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unnamed faults in the Strait of Juan de Fuca and Puget Sound (Class B) No. 551

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Synopsis	These unnamed faults in the Strait of Juan de Fuca and northern Puget Sound include mostly northwest-striking faults in the east-central part of the strait and principally westerly striking faults in the west-central and western parts of the strait and northern Puget Sound. Several prominent northeast-striking faults are also are mapped near the mouth (west end) of the strait. Evidence for Quaternary movement along these unnamed faults is based mostly on interpretation of seismic-reflection data that implies Pleistocene and Holocene deposits are offset along these faults, as well as deformed by folds (not shown herein) that appear to be related to these faults. A few of these faults have been inferred to connect with exposed or inferred faults on land north and south of the strait, but specific evidence for Quaternary offset along these possible on-land continuations has not been reported. Some named faults in the eastern part of the Strait of Juan de Fuca, such

	as the Southern Whidbey Island fault [572], are described elsewhere herein and have reported paleoseismologic evidence that indicates tectonic offset as recent as the late Holocene. Paleoseismologic studies have not been conducted along these unnamed faults, but it seems likely that at least some of these faults were also tectonically active during the Quaternary. A non-tectonic origin for some or most of these faults and folds, however, is also possible. Inasmuch as, non-tectonic processes, such as isostatic adjustment and ice-shove during Pleistocene continental glacial events of this region, might have formed some of the faults and folds identified in the seismic-reflection data. Consequently and at this time, these unnamed faults are classified herein as Class B structures until more detailed study and characterization of these features is reported.
Name comments	Refers to mostly west- to northwest-striking, and some northeast-striking, unnamed faults that are mapped in the Strait of Juan de Fuca and northern Puget Sound. Based mostly on aeromagnetic anomalies, MacLeod and others (1977 #6531) reported and showed on a sketch map some inferred major faults and folds in the Strait of Juan de Fuca. They connected a few of these inferred faults in the Strait with the Leech River fault on San Juan Island, Canada, and connected one fault and a syncline with an inferred thrust fault and syncline mapped in the northeastern part of the Olympic Peninsula. Gower (1980 #6229) and Gower and others (1985 #4725) also showed parts of these inferred faults, as identified by MacLeod and others (1977 #6531), on their geologic and seismotectonic maps of this region. Dragovich and others (2002 #5715) also show some inferred faults in the southwest and south-central parts of the Strait of Juan de Fuca on a 1:250,000-scale geologic map that includes the southern part of the strait and northern Puget Sound. The unnamed faults in the Strait of Juan de Fuca and Puget Sound shown herein, are compiled from a 1:250,00-scale map of seafloor geology in the Strait of Juan de Fuca (Plate 3, Wagner and Tomson, 1987 #6249) and from a later map of Tertiary and Quaternary structures in the eastern Strait of Juan de Fuca and northern Puget Sound (Johnson and others, 2000 #4750). These maps are based mostly on interpretation of seismic-reflection data. Most of the faults shown on the map by Wagner and Tomson (Plate 3, 1987 #6249) are also shown on a 1:2,000,000-scale map of known and suspected Quaternary faults in the Pacific Northwest (Plate 1, Rogers and others, 1996 #4191). These faults are not named in the reports cited above, nor named on the maps, plates, or sketch maps included in these reports. On

