The tsunami caused by the 30 October 2020 Samos (Greece), East Aegean Sea, Mw6.9 earthquake: impact assessment from post-event field survey and video records

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Abstract: In this report we present results regarding the impact and the hydrodynamic features of the tsunami that hit Samos and other Eastern Aegean Sea Greek islands soon after the 30 October 2020 earthquake (Mw=6.9). The analysis combines post-event field survey observations, video records examination and an evaluation of interviews with local authority officers and eyewitnesses. The event was a near-field tsunami arriving within 10'-15' at the north coast of Samos and at the eastern side of Ikaria island. From seven far-field tide records we calculated tsunami magnitude Mt=Mw=6.8. In Vathy town (NE Samos) two strong inundations have been clearly recognized with arrival time difference of 20', the second being more powerful as compared to the first. Maximum run-up was measured at h~2.0 m asl in run-in distance d=97 m. In Karlovasi (NW Samos) a strong inundation (h~1.70 m at d=80 m) was reported immediately after an initial sea water retreat in ~10' after the earthquake. In Vathy the water flow velocity inland ranged from 1 m/s to 1.9 m/s while remarkable material damage was caused in various shops and offices. Damage was also noted in cars and small vessels which drifted away by the wave. Less damage was caused in Karlovasi. No casualties were reported. In the south coast of Samos the wave didn’t exceed h~0.6 m. In south Chios island h~1 m was estimated, a few boats crushed on the water break stones. In Evdilos and Ayios Kirikos ports, Ikaria island, h~1.0 m was estimated but no damage caused. Inundation of h~1.0 m has been documented from other islands, e.g. Andros and Patmos. After the seismic tsunami of Samos (2020), Lesvos (2017) and Kos (2017) the tsunami hazard and risk assessment in the Eastern Aegean Sea should be reconsidered. Preliminary field observations indicating co-seismic 10-25 cm uplift of Samos may imply lower impact than that would have happened if no uplift had occurred.

1. Introduction

On 30 October 2020, 11:51:27 UTC, a large shallow earthquake of moment magnitude Mw=6.9 (National Observatory of Athens, NOA) or Mw=7.0 (USGS, GFZ) ruptured the Eastern Aegean Sea area to the north of the island of Samos, Greece (Figure 1). Consistent focal mechanisms produced by several seismological institutes show E-W normal faulting (Figure 1) with fault plane very likely dipping towards north. In Samos the most important earthquake impact included two fatalities, 19 minor injuries and damage in hundreds of houses, churches and port infrastructures. In the area of Izmir (W. Turkey), however, at least 114 people are known to have died due to the collapse of
buildings and more than 1030 were injured. Powerful tsunami inundation was reported from Samos and other Greek islands as well as from several coastal sites of western Turkey. In Greece, the General Secretary for Civil Protection disseminated to residents of the eastern Aegean Sea Greek islands a tsunami warning sms via the European emergency phone number 112. The message was sent at 14:15 local time (12:15 UTC). Remarkable material damage was caused by the tsunami but no fatalities were reported. Other important earthquake associated phenomena, such as co-seismic coastal uplift and several types of ground failures, were also observed in Samos.

Although Samos has long seismic history no tsunami associated with the earthquake activity was reported so far. The only exception is the very strong tsunami generated by the distant large earthquake (Mw=7.7, ISC-GEM) of 9 July 1956 in the South Aegean Sea. That tsunami was reportedly observed in coastal spots of south Samos but also in Vathy, the main town at the NE of the island (e.g. Galanopoulos, 1957).

In this report we study the impact as well as the hydrodynamic features of the 30 October 2020 tsunami in several observation points along the coasts of Samos and of other Greek islands. In addition, we calculate the tsunami magnitude from far-field tide-gauges records.

