Geologic Hazards Science Center
U.S. Geological Survey
Golden, Colorado
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Updates to the subduction interface portion of the Alaska 2023 USGS National Seismic Hazard Model

Rich Briggs (rbriggs@usgs.gov); Rob Witter (rwitter@usgs.gov); Jeffrey Freymueller (freymuel@msu.edu); Stephanie Ross (sross@usgs.gov); Hong Kie Thio (hong.kie.thio@aecom.com)

There is abundant new geologic and geodetic data to incorporate into the USGS National Seismic Hazard Model since the last update in 2007.

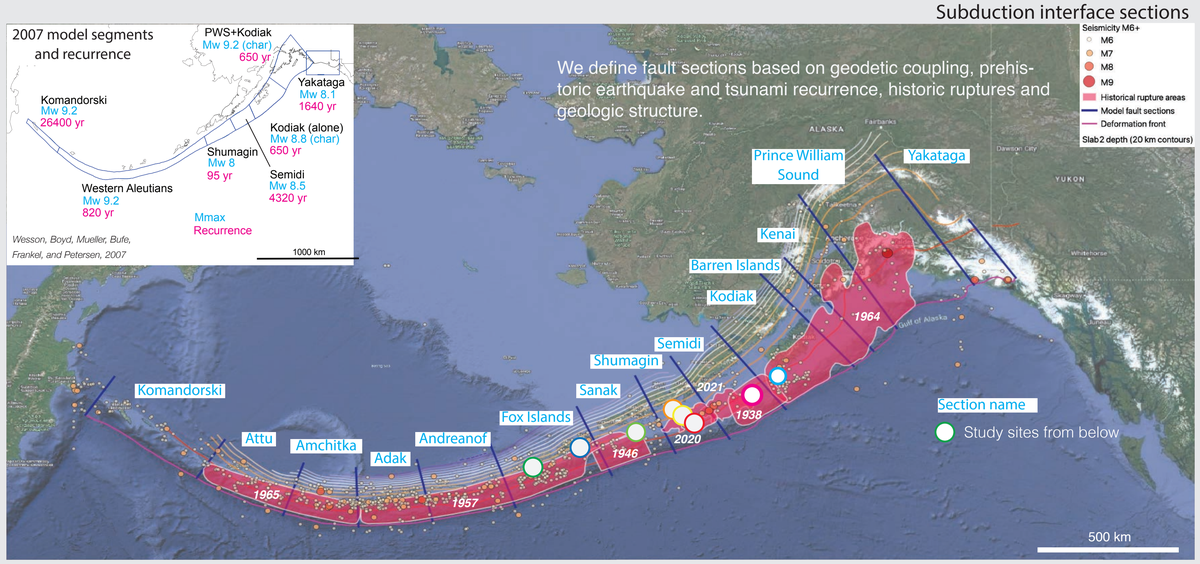
The approach:
-Divide the subduction interface into sections based on geodetic coupling, prehistoric earthquake and tsunami recurrence, historic ruptures and geologic structure.
-Generalize the geologic and geodetic character of each section.
-Calculate recurrence intervals from geologic and geodetic data.

The primary assumption in this recurrence model is that we can reasonably characterize behavior by fault section. Actual behavior is undoubtedly more complex, and will be modeled by single section, multisection, and floating ruptures.

