

RESEARCH ARTICLE

A preliminary assessment of the mass mortality of some benthic species due to the mucilage phenomenon of 2021 in the Çanakkale Strait (Dardanelles) and North Aegean Sea

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Abstract

Mucilage events may severely affect the benthic fauna and flora in marine environment, likely causing serious mortality in marine life. The present study was made on a massive mucilage phenomenon in the Çanakkale Strait (Dardanelles) and North Aegean Sea in 2021. Blanket type of mucilage existed for five months between March and July in the Çanakkale Strait, impacting marine benthos, which lead to a likely ecological destruction at some locations. Saros Bay, Gökçeada, Bozcaada and Tavşan Islands (Mavriya) were also impacted by this massive mucilage phenomenon. The highest mean thickness of blanket type of mucilage was observed as 16.26 ± 5.97 cm, while the lowest value was measured as 3.5 ± 0.86 cm. Regarding mucilage aggregates-based mortality in marine invertebrates, 77 individuals of the Pennatulacean coral *Pteroeides spinosum* were found dead. Data of thickness on substratum of mucilage aggregates is reported for the first time in the inventory of the Turkish marine researches.

Keywords: Mucilage, invertebrates, mass mortality, Çanakkale Strait, North Aegean Sea

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Introduction

Marine mucilage, mainly occurred due to a production of the photosynthetic and filamentous algae (Schiaparelli *et al.* 2007), is known as a consequence of marine pollution and water temperature increase in aquatic habitats (Danovaro *et al.* 2009; Malone and Newton 2020; Savun-Hekimoğlu and Gazioğlu 2021). Process

of mucilage formation that is natural and ubiquitous massive aggregates causing oxygen deficiency, mortalities of fish and benthic organisms (Aktan and Topaloğlu 2011; Piazzì *et al.* 2018) has rarely been reported in the coastal areas. Giani *et al.* (2005), Aktan *et al.* (2008), Filipuci (2011) and Xie *et al.* (2018) defined the ongoing process of this phenomenon as an ecological destruction for some specific regions as it lasts for a long time in large formations effecting severely on both the surface waters and the benthic zone. Medecc (2019) has identified its negative effects on environment and how mucilage causes habitat destruction in marine environment. Basically, blanket type of mucilage (BM), also known as ponjave (Babić 1911), is a layer of combined aggregates covering uniformly cliffs and benthic organisms, spreading on the largest area on the bottom (Precali 2005) and may be more destructive than other types of mucilage formations (Özalp 2021) and has a long-term impact on habitat ecology and health of marine species (Cerrano and Bavestrello 2008; Lewis *et al.* 2018; Garrabou *et al.* 2019; Karlson *et al.* 2021).

On 31 December 2020, a massive mucilage event occurred in the Çanakkale Strait (Dardanelles), severely affecting the areas of coral-dominated biodiversity hotspots and by time, causing mortality in gorgonian corals, putting many other invertebrates in danger (Özalp 2021). In the following months, the phenomenon was also recorded as an intense formation both