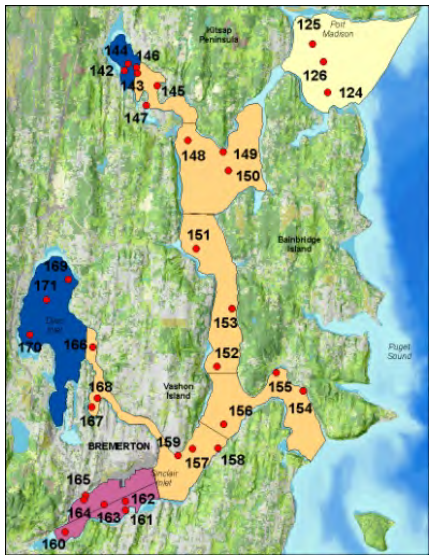
b) Cumulative Distribution Functions



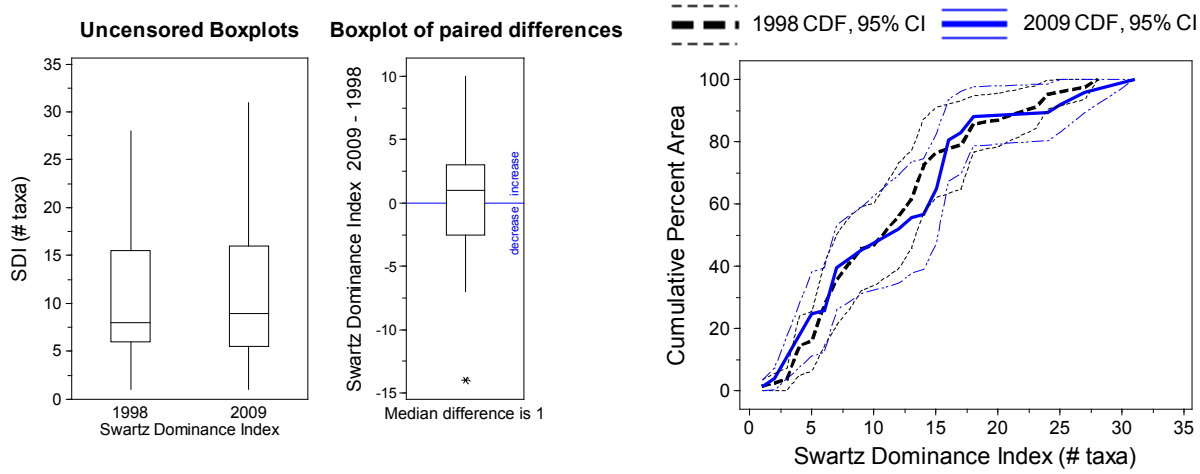
c) 1998 and 2009 data by station





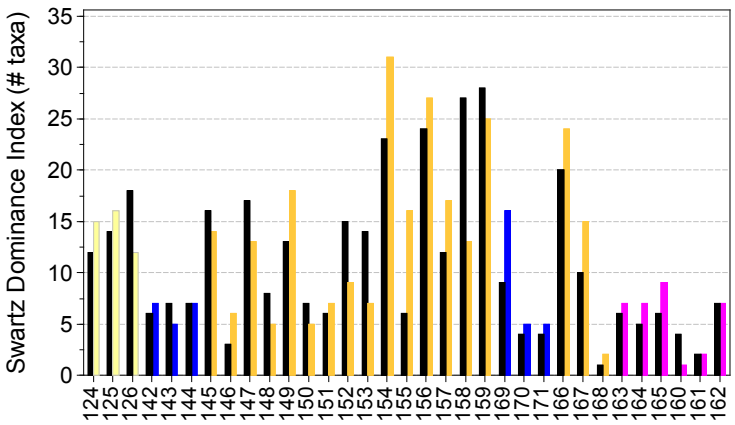
d) Differences (2009 minus 1998) by station

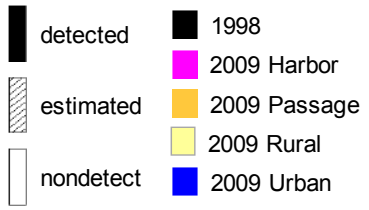
Swartz Dominance Index



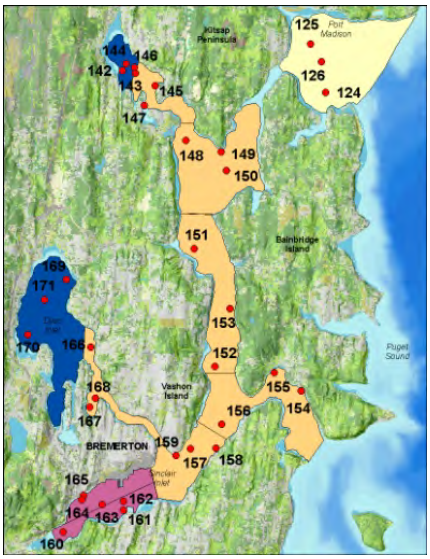
a) Boxplots of 1998, 2009 data and differences