	some tectonic sketch maps of this region, however, one or more of the northerly striking faults, in or near Discovery Bay and in the east-central part of the strait, are identified as the "Discovery Bay fault" (e.g., Babcock and others, 1992 #6245). On other tectonic sketch maps this fault, or a zone of faults, is also connected to the Hood Canal fault zone [552] to the south and the connected fault is referred to as the "Hood Canal-Discovery Bay fault zone" (e.g., Pratt and others, 1997 #6238). Such a connection, however, or even the precise location of the "Discovery Bay fault," do not appear to be well known or tightly constrained. Consequently, faults in and near Discovery Bay are not distinguished herein from the other unnamed faults in this part of the Strait of Juan de Fuca and northern Puget Sound (see also, discussion of Hood Canal fault zone [552]). These unnamed faults occupy much of the Strait of Juan de Fuca between the Olympic Peninsula of Washington on the south and Vancouver Island of Canada on the north, and include some faults in northern Puget Sound and bays along the north side of the Olympic Peninsula.
County(s) and State(s)	CLALLAM COUNTY, WASHINGTON (offshore) JEFFERSON COUNTY, WASHINGTON (offshore) SAN JUAN COUNTY, WASHINGTON (offshore)
Physiographic province(s)	PACIFIC BORDER
Reliability of location	Good Compiled at 1:250,000 scale. *Comments:* Fault traces are from a 1:250,000-scale map of seafloor geology in the Strait of Juan de Fuca by Wagner and Tomson (Plate 3, 1987 #6249) and from a map of Tertiary and Quaternary structures in the eastern part of the strait and northern Puget Sound by Johnson and others (2000 #4750). These two maps are both based mostly on interpretation of seismic reflection data and they overlap and differ in some respects in their interpretations of structural relations in the central to east-central part of the Strait of Juan de Fuca. In this overlap area, the fault traces shown in Johnson and others (2000 #4750) are used herein because they are based on additional and more robust seismic-reflection data.
Geologic setting	The Strait of Juan de Fuca trends about N. 70? W., is about 20 km wide, and separates the Olympic Peninsula on the south from the Vancouver Island on the north. The eastern part of the strait connects with Puget Sound near the northeastern tip of the

Olympic Peninsula. Exposed faults south and north of the strait, in the northern part of the Olympic Peninsula and southern part of the Vancouver Island, respectively, are mostly northerly dipping thrust faults related to Eocene and younger subduction events of this region (Glassley, 1974 #6244; Tabor, 1975 #6220; Snavely and others, 1976 #6535; MacLeod and others, 1977 #6531; Tabor and Cady, 1978 #6221; 1978 #6222). Based on regional geology and geophysical anomalies, MacLeod and others (1977 #6531) concluded that similar faults with Tertiary ancestry are present beneath marine water and Quaternary sediment in the strait. They further concluded that offshore structures in this part of the strait can be interpreted in a framework of Eocene and younger oceanic and continental plate interactions, which are more evident in rock-unit and structural relations north and south of the strait. Several prominent northeast-striking faults are mapped near the mouth (west-end) of the strait. One or more of these northeast-striking faults probably is a southwestern continuation of the Leech River fault mapped in the southern part of Vancouver Island Canada (Snavely and others, 1976 #6535; MacLeod and others, 1977 #6531). The Leech River fault commonly is interpreted as a major thrust fault zone, along which oceanic crust was thrust beneath continental crust during Eocene-Oligocene subduction events in this region (Snavely and others, 1976 #6535; MacLeod and others, 1977 #6531). Farther east, a southeastern continuation of the Leech River fault may cross the central part of the strait and extend southward into the Puget Lowlands (MacLeod and others, 1977 #6531). This southeastern continuation may be marked by one or more of the northwest-striking faults in the east-central part of the strait. Some tectonic interpretations of this region also connect one or more of these northwest-striking faults in the east-central part of the strait with the Hood Canal fault zone [552] in the Puget Lowlands to the south. This connected fault, or fault zone, is commonly referred to as the "Hood Canal-Discovery Bay fault zone " (e.g., Pratt and others, 1997 #6238; Haug, 1998 #6519; Haug, 1998 #6520), which is also briefly described in the discussion of the Hood Canal fault zone [552] elsewhere herein. During the Pleistocene, the Strait of Juan de Fuca and the Puget Lowlands, to the south and southeast, experienced several episodes glacial erosion and deposition related to advances and retreats of continental ice sheets (e.g., Booth, 1994 #4719; Porter and Swanson, 1998 #6237). Pleistocene sediments deposited during these glacial events and younger Holocene sediments now blanket Tertiary rocks and structures in the region of the Strait of Juan de Fuca, Puget Lowland, and coastal regions of the Olympic

