9. SELECTED INVERTEBRATES

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Numerous invertebrates use the nearshore environment in Puget Sound, including native littleneck, butter clam, Manila clam, geoduck, Olympia oyster, northern abalone, and Dungeness crab(Figure 20). This section discusses the populations of these invertebrates in WRIAs 8 and 9.

Known stressors to invertebrates tend to be the same as those for nearshore fish. These include habitat loss; shoreline siltation caused by construction; dredging in nearshore habitats; water pollution, especially from non-point sources; and overharvesting.

There are no recent quantitative studies of invertebrate populations in WRIAs 8 and 9. Several site-specific studies, referenced in the following sections, have given us data about populations along the coasts of Vashon Island and Maury Island. Without comprehensive data, however, this gap makes it difficult to thoroughly assess population trends.

NATIVE LITTLENECK (PROTOTHACA STAMINEA)

The species is also known as the Pacific littleneck or any of several other common names (Emmett et al. 1991; Turgeon et al. 1998).

Current Distribution

The native littleneck occurs over a wide range of the North Pacific basin, ranging from Mexico to the Aleutian Islands, possibly to the northern portion of the Sea of Japan (Emmett et al. 1991). This species, which is a poor burrower (Ricketts et al. 1985), is primarily found in gravel to clay-gravel habitats, but can occur in sediments ranging from mud to cobble (Emmett et al. 1991). Current information on the distribution and abundance of the native littleneck and other hardshell clams is derived from the Beach Assessment Program Report (King County 1998). This study involved a considerable amount of sampling at 14 beaches in King County. However, before using the abundance (or biomass) data collected during the study, it should be mentioned that the clam surveys were "stratified" (i.e., restricted) to certain portions of the beaches (presumably known clam beds) and therefore the data presented reflect only those beds and not the entire beach area. Also, densities reported in the study were calculated including only those samples that contained clams and are thus overestimates of the true clam densities within a bed. All of the clam densities reported below (Table 32) were recalculated from the raw collection data and include samples that contained no clams. In two cases, Burton Acres Park and Tramp Harbor, the calculated densities are only estimates because the exact number of samples collected was not presented in the report. Nonetheless, the report is a valuable contribution to the present knowledge of the nearshore environments in King County.

WRIA 8 – Density of littleneck clams at Edwards Point at the south end of reach 1, has been measured at $28/m^2$ (J. Houghton, Pentec Environmental, unpublished data). Remaining littleneck data are from areas comprising reach 2. Littlenecks were most abundant at Carkeek Park ($77/m^2$) and at Point Wells ($31/m^2$) and least abundant at Richmond Beach ($0.5/m^2$).

WRIA 9 – Along the mainland portion of WRIA 9, littlenecks were most abundant in reach 5, where abundance ranged from 46/m^2 (Mee Kwa Mooks Park) to 81/m^2 (Alki Beach). Littleneck densities along the southern mainland coast of the area were much lower, ranging from 6/m^2 (Seahurst State Park) to 17/m^2 (Lincoln Park South). Along Vashon Island (reaches 9 and 10), littleneck abundances were relatively high, ranging from 19/m^2 (Dockton Park) to 110/m^2 (Burton Acres Park).

Historical Distribution

Within Puget Sound, the native littleneck was listed as very abundant (Emmett et al. 1991) and typically has been among the most abundant larger clams reported in several environmental surveys since the 1970s (i.e., Armstrong et al. 1976; Armstrong et al. 1976; Thom et al. 1984). Lincoln Park (reaches 5 and 6) is the only location within WRIA 8 or WRIA 9 that has been sampled more than once between the early 1970s and the late 1990s. Throughout that time period, littleneck densities may have decreased slightly from 18/m^2 in 1974-76 (Armstrong et al. 1976) to 8/m^2 in 1990 (Thom and Hamilton 1990). From data supplied in the recent beach survey (King County 1998), littleneck density at Lincoln Park was calculated at 29/m^2. Armstrong et al. (1976) also reported littleneck abundances at Carkeek Park (30/m^2), Point Wells (6/m^2), and West Point (1/m^2). Data from the late 1990s (King County 1998) showed increased densities at Carkeek Park (81/m^2) and Point Wells (31/m^2), but had no data from West Point. Thom et al. (1984) reported littleneck densities at Seahurst Park that ranged from 50/m^2 to 133/m^2 between summer 1982 and winter 1983/4. The beach assessment study found littleneck densities of about 6/m^2 at Seahurst in 1996 (King County 1998).

