



2022 Alaska Seismicity Summary

Technical Report

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1. Abstract

The Alaska Earthquake Center reported 47,045 seismic events in Alaska and neighboring regions in 2022. The largest earthquake was a magnitude 6.8 event that occurred on January 11 in the Fox Islands region of the Aleutian Islands. Other active spots include two M6.3 earthquakes in the Rat Islands on June 4 and December 14, both of which were followed by moderate aftershock sequences. A magnitude 5.4 earthquake was recorded in an unusual location in the Bering Sea, east of St. George Island, on July 4. The two largest earthquakes in mainland Alaska, both magnitude 5.2, occurred in the Yakutat Bay region on January 8 and in central Alaska on February 6. We continued to monitor ongoing activity within the 2018 M7.1 Anchorage, 2018 M6.4 Kaktovik, 2018 M7.9 Offshore Kodiak, 2020 M7.6 Simeonof, and 2021 M8.2 Chignik aftershock sequences, the Purcell Mountains earthquake swarm, and the Wright Glacier cluster northeast of Juneau. All aftershock sequences continued to slow down compared to the previous years.

2. Introduction

The Earthquake Center reported 47,045 seismic events in Alaska and nearby regions in 2022 (Figure 2.1), making it the state's fifth largest year, after 2018 (about 55,000 seismic events), 2019 (about 50,000 seismic events), 2020 (about 49,250 seismic events), and 2021 (about 49,000 seismic events) (Figure 2.2) (*Ruppert & Gardine, February 2021, February 2022*). AEC data analysts picked and cataloged 1,484,054 seismic phases, about the same number as in each of the previous 3 years (Figure 2.3). The largest earthquake was a magnitude 6.8 event that occurred on January 11 in the Fox Islands region of the Aleutian Islands. Four other earthquakes had magnitudes greater than 6. The largest earthquakes in mainland Alaska were two M5.2 events: on January 8 in the Yakutat Bay region and on February 6 in central Alaska.

Seismicity rate did not vary significantly throughout the year with all new aftershock and swarm sequences being rather short-lived (Figure 2.4-2.6). Throughout the year we averaged 902 reported earthquakes per week, which is slightly less than in the previous 3 years. The overall magnitude of completeness for this time period was at $M_c=1.3$ (Figure 2.7), ranging from $M_c=1.1$ in the Interior region to $M_c=2.0$ in the Alaska Peninsula and the Aleutians (Figure 2.8). Most of the seismic events occurred at shallow depths, with the deepest events down to 285 km located in the central and western Aleutians (Figure 2.9).

We reported 2,301 seismic sources that were classified as something other than regional tectonic earthquakes (Figure 2.10). Of these, 366 were suspected quarry blasts (magnitudes $M=0.3-2.5$), the majority of which were located in the vicinity of Fort Knox and Healy mines in Interior Alaska. The reported events included 1,211 glacial quakes (magnitudes $M=0.5-3.0$), primarily located in the Prince William Sound, Icy Bay, and Yakutat Bay regions, and near Wright Glacier northeast of Juneau. We characterized 651 quakes as seismic events associated with volcanic activity ($M=0.3-4.6$). The remaining 73 events were classified as "other" type ($M=0.5-2.9$). Two of these events were confirmed large landslides. One occurred on September 15, 2022 near Seward on the Kenai Peninsula and another on September 19, 2022 in the Glacier Bay National Park region in Southeast Alaska (*Ruppert et al., November 2022*).

Between 12 and 31 earthquakes per month were reported felt in Alaskan communities (Figure 2.11), with magnitudes of these events ranging from as small as 2.0 to as large as 6.8. The largest number of DYFI (Did You Feel It) responses, 1,869, came from the M4.9 earthquake that occurred on November 18 at 00:03:09 UTC 22 km northwest of Anchorage (<https://earthquake.usgs.gov/earthquakes/eventpage/ak022esj2eua/dyfi/intensity>). The largest earthquakes each month ranged from 4.9 in October to 6.8 in January (Figure 2.11).

We continued monitoring several ongoing aftershock sequences such as the 2021 M8.2 Chignik, 2020 M7.8 Simeonof, 2018 M7.9 Offshore Kodiak, 2018 M6.4 Kaktovik, and 2018 M7.1 Anchorage earthquakes, and the earthquake swarm in the Purcell Mountains. See details on notable sequences in the following sections and in Table 1.

3. Notable earthquakes and sequences of 2022

3.1. January 11 M6.8 and M6.6 and January 22 M6.2 earthquakes in the Fox Islands

On January 11 a magnitude 6.8 earthquake occurred about 100 km south of Nikolski (Figure 3.1). It was followed by an energetic aftershock sequence including a M6.6 aftershock an hour later. On January 22, a M6.2 earthquake occurred about 70 km south of Unalaska and 123 km northeast of the M6.8 earthquake. We recorded about 300 aftershocks prior to the January 22 earthquake and about 150 aftershocks following the M6.2 earthquake through the end of January (*Ruppert et al., May 2022*). Source mechanisms for the mainshocks and largest aftershocks are consistent with these earthquakes rupturing the plate boundary along the Aleutian megathrust.

3.2. June 4 M6.3 and December 14 M6.3 earthquakes in the Rat Islands

Two M6.3 earthquakes were reported in the Rat Islands in 2022: on June 4 an event occurred at 119 km depth 66 km northwest of Amchitka and on December 14 an event occurred at 78 km depth 28 km northwest of Amchitka (Figure 3.2). We recorded about 100 aftershocks with magnitudes ranging between 1.5 and 4.2 after the June event and about 80 aftershocks with magnitudes ranging between 1.9 and 3.6 after the December event (*Ruppert et al., August 2022, February 2023*). Most aftershocks occurred within a few days of the mainshocks. The source mechanisms and depths indicate that both earthquakes originated inside the subducted Pacific Plate. These were the largest earthquakes of this type to occur in the region since the M7.9 Little Sitkin Earthquake of June 23, 2014.

3.2. July 4 M5.4 in the Pribilof Islands

On July 4 a magnitude 5.4 earthquake occurred at 9:17:43 UTC 28 km east of St. George Island in the Bering Sea region (Figure 3.3). We recorded about 40 aftershocks with magnitudes ranging between 2.5 and 4.1 (*Ruppert et al., November 2022*). Most of the aftershocks occurred within 3 days after the mainshock and this activity subsided after about 10 days. Due to the lack of seismic stations in the region, only events with magnitudes about 3 or above can be reliably detected and located. A similar sequence occurred in the same location in January-February 2015. The normal faulting source mechanism for the mainshock is typical for events that occur along the continental shelf in this region.

4. Ongoing aftershock sequences and swarms

4.1. 2021 M8.2 Chignik aftershock sequence

A magnitude 8.2 earthquake struck offshore of the Alaska Peninsula on July 29, 2021, the largest earthquake in the U.S. in 50 years (*Ruppert & Gardine, February 2022*). In 2022 we reported about 397 aftershocks for this sequence (Figure 4.1), about 8 events per week on

average. About 10 aftershocks had magnitudes greater than 4.0. The largest aftershock, magnitude 5.3, occurred on February 20. Estimated magnitude of completeness for 2022 is around 2.5, the same as in 2021. While the rate of the aftershocks continued to decline through 2022 (*Ruppert et al., May 2022, August 2022, November 2022, February 2023*), we expect this sequence to extend through 2023.

4.2. 2020 M7.8 Simeonof aftershock sequence

The Simeonof Earthquake continued to produce the most active ongoing aftershock sequence with about 1,563 reported aftershocks between magnitude 1.0 and 5.2 (Figure 4.1). About 10 aftershocks had magnitudes greater than 4.0. The largest aftershock, magnitude 5.2, occurred on February 3. The M7.6 aftershock cluster continues to be more active than the larger M7.8 patch (*Ruppert & Gardine, February 2021, February 2022*). Estimated magnitude of completeness is around 2.0, slightly better than in 2020 and 2021 observations. While the rate of the aftershocks continued to decline through 2022 and was about half of that of 2021 (*Ruppert et al., May 2022, August 2022, November 2022, February 2023*), we expect the Simeonof aftershock sequence to extend through 2023.