	Peninsula and Vancouver Island. Based mostly on interpretation of seismic-reflection data, Wagner and Tomson (plate 3, 1987 #6249) and Johnson and others (2000 #4750) mapped several faults and folds that deform these Quaternary sediments in the Strait of Juan de Fuca and northern Puget Sound. They cautioned, however, that some or many of these structures could also be interpreted as structures related to isostatic adjustments that took place between Pleistocene glacial maximums and minimums and (or) related to ice shove during these glacial events. Faults in the eastern part of the Strait, such as the Southern Whidbey Island fault [572], have been better studied and show evidence of late Holocene tectonic activity. The tectonic regime of the Strait of Juan de Fuca and adjacent regions appears to have evolved between the Eocene and present. The nature and orientation of Quaternary crustal stresses in this region are not completely known. These crustal stresses may include both deep-seated, east-west compression related to subduction of the Juan de Fuca plate to the west, as well as shallower, north-south compression (e.g., Magee and Zoback, 1992 #6246; Ma and others, 1996 #6247; Wells and others, 1998 #4742; Wells and Johnson, 2000 #4743) related to other plate interactions among the Juan de Fuca, Pacific, and North American plates (McCrory, 1996 #6321; 1997 #6323).
Length (km)	169 km.
Average strike	N70°W
Sense of movement	Normal, Reverse *Comments:* Based on interpretation of seismic-reflection data, Wagner and Tomson (Plate 3, 1987 #6249) ornament fault traces in the Strait of Juan de Fuca with symbology that indicates some of these faults show normal offset and others show reverse offset. It is possible that some of these faults are oblique-slip or strike-slip faults, but lateral slip or components of lateral slip on these faults is not indicated or discussed by Wagner and Tomson (1987 #6249). Lateral slip, however, is not commonly apparent in seismic-reflection data. The long northwest-striking fault, which Wagner and Tomson (1987 #6249) mapped in the southwestern part of the strait, is shown as a northerly dipping thrust fault on some tectonic sketch maps and geologic maps of this region (e.g., Snavely and Wells, 1996 #4290; Dragovich and others, 2002 #5715). Johnson and others (2000 #4750) did not ornament faults with slip or sense of movement symbology on their map and they did not discuss apparent offset relations of these unnamed faults.

Dip Direction	N; S *Comments:* Precise dip measurements for these faults have not been reported. Based on interpretation of seismic-reflection data, Wagner and Tomson (Plate 3, 1987 #6249) ornament fault traces in the Strait of Juan de Fuca with symbology that indicates most of these faults dip moderately to steeply. They also indicate, however, that some of these faults and parts of certain faults are vertical and others dip at low angles. Similarly, Wagner and Tomson (Plate 3, 1987 #6249) indicate various dip directions for these faults; they show both northerly and southerly dip directions for west- to northwest-striking faults and show both easterly and westerly dip directions for the less abundant northeast-striking faults. In general, northerly dips appear to be most common. Johnson and others (2000 #4750) do not indicate on their map, nor discuss, dip directions and angles of these unnamed faults.
Paleoseismology studies	Paleoseismology studies have not been conducted offshore along these unnamed faults in the Strait of Juan de Fuca and northern Puget Sound, nor have such studies been conducted along possible on-land continuations of some of these faults in Washington State. Seismic-reflection data (Wagner and Tomson, 1987 #6249; Johnson and others, 2000 #4750) currently provides the most detailed information on the character of these unnamed faults. Paleoseismologic investigations of shoreline deposits conducted at two sites in the eastern part of the Strait of Juan de Fuca are briefly described below. One site is located at the head of Discovery Bay along the southern shore of the Strait of Juan de Fuca and the other site is located along the west coast of northern Whidbey Island at Swantown Marsh. Probable late Holocene tsunami deposits and subsidence at these sites may correlate with known prehistoric earthquakes along the Cascadia subduction zone [#781] to the west, and (or) with local earthquakes along upper-plate faults of Cascadia that include faults in the Strait of Juan de Fuca and Puget Lowland. At this time, however, these apparent tsunami events, and an event of subsidence at one of these sites, cannot be definitively correlated with either the Cascadia subduction zone or with a specific fault or zone of faults in the region of the Strait of Juan de Fuca and Puget Lowland. These sites are included herein with the unnamed faults in the Strait of Juan de Fuca and northern Puget Sound, based mostly on their proximity to these faults. Some other coastal study sites nearby in the Puget Lowland, such as the Shine and Hansville