![Figure 1](image)

**Figure 1.** Coastal sites where tsunami inundation has been documented. Key: A and E are Ayios Kirikos and Evtilos ports, Ikaria; Ka, V and P are Karlovasi, Vathy and Pythagorio, Samos; K=Komi village, Chios; N=Nimporios port, Andros; S=Skala port, Patmos; beachball shows the NOA fault-plane solution of the 30 October 2020 mainshock; solid circle shows the epicenter of the Mw=7.7 (ISC) 9 July 1956 tsunamigenic earthquake.

### 2. Materials and Methods

The Samos 2020 tsunami caused considerable material damage along the coastal zones of Vathy and Karlovasi towns both situated at the north side of Samos facing the earthquake source. For the
tsunami study we performed post-event field survey in several coastal sites of Samos from the 31st October up to the 2nd November 2020. In addition, we interviewed with port authority officers and eyewitnesses and examined several videos recorded by security cameras and mobile phones in Samos and other islands. Near-field tide-gauge records for the Samos 2020 tsunami wave are not available. The closest records come from one tide-gauge station in Bodrum, SW Turkey, as well as from another two stations in Kos island, Greece, situated at epicentral distances of 112-120 km (Table 1). From far-field tide-gauge records, however, we were able to calculate the tsunami magnitude in Mt/Mw scale. Apart from the seven sites where tide-gauge records are available, we documented tsunami inundations in 15 coastal sites of Samos as well as in 5 sites in other islands. From the observations collected we evaluated the wave impact and calculated several hydrodynamic features of the tsunami wave including the number and times of wave arrivals, times of wave retreat, wave run-up, wave run-in and water flow velocity inland. It has not been possible, however, to calculate all parameters for all the observation sites due to restrictions in the data availability. In our analysis we use the next notation: D for distance of an observation site from the shoreline, d for tsunami wave run-in (distance of penetration inland), h for wave run-up above sea level (asl) unless otherwise indicated. All times reported are in UTC unless otherwise indicated.

**Table 1.** Data set used to calculate tsunami magnitude, Mt, from tsunami height, H, recorded at 7 tide stations situated at epicentral distances Δ. H is taken as the half of the maximum crest-to-trough height. Stations are operated by the next agencies: 1, jointly by the Space, Security and Migration Directorate-Joint Research Center at Ispra (JRC, EC) and the Kandilli Observatory and Earthquake Research Institute (KOERI, Turkey); 2, 3, 4 jointly by the JRC and the NOA: 5 by the Hellenic Navy Hydrographic Service (HNHS, Greece); 6, 7 by NOA. Tide records were retrieved from the JRC World Sea Levels platform ([https://webcritech.jrc.ec.europa.eu/](https://webcritech.jrc.ec.europa.eu/)) and from the Sea Level Station Monitoring Facility of IOC/UNESCO ([http://www.ioc-sealevelmonitoring.org/](http://www.ioc-sealevelmonitoring.org/)).

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<th>Lon° E</th>
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From the urban planning point of view the coastal zone in Vathy bay consists of three parallel lanes, which from the shoreline towards inland are: a pedestrian lane, the two-way main road and a
second pedestrian lane (Figure 2). The total width of this zone ranges from 40 to 45 m. The inland pedestrian lane is dominated by buildings with various shops, offices, cafeterias, restaurants and other commercial stores. Small streets perpendicular to the main road drive further inland. Similar urban planning characterizes the Karlovasi coastal zone. The height of the seaward pedestrian zone was measured at 60 cm and 110 cm asl in the eastern Vathy bay and in Karlovasi near the Port Authority building, respectively. In western Vathy bay, near the site Malagari where remarkable tsunami impact was observed, no shops and pedestrian zone exist. The area is characterized by the presence of the new commercial port and a marina.

For the tsunami magnitude calculation seven far-field tide-gauge records have been utilized. Details of the tide-gauge stations and sources used to retrieve records are summarized in Table 1.