4.3. 2018 M7.1 Anchorage aftershock sequence

Aftershocks from the November 30, 2018 M7.1 Anchorage Earthquake continued into their fourth year at an average pace of about 14 earthquakes per week, which is about 20% less than in 2021 (*Ruppert & Gardine, February 2022*). The largest aftershock, magnitude 5.0, occurred on November 18. Approximately 700 aftershocks were reported in 2022 with a magnitude of completeness of $M_c=1.1$, bringing the total count for the sequence to more than 14,000 aftershocks. About 20 of these aftershocks were reported as felt in 2022. While the original estimates for the duration of this aftershock sequence were on the order of 2-2.5 years (*Michaels et al., 2019*), the seismicity rate remains elevated compared to the background rate prior to the M7.1 earthquake. We expect this sequence to continue at a decreasing rate in 2023.

4.4. 2018 M6.4 Kaktovik aftershock sequence

We continued to record aftershocks of the 2018 M6.4 Kaktovik Earthquake, the largest earthquake ever recorded on the North Slope. During 2022, we reported about 188 aftershocks at a magnitude of completeness of $M_c=1.3$, bringing the sequence up to approximately 7,500. A slightly higher rate and lower magnitude of detection were observed in summer months when seismic stations were in a continuous recording mode. To conserve power, northern Alaska stations operate in an on/off regime during winter months, resulting in smaller events (less than M1.5) not being routinely detected. The largest aftershock was a M4.1 on March 15. In the fourth year of this aftershock sequence we registered about 4 events per week on average, which is about 40% less than in 2021 (*Ruppert & Gardine, February 2022*). The activity is still above background level and we expect this sequence to continue in 2023 at a decreasing rate. Due to its low activity of less than 1 event per day on average, we will not be tracking this sequence in future quarterly or annual reports.

4.5. 2018 M7.9 Offshore Kodiak aftershock sequence

We continued to record aftershocks of the 2018 M7.9 Offshore Kodiak Earthquake, a complex strike-slip rupture on a series of conjugate faults and fractures. During 2022, we reported only about 206 earthquakes, bringing the sequence up to approximately 5,650. Due to its offshore location, about 200 km from the nearest on-land seismic stations, the magnitude of completeness for this sequence remains rather high at $M_c=2.5$. The largest aftershock was a M4.9 on February 3. A slightly higher rate and lower magnitude of detection were observed in summer months, perhaps due to more seismic stations being in operation. The aftershock rate in 2022 was 30% less than in 2021 at about 4 events per week on average (*Ruppert & Gardine, February 2022*), however it is still above the background level and we expect this sequence to continue in 2023. Due to its low activity of less than 1 event per day on average, we will not be tracking this sequence in future quarterly or annual reports.

4.6. Purcell Mountains earthquake swarm

The Purcell Mountains Swarm, which began in March 2019, had about 441 events in 2022 (Figures 4.2 & 4.3), which is less than half of what was recorded in 2021 (*Ruppert & Gardine, February 2022*). The activity rate continued at an average pace of about 8 earthquakes per week, with a period of increased activity in November-December, bringing the sequence total to more than 9,600 events. The largest events in the swarm during 2022 were M3.4 and M3.5 on April 15, with only one other earthquake registering larger than M3.0. Performance of the nearest seismic station G19K became intermittent in July, which compromised detection of smaller events in the swarm (*Ruppert et al., November 2022*). This caused a slight increase in magnitude of completeness to $M_c=1.1$.

5. Glacial seismicity and Wright Glacier cluster

Glacial seismicity is being recorded and studied globally; Alaska is no exception due to its large expanse of glaciated areas. In 2022, we reported over 1,200 glacial quakes, ranging in magnitudes up to M3.0. We normally record the majority of glacial activity near the termini of tidewater glaciers such as in the Prince William Sound region, Icy Bay, and Yakutat Bay (Figure 5.1). This activity follows seasonal variability and peaks at different times in different areas (Figure 5.2). This year the pace of glacial seismicity picked up in April and did not subside until December (Figure 2.10). This year, glacial seismic activity in Prince William Sound peaked much later in the season in October-November. Seasonality within the Icy Bay and Yakutat Bay regions was similar to previous years, although slightly higher activity was observed in the mid-fall.

We continued to record events in a cluster under Wright Glacier, which is about 40 miles northeast of Juneau. A few of these events reached magnitudes between 2.8-2.9 and were felt in Juneau. The 2022 activity picked up in late May and had 3 different episodes of elevated rates: in late June, late August and again in October (Figure 5.3). This year activity continued much later into the season than observed in 2020 or 2021 (*Ruppert & Gardine, February 2021, February 2022*). Periodic seismicity in this area has been observed since the 1970s, with event

rates usually peaking in summer and early fall. These quakes tend to cluster near the Speel River, where it drains glaciated areas of Mt. Ogden. The levels of activity, however, are not the same every year. Seismicity rates observed in 2020-2022, for example, have not been observed since 2011-2012.

6. Acknowledgments

We would like to acknowledge the center's seismic data analysts who analyzed and cataloged thousands of events and seismic phases in 2022: Ayumi Bakken, Kenneth Becker, Shila Cotton, Shah Khan, Natalia Kozyreva, Heather McFarlin, and Ronald Wilkes.

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7. References

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Table 1. Notable Alaska seismic sequences in 2022.*

Magnitude, Name (start date)	Total number of events	Magnitude of the largest event	Magnitude of completeness (Mc)	Rate of events per week
M7.6 Simeonof Earthquake (7/22/2020)	1,563	5.2	2.0	30
M7.1 Anchorage Earthquake (11/30/2018)	714	5.0	1.1	14
Purcell Swarm (March 2019)	441	3.5	1.1	8
M8.2 Chignik Earthquake (7/29/2021)	397	5.2	2.5	8
M7.9 Offshore Kodiak Earthquake (1/23/2018)	206	4.9	2.8	4
M6.4 Kaktovik Earthquake (8/12/2018)	188	4.1	1.3	4

* The 2018 M6.4 Kaktovik and 2018 M7.9 Offshore Kodiak earthquake aftershock sequences decreased to less than 1 event per day on average and will no longer be tracked in the summary table in future annual and quarterly reports.

