Acknowledgments

The white box outlines an area of daimyo mansions (enlarged view, and samurai neighborhoods spiraling around the castle grounds of Edo in Ichirōbei. Courtesy of East Asian Library, University of California, Berkeley—shows moats.

Libraries in Berkeley, Morioka, Seattle, Tanabe, and Tokyo made available, for use in this book, maps that aid in visualizing the bygone world of the orphan tsunami of 1700. The example above—from the collection of the East Asian Library of the University of California, Berkeley—shows moats and samurai neighborhoods spiraling around the castle grounds of Edo in 1684. The white box outlines an area of daimyo mansions (enlarged view, p. 61).

WHERE JAPANESE WRITERS recorded the 1700 tsunami, dozens of people helped us explore questions central to this book: Who wrote the original accounts of the flooding and damage? Why were these accounts written and how were they preserved? Which passages contain errors in copying? Where are the places described as flooded? Were these same places reached by the 1960 tsunami as well?

In Morioka, Konishi Hiroaki granted access to the Morioka-han documents reproduced on pages 36, 38-39, 44-45, 58, and 60. He provided clues on how Morioka-han “Zassho” was compiled, documentation on senior ministers named there, and likely dates for the early 18th-century maps of Miyakodōri and Ōtsuchi-dōri (p. 36, 44, 58). He serves as librarian of the Documents Office, Morioka City Central Community Center (Kyōdo Shiryō Shitsu, Morioka-shi Chūō Köminkan).

On the coast in modern Miyako city, Yamazaki Toshio and Sasaki Tsutomu identified places inundated by the 1960 tsunami in Kuwagasaki and Tsugaruishi (photos, p. 49 and 51). In 1999, Mr. Yamazaki was fire chief and Mr. Sasaki one of his deputies at the Central Fire Station of the Miyako Unified Fire District (Miyako-chiku Kōki Kumiai Gyōsei, Shōbōsho Honbu). Shuto Nobuo of Iwate Prefectural University provided an introduction to Mr. Yamazaki and a walking tour of Kuwagasaki’s tsunami-prone districts. Kishi Shōichi, a historian for Miyako city, shared his knowledge of Miyako’s Edo-period governance. His successor, Kariya Yūichirō, helped us interpret and photograph Moriai-ke “Nikki kikatome chō.”

In Tsugaruishi, Moriai Mitsunori granted access to his family’s notebook, Moriai-ke “Nikki kikatome chō.” He and his mother welcomed three of us into the family home (p. 53). Iwamoto Yoshiteru, an authority on the area’s Edo-period economy (books, p. 116), provided guidance on obscure place names of Tsugaruishi (p. 50, 51, 56).

Morikoshi Ryō of Hachinohe helped Ueda identify copyist’s errors in Moriai-ke “Nikki kikatome chō” by providing a transcription, in printed Japanese, of official records of Hachinohe-han, its “Han nikki” (footnoted, p. 52). Mr. Morikoshi leads Hachinohe Komonjo Benkyō-kai, a group that studies historical documents and which made the transcription of Hachinohe “Han nikki.”

Moriai Mutsuharu, a retired schoolteacher in Tsugaruishi, adopted Atwater and Yamaguchi for a day of interviewing his fellow villagers about the 1960 tsunami (sites marked by blue and yellow dots, p. 56). Those who identified inundation limits include Yonezawa Takuji (in color photo, p. 57, upper right) and Moriai Miya (photo, below).

In Ōtsuchi, Maeda Zenji, Fujimoto Toshiaki, and Kamata Seizō provided guidance on Edo-period neighborhoods. They also shared the town’s collection of photographs and maps showing sites inundated by the 1960 tsunami. When interviewed in 1999, Mr. Maeda headed Ōtsuchi’s Historical Preservation Council (Ōtsuchi-chō Bunkazai Hogo Shingikai), while Messrs. Fujimoto and Kamata served as assistant director and archaeologist, respectively, in the town’s office of continuing education (Ōtsuchi-chō Kyōiku I’inkai, Shakai Kyōiku).

Ogawa Kaori journeyed to Ōfunato to learn about that city’s devastation by the 1960 tsunami and its lack of writings on the 1700 tsunami (p. 81). She also checked for written records in Sendai. In Ōfunato she received help from Satō Etsuro of Ōfunato city, Shirato Yutaka and Kīno Ryoichi of Ōfunato Museum, and Honda Fumito of nearby Rikuzentakada city.

Town officials, local historians, and private citizens of Hitachinaka (formerly Nakaminato) twice received visitors interested in tsunami evidence from Ōuchi-ke “Go-yūdôme.” The hosts included Kawasaki Osamu, Onizawa Yōichi, Onizawa Yasuhiko, Saitō Arata, Satō Tsugio, and, from the family that conserves the document, Ōuchi Yoshikuni. Town officials permitted photographs of the volume and of a picture map (p. 66-70).

In Miho, Endō Kunio kindly met with three North Americans to share with them “Miho yōjō oboe” and how he came to possess it (p. 76). Mr. Endō’s daughter, Mayumi, arranged a later gathering with two local historians, Endō Shōji and Watanabe Yasuhiro. She also provided copies of books on “Oboe” by Endō Shōji and others (p. 115).

Nagao Toshiyasu of Tokai University joined two of us in Miho for interviews of witnesses to the 1960 tsunami and 1974 storm: Shiba Tsune, Mizuno Teruko, and a lady in the Ishino family (p. 82-83). Moriguchi Osamu, of the central fire office of Shimizu city, arranged for an interview with another witness to the 1960 tsunami, Aoki Yukio.

Officials and residents of Tanabe welcomed us repeatedly for visits that included informative discussions with Kishi Akinori, a local historian, and field trips guided by...
members of the city’s general affairs office: its directors, Yamasaki Kiyohiro and Okamoto Yoshihiko, and staffers Urabe Shunji and Shin’ya Jun. Ōta Yuji, librarian with the municipal library, granted access to Tadokoro documents and shared his views of their history (p. 84–87). Hashimoto Kuniko and Minakata Fumio provided a tour of a Tanabe storehouse (photo, below left). In Shinjō, Matsuzaki Tomiji welcomed visitors to a storehouse site (p. 88) and Kashiwagi Tomio provided photos of the 1960 tsunami (p. 89).

Not far from Tanabe, in Hirogawa, Shimizu Isao gave three North Americans an enthusiastic, full-day field trip on Hamaguchi Goryō and his response to the 1854 tsunami that devastated Hiro-mura (photo, below right). At the time of that field trip, Mr. Shimizu was continuing education specialist at the town’s community center, Hirogawa-chō Chōkō Kōminkan. Tsumura Ken shiro, formerly of Hirogawa, further advised us on Goryō and “Inamura no hi.” The picture on page 47 was taken by him and is reproduced with permission of the painting’s owner, Yögen Temple.

IN FORMER EDO, Watanabe Tokie of the Earthquake Research Institute (ERI), University of Tokyo, set up some of the rural visits. Murakami Yoshikane, while a graduate student at ERI, provided a speedy drive to northeast Japan. Katō Teruyuki of ERI advised us on tide-gauge data. Hirata Sakura and Kikuchi Ryōichi of Meiji University allowed us to examine maps of Japan and Suruga province from 1702 (p. 32, 76). Ota Yoko, formerly of Yokohama National University, helped us interpret the picture maps of Morioka-han (p. 36, 44, 58), the inland waterways between Nakaminato and Edo (p. 67), and land-level changes in northeast Japan (p. 65). She also arranged for an Edo mansion for Atwater and his family; and Joel Muraoka provided Tokyo lodging for Yamaguchi.