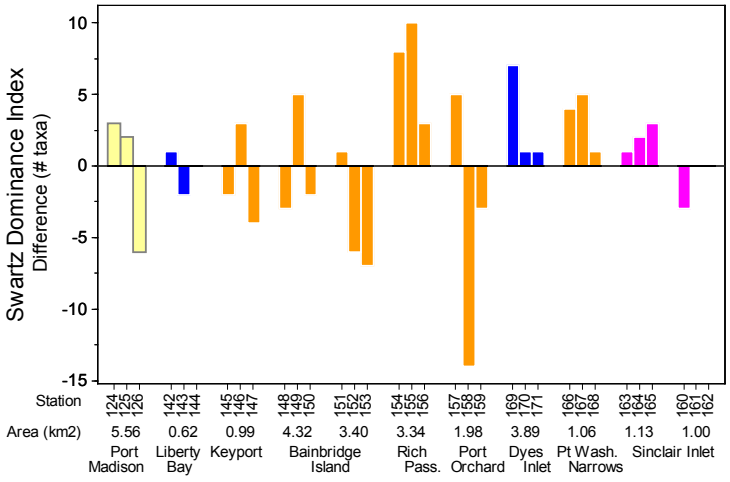
b) Cumulative Distribution Functions





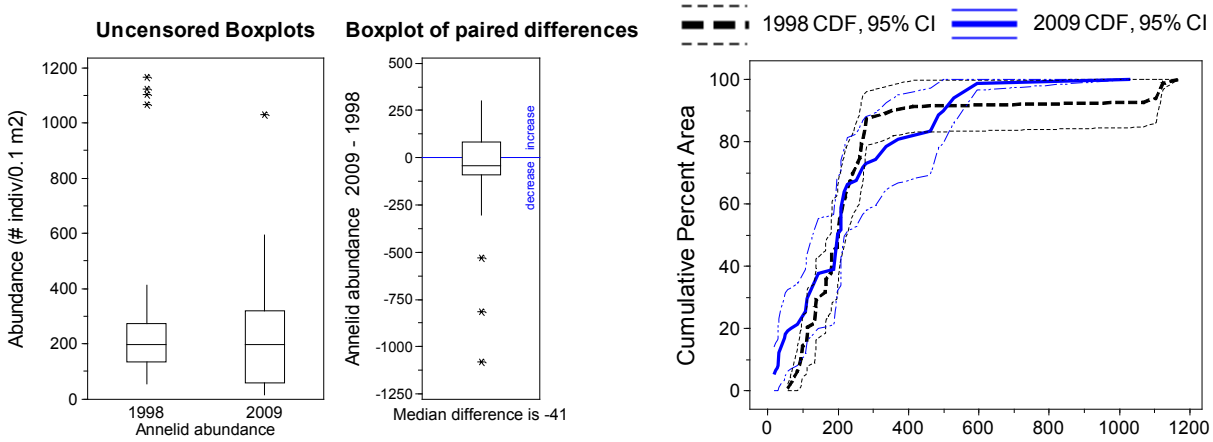
c) 1998 and 2009 data by station





d) Differences (2009 minus 1998) by station

Annelida



a) Boxplots of 1998, 2009 data and differences

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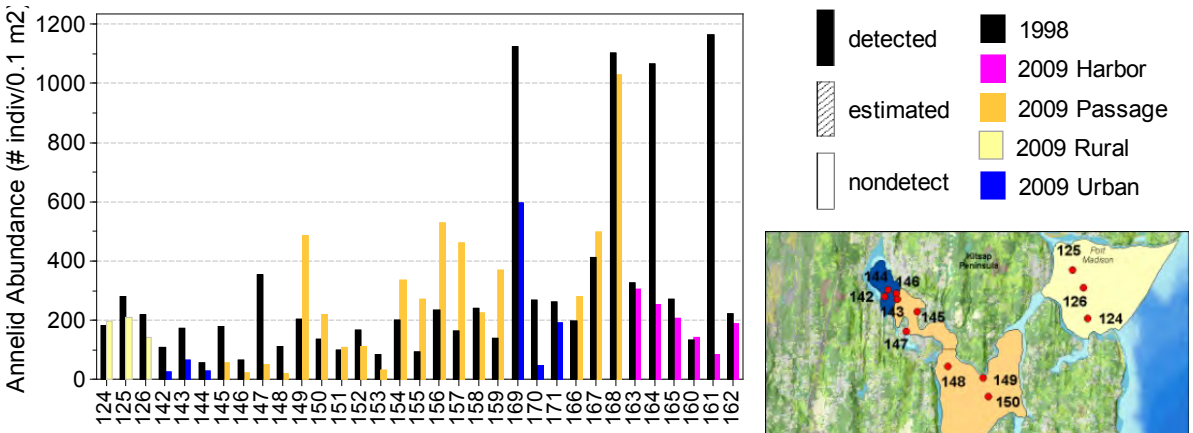
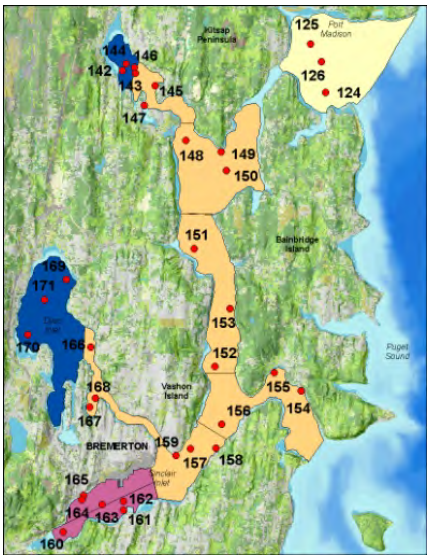
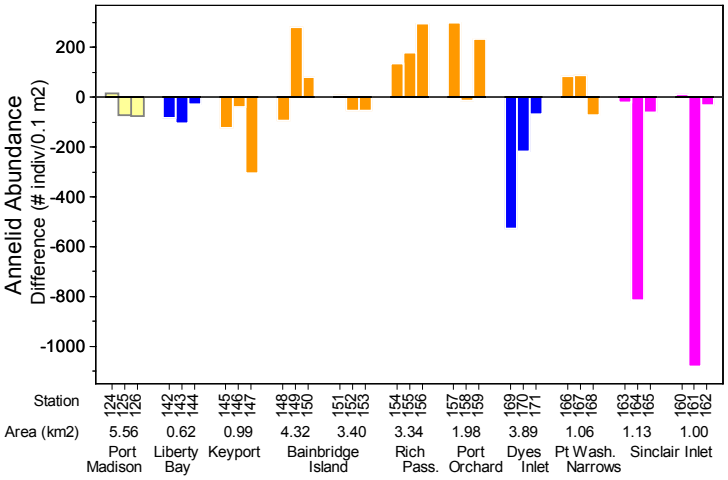


