Appendix B – Region 13

Country and regional profiles of volcanic hazard and risk:

Hawaii and Pacific Ocean

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This download comprises the profiles for Region 13: Hawaii and Pacific Ocean only. For the full report and all regions see Appendix B Full Download. Page numbers reflect position in the full report. The following countries are profiled here:

Brown, S.K., Sparks, R.S.J., Mee, K., Vye-Brown, C., Ilyinskaya, E., Jenkins, S.F., and Loughlin, S.C. (2015) Country and regional profiles of volcanic hazard and risk. In: S.C. Loughlin, R.S.J. Sparks, S.K. Brown, S.F. Jenkins & C. Vye-Brown (eds) *Global Volcanic Hazards and Risk,* Cambridge: Cambridge University Press.

Region 13: Hawaii and Pacific Ocean

Region 13: Hawaii and the Pacific Ocean comprises volcanoes throughout the central Pacific, from the region's westernmost volcano of the Antipodes Island south of New Zealand to multiple volcanoes off the coast of the Americas. All are included in this regional discussion, and individual country profiles are provided. See Region 4 for the New Zealand profile.

Country	Number of volcanoes
France	4 + 4 from Regions 4 and 5
New Zealand (see Region 4)	1
USA	11

Table 13.1 The countries represented in this region and the number of volcanoes. Volcanoes located on the borders between countries are included in the profiles of all countries involved. Note that countries may be represented in more than one region, as overseas territories may be widespread.

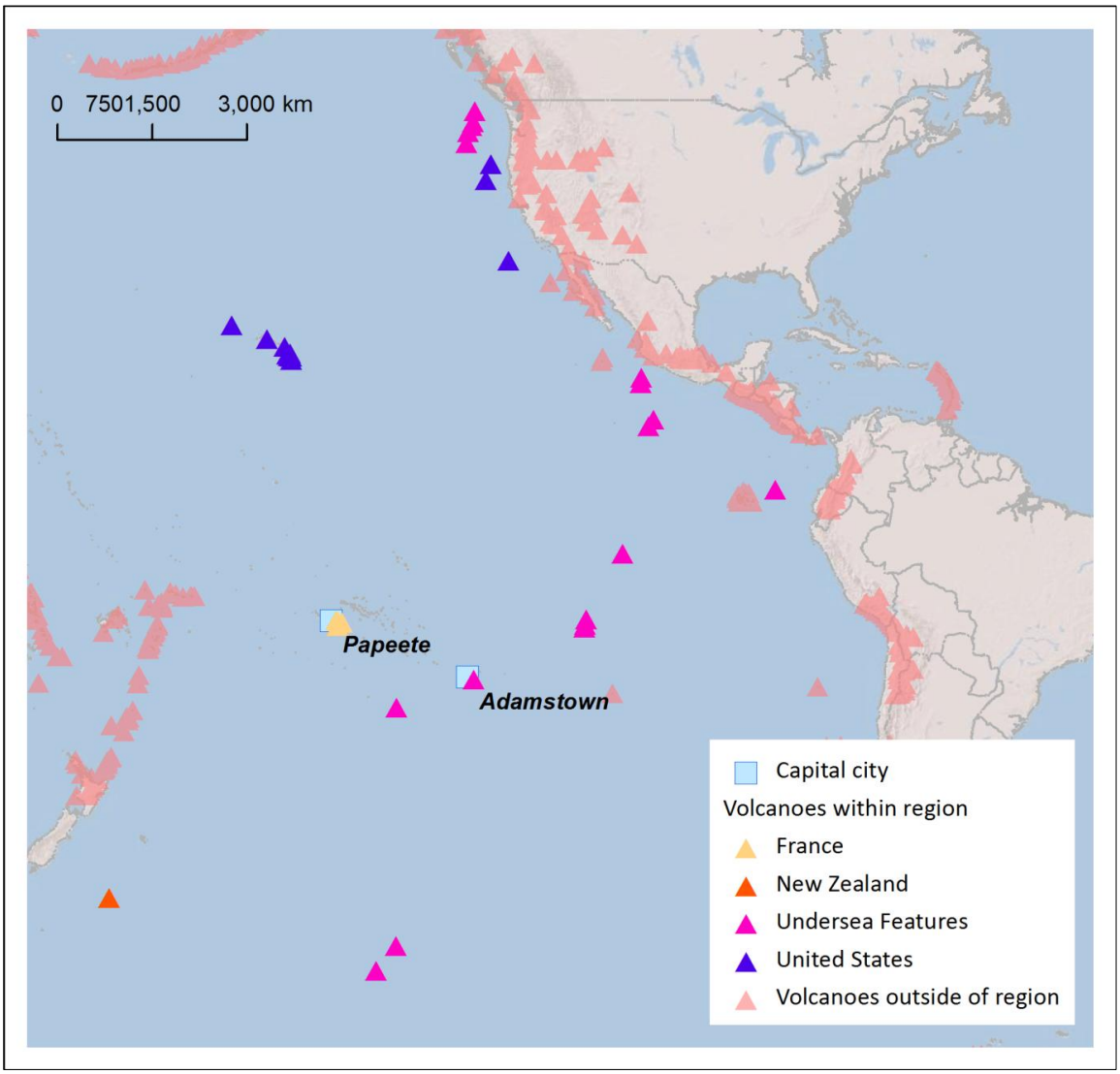

Figure 13.1 The distribution of Holocene volcanoes through the Hawaii and Pacific Ocean region. The capital cities of the constituent countries are shown.

Description

Thirty-four Holocene volcanoes are located in Hawaii and the Pacific Ocean. Most of these volcanoes are undersea features of no specific nationality. Volcanism here is largely due to intra-plate, hotspot activity.

Most volcanoes in this region are submarine, and indeed this region has the highest proportion of submarine volcanoes. Most subaerial volcanoes are shields, with five located in Hawaii. One stratovolcano, Mehetia, is located in French Polynesia while the Antipodes Island of New Zealand is a group of pyroclastic cones. The composition of these volcanoes and their products is dominantly basaltic.

348 Holocene eruptions are confirmed throughout this region of VEI 0 to 4. Despite this range of activity the record is dominated by VEI 0 events, with nearly 90% of all eruptions classed as such demonstrating the prevalence of effusive eruptions of lavas. Just one eruption is recorded of VEI ≥ 3. Lava flows are recorded in 300 eruptions in this region, whilst just one eruption with a pyroclastic flow is recorded at Kilauea.

Twenty-one volcanoes have historical records of 172 eruptions, indicating that the geological record for this region is reasonably well populated. About 81% of historical eruptions have associated records of lava flows.

Just 3% of historical eruptions have resulted in loss of life, largely due to the low proximal populations at most volcanoes (91%) and the number of submarine volcanoes. This low population coupled with the dominantly effusive nature of eruptions here means that all but one classified volcano are classed as Risk Level I. Hualalai in Hawaii is classed at Risk Level II with the largest proximal population in the region.

Away from the subaerial volcanoes of Hawaii dedicated ground-based monitoring is largely absent. Within Hawaii, the Hawaiian Volcano Observatory monitor the volcanoes and provide hazard data and advice.

Volcano facts

Number of Holocene volcanoes	34
Number of Pleistocene volcanoes with M≥4 eruptions	-
Number of volcanoes generating pyroclastic flows	1 (1 eruption)
Number of volcanoes generating lahars	0
Number of volcanoes generating lava flows	23 (300 eruptions)
Number of eruptions with fatalities	6
Number of fatalities attributed to eruptions	5,497?
Largest recorded Pleistocene eruption	-

Largest recorded Holocene eruption	The 2560 and 2079 BP eruptions of the Older and Younger Uwekahuna Ash at Kilauea, Hawaii, are the largest recorded Holocene eruptions in this region at M4.2. No larger events are recorded in the Pleistocene in the LaMEVE database.
Number of Holocene eruptions	348 confirmed Holocene eruptions
Recorded Holocene VEI range	0 – 4 and unknown
Number of historically active volcanoes	21
Number of historical eruptions	172

Number of volcanoes	Primary volcano type	Dominant rock type
1	Large cone(s)	Basaltic (1)
5	Shield(s)	Basaltic (5)
1	Small cone(s)	Basaltic (1)
27	Submarine	Basaltic (21), Trachytic/Andesitic (1), Unknown (5)

Table 13.2 The volcano types and dominant rock types of the volcanoes of this region according to VOTW4.0.

Eruption Frequency

VEI	Recurrence Interval (Years)
Small (< VEI 4)	1
Large (> VEI 3)	-

Table 13.3 Average recurrence interval (years between eruptions) for small and large eruptions in Hawaii and the Pacific.

The eruption record indicates that on average small to moderate sized eruptions of VEI <4 occur in this region with an average recurrence interval (ARI) of about a year.