In nearby Tsukuba, Okada Masami and Tanioka Yūichirō of the Meteorological Research Institute, Japanese Meteorological Agency, checked tidal measurements and datums. Odagiri Satoko, of the Geographical Survey Institute, provided old topographic maps. Staff of the Active Fault Research Center, a part of the National Institute of Advanced Industrial Science and Technology, extended countless courtesies to Atwater. These included telephone interviews and trip planning by Isoda Hisako, guidance on Japanese history and language from Horikawa Haruo and Nanayama Futoshi, and bibliographic work by Satō Nobue. Dr. Horikawa photographed the monument on page 45; Ms. Satō, the anthologies on pages 62 and 123. Azuma Takashi led the visits to Hitachinaka and to the shogunal maps at Meiji University (p. 32, 76).

Atwater’s contributions to the book were made possible, in part, by several visits to Japan. During the longest of these, for nearly a year, his travel and living expenses were covered by Japanese government fellowships from the Center for Global Partnership, ERI, the Science and Technology Agency, and the Geological Survey of Japan. Persons who made these fellowships possible include Usui Akira and Ozaki Hiromi of the Geological Survey of Japan; Satō Hiroshi, Shimazaki Kunihiko, and Murakami Tomoko of ERI; and Ruth Reid and Rebecca Barnhart, and Jack Medlin of the U.S. Geological Survey (USGS).

Matsuda Izumi welcomed Atwater to her first-year Japanese language course at the University of Washington. Yamaguchi drew on Japanese language training that includes a summer program in 1976 (sponsored by Sumitomo Bank) and immersion during an appointment at the Hokkaido Research Center of the Forestry and Forest Products Research Institute from 1994 to 1996 (supported by Japan’s Science and Technology Agency).

THE NORTH AMERICAN PARENT for Japan’s orphan tsunami of 1700 became known through the work of a great many people. The principals include Hiroo Kanamori of the California Institute of Technology; Tom Heaton and Alan Nelson of the USGS; and Minze Stuiver of the University of Washington.

The Nuclear Regulatory Commission underwrote the radiocarbon dating of trees and herbs killed by tidal submergence from the 1700 earthquake (p. 24–25). In Minze Stuiver’s lab, Philip Wilkinson analyzed the spruce samples.

Unsung heroes of the earthquake’s tree-ring dating include Boyd Benson, Lori Davis, John Shulene, Karl Wegmann, and Marco Cisternas, all of whom helped dig out and sample the stumps of earthquake-killed red cedar.

Pierre Saint-Amand provided sharp prints of the Chilean photos on pages 10 and 11. The Alaskan airphoto on page 14 comes from the collection of A. Thomas Ovenshine and Susan Bartsch-Winkler, formerly of the USGS. Ian Shennan supplied one of the more recent Alaskan images on page 95.
The Nuclear Regulatory Commission, reviewing the design of this power plant, supported carbon-14 dating of Cascadia earthquakes (p. 25).

Satsop, Washington (location map, p. 96).

Boyd Benson, in an Oregon tidal swamp, checks the annual rings of a spruce survivor of the 1700 earthquake (p. 97).

Acknowledgments
THE STORY OF THE 1700 TSUNAMI draws on human history interpreted from old Japanese documents, on natural history inferred from North American sediments, trees, and native legends, and on mathematical modeling of tsunamis. The authors pooled their backgrounds in these and other fields. Below, as on the cover and title page, their names appear alphabetically.

Brian F. ATWATER ブライアン・F・アトウォーター conceived of the book and led in its preparation. To this work he brought over a decade of experience with geologic records of the 1700 earthquake and tsunami in North America. Through field work in 1999 he also contributed to size estimates for the 1700 tsunami in Japan. He holds B.S. and M.S. degrees in geology from Stanford University and a Ph.D. in geology from the University of Delaware. In thirty years with the U.S. Geological Survey he has studied bay and river geology in California, ice-age floods in Washington, and geologic records of earthquakes and tsunamis in the United States, Chile, and Japan. He lives in Seattle and is based at the University of Washington.

MUSUMI-ROKKAKU Satoko 六角 聡子 guided the transliteration and translation of the tsunami accounts. She also contributed to interviews in northeast Japan and to historical background material. Her education includes a B.A. in Humanities at Tokyo’s International Christian University and an ensuing year as a Fulbright Fellow at the University of Chicago, where she did graduate work in Islamic cultural history and Arabic language. Since 1979 she has coordinated the United Nations University fellowship program for Asian food scientists while teaching at Tokyo’s Obirin University. She has served as an officer in the UNU Women’s Association and holds an honorary professorship at the Mongolian University of Science and Technology. Her travels have taken her to 33 countries.

SATAKE Kenji 佐竹 健治 estimated sizes of the 1700 tsunami in Japan and the 1700 earthquake at Cascadia. He also tracked down primary sources for accounts of the 1700 tsunami in Tsugaruishi and Nakaminato. These contributions stem from his broad interest in subduction-zone earthquakes, which he studies with instrumental, written, and geological records, and with geophysical modeling. He holds B.S. and M.S. degrees in geophysics from Hokkaido University and a Ph.D. in geophysics from the University of Tokyo. He spent seven years in the United States, as a postdoctoral researcher at the California Institute of Technology and as an assistant professor at the University of Michigan. Since 1995 he has worked at the Geological Survey of Japan, where he is now deputy director of the Active Fault Research Center of the National Institute of Advanced Industrial Science and Technology. His field work in 2005 included post-tsunami surveys in Myanmar and Thailand. He chairs the tsunami commission of the International Union of Geodesy and Geophysics, serves on governmental committees that evaluate earthquake hazards in Japan, and edits “Rekishi Jishin,” the journal of Japan’s Society of Historical Earthquake Studies.

TSUJI Yoshinobu 都司 嘉宣 identified places reached by the 1700 tsunami, computed tides for estimates of the tsunami’s height, and helped transliterate and translate the tsunami accounts. From the University of Tokyo he earned a B.S. in civil engineering, and M.S. and Ph.D. degrees in geophysics. His studies of Japan’s historical earthquakes and tsunamis began in the 1970s, when he worked for the National Research Center for Disaster Prevention. In 1987 he joined the faculty of the University of Tokyo’s Earthquake Research Institute. He subsequently participated in post-tsunami field surveys in Nicaragua and Papua New Guinea, and he led such surveys in 2005 in Aceh and Thailand. He has also investigated storm surges and tsunami-induced damage to buildings. His second languages include Korean, Chinese, Russian, English, and Fortran.
UEDA Kazue 上田 和枝 discovered, transliterated, and translated accounts of the 1700 tsunami. She also confirmed the tsunami’s misdating in Moriai-ke "Nikki Kakitome-chō" (p. 53), investigated the historical context of the tsunami’s accounts, and interviewed witnesses to the 1960 tsunami. For over thirty years she has specialized in the written records of Japanese earthquakes. She entered that field eleven years after earning a B.A. in psychology at Tokyo Woman’s Christian College and joining the Earthquake Research Institute, University of Tokyo. The 21-volume, 16,812-page earthquake anthology, “Shinshū Nihon jishin shiryō” (p. 123), resulted largely from her efforts. These included some 300 visits to libraries, prominent families, government offices, temples, and shrines where she searched thousands of pages daily for accounts of earthquakes and tsunamis. Since retiring from the Earthquake Research Institute in 1998 she has remained active in meetings and publications on Japan’s historical earthquakes.