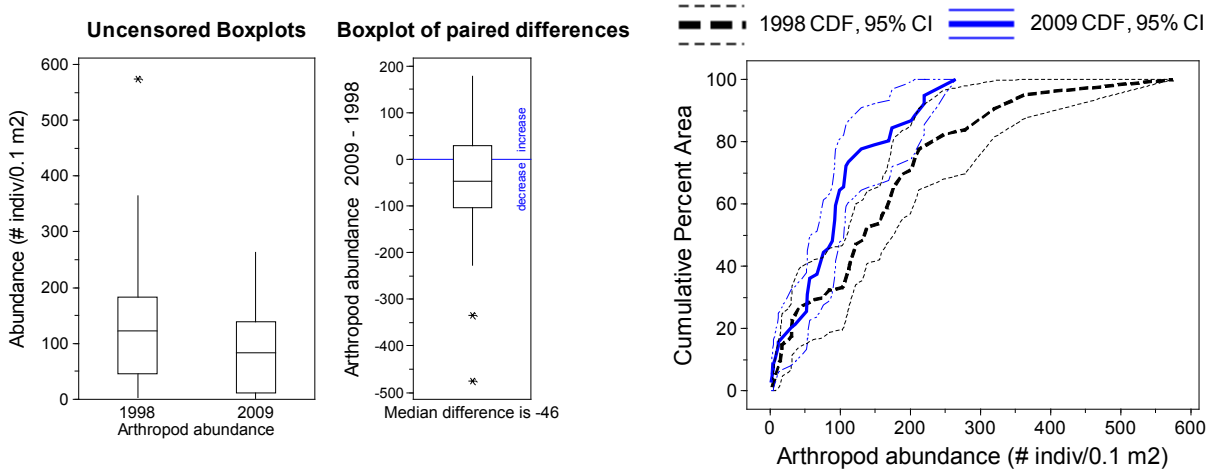
c) 1998 and 2009 data by station





d) Differences (2009 minus 1998) by station

Arthropoda