Eruption Size

Eruptions are recorded through the Hawaii and Pacific Ocean region of VEI 0 to 4, representing a range of eruption styles from gentle effusive events to explosive eruptions. VEI 0 events dominate the record, with nearly 90% of all Holocene eruptions classed as such. Just 0.3% of eruptions here are explosive at VEI ≥4.

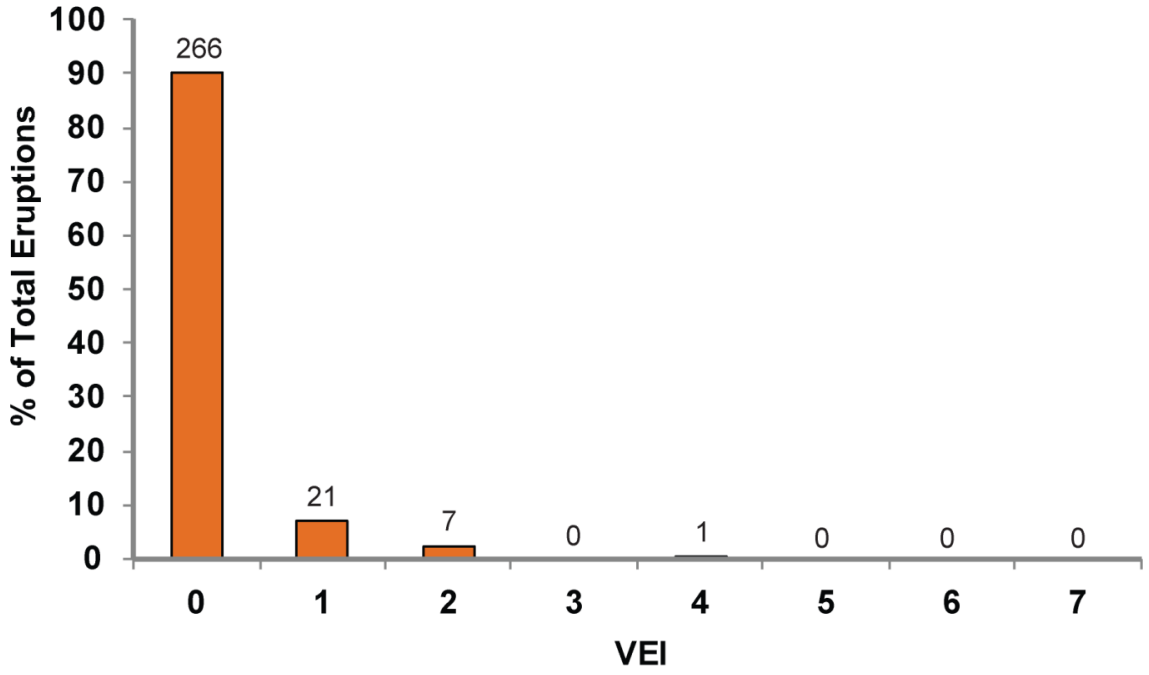

Figure 13.2 Percentage of eruptions in this region recorded at each VEI level; the number of eruptions is also shown. The percentage is of total eruptions with recorded VEI. A further 53 eruptions were recorded with unknown VEI.

Socio-Economic Facts

Total population (2011)	1,390,090
Gross Domestic Product (GDP) per capita (2005 PPP $)	
Gross National Income (GNI) per capita (2005 PPP $)	
Human Development Index (HDI) (2012)	

Population Exposure

Number (percentage) of people living within 10 km of a Holocene volcano	65,387 (4.70 %)
Number (percentage) of people living within 30 km of a Holocene volcano	132,822 (9.55 %)
Number (percentage) of people living within 100 km of a Holocene volcano	1,691,007 (>100 %)

Infrastructure Exposure

Number of airports within 100 km of a volcano	6
Number of ports within 100 km of a volcano	23
Total length of roads within 100 km of a volcano (km)	865
Total length of railroads within 100 km of a volcano (km)	0

CLASSIFIED	**Hazard III**							
	Hazard II							
	Hazard I	Adams Seamount; Macdonald; Unnamed; Southern EPR-Segment K	Mauna Loa; Teahitia	Kilauea		Hualalai		
UNCLASSIFIED	**U – HHR**	**CoAxial Segment**; **Axial Seamount**; **Cleft Segment**; **North Gorda Ridge**; **Unnamed (332090); Unnamed (334040); Galápagos Rift; Unnamed (334100);** Southern EPR-Segment J; **Southern EPR-Segment I**	**Loihi**; **Rocard**; **Moua Pihaa**		Haleakala			
	U- HR	**Endeavour Ridge**; Cobb Segment; Escanaba Segment; Northern EPR-Segment RO2; Northern EPR-Segment RO3	Mauna Kea					
	U-NHHR	Unnamed; Antipodes Island; Unnamed; Unnamed	Unnamed; **Mehetia**					
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 13.4 Identity of the volcanoes in this region in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'Classified' (top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in **bold** have experienced unrest or eruptions since 1900 AD, and those in red have records of at least one Holocene VEI ≥4 eruption.*

Population Exposure Index

Number of Volcanoes	Population Exposure Index
0	7
0	6
1	5
1	4
1	3
8	2
23	1

Table 13.5 The number of volcanoes in Hawaii and the Pacific classed in each PEI category.

Risk Levels

Number of Volcanoes	Risk Level
0	III
1	II
7	I
26	Unclassified

Table 13.6 The number of volcanoes in the Hawaii and Pacific Ocean region classified at each Risk Level.

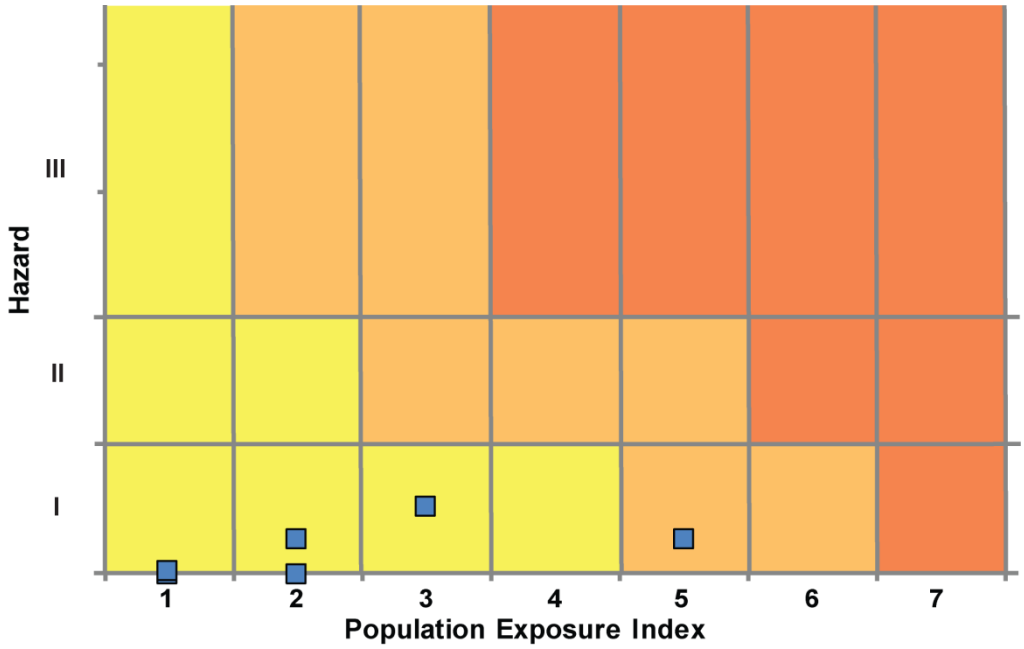

Figure 13.3 Distribution of the classified volcanoes of this region across Hazard and Population Exposure Index levels. The warming of the background colours illustrates increasing Risk levels from Risk Level I - III.

