G322 Lab Exercise
Neotectonic and Coastal Processes of Oregon

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G322 Lab Exercise - Neotectonic and Coastal Processes of Oregon

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Part I. Pre-Lab Questions

Use your notes, textbook, wall maps, and reading assignments to answer the following questions.

A. Match the Following Coastal Locations with the terms on the Right. List all that apply.

___________________	1. Oregon Coast	Passive Margin Tectonics (inactive)
___________________	2. Washington Coast	Active Margin Tectonics - subduction
___________________	3. Southern California Coast	Active Margin Tectonics - transform
___________________	4. Northern California Coast	Active Margin Tectonics - rifting / spreading
___________________	5. Aleutian Islands of Alaska	Emergent Coastline
___________________	6. Southeast Alaskan Coast	Submergent Coastline
___________________	7. Gulf of Mexico - Texas	Active Subsidence
___________________	8. Central Atlantic / U.S.	Active Uplift

B. Thinking Questions

9. The last major glaciation (i.e. a pervasive cold-wet climate regime) in the northern hemisphere was at it's peak 18,000 to 20,000 years ago. 100's to 1000' of feet of Ice covered much of Canada and the northern tier of the U.S.

A. From what major hydrologic source does the precipitation that forms glacial ice originate?

B. Describe how this moisture is cycled into glacial ice (what are the processes associated with this part of the hydrologic cycle).

C. What happens to global sea level during a major glacial climate? What happens to global sea level during a major interglacial (i.e. warm / melting) climate?

D. What happens to land surface elevation at convergent tectonic boundaries (i.e. subduction zones), especially where accretionary tectonics is prevalent?

E. What happens to land surface elevation at passive tectonic boundaries, where sediment accumulates over time (think about what happens to water saturated sediment as it accumulates, becoming thicker over time, under increasing weight).

10. If global sea level is rising at a rate of 2 mm/yr, at a passive continental margin, how long will it take for sea level to rise 5 m? Show your math work.

11. If global sea level is rising at a rate of 5 mm/yr, and an active tectonic coastline is experiencing uplift at a rate of 5 mm/yr, what will be the net relative rate of sea level change at this location? Show your math work.

12. If global sea level is rising at a rate of 3 mm /yr, and a passive margin coastline is actively subsiding at a rate of 5 mm /yr, what will be the net relative rate of sea level change at this location? Show your math work. Is this coastline best characterized as "emergent" or "submergent"?

13. If global sea level is rising at a rate of 1 mm/yr and an active tectonic coastline is experiencing uplift at a rate of 5 mm/yr, what will be the net relative rate of sea level change at this location? Show your math work. Is this coastline best characterized as "emergent" or "submergent"?

14. List two dominant oceanic processes associated with the Oregon Coast.

15. List two dominant tectonic processes associated with the Oregon Coast.

16. List three geologic hazards that you can think of, associated with the Oregon Coast (think about the news reports that you hear every year).

17. In terms of temperature as related to the physics of volume expansion / contraction (think hot air baloon), which condition would have a greater volume, warm sea water or cold sea water?

18. In terms of density driven currents: warm sea water is _______________ (more dense or less dense?) compared to cold sea water. Therefore, warm sea water will tend to _______________ (rise or sink), and cold sea water will tend to _______________(rise or sink?).

19. Similarly, in terms of density-driven motion in rock material: hot, young oceanic crust is _____________ (more dense or less dense?) compared to cold, old oceanic crust. Therefore, hot, young oceanic crust will tend to (rise or sink?), and cold, old oceanic crust will tend to _________________ (rise or sink?).

20. Question for you: What would happen to global sea level under conditions of very rapid seafloor spreading? Why?

    What would happen to global sea level under conditions of very slow seafloor spreading? Why?

Part 2. Wave Processes along the Oregon Coast.

Wind-driven ocean waves at the Oregon Coast provide for a very dramatic geomorphic environment. High-energy waves and currents serve as the dominant agents of erosion, constantly reshaping the shoreline. Severe storms provide an extra energy boost to wave formation, and are associated with very dynamic geomorphic processes at the Oregon Coast.

A. Thinking Questions

2.A.1. Which type of wind conditions will result in larger wave heights at the beach: low velocity wind or high velocity wind?

2.A.2. Which seasons are associated with storms tracking into Oregon from the central and northern Pacific?

2.A.3. Which times of year would you hypothesize are associated with high-energy wave conditions on the Oregon Coast, and why?

2.A.4. What would happen to relative sea level at the Oregon Coast under conditions of high velocity, persistent annual winds from the west? Why?

2.A.5. What would happen to relative sea level at the Oregon Coast under conditions of low velocity, or non-existent winds, as compared to question 4 above.

2.A.6. Which condition would result in higher wave erosion potential at the Oregon Coast: winter / storm-driven waves or summer waves? Why?

B. Seasonal Variations in Wave Characteristics at the Oregon Coast.

Wave breaker heights and wave periods were measured at Newport, Oregon during 1972 and 1973. The data are shown in Table 1, and are available on the class web site as an Excel spreadsheet file "coastdata.xls". Check the lab data section of the class web site. Perform the following tasks and analyses.

Task 1. Using the data in Table 1, plot Average Wave Height (m) and Maximum Wave Height (m) vs. Time on the blank graph provided in Figure 1, i.e. draw two separate plots on the same graph paper (alternatively, create the graph using the chart wizard in microsoft Excel). Draw lines connnecting your data points for each data set.

Task 2. Using the data in Table 1, plot Wave Period (sec) vs. Time on the blank graph provided in Figure 2 (alternatively, create the graph using the chart wizard in microsoft Excel). Draw lines connnecting your data points.

Task 3. Using the data in Table 1, plot Average Wave Breaker Height (y-axis) vs. Wave Period (x-axis) on the blank graph provided in Figure 3 (alternatively, create the graph using the chart wizard in microsoft Excel). Match the wave height data to the wave period data, as they occur on approximately the same day of the month. **Do not** draw lines connnecting your data points, instead...

Task 3A. Draw a "best-fit" line to the wave height vs. period data, extend your line to the y-axis and determine the equation of the linear relationship: the general form of the equation is

$$y = mx + b,$$

where y = wave ht., x = wave period, m = slope of line (rise/run), b = y-intercept (the point on the y-axis where the line intersects it). Write your line equation on the graph.

Question 2.B.1. During which season does the Oregon Coast experience the largest waves and highest wave energy? What processes account for this seasonal relationship?

Question 2.B.2. During which season does the Oregon Coast likely experience the greatest degree of beach erosion and why?

Question 2.B.3. What is the seasonal relationship associated with wave periods at the Oregon coast? What is the relationship between wave height and wave period? How could you quantitatively predict wave height by using wave period?

Part 3. Relative Sea Level Fluctuations

Sea levels fluctuate over time according to climatic and tectonic conditions of the Earth. There are periods in Earth history where sea levels are high, and periods where they are low. There are also small seasonal changes in sea level that are detectable by examining tide-gauge records at monitoring stations. Tide-gauge records are available for historic times, longer sea level records are derived from coastal terraces and fossiliferous geologic deposits (e.g. coral reefs), as well as oxygen isotope records. The exercises below provide an opportunity to think about relative changes in sea level, both on the short-term time scale, and over longer periods of Earth history.

Monthly tide-gauge records for Yaquina Bay (Newport) Oregon during 1982 and 1983 are listed in Table 2 (**Remember**: all tables are available in the "lab data" (Excel file coastdata.xls) section of the class web site). Table 3 is a summary of historic mean annual sea level measurements for four gauge stations around the U.S. (Astoria, OR; Galveston, TX; Juneau, AK; and New York, NY). The longer-time geologic record of sea level fluctuations for the late Pleistocene (back to about 19,000 years ago) are listed in Table 3A.

Task 4. Using the data in Table 2, plot of relative sea level (y-axis) vs. time (x-axis: months in 1982-83) on the graph provided in Figure 4 (alternatively, create the graph using the chart wizard in microsoft Excel). Make two plots on the same graph, one showing the 1982-83 data, and the other showing the historic monthly average data. Use "dots" for the 82-83 data, and "triangles" for the longer-term monthly average data. Draw lines connnecting your data points.

Question 3-1. During which season(s) does the Yaquina Bay gauging station experience the highest relative sea levels? What is the difference between lowest yearly sea levels and the highest sea levels (i.e. what is the maximum sea level difference experienced during the year?).

Question 3-2. Thinking back to Part 2B, what process(es) account for the seasonal changes in relative sea level that you observe?

Question 3-3. 1982-83 was an El Nino year for the Oregon coast. El Nino cycles bring warm ocean currents to the west coast of South America. The current splits at South America, and forces warm ocean water to the north into the western U.S.

How do "El Nino year" sea level cycles compare to the long-term historic monthly average cycles? Are the seasonal sea level changes the same for both El Nino and historic conditions?

Question 3-4. Hypothesize mechanisms in the ocean that may account for your observations in question 3-3.

Task 5. Using the historic mean annual sea level data in Table 3, make a set of plots for Average Relative Sea Level (y-axis) vs. Time (x-axis: years) for Astoria, OR; Galveston, TX; and Juneau, AK. Blank graphs for each plot are provided in figures 5A, 5B, and 5C, respectively (alternatively, create the graph using the chart wizard in microsoft Excel). Draw lines connecting your data points in each graph.

Task 5A. Draw a best-fit line for each of your graphs in Figure 5A, 5B, and 5C.

Task 5B. The slope of the best-fit line (rise / run) equals the rate of sea level change over time (in cm /yr). A negative slope = falling sea level, a positve slope = rising sea level. Calculate the slope of the best-fit line (i.e. the rate of historic sea level change) for each of the graphs in Fig. 5A, 5B, and 5C. Show your work on the graphs.

Question 3-5. From your graph data in Task 5, fill in the chart below.

Location	Rate of Historic Relative Sea Level Change
Astoria, OR	____________
Galveston, TX	____________
Juneau, AK	____________

Question 3-6. Thinking about the historic condition of sea level change in the past 100 years (i.e. what is the modern climate affecting sea level), and the tectonic setting of each of the locations (Astoria, Galveston, and Juneau), systematically explain the processes creating the relative sea level fluctuations shown in Fig. 5A, 5B, and 5C.