3. Tsunami observation results

In the next subsections we provide the results of the observations collected, the estimated tsunami hydrodynamic parameters as well as the tsunami impact in each one of the 20 inundation sites in Samos and the surrounding islands. For each site the description starts with the site code number, the site name and the distance D of the site from the seashore, when relevant. Minor tsunami inundation was also reported from other islands, including Fourni and Mykonos, but no specific information has been collected.

3.1. Samos Isl.

3.1.1. Vathy town, east coast (Figure 2).

![Figure 2](image.png)

**Figure 2.** Three characteristic tsunami inundations measured along the eastern coast of Vathy bay. Run-up, \( h \) (asl), measured at A, B, C sections are 1.95 m, 2.0 m and ~1.5 m at run-in distances 101 m, 97 m and 87 m, respectively. Numbers 1-6 correspond to observation spots examined in text.
1. **Hertz office** (*D* = 43 m). Two video records from security cameras were provided by the office owner. The time in both cameras was not correct since they advanced time by about 4 min and 45 s with respect to the library security camera (Site 4). The corrected time is hereafter used. The video from the external security camera starts at 12:24:13. The coastal road and part of the pedestrian zone are seen already wet due to the first wave arrival. From the wet zone shown in the record and the field inspection of the area we estimated *d* = 39 m and *h* = 0.75 m. The record shows a second strong tsunami inundation starting at 12:24:15 and inundating the entire width of D=43 m. In the inundated zone the video shows people running to evacuate, cars floating and fishes swimming towards the sea (Figure 3). From the video and the field inspection we estimated *h* = 1.2 m. The velocity of the water flow inland was found equal to 1.95 m/s (7 km/h).

   The video from the interior security camera starts at 12:24:21. Outside of the entrance door the water level is already at *h* = 0.6–0.7 m from the ground level. The sea wave breaks the door glass at 12:25:51, the door opens violently and the water flows into the office causing material damage. One internal plaster board breaks and collapse. In walls we found watermarks at *h* = 0.4 m from the office ground level. This was verified by the office owner. Then we get *h* = 1.6 m asl.

![Figure 3](image1.png)

**Figure 3.** Vathy, Site 1. Inundation starts at 12:24 (corrected time), people run to evacuate (left). At 12:26 (corrected time) general flooding is noticed, cars float (right) (photos credit, Hertz office).

2. **Zen fish restaurant** (*D* = 42 m). The second wave hit violently the restaurant causing remarkable material damage (Figure 4). From watermarks on walls at *d* = 50 m in the small street perpendicular to the main coastal road we measured *h* = 1.09 m from the ground level (Figure 4). Then the run-up has been *h* = 1.69 m asl.

![Figure 4](image2.png)

**Figure 4.** Vathy, Site 2. Damage caused by the tsunami attack in the fish restaurant (left.) Watermark of *h* = 1.09 m was measured at run-in distance of ~50 m (right) (photos credit, I. Triantafyllou).
3. **Piraeus Bank (D~42 m).** The water flow inundated the entire coastal zone and through a network of small streets, either perpendicular or parallel to the main coastal road (Figure 5), inundated at run-in distance up to d=98 m. From watermarks on walls (Figure 6), we measured run-up of h=1.6 m at d=70 m and maximum h=1.95 m at d=98 m. The area was extensively littered while sand and pebbles were left behind.

![Figure 5](image)

**Figure 5.** Vathy, inland from Site 3, eyewitnesses (left) reported that the water reached up to the yard of the “Garden Restaurant” (yellow bar, right; see also Figure 6) at Xrisostomou Smirnis Street and caused material damage (photos credit, M. Gogou).

![Figure 6](image)

**Figure 6.** In Xrisostomou Smirnis Street, close to “Garden Restaurant” (Figure 5) we measured h=0.3 m and h=0.24 m from ground level at d=94-96. The value of h minimized at d=98, where we estimated maximum h=1.95 m asl (photos credit, I. Triantafyllou).