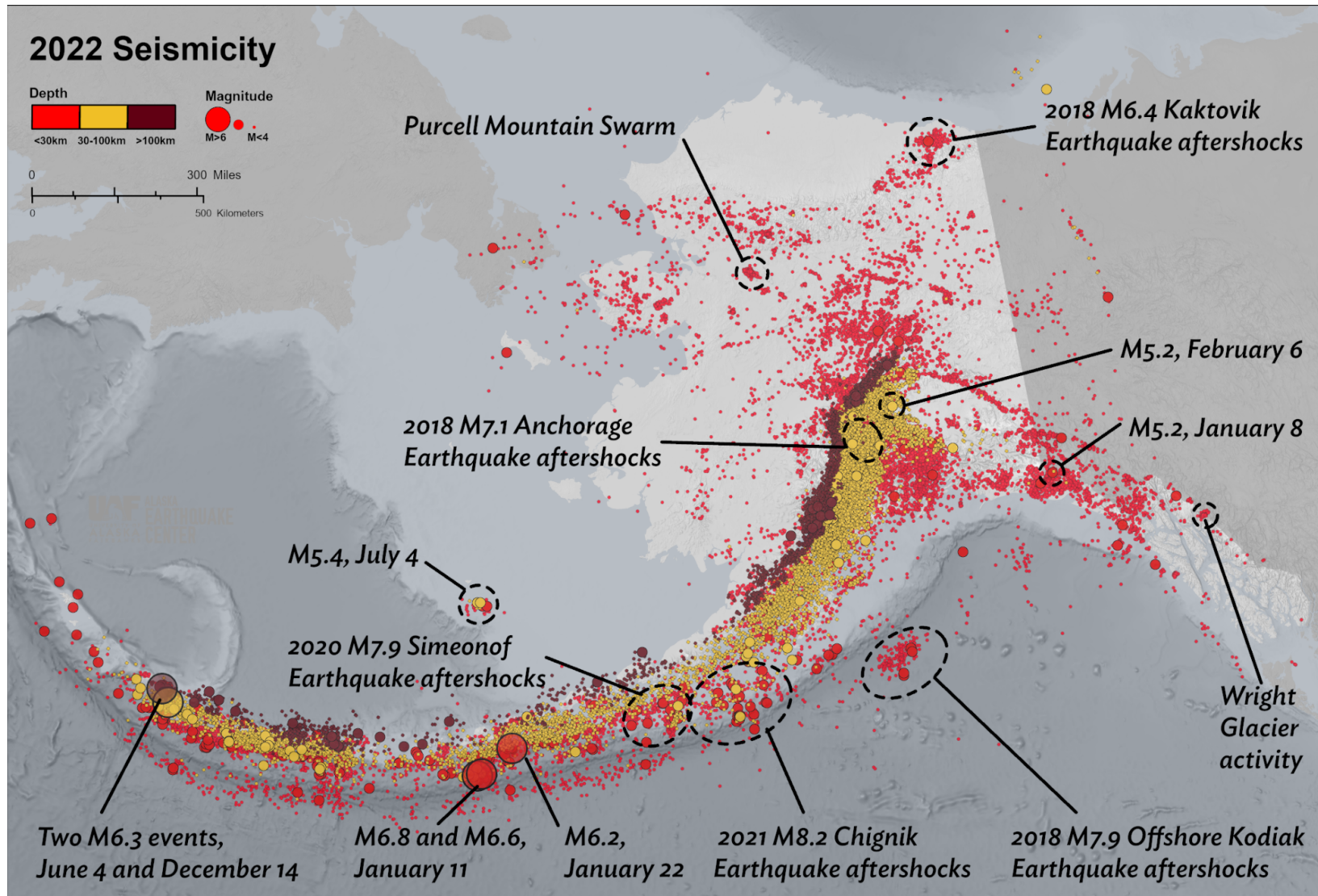


Figure 2.1. 2022 seismicity map for Alaska and the neighboring regions.

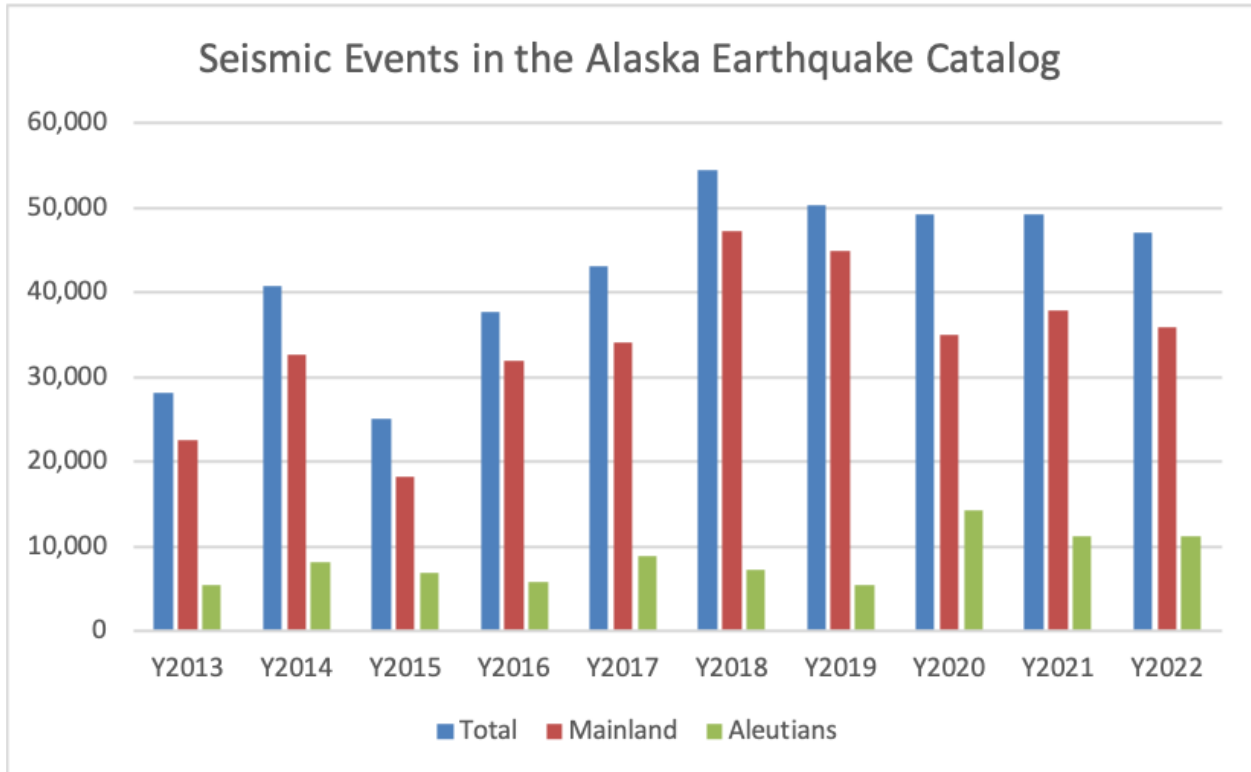


Figure 2.2. Earthquakes reported in the Alaska earthquake catalog for the past 10 years. The total number of events, as well as the number of events in the Aleutians and mainland Alaska, are shown. 2018 was the highest year, with about 55,000 events; 2022 is in 5th place, with about 47,045 events.

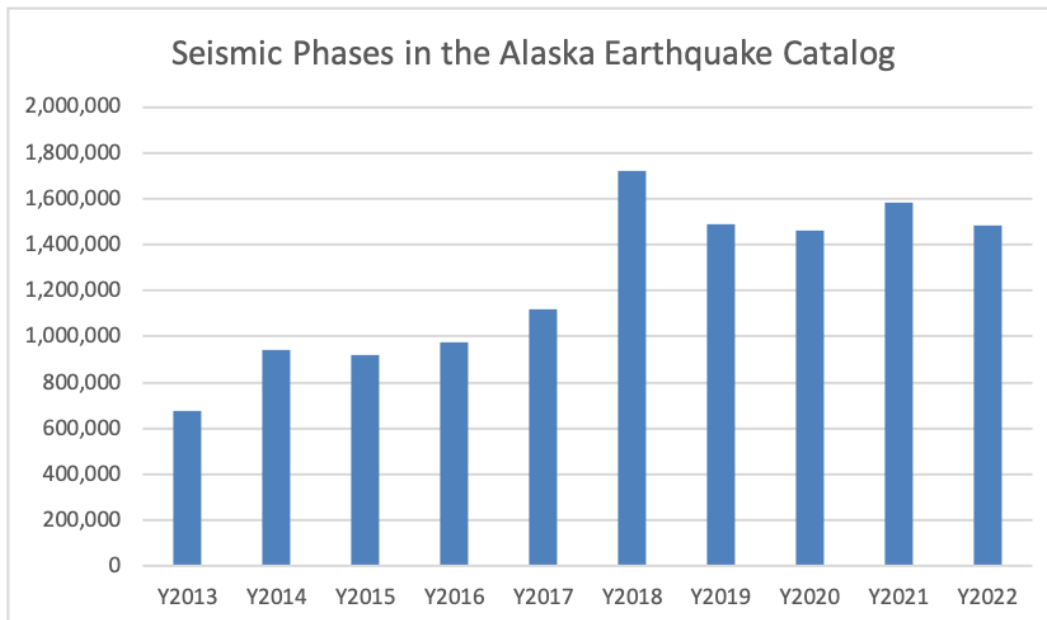


Figure 2.3. Seismic phases reported in the Alaska earthquake catalog for the past 10 years. 2018 was the highest year.