Task 6. Using the reconstructed global sea level data for the late Pleistocene, in Table 3A, plot change in relative sea level (y axis) vs. calendar age (kyr BP - x axis). Use the blank graph provided in Figure 5D (alternatively, create the graph using the chart wizard in microsoft Excel).

Task 6A. Using the graph / slope method described in Task 5B above, determine the rate of sea level change between 80,000 yr BP and 20,000 yr BP. Show your work and calculation on Figure 5D.

Question 3-7. What has happened to global sea level during the past 120,000 years? Has there been a constant or variable rate of sea level change? What time periods experienced the highest rate of sea level change, how about the lowest rates?

Question 3-8. Thinking about climate change and glacial/interglacial cycles, explain the sea level curve in Figure 5D in terms of late Pleistocene climate. Has the climate been warming, cooling, or what? How do you know, explain your line of reasoning in great detail. Draw diagrams as necessary to support your argument.

Question 3-9. For the sake of simplicity, let's assume that the Oregon coast has been tectonically stable for the late Pleistocene (which, we know is false, but let's make it simple). According to the graph in Fig. 5D, what was the position of relative sea level, compared to modern, along the Oregon coast 120,000 years ago? How about 50,000 years ago?

Task 5C. Figure 5E is a topographic profile of the Oregon coast at the latitude of Newport. Note the position of modern sea level, the continental shelf, and continental slope. Using colored pencils, draw and label the position of sea level along the Oregon coast at 120,000 years ago and 50,000 years ago (refer back to your graph in Fig. 5D).

Question 3-10. Comment on what the topography of the Oregon coast looked like 120,000 and 50,000 years ago, compared to that of today. Were there rocky shorelines and sea cliffs? Was there more or less "beach" area. What did the coastal rivers (e.g. Yaquina, Nestucca, Columbia) look like at those times, compared to today? Draw diagrams as necessary to support your answer.

Part 4. Rates of Coastal Erosion in Oregon.

Coastal Oregon is very dynamic with respect to geomorphic process. Cliff erosion, beach erosion, landsliding, and flooding are common occurrences, particularly during the stormy winter months. Each year, millions of dollars in damage occurs to property along the Oregon coast. The understanding of geomorphic process is critical for the appropriate design of land-use regulations and housing plans.

Figure 6 is a map of the Nye Beach area of Newport, OR. The Jumpoff Joe sea cliff area is a classic example of very active historic erosion along the Oregon coast. By examining historic aerial photographs, it is possible to map out the position of the sea cliffs, and the rate of erosion over time. The map shows sea cliff positions for the years 1868, 1939, and 1967. The black squares represent the position of buildings and houses during this time frame.

Task 6. Using the map data in Fig. 6, determine the historic rates of sea cliff erosion at the Nye Beach area. Fill in the table below for cross-sections A-A', B-B', and C-C'.

Section I.D.	Record Period (date range)	Retreat Distance (meters)	Time Interval (years)	Retreat Rate (m/yr)
A-A'	1868-1939	________	________	_______
A-A'	1939-1967	________	________	_______
A-A'	1868-1967	________	________	_______
B-B'	1868-1939	________	________	_______
B-B'	1939-1967	________	________	_______
B-B'	1868-1967	________	________	_______
C-C'	1868-1939	________	________	_______
C-C'	1939-1967	________	________	_______
C-C'	1868-1967	________	________	_______

Question 4-1. How does the rate of sea cliff erosion vary spatially from section A-A', south to section C-C' along Nye Beach?

Question 4-2. How has the rate of sea cliff erosion varied temporally between 1868 and 1967, at each of these localities? Which show the highest rates, the lowest rates, how have the rates changed over time?

Question 4-3. Hypothesize why the rates of sea cliff erosion have slowed in the Jumpoff Joe area, historically.

Question 4-4. Look at a geologic map of Oregon (e.g. on the lab room wall), what geologic unit(s) underlies the Nye Beach area? Hypothesize how bedrock geology may be controlling the spatial patterns you observed in Question 4-1.

Question 4-5. What has happened to the large cluster of houses between points B and B'? When did this happen? List the processes that were likely involved.

Question 4-6. Given the 1939-1967 rates of erosion in the Jumpoff Joe area (line A-A'), how long did it take for the three houses southeast of the 1967 shoreline to bite the dust? Do you think they are still there? Why or why not?

Part 5. Neotectonics of the Oregon Coast

Western Oregon is the site of plate tectonic covergence, with subduction of the Juan de Fuca plate beneath the North American plate. This convergent zone is associated with accretionary tectonics, compressional strain, and Cascade arc volcanism. As such, neotectonic deformation, crustal motion, and differential uplift/subsidence of the Oregon coast must be reconciled with any geomorphic model of the region.

Historic crustal motion of the Earth is measured via re-leveling surveys of surface elevation (re-leveling = re-measurement of land surface elevation over time), or with satellite positioning systems (GPS = global positioning system). Longer term uplift of coastal areas is reconstructed by examination of wave-cut terrraces and coast terrace deposits, with related application of geologic dating techniques.

Mitchell and others (1994) examined historic re-leveling data of surface elevations along a transect extending from northern California to Washington. They combined the re-leveling data with tide gauge measurements to determine net relative vertical ground motion velocities for coastal regions of the Pacific Northwest. Table 4 is a summary of historical ground motion velocity data for a south-to-north transect, arranged by latitude (degrees north); positive velocities = uplift, negative velocities = crustal subsidence.

Task 7 Using the data in Table 4, plot a south-to-north transect of historic ground motion velocity (y axis) vs. latitude (x axis). Use the blank profile paper provided in Figure 7 (alternatively, create the profile using the chart wizard in microsoft Excel). List the geographic names of the data localities above the profile, for reference.

Question 5-1. Identify regions of coastal PNW that are experiencing rapid historic uplift. Identify regions of coastal PNW that are experiencing no net uplift, or subsidence. Do you see any spatial patterns in terms of uplift / stability / subsidence along the south-to-north transect?

Question 5-2. Assuming that sea level is presently rising, what can you conclude about the rate of tectonic uplift, and rate of sea level rise for the Newport, OR area?

Question 5-3. Examine a tectonic map of the PNW (see the "fractured surface" map on the wall of the lab room). Identify the area of highest rates of tectonic uplift on your profile, and locate that area on the tectonic map. Comment on the relationship between the type of tectonic boundary(ies) and the highest rates of coastal uplift in the PNW.

Question 5-4. Which areas of the coastal transect would you expect to find the highest, and most well-developed flights of coastal terraces? Which areas would you expect to find the most well-developed coast-terrace soils? Why? Draw sketches to support your answer.

Task 8. Figure 8 is a map of interpolated uplift rates for select points in the Pacific Northwest (west of the Cascades). Draw contour lines on the map data connecting points of equal uplift rates. Use a contour interval = 1 mm/year. Using colored pencils, color code the neotectonic domains using the following classification scheme (i.e. color all regions of the map according to uplift rate):

uplift 0-1 mm /yr	blue
uplift 2-3 mm/yr	yellow
uplift 4-5 mm/yr	red

Question 5-5. Identify the zone of highest uplift. What type of tectonic process is occurring in this region.

Question 5-6. Locate Monmouth, OR on the map. What is our historic rate of uplift on campus? Which part of western Oregon is associated with the highest rates of uplift?

Question 5-7. What is the rate of uplift in the Puget Sound region? What other isostatic process(es) must be accounted for in the Puget Sound region, and to the north of that point.

Task 8. Table 5 is a listing of data collected from uplifted marine terraces in southern Oregon. The terraces are formed by wave-base erosion, at or below sea level. They are elevated along the Oregon coast through the process of relative uplift over time. The age of the terrace is derived by numerically dating preserved marine deposits. The original depth of the wave-cut platform is reconstructed from fossil organisms. Paleo-sea level (compared to modern sea level) is derived from the global marine sea level record.

Complete the data in Table 5 by using Microsoft Excel. Download the table from the class web site and use the spreadsheet math functions to determine parameters in columns e, f, and g (total tectonic uplift and average uplift rate). To help in resolving the parameters, draw a cross-sectional sketch of modern sea level, paleo-sea level, original depth of terrace, and present elevation. Calculate the total tectonic uplift that the terrace has experienced, combine that with the age data to determine the long-term average rate of uplift on the southern Oregon Coast.

Question 5-8. How do the long term average uplift rates in Table 5 compare with the historic uplift rates presented in Table 4, and Figures 7-8? Explain the differences or similarities that you observe.

Question 5-9. In looking at degree of soils development on the Whiskey Run, Cape Blanco, and Pioneer terraces; explain which terraces would have more well-developed soils, and which less. Describe the physical and chemical characteristics of the soils that you would expect to sea when visiting all three of the localities.

Question 5-10. If you were asked to find these marine terraces on a map and in the field, what types of topographic and geologic evidence would you look for (how would you go about doing this from scratch?)? Explain how county soils surveys would help in this process.

Table 1. Monthly Variations of Wave Breaker Height
and Wave Periods at Newport, Oregon, 1972-1973 (from Komar, 1992).