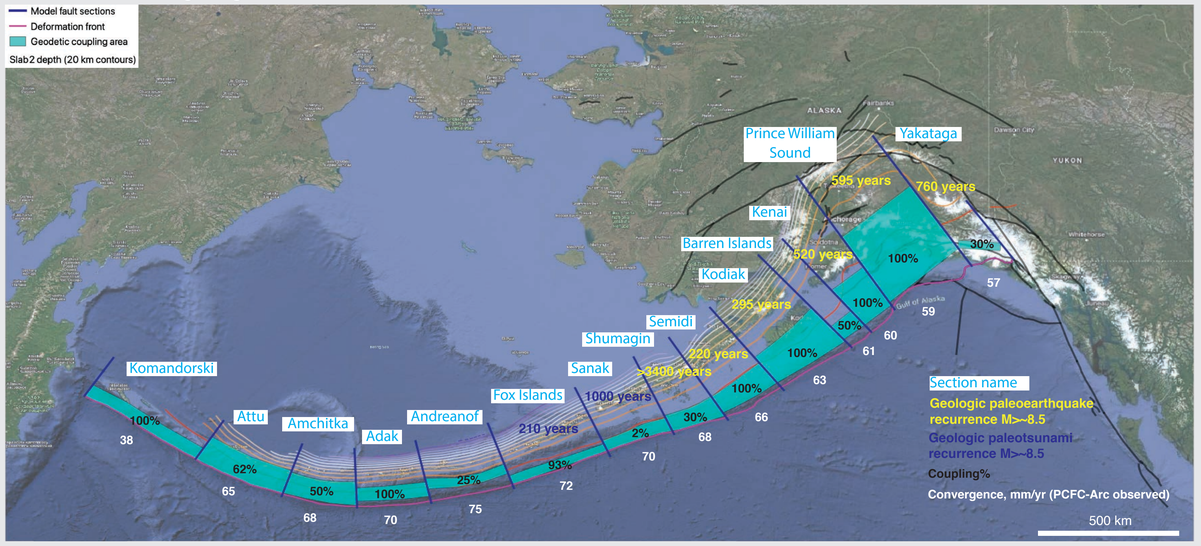
The geodetically-determined locked zone is a reasonable approximation for strain accumulation, but strain release (model ruptures) will span larger areas of the interface.

Shallowest megathrust ruptures aren't considered major contributors to onshore shaking, but a better understanding of these events will help place geodetic data in context and provide a link to tsunami hazard models.

Subduction interface sections



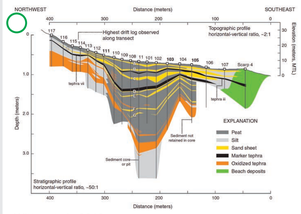
Geodetic model and geologic recurrence values



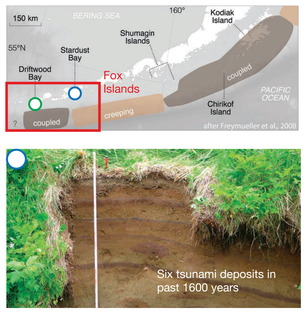
USGS-led geologic studies west of the 1964 rupture since the last NSHM update

Fox Islands section

- 9 sand sheets in past 2200 years
- 160–260 year recurrence interval
- Sites bracket coupled/creeping boundary



Witter et al., 2019

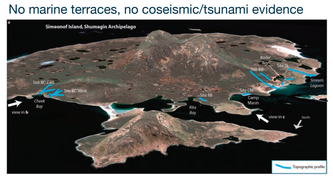


Witter et al., 2016

Shumagin section

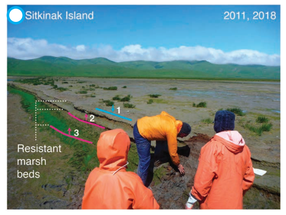
- No uplifted shorelines
- No marine deposits above modern high tide
- Storms/tsunamis deposited low, thin deposits
- Models allow M_w7.7–8.5 near-trench rupture

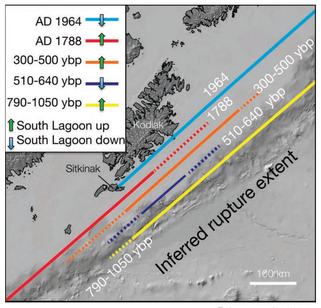
No marine terraces, no coseismic/tsunami evidence



Kodiak section

The far western end of the great 1964 rupture is a nonpersistent boundary that failed to arrest past ruptures like the 1788 earthquake.

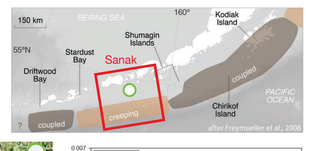


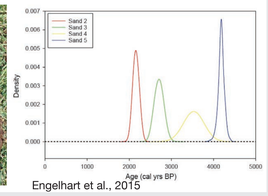


Briggs et al., 2014

Sanak section

- 5 sand sheets in past 4200 years
- Youngest sand sheet deposited in 1946
- Drift logs indicate 9+ m runup in 1946
- 4 sand sheets deposited 2000-4000 yr ago
- No evidence for a 1788 tsunami





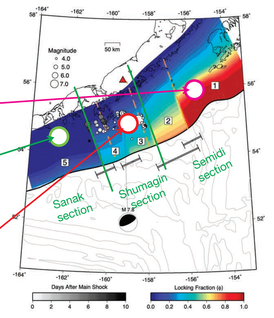
Engelhart et al., 2015

Sanak, Shumagin, and Semidi sections in context of geodetic coupling model

Chirikof Island—fully locked, 180–270 year average tsunami recurrence interval (Nelson et al., 2015)