Regional monitoring capacity

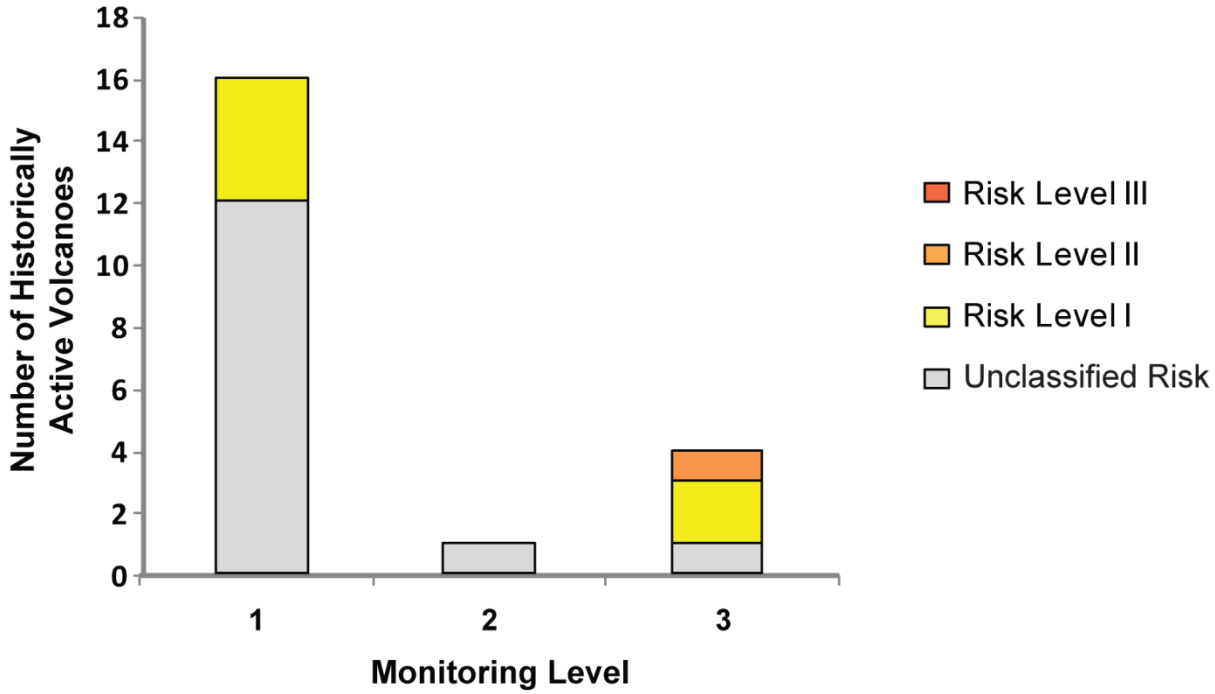

Figure 13.4 The monitoring and risk levels of the historically active volcanoes in Hawaii and the Pacific Ocean. Monitoring Level 1 indicates no known dedicated ground-based monitoring; Monitoring Level 2 indicates that some ground-based monitoring systems are in place including ≤3 seismic stations; Monitoring Level 3 indicates the presence of a dedicated ground-based monitoring network, including ≥4 seismometers.

France – Multiple Pacific Ocean islands

See Region 1 for mainland France, Region 3 for the French territories in the Indian Ocean. Note that here we include Region 13's Teahitia, Rocard, Moua Pihaa and Mehetia of French Polynesia, Wallis Islands from Region 4 and Eastern Gemini Seamount, Matthew Island and Hunter Island from Region 5 in discussion.

Description

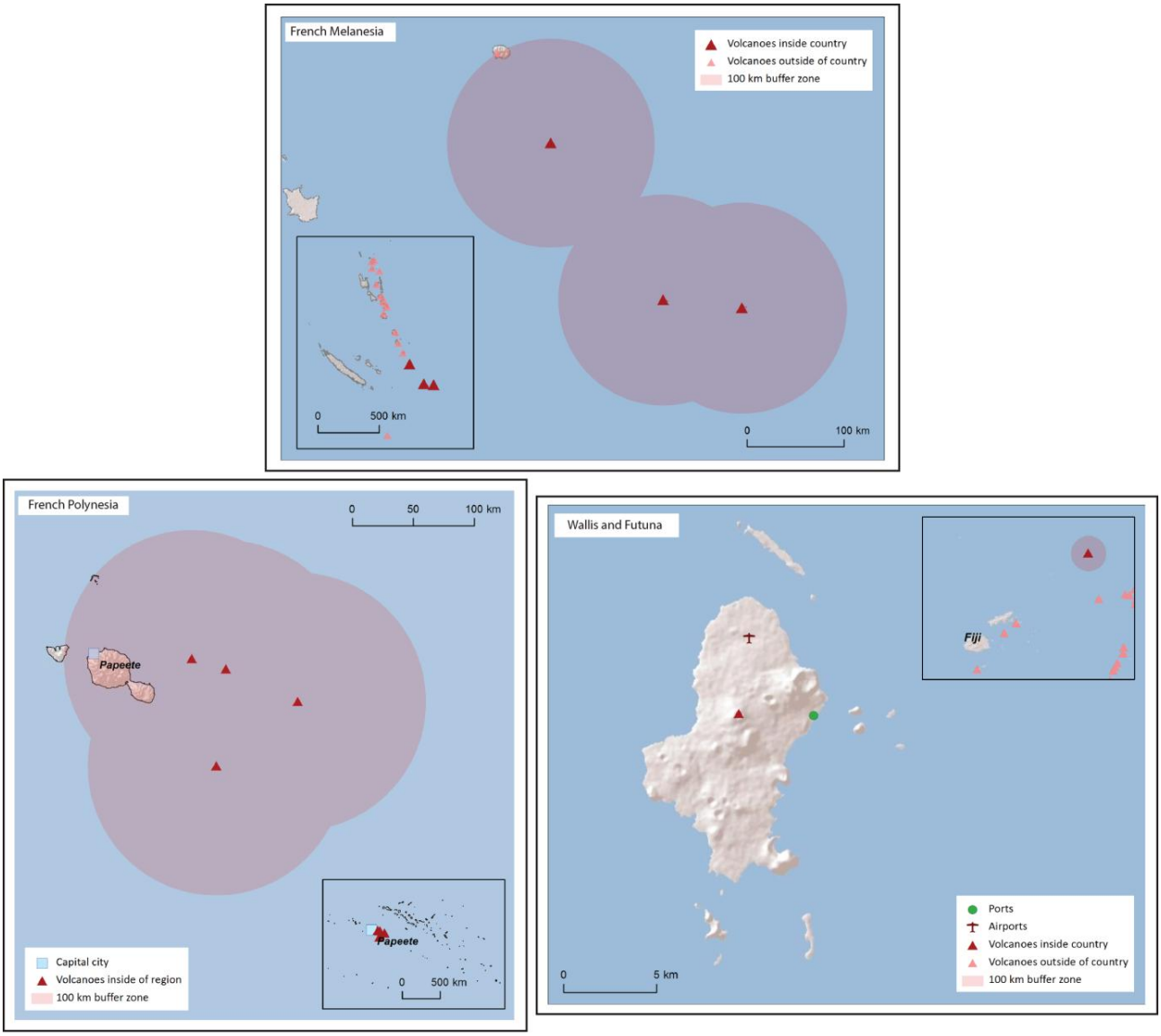

Figure 13.5 Location of the Pacific Ocean French volcanoes, the capital and largest cities. A zone extending 200 km beyond the country's borders shows other volcanoes whose eruptions may directly affect the Pacific Ocean French volcanoes.

A number of islands in the Pacific are French overseas territories. Eight Holocene volcanoes are located on these islands, with three located between Fiji and New Caledonia (Matthew Island, Hunter Island and the Eastern Gemini Seamount, these being located in a rift setting); the Wallis Islands located to the north-east of Fiji (in a subduction zone), and four located in French Polynesia

(due to intra-plate hotspot processes). Four of these volcanoes are submarine, whilst the subaerial volcanoes comprise three stratovolcanoes and one shield volcano.

Seventeen Holocene eruptions of VEI 0 to 2 are recorded here, indicating predominantly mild activity and indeed lava flows are recorded in four events. All seventeen eruptions are recorded historically, with no geological record available for these volcanoes. All are recorded post-1835.

Only three of these volcanoes – Wallis Islands, Matthew Island and Mehetia have a population within 10 km. Assessment of hazard at these volcanoes is complicated by the sparse eruption history, but the risk here is considered relatively low. However, large eruptions cannot be ruled out.

Volcano Facts

Number of Holocene volcanoes	4 in Region 13, 1 in Region 4, 3 in Region 5
Number of Pleistocene volcanoes with M≥4 eruptions	
Number of volcanoes generating pyroclastic flows	-
Number of volcanoes generating lahars	-
Number of volcanoes generating lava flows	2
Number of fatalities caused by volcanic eruptions	
Tectonic setting	Region 13: Intra-plate, Region 4: Subduction zone, Region 5: Rift zone
Largest recorded Pleistocene eruption	
Largest recorded Holocene eruption	
Number of Holocene eruptions	17
Recorded Holocene VEI range	0 – 2 and unknown
Number of historically active volcanoes	6
Number of historic eruptions	17

Number of volcanoes	Primary volcano type	Dominant rock type
3	Large Cone(s)	Andesitic (2), Basaltic (1)
1	Shield(s)	Basaltic (1)
4	Submarine	Basaltic (3), Trachytic/Andesitic (1)

Table 13.7 The number of the Pacific Ocean French volcanoes, their volcano type classification and dominant rock type according to VOTW4.0.