Date	Average Wave Height (meters)	Date	Maximum Wave Height (meters)	Date	Wave Period (Seconds)
07/05/72	1.7	07/07/72	2.4	07/06/72	7.7
07/16/72	2.3	07/17/72	2.7	07/16/72	9.0
07/26/72	1.3	07/26/72	2.1	07/26/72	7.9
08/04/72	1.3	08/04/72	1.6	08/04/72	7.4
08/15/72	1.0	08/15/72	1.5	08/15/72	7.8
08/25/72	1.4	08/26/72	2.4	08/25/72	8.3
09/05/72	1.5	09/05/72	2.1	09/05/72	8.2
09/14/72	1.7	09/15/72	2.7	09/14/72	8.5
09/26/72	1.7	09/26/72	2.9	09/26/72	8.4
10/04/72	2.4	10/05/72	3.9	10/05/72	10.1
10/16/72	1.6	10/16/72	2.4	10/16/72	10.1
10/25/72	2.0	10/25/72	3.2	10/26/72	9.7
11/05/72	3.7	11/04/72	5.2	11/04/72	10.8
11/14/72	3.7	11/15/72	4.9	11/16/72	11.7
11/24/72	4.1	11/24/72	6.0	11/25/72	12.4
12/06/72	2.5	12/05/72	3.0	12/05/72	10.3
12/15/72	2.8	12/14/72	5.4	12/16/72	9.6
12/25/72	4.4	12/25/72	6.8	12/27/72	11.1
01/05/73	2.1	01/04/73	4.0	01/05/73	10.3
01/15/73	4.0	01/14/73	5.9	01/15/73	10.7
01/24/73	3.9	01/24/73	4.8	01/26/73	10.7
02/04/73	2.9	02/05/73	4.9	02/04/73	11.2
02/13/73	3.2	02/13/73	4.8	02/15/73	10.7
02/23/73	3.2	02/25/73	4.3	02/25/73	10.8
03/06/73	3.0	03/05/73	3.5	03/07/73	9.8
03/15/73	3.8	03/15/73	5.1	03/17/73	10.6
03/26/73	2.8	03/25/73	5.6	03/27/73	9.8
04/05/73	2.3	03/28/73	4.5	04/06/73	10.1
04/15/73	2.5	04/06/73	2.6	04/16/73	9.4
04/25/73	1.9	04/16/73	3.2	04/26/73	8.6
05/04/73	2.6	04/25/73	2.4	05/07/73	9.8
05/15/73	1.9	05/05/73	3.9	05/16/73	9.0
05/25/73	2.4	05/14/73	3.2	05/27/73	9.2
06/04/73	1.8	05/25/73	4.2	06/06/73	8.5
06/14/73	2.3	05/28/73	3.5	06/16/73	9.2
06/24/73	1.4	06/04/73	2.4	06/27/73	7.6
		06/14/73	4.0		
		06/24/73	2.8		

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Table 2. Monthly Sea Levels Measured with Tide Gauge in Yaquina Bay, Oregon. Data is from the 1982-1983 El Nino Year and from Long-Term Historic Averages (from Komar, 1992).

Date	El Nino Year (82-83) Monthly Relative Sea Levels (cm)	Date	Historic Monthly Average Relative Sea Levels (cm)
05/17/82	8.3	05/17/82	12.6
06/17/82	18.7	06/16/82	12.7
07/17/82	17.8	07/18/82	15.0
08/17/82	21.5	08/16/82	17.7
09/15/82	27.9	09/15/82	22.2
10/15/82	36.1	10/16/82	22.5
11/15/82	51.4	11/14/82	30.1
12/16/82	56.4	12/15/82	36.4
01/15/83	64.5	01/13/83	34.6
02/15/83	67.7	02/13/83	35.1
03/18/83	59.2	03/18/83	28.8
04/16/83	32.3	04/15/83	18.6
05/15/83	24.3	05/15/83	12.7

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Table 3. Relative Changes in Mean Yearly Sea Level for Select Tide Gauge Stations in the U.S. (data from Komar, 1992; after Hicks and others, 1983).

Year	Yearly Average Relative Sea Level (cm) for Astoria, OR	Year	Yearly Average Relative Sea Level (cm) for Galveston, TX	Year	Yearly Average Relative Sea Level (cm) for Juneau, AK	Year	Yearly Average Relative Sea Level (cm) for New York, NY
1925	13.7	1908	10.1	1935	45.6	1892	0.1
1926	11.8	1909	2.9	1936	44.2	1893	1.0
1927	20.5	1912	14.7	1939	45.3	1894	-0.3
1929	3.2	1914	9.8	1939	48.9	1897	3.6
1933	16.4	1915	10.4	1942	37.3	1897	4.0
1934	16.8	1916	4.0	1945	33.5	1899	3.6
1935	10.5	1917	5.6	1948	30.4	1900	0.2
1936	10.0	1918	17.0	1951	20.7	1901	6.8
1937	12.4	1919	14.1	1951	27.1	1902	7.5
1939	8.2	1920	23.1	1952	27.3	1903	5.5
1940	14.5	1921	18.3	1954	15.1	1904	1.3
1941	16.3	1922	19.0	1956	14.2	1905	0.3
1942	12.8	1923	10.9	1957	17.5	1906	3.0
1943	12.2	1924	10.4	1958	14.6	1907	2.2
1944	3.9	1925	11.3	1959	16.4	1908	1.2
1945	11.5	1926	19.0	1960	16.4	1909	4.3
1947	10.9	1927	13.9	1961	13.8	1910	6.1
1948	25.5	1928	25.2	1962	15.8	1912	0.5
1949	16.6	1930	10.8	1964	7.0	1914	4.3
1951	16.6	1932	23.0	1965	9.6	1915	6.3
1952	11.8	1934	15.3	1966	6.4	1916	5.6
1952	14.7	1934	19.7	1967	8.8	1917	6.2
1954	15.1	1935	20.1	1968	7.0	1918	5.9
1955	9.3	1936	23.4	1969	0.5	1919	10.6
1956	12.9	1937	22.2			1919	9.1
1957	13.6	1939	16.8			1921	10.0
1957	16.9	1940	26.7			1922	6.2
1960	9.6	1942	27.4			1924	7.1
1961	11.1	1944	34.6			1925	4.6
1961	9.4	1945	35.1			1927	7.7
1963	11.4	1946	33.3			1928	3.8
1963	9.5	1948	38.2			1929	4.4
1965	13.6	1949	38.5			1930	3.8
1966	10.1	1950	29.9			1931	7.7
1967	11.4	1951	32.2			1932	8.0
1968	15.3	1952	32.4			1933	10.4
1970	8.4	1954	27.8			1934	6.5

Table 3. Relative Changes in Mean Yearly Sea Level for Select Tide Gauge Stations in the U.S. (data from Komar, 1992; after Hicks and others, 1983).

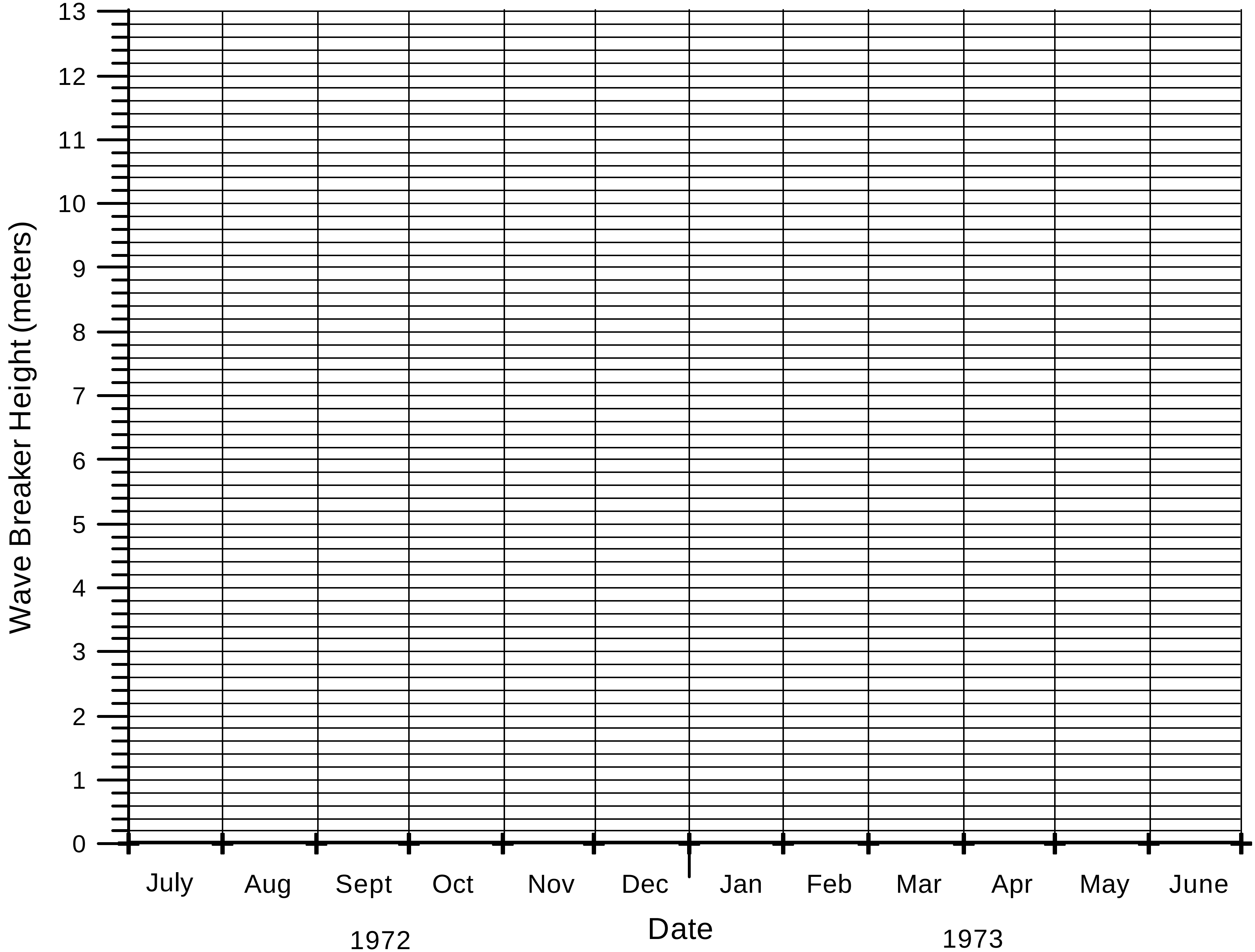
Year	Yearly Average Relative Sea Level (cm) for Astoria, OR	Year	Yearly Average Relative Sea Level (cm) for Galveston, TX	Year	Yearly Average Relative Sea Level (cm) for Juneau, AK	Year	Yearly Average Relative Sea Level (cm) for New York, NY
		1955	32.1			1935	10.0
		1956	29.5			1936	8.7
		1956	38.6			1937	12.8
		1957	38.0			1940	13.3
		1959	36.5			1941	11.4
		1961	41.2			1942	14.5
		1962	31.7			1944	12.9
		1964	33.1			1945	16.9
		1964	39.5			1947	14.9
		1965	37.6			1948	18.2
		1966	41.5			1950	12.6
		1967	40.0			1951	17.9
		1968	41.8			1953	17.8
		1969	41.0			1954	16.1
						1956	19.7
						1957	15.9
						1958	22.0
						1958	20.5
						1959	16.6
						1960	20.8
						1961	19.1
						1962	21.6
						1963	16.0
						1965	19.5
						1966	19.4
						1966	21.9
						1968	19.7
						1969	21.9

wou:geomorph:f00:coastdata.xls / yearly sea level- U.S.