David K. YAMAGUCHI デイビッド・K・ヤマグチ relentlessly revised the entire book for presentation and content. He also contributed tree-ring dates, photographs, and bilingual interviews in Tsugaruishi, Miho, and Tanabe. A Seattle-born grandson of Japanese immigrants, he earned a B.S. in biology at Yale and a Ph.D. in forestry at the University of Washington. While a graduate student, he dated two eruptions of Mount St. Helens to 1479-1482 from the thin rings of trees damaged downwind. These findings led to a postdoctoral fellowship with the U.S. Geological Survey, where he dated volcanic debris flows by matching the ring-width patterns of entombed trees with those of living ones. During that fellowship he began the coastal tree-ring studies that helped identify Cascadia as the source of the orphan tsunami (p. 24, 96-97). Those studies progressed while he served on the research faculty of the University of Colorado and worked as a visiting scholar at the Forestry and Forest Products Research Institute, Hokkaido. Later he became a financial advisor at Merrill Lynch and a public-health statistician at the University of Washington's School of Dentistry. He now analyzes public-health data as a programmer at the Center for Health Studies, Group Health Cooperative, Seattle.
Two accounts of the 1700 tsunami were first published in Musha Kinkichi’s second volume of collected materials on Japanese historical earthquakes. The accounts, boxed above, are quoted on page 62. The volume is listed in the references by its corporate author, Mombushō Shinsai Yobō Hyōgikai.

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T


TEXTBOOK on page 113, “Shōgaku kokugo tokuhon” [“Elementary Japanese-language textbook”], was published by Japan’s education ministry, Mombushō, as the fifth volume of a 12-volume set for primary grades. The copy is a reprint from 1971 in the collection of a grade school in Hirogawa, Hiro Shōgakkō. Courtesy of Ikuta Shunji, principal.

VIDEO FRAMES from “Inamura no hi” [“The rice-sheaf fire”], courtesy of Gakken Co., Tokyo.

When the tsunami comes ashore, every villager is standing safely on high ground.


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Accounts of the 1700 tsunami form part of the 21-volume, 16,812-page earthquake anthology, “Shinsḥ Nihon jishin shiryō” (p. 62). Two of the volumes are cited at the top of the facing page, under Tokyo Daigaku Jishin Kenkyūsho.

First volume, shelved at upper right, was published in 1981.

Fingered volume, published in 1993, contains accounts of the orphan tsunami of 1700.
Index 索引

Aberdeen, town beside Grays Harbor, Washington:
- tsunami-evacuation map, 102n
- tsunami hazards, 102-103
Abiki あびき, term for “unusual seas” in Tanabe account of 1700 tsunami, 40, 86
Ainu, native people of Ezo (Hokkaido), 61n
Akamae 赤前, village near Tsugaruishi;
- tsunami inundation, 51, 56-57
- sand sheet from 1960 tsunami, 18n
Alaska earthquake of 1964:
- damage by shaking, 9
- enormity, 9, 98

m, on map only; n, in footnote only
Italicized entries are Japanese terms other than place names

ground records of subsidence, 14-15
liquefaction features, 22n
predecessors, 95
rupture area, 9m
Alaska tsunami of 1964:
- deaths in Oregon and California, 11
- height in Japan, 94-95
- sand in British Columbia, 18n
Archaeological sites, in coastal Washington and Oregon, abandoned around 1700, 20-21
Astoria, Oregon, town near mouth of Columbia River; tide-gauge record of 1854 Tokai tsunami, 91
Atonoura となくなり, village near Tanabe; fields flooded by 1700 tsunami, 85-86, 90
Ayukawa 鮎川, town on southern Sanriku coast; subsidence recorded by tide gauge, 65

m, on map only; n, in footnote only
Italicized entries are Japanese terms other than place names
A

Alaska earthquake of 1964: village near Tsugaruishi; Akamae 赤前, term for "unusual seas" in Tanabe account of 1700

Ainu, native people of Ezo (Hokkaido): Washington town beside Grays Harbor, A

Albright, Edward S. (1882-1960), paleontologist, 11

Amagasaki, Osaka, port on the Inland Sea, 37

Amakusa Seichū (1557-1624), daimyo of Oki Province, 6

Amakusa Shingen (1358-1421), daimyo of Oki Province, 6

American tide-gauge records of Japanese tsunamis of December 1854, 9

Archaeological sites, in coastal Washington and Oregon, abandoned

Asahimaru, village near Tanabe; fields flooded by 1700 跡ノ浦

Astoria, Oregon, town near mouth of Columbia River; tide-gauge

Auburn, Washington, geologic evidence of 1700 tsunami, 18

B

Bache, Alexander Dallas (1806-1867), superintendent, U.S. Coast Survey; report on American tide-gauge records of Japanese tsunamis of December 1854, 91

Bakufu (“tent government”), national military government headed by a shogun; the shogunate:

Fiscal burden to daimyo domains, 61

Shogunal headquarters in Kamakura, Kyoto, and Edo, 63

Balch, Billy, Makah leader (Makah name, Yelakub); told flood tradition, 12-13

Bandon, Oregon, tsunami-evacuation map, 102n

Bay Center, village beside Willapa Bay, Washington; tsunami-evacuation map, 102n

Bellevue, city east of Seattle, Washington; tall buildings and shaking hazards, 104-105

Biak, Indonesia; source region of 1996 tsunami in Japan, 54m, 94

Bookworms, trails in old documents, 32m, 87

Boston, Massachusetts, population in 1700, 5n

British Columbia:

1700 tsunami, geologic evidence, 18m

Clayoquot and Nootka mentioned in Native American flood tradition, 12-13

radiocarbon dating of earthquakes, 101

sand deposited by 1964 Alaska tsunami, 18n

subsidence during earthquakes, geologic evidence, 16m

tall buildings and shaking hazards, 104-105

Brookings, Oregon, tsunami-evacuation map, 102n

C

Calendars, 42 (see also Eras, Zodiac)

California:

1700 tsunami, geologic evidence, 18m
Chile tsunami of 1960, Cape Flattery, near Neah Bay, Washington; in Native American flood tradition, 12-13

Chüemon, Miho headman in 1698; may have written the account of Chile earthquake of 1700: Turbidity currents Cascadia channel, see Turbidity currents