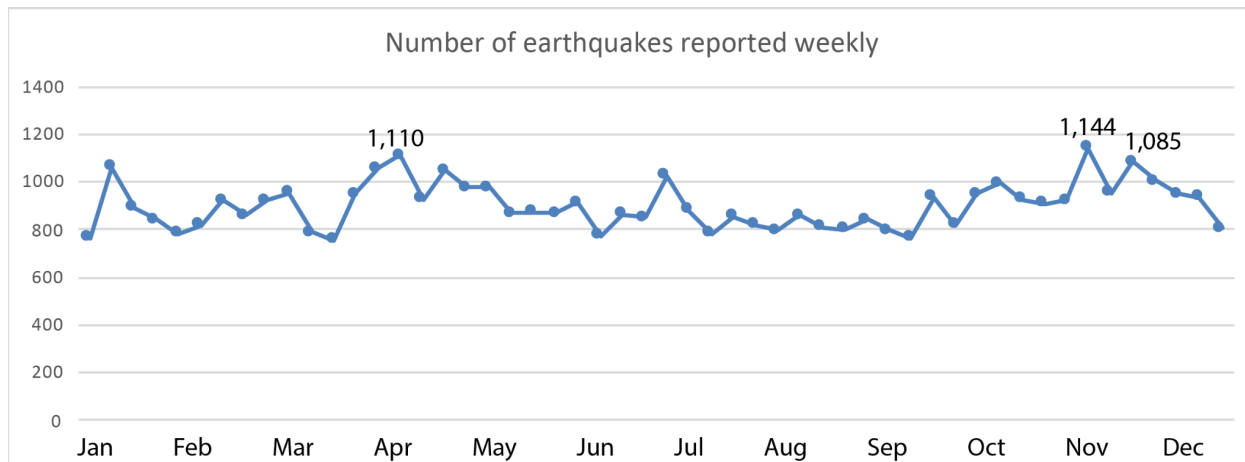


Figure 2.4. Weekly earthquake reporting in 2022. The week of November 14 had the highest number of earthquakes reported at 1,144, the week of April 11 was the 2nd highest with 1,110 events, and the week of November 28 was the 3rd highest with 1,085 events reported.

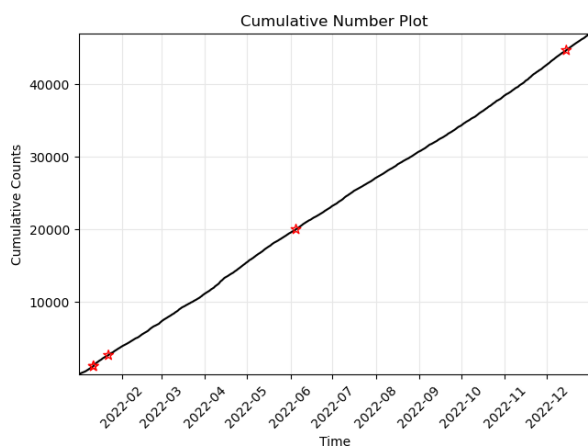


Figure 2.5. Cumulative number of seismic events in the 2022 Alaska Earthquake Catalog. Red stars indicate the five largest earthquakes.

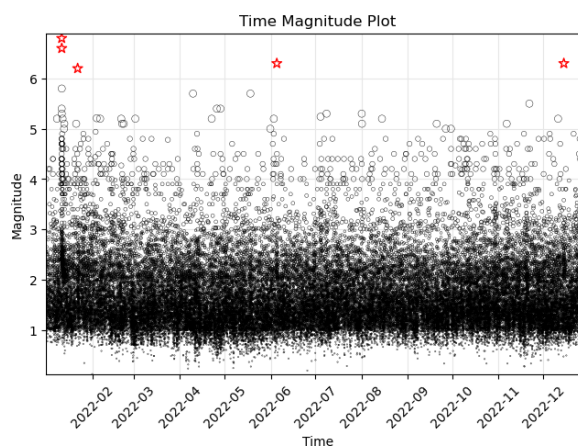


Figure 2.6. Time-magnitude plot of seismic events in the 2022 Alaska earthquake catalog. Red stars indicate the five largest earthquakes.

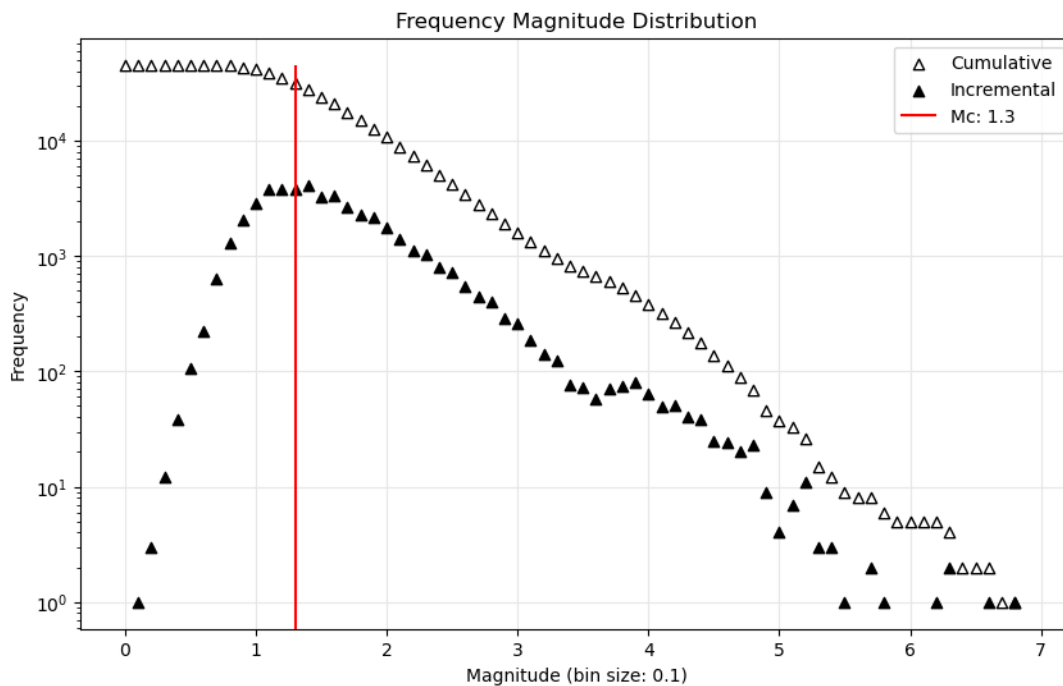


Figure 2.7. Frequency-magnitude distribution of events for 2022 Alaska earthquake catalog (glacial, unknown, and quarry blast types are not included).

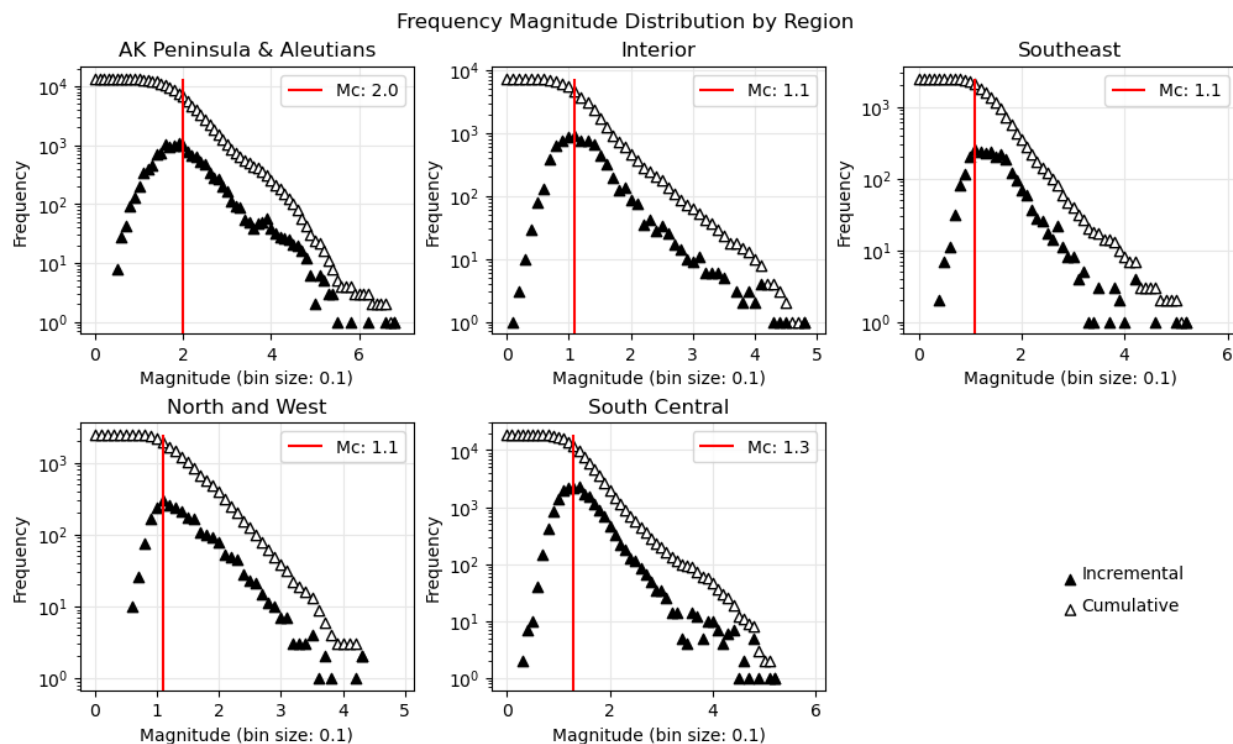


Figure 2.8. Cumulative distribution of events for 2022 Alaska Earthquake Catalog grouped by geographic region (glacial, unknown, and quarry blast types are not included).