4. **Library (D~43 m).** A valuable video record has been obtained from an external security camera. The video timer was absolutely accurate as one may conclude from the time it recorded the earth shaking, i.e. 11:51:34. This has been useful to correct the video timer at Site 1. The first tsunami arrival was recorded at 12:04:15. People are seen running to escape (Figure 7). The inundation covered the entire zone of 43 m and flowed further in a nearby small street. The second and strongest wave arrived at 12:24:10. From the video record and the field inspection in front of the building we estimated h=0.8 m and h=1.2 m due to the first and second tsunami wave, respectively. The second wave penetrated further inland through the nearby small street which, however, is not shown in the video record. No watermarks were found in the small street and, therefore, no estimation of the final run-in and run-up has been made for this observation site.
The velocity, $v$, of the water flow inland was calculated equal to $v_1=1.08 \, \text{m/s} (3.9 \, \text{km/h})$ and $v_2=1.27 \, \text{m/s} (4.6 \, \text{km/h})$ for the first and second tsunami wave, respectively.

5. *Square of Pythagoras.* The inundation from the first and second waves has been documented in several video records (Figures 9-11). The owner of a kiosk at $D=45 \, \text{m}$ (Figure 10, right) estimated $h\sim1 \, \text{m}$ from the street level. We found no water marks there but from other eyewitness accounts and several videos publicly available we were able to roughly verify the water depth reported in the kiosk area. Then, we estimated a value $h\sim1.6 \, \text{m asl}$. Further inland, at the Pharmacy of the square at $D=80 \, \text{m}$ (Figure 10, left) we interviewed with the owner and estimated $h\sim0.3 \, \text{m}$ from the ground level. The wave inundated for another $\sim17 \, \text{m inland}$. After talking with eyewitnesses and from a video record (Figure 11, right) we concluded that the maximum run-up has been $h\sim2.0 \, \text{m asl}$ at $d=97 \, \text{m}$. From a video record of BBC (Figure 9) we calculated water flow velocity inland of $\sim1\,\text{m/s} (3.6 \, \text{km/h})$. 

![Figure 7](image7.png)

*Figure 7.* Vathy, Site 4. First tsunami inundation starts at 12:04, people run to escape (left). In less than 1’ the main road and pedestrian zones were flooded, two car drivers try to drive backwards (right) (photos credit, security camera 11).

![Figure 8](image8.png)

*Figure 8.* Vathy, Site 4. Second tsunami inundation starts at 12:24 (left). In less than 1’ the flood completed; the book stand drifts away and after a few seconds it disappeared (right) (photos credit, security camera 11).
Figure 9. Vathy, Site 5. The first tsunami inundation starts, people cross the main road to evacuate inland (left). In ~40 s the seaward pedestrian zone and the main road were flooded (right) (photos credit, BBC).

Figure 10. Vathy, Site 5. After the first tsunami inundation the entire square is still wet. The second tsunami arrival already started, people watch towards the sea side. At the right hand side the Pharmacy mentioned in text is shown (left). The second wave inundated the main road and flows inland in the square (right). In the background at the right hand side the kiosk mentioned in text is shown (photos credit, Samos.24).

Figure 11. Vathy, Site 5. Strong water flow inland in the square during the second inundation (left). The entire square has been covered by water, at distance d=97 m the water depth is only of a few cm (right) but h~2m asl has been estimated. Most people evacuated but a few look like enjoying the inundation! (photos credit, Samos.24).

6. **Zarbanis shop gallery (D~50 m).** A video record shows the second wave inundating a commercial gallery, perpendicular to the main road, up to d~65 m from the shoreline. Pedestrians and motorcyclists run to escape. From the video and the field inspection we estimated h=1.2 m. The water flow velocity inland was found equal to ~1 m/s (3.6 km/h).
Figure 12. Vathy, Site 6, D~60 m from shoreline. People realize that inundation starts and run inland to evacuate (left). In about one minute later the gallery was inundated (right) (photos credit, Samostoday.gr).