Cascadia earthquake of 1700: estimated size, 48, 98-99 exact date inferred from tsunami accounts in Japan, 43 implications for tsunami and shaking hazards, 102-105 inferred from North American geologic evidence, 16-25 radiocarbon ages, 24-25 tree-ring dates, 96-97 Cascadia subduction zone: boundary between tectonic plates, 8, 99, 104 multiple earthquake sources at, 8, 104 probable source of an orphan tsunami in Japan, 93-97 Charleston, town near Coos Bay, Oregon; tsunami-evacuation map, 102n Chehalis River, Washington; tsunami hazard from piled logs, 103 Chikamatsu Monzaemon (1653-1725), playwright, 63 Chile, as source region for 1730, 1751, 1837, 1868, 1877, 1922, and 1960 tsunamis in Japan, 54 Chile earthquake of 1960: accompanied by lowering of coastal land, 13 damage from shaking, 9 enormity, 98 rupture area, 9m Chile tsunami of 1960, in Japan: comparisons with 1700 tsunami, 48-49, 56-57, 64-65, 73, 81-83, 88-90, 94 duration, 19, 46, 49, 73 evacuation, 46 flooding and damage, in photographs, 49, 51, 55, 57, 80, 81, 85, 89, 133 forerunner waves, 46 heights mapped regionally, 55 tide-gauge records, 19, 46, 49, 73 tide levels during, 83 Chile tsunami of 1960, outside Japan: damage in Queule, Chile, 10-11 tide-gauge record in Crescent City, California, 49 Châémon, Miho headman in 1698; may have written the account of the 1700 tsunami later included in “Miho-mura yōjī oboe,” 77 Clallam Bay, Washington town on Strait of Juan de Fuca; tsunami-evacuation map, 102n Clayoquot Sound, British Columbia; in Native American flood tradition, 12-13

Columbia River estuary, Washington and Oregon: ocean waves raised by ebb currents, 73n shaking by 1700 earthquake, evidence, 22-23 Sitka spruce that survived 1700 earthquake, 96-97 Coos Bay, Oregon, tsunami-evacuation map, 102n Copalis River estuary, Washington: radiocarbon ages, 25 red-cedar ghost forest, 16, 96m submerged archaeological site, 20m tsunami-inundation map of nearby town of Copalis, 102n Coquille River estuary, near Bandon, Oregon; radiocarbon ages, 25 Cosmopolis, Washington, town beside tidal Chehalis River, Grays Harbor: log yard in mapped tsunami inundation zone, 103 tsunami-evacuation map, 102n Crescent City, California; tide-gauge records of tsunamis from Japan, Kamchatka, and Chile, 49

Daimyo, baron of lands expected to produce at least 10,000 koku (1,800,000 liters) of rice annually (大名 daimyō, “great name”):

Date Masamune of Sendai-han, 41 Nambu Nobuao and Nambu Yukinobu of Morioka-han, 45 named on 1694 tourist map, 29 sankin kōtai, periodic attendance upon the shogun, 29, 61 Sōma clan in Nakamura-han, 69n weather recorded at Edo mansions, 72

Date Masamune (1567-1636), daimyo of Sendai-han, 41

Deep-sea channels, earthquake evidence within, 22

Del’Isle, Guillaume (1675-1726), French cartographer; map of western hemisphere, frontispiece, 2

Denbei, headman of Shinjō village; likely role in reporting 1700 tsunami, 85

Depoe Bay, Oregon, tsunami-evacuation map, 102n


Earthquakes:

energy release on linear scale, 98 great (magnitude 8 or larger), since 1900, 98 magnitudes compared with distant tsunami height, 49, 98 recurrence, in Alaska, 95; at Cascadia, 100-101 variability in size at subduction zones, 24-25, 101

Earthquakes in Japan (and era)*:

1611 (Keichō) Sanriku, tsunami from, 41 1703 (Genroku) Kanto, 77

* MAJOR JAPANESE EARTHQUAKES are known in Japan by their era name and region; the 1611 event, for instance, is the Keichō Sanriku earthquake. The 1854 events, though traditionally assigned to the Ansei era, predated the start of that era by three weeks.
Cascadia subduction zone:

126

Cascadia earthquake of 1700:

Cascadia channel, see

105n

1946 (Shōwa) Nankai, 77, 85, 91, 99, 101

chronicled in Morioka-han “Zasshō,” 45
tallied from accounts in old documents, 62-63

Edo 江戸 (now Tokyo 東京), shogunal capital 1603-1867:
daimyo mansions, 61
earthquakes abundantly recorded, 63
inland waterways, 67
weather in January 1700, 72

Edo period, 1603-1867; defined, 37

Elephant, described by Miho headman, 77n

Endō, Kunio, possessor of “Miho-mura ōyō oboe,” 76

Era, named period of years in Japanese calendar:
plotted on timeline, 42

see also examples under Earthquakes in Japan, Genroku, and

Tsunamis in Japan

Espeu, Yurok settlement on northern California coast; source of story
about coastal submergence, 20

Ezo 銀煕 (now Hokkaido 北海道), mostly outside Japanese control in
era of 1700 tsunami, 30, 61m, n

F

Famines of 1695 and 1699 in Morioka-han, 61

G

Gearhart, Oregon, tsunami-escape routes, 102
“Genji monogatari” (“The tale of Genji”), early novel, 63
Genroku 元禄, era (1688-1704):
apex of Edo-period literature and scholarship, 63
on historical timeline, 42

Girdwood, Alaska, town near Anchorage; stratigraphic records of
repeated great earthquakes, 95

Gold Beach, Oregon, tsunami-evacuation map, 102n

Gorōemon, Miho headman in 1698; may have written the account of
the 1700 tsunami later included in “Miho-mura ōyō oboe,”
77

Grays Harbor, Washington:
charted in 1790s, 12
dating of tree death, 96m
shaking in 1700, geologic evidence, 22
subsidence at, geologic evidence, 16m, 22, 100

tsunami hazards, 102-103

Great earthquakes, shocks of magnitude 8 or larger; since 1900, 98

Gun 干支, a county-like division of a Japanese province:

Minami Hei gun of Mutsu province, in account of 1700 tsunami,
60n
tallied on 1694 tourist map, 29, 31

H

Hachinohe 八戸, coastal city north of Kuwagasaki:
modern subsidence, recorded by tide gauge, 65
snowstorm, used to identify copyist’s error, 52, 53

Haiku, Japanese poem of 17 syllables, 63

Hamaguchi Gohei, fictional headman, 47, 113, 115, 117, 119, 121

Hamaguchi Goryō (1820-1885), leader of Hiro village and later of

Wakayama prefecture; model for Hamaguchi Gohei, 47

Han 阪, daimyo domain; lands officially expected to produce,
annually, no less than 10,000 koku (1,800,000 liters) of rice
or its equivalent in other crops:
examples of putative yield, 71
financial troubles, 53, 61

see also domains named on maps, 41, 67, 72

Hearn, Lafcadio (1850-1904), author nostalgic about Japanese
traditions; brought tsunami into the English language, 47

Hepburn, James Curtis (1815-1911), missionary and linguist;
devised system for writing Japanese sounds in Roman
letters, v footnote

High ground as refuge from a tsunami, 46-47, 102

Hilo, Hawaii, 1837 Chile tsunami, 54

Hiro village 広村 (now Higawa town 広川町), near Tanabe; role in
first use of tsunami in English, 47

Hokusai, see Katsushika

Honshu 本州, largest Japanese island; size relative to estimated
rupture area of 1700 Cascadia earthquake, 98

Hoquiam, town beside Grays Harbor, Washington:
tsunami-evacuation sign, 102; evacuation map, 102n
tsunami hazards, 103

Horidobashi 堅土橋, 1700 tsunami limit in Tanabe, 86

Hyō (byō or ppyō if sound changes in a compound word), unit of
volume commonly 0.4 koku, or 72 liters; rice bale, 71

I

Idaho, hazard from seismic shaking in; small contribution by great
Cascadia earthquakes, 105

Ihara Saikaku (1642-1693), writer of short stories and poems, 63

Ilwaco, Washington town near Columbia River mouth; tsunami-
evacuation map, 102n

Imaizumi 今泉, district headquarters for Edo-period Ōfunato, 81
“Imamura no hi” (“The rice-sheaf fire”), 47, 113

Inarino-shita 稲荷の下 (“below Inari shrine”), 1700 tsunami limit in

Tsugaruishi, 50, 52, 56-57

Indian Ocean tsunami of 2004:
earthquake as natural warning, 4
precedent for, 5n
tide-like waves, 80

Ishikawa Tomonobu (c. 1660-c. 1721), poet, illustrator, mapmaker:
career, 29
tavel map of Japan, 29-31
world map, 28, 29

Isohama 萩浜 (now Oōrai 大洗), shipwreck site near Nakaminato, 67

Date
Masamune, daimyo of Sendai-han, is associated with
the earliest known writing of 津波
(p. 41).