Population Exposure

Number (percentage) of people living within 30 km of a Holocene volcano	115
Total population	295,587 (280,026 in French Polynesia and 15,561 in Wallis and Futuna in 2014, https://www.cia.gov/library/publications/the-world-factbook/)

Largest cities, as measured by population and their population size:

Papeete (French Polynesia)	26,357

Infrastructure Exposure

Number of airports within 100 km of a volcano	2
Number of ports within 100 km of a volcano	2
Total length of roads within 100 km of a volcano (km)	-
Total length of railroads within 100 km of a volcano (km)	-

The volcanoes of French Polynesia are located to the east of the main island of Tahiti, with all but Mehetia lying within 100 km of this island. The 100 km radii of these volcanoes extend to fully encompass Tahiti, and much of the islands of Moorea and Tetiaroa. The capital, Papeete lies within these radii and all critical infrastructure is exposed.

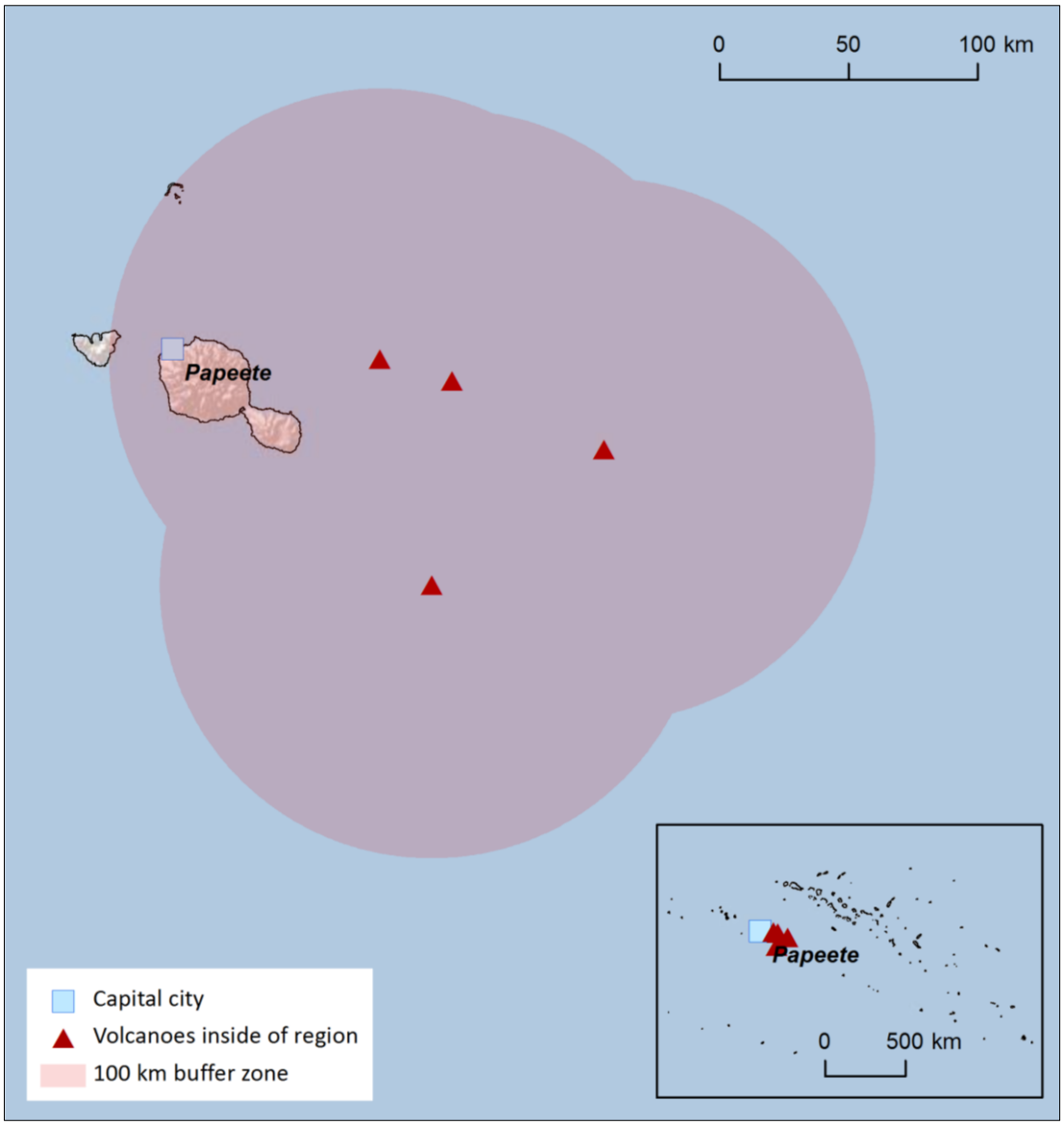

Figure 13.6 The volcanoes of French Melanesia, Matthew Island, Hunter Island and Eastern Gemini Seamount lie beyond 100 km to the south of Vanuatu.

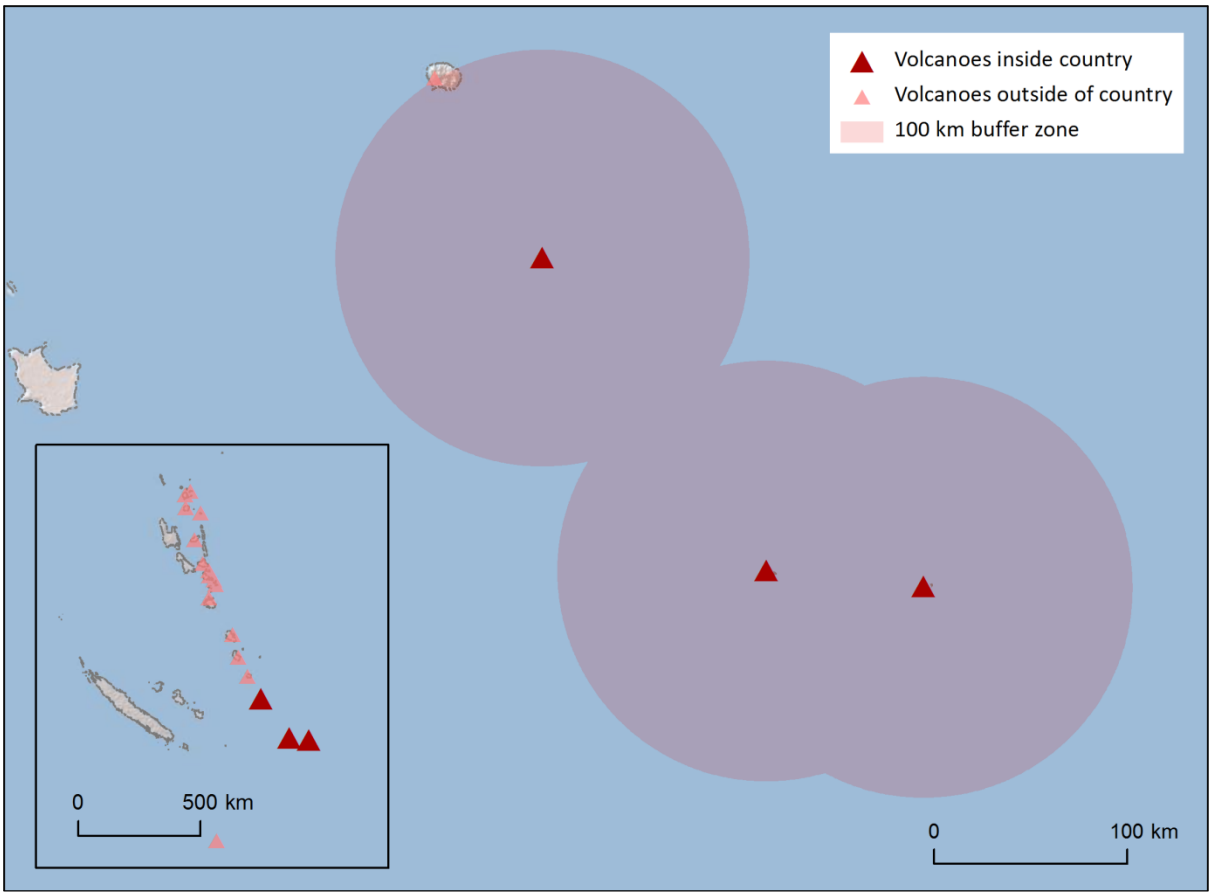

Figure 13.7 The location of French Melanesia and the volcanoes here and the extent of the 100 km zone surrounding them.

The Wallis Islands volcano is located on Wallis and Futuna, over 300 km from Samoa. The island measures no more than 30 km across and therefore all infrastructure here is exposed to volcanic hazards, lying within the 100 km radius of Wallis Islands volcano. This includes the capital, Mata-utu.