BUTTER CLAM (SAXIDOMUS GIGANTEA)

The species is also known as the Washington or money clam (Ricketts et al. 1985), or the smooth Washington clam (Abbott 1974).

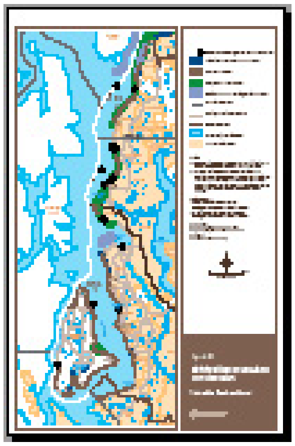
Current Distribution

The butter clam ranges from the Aleutian Islands to about Monterey California (Abbott 1974).

WRIA 8 – Density of butter clams at Edwards Point at the south end of reach 1, has been measured at 6.7/m^2 (J. Houghton, Pentec Environmental, unpublished data). Butter clam densities in reach 2 were relatively high at three of the sites sampled during the beach assessment program, ranging from 28/m^2 at Carkeek Park to 42/m^2 at Point Wells (King County 1998). Densities were low, 7/m^2, at Richmond Beach.

WRIA 9 – Along the mainland portion of the area, butter clams were abundant only in reach 5. Abundances ranged from 16/m^2 (Mee Kwa Mooks Park) to 42/m^2 (Alki Beach). The southern mainland section of the area, reaches 6, 7, and 8, contained relatively few butter clams ($< 10/m^2$). In portions of WRIA 9 on Vashon Island, butter clams were relatively abundant (19/m^2) only at Point Robinson (reach 9).

Figure 20 Distribution of Selected Invertebrates



Click here to view figure

Historical Distribution

Butter clam densities reported during the 1970s and 1980s were generally much lower than those reported in the beach assessment report. At the sites studied by Armstrong et al. (1976), butter clams ranged from $2/m^2$ at West Point to $10/m^2$ at Carkeek Park. At Lincoln Park, butter clam densities have been fairly consistent over the past 30 years. Armstrong et al. (1976) and Thom and Hampel (1984) each reported the density as $8/m^2$, which matches that reported for Lincoln Park South by the beach assessment study (King County 1998). However, at Seahurst Park, Thom et al. (1984) reported the butter clam density as $17/m^2$, whereas the beach assessment recorded $7/m^2$.

MANILA CLAM (VENERUPIS [RUDITAPES] PHILIPPINARUM)

The species is also commonly known as the Japanese Littleneck, Manila cockle, Japanese cockle, Manila littleneck, and Philippine cockle (Emmett et al. 1991). Several scientific synonyms occur in the literature, including *Tapes japonica*, *Venerupis japonica*, and *Ruditapes philippinarum*. However, the current accepted scientific name is Venerupis (Ruditapes) philippinarum (A. Fukuyama, University of Washington pers. comm.).

Current Distribution

The Manila clam is native to the western North Pacific. It was introduced to the North American Pacific coast in the 1930s and now occurs from British Columbia to Elkhorn Slough, California (Emmett et al. 1991). This species has become the second most important commercial clam along the Pacific Coast (Emmett et al. 1991). It is cited as very abundant in Puget Sound, Willapa Bay, and San Francisco Bay (Emmett et al. 1991), and abundant in Tomales Bay, California (Ricketts et al. 1985).

WRIA 8 – The most recent clam survey, the beach assessment study (King County 1998), reported that Manila clam densities were low in WRIA 8, except at Carkeek Park, where they occurred at a density of $32/m^2$. Manila clams were not found at Point Wells or Golden Gardens.

WRIA 9 – Manila clam densities were generally low along mainland King County, with clams occurring at abundances of $\leq 10/m^2$ at all sites sampled except at Alki Beach (reach 5), where they were found at $21/m^2$ (King County 1998). No Manila clams were found at Lincoln Park (reach 5/6). On Vashon Island, the highest manila clam density, $56/m^2$, was found at Burton Acres Park (reach 11). Other densities on Vashon Island ranged from $6/m^2$ at Point Robinson (reach 9) to $21/m^2$ at Dockton Park (reach 11).