Table 3A. Reconstructed Global Sea Level Data for the Late Pleistocene (data reconstructed from coral assemblages in Tahiti, New Guindea, Barbados).

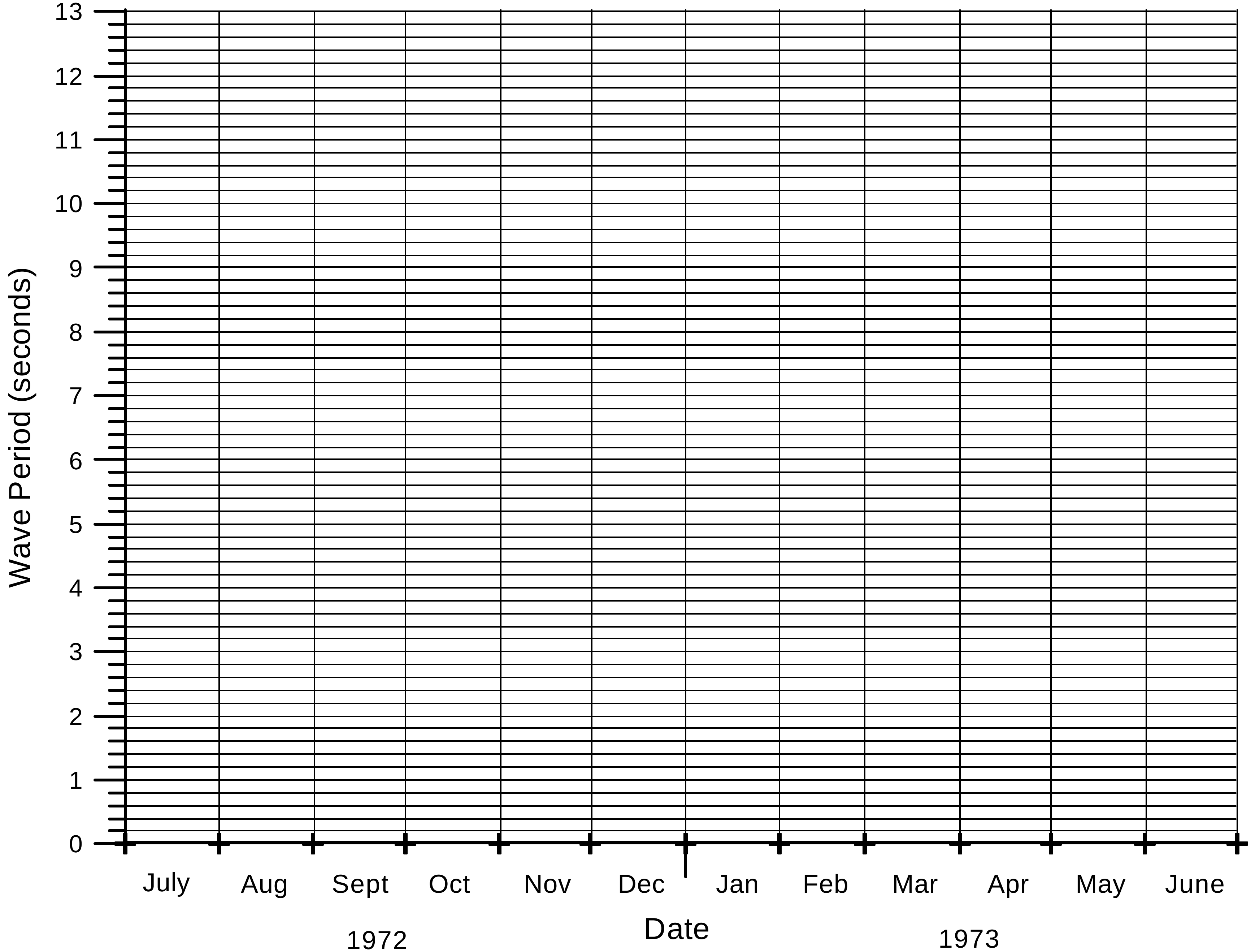
Calendar Age (kyr BP)	Reconstructed Relative Sea Level Compared to Modern (meters)
3.0	-0.07
5.8	-0.60
6.8	-4.19
7.3	-6.90
7.8	-11.43
8.2	-15.46
9.0	-22.71
9.5	-29.89
10.1	-39.79
10.5	-43.03
11.0	-48.90
11.5	-55.47
12.2	-61.60
12.8	-68.48
13.3	-74.56
13.9	-79.86
14.3	-93.12
14.6	-96.44
14.9	-98.87
16.8	-109.32
17.8	-112.38
18.4	-116.09
19.0	-118.24

Figure 1. Time-Series Plot of Wave Breaker Heights at Newport, Oregon (1972-1973).



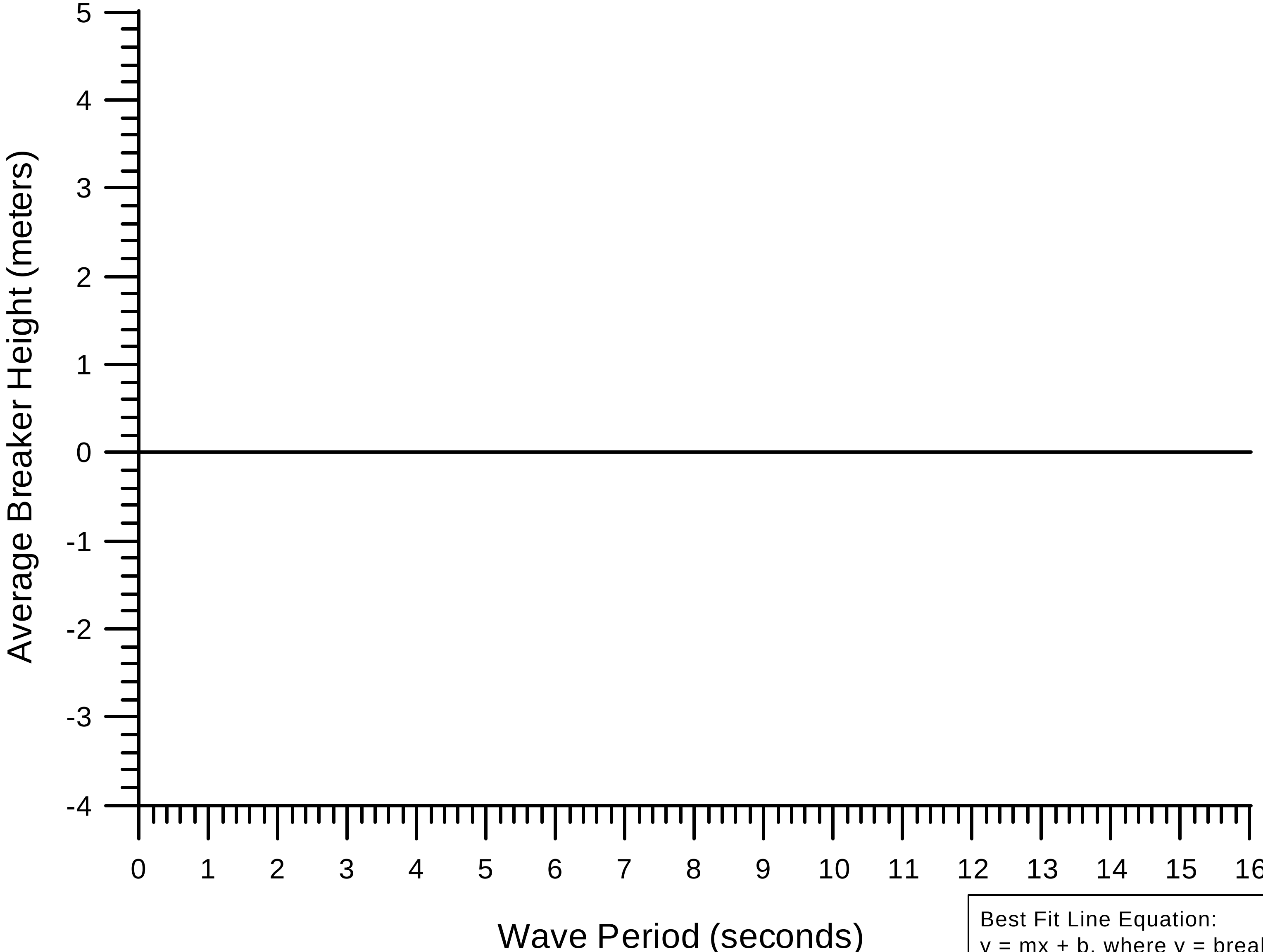
wou:geomorph:f00:coastlab:fig1blnk.grf

Figure 2. Time-Series Plot of Wave Period at Newport, Oregon (1972-1973).



wou:geomorph:f00:coastlab:fig2blnk.grf

Figure 3. Plot of Wave Period (sec) vs. Average Breaker Height (m) Newport, Oregon (1972-1973).