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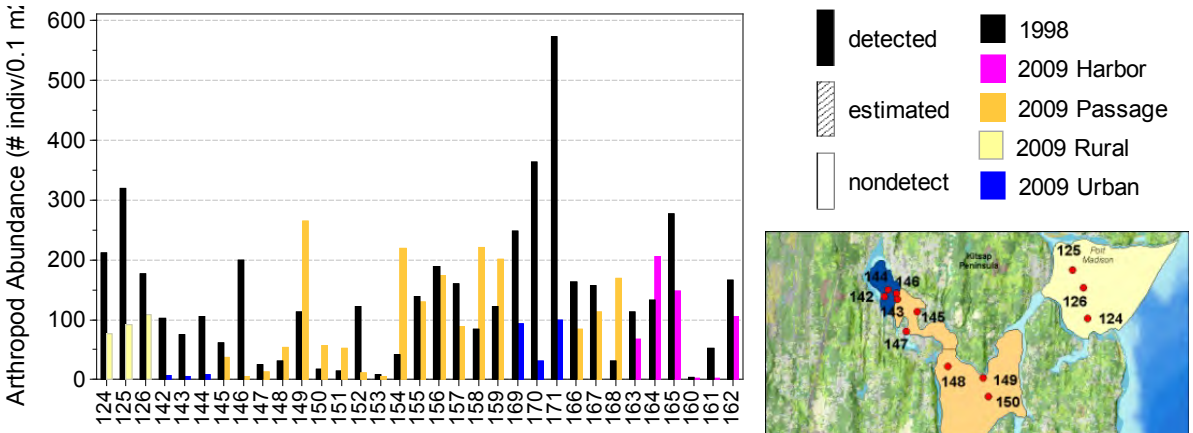
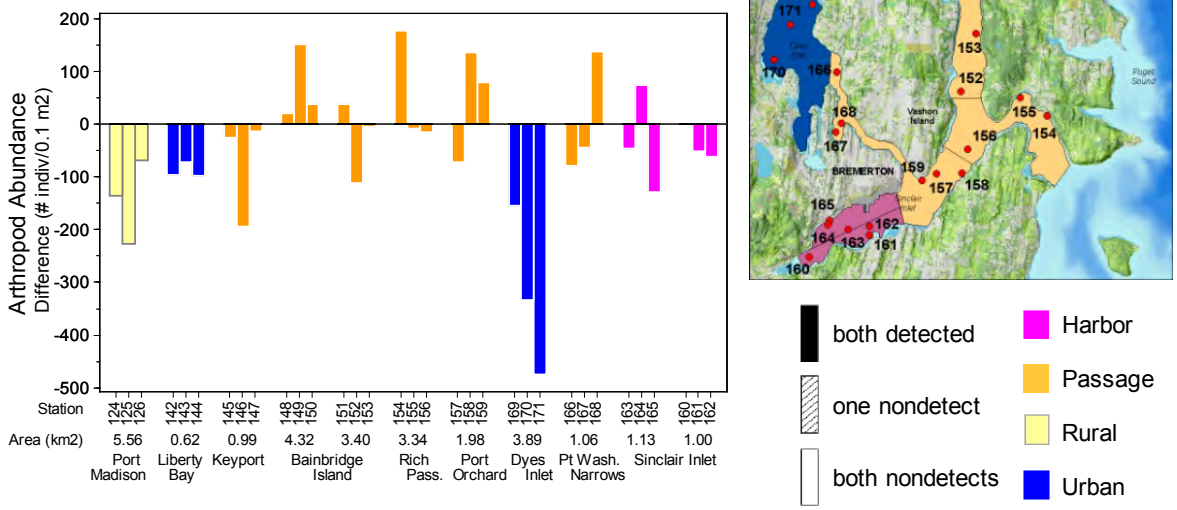
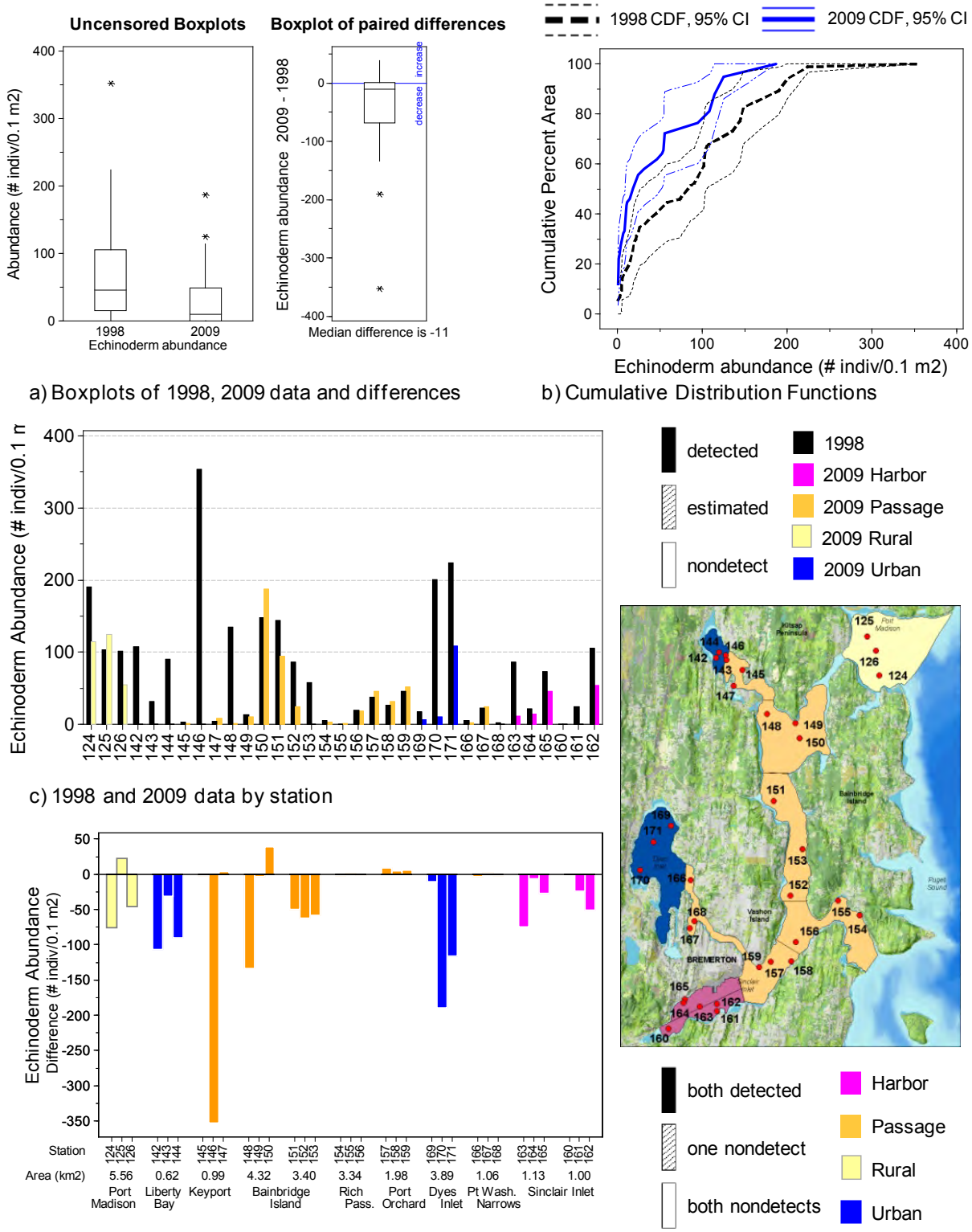