7. Gagou beach, northeast Vathy, outside the bay. In this small beach a local man, who uses to swim, experienced both the earthquake and tsunami. On the earthquake time the eyewitness (Figure 13, shown taking sunbath near the wall before we talk to him) was taking sunbath when the earth shook. Then, ~10’ after the earthquake the first tsunami wave arrived. It was a relatively small wave and penetrated inland for d=4-5 m. After ~15’ the second tsunami wave arrived. It was stronger and penetrated inland up to d=7-8 m. The eyewitness reported that the line of seaweed left in the beach was a watermark of the maximum tsunami run-in (Figure 13). The estimated run-up didn’t exceed h~0.4 m. The eyewitness said that the sea oscillated for another 2-3 times with period of about 10-15’.

Figure 13. Vathi, Site 7. Tsunami watermark found in Gagou beach (photo credit, I. Triantafyllou).

Figure 14. Vathy bay, east coast. After the tsunami attack in the east Vathy coast (photos credit, https://www.facebook.com/manolis.pyrgiotis/videos/10221821513181839/).
3.1.2 Vathy town, west coast. The main observations in this area were performed in Malagari beach (Figure 15).

8. **Malagari beach, west Vathy bay (D=15 m).** The owner of a local cantina experienced the tsunami and reported water run-up h~1.2 m and material damage. In a fence wall at D~3 m further inland we measured h~1.35 m (Figure 15). The eyewitness said that from the three small fishing boats he had onshore nearby the cantina only one remained standing. One boat drifted away by the wave and lost in the sea, while another one drifted away for ~20 m (Figures 16, 17). Ground erosion was locally caused during the wave retreat (Figure 16). The coast and the nearby pier were found covered by sea sand and salt. In the same area, an iron container of 13m x 2m x 2m in dimension was drifted away for about 6-7 m and rotated ~30° counterclockwise (Figures 15-17). According to Port Authority officers the container was full of marine anti-pollution equipment. We roughly estimated the container weight at ~10 tn.

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**Figure 15.** Vathy, Site 8. Tsunami run-up of h~1.35 m was measured at d=18 m (yellow arrow). A boat was drifted away by ~20 m (blue arrow, see also Figure 16). Another boat was lost in the sea (brown arrow). An iron container (red arrow) was drifted away by ~6-7 m and rotated counterclockwise ~30° (see Figures 16 and 17).
Figure 16. Vathy, Site 8. A boat was moved by the tsunami by ~20 m (blue arrow). The ground near the moved boat was eroded during the tsunami withdrawal (photo credits, I. Triantafyllou).

Figure 17. Vathy, Site 8. The tsunami drifted away an iron container by ~6-7 m (blue arrow, left) from its initial position on the pier (right) (photos credit I. Triantafyllou). See also Figures 15 and 16. In the background the Vathy town at the east bay coast is seen.

3.1.3. Karlovasi town, NW Samos (Figure 18).

In Karlovasi town the tsunami and its impact have been documented by field observations, video records and eyewitness accounts. The documentation is presented from the east of the port to the west of it.
Figure 18. Main area of field observations in the Karlovasi vessels shelter (marina) situated to the east of the port.

9. **Restaurant, east of marina (D~5 m).** Two videos taken with mobile phone showed sea retreat for several meters (Figure 19). This is consistent with the accounts of eyewitnesses (see Site 11).

Figure 19. Karlovasi, Site 9. Sea retreat a few minutes before inundation (photos from mobile phone videos by anonymous eyewitness).

10. **Marina area.** In the localities A, B and C (Figures 18, 20, 21) watermarks were found. In B the wave penetrated inland from the beach, overtopped the narrow pedestrian zone and reached the main road at D~84 m. In locality C we measured D~65 m. Light wooden structures were removed from their initial positions (localities D and E) and a small boat moved ashore on a pier at h~0.7 m (locality F). Between localities C and D the goal posts and the perimeter fences of a small football terrain were displaced and deformed respectively by the tsunami inundation and retreat.
Figure 20. Tsunami watermarks in positions A (left) and B (right) shown in Figure 18 (photo credit M. Gogou).