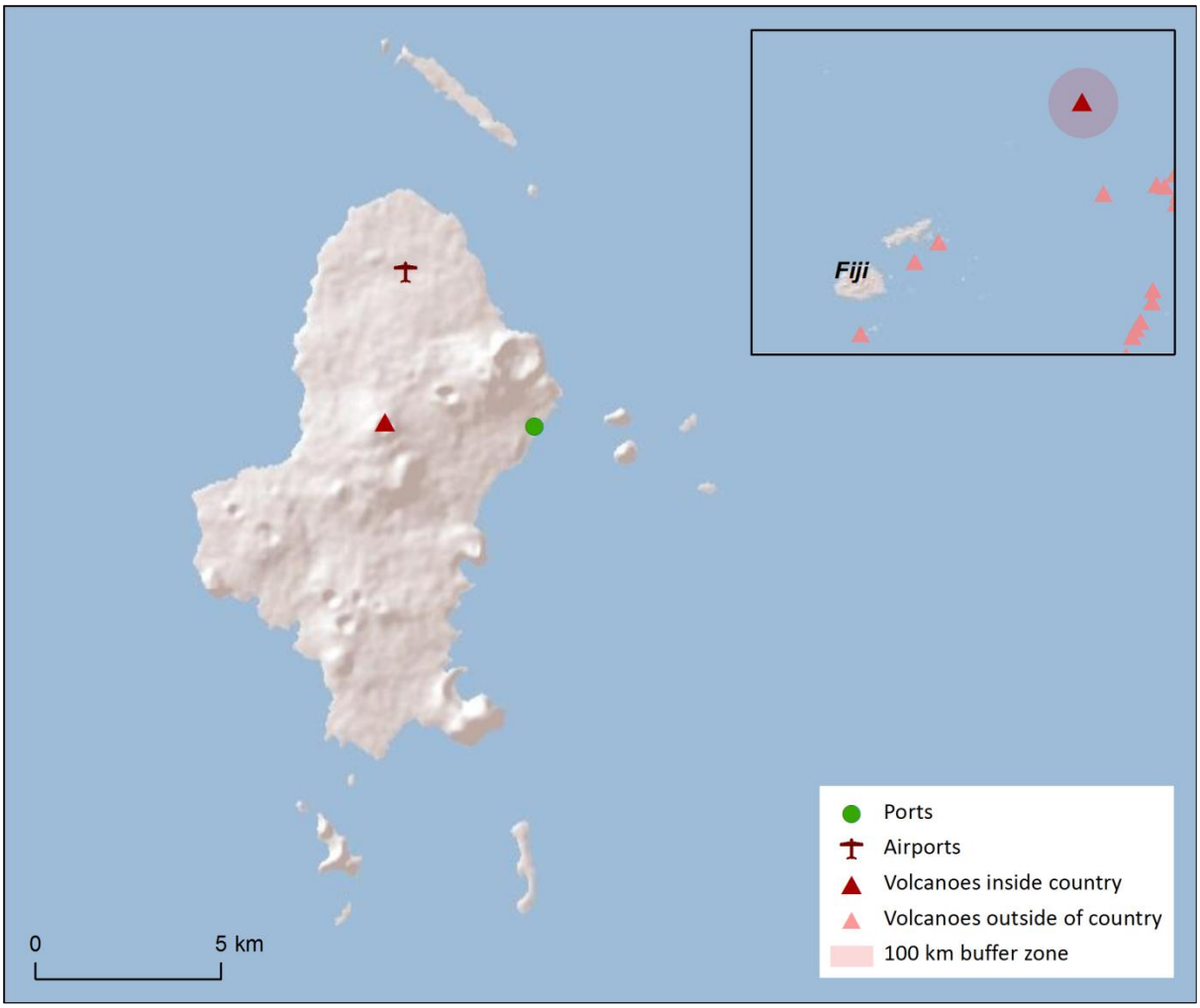

Figure 13.8 The location of Wallis and Futuna and the volcanoes here and the extent of the 100 km zone surrounding them.

Hazard, Uncertainty and Exposure Assessments

With the exception of Teahitia, the eruptive histories at all volcanoes here are insufficiently detailed to permit the determination of hazard through the calculation of the VHI without large associated uncertainties. Teahitia is classified at Hazard Level I, from historical VEI 0 eruptions. Of the unclassified volcanoes, two have no confirmed Holocene eruptions. The remaining unclassified volcanoes all have historical records only of eruptions of VEI 0 – 2.

The proximal population to these volcanoes is small, with only Wallis Islands, Matthew Island and Mehetia having a population within 10 km. For the latter two volcanoes, this doesn't increase within 100km. Whilst the islands of French Polynesia have a larger population within 100 km, all but Wallis Islands are classed with a low PEI of 2. With the population within 10 km at Wallis Islands, the PEI here is moderate at 4.

CLASSIFIED	**Hazard III**							
	Hazard II							
	Hazard I		Teahitia					
UNCLASSIFIED	**U – HHR**	**Eastern Gemini Seamount; Hunter Island**	**Rocard; Moua Pihaa; Matthew Island**					
	U- HR							
	U- NHHR		**Mehetia**		Wallis Islands			
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 13.8 Identity of the volcanoes in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'Classified' (top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in **bold** have experienced unrest or eruptions since 1900 AD, and those in red have records of at least one Holocene VEI ≥4 eruption.*

Volcano	Population Exposure Index	Risk Level
Teahitia	2	I

Table 13.9 The classified Pacific Ocean French volcanoes ordered by descending Population Exposure Index (PEI). Risk levels determined through the combination of the Hazard Level and PEI are given. Risk Level I – 1 volcano; Risk Level II – 0 volcanoes; Risk Level III – 0 volcanoes.

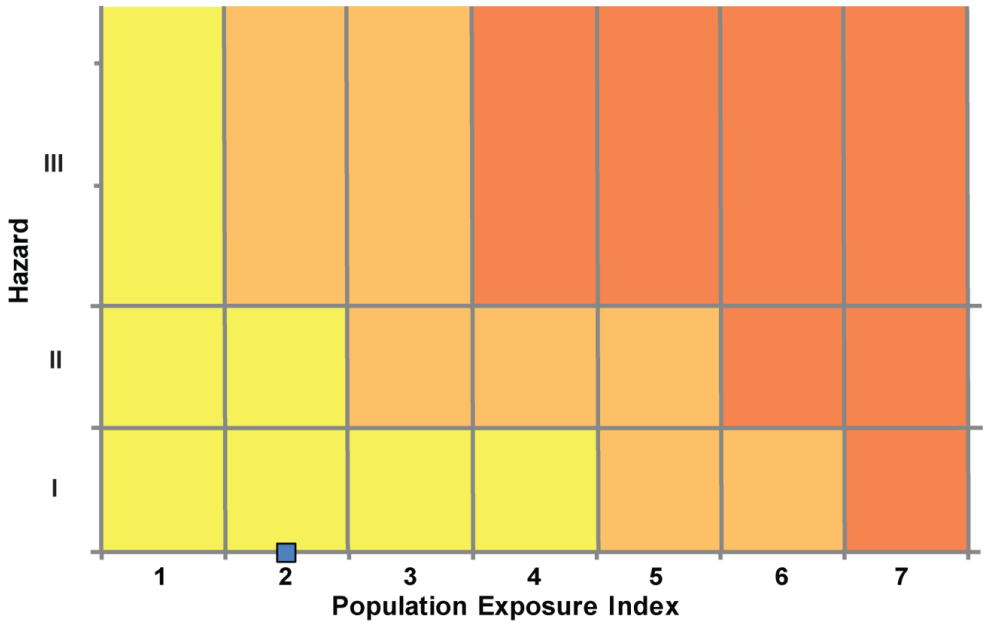

Figure 13.9 Distribution of the Pacific Ocean French classified volcanoes across Hazard and Population Exposure Index levels. The warming of the background colours illustrates increasing Risk levels from Risk Level I - III.

National Capacity for Coping with Volcanic Risk

Six volcanoes have records of historical activity in the French islands of the Pacific. At the time of the writing of this report there is no information available to indicate the presence of dedicated ground-based monitoring systems on these volcanoes.