c) 1998 and 2009 data by station

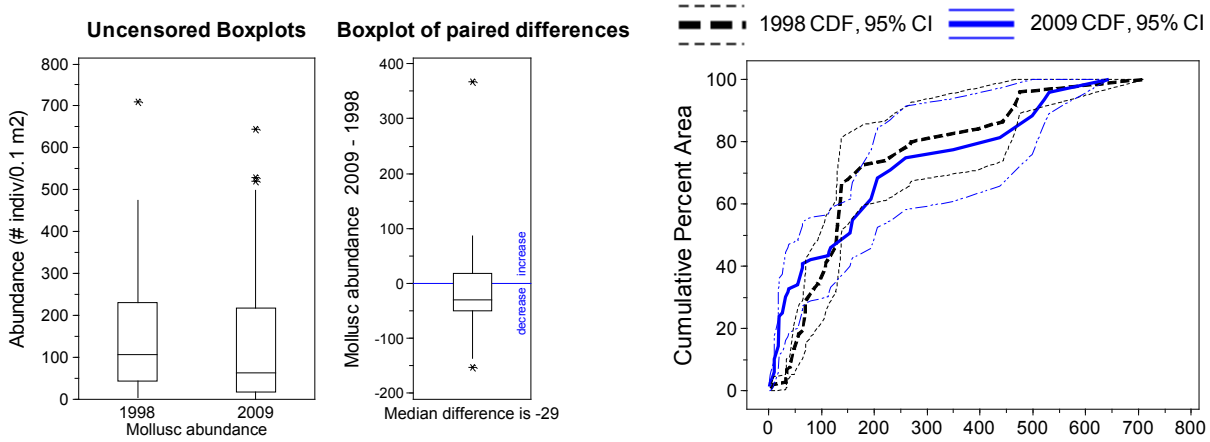


d) Differences (2009 minus 1998) by station

Echinodermata



Mollusca



a) Boxplots of 1998, 2009 data and differences

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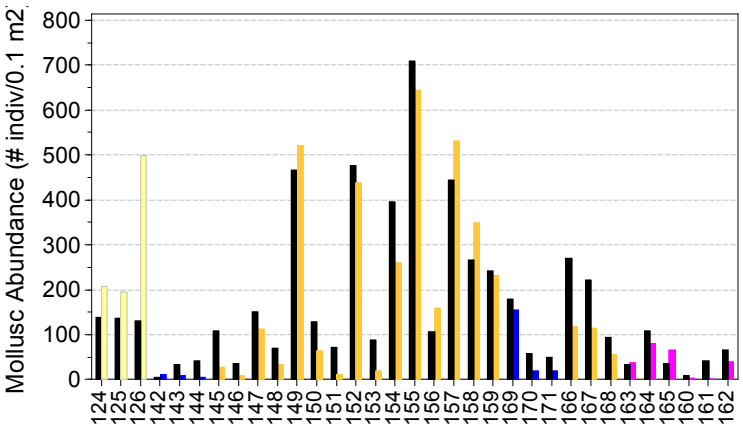
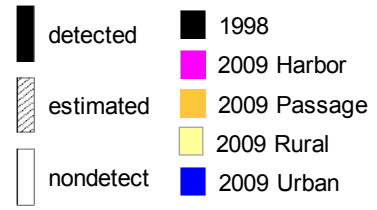
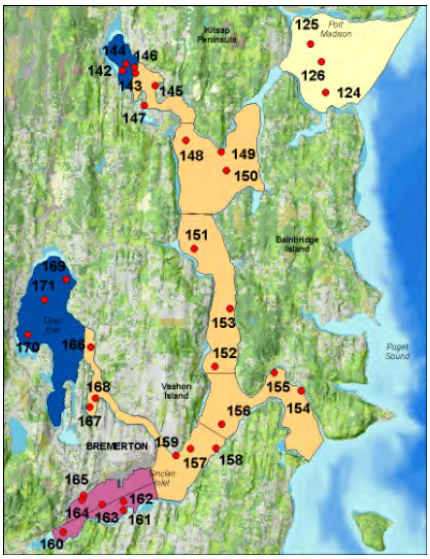
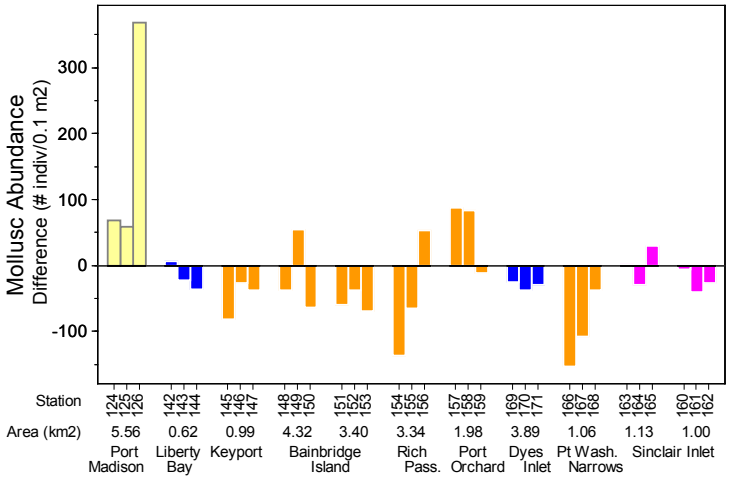




