Tsunami Hazard Evaluation of the Eastern Mediterranean: Historical Analysis and Selected Modeling

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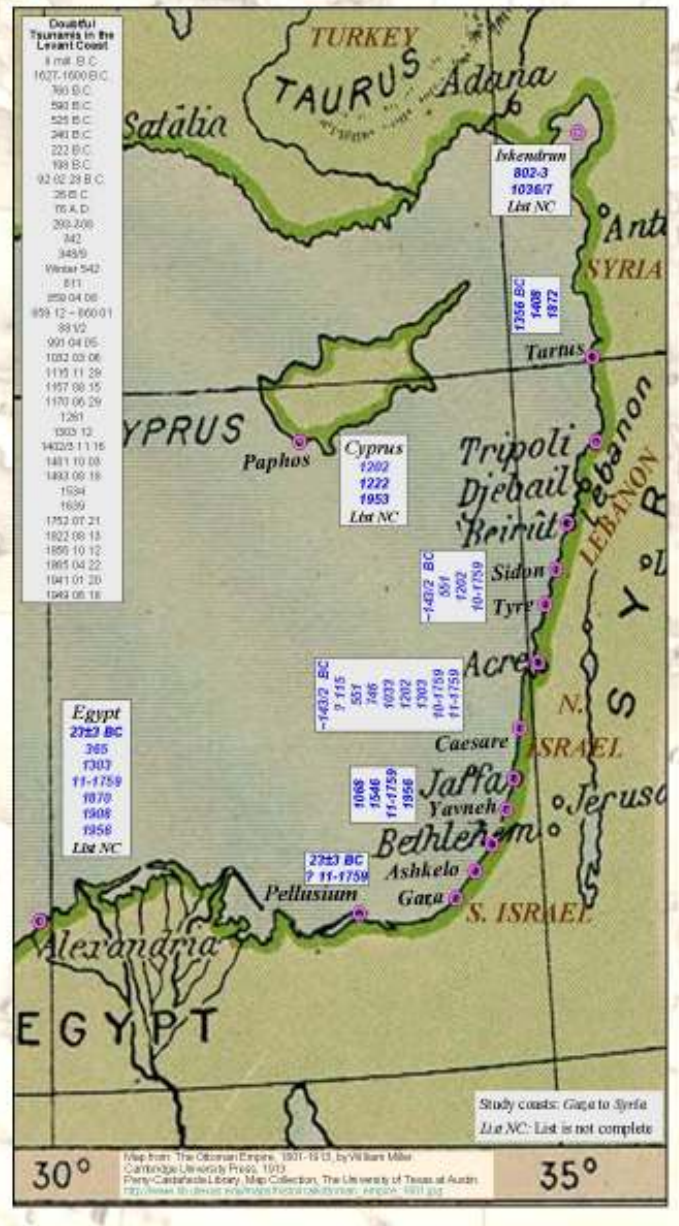
List of Tsunamis and Earthquakes

Earthquake	Tsunami Source: Remote	Tsunami Source: Local (DST > 1500)	Tsunami
760, 730 B.C.		C	Speculated
199 - 198 B.C.		S	-
184 [illegible] B.C.		S	184/24 not B.C. 1145/8 B.C.?
1833 [illegible]		S	-
1000 B.C.		S	-
65 - 62 B.C.		S	-
31 B.C.		C	-
?	CA		2348 B.C.
170 B.C.			?
30 - 33 A.D.		S	-
70	CA		Rhodes wave
115 - 121 A.D.		S	(115 - 121 A.D.)
121 - 138		C	-
359-384		S	-
363 - 365		C	-
551-07-23	EA-W		551-07-23
460		C	-
502-03-18		N?	-
524-01-28-29		S	-
526-11-28		S	-
701-07-08		S	701-07-08
Ca. 700		S	-
816-402		S	-
839-860		C	-
713-03-20 - 715-10		S	-
746-01-18		C	746-01-18
802-03-30 - 803-03-29	CA - EAP		803-03-30 - 803-03-29
847-11-24		S	-
859-12-05 - 860-06-29		S	-
893-9-463		S	-
956-10-29 - 957-10-28		S	-
1000-1-05		C	1001-02-05
1030-03-04 - 1031-10-11	CA - EAP		1030-03-04 - 1031-10-11
1063-07-30 - 10-23		S	-
1068-10-10-20-30		S	-
1068-02-29		S-C	1068-02-29
1139-10-11		S	-
Ca. 1150		C	-
1156-12-09		S	-
1170-04-02		S	-
1170-07-05		S	-
1170-08-12		S	-
1183-08		S	-
1178-06-20-30-40		S	-
1202-05-20-30-40		C-S	1202-05-20
1212-05-14		S	-
1222-05-11-06-12	CA		1222-05-12
1287-02-7 - 02-22		S	-
1293-05-11 - 02-08		S-C	-
1302-05-03-20-30	EA-E		1301-08-08
1408-02-20		S	-
1408-12-29		S	1408-12-29
1409-11-08 - 10		S	-
1481-07-05	EA-E		1481-07-05 (?)
1546-01-14 (Lebanon)		C	1546-01-14
1588-10-04-11-30		S	-
1703-11-28		S	-
1759-09-20		S	-
1759-10-30-30-45		C-S	1759-10-30
1759-11-21-22-23		S	1759-11-22
1796-06-26-30-31		S	-
1822-08-13-20-30		S	-
1834-05-20-08-00		C	-
1837-01-11-12-04		C	-
1837-10-10-06	CA		1837-10-13
1856-07-09-00-12	EA		1856-07-09
1857-11-22-08-47		S	-
1872-12-02			-