Figure 21. Tsunami watermarks in positions C (left) and D (right) shown in Figure 18. In position D a wooden structure of the cultural association of Karlovasi was drifted away from its initial position for ~10 m (photos credit, M. Gogou).

Figure 22. In locality E (Figure 18) a wooden structure of the cultural association of Karlovasi was drifted away from its initial position for ~10 m (left), while in locality F the wave overtopped the pier (h=0.7 m) and moved ashore a small boat (right) (photos credit, M. Gogou).
11. **Port Authority building, west port side (D-45 m).** A fisherman reported that he felt the earthquake violently onboard offshore Karlovasi Port. The first sea motion was a retreat and boats were seen strand as in dry land. This was verified from an independent local resident being at the seashore at the event time. Some minutes later inundation followed and the sea water covered the coastal pedestrian zone. In a video record available to the Port Authority officers sea retreat is seen soon after the earthquake at about 11:57:30. A couple of minutes later inundation occurred covering the entire distance from the seashore to the building with the water entering the Port Authority building. This is verified by a second video record publicly available (Figure 23). However, according to Port Authority officers no damage was caused in their building. At the building entrance we measured wave run-up $h=1.60$ m. The eyewitness said that next to the Port Authority building, in a narrow street perpendicular to the shoreline and lying at lower level than the building, the water penetrated inland for another $\sim 35$ m. Then, $h=1.70$ m was found at $d=80$ m. Sand and pebbles were left behind. Next to the small street the wave entered violently a coffee-shop causing material damage. From a video record shooting to the east of the Port Authority building it results that the pedestrian zone was inundated violently by the wave, while people run inland to escape. From the field inspection and the video records analyzed we estimated run-up varying from $h=1.50$ m to $h=1.70$ m. It is noteworthy that in Karlovasi only one inundation was reported.

![Figure 23](image-url). The Karlovasi pedestrian zone in front of the Port Authority building inundated. At the right hand side, a few meters from the building, a car of the port police is shown (photo credit, port authority officers).

3.1.4. South coast of Samos

12. **Psili Amnos bay.** To the east of Pythagorio (Site 13), in the sandy beach of the bay we observed a wet zone of width $d=5-6$ m from the shoreline as well as a watermark of seaweed at the same distance (Figure 24). A local resident eyewitness of the event verified that the wet zone and the watermark were due to the tsunami inundation. He said also that the first wave arrived $\sim 25-30$ min after the earthquake. Possibly this was the second wave observed in Vathy. After water retreat for $\sim 20-25$ m the sea inundated slightly and oscillated 3-4 times with period of $\sim 10-15'$. We roughly estimated $h=0.5$ m.

13. **Port of Pythagorian town.** Eyewitnesses said that the sea level oscillated 3-4 times with period $\sim 10'$ but no inundation was observed. We found the mean height of the piers varies from $\sim 0.5$ m to $\sim 0.6$ m asl. The eyewitnesses were unable to specify the time and the mode of the first sea motion.
14. **Heraion beach.** To the west of Pythagorio, a local resident motivated by the tsunami warning message, run in the beach to watch the tsunami and took the picture shown in Figure 24, right. The picture shows a wet zone of 3-4 m in width, which indicates small tsunami inundation.

![Image of Heraion beach](https://example.com/figure24)

**Figure 24.** Tsunami watermarks in Psili Ammos beach, SE Samos (left, photo credit, G. A. Papadopoulos) and in Heraion beach SW Samos (right, photo credit anonymous eyewitness).

15. **Kampos beach.** A local resident, civil engineer, reported that after the earthquake a drop of the sea level by ~0.3 m was observed. Then, the sea level rose ~0.2-0.3 m above its initial position.