Courtesy of
Sendai Museum

Index

127
Jomon, ancient people of Japan; shell mounds, ideogram, typically of Chinese origin, in Japanese script, 38 Kanji, 44
Juan de Fuca Plate, slab of Earth’s crust and mantle: coastal town near Ōtsuchi; subsidence recorded by 日本海溝
Kamakura 錦倉, earliest shogunal capital, 1185-1333; source of earthquake records, 63
Kambe’e, captain of rice boat wrecked off Nakaminato, 70 Kamchatka, Russia, 1952 tsunami of: heights in Japan, 37, 51, 54, 59, 94, 95
Kamaishi 石巻, coastal town near Ōtsuchi; subsidence recorded by tide gauge, 64-65
Kamakura 錦倉, earliest shogunal capital, 1185-1333; source of earthquake records, 63
Kambe’e, captain of rice boat wrecked off Nakaminato, 70
Kamchatka, Russia, 1952 tsunami of: heights in Japan, 37, 51, 54, 59, 94, 95

Land-level change:
cycles at subduction zones, 10, 91, 100
modern trends in Japan, 65
spatial patterns during plate-boundary earthquakes at subduction zones, 10, 11, 14, 99
Lincoln City, Oregon, tsunami-evacuation map, 102n
Liquefaction, loss of shear strength, typically in shaken sand; geologic evidence, 22-23
Long Beach, town on sand spit west of Willapa Bay, Washington; tsunami-evacuation map, 102n
Long Island, in Willapa Bay, Washington; source of tree rings used like bar codes to date earthquake-induced death of western red cedar, 96m, 97

Makah, native people of Neah Bay, Washington (early photo, opposite); oral history likely inspired by 1700 tsunami, 12-13
“Mandaiki” (“Diary of ten thousand generations”), family record of Tanabe’s Todokoro family 1471-1839, 84
Manzanita, Oregon, tsunami-evacuation map, 102n
Maps, historical:
Edo, 61, 106
mandated by Tokugawa shogunate, 32n, 77n
North America ca. 1720, frontispiece, 2
ōezu, large picture maps, 26, 32, 36, 44, 50, 56, 58, 66, 76
tourist, of Japan, 1694 edition, 29-31
world, published in 1708, 28-29

Matsuo Bashō (1644-1694), haiku poet, 63
Mera 目良, village near Tanabe; crops damaged by 1700 tsunami, 85, 86n, 90
Mexico City, 1985 earthquake, 8-9
Miho 三保, village now part of Shimizu city 清水市:
1700 tsunami, 76-79, 82
1703 tsunami, 77
Edo-period picture maps, 26, 31, 76
flooded by storms in 1699 and 1974, 83
height estimates for 1700 tsunami, 82
lack of precursory earthquake, 54, 77-79
uplifted during 1854 earthquake, 82m

“Miho-mura yōji oboe,” collection of 71 writings by Miho headmen, most dated 1694-1730:
alludes to 1700 tsunami as “rabbit-year waves,” 77
main entry on 1700 tsunami, 34, 78-79
mentions lack of precursory earthquake, 54
other entries, 77n
preserved by Endō family, 76n
quoted briefly, 26, 40, 46, 54, 80, 82, 105
use of kana, 78n
Mikono-hama 神子の浜, village near Tanabe; crops damaged by 1700 tsunami, 85, 90
Mito-han 水戸藩, daimyo domain of a branch of the Tokugawa clan; role in certifying a shipwreck in 1700, 70

Neah Bay, Washington:
南海トラフ

Nambu, hereditary ruling family of Morioka-han: Nakanosaka domain, 1644-1840: castle town of Morioka-han, now capital of Iwate

Nakamura-han 鍋島藩

Nakahama 金浜, village near Tsugaruishi, 56:
deposits of 1960 Chile tsunami, 19

Kanji, ideogram, typically of Chinese origin, in Japanese script, 38; period of origin, 100

Karō, senior minister in daimyo governments:
named in daily headnotes of Morioka-han “Zassho,” 44, 60
represented by deputies in shipwreck investigation near Nakaminato, 70
source of weather reports, 72

Katsushika Hokusai (1760-1849), woodblock artist:
great wave misused as tsunami icon, 80
“Men baling rice,” 66

Koku, unit of volume equivalent to 180 liters:
measured expected yield, 61n, 77n, 71
measured samurai stipends, 53n, 58n, 71

Kubota Crossing 長保田渡り, tsunami limit near Tsugaruishi, 50, 56-57

Kura, storehouse:
entered by 1700 and 1707 tsunami in Shinjō, 88-89
entered by 1707 tsunami in Tanabe, 89
protected Morioka-han “Zassho” in Morioka, 44n
protected Ōuchi-ke “Go-yōdome” in Nakaminato?, 131

Kuwagasaki 錦ヶ崎, port now part of Miyako city 宮古市, 36:
flooded by 1700 tsunami, 36-39, 46, 48
flooded by 1960 Chile tsunami, 37, 46, 49
height estimates for 1700 tsunami, 48-49
other tsunamis, 36

Kyoto 京都, imperial capital 794-1867, shogunal capital 1333-1573:
sources of earthquake records, 63
weather, during 1700 tsunami, 72

Kyushu 九州, southernmost of Japan’s four main islands; 1699 typhoon, 83

Mexico City, 1985 earthquake, 8-9

Miho, village in Shizuoka Prefecture, 85, 90

Morioka, village in Iwate Prefecture, 85, 90

Morioka-han 真宗家

Moriai-ke "Nikki kakitome chō," diary notebook of Moriai family

Morioka domain, 1644-1840: castle town of Morioka-han, now capital of Iwate

Moriai-ke "Nikki kakitome chō," diary notebook of Moriai family

Morioka domain, 1644-1840:

Moriai-ke "Nikki kakitome chō," diary notebook of Moriai family

Moriai-ke "Nikki kakitome chō," diary notebook of Moriai family

Moriai-ke "Nikki kakitome chō," diary notebook of Moriai family
Miyako 宮古, now a city that contains Kuwagasaki and Tsurugiushi: as headquarters of a district of Morioka-han, 36, 44
names of district officials who reported the 1700 tsunami, 38
weather station’s log of 1960 Chile tsunami, 46
Miyako Bay; amplified the 1960 tsunami, 55
Moriai, merchant family in Tsugaru: commercial rise in 18th century, 53
Mitsunori, headed family in 2004, 53
Mitsutatsu, headed family 1690-1730, 53
Moriai-ke “Nikki kagitome chō,” diary notebook of Moriai family 1696-1703, 50:
entry on orphan tsunami, 35, 50, 52
mentions lack of precursory earthquake, frontispiece, 54
probable error from copying, 53
quoted briefly, frontispiece, 40, 53, 54, 56
Morioka 盛岡, castle town of Morioka-han, now capital of Iwate: administrative center and its documents, 44-45, 60-61
earthquakes recorded, 44
senior ministers (kari) in 1700, 44n, 60
weather, during 1700 tsunami, 72
Morioka-han 盛岡藩, Edo-period domain of Nambu family:
record-keeping, 38, 60, 81
financial troubles, 53, 61
Morioka-han “Zassho,” miscellaneous administrative records of Morioka domain, 1644-1840:
bookworm trails, 67
compilation, 44
entries on 1700 tsunami, 35, 36, 38-39, 60
quoted briefly, 40, 42, 43, 44, 46, 48, 64
volumes shelved in community center, 44
Mount Fuji 富士山, volcano:
depicted on Edo-period maps, 26, 31, 32, 76
in woodblock print of wave misused as tsunami icon, 80
Murakami-han 村上藩, daimyo domain ruled by clan that recorded Edo weather in January 1700, 72
Musha Kinkichi (1891-1962), educator, geographer, and earthquake historian; anthology of historical earthquakes, 62, 112

N
Nagoya 名古屋, castle town in southwest Honshu; weather recorded in 1700 by samurai in charge of floor mats, 72
Nakaminato 那珂湊, now part of Hitachinaka city:
estimated duration of 1700 tsunami, 72-73
port for goods headed to Edo, 66-67
Nakamura-han 中村藩, feudal domain in central Honshu; source of rice boat bound for Nakaminato in January 1700, 67, 70
Nambu, hereditary ruling family of Morioka-han:
Edo mansions, 61
family crest, 45, 61
Nobunao, domain founder under Hideyoshi, 45
Yukinobu, peacetime daimyo in 1700, 45
Nankai trough 南海トラフ, deep-sea trench at seaward edge of subduction zone off southwest Honshu, 65, 77, 85, 91, 94
Nara 奈良, Japan’s capital A.D. 710-794, 63; weather, during 1700 tsunami, 72
Naselle River, arm of Willapa Bay, Washington:
radiocarbon ages of herbaceous plants, 25
spruce stump in bank, 17
Neah Bay, Washington:
likely oral history of the 1700 tsunami, 12-13

Makah Indians sit for a portrait by J.G. Swan, probably in the 1860s. In 1864, another Makah told Swan a sea-flood legend the 1700 tsunami may have inspired (p. 12-13).
North Cove, north shore of Willapa Bay, Washington; tsunami-evacuation map, 102n
Nuclear power plants at Cascadia subduction zone, 109

Ocean City, town between Grays Harbor and Copalis River, Washington; tsunami-evacuation map, 102n
Ocean Park, town on sand spit west of Willapa Bay, Washington; tsunami-evacuation map, 102n
Ocean Shores, city beside Grays Harbor, Washington; tsunami-evacuation map, 102n
tsunami hazard, 103m
Oceanside, Oregon, tsunami-evacuation map, 102n
Ofunato 大船渡, town on southern Sanriku coast: devastated by 1960 Chile tsunami, 54, 81, 133 subsidence, recorded by tide gauge, 65

Oregon:
earthquake-induced subsidence, 16m, 20
legislation on public facilities in tsunami-hazard zones, 102n
radiocarbon dating of earthquakes, 25m, 101
shaking evidence, 22m
shaking hazards, 105m
tree-ring dating of earthquakes, 96m
tsunami-evacuation maps, 102n
tsunami-inundation maps, 103m

Orphan tsunamis, wave trains of unknown origin, 3:
later matched with earthquakes in the Americas, 54, 94
still of unknown source, 54

Oshika 東北半島, peninsula at south end of Sanriku coast; flooded by 1730 Chile tsunami, 54m

Ōtsuchi 大槌, town on Sanriku coast: district headquarters in Edo period, 44, 58-60, 81
entered by 1700 tsunami, 58-60
estimated height of 1700 tsunami, 64
Musha’s summary of magistrates’ account of 1700 tsunami, 62
other tsunamis, 59, 65
“Ōtsuchi kokon daidenki,” summary of magistrates’ records 1596-1796; account of 1700 tsunami, 59
Ōuchi-ke “Go-yōdome,” Ōuchi-family collection of business records on 131 shipwrecks, 1670-1832:
compilation, 66n
total volume, 66
entry that mentions waves likely caused by tsunami, 35, 68-69
petition and certificate for shipwreck in 1700, 70
quoted briefly, 40, 71, 73
storehouse where collection may have been conserved, 131

Oysterville, Washington, town beside Willapa Bay; exhumed spruce stumps, 6

P
Pacific Beach, town north of Copalis River, Washington; tsunami-evacuation map, 102n
Pacific Plate, large slab of Earth’s crust and mantle: generated at spreading ridge, 8m
subducting beneath Japan, 65
Paper, Japanese (washi), in old documents, 87
Penticton, inland city in British Columbia; endpoint of baseline for measuring overall contraction and periodic extension of the North America Plate, 99

Peru:
B eru in kana on Japanese map from 1708, 28-29
source region of tsunamis in Japan in 1586 and 1687, 54

Philippine Sea Plate, slab of Earth’s crust and mantle; subducting beneath Japan, 65, 77

Plate tectonics, unifying theory for movement of Earth’s crust and mantle, 8:
at Cascadia, 8, 98-99, 104
in Alaska, 9, 14
in Chile, 9, 11
in Japan, 65, 77

Portage, Alaska, hamlet near Anchorage:
classic modern example of tidal submergence from earthquake-induced subsidence, 14-15
genealogic evidence for shaking, 22n

Port Angeles, Washington city midway along Strait of Juan de Fuca; tsunami-evacuation map, 102n
Port Orford, Oregon, tsunami-evacuation map, 102n
Port Townsend, Washington city at east end of Strait of Juan de Fuca; tsunami-evacuation map, 102n

Port Angeles, Washington city midway along Strait of Juan de Fuca; tsunami-evacuation map,

Port Angeles, Washington
tsunami-evacuation map,

Potlatch, zodiac sign; orphan tsunami during Rabbit Year,

Quileute (Quilleyute, Quillehuyte), Washington:

R
Raymond, city at east end of Willapa Bay, Washington; tsunami-evacuation map, 24-25, 100-101

Rabbit, zodiac sign; orphan tsunami during Rabbit Year,

Raymond, city at east end of Willapa Bay, Washington; tsunami-evacuation map, 24-25, 100-101

Ra’s, 3.93 kilometers, 28m, 30m, 33m, 61n

Rice:
as measure of expected yield of daimyo domains, 61, 71
as stipend to samurai, 53n, 58n, 71
bales, 71
issued to 159 persons after 1700 tsunami, 38
lost in nautical accident started by 1700 tsunami, 71
sheaves burned during fictional harvest-time tsunami, 47, 119, 121
straw burned during December 24, 1854 tsunami, 47

Richmond, suburb of Vancouver, British Columbia; tall buildings and shaking hazards, 104-105

Rikuzen 陸前, area on southern Sanriku coast; flooded by 1730 Chile tsunami, 54

Rockaway Beach, Oregon, tsunami-evacuation map, 102n

Ryō, monetary unit about equal in value to 1 koku of rice:
in estimated cost of attending on the shogun, 61n
in holdings of merchant family, 53
in sales of samurai status, 53