sites (e.g., Bucknam and others, 1992 #602; Sherrod, 2001 #4740), have been reported to show evidence that indicates an absence of late Holocene land-level changes, tsunami deposits, and other possible earthquake-related features. These other sites may provide information that limits the extent of late Holocene earthquake-related uplift, subsidence, and tsunamis. However, these other sites apparently do not record direct evidence of earthquake and faulting events and they are not included herein. Coastal study sites on southern Vancouver Island, British Columbia, may also record evidence for earthquakes and faulting events along faults in the Strait of Juan de Fuca (e.g., Clague and Bobrowsky, 1994 #6710; Clague, 1996 #6709), but these sites and Quaternary faults in Canada are not shown or described in this compilation.

Discovery Bay site (551-1). Recent investigations by Williams and others (2004 #6297) identified nine muddy sand beds, which interrupt a 2500-yr-old sequence of peat deposits, beneath a tidal marsh at the head of Discovery Bay. Based on six criteria they conclude that tsunamis deposited at least four, and probably at least six, of these nine late Holocene sand lenses; the extent of the oldest three sand lenses is too limited to confirm their origin as tsunami deposits. Radiocarbon ages obtained from this sand and peat sequence indicate that the age ranges of four of the sand beds overlap with known late Holocene tsunamis generated by plate-boundary earthquakes along the Cascadia subduction zone [#781]. Diatom assemblages of peat deposits bracketing these four sand beds do not indicate land level changes at this site concurrent with these four tsunami events. Diatoms in peat deposits that bracket another sand bed that was deposited about 1000 cal. yr B.P., however, do indicate a few decimeters of concurrent subsidence. The subsidence suggests that this tsunami was generated by deformation along a nearby upper-plate fault, possibly a fault in the Strait of Juan de Fuca or other nearby faults in the Puget Lowland, such as the Seattle fault. Other sand beds at this site, which have not been correlated with previously documented tsunamis and (or) earthquake events, may have been produced by more distant plate-boundary or upper-plate earthquakes and (or) reflect submarine landslides that might have been triggered by earthquake shaking (Williams and others, 2004 #6297).

Swantown Marsh site (551-2). Investigations by Williams and Hutchinson (2000 #6296) identified four muddy sand sheets within tidal marsh peat deposits at Swantown Marsh along the

	west coast of northern Whidbey Island, Washington. Based on characteristics of the deposits they concluded that these sand sheets are tsunami deposits. They reported calibrated radiocarbon ages for these four sand sheets of 1160-1350, 1400-1700,1810-2060, 1830-2120 cal. yr B.P. The ages of the two youngest sand sheets overlap ages of inferred great earthquake events along the Cascadia subduction zone [#781], about 250 km to the west, and may indicate that these sand sheets reflect tsunamis generated by those Cascadia plate-boundary earthquakes (Williams and Hutchinson, 2000 #6296). The ages of the two older sand sheets do not correlate with known plate-boundary events. The two older sand sheets may be products of tsunamis caused by earthquakes along named or unnamed faults in the region of the Strait of Juan de Fuca and Puget Sound, and (or) products of submarine landslides in this region that might also have been triggered by earthquakes (Williams and Hutchinson, 2000 #6296). Williams and Hutchinson (2000 #6296) also noted that one of these older sand sheets may record a large tsunami generated by an inferred large earthquake about 1900 cal. yr B.P. That earthquake is also correlated with liquefaction and subsidence at sites in British Columbia on southern Vancouver Island (Mathewes and Clague, 1994 #4207; Clague and others, 1997 #6711).
Geomorphic expression	Interpretation of seismic-reflection and bathymetric data provide the principal evidence for geomorphic expression of these faults. Based on interpretation of these data, Wagner and Tomson (Plate 3 1987 #6249) report evidence that indicates some of these faults and parts of these faults offset the seafloor and may be associated with some submarine landslide features.
Age of faulted surficial deposits	These faults are mapped principally beneath marine water in the Strait of Juan de Fuca and northern Puget Sound, but a few of these faults are projected to connect with known and inferred faults on land. Based on interpretation of seismic-reflection data, Wagner and Tomson (Plate 3, 1987 #6249) indicated that most of the faults they mapped offset and deform Pleistocene and (or) Holocene deposits along and beneath the seafloor of the Strait of Juan de Fuca. Similarly, Johnson and others (2000 #4750) indicated that Quaternary sediments are offset along many of the faults they mapped in this region and indicated that some of these faults offset deposits as young as Holocene in age. The 1:250,000-scale geologic map of Dragovich and others (2002 #5715) shows two of the faults in the southwestern part of the

