Introduction

The concept of seismic gaps grew contemporaneously (although separately) with the concept of plate tectonics. The intuitive basis for seismic gaps can even be traced to the original work on elastic rebound by H.F. Reid following the 1906 San Francisco earthquake. The idea is that stress is applied across a fault in the Earth. Over time, the sides of the fault begin to move relative to each other. So long as neither side slips, strain accumulates. This strain is the internal deformation of the atomic bonds present inside the rock. Once the strength of the rock is exceeded, the fault ruptures.

The intuitive idea is that once a fault ruptures, once the strain is resolved, in other words, there should be no (or very little) strain left for a second rupture in the near future. The strain will have to build up slowly until there is enough stored in the rock again for another rupture. The seismic gap hypothesis then says that, following a large earthquake, there is insufficient strain left in a rock for additional rupture in the near future. Thus, regions that experience a large earthquake should not rupture again in the near future, while regions that have not ruptured in the recent past should have built up a sufficient amount of strain and should rupture in the near future. The more time that passes without a large earthquake, the more likely a large earthquake is to occur. These regions lacking large earthquakes are called seismic gaps.

The first paper that presented a testable definition of the seismic gap hypothesis was "Seismic Gaps and Plate Tectonics: Seismic Potentials for Major Boundaries" by McCann and others, 1979. This paper not only attempted to establish a definition for seismic gaps, but used them to *predict* the locations where large earthquakes would occur in the future. Research in this topic continued through the 1980's and culminated in the creation of a map of circum-Pacific seismic potential for the time period 1989–1999.

Lab

Using actual earthquake data from the circum-Pacific region, we are going to make predictions about where earthquakes should occur in the immediate future. While McCann's paper specified 6 categories of seismic potential, not all of them are well defined. For our predictions, we will use the following category definitions:

Red A portion of a plate boundary has experienced at least one large earthquake more than 100 years ago

Orange A portion of a plate boundary has experienced at least one large earthquake more than 30 years ago, but less than 100 years ago

Green The region has been ruptured by a large earthquake during the last 30 years.

1. The map scale is 1:33,500,000, what is the shortest distance (in kilometers) you can reliably measure?

2. Assume the approximate along-strike rupture lengths for a thrust earthquake of magnitude 7.0 is 50 km, for magnitude 8.0 is 200 km and for magnitude 9.0 is 600 km. Using the map scale, how many millimeters correspond to a magnitude 7.0, 8.0, and 9.0 rupture?

3. Could you reliably indicate the rupture area for a magnitude 7.0 on this map? How about a magnitude 8.0?

This lab consists of four maps, each with (approximately) 30 years of global seismicity on them. Our goal is to use these maps to test predictions for the locations of future big earthquakes. To do this, we need to identify regions that have already ruptured in the past 30 years (green category). You may choose to mark segments only in the "Ring of Fire" and may neglect other regions such as the Caribbean and Scotia. Choose a time period and answer the following questions.

4. Using your map showing 30 years of seismicity, divide the map into segments that have ruptured during the 30 year period; these are the **Green** category earthquakes. Transfer these segments to a handout and be sure to indicate somewhere on your map which time period you are starting with.

Now, we need to go back and mark the regions that had earthquakes more than 30 and less than 100 years before (**Orange** category). To do this, you will need to compare your handout map with all of the laminated maps covering earlier time periods. For example, if you have a handout on which you have drawn green segments for the time period 1930–1960, you would need to then mark the earthquakes from 1900–1930 as well as any earthquakes from the following table that occurred after 1860 on this handout using orange. While you are marking the orange segments, make note of any existing green segments that would also be marked as orange.

The following are select circum-Pacific earthquakes from 1700–1900:

Date	Location	Magnitude
26 Jan 1700	Cascadia	9.0
08 Jul 1730	Valparaiso, Chile	8.7
28 Oct 1746	Lima, Peru	Unknown
26 Mar 1812	Caracas, Venezuela	7.7
10 Jul 1821	Camana, Peru	8.2
20 Feb 1835	Concepcion, Chile	8.2
08 Feb 1843	Leeward Islands (Caribbean)	8.3
23 Jan 1855	Wellington, New Zealand	8.0
18 Nov 1867	Puerto Rico	Unknown
13 Aug 1868	Arica, Peru (Chile)	9.0
23 Nov 1873	northern California/Southern Oregon	7.3
18 May 1875	northern Colombia	7.3
10 May 1877	Tarapaca, Chile	8.3
27 Oct 1891	Mino-Owari, Japan	8.0
15 Jun 1896	Sanriku, Japan	8.5
04 Sep 1899	Cape Yakataga, Alaska	7.9
10 Sep 1899	Yakutat Bay, Alaska	8.0
23 Sep 1899	Copper River Delta, Alaska	7.0

5. Using the maps showing earlier seismicity, identify the segments that are part of the **Orange** category.
6. Finally, mark all of the intervening segments **Red**. These segments represent the locations were earthquakes have not occurred within the past 100 years.
7. Now that you have marked green, orange, and red segments, you can predict where the next large earthquakes will occur. Find the map for the 30 year period subsequent to your prediction and identify any segments that have ruptured? Did any seismic gaps rupture?
8. Did any regions rupture more than once? Where are they located.

Repeat questions 4 to 8 starting with a map covering a different time period.