Sanak Island—freely slipping, 1946 tsunami, 4 paleotsunami deposits in past 4200 yrs (Engelhart et al., 2015)

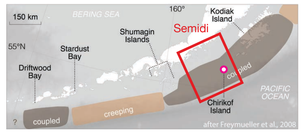
Shumagin Islands—mostly creeping, no evidence for high tsunamis (Witter et al., 2014)

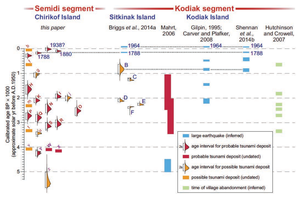


Droof and Freymueller, 2021

Semidi section

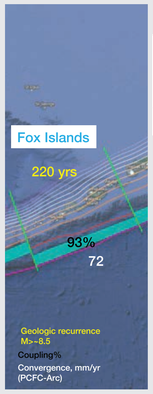
Coastal geology records tsunamis that occurred every 180-270 years, including events in 1788 and 1938





Nelson et al., 2015

Subduction interface - example geodetic recurrence calculation



Coupled geodetic area on model interface (km^2)	Plate conver-gence, PCFC-ARC Observed (mm/yr)	Coupling (%)	Mw1, Shaw +3.9 regression	Mw2, Shaw +4.0 regression	Mw3, Shaw +4.1 regression	Mw1, slip per event (m)	Mw 2, slip per event (m)	Mw 3, slip per event (m)	Geodetic recurrence, Mw1 (years)	Geodetic recurrence, Mw2 (years)	Geodetic recurrence, Mw3 (years)
17133	72	93	8.13	8.23	8.33	3.5	4.9	6.9	52	73	103

Coupled area on model interface
Convergence rate (PCFC
Coupling
Magnitude from area
Slip per event
Geodetic recurrence

This information is preliminary and is subject to revision. It is being provided to meet the need for timely best science. The information is provided on the condition that neither the U.S. Geological Survey nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the information.

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Draft table of geodetic recurrence values

Sections	Geodetic area on model interface (km^2)	Plate convergence, PCFC-Arc Obs (mm/yr)	Coupling (%)	Mw1, Shaw (3.9)	Mw2, Shaw (4.0)	Mw3, Shaw (4.1)	Mw1, slip per event (m)	Mw2, slip per event (m)	Mw3, slip per event (m)	Geodetic recurrence, Mw1 (years)	Geodetic recurrence, Mw2 (years)	Geodetic recurrence, Mw3 (years)	Average geologic recurrence interval Mw>8.5 (yrs)
Yakataga	4823	57	30	7.58	7.68	7.78	1.84	2.60	3.67	108	152	215	757
PrinceWilliamSound	102210	59	100	8.91	9.01	9.11	8.46	11.96	16.89	143	203	286	594
Kenai	27712	60	100	8.34	8.44	8.54	4.41	6.23	8.79	70	99	140	nd
Barren Islands	7965	61	50	7.80	7.90	8.00	2.36	3.34	4.71	72	101	143	516
Kodiak	56138	63	100	8.65	8.75	8.85	6.27	8.86	12.52	95	134	190	295
Semidi	23460	66	100	8.27	8.37	8.47	4.06	5.73	8.09	60	84	119	222
Shumagin	17906	68	30	8.15	8.25	8.35	3.54	5.00	7.07	169	238	337	>3400
Sanak	16766	70	2	8.12	8.22	8.32	3.43	4.84	6.84	2381	3363	4750	999
FoxIslands	17133	72	93	8.13	8.23	8.33	3.47	4.90	6.92	50	70	99	210
Andreanof	15759	75	25	8.10	8.20	8.30	3.32	4.70	6.63	190	268	379	nd
Adak	21314	70	100	8.23	8.33	8.43	3.87	5.46	7.71	57	80	113	nd
Amchitka	32877	68	50	8.42	8.52	8.62	4.80	6.78	9.58	148	209	295	nd
Attu	42113	65	62	8.52	8.62	8.72	5.43	7.68	10.84	231	326	460	nd
Komandorski	16100	38	100	8.11	8.21	8.31	3.36	4.75	6.70	88	125	176	nd

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Draft table of geologic recurrence values