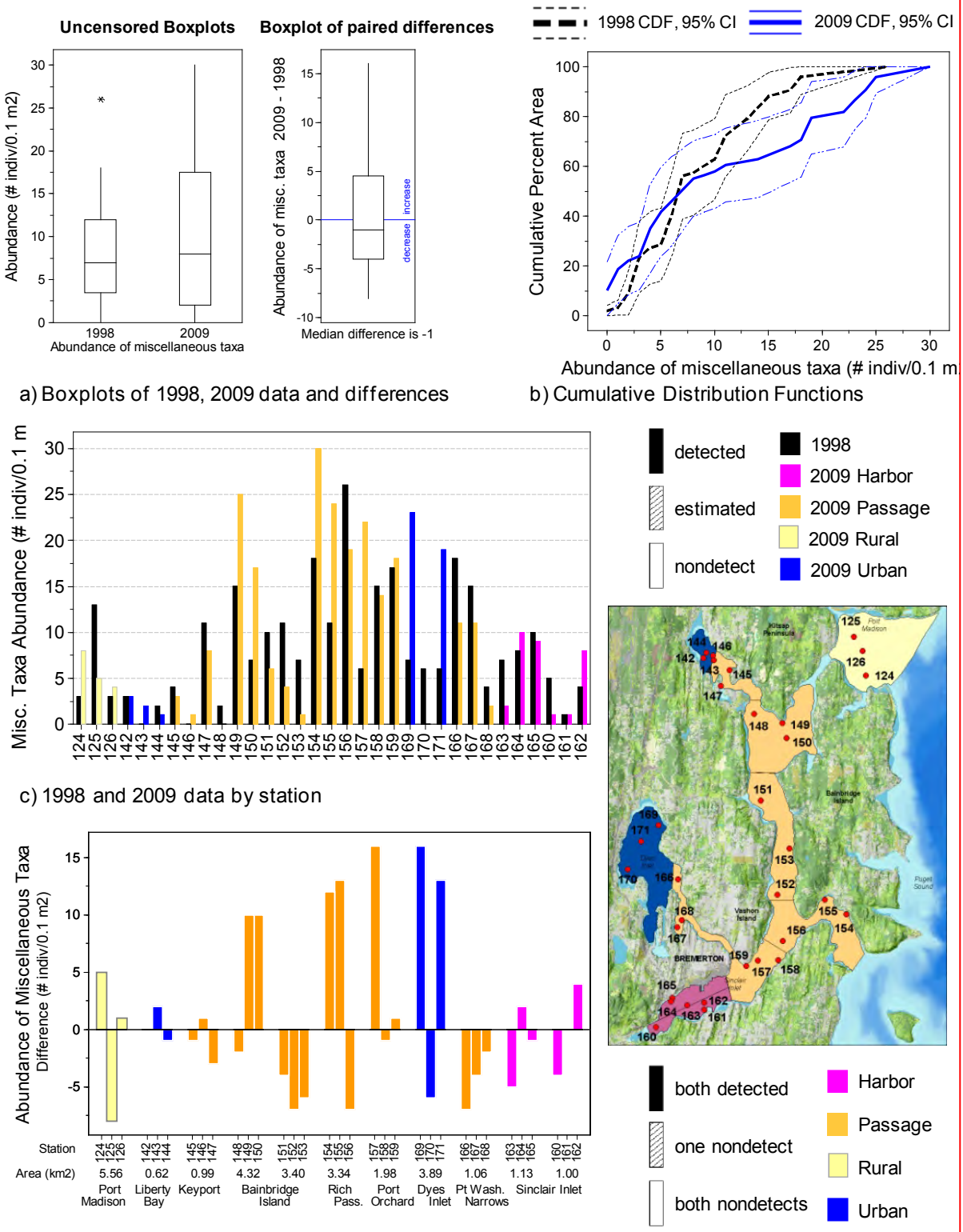
c) 1998 and 2009 data by station





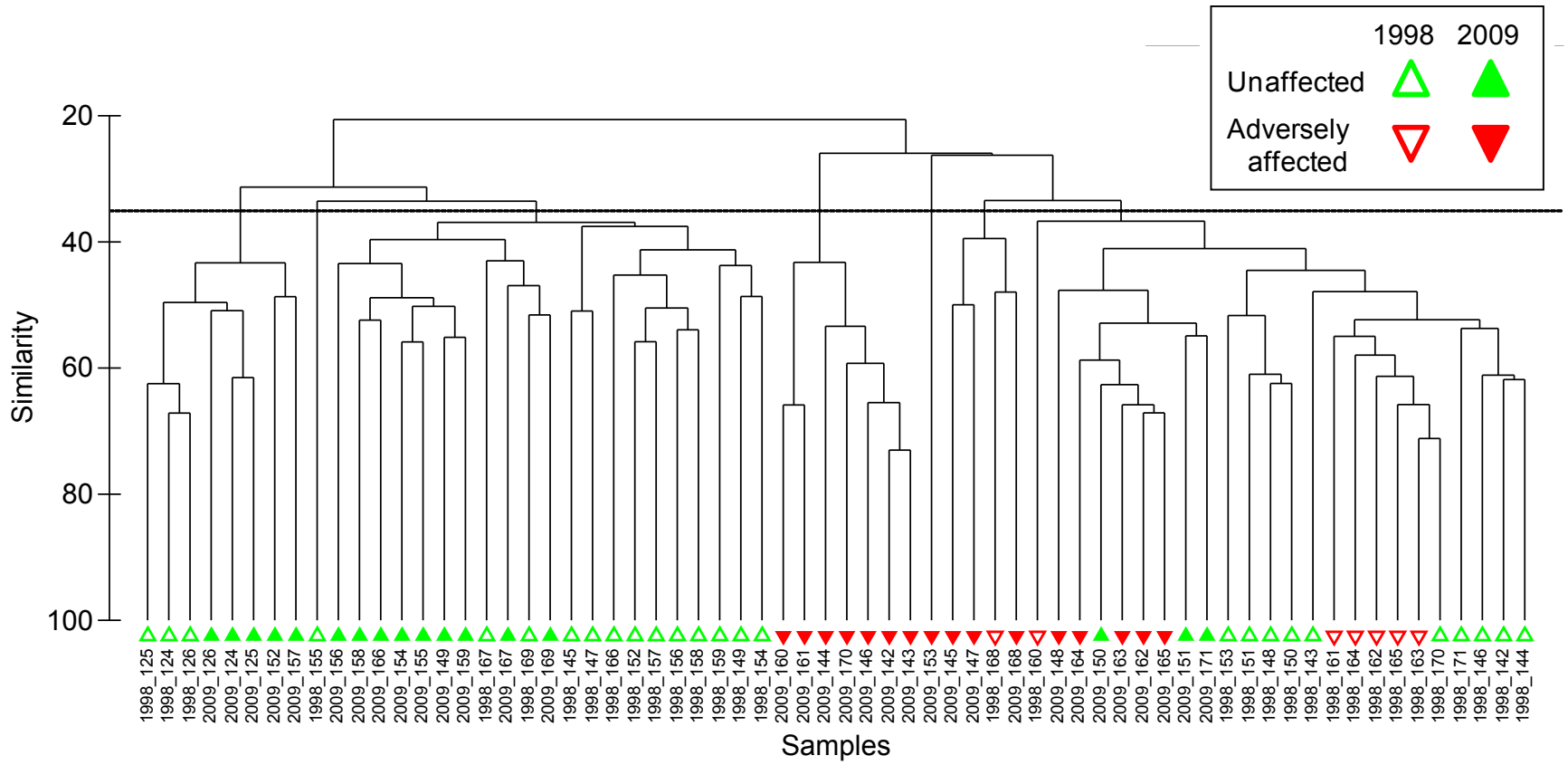
d) Differences (2009 minus 1998) by station