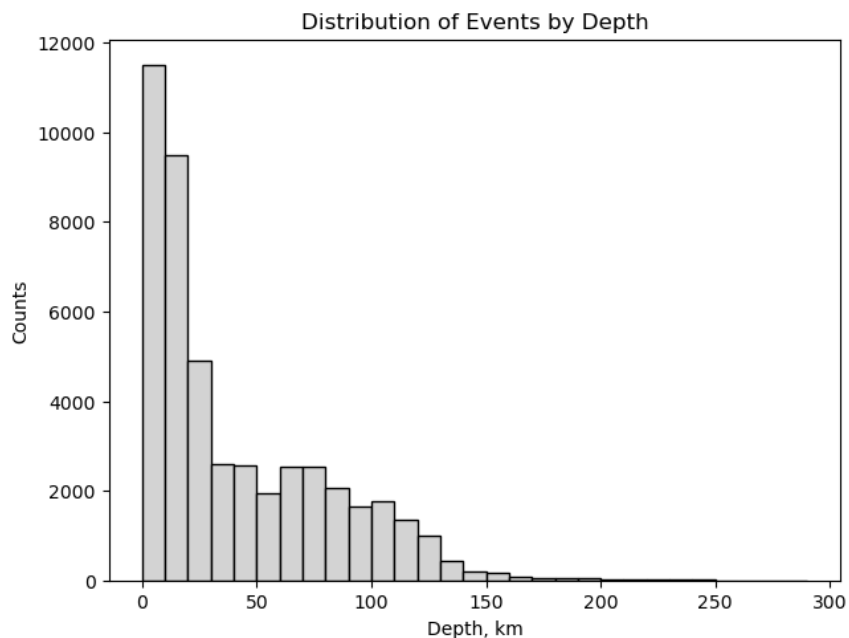


Figure 2.9. Depth distribution of events for the 2022 Alaska earthquake catalog. Majority of the events occurred in the 0-50 km depth range. The deepest earthquake occurred at 285 km in central Aleutians.

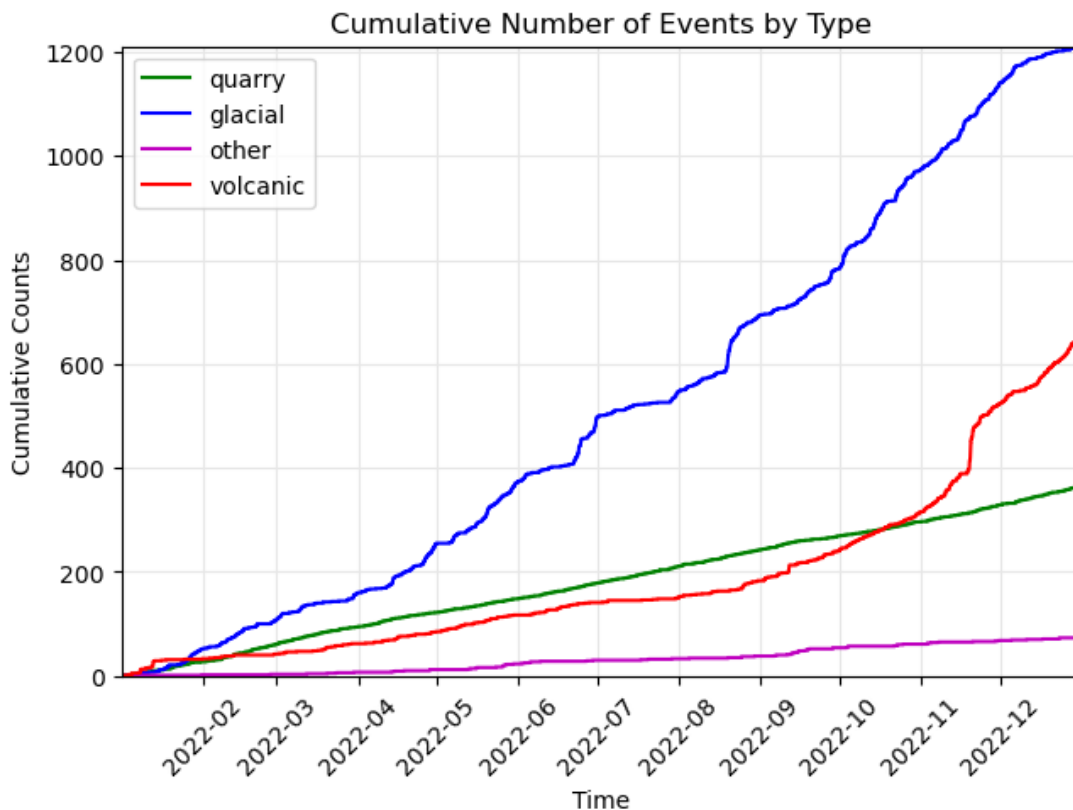


Figure 2.10. Cumulative number of non-tectonic seismic events for the 2022 Alaska earthquake catalog (volcanic, glacial, quarry blast, and other types).

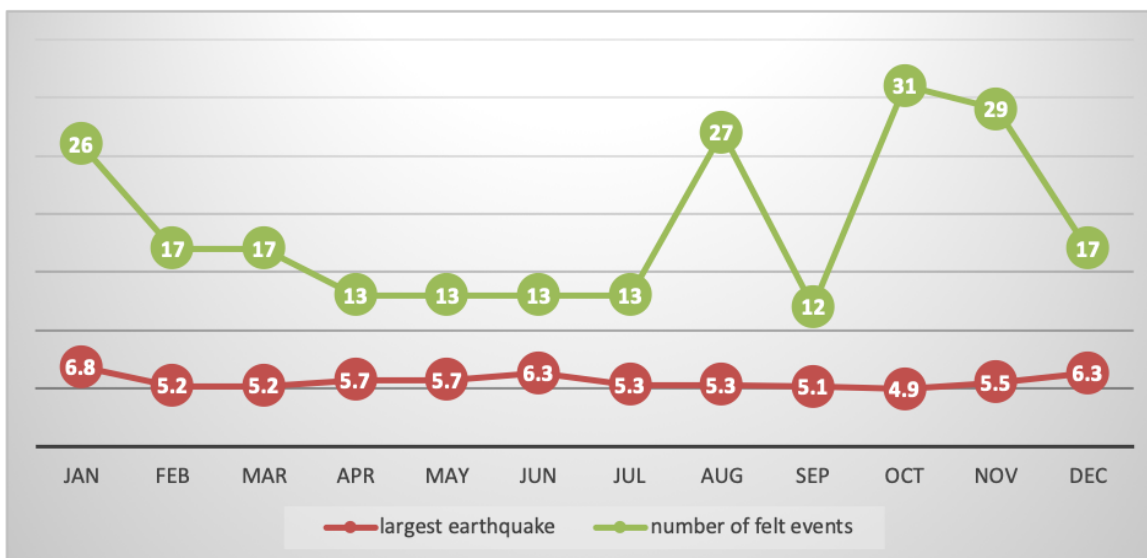


Figure 2.11. Largest earthquake recorded (red line, with magnitude denoted inside a circle) and number of felt events (green line) each month in 2022 in Alaska.