Fault Section	References for fault section	Paleoearthquake timing	Mean paleoearthquake recurrence	References for paleoearthquakes	Paleotsunami timing	Mean paleotsunami recurrence	References for paleotsunamis
Yakataga	We 2007; Sh09	~870 BP, ~1440 BP	1513/2 = 757 (open interval)	Sh09, modified by Sh14	n/a	n/a	n/a
PWS	P92; H05; CP08; Sh08	1964 AD, ~870 BP, ~1440 BP, ~2050 BP, ~2615 BP, ~3130 BP, ~3550 BP	3564/6 = 594 (closed interval)	CP08; Shennan et al., 2014	n/a	n/a	n/a
Barren Islands	L16			n/a	n/a	n/a	n/a
Kenai	HC07	1964 AD, ~870 BP, ~1440 BP, ~2050 BP	2064/4 = 516 (closed interval)	CP08; Sh14; K15	n/a	n/a	n/a
Kodiak	NJ90; CB94;	1964 AD, 1788 AD, ~500 BP, ~870 BP	884/3 = 295 (closed interval)	CP08; Sh14	n/a	n/a	n/a
Semidi	NJ90	1788 AD, ~500 BP, ~650 BP, ~870 BP, ~1050 BP	888/4 = 222 (closed interval)	B14	13 since 3.5 ka	180-270, mean = 225	N15
Shumagin	D81	>3,400 years	>3,400	W14	n/a	n/a	n/a
Sanak	FF07	n/a	n/a	n/a	1946, gap to 2ka, then 4 sands ~2 ka to ~4 ka	~4ka to 1946 is 3996/4 =999 (closed interval)	En15
Fox Islands	J94	n/a	n/a	n/a	1957, and 6-8 total since ~2 ka	164–257, mean=210	W18
Andreanof	J94	n/a	n/a	n/a	n/a	n/a	n/a
Adak	J94	n/a	n/a	n/a	n/a	n/a	n/a
Amchitka	Sy71	n/a	n/a	n/a	n/a	n/a	n/a
Attu	Sy71	n/a	n/a	n/a	n/a	n/a	n/a
Komandorsky	Sy71	n/a	n/a	n/a	n/a	n/a	n/a

Geologic data is land-level change west of Semidi section

Only paleotsunami data here

No geologic data for ~2,000 km of subduction zone west of Fox Islands

The geodetic model generalizes coupling by fault section, based on decades of studies by Freymueller and collaborators.

Geodetic recurrence values are estimated from coupled area, plate convergence (modified in the west due to obliquity), coupling value, and estimates of magnitude, slip, and recurrence from magnitude-area regressions by Shaw (in review).

Geologic recurrence intervals, presumably from events >Mw 8.5, are from published studies.

In general, geodetic recurrence values are shorter than recurrence values from geology for >Mw 8.5 events, as expected.

References: B14, Briggs et al. (2014); C08, Cross and Freymueller (2008); CB94, Christensen and Beck (1994); CP08, Carver and Plafker (2008); D81, Davies et al. (1981); E20, Elliott and Freymueller (2020); En15, Engelhart et al. (2015); F08, Freymueller et al. (2008); FF07, Fournier and Freymueller (2007); G88, Geist et al. (1988); H05, Hamilton et al. (2005); HC07, Hutchinson and Crowell, 2007; J94, Johnson et al. (1994); K15, Kelsey et al. (2015); L16, Li et al. (2016); N15, Nelson et al. (2015); N16, Nicolsky et al. (2016); MJ90, Nishenko and Jacob (1990); P92, Plafker et al. (1992); SF09, Suito and Freymueller (2009); Sh09a, Sh09b, Sh14a, Sh14b, Sh16, Sh18, Shennan et al. (2009a, 2009b, 2014a, 2014b, 2016, 2018); Sy71, Sykes et al. (1971); W14, W16, W19, Witter et al. (2014, 2016, 2019); We07, Wesson et al. (2007)

Thank you to the many scientists involved in this effort, including (but not limited to!) Peter Haeussler (USGS), Simon Engelhart (University of Durham), Tina Dura (Virginia Tech), Rich Koehler (UNR), Alan Nelson (USGS), and Guy Gelfenbaum (USGS). We also thank member of the National Tsunami Hazard Mitigation Program (NTHMP) Powell Center Working Group, including co-PIs Marie Eble (National Oceanic and Atmospheric Administration), Dmitry J. Nicolsky (University of Alaska Fairbanks), and Rick Wilson (California Geological Survey).