Historical Distribution

Within Puget Sound, the Manila clam has typically been cited as rare or absent, although Armstrong et al. (1976) stated that it was common (defined as $2–100/m^2$) at Alki Beach. Quantitative data were reported only at Lincoln Park, where the species was listed at $< 0.1/m^2$ in 1985 (Thom et al. 1984) and at $0.5/m^2$ in 1990 (Thom and Hamilton 1990).

GEODUCK (PANOPEA ABRUPTA)

Other common names include the Pacific geoduck, giant panopaea, and gooey-duck (Emmett et al. 1991).

Current Distribution

The geoduck is a wide-ranging temperate species that is known from Kyushu and Hokkaido Islands, Japan, to southeast Alaska and Baja California (Emmett et al. 1991). The species ranges from the intertidal zone to depths of 110 m or more, occurring in stable mud or sand substrates (Emmett et al. 1991). The data on the current and historical status of geoducks in King County was derived from the 2000 Geoduck Atlas (Sizemore and Ulrich 2000).

WRIA 8 – Density of geoduck clams was measured on diver transects at locations north and south of the Edmonds Marina (reach 1) in early October 1994 (Pentec Environmental unpublished data). Transects between 30 and 60 ft MLLW between the marina and the ferry terminal yielded a density of 0.5/m^2. Similar transects across a limited gravel and sand patch between –26 ft and –70 ft, between the marina and the Union Oil dock at Edwards Point, had a density of 2.6/m^2. The next most recent data for WRIA 8 were collected in 1971 and are presented in the Historical Distribution section below.

WRIA 9 – The most recent data for the mainland King County portion of WRIA 9 were collected in the 1970s and are presented in the Historical Distribution section below. Seven beds, comprising 204 hectares (505 acres) on Vashon and Maury Islands were surveyed in the 1990s, most surveyed after the bed had been fished sometime within the previous decade. Geoduck densities at most tracts within reaches 8 through 12 were relatively low, ranging from ~1/m^2 (Point Vashon North) to ~2/m^2 (Point Robinson). In only one case (Vashon East Recovery Bed, reach 9) was the geoduck population reduced by harvesting (2.3/m^2 to 1.3/m^2) (Sizemore and Ulrich 2000).

Historical Distribution

WRIA 8 – A single geoduck tract, Richmond Beach (tract #06100), occurs within the King County portion of WRIA 8 (Sizemore and Ulrich 2000). Part of the 100-hectare (248 acres) tract also occurs within Snohomish County. Geoduck density within the bed was low, < 1/m^2, when last surveyed in 1971. The bed may be polluted by the Carkeek outfall.

WRIA 9 – Along the mainland portion of WRIA 9, eight geoduck tracts have been identified (Sizemore and Ulrich 2000). All of the tracts were last surveyed in the early to middle 1970s and are listed as polluted or possibly polluted. One small (74 hectares or 183 acres), low-density (~ 2/m^2) bed is located southwest of West Point (reach 4). Two geoduck tracts occur in reaches 5, 6, and 7. These extend from Alki Point to Point Pully and comprise 114 hectares (282 acres), but have small numbers of geoducks (~1.4/m^2). Five tracts, which extend from Point Pully to west of Dumas Bay, occur within reach 8. Two of the tracts (Tract # 09850 and # 09950, both in reach 8) have not been surveyed. The three remaining tracts comprise 95 hectares (235 acres) and have geoduck densities (~ 4/m^2–7/m^2) that are among the highest reported within Puget Sound (Sizemore and Ulrich 2000).

Seven geoduck tracts, comprising 253 hectares (625 acres) on Vashon and Maury Islands, have not been surveyed since the 1980s and two tracts have not been surveyed. Geoduck population densities within the surveyed beds were very low (~$0.5/m^2$–$2.4/m^2$) and the beds are partly polluted, have harvest restrictions in place to protect spawning herring, or have poor quality clams (Sizemore and Ulrich 2000). Two beds that were harvested in the 1980s have pre-harvest and post-harvest density data. One bed, Point Beals (reach 9) experienced a substantial decline in geoduck density from ~$2.5/m^2$ in 1983 (prior to harvest) to < $1/m^2$ in 1987, two years after harvest occurred. Densities within the other bed, Rosehilla (reach 11), were similar before ($1.9/m^2$) and after ($1.7/m^2$) harvest

OLYMPIA OYSTER (OSTREA CONCHAPHILA)

Other common names include California oyster, native oyster, and Yaquina Bay oyster (Couch and Hassler 1989). Other scientific names used for the species include *Ostrea lurida*, *Ostrea lurida conchaphila*, and *Ostreola conchaphila*. The current name is taken from Coan et al. (2000).

Current Distribution

The geographic range for the species extends from southeast Alaska to Baja California (Couch and Hassler 1989). Within Puget Sound, the species is known from scattered locations, but primarily in the Sound's southwestern corner (Cook et al. 1998). The species does not occur in King County (Cook et al. 1998).

Historical Distribution

Historical distributions within Puget Sound include several small, isolated areas, but do not include King County (Cook et al. 1998).

NORTHERN ABALONE (HALIOTIS KAMTSCHATKANA)

The species is also known as the pinto abalone (Abbott 1974; West 1997).

Current Distribution

The species ranges from Sitka, Alaska, to Baja California (West 1997). The species is not found in King County; It is only found in the San Juan Islands and the Strait of Juan de Fuca (West 1997).

Historical Distribution

The species has not been recorded in King County.

Dungeness Crab (*Cancer magister*)

This species is also known as Pacific edible crab, market crab, commercial crab, and edible crab (Williams et al. 1988; Pacific States Marine Fisheries Commission 1996).

Current Distribution

Dungeness crab range from the Pribilof Islands in Alaska to Santa Barbara in southern California (Pacific States Marine Fisheries Commission 1996). Dungeness crab probably inhabit all estuaries from Morro Bay, California, to Puget Sound, Washington. In Puget Sound, they are found from the nearshore to depths of more than 250 feet, depending on age and time of year. Dungeness crab are most common north of WRIAs 8 and 9, from Port Gardner to Boundary Bay (Washington Department of Fisheries 1992).

WRIA 8 – Along the shorelines of WRIA 8, Dungeness crab is harvested commercially by Indian tribes and harvested for sport by non-tribal parties. Tribal gear has been observed from Carkeek Park to Meadow Point, along the Shilshole Flats, in the channel of Shilshole Bay up to the railroad bridge, and between West Point and Four-Mile Rock. Sport harvest by pots and wading is common along the shoreline where the public has access. In the typical year, Dungeness crab are taken at Richmond Beach, Carkeek Park, and Golden Gardens Park (Burton, pers. comm.). Young of the year (YOY) crab were abundant ($28/m^2$) in eelgrass patches at Edwards Point between –1 and –6 ft MLLW just south of the Edmonds ferry terminal in fall of 1994 (Pentec Environmental unpublished data). Fewer YOY crab were taken at about MLLW at Edwards point. Limited numbers of adult crab and no gravid females were seen in diver transects offshore of these stations.

WRIA 9 – The abundance of Dungeness crab markedly decreases south of Seattle. The southern boundary of significant crab concentration is considered to be the southern tip of Vashon Island. Typically, crab are taken by sport waders during low tides along Alki Beach, and they occasionally occur in wader catches at Saltwater State Park (J. Odell, pers. comm.).

Historical Distribution

Because Dungeness crab are motile and yearly abundance is dependent on oceanographic conditions, there has been little change in the geographic range of this species in WRIAs 8 and 9. The recent (within the last 5 years) average annual production is estimated to vary between 80,000 and 100,000 per year, harvests being equally split between tribal and non-tribal fishers in central Puget Sound (J. Odell, WDFW pers. comm.; S. Burton, WDFW pers. comm.).

ALL SELECTED INVERTEBRATES

Reasons for Change

Certainly one of the explanations for the apparent patterns of change in abundance of the native littlenecks and butter clams during the past 30 years is that the study areas and methods have not been the same. For example, Armstrong et al. (1976) sampled four transects, two north and two south of Point Williams, whereas Thom and Hampel (1984) and later Thom and Hamilton (1990) sampled 10 transects south of and 1 north of the point. The beach assessment study established two clam assessment areas, one well to the north of and one south of the point. The studies no doubt have sampled potentially different subsets of the Lincoln Park region. The focus of the various studies has differed resulting in different sampling strategies. The early environmental studies largely were concerned with overall habitat conditions, thus the sampling was designed to cover the range of habitats within each beach area regardless of the likelihood of encountering clams. Sampling for clams during the beach assessment study was restricted to specified clam assessment areas, which probably excluded areas where clams were not abundant. The effect of the latter stratified sampling strategy is that clam abundances would likely be higher than those reported by the previous studies because of the sampling design rather than reflecting actual changes in population sizes. The size of individual samples also has differed among the studies, thereby making comparisons among them less reliable. Armstrong et al. (1976) sampled clams from within a 0.25-m^2 quadrat, whereas Thom and coworkers (1986, 1990) sampled a 0.06 m^2 area and the beach study sampled from a 0.0929 m^2 (1 ft^2) area.

The reasons for the change in abundance of Manila clams could be the same as mentioned above, although this clam species could be increasing in Puget Sound.

Because the only data for geoducks available for comparison between historical and current population densities were collected before and after harvest, the changes noted most likely are attributable to the harvesting activity.

Olympia oyster populations have declined since the early part of the 20^{th} century primarily from pollution caused by urbanization and pulp mills (Couch and Hassler 1989; Cook et al. 1998). Overharvesting caused the demise of the population in Samish Bay (Cook et al. 1998). In addition, abalone overharvesting has probably has a major impact on northern abalone populations (West 1997).

There is insufficient information on the distribution and abundance of Dungeness crab in central Puget Sound to compare changes from historical distribution to current distribution.

Stressors

Loss of habitat, recreational overharvest, shoreline siltation caused by construction (upland development and marinas), clam dredging in nearshore habitats (resulting in increased siltation), antifouling compounds, and water pollution negatively affect all invertebrate species in Puget Sound populations (Emmett et al. 1991). Dredging operations can alter bathymetry such that areas are no longer suitable for invertebrate colonization. Filling buries habitats under sediments or structures such as bulkheads or breakwaters. Shoreline armoring can change substrate to hardpan or other types inhospitable to certain species. Population size may be determined primarily by recruitment, which is highly variable (Emmett et al. 1991).

Pollution from pulp mills was a major historic factor affecting Olympia oyster populations, but with the close of those mills, non-point pollution has become a major cause of deteriorating water quality that has affected the oyster (Cook et al. 1998). The Olympic oyster may also be affected by the harvesting of other oysters that occurs in the same habitats (Cook et al. 1998). Within Puget Sound, competition with the slipper shell, *Crepidula fornicata*, may affect oyster populations (Couch and Hassler 1989).

Lack of rocky subtidal habitat limits northern abalone populations in Central Puget Sound while overharvesting by divers has been the primary factor affecting populations in the northwest straits area of Washington (West 1997). The recreational fishery for northern abalones was closed by the State of Washington in 1994 and by British Columbia in 1991; illegal harvesting still occurs (West 1997).

The primary stressors on Dungeness crab are human handling during soft-shell stages, human-made pollution, and loss of rearing habitat (J. Odell, WDFW, pers. comm.; S. Burton, WDFW, pers. comm.). Directed crab harvest is prohibited during soft-shell seasons (generally April 16 though July 15) to avoid mortality.

Dungeness crab are intolerant of low DO conditions, and even low concentrations of ammonia are toxic. The insecticide sevin (carbaryl) is extremely toxic to Dungeness crab. Crab larvae are highly sensitive to other insecticides and fungicides as well. They are also affected by urban pollutants such as heavy metals, PCBs, and hydrocarbons.

During the transition from pelagic larval forms to demersal forms, estuaries with eelgrass and shell fragment substrates are especially important; thus any action, such as bulkheads, dredging, or habitat modification projects, should be considered in light of their impacts on Dungeness crab (Pacific States Marine Fisheries Commission 1996).

Data Gaps

Along the mainland, there are no recent quantitative studies of invertebrates from WRIAs 8 and 9. Along the coast of Vashon Island, studies for native littlenecks have concentrated on and near Maury Island. The west coast of Vashon Island (reach 12) and much of the northeast coast (reach 9) remains unstudied. There are no data available to accurately assess population trends. Table 32 lists the abundance of three species of hardshell clams at selected King County beaches.

No data are available to accurately assess population trends of Manila clams. It is not known whether Manila clams are invasive or simply filling a previously vacant ecological niche in Puget Sound.

Except for a limited area around Edmonds, there are no recent population data for geoduck beds in WRIAs 8 and 9. There are no data for population trends that is not confounded by harvesting. Data are lacking on the effects of stressors on geoduck populations (Table 31). Although they do not occur in the study area, assessments of Olympia Oyster and abalone population structure and trends are lacking

The abundance of Dungeness crab in central Puget Sound is unknown. This is because King County is at the southern range of abundance and fishing effort is not concentrated or consistent. A mark/recapture study is planned for the winter of 2000-2001 (J. Odell, WDFW, pers. comm.). Additional information would be valuable regarding lethal and sublethal effects of organic and inorganic pollution, and impacts of shoreline alterations on various life history stages of Dungeness crab (Table 31).

Table 31: Data gaps for invertebrates

Gaps	WRIA 8	WRIA 9
Recent quantitative abundance studies for all species	Reach 3	Reaches 4 and 12, and much of reaches 7-9
Effects of changes in habitat structure due to shoreline armoring, dredging, filling, and other development practices on recruitment and survival	All reaches	All reaches
Effects of exposure to lethal and sublethal contaminants on invertebrate populations and community structure	All reaches	All reaches
Effects of changes in detrital organic matter due to loss of marine and riparian vegetation on food supply	All reaches	All reaches

Key Findings

- Shellfish populations occurring within WRIAs 8 and 9 include native littleneck clams, butter clams, Manila clams, geoduck and other clams, and Dungeness crab. All of these species are commercially and/or recreationally harvested.
- Current information on hardshell clam distribution and abundance in WRIAs 8 and 9 is derived from the King County Beach Assessment Program. Some discrepancies and inconsistencies in sampling methods and locations exist to complicate analysis of hardshell clam abundance trends.
- Lincoln Park is one of the only beach habitats that has been quantitatively sampled repeatedly between the early 1970s and late 1990s.
- Shoreline siltation, loss of habitat, and water pollution affect hardshell clam populations.
- Except for a limited area around Edmonds, the most recent geoduck surveys from the mainland sections of nearshore marine habitats of WRIA 8 and 9 were collected in the 1970s; more recent surveys were conducted (1990s) from around Vashon and Maury Islands.

Table 32: Abundance of three species of hardshell clams at selected King County beaches

WRIA	reach	Beach	Sample Size	Manila clams			Native littlenecks			Butter clams		
				clams	#/ft²	#/m²	clams	#/ft²	#/m²	clams	#/ft²	#/m²
8	2	Pt. Wells	18	0	0.0	0.0	51	2.8	30.5	70	3.9	41.9
8	2	Richmond Beach	22	5	0.2	2.4	1	0.0	0.5	14	0.6	6.8
8	2	Carkeek Park	40	119	3.0	32.0	286	7.2	77.0	104	2.6	28.0
8	2	Golden Gardens	25	0	0.0	0.0	33	1.3	14.2	77	3.1	33.2
8	3/4	West Point	ND	--	--	--	--	--	--	--	--	--
9	4/5	Alki	35	68	1.9	20.9	262	7.5	80.6	136	3.9	41.8
9	5	Mee Kwa Mooks	80	57	0.7	7.7	342	4.3	46.0	120	1.5	16.1
9	5	Lincoln Park-N	12	0	0.0	0.0	80	6.7	71.8	36	3.0	32.3
9	6	Lincoln Park-S	41	0	0.0	0.0	64	1.6	16.8	32	0.8	8.4
9	5/6	Lincoln Park (combined)	53	0	0.0	0.0	144	2.7	29.2	68	1.3	13.8
9	7	Seahurst	72	8	0.1	1.2	41	0.6	6.1	49	0.7	7.3
9	8	Saltwater SP	28	26	0.9	10.0	21	0.8	8.1	14	0.5	5.4
9	8	Dash Point	ND	--	--	--	--	--	--	--	--	--
9	9	Tramp Harbor	26	37	1.4	15.3	142	5.5	58.8	14	0.5	5.8
9	9	Pt. Robinson	19	11	0.6	6.2	43	2.3	24.4	34	1.8	19.3
9	11	Dockton Park	62	119	1.9	20.7	112	1.8	19.4	3	0.0	0.5
9	11	Burton Acres Park	60	314	5.2	56.3	611	10.2	109.6	27	0.5	4.8

Source: King County 1998
Note: Burton Acres Park samples given as 60+, so values represent overestimate; Tramp Harbor sample number may be higher.