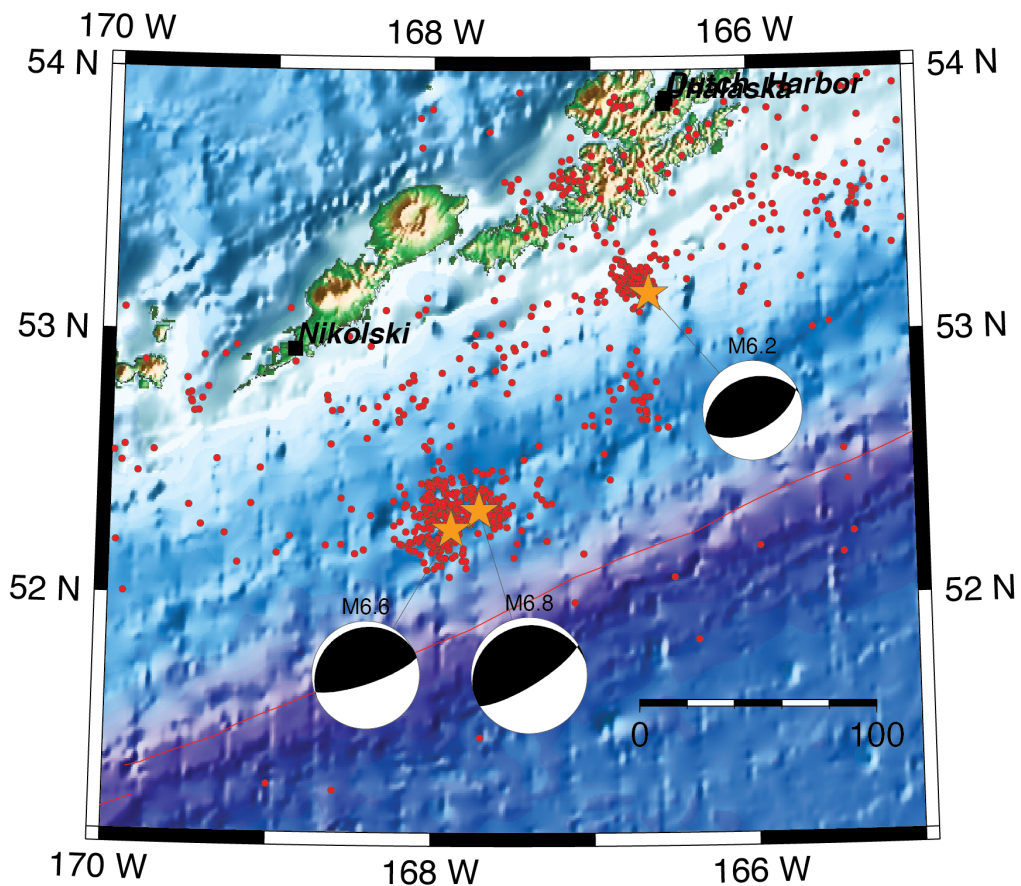


Figure 3.1. Earthquake location map for January 2022 sequences in the Fox Islands. Red circles are all earthquakes reported between January 1-March 31, 2022. Orange stars are epicenters of January 11 M6.8 and M6.6 and January 22 M6.2 earthquakes. Focal mechanisms are from the Global CMT catalog.

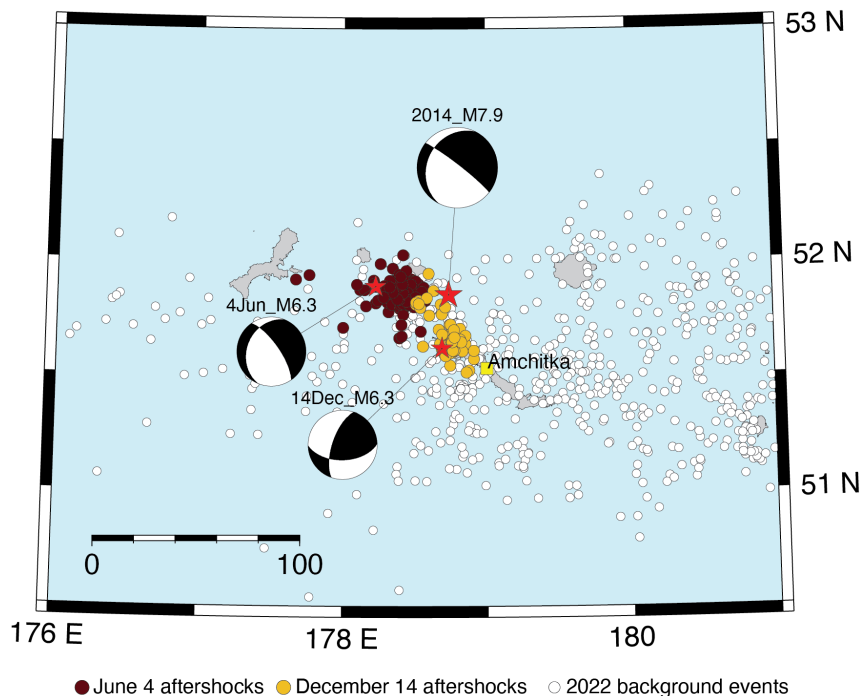


Figure 3.2. Earthquake location map for the M6.3 June 4 and December 14, 2022 earthquakes (small red stars) in the Rat Islands. Recorded aftershocks are shown as brown circles for the June 4 event and orange circles for the December 14 event. White circles are earthquakes recorded in the region in 2022. The large red star indicates the location of the M7.9 2014 Little Sitkin Earthquake. Focal mechanisms are from the Global CMT catalog.

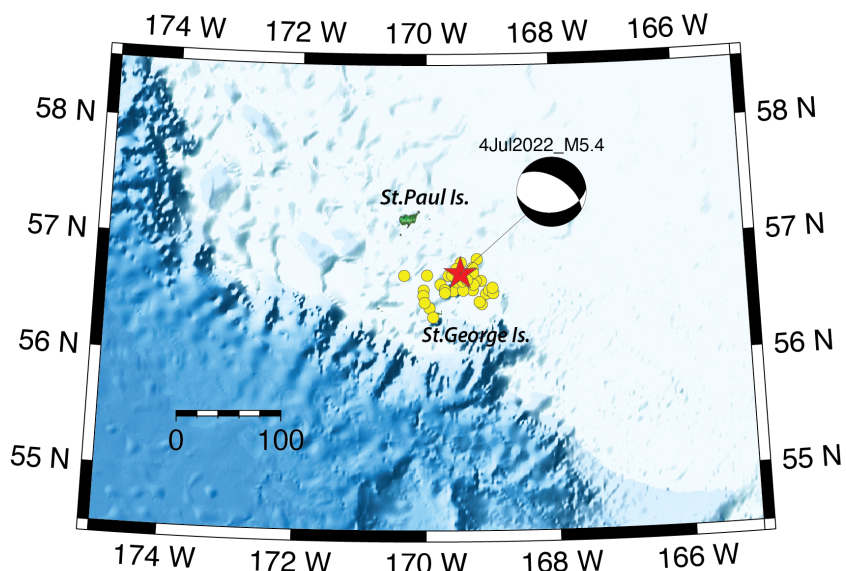


Figure 3.3. Earthquake location map for the M5.4 July 4, 2022 earthquake in the Pribilof Islands. Yellow circles are recorded aftershocks. The nearest seismic station is located on St. George Island (AK.P08K). The seismic site located on St. Paul Island (AK.SPIA) was inoperable at the time of this sequence. Focal mechanism is from the Global CMT catalog.