3.2. Ikaria Isl.

16. **Evdilos Port.** According to our telecommunication with Port Authority officers, sea retreat of d=5-10 m happened immediately after they had communicated with Port Authorities in Samos and learning that the first wave had already arrived in Vathy. This implies that in Evdilos the sea retreat occurred ~15 min after the earthquake. Then inundation happened in the port and the water covered one pier with its surface lying at ~1m asl (Figure 25). This is verified by a video taken with mobile phone. The sea oscillation in the port repeated 2-3 times for about 1 hour. From another video, which has been taken from a security camera but at considerable distance and at high level inland, we tentatively concluded that the sea retreat happened at ~12:02 and the first strong wave arrival occurred at ~12:05. These remarks are consistent with the officer’s accounts. A second strong arrival is seen at ~12:28. The waves didn’t inundate inland and no damage was reported.

![Image of Evdilos port](https://example.com/figure25)

**Figure 25.** Evdilos port, Ikaria island: during (left) and after (right) tsunami inundation (photos credit, https://www.facebook.com/petrakisikaria/videos/10218569660734726/).

17. **Ayios Kirykos Port.** According to our telecommunication with Port Authority officers, sea retreat for a few meters was observed about 15’ after the earthquake. Then sea level rise occurred and the water reached the surface of the pier at h=0.7 asl. The sea oscillation in the port repeated 2-3
times for about 1 hour, as it did in Evdilos port. The waves didn’t inundate inland. No damage was caused. In a video taken from a security camera installed at considerable distance from the port we observed vessels to leave the port and sail to open sea. This happened at 12:10. One minute later inundation occurred in the marina, which is situated closer to the camera. Therefore, we concluded that the first tsunami arrival in the port was noted at ~12:10. The same video shows a second sea level rise occurring in marina at 12:43. Both inundations reached the marina’s pier level at h~1 m. The second inundation was likely stronger than the first one. After the first inundation the sea was in continual oscillation until ~14:00.

3.3. Chios Isl.

18. Komi village. A local news agency site uploaded a photo showing several small vessels crushed on the stone blocks of the breakwater (Figure 26). The vessels were moved by the tsunami from the nearby small marina of the village. According to an eyewitness about 1 hour after the earthquake sea retreat by about 15 m was observed and ~3’ later tsunami inundation of h~1.1 m occurred in the nearby pier. In the beach the run-in was estimated at 15-20 m. The sea oscillation continued for about 3 hours.

![Figure 26](astraparis.gr)  
Figure 26. Boats crushed on water break stones in Komi village, south Chios island (right) (photo credit, astraparis.gr).

3.4. Patmos Isl.

19. Scala port. From a video taken with mobile phone it comes out that part of the pier was inundated by the tsunami; we roughly estimated h~0.5 m.

![Figure 27](Patmostimes.gr)  
Figure 27. Scala port, Patmos Isl. The pier inundated (left) and after the sea retreat (right) (photos credit, Patmostimes.gr).

3.5. Andros Isl.

20. Nimporio bay. According to information provided by "AKTES-Society for the Study of Ancient
Coastlines” the tsunami was observed at the eastern coast of the island ~1 hour after the earthquake. A video record by “AKTES” shows that the pier at height of h~0.6 m was slightly inundated.

Figure 28. Nimporio bay, Andros island. Slight inundation of h~0.6 m was observed (photo credit, AKTES-Society for the Study of Ancient Coastlines).

3.5. Tsunami magnitude

Although several efforts have been made for the establishment of tsunami magnitude scales, no standard method has been introduced so far (see review in Papadopoulos et al., 2020a). One of the most promising approaches is the one proposed by Abe (1989), which is based on Pacific Ocean data and uses formula (1) to calculate tsunami magnitude, $M_t$ where $H$ (in m) is the maximum wave heights at nearshore tide-gauge records at epicentral distances, $\Delta$ (in km):

$$M_t = \log_{10} H + \log \Delta + 5.80$$  \hspace{1cm} (1)

The constant in (1) has been obtained under the requirement $M_t=M_o$ on the average for the calibration data set used in [6]. $M$ represents not only the overall physical size of a tsunami but also the seismic moment of the tsunamigenic earthquake. In the Mediterranean Sea basin the applicability of formula (1) was for the first time tested with success (Papadopoulos et al., 2020a,b) after the earthquakes of 25 October 2018 ($M_o=6.8$) and 2 May 2020 ($M_o=6.6$) that ruptured along the Hellenic arc. We applied the method for the Samos 2020 tsunami by utilizing seven tide records available (Table 1). It was found $M_t=6.8$, which is close to $M_o=6.9$ or $M_o=7.0$ calculated independently from seismic records.