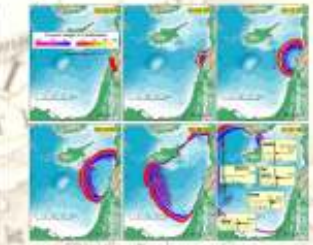
AE - Aegean Sea; CA - Cyprus Arc; EA E - East Hellenic Arc; EA W - West Hellenic Arc; IT - Italy; DST - Dead Sea Transform; N - North; C - Central; S - South

Past Tsunamis Since Mid 2nd Century BC



Map from: The Ottoman Empire, 1801-18 13, by William Miller Cambridge University Press, 1913 Perry-Castañeda Library, Map Collection, The University of Texas at Austin http://www.lib.utexas.edu/maps/historical/ottoman_empire_1801.jpg

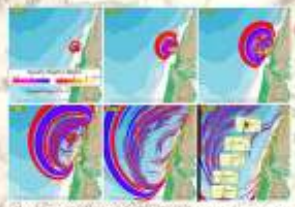
Future Scenarios



Tsunami from the Beirut Thrust Earthquake Scenario. Red colors are areas elevated relative to still water. Blue areas are lowered relative to still water

1 Beirut Thrust

Assumed parameters of the Beirut Thrust Earthquake scenario. Two minute bathymetry from ETOPO2



Tsunami from the Akhziv Canyon Landslide scenario. Numbers in the yellow circles show estimated peak run-up height up to the indicated time of the frame

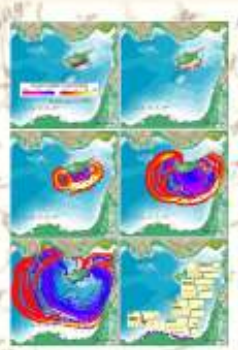
2 Submarine Slump

Assumed parameters of the Akhziv Canyon Landslide scenario. Quarter minute bathymetry from Hall (1991)

Scenario	M_w Mechanism	Time to Haifa Coast	Wave Height	First Phase
1 Beirut Fault	7.4 thrust	30 sec	0.5 m	~
2 Submarine Slump	landslide	10 sec	4-6 m	Up and Sliding down
3 Cypriot Arc	7.8 thrust	30 sec	1.5 m	Up

3 Cypriot Arc

Tsunami from the Cypriot Arc Thrust Scenario. Numbers sample wave heights and depressions in meters



Tsunamigenic Sources

Blue, Adrien Hubert, 1830 - 1832. Monde connu des Hébreux: seconde édition. http://nla.gov.au/nla.map-rm246

Abstract

We constructed a catalogue of tsunamis that occurred since about the middle of the 2nd century B.C. along the eastern Mediterranean coast, along with the significant earthquakes originating from the Dead Sea Transform (DST) system. We identified 22 sea waves that struck the Levant coast, from Alexandria to Iskenderun Bay and Cyprus, with an average frequency of about once in a century. These tsunamis varied in size, from barely noticeable in local ports to greatly damaging along several coasts.

Ten of the tsunamis were triggered by earthquakes that originated in the DST system. We estimate that the threshold of tsunamigenic DST earthquakes is likely to be in the range of M6-6.5. Thus about a seventh (14%) of the moderate and between one-fourth to a third (29%) of the large DST earthquakes were probably tsunamigenic.

Another ten tsunamis were associated with remote and non-DST sources in the eastern Mediterranean, including the Cypriot and the Hellenic Arcs and as far away as Italy. The source of the remaining two tsunamis is as yet unidentified. Most of the DST originated tsunamis are clearly associated with on-land earthquakes, and were associated with a significant retreat of the sea. This suggests that the waves resulted from seismic triggering of offshore submarine landslides.

We recognize three characteristic tsunamigenic mechanisms: convergent arc earthquakes focused in the sea; seismically-induced submarine slumps; and on-land active faults that cross into the sea. We modeled each of these mechanisms and, due to the great concern generated by the Sumatra giant-tsunami, we focused on the worst case scenarios.

Earthquake scenarios produced run-ups ranging from 1 - 3 meters and the landslide scenario produced a run-up of 4 - 6 meters. Tsunami travel time between start and arrival of the waves to northern Israel ranges from several minutes for near offshore landslides to about half an hour for tsunamis originating in the Cypriot Arc.

Historic Tsunamis

551 07 09

In Beirut: "As the sea was rising up against them from behind, the earthquake brought down the city in front of them"
Rashbam et al. (1990) after
Isaac ibn Ephraim

746 01 18, morning

In Palestine: "...the waves rose up to the sky, and, just as a cauldron is made to boil by the flames of fire, so the waves surged with a horrible and terrifying noise. The sea boiled and overflowed..."
Rashbam et al. (1990) after
Michael the Syrian

1033 12 05

In Palestine: "...people could gather fish from the sea bed... found objects of lead and iron and other objects, and the sea return to its original position."
Rashbam and Sumatra (2010) after
Sanjiva ibn al-Muqaffa