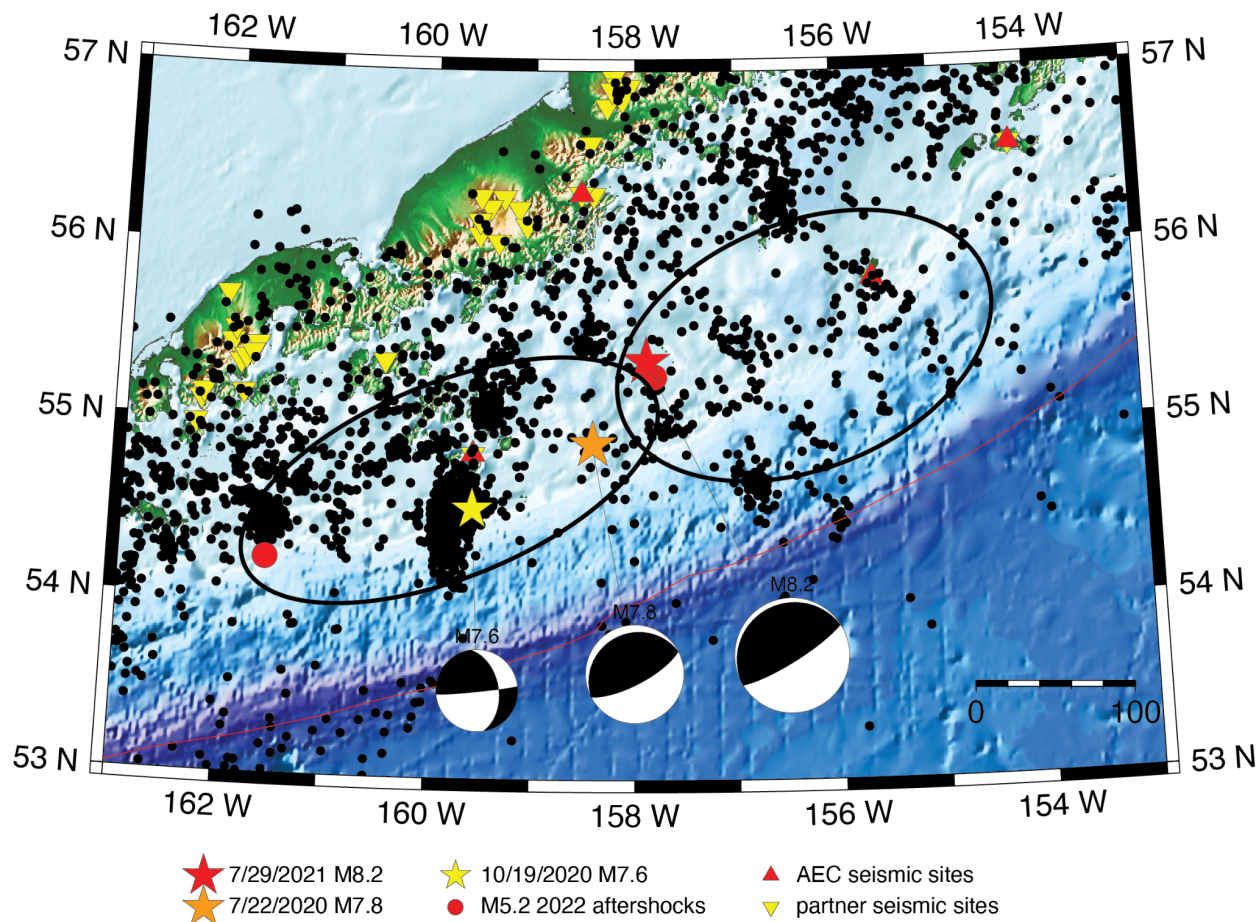


Figure 4.1. Map of the July 22, 2020 M7.8 Simeonof and the July 29, 2021 Chignik earthquakes, their aftershocks, and nearby regional seismicity recorded in 2022 (black circles). Approximate rupture areas of the two earthquakes are outlined by the ovals. Red circles indicate two largest aftershocks recorded in 2022, magnitude 5.2.

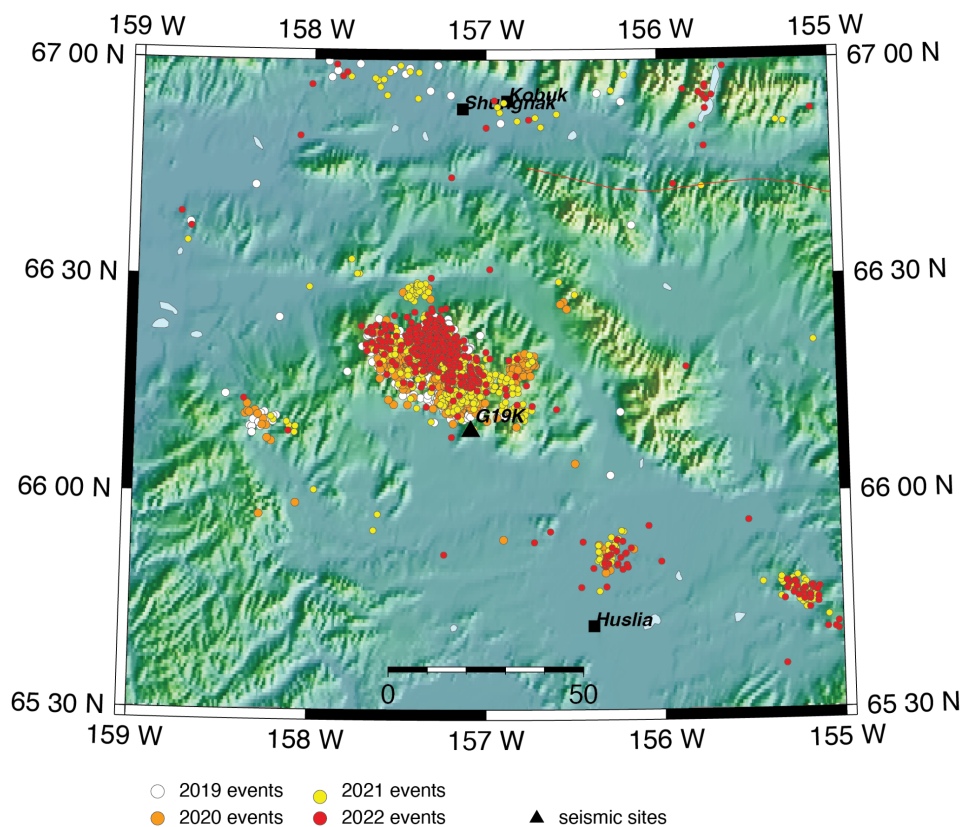


Figure 4.2. Purcell Mountains Swarm location map. Events are color-coded by year of occurrence. No new areas of activity were observed in 2022.

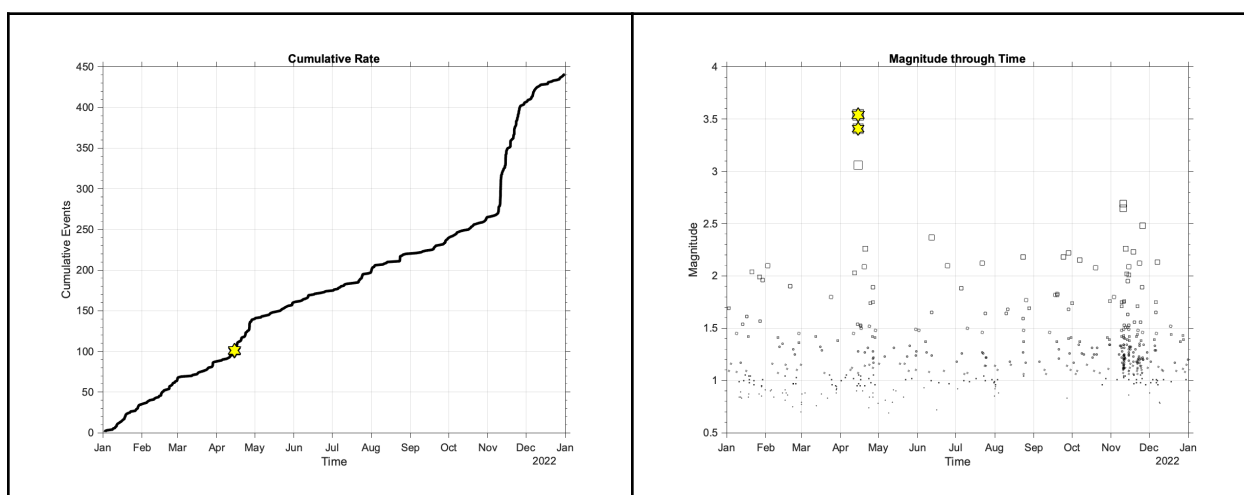


Figure 4.3. Cumulative number (left) and time-magnitude (right) plots for the Purcell Mountains Swarm in 2022. The two largest earthquakes are shown by yellow stars.