4. Conclusions

The tsunami caused by the large ($M_w=6.9$) earthquake of 30 October 2020 in the Eastern Aegean Sea has been a very near-field event for Samos and other coasts close to the source. However, no tide-gauge records are available in the near-field domain. From seven far-field tide records we were able to calculate tsunami magnitude $M_t=6.8$, equivalent to seismic moment magnitude, which is a good approximation of the earthquake magnitude calculated independently from seismic records.

The post-event field survey performed during the three days following the event, combined with the analysis of several video records and the evaluation of accounts collected from local authorities and eyewitnesses, we reached at useful results for understanding the tsunami impact on the coastal
communities as well as the wave hydrodynamic features in several coastal sites of the Greek islands in the East and South Aegean Sea.

At all evidence the first tsunami arrival was noted in Karlovasi town, NW Samos, where the wave reportedly arrived in a few minutes before its arrival in the Vathy bay, NE Samos, i.e. ~10' after the earthquake origin time. No doubt that in Vathy two strong waves inundated the coastal zone at 12:04 and 12:24 UTC, the second being more powerful as compared to the first one. However, no more than one inundation was reported from Karlovasi. On the other hand, in Karlovasi the first sea motion was a retreat causing vessels to strand as in dry land.

In Vathy coastal zone the wave run-up in general exceeded 1.5 m. The maximum run-up of h~2.0 m asl was measured in the main square of Vathy bay at run-in distance of d~98 m. From several video records we estimated that in various observation sites the maximum water flow velocity inland ranged from 1.0 m/s to 1.95 m/s. In Karlovasi maximum h~1.70 m was found at d~85 m. In both Vathy and Karlovasi the tsunami was powerful enough and caused material damage along the coastal zones. No human victims were reported. It is of interest to further examine at what extent the tsunami warning message sent to local population at time between the first and the second wave facilitated or not evacuation. More extensive has been the tsunami impact in Vathy where the various stores, offices, restaurants and other tourist and commercial shops situated along the coastal zone suffered remarkable damage. Damage was also caused to several cars and small vessels that drifted away by the tsunami. In several observation sites sea sand and pebbles were left behind while extensive littering occurred. In at least one coastal spot the tsunami withdrawal caused local ground erosion.

In both Evdilos and Ayios Kirykos ports, NE and SE Ikaria island, respectively, sea retreat of ~5-10 m was first reported about 10-15' after the earthquake. Possibly two inundation phases happened in the ports with the water covering the piers at ~1 m asl. The waves didn’t inundate inland and no damage was caused. Inundation of ~1 m or less was reported from other islands, including Patmos and Andros as well as south Chios where a few small vessels crashed on the rocks of the water break.

Low tsunami hazard has been considered so far for the area of the Eastern Aegean Sea. However, the Samos 2020 tsunami is the third in series that occurred in the area after the tsunamis caused by the strong earthquakes occurring on 12 June and 20 July 2017 with magnitudes Mw=6.3 and M=6.6. These tsunami waves, although have been only local, call for a re-evaluation of the tsunami hazard level and the preparedness for tsunami risk mitigation in the area. Last but not least, it is of interest to note that according to preliminary results of field observations the island of Samos very likely uplifted co-seismically with amplitude varying from ~0.1 m to ~0.25 m. Then the tsunami impact has been lower than it would be possible if no co-seismic uplift had occurred. Further research regarding this point is a challenge.

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