	Strait of Juan de Fuca connected to inferred, on-land fault traces along the northern coast of the Olympic Peninsula. These inferred on-land fault traces are mapped in Pleistocene and Holocene deposits. Deformation of these Pleistocene and Holocene deposits and geomorphic expression along these inferred, on-land faults have not been reported. Gower and others (1985 #4725), however, have reported localities of deformed Quaternary sediments along a mostly inferred, unnamed, south-dipping thrust fault near Port Angeles [555] that is discussed elsewhere herein. These localities of deformed Quaternary sediments near Port Angeles are located about 1-3 km north of the apparent on-land continuation of a Strait of Juan de Fuca fault that Dragovich and others (2002 #5715) show as an inferred north-dipping thrust fault.
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* Wagner and Tomson (Plate 3, 1987 #6249) and Johnson and others (2000 #4750) indicate that many of these unnamed faults offset and deform Pleistocene and (or) Holocene deposits, which implies latest Quaternary (<15 ka) offsets along some of these unnamed faults. They also mapped numerous folds (not shown herein) that appear to be associated with these faults. They both noted, however, that some or many of these faults and folds might be non-tectonic features. Perhaps resulting from isostatic adjustment, ice shove, erosion, and (or) deposition processes related to the several advances and retreats of continental ice sheets across this region during the Pleistocene. Based on some of the seismic-reflection data, that provided deeper resolution of structural features, Wagner and Tomson (1987 #6249) and Johnson and others (2000 #4750) both reported that some of these faults are rooted in bedrock beneath the Quaternary sediments. A tectonic origin for these rooted faults seems likely and implies that at least some of these unnamed faults are Quaternary tectonic structures. Evidence for late Holocene tectonic activity along some named faults in the eastern part of the strait, such as the Southern Whidbey Island fault [572], also suggests the likelihood that at least some of these unnamed faults were also tectonically active during the Holocene. Consequently, a latest Quaternary (<15 ka) age category assignment seems likely for the time of most recent prehistoric faulting for some of these unnamed faults. At this time, however, these faults are poorly characterized and probably include faults

	and folds that are not tectonic features. Consequently, these unnamed faults and associated folds are at this time and herein classified as Class B structures until more detailed studies are conducted.
Recurrence interval	*Comments:* At this time, there is no information on prehistoric surface-rupturing earthquakes or recurrence interval for these unnamed faults in the Strait of Juan de Fuca and Puget Sound.
Slip-rate category	Less than 0.2 mm/yr *Comments:* Existing data and interpretations do not specifically address or constrain slip-rates of these unnamed faults in the Strait of Juan de Fuca and northern Puget Sound. Based mostly on this lack of information, a conservative <0.2 mm/yr slip-rate category is assigned herein. Data presented by Wagner and Tomson (1987 #6249) and Johnson and others (2000 #4755), however, imply Holocene movement and seafloor offsets along some of these faults, which might also imply slip rates that exceed the amount assigned.
Date and Compiler(s)	2004 David J. Lidke, U.S. Geological Survey
References	#6245 Babcock, R.S., Burmester, R.F., Engebretson, D.C., Warnock, A., and Clark, K.P., 1992, A rifted margin origin for the Crescent basalts and related rocks in the northern Coast Range province, Washington and British Columbia: Journal of Geophysical Research, v. 97, no. B5, p. 6799-6821. #4719 Booth, D.B., 1994, Glaciofluvial infilling and scour of the Puget Lowland, Washington, during ice-sheet glaciation: Geology, v. 22, p. 695-698. #602 Bucknam, R.C., Hemphill-Haley, E., and Leopold, E.B., 1992, Abrupt uplift within the past 1700 years at southern Puget Sound, Washington: Science, v. 258, p. 1611-1614. #6710 Clague, J.J., and Bobrowsky, P.T., 1994, Tsunami deposits beneath tidal marshes on Vancouver Island, British Columbia: Geological Society of America Bulletin, v. 106, p. 1293-1303. #6709 Clague, J.J., compiler, 1996, Paleoseismology and seismic hazards, southwestern British Columbia: Geological Survey of