Miscellaneous Taxa

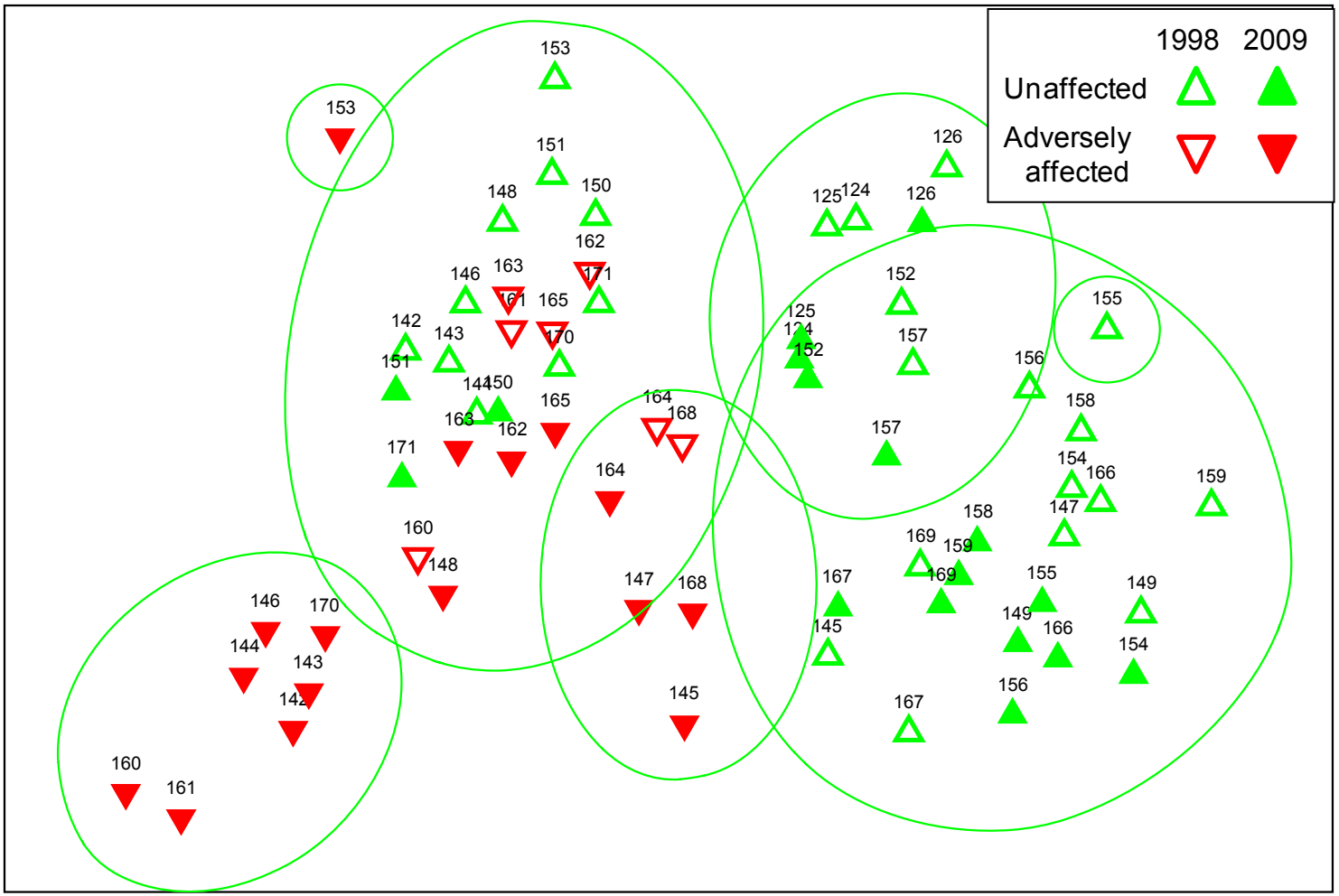


Summary statistics for benthic indices in the 1998 PSAMP/NOAA survey and the 2009 Urban Waters survey of the Bainbridge Basin.

Benthic index	1998 (N=33)					2009 (N=33)				
	Mean	StDev	Median	Min	Max	Mean	StDev	Median	Min	Max
Total abundance (# orgs/0.1 m^2)	689	339	650	149	1574	517.3	385.4	492	36	1305
Taxa richness (# taxa/0.1 m^2)	58.8	27.44	48	21	112	53.8	37.79	39	8	128
Pielou's Evenness (J')	0.68	0.125	0.7	0.26	0.87	0.74	0.13	0.76	0.34	0.95
Swartz Dominance (SDI) (# taxa)	10.9	7.33	8	1	28	11.4	7.53	9	1	31
Annelid abundance	303.6	316.8	199	56	1165	235.2	216.4	197	17	1030
Arthropod abundance	139.1	119.3	122	3	574	88.8	75.9	83	1	264
Mollusc abundance	75.1	80.6	46	0	353	31.7	45.74	10	0	187
Echinoderm abundance	163	165.2	107	4	709	152.1	183.4	64	1	644
Abundance of misc. taxa	8.3	6.14	7	0	26	9.5	8.73	8	0	30



Cluster dendrogram of benthic invertebrate assemblages in the 1998 and 2009 Bainbridge Basin surveys, indicating adversely affected and unaffected assemblages (Bray-Curtis similarities of 4th-root-transformed abundances, all species). The dendrogram is sliced at 35% similarity.



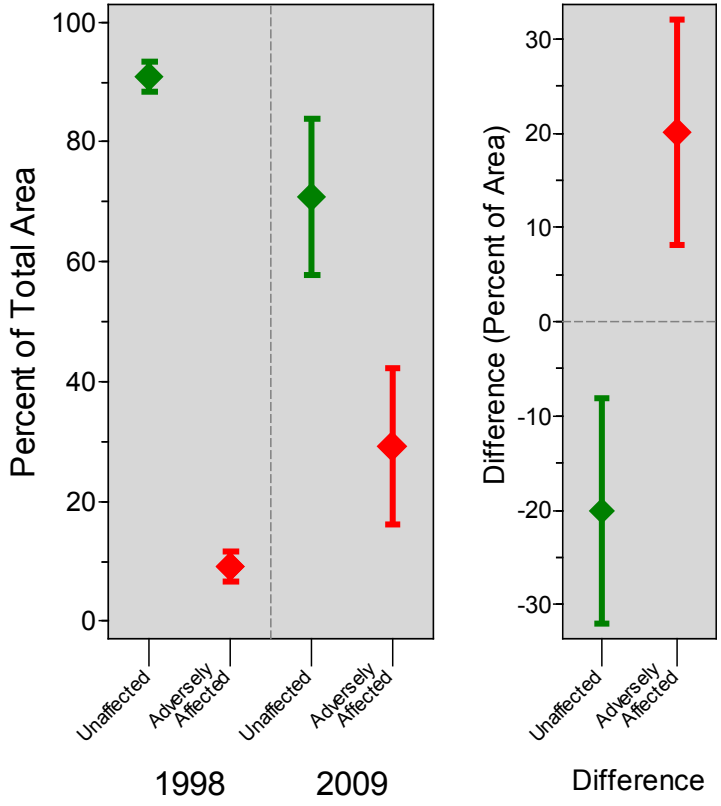
Nonmetric multidimensional scaling (MDS) diagram indicating relative similarities of adversely affected and unaffected benthic invertebrate assemblages in the 1998 and 2009 sediment surveys of Bainbridge Basin (Bray-Curtis similarities of 4th-root-transformed abundances, all species; 2D stress=0.15). The closer the symbols are in the diagram, the more similar their assemblages are. Ellipses indicate 35% similarity.