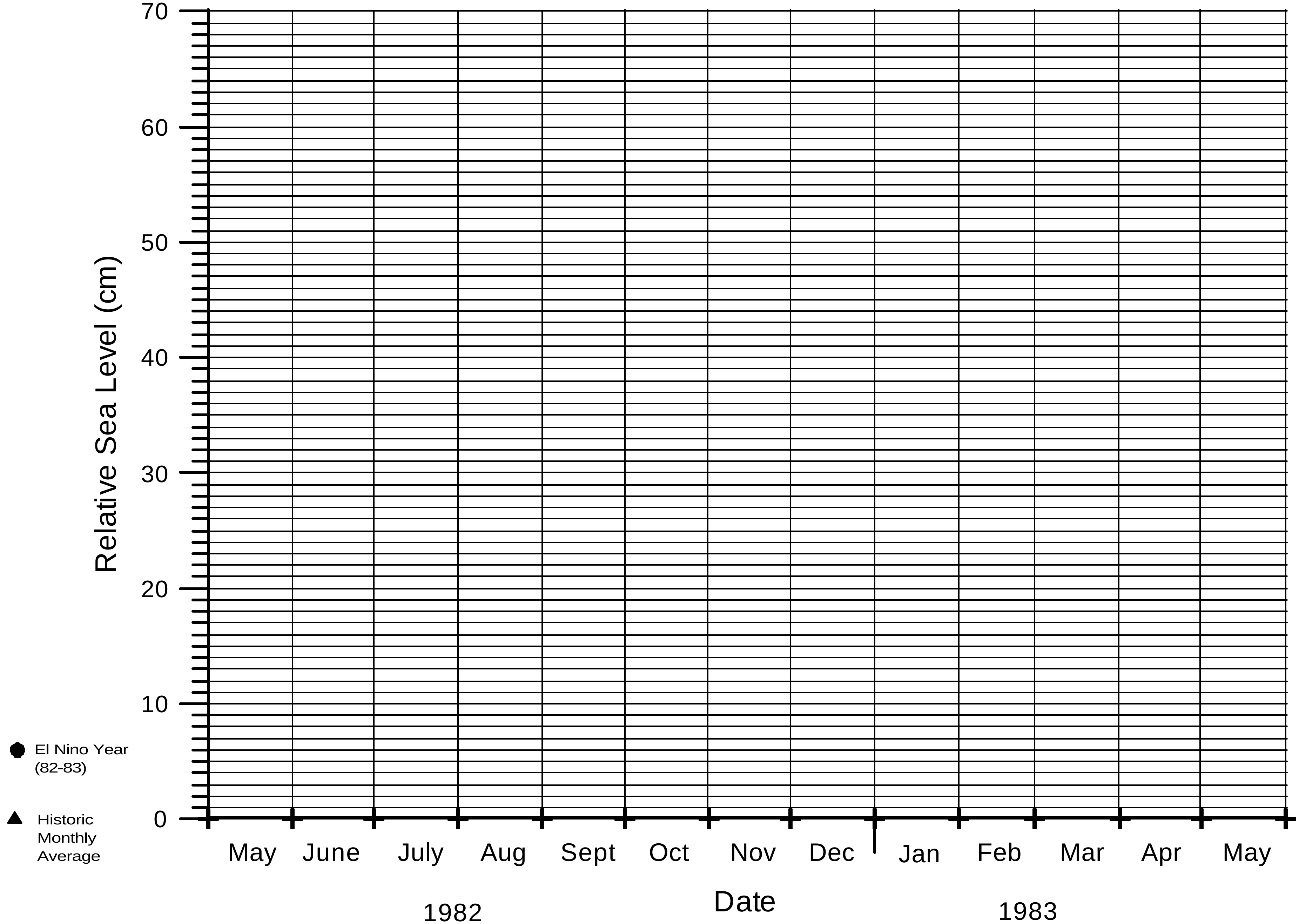


Best Fit Line Equation:
y = mx + b, where y = breaker ht,
m = slope of line,
x = period, b = y intercept

Your Answer Here:

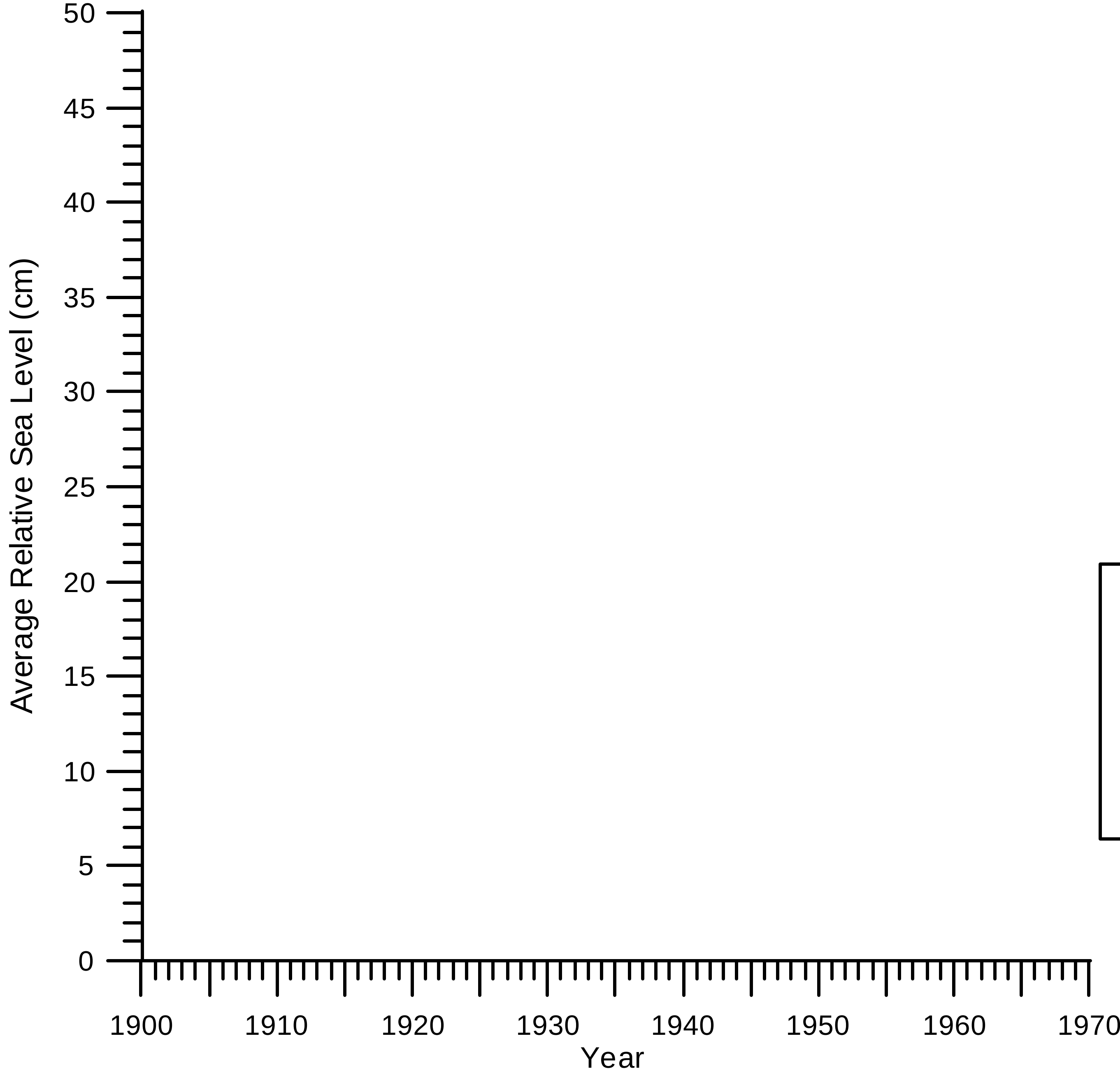
wou:geomorph:f00:coastlab:fig3blnk.grf

Figure 4. Plot of Average Monthly Relative Sea Levels at Yaquina Bay - El Nino Year (1982-1983) Compared to Long-Term Historic Data



wou:geomorph:f00:coastlab:fig4blnk.grf

Figure 5A. Plot of Yearly Changes in Average Relative Sea Levels at Astoria, Oregon



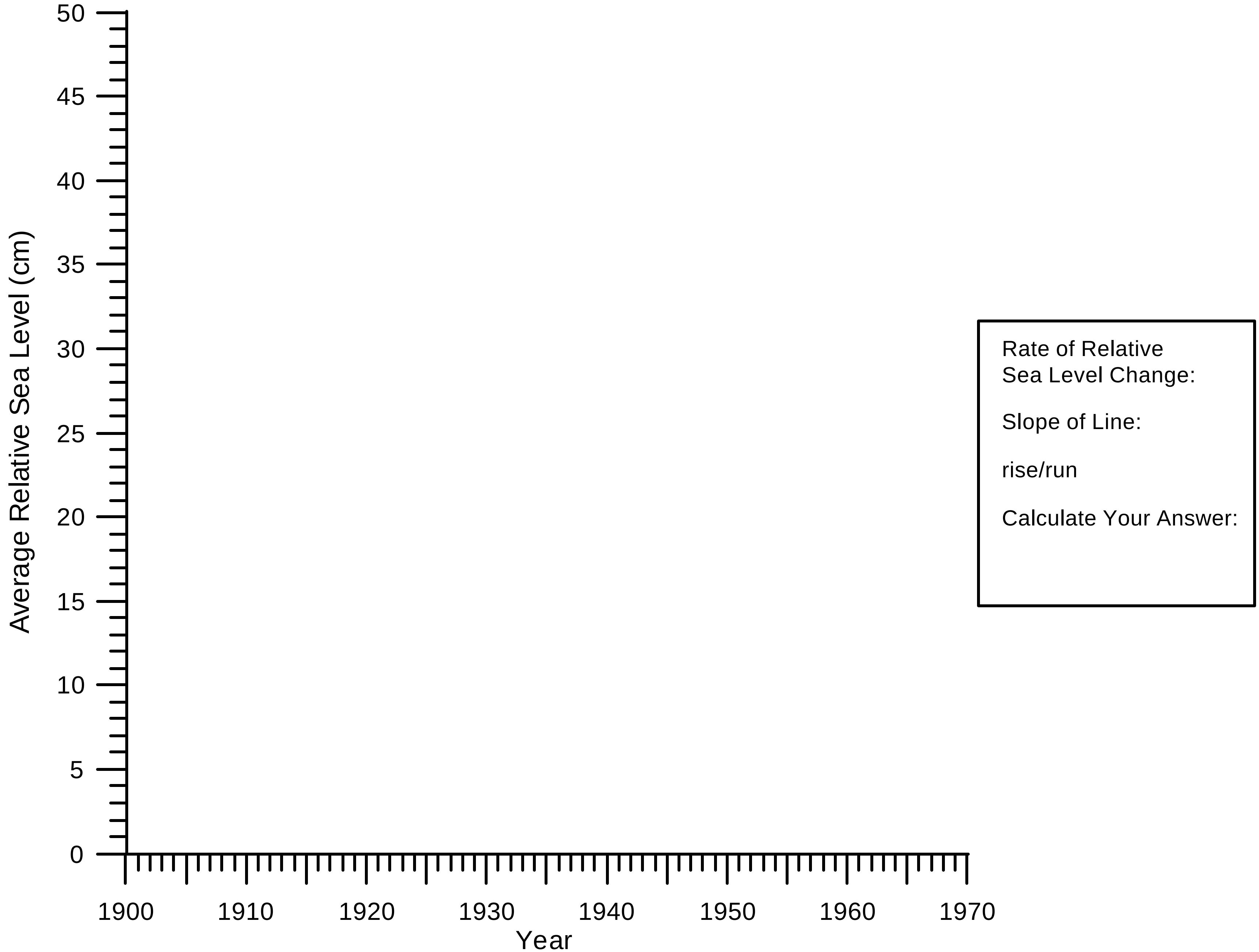
Relative Rate of Sea Level Change:

Slope of Line = Rise / Run

Calculate Your Answer Here:

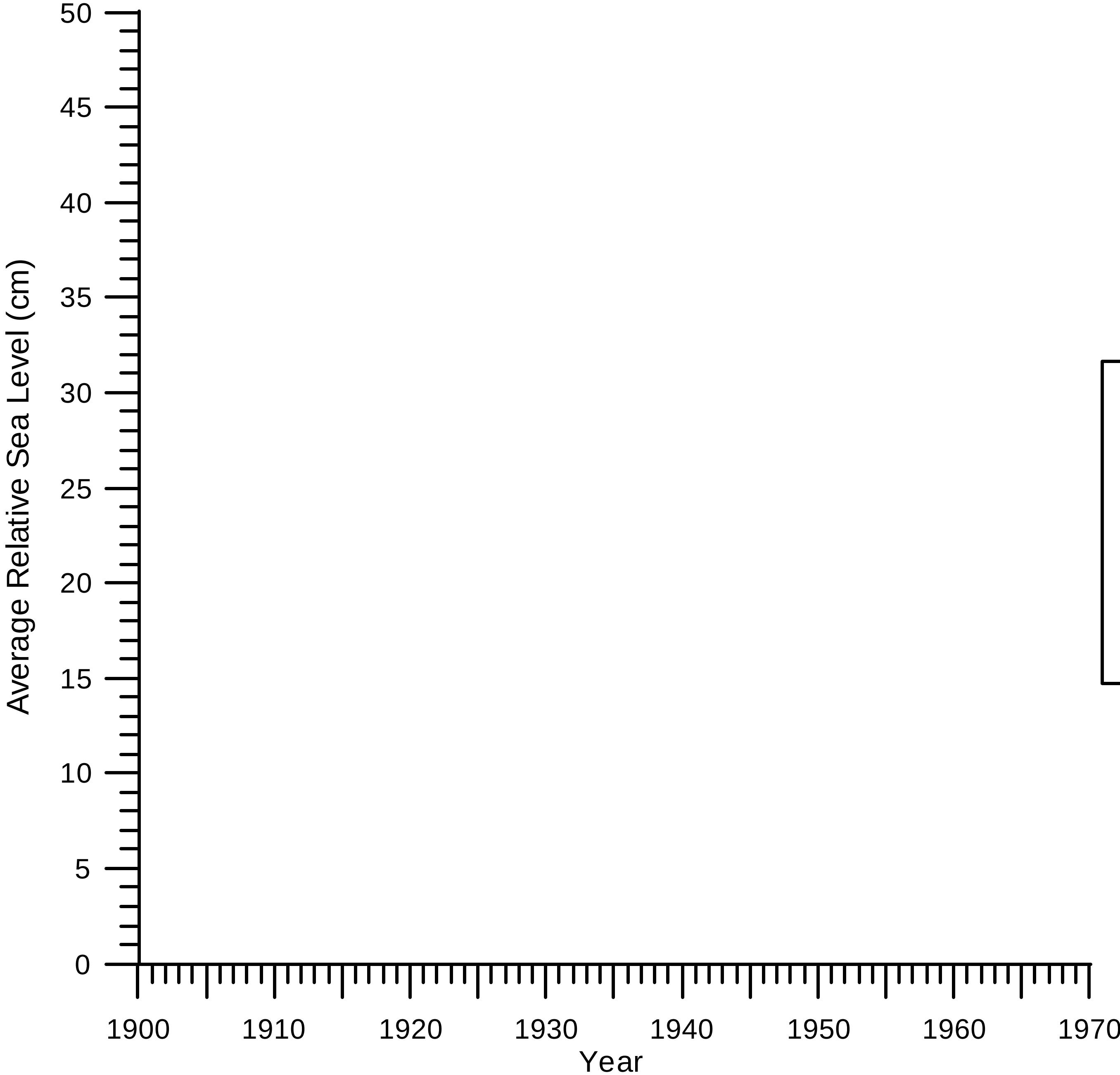
wou:geomorph:f00:coastlab:fg5ablnk.grf (coastdat.dat)

Figure 5B. Plot of Yearly Changes in Average Relative Sea Levels at Galveston, TX



wou:geomorph:f00:coastlab:fg5bblnk.grf (coastdat.dat)

Figure 5C. Plot of Yearly Changes in Average Relative Sea Levels at Juneau, AK



Rate of Relative
Sea Level Change:

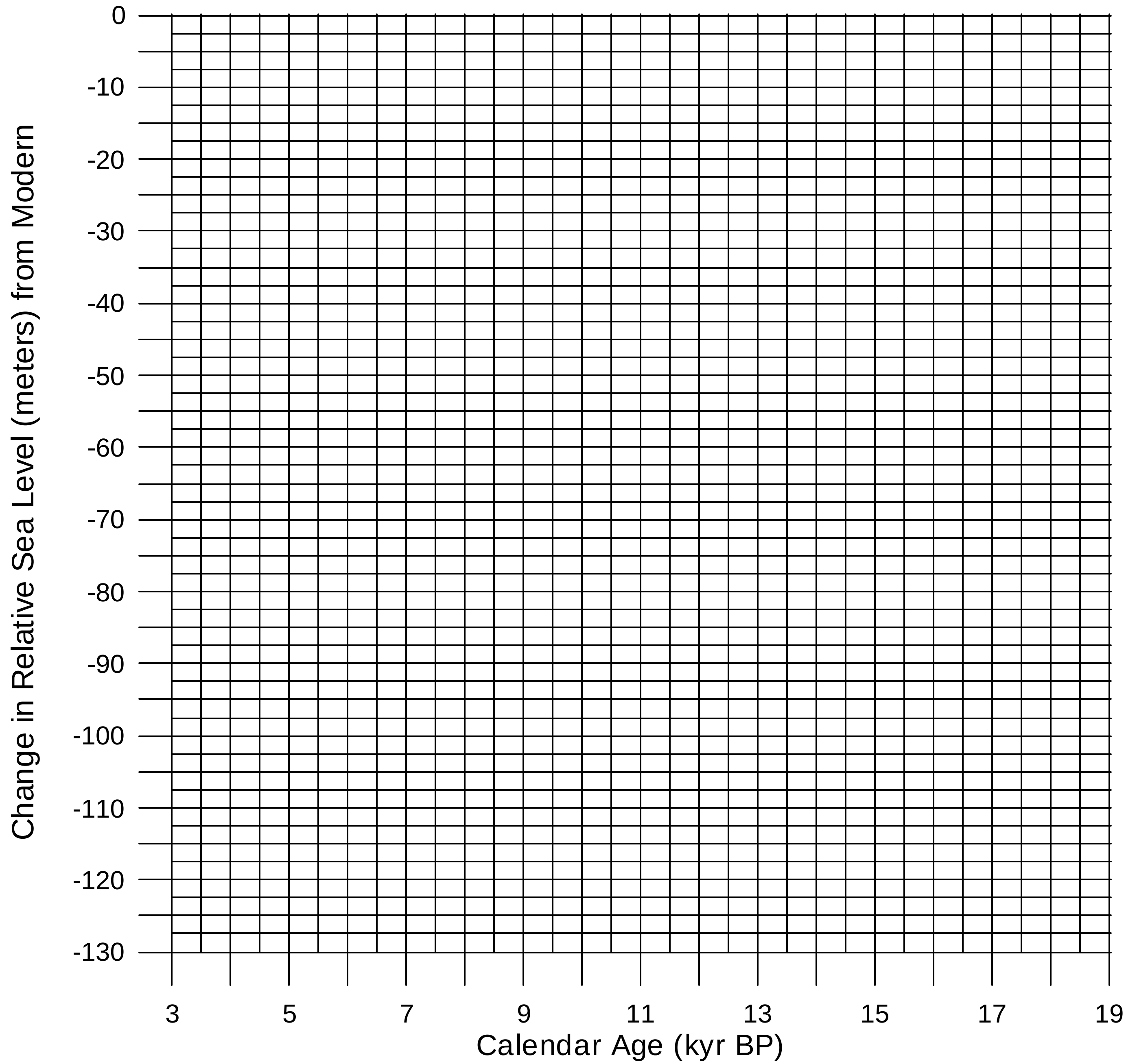
Slope of Line:

rise/run

Calculate Your Answer:

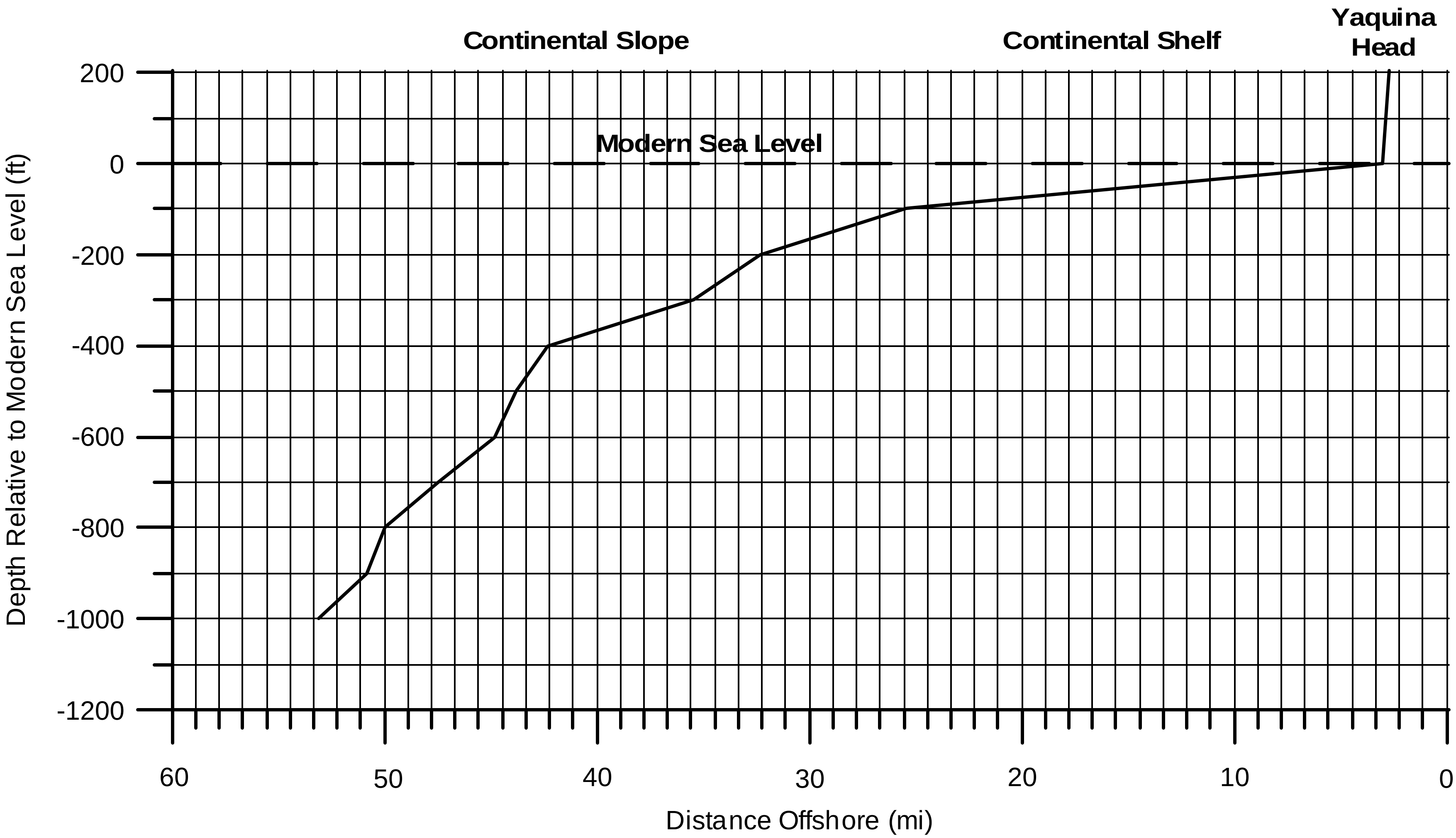
wou:geomorph:f00:coastlab:fg5cblnk.grf (coastdat.dat)

Figure 5D. Reconstructed Global Sea Level Curve for the Late Pleistocene.



c:wou:geomorph:f00:coastlab:fg5dblnk.grf (coastdat.dat)

Figure 5E. Profile of the Continental Shelf, West of Newport Oregon.



c:wou:geomorph:f00:coastlab:shlfprof.grf (shlfprof.dat)

Figure 6. Map showing sea cliff retreat in the Jumpoff Joe area of Newport, Oregon (from Komar, 1992; as documented by Stembridge, 1976).

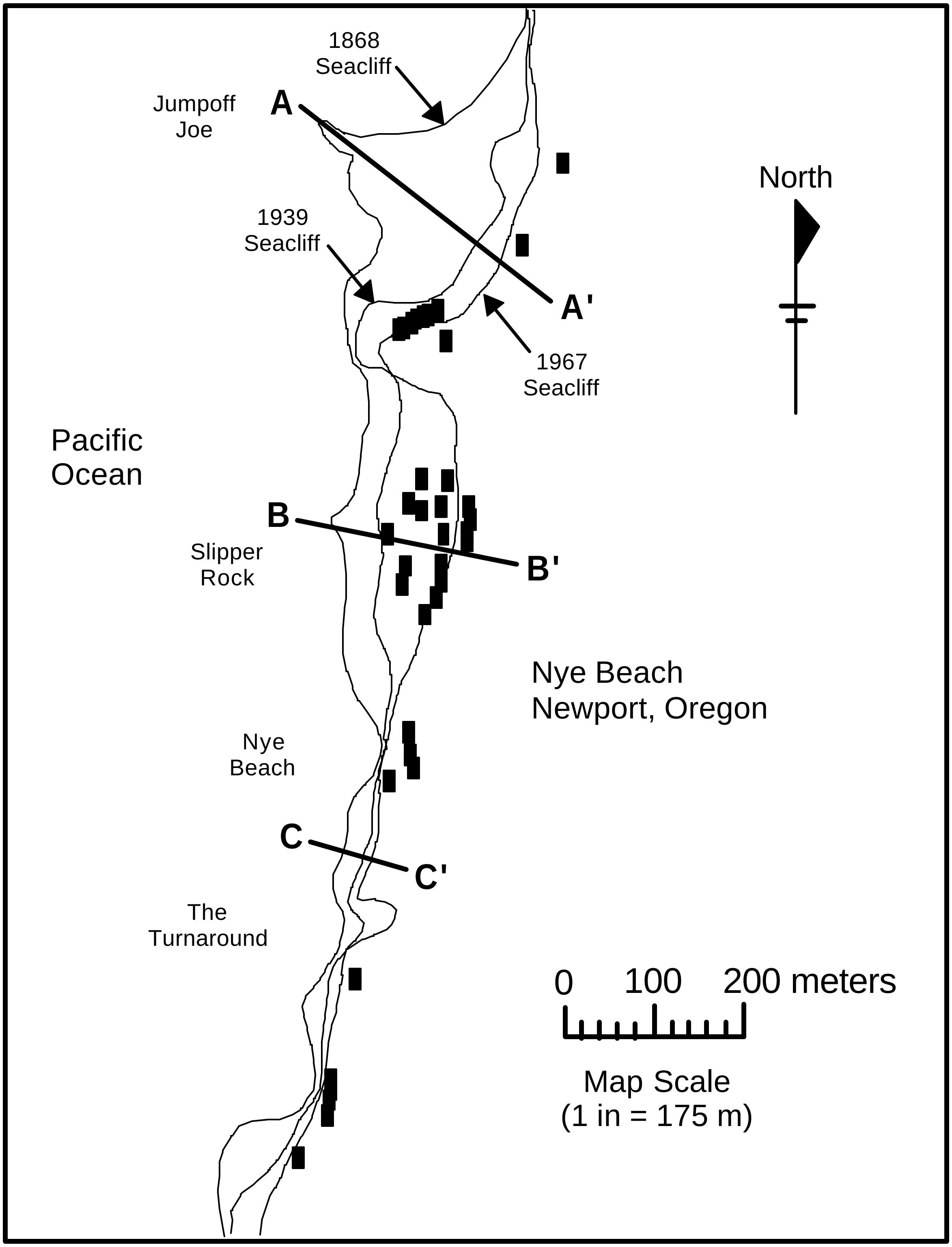


Table 4. Average Vertical Ground Motion Velocities for a South-to-North Transect Along the Coast of the Pacific Northwest

(Data derived from Mitchell et al., 1994 via releveling surveys).
(Note: positive velocity = uplift, negative velocity = subsidence)
c:wou:geomorph:f00:coastlab:neotect.xls / coastup