Canada Bulletin 494, 88 p.

#6711 Clague, J.J., Naesgaard, E., and Nelson, A.R., 1997, Age and significance of earthquake-induced liquefaction near Vancouver, British Columbia, Canada: Canadian Geotechnical Journal, v. 34, p. 53-62.

#5715 Dragovich, J.D., Logan, R.L., Schasse, H.W., Walsh, T.J., Lingley, W.S., Jr., Norman, D.K., Gerstel, W.J., Lapen, T.J., Schuster, J.E., and Meyers, K.D., 2002, Geologic map of Washington—Northwest quadrant: Washington Division of Geology and Earth Resources Geologic Map GM-50, 72 p. pamphlet, 3 sheets, scale 1:250,000.

#6244 Glassley, W., 1974, Geochemistry and tectonics of the Crescent volcanic rocks, Olympic Peninsula, Washington: Geological Society of America Bulletin, v. 85, p. 785-794.

#6229 Gower, H.D., 1980, Bedrock geologic and Quaternary tectonic map of the Port Townsend area, Washington: U.S. Geological Survey Open-File Report 80-1174, 19 p., 1 sheet, scale 1:100,000.

#4725 Gower, H.D., Yount, J.C., and Crosson, R.S., 1985, Seismotectonic map of the Puget Sound region, Washington: U.S. Geological Survey Miscellaneous Investigations Map I-1613, scale 1:250,000.

#6519 Haug, B.J., 1998, 1998, High resolution seismic reflection interpretations of the Hood Canal-Discovery Bay fault zone; Puget Sound, Washington: Geological Society of America Abstracts with Programs, v. 30, no. 5, p. 18.

#6520 Haug, B.J., 1998, High resolution seismic reflection interpretations of the Hood Canal-Discovery Bay fault zone; Puget Sound, Washington: Portland, Oregon, Portland State University, , 102 p.

#4750 Johnson, S.Y., Mosher, D.C., Dadisman, S.V., Childs, J.R., and Rhea, S., 2000, Tertiary and Quaternary structures of the eastern Strait of Juan de Fuca—Interpreted map, *in* Mosher, D.C., Johnson, S.Y., Rathwell, G.J., Kung, R.B., and Rhea, S.B., eds., Neotectonics of the eastern Strait of Juan de Fuca; a digital geological and geophysical atlas: Geological Survey of Canada

Open File Report 3931 (CD digital product), 1 sheet.

#4755 Johnson, S.Y., Rhea, S., and Dadisman, S.V., 2000, Industry seismic-reflection tracklines, *in* Mosher, D.C., Johnson, S.Y., Rathwell, G.J., Kung, R.B., and Rhea, S.B., eds., Neotectonics of the eastern Strait of Juan de Fuca; a digital geological and geophysical atlas: Geological Survey of Canada Open File Report D3931, (CD digital product), 1 sheet.

#6531 MacLeod, N.S., Tiffin, D.L., Snavely, P.D., Jr., and Currie, R.G., 1977, Geologic interpretation of magnetic and gravity anomalies in the Strait of Juan de Fuca, U.S.—Canada: Canadian Journal of Earth Science, v. 14, no. 2, p. 223-238.

#6246 Magee, M., and Zoback, M.L., 1992, Well-bore breakout analysis for determining tectonic stress orientations in Washington State: U.S. Geological Survey Open-File Report 92-715, 56 p.