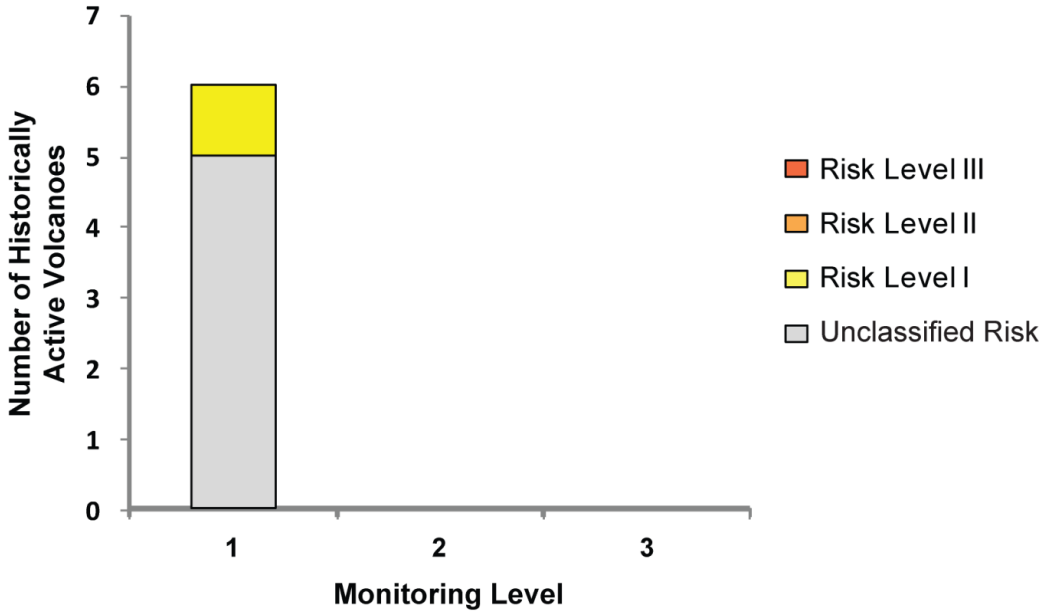

Figure 13.10 The monitoring and risk levels of the historically active volcanoes in the Pacific Ocean French volcanoes. Monitoring Level 1 indicates no known dedicated ground-based monitoring; Monitoring Level 2 indicates that some ground-based monitoring systems are in place including ≤3 seismic stations; Monitoring Level 3 indicates the presence of a dedicated ground-based monitoring network, including ≥4 seismometers.

USA – Hawaii and Pacific

See Region 4 for American Samoa, Region 8 for the Marianas, Region 11 for Alaska, Region 12 for the contiguous states.

Here we discuss the volcanism in the US-Pacific. The profile focuses on the subaerial volcanism in Hawaii, then goes on to provide analysis of the submarine volcanoes located in the northern Pacific – the North Gorda Ridge, Escanaba Segment and an Unnamed volcano.

Description

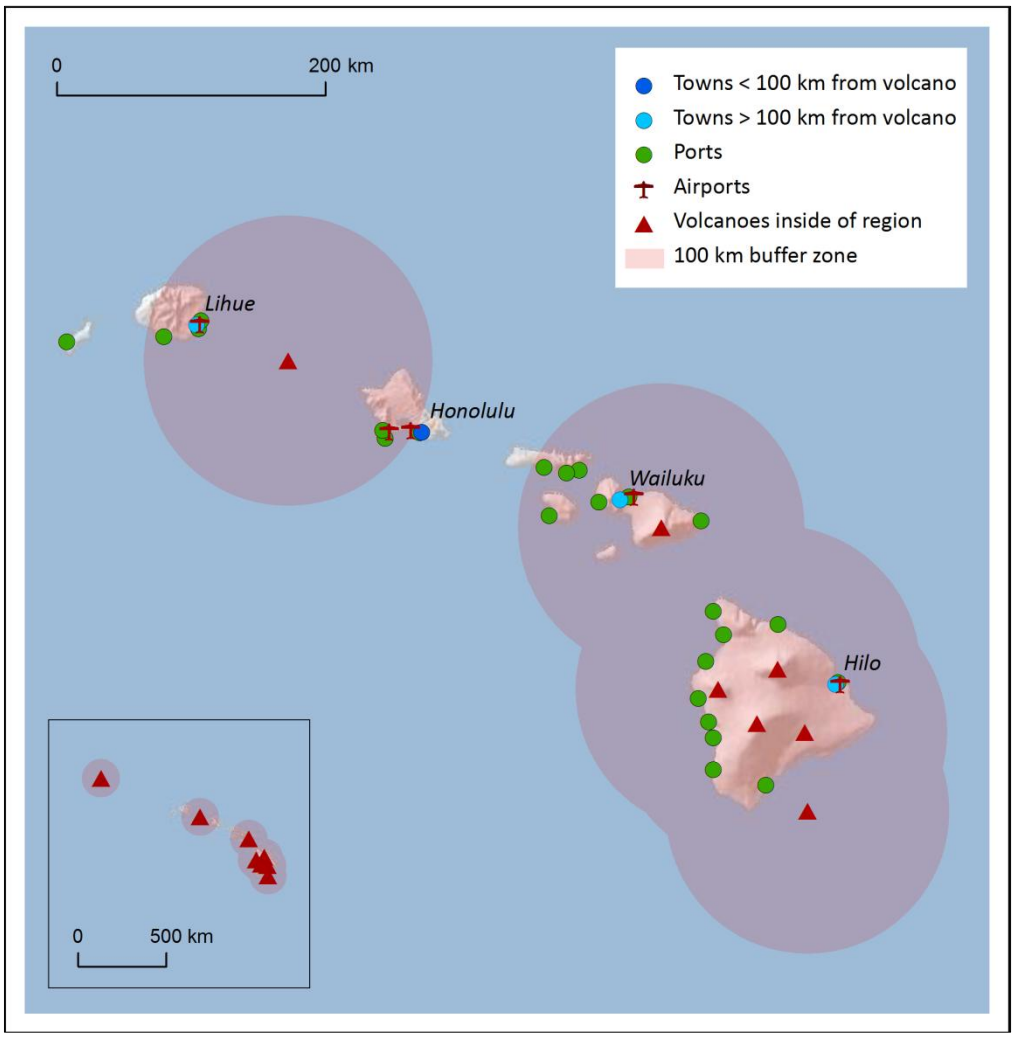

Figure 13.11 The location of Hawaii's volcanoes and the extent of the 100 km zone surrounding them. Ports, airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

Eight Holocene volcanoes are located in Hawaii. Three submarine volcanoes are located off the southern coast of the Big Island (Hawaii), between Oahu and Kauai and beyond Kauai into the northwestern leeward islands. The remaining volcanoes are subaerial shields located on Hawaii and

Maui. These volcanoes are dominantly basaltic in composition and result from intra-plate hotspot processes.

VOTW4.22 records 277 confirmed Holocene in Hawaii. These ranged from VEI 0 to 4. Of these, 123 eruptions are recorded historically, post-1500 AD.

The nature of the volcanoes in Hawaii are such that eruptions are not restricted to the summit, as rift zones are active across Hawaiian volcanoes including Hualalai, Mauna Loa and Kilauea. These rift zones are areas of weakness which are exploited by magma bodies. Eruptions therefore commonly occur along these rifts, some of which are over 100 km long. Indeed, the East Rift Zone of Haleakala is about 150 km long and extends into the ocean. Basaltic rift zones such as in Hawaii are typically associated with effusive events, producing extensive basaltic lava flows. These lavas can extend from many points along the rift zone, propagating downhill, and much of the surface of Mauna Loa and Kilauea comprises lava flows younger than 1000 years old. The population at risk cannot therefore be thought of in relation to a summit point, but is in fact more widespread along the lengths of the rifts and downhill from these features. With development of land expanding towards rift systems, the threat to life and property increases. Several eruptions of Kilauea, Mauna Loa have lead to property damage and several have resulted in loss of life.

Just one historical eruption of VEI 4 is recorded at Kilauea in 1790 in VOTW4.22. This explosive eruption produced pyroclastic flows and ballistics killing hundreds. Ongoing work investigating this eruption suggests that it was in fact a VEI 3 event (J.Kauahikaua, pers. comm., 2014). Indeed, explosive activity is rare here.

The U.S. Geological Survey's Hawaiian Volcano Observatory (HVO) was founded in 1912. Here scientific research and monitoring of the active volcanoes is undertaken, with a large monitoring network focussed on the island of Hawaii. Hazard assessment reports have been produced for Kilauea and Mauna Loa. The HVO provide Volcanic Activity Notices (VAN) for changes in alert levels and aviation colour codes. Regular updates are also released. See the profile for the U.S. contiguous states for description of the U.S. Geological Survey's NVEWS approach to monitoring.

See also:

Guffanti, M., Diefenbach, A.K., Ewert, J.W., Ramsey, D.W., Cervelli, P.F., and Schilling, S.P., 2009, Volcano-monitoring instrumentation in the United States, 2008: U.S. Geological Survey Open-file Report 2009-1165, 32 p. pubs.usgs.gov/of/2009/1165/

Hawaiian Volcano Observatory: hvo.wr.usgs.gov/observatory/

Volcano Facts

Number of Holocene volcanoes	8
Number of Pleistocene volcanoes with M≥4 eruptions	1
Number of volcanoes generating pyroclastic flows	1

Number of volcanoes generating lahars	0
Number of volcanoes generating lava flows	8
Number of fatalities caused by volcanic eruptions	Hundreds
Tectonic setting	Intra-plate
Largest recorded Pleistocene eruption	-
Largest recorded Holocene eruption	Three VEI 4 eruptions during the Holocene (VOTW4.22), however currently ongoing unpublished work indicates that these eruptions were no more than VEI 3 in size.
Number of Holocene eruptions	277 confirmed eruptions
Number of historically active volcanoes	6
Number of historical eruptions	123

Number of volcanoes	Primary volcano type	Dominant rock type
5	Shield(s)	Basaltic (5)
3	Submarine	Basaltic (1), Unknown (2)

Table 13.10 The number of volcanoes, their volcano type classification and dominant rock type according to VOTW4.0.