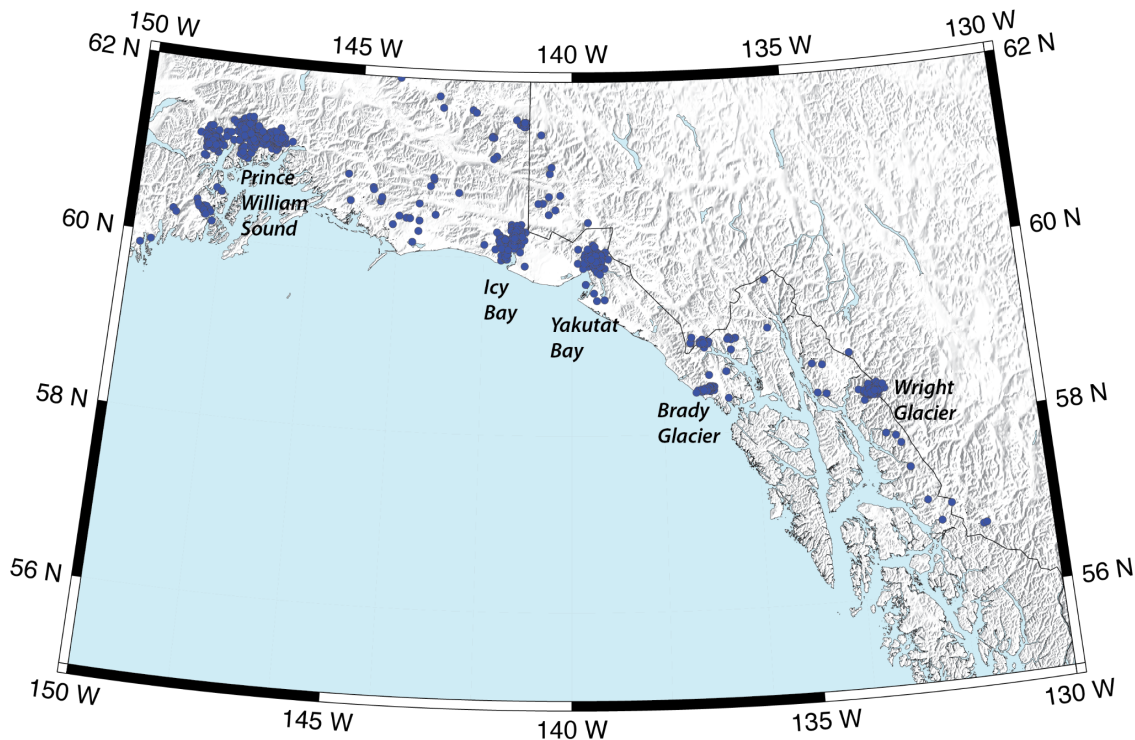


Figure 5.1. Glacial events reported in 2022, with the most active areas labeled.

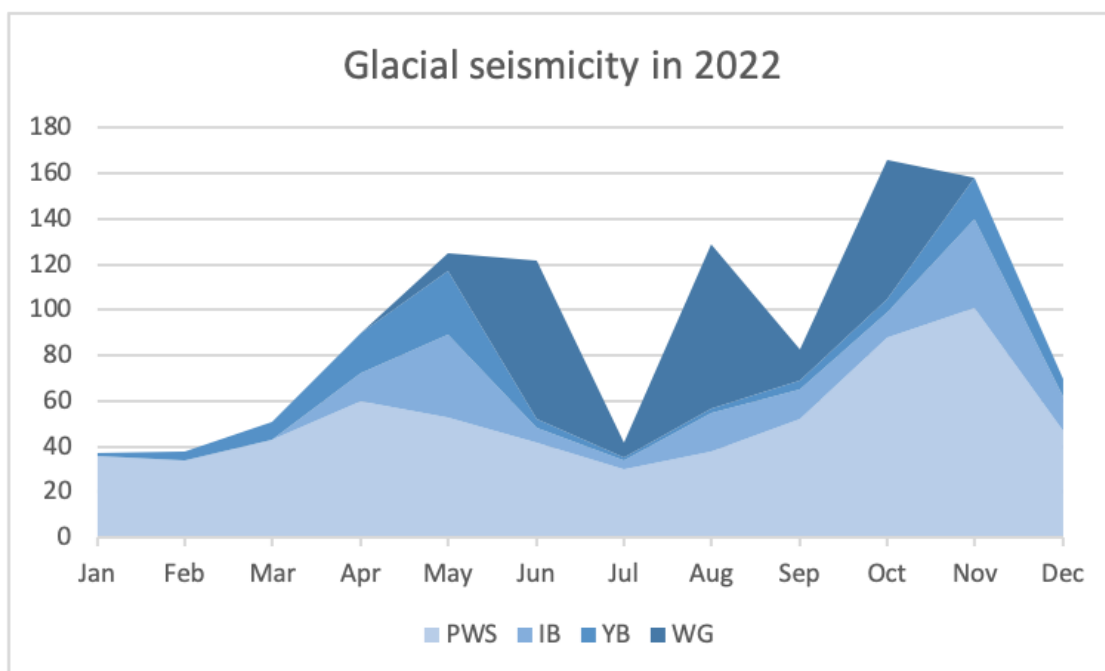


Figure 5.2. Monthly counts of reported glacial events separated into the four main regions of activity. The highest peak of activity was recorded in the October-November time frame. PWS - Prince William Sound; IB - Icy Bay; YB - Yakutat Bay; WG - Wright Glacier in Southeast Alaska.

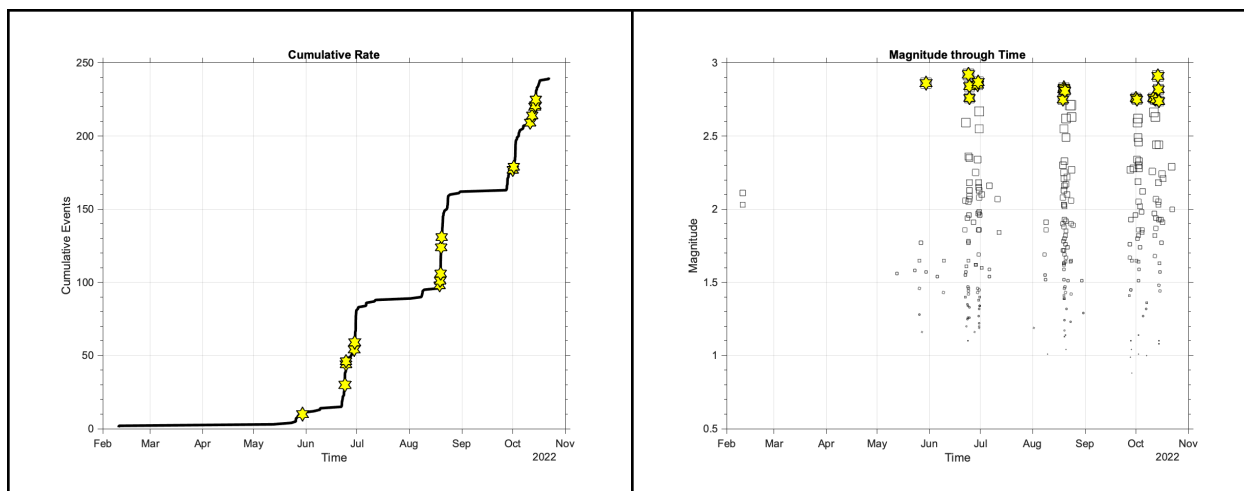


Figure 5.3. Cumulative number (left) and time-magnitude (right) plots for the Wright Glacier cluster for 2022. Note 3 different episodes of increased activity. Yellow stars indicate earthquakes with magnitude 2.7 and greater.