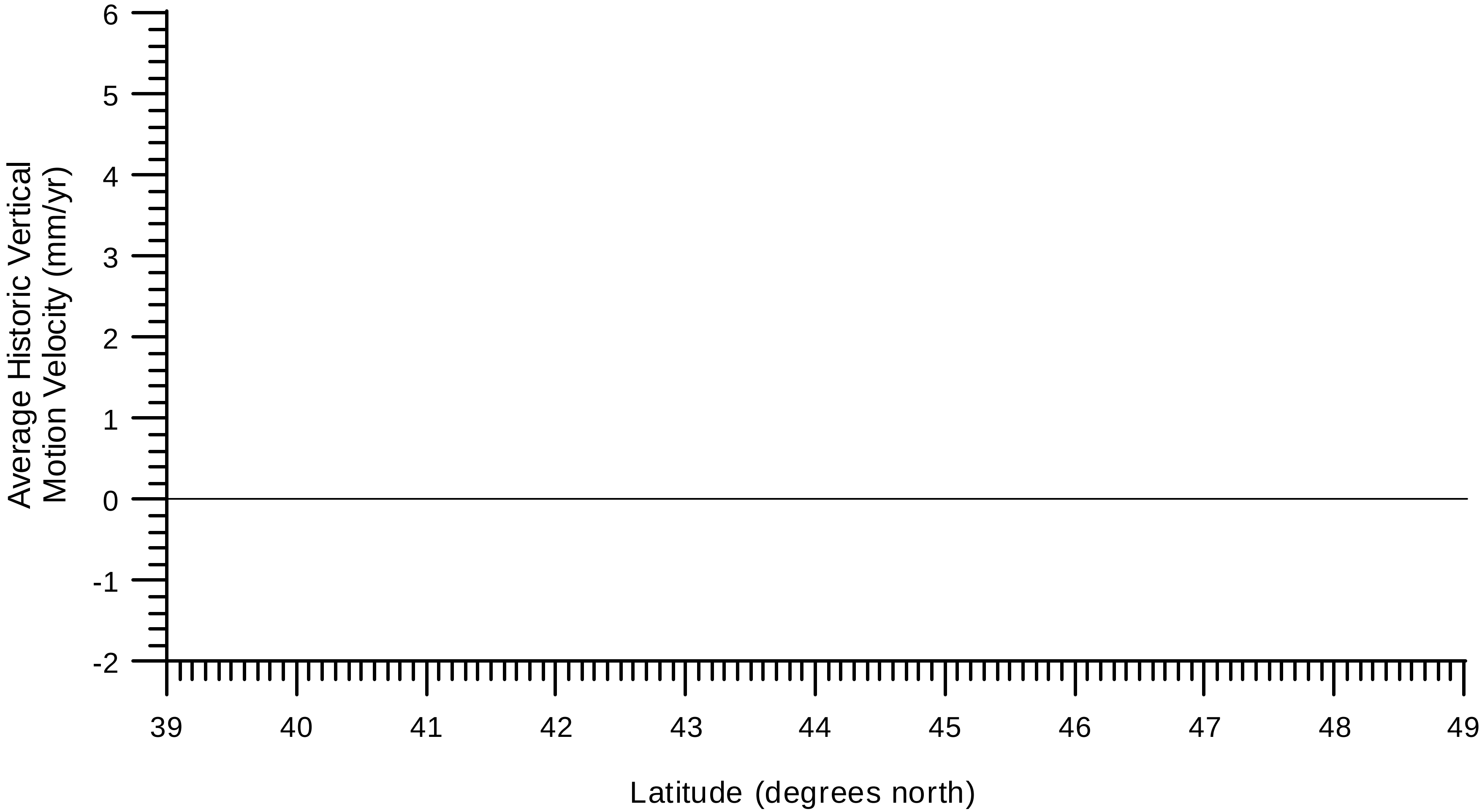
Latitude (degrees N)	Historic Average Vertical Ground Motion Velocity (mm/yr)	Approximate Geographic Location
39.5	1.2	Fort Bragg, CA
39.6	1.5	
39.7	1.8	
39.9	3.0	
40.0	4.1	
40.2	4.5	Garberville, CA
40.4	5.1	
40.6	5.4	
40.7	5.2	
40.9	4.9	Arcata, CA
41.0	4.8	
41.0	4.4	
41.0	3.8	
41.1	3.5	
41.2	3.3	
41.3	3.1	
41.4	2.8	
41.5	2.8	
41.7	2.8	
41.8	2.8	
41.9	2.9	
42.0	3.3	
42.1	3.8	Brookings, OR
42.1	4.0	
42.2	4.1	
42.3	4.1	
42.3	3.6	
42.4	3.3	
42.5	3.1	Gold Beach, OR
42.6	3.0	
42.7	3.0	
42.8	3.4	
42.9	3.7	
43.0	4.4	
43.1	4.4	
43.2	4.1	Bandon, OR
43.2	3.7	
43.3	3.4	
43.4	3.0	
43.5	2.5	
43.8	1.4	Reedsport, OR

Table 4. Average Vertical Ground Motion Velocities for a South-to-North Transect Along the Coast of the Pacific Northwest

(Data derived from Mitchell et al., 1994 via releveling surveys).
(Note: positive velocity = uplift, negative velocity = subsidence)
c:wou:geomorph:f00:coastlab:neotect.xls / coastup

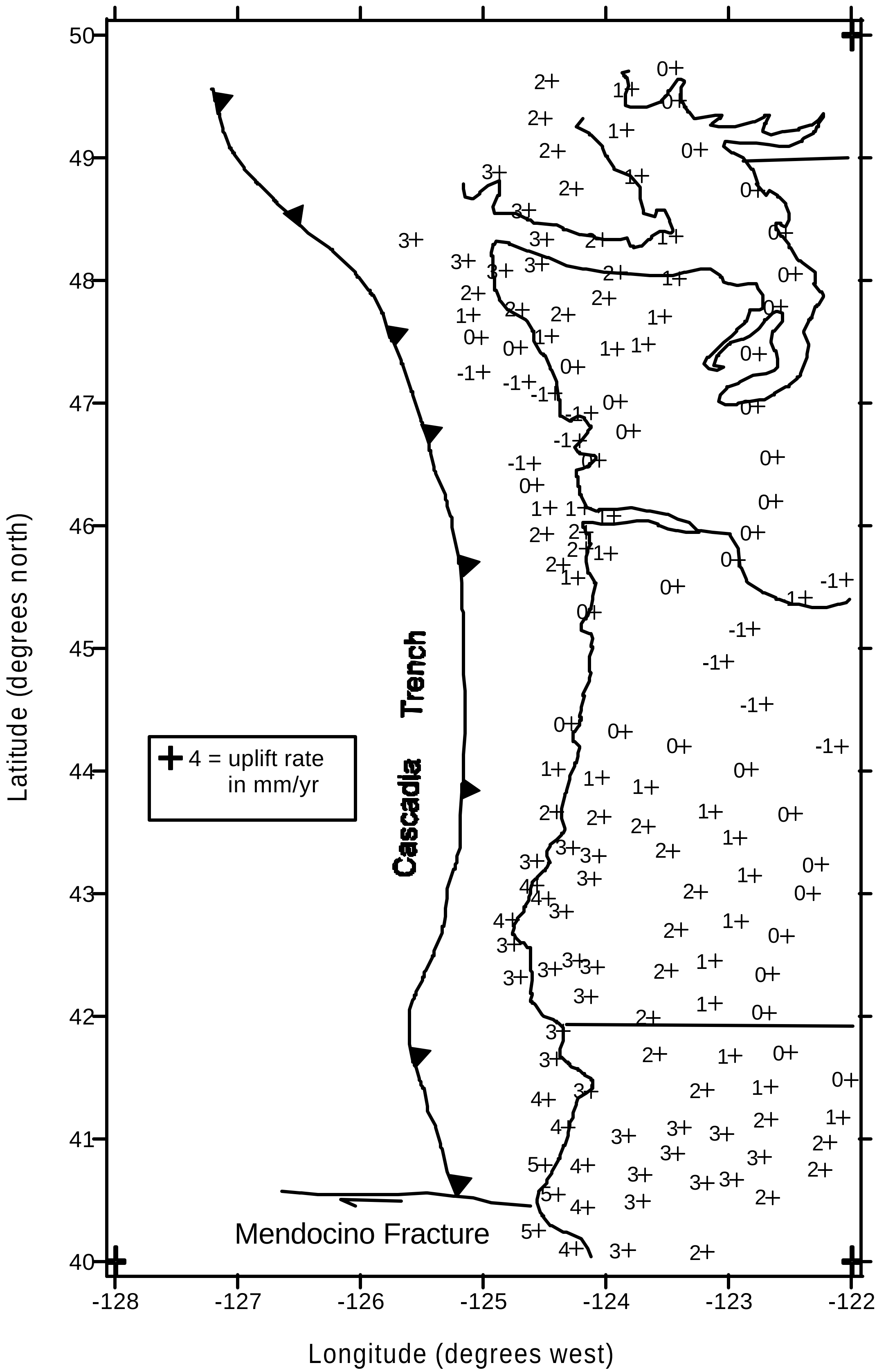
Latitude (degrees N)	Historic Average Vertical Ground Motion Velocity (mm/yr)	Approximate Geographic Location
44.0	0.9	Florence, OR
44.2	0.6	
44.3	0.2	
44.4	0.0	
44.6	-0.1	Newport, OR
44.7	-0.2	
44.9	-0.2	Lincoln City, OR
45.2	-0.3	
45.5	-0.4	Tillamook, OR
45.6	-0.1	
45.7	0.2	
45.9	0.5	
45.9	1.2	
46.0	1.5	Seaside, OR
46.1	1.6	
46.1	1.5	
46.2	1.0	
46.4	0.4	
46.5	0.0	Willapa, WA
46.7	-0.6	
46.8	-0.8	
47.0	-1.0	Aberdeen, WA
47.2	-1.1	
47.3	-1.2	
47.4	-1.1	Queets, WA
47.6	-0.7	
47.7	-0.4	
47.7	0.3	
47.8	1.1	
47.9	1.8	La Push, WA
48.0	2.6	
48.1	3.2	Lake Ozette, WA

Figure 7. Plot of South-to-North Average Uplift Rate Profiles Along the Coast of the Pacific Northwest



wou:geomorph:f00:coastlab:fig7blnk.grf (uplift.dat)

Figure 8. Map of Interpolated Uplift Rates for the Pacific Northwest, West of the Cascade Range (data derived from Mitchell et al., 1994)



wou:geomorph:f00:coastlab:pnwup2.srf (pnwup.dat)

Table 5. Worksheet Calculation of Late Quaternary Uplift Rates in the PNW, as Derived from Marine Terrace Data (data derived from Muhs et al., 1990).

Terrace Name	Location	Terrace Age (ka)	Present Elevation (m)	Original Depth of Wave-Cut Platform (meters)	Paleo-Sea Level (meters)	Total Tectonic Uplift (meters)	Average Uplift Rate (m/kyr)	Average Uplift Rate (mm/yr)
		a	*b*	*c*	*d*	*e*	*f*	*g*
Whiskey Run	Coquille Point, OR	80	17	14	-19			
Whiskey Run	Coquille Point, OR	80	17	48	-19			
Whiskey Run	Coquille Point, OR	80	17	14	-5			
Whiskey Run	Coquille Point, OR	80	17	48	-5			
Cape Blanco	Cape Blanco, OR	80	53	10	-19			
Cape Blanco	Cape Blanco, OR	80	53	28	-19			
Cape Blanco	Cape Blanco, OR	80	53	10	-5			
Cape Blanco	Cape Blanco, OR	80	53	28	-5			
Pioneer	Cape Blanco, OR	105	57	26	-9			
Pioneer	Cape Blanco, OR	105	57	90	-9			
Pioneer	Cape Blanco, OR	105	57	26	-2			
Pioneer	Cape Blanco, OR	105	57	90	-2			

Explanation of Data:

Column a: "ka" = kiloans = 1000's of years ago (how long ago the wave-cut platform was formed)
Column b: "present elevation" = present day elevation of coastal terrace above sea level
Column c: "original depth" = original depth of wave-cut platform below sea level, at time of wave erosion
Column d: "paleo-sea level" = level of sea, relative to present, at time wave-cut platform was eroded
Column e: total tectonic uplift of wave-cut platform from time in column a to present.
Column f: tectonic uplift rate of terrace in meters per 1000 yrs
Column g: tectonic uplift rate of terrace in millimeters per yr

c:wou:geomorph:f00:coastlab:neotect.xls / table 5 terrace data