#6247 Ma, L., Crosson, R.S., and Ludwin, R.S., 1996, Western Washington earthquake focal mechanisms and their relationship to regional tectonic stress, *in* Rogers, A.M., Walsh, T.J., Kockelman, W.J., and Priest, G.R., eds., Assessing earthquake hazards and reducing risk in the Pacific Northwest: U.S. Geological Survey Professional Paper 1560, v. 1, p. 1-67.

#4207 Mathewes, R.W., and Clague, J.J., 1994, Detection of large prehistoric earthquakes in the Pacific Northwest by microfossil analysis: Science, v. 264, p. 688-691.

#6321 McCrory, P.A., 1996, Tectonic model explaining divergent contraction directions along the Cascadia margin, Washington: Geology, v. 24, p. 929-932.

#6323 McCrory, P.A., 1997, Evidence for Quaternary tectonism along the Washington coast: Washington Geology, v. 25, no. 4, p. 14-20.

#6237 Porter, S.C., and Swanson, T.W., 1998, Radiocarbon age constraints on rates of advance and retreat of the Puget lobe of the Cordilleran ice sheet during the last glaciation: Quaternary Research, v. 50, p. 205-213.

#4737 Pratt, T.L., Johnson, S., Potter, C., Stephenson, W., and

Finn, C., 1997, Seismic reflection images beneath Puget Sound, western Washington State—The Puget Lowland thrust sheet hypothesis: Journal of Geophysical Research, v. 102, p. 27,469-27,489.

#4191 Rogers, A.M., Walsh, T.J., Kockelman, W.J., and Priest, G.R., 1996, Assessing earthquake hazards and reducing risk in the Pacific Northwest—Volume 1:U.S. Geological Survey Professional Paper 1560, 306 p.

#4740 Sherrod, B.L., 2001, Evidence for earthquake-induced subsidence about 1100 years ago in coastal marshes of southern Puget Sound, Washington: Geological Society of America Bulletin, v. 113, p. 1299-1311.

#4290 Snavely, P.D., and Wells, R.E., 1996, Cenozoic evolution of the continental margin of Oregon and Washington, *in* Rogers, A.M., Walsh, T.J., Kockelman, W.J., and Priest, G.R., eds., Assessing earthquake hazards and reducing risk in the Pacific Northwest: U.S. Geological Survey Professional Paper 1560, v. 1, p. 161-182.

#6535 Snavely, P.D., Macleod, N.S., and Pearl, J.E., 1976, Tectonic framework of the Strait of Juan de Fuca and the Pacific continental shelf: U.S. Geological Survey Professional Paper 1000, p. 147-148.

#6220 Tabor, R.W., 1975, Guide to the geology of Olympic National Park: Seattle, Washington, University of Washington Press, 144 p.

#6221 Tabor, R.W., and Cady, W.M., 1978, Geologic map of the Olympic Peninsula, Washington: U.S. Geological Survey Miscellaneous Investigations Map I-994, scale 1:125,000.

#6222 Tabor, R.W., and Cady, W.M., 1978, The structure of the Olympic Mountains; analysis of a subduction zone: U.S. Geological Survey Professional Paper 1033, 39 p.

#6249 Wagner, H.C., and Tomson, J.H., 1987, Offshore geology of the Strait of Juan de Fuca, State of Washington and British Columbia, Canada: Washington Division of Geology and Earth Resources Open-File Report 87-1, 16 p.

#4743 Wells, R.E., and Johnson, S.Y., 2000, Neotectonics of western Washington and the Puget Lowland from northward migration of the Cascadia forearc: Geological Society of America Abstracts with Programs, v. 32, p. A-75.

#4742 Wells, R.E., Weaver, C.S., and Blakely, R.J., 1998, Forearc migration in Cascadia and its neotectonic significance: Geology, v. 26, p. 759-762.

#6296 Williams, H., and Hutchinson, I., 2000, Stratigraphic and microfossil evidence for late Holocene tsunamis at Swantown marsh, Whidbey Island, Washington: Quaternary Research, v. 54, p. 218-227.

#6297 Williams, H., Hutchinson, I., and Nelson, A.R., 2004, Multiple sources for late Holocene tsunamis at Discovery Bay, Washington State, USA: The Holocene, (in press).