Population Exposure

Capital city	Honolulu
Distance from capital city to nearest Holocene volcano	100 km
Total population (2010) (US Census Bureau[1])	1,360,301

Ten largest cities, as defined by population size, and populations (2010 US Census):

Honolulu	337,256
East Honolulu	49,914
Pearl City	47,698
Hilo	43,263
Kailua	38,635
Waipahu	38,635
Waipahu	38,216
Kaneohe	34,597
Mililani Town	27,629
Kahului	26,337

[1] factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk

Infrastructure Exposure

Number of airports within 100 km of a volcano	5
Number of ports within 100 km of a volcano	22
Total length of roads within 100 km of a volcano (km)	865
Total length of railroads within 100 km of a volcano (km)	0

With the exception of the island Ni'ihau, almost the entirety of the main islands of the Hawaiian island chain fall within 100 km of a Holocene volcano, therefore including much of the critical infrastructure and the largest cities, including the capital, Honolulu. Being volcanic islands, a large number of ports lie within the 100 km radii, 5 airports and a substantial road network is also affected.

Hazard, Uncertainty and Exposure Assessments

There are varying levels of information in the eruption records of Hawaii's volcanoes. Mauna Loa, Kilauea and Hualalai have sufficient detail to determine hazard through the calculation of the VHI and all are classified at Hazard Level I due to a largely effusive eruptive history.

There is insufficient data to calculate the VHI at the remaining volcanoes without large associated uncertainties. With the exception of an unnamed volcano, all unclassified volcanoes have a Holocene record of activity, with historical eruptions at Haleakala, Loihi and another unnamed volcano.

The PEI ranges from low to high in Hawaii, and with a Hazard Level of I, the classified volcanoes are classed at Risk Levels I and II. Just Hualalai is classed as Risk Level II, with the largest population within 10 km of all Hawaiian volcanoes.

CLASSIFIED	**Hazard III**							
	Hazard II							
	Hazard I		Mauna Loa	Kilauea		Hualalai		
UNCLASSIFIED	**U – HHR**	**Unnamed (332090)**	**Loihi**		Haleakala			
	U- HR		Mauna Kea					
	U-NHHR		Unnamed (332080)					
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 13.11 Identity of volcanoes in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'Classified' (top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in **bold** have experienced unrest or eruptions since 1900 AD, and those in red have records of at least one Holocene VEI ≥4 eruption.*

Volcano	Population Exposure Index	Risk Level
Hualalai	5	II
Kilauea	3	I
Mauna Loa	2	I

Table 13.12 Classified volcanoes ordered by descending Population Exposure Index (PEI). Risk levels determined through the combination of the Hazard Level and PEI are given. Risk Level I – 2 volcanoes; Risk Level II – 1 volcano; Risk Level III – 0 volcanoes.

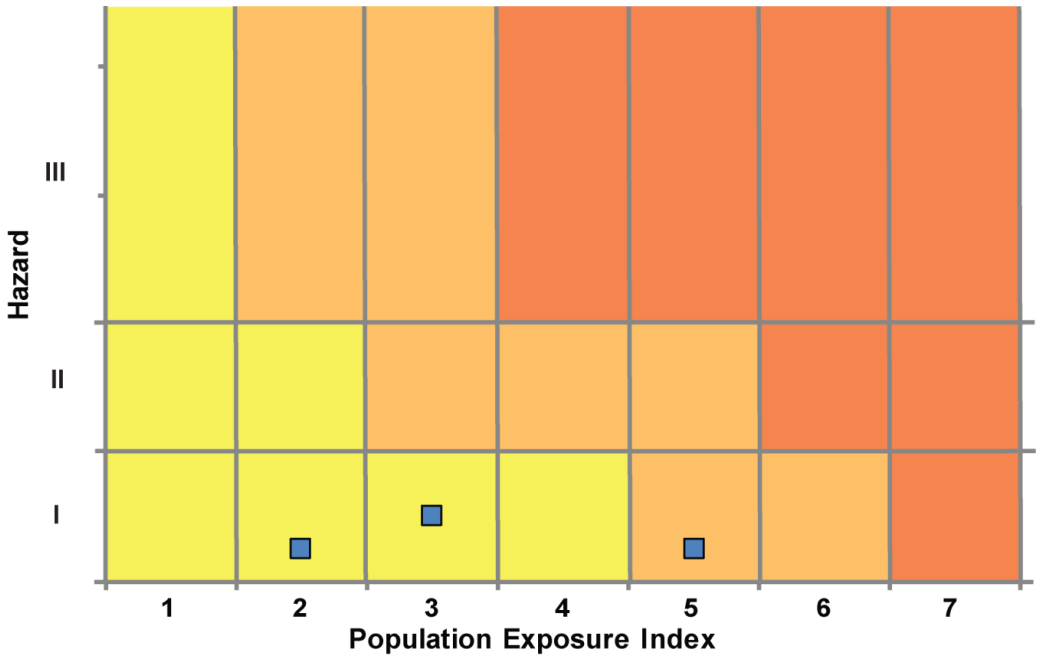

Figure 13.12Distribution of classified volcanoes across Hazard and Population Exposure Index levels. The warming of the background colours illustrates increasing Risk levels from Risk Level I - III.

National Capacity for Coping with Volcanic Risk

Seven volcanoes in Hawaii have historical records of activity. The unnamed submarine volcano does not have dedicated ground-based monitoring. The volcanoes on the Big Island, Loihi, Kilauea, Mauna Loa and Hualalai are monitored through an extensive seismic network, with additional deformation and gas monitoring at Kilauea and Mauna Loa. Numerous seismic stations are also located near Haleakala on Maui.

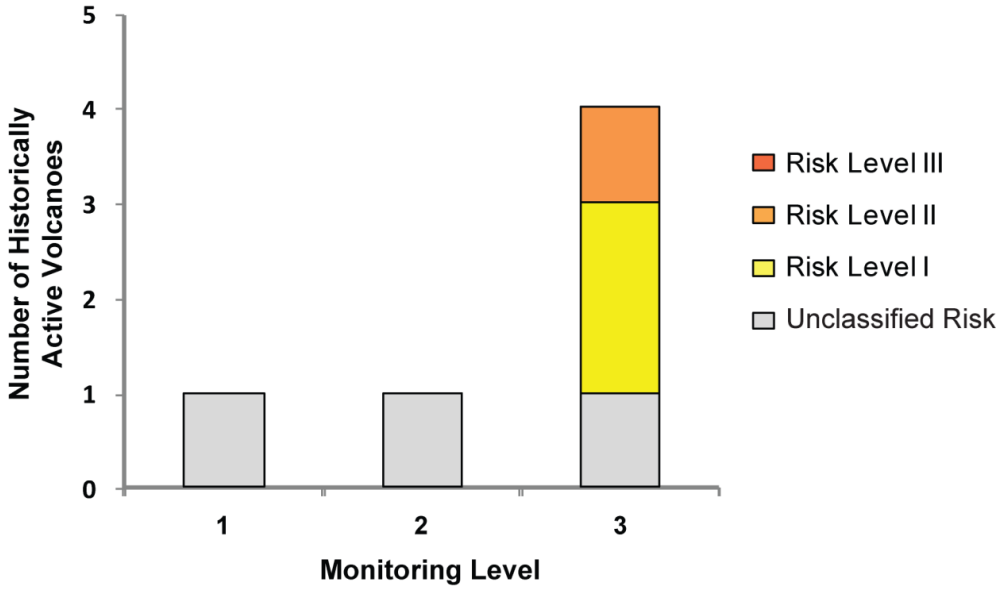

Figure 13.13 The monitoring and risk levels of the historically active volcanoes. Monitoring Level 1 indicates no known dedicated ground-based monitoring; Monitoring Level 2 indicates that some ground-based monitoring systems are in place including ≤3 seismic stations; Monitoring Level 3 indicates the presence of a dedicated ground-based monitoring network, including ≥4 seismometers.