Ryūkū Islands 琉球列島, record of 1687 Peru tsunami, 54

THE ORPHAN TSUNAMI OF 1700
Penticton, inland city in British Columbia; endpoint of baseline for 87
Pacific Plate, large slab of Earth’s crust and mantle:

Pacific Beach, town north of Copalis River, Washington; tsunami-

Öuchi-family compound of business records

summary of magistrates’ records 1596-\n
大槌

Oshika

3

Orphan tsunamis, wave trains of unknown origin,

102n
Oregon:

鶴取

Öfunato

大船渡

Ocean City, town between Grays Harbor and Copalis River,

109
North Cove, north shore of Willapa Bay, Washington; tsunami-

130
65
storehouse where collection may have been conserved,

66
entire volume,

64
estimated height of 1700 tsunami,

65
entered by 1700 tsunami,

58n

tsunami story as public art,

67
uncertainty in locating this storehouse,

85, 88-89
computed tide stages for 1700 and 1960 tsunamis,

83
subidence recorded by tide gauge, 65

tide-gauge record of 1960 Chile tsunami, 73

Shimotsu 下津, town near Tanabe; computed tide stages for 1700 and

1960 tsunamis, 83

Shinjō 新庄, village near Tanabe, now part of Tanabe city 田辺市:

storehouse entered by 1700 tsunami, 85, 88-89

uncertainty in locating this storehouse, 89

Shioama 塩釜, port near Sendai; flooding by 1837 Chile tsunami,

54

Shipwrecks near Edo-period Nakaminato:

certification, 70

recorded in family documents, 67

Shirahama 白浜, town near Tanabe:

computed tide stages during 1700 and 1960 tsunamis, 83

uplift recorded by tide gauge, 65, 91n

Shoolwater Bay (now Willapa Bay), Washington; red-cedar ghost

forests noted 1853-1854, 16n

Shogun (shōgun), head of military government (shogunate, or

bakufu) in pre-modern and early modern Japan:

chronology of residence in Kamakura, Kyoto, and Edo, 63

see also Tokugawa Ieyasu, Tokugawa Tsunayoshi

Sitka spruce (Picea stichensis), North American conifer:

killed after Cascadia earthquakes, 6, 16-17

killed by tidal submergence after 1964 Alaska earthquake, 14-15

radiocarbon dating of death at Cascadia, 24-25

survived tidal submergence at transitions to floodplains after

1700 Cascadia earthquake, 96-97

South Bend, city near east end of Willapa Bay, Washington; tsunami-
evacuation map, 102n

South Fork Palix River, arm of Willapa Bay, Washington; red cedar
killed by submergence after 1700 earthquake, 98m, 97

South Fork Willapa River, arm of Willapa Bay, Washington;
bordered by a few Sitka spruce that survived tidal
submergence after 1700 earthquake, 96-97

Spokane, Washington, tall buildings and shaking hazards, 104-105

Strait of Juan de Fuca, British Columbia and Washington; 12m

Subduction zone, where one tectonic plate dives beneath another, 8:

as distant sources of tsunamis that reach Japan, 54

cartoons, 41, 65, 77, 99, 104

zones on the Pacific Rim, 54m, 94

Submergence, rise in sea relative to land, or lowering of land relative
to sea; geologic records, 16-17

Subsidence, lowering of land or seafloor; examples from subduction
earthquakes:

at Cascadia, 16-17, 99m, 100

complemented by uplift between earthquakes, 91, 100

during 1960 Chile earthquake, 13

during 1964 Alaska earthquake, 14

Sumpu 諏訪, (now Shizuoka 現同), castle site near Miho:
castle depicted on map from 1687, 26, 41, 76
diary, “Sumpuki,” and earliest known use of 津波, 41

Surrey, suburb of Vancouver, British Columbia, tall buildings and
shaking hazards, 104-105

Swan, James G. (1818-1900), writer, teacher, ethnologist:
diary, 12-13

photograph by, 129

T

Tacoma, Washington, tall buildings and shaking hazards, 104-105

Tanabe 田辺, castle town for part of Wakayama-han:
devastation during 1707 earthquake and tsunami, 89n

estimated height of 1700 tsunami, 90

merchants in 1725, 85

moat, ascended by 1700 tsunami, 84-86, 90

Tanabe-family documents, 84

“Tanabe-machi daichō,” municipal records of Tanabe, 1585-1866:

entry on 1700 tsunami, 34, 86

quoted briefly, 40, 87, 88, 90

volumes stored temporarily in Tanabe library, 84

water damage, 87

Taxes:

Collected at port of Kuwagasaki, 36n

Divided among recipients near Otsuchi, 58n

Levied on samurai of Morioka-han, 61n

Tide-gauge measurements:

land-level changes in Japan, 65

tsunamis in Crescent City, California, 49

tsunamis in Japan, 46, 73, 94-95

Storehouse Residence

 Courtesy of Hitachinaka City

Index
Time, conversions from traditional to modern, 42-43, 73
Tokai gap, section of tectonic plate boundary near Miho; earthquake potential, 77
Tokaidō (Eastern Sea Road), historic highway connecting Kyoto and Edo, 29-31, 76
Tokugawa Ieyasu (1543-1616), last of three unifiers of early modern Japan and founding shogun of the Edo period: at Sumpu castle, learns of “so-called tsunami,” 41
shrine at Nikkō, weather in January 1700, 72
Tokugawa Tsunayoshi (1646-1709), fifth Tokugawa shogun;
Tree rings, used in identifying and dating great Cascadia earthquakes:
matched patterns of ring width, 96-97
months of growth, 96
narrowed by tidal submergence, 96-97
radiocarbon ages, 24-25
widths consistent with tree death from sudden submergence, 17
Tsurugushi 津軽石, village now part of Miyako city:
limits of 1960 tsunami, 56
Moriai-family merchants, 53
notable tsunamis, 51
Tsugaruishi 津軽石, train of water waves driven by gravity, commonly triggered by sea-floor displacement from fault slip during an undersea earthquake, 10, 41, 91:
directivity, 49, 54n, 54m, 99m
enters English language, 47
first known Japanese usage, 41
height, compared with earthquake size, 49
Hokusai’s wave as inappropriate tsunami icon, 80
natural warnings, 4, 47, 80n
other Japanese terms for 1700 tsunami, 40
roadside signs at Cascadia, 46, 102
test times across the Pacific Ocean, 43, 91
Tsunami of 1700 in Japan:
arrival times, 43, 72-73
comparing with 1960 Chile tsunami in Japan:
48-49, 56-57, 64-65, 73, 81-83, 88-90, 94
comparing with other tsunami in Japan, 37, 51, 59, 77, 85
computer simulation, cover, 37, 74-75, 99
Tsushima-han 東海道, island domain near Korea; Edo diary, as source of weather reports from 1700, 72
Tsunamis in Japan, of remote origin, 54:
1751 Chile, large in Ōtsuchi, 59; noted in Shinjō, 54, 85
1952 Kamchatka, heights in Kwawasaki, Tsurugushi, and Ōtsuchi, 37, 51, 59; elsewhere in Japan, 94-95
compared with 1700 tsunami, 94
earliest known, from 799 and 1420, 54
in Edo period, 54
matched to South American sources by Ninomiya Saburo, 54
see also Alaska tsunami of 1964, Chile tsunami of 1960, Tsunami of 1700 in Japan
Tsurugushi 津軽石
Tsushima-han 東海道
Typhoon of September 1699 in Japan,
1707 (Höei) Nankai,
1703 (Genroku) Kanto, 77
1707 (Höei) Nankai, 77, 85
1793 (Kansei) Sanriku, 59
Tsunami of 1700 in North America:
coincidence with neap tides, 83n
inferred starting time, 43
probable oral histories, 12-13
sand sheets, 18, 20
Tsunamis in Japan*, of nearby origin:
684 (Hakuho) Nankai, 54n
1611 (Keichō) Sanriku, 37, 41, 51, 59
1677 (Empō) Tokachi-oki, 37, 51, 59
1703 (Genroku) Kanto, 77
1707 (Höei) Nankai, 77, 85
1793 (Kansei) Sanriku, 59
1854 (Ansei) Tōkai, on 23 December; 47, 77, 85, 91
1854 (Ansei) Nankai, on 24 December; 47, 85
1856 (Ansei) Tokachi-oki, 59
1896 (Meiji) Sanriku, 37, 41, 47, 51, 59
1933 (Shōwa) Sanriku, 37, 51, 59
1944 (Shōwa) Tōkai, 77, 85
1946 (Shōwa) Nankai, 77, 85; tide-gauge record, in Crescent City, California, 49
1968 (Shōwa) Tokachi-oki, 37, 51, 59
anthology, 62n
time to North America, 43n, 91
Tsunamis in Japan, of remote origin, 54:
1751 Chile, large in Ōtsuchi, 59; noted in Shinjō, 54, 85
1952 Kamchatka, heights in Kwawasaki, Tsurugushi, and Ōtsuchi, 37, 51, 59; elsewhere in Japan, 94-95
compared with 1700 tsunami, 94
earliest known, from 799 and 1420, 54
in Edo period, 54
matched to South American sources by Ninomiya Saburo, 54
see also Alaska tsunami of 1964, Chile tsunami of 1960, Tsunami of 1700 in Japan
Tsurugushi 津軽石
Tsushima-han 東海道
Typhoon of September 1699 in Japan, 83
U
Ura shōmon, port certificate; use in certifying losses from Edo-period shipwrecks, 70
V
Vancouver, British Columbia, and Vancouver, Washington, tall buildings and shaking hazards, 104-105
Victoria, British Columbia, tall buildings and shaking hazards, 104-105
W
Wakayama 和歌山, castle town of Wakayama-han; weather during 1700 tsunami, 72
Washi, traditional Japanese paper, 87

* Like the associated earthquakes (footnote, p. 126), these tsunamis are known by era and region. Complications: Hakuho is obsolete as an era name, and the 1854 tsunami predate the Ansei era but are customarily assigned to it.
Washington State:
earthquake-induced subsidence, 6, 16-18, 20-22
radiocarbon dating of earthquakes, 24-25, 101
shaking hazards, 104-105
strength of shaking, 22-23
tree-ring dating of earthquakes, 96-97
tsunami deposits, 18
tsunami-evacuation maps, 102n
tsunami-inundation maps, 103n
Western red cedar (*Thuja plicata*), North American conifer:
death dated to 1699-1700, 92, 96-97
ghost forests, 16
Westport, town beside Grays Harbor, Washington:
tsunami-evacuation map, 102n

Willapa Bay, Washington (formerly Shoalwater Bay): geologic evidence for earthquakes,
6, 16n, 17, 18, 20-21, 24-25, 92, 96-97
red-cedar ghost forests, described in 1853-1854, 16n
*see also* Naselle River, Niawiakum River, South Fork Willapa River

**Z**
Zodiac, Chinese; uses in Edo-period Japan:
compass directions, 43
hours, 44
sixty-year cycle, 42, 70, 77, 87

*A wave from Chile* in 1960 approaches roofs of Öfunato, Japan (p. 81).
A SIMULATED TSUNAMI modeled on the one in 1700 floods nearly all of the peninsula town of Westport, Washington (p. 103). The area mapped as tsunami-prone includes the grounds of the town’s public schools, which stand on a low sandy plain between the Pacific Ocean and Grays Harbor.

A partial remedy was rising from that plain in 2015, as this book approached reprinting. Two years earlier, voters in Grays Harbor and Pacific Counties had approved a $13.8 million bond issue for school reconstruction. The measure provided for a tsunami haven—a rooftop platform with space for as many as a thousand persons.

The platform design combines resistance to earthquake shaking, safeguards against tsunami scour, and ample height. Reinforced concrete towers support the flat roof at its four corners. Piles are driven fifteen meters into the sand. The platform stands nine meters above ground, well above simulated water levels in an extreme scenario (diagrams, opposite).

This engineered refuge, North America’s first for tsunamis, has roots across the Pacific. Its design incorporates lessons from the catastrophic tsunami of March 2011. Its funding came about while memories of that disaster were fresh. Its necessity came to light, in large part, through matching of North American and Japanese clues to the transpacific tsunami of January 1700.

—Prepared by Brian Atwater and David Yamaguchi from information provided by Paula Akerlund, superintendent, Ocosta School District; Cale Ash, associate principal with Degenkolb Engineers in Seattle and engineer of record for the Ocosta project described here; Robert Butler, professor, University of Portland, and founder, Cascadia Earthscope Earthquake and Tsunami Education Program (CEETEP); Jon Wood, science and math teacher, Ocosta Secondary Schools; John Schelling, earthquake, tsunami, and volcano programs manager, Emergency Management Division, Washington State Military Department; Beth Pratt-Sitaula, CEETEP program director; and Charles Wallace, deputy director, Grays Harbor County Department of Emergency Management.


THE BOND MEASURE of April 23, 2013, won approval in 70 percent of the 1,518 ballots cast (http://ballotpedia.org/Ocosta_School_District_172_Renovation_Bonds_Measure_%28April_2013%29).

THE SIMULATED TSUNAMI begins with a scenario earthquake selected to resemble or exceed the 1700 event. Fault rupture occurs in a mainly offshore area about 1,000 km long between southern British Columbia and northern California. A hypothetical splay off the master fault raises the ocean floor by as much as ten meters on the continental slope west of Grays Harbor (González, F., LeVeque, R., and Adams, L., 2013, Tsunami hazard assessment of the Ocosta School site in Westport, WA: https://digital.lib.washington.edu/researchworks/handle/1773/24054).

THE ROOFTOP CAPACITY compares with a campus population of 700 and a Westport total of close to 2,000 persons counted in the 2010 census. CONSTRUCTION PHOTO by Sonya Miller, Ocosta School District, July 27, 2015.

ARTIST’S CONCEPTION from TCF Architecture, used by permission.

Most of this mile-wide strip between the Pacific Ocean and Grays Harbor, Washington, has been mapped as tsunami-prone. The circular building on the school grounds was being replaced, in 2015, by a gymnasium specially designed to withstand a giant Cascadia earthquake and to accommodate as many as a thousand persons on its roof during the tsunami that soon follows.
The refuge design was guided by this tsunami simulation, which allows for subsidence during the earthquake (p. 14–17) and for erosion during the tsunami.

The four corner towers rose first (photo, July 2015). The completed tsunami refuge will span the flat roof of a gymnasium, with doors at ground level providing access through the corner towers (artist’s conception).