Comparison of Interim Sediment Benthic Index Categories by Year

Estimated spatial extent (percent of area) and 95% confidence intervals for each of the Interim SBI categories for the Bainbridge Basin in 2009, compared to 1998. The differences between the years are statistically significant, as indicated by the difference confidence intervals *not* containing the value zero.

Interim Sediment Benthic Index Category	1998			2009			Difference (2009-1998)			* = significantly different (alpha=0.05)
		Confidence Limit			Confidence Limit			Confidence Limit		
	Estimate	Lower	Upper	Estimate	Lower	Upper	Estimate	Lower	Upper	
Unaffected	90.89	88.33	93.45	70.81	57.84	83.78	-20.08	-32.08	-8.08	*
Adversely affected	9.11	6.55	11.67	29.19	16.22	42.16	20.08	8.08	32.08	*

* Olsen et al. (in prep.), α = 0.05



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
Bainbridge Basin	1998	33	21.2	9.1
	2009	33	48.5	29.2
Central Puget Sound	1998-1999	128	32.8	6.9
	2008-2009	80	33.8	28.0
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 2009 Bainbridge Basin.

StationID	Location	Date Sampled	Sorted by	QA/QC Sorter	25% QA/QC Pass/Fail	Action Taken
124	Port Madison	6/4/09	S Weeks	S Weakland	Pass	none
125	Port Madison	6/4/09	S Weeks	S Weakland	Pass	none
126	Port Madison	6/4/09	S Weeks	S Weakland	Pass	none
142	Liberty Bay	6/8/09	S Weeks	S Weakland	Fail	100% resort
143	Liberty Bay	6/8/09	S Weeks	S Weakland	Pass	none
144	Liberty Bay	6/8/09	S Weeks	S Weakland	Pass	none
145	Liberty Bay	6/8/09	S Weeks	S Weakland	Fail	100% resort
146	Liberty Bay	6/8/09	S Weeks	S Weakland	Pass	none
147	Liberty Bay	6/8/09	S Weeks	S Weakland	Fail	100% resort
148	Southeast of Keyport	6/8/09	S Weeks	S Weakland	Pass	none
149	North Port Orchard Pt.Bolin	6/9/09	S Weeks	S Weakland	Pass	none
150	North Port Orchard	6/8/09	S Weeks	S Weakland	Pass	none
151	North Port Orchard E. of Brownsville	6/9/09	S Weeks	S Weakland	Pass	none
152	Port Orchard Illahee	6/9/09	S Weeks	S Weakland	Pass	none
153	Port Orchard	6/9/09	S Weeks	S Weakland	Pass	none
154	Rich Pass Pleasant Beach	6/9/09	S Weeks	S Weakland	Pass	none
155	Rich Pass Lynwood Center	6/9/09	S Weeks	S Weakland	Pass	none
156	South Port Orchard	6/12/09	S Weeks	S Weakland	Pass	none
157	South Port Orchard East Bremerton	6/12/09	S Weeks	S Weakland	Pass	none
158	South Port Orchard	6/12/09	S Weeks	S Weakland	Pass	none
159	South Port Orchard Pt.Herron	6/12/09	S Weeks	S Weakland	Pass	none
160	Sinclair Inlet	6/15/09	S Weeks	S Weakland	Pass	none
161	Sinclair Inlet	6/15/09	S Weeks	S Weakland	Pass	none
162	Sinclair Inlet	6/15/09	S Weeks	S Weakland	Pass	none
163	Sinclair Inlet	6/15/09	S Weeks	S Weakland	Fail	100% resort
164	Sinclair Inlet	6/15/09	S Weeks	S Weakland	Pass	none
165	Sinclair Inlet	6/15/09	S Weeks	S Weakland	Pass	none
166	Dyes Inlet Tracyton	6/10/09	S Weeks	S Weakland	Pass	none
167	Phinney Bay	6/10/09	S Weeks	S Weakland	Fail	100% resort
168	Phinney Bay	6/10/09	S Weeks	S Weakland	Pass	none

StationID	Location	Date Sampled	Sorted by	QA/QC Sorter	25% QA/QC Pass/Fail	Action Taken
169	Dyes Inlet SE of Silverdale	6/10/09	S Weakland	K Welch	Pass	none
170	Dyes Inlet North Chico Bay	6/10/09	S Weakland	K Welch	Pass	none
171	Dyes Inlet	6/10/09	S Weakland	K Welch	Pass	none

Infauna sediment sample taxonomy quality assurance and quality control for the 2009 Bainbridge Basin survey.

	Crustacea	Misc. Taxa	Echinodermata	Annelida	Mollusca
Primary Taxonomist	Jeffery Cordell	Steven Hulsman	Steven Hulsman	Eugene 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	2	0	13	0
Voucher Specimens confirmed	NA	2	NA	13	NA