USA –Pacific-Other

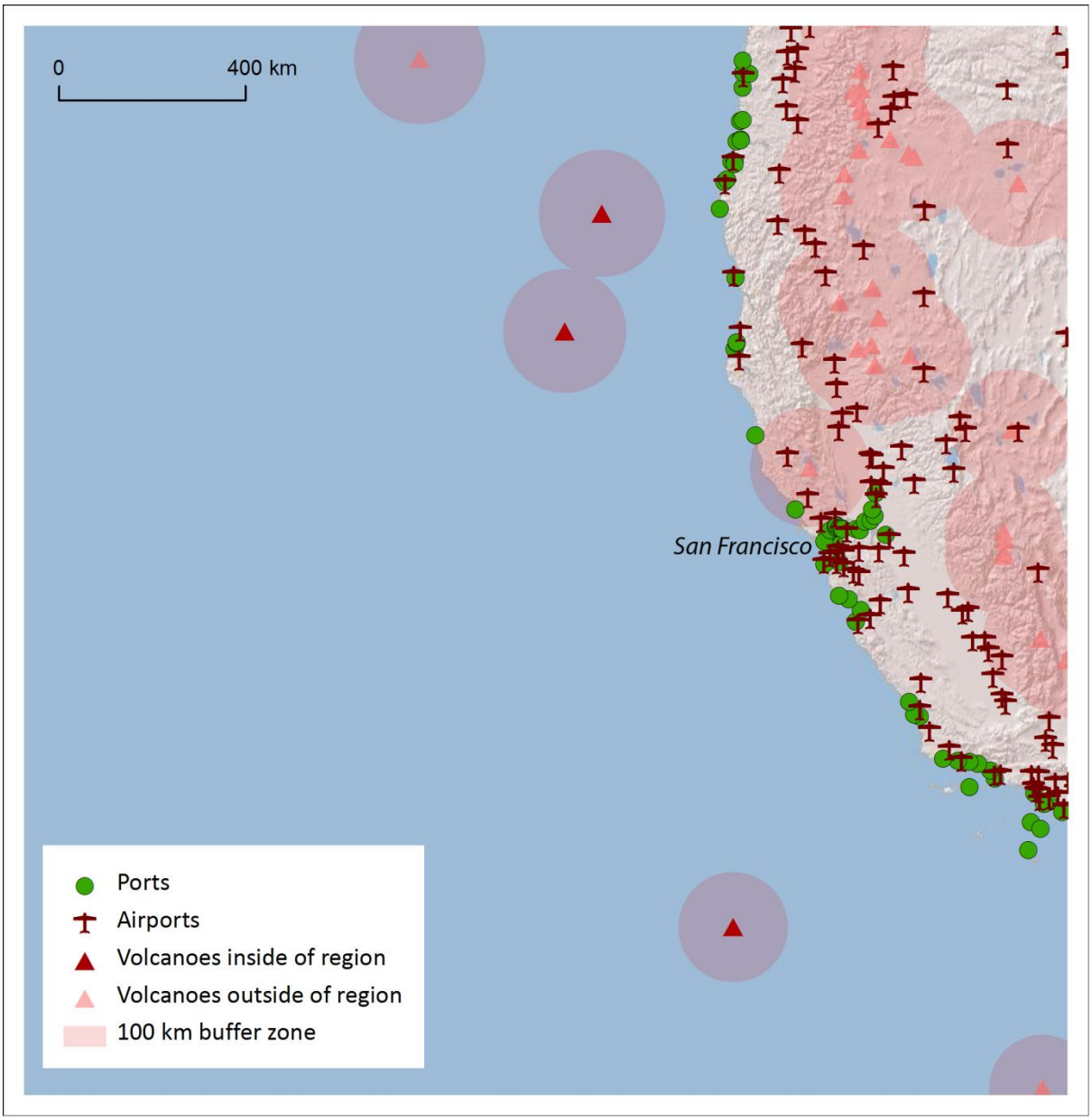

Figure 13.14 The location of the Pacific US volcanoes and the extent of the 100 km zone surrounding them. Ports, airports and the major cities are just some of the infrastructure that may be exposed to volcanic hazards.

Three submarine volcanoes are located beyond about 200 km off the coast of Oregon and California. These volcanoes – the North Gorda Ridge, Escanaba Segment and an unnamed volcano, are submarine features.

North Gorda Ridge formed on a spreading centre south of the Juan de Fuca ridge. An eruption occurred here in 1996, forming a submarine lava flow.

Being remote submarine features there is no population living within 100 km of any of these volcanoes. The hazard is considered low to the nature of lava effusions at spreading ridges and with no permanent population the risk is therefore low.

Volcano Facts

Number of Holocene volcanoes	3
Number of Pleistocene volcanoes with M≥4 eruptions	-
Number of volcanoes generating pyroclastic flows	-
Number of volcanoes generating lahars	-
Number of volcanoes generating lava flows	2
Number of fatalities caused by volcanic eruptions	-
Tectonic setting	Intra-plate, rift-zone
Largest recorded Pleistocene eruption	-
Largest recorded Holocene eruption	All eruptions of VEI 0
Number of Holocene eruptions	4 confirmed eruptions
Number of historically active volcanoes	1
Number of historical eruptions	1

Number of volcanoes	Primary volcano type	Dominant rock type
3	Submarine	Basaltic (2), Unknown (1)

Table 13.13 The number of volcanoes, their volcano type classification and dominant rock type according to VOTW4.0.

Hazard, Uncertainty and Exposure Assessments

The eruptive record for these volcanoes prevents the determination of hazard through calculation of the VHI without large uncertainties. These volcanoes are therefore unclassified. Just Escanaba Segment and North Gorda Ridge have a Holocene eruption record, most recently with a 1996 VEI 0 eruption of North Gorda Ridge. Despite the hazard being unclassified, the absence of a local population means the risk here is low.

CLASSIFIED	**Hazard III**							
	Hazard II							
	Hazard I							
UNCLASSIFIED	**U – HHR**	**North Gorda Ridge**						
	U- HR	Escanaba Segment						
	U- NHHR	Unnamed (331050)						
		PEI 1	**PEI 2**	**PEI 3**	**PEI 4**	**PEI 5**	**PEI 6**	**PEI 7**

*Table 13.14 Identity of volcanoes in each Hazard-PEI group. Those volcanoes with a sufficient record for determining a hazard score are deemed 'Classified' (top). Those without sufficient data are 'Unclassified' (bottom). The unclassified volcanoes are divided into groups: U-NHHR is Unclassified No Historic or Holocene Record: that is there are no confirmed eruptions recorded in the Holocene. U-HR is Unclassified with Holocene Record: that is there are confirmed eruptions recorded during the Holocene, but no historical (post-1500) events. U-HHR is Unclassified with Historic and Holocene record. The unclassified volcanoes in **bold** have experienced unrest or eruptions since 1900 AD, and those in red have records of at least one Holocene VEI ≥4 eruption.*

National Capacity for Coping with Volcanic Risk

One volcano has historical records of activity. This volcano, the submarine North Gorda Ridge volcano, does not have dedicated ground-based monitoring.

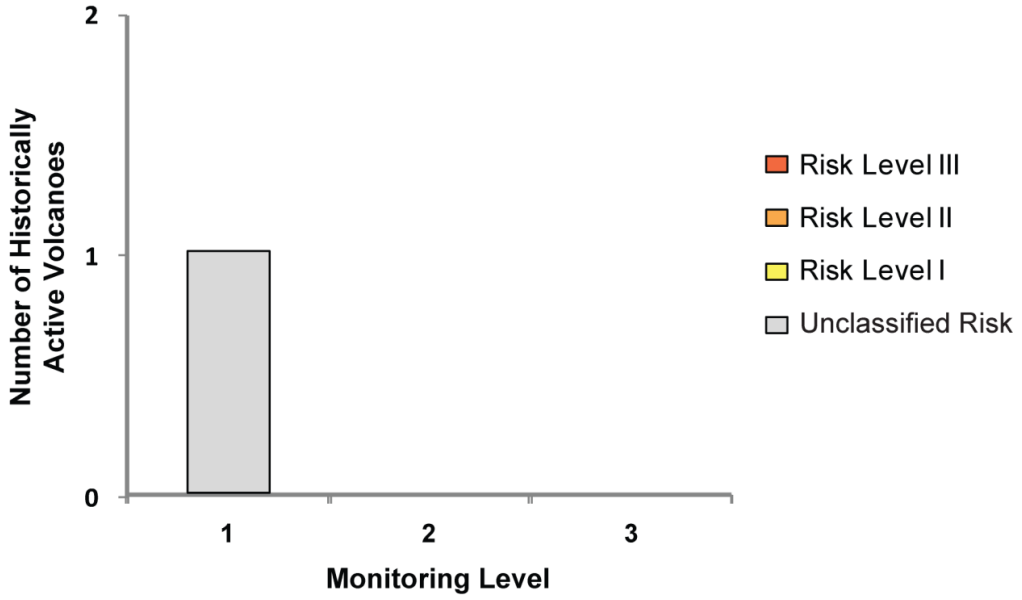

Figure 13.15 The monitoring and risk levels of the historically active volcanoes. Monitoring Level 1 indicates no known dedicated ground-based monitoring; Monitoring Level 2 indicates that some ground-based monitoring systems are in place including ≤3 seismic stations; Monitoring Level 3 indicates the presence of a dedicated ground-based monitoring network, including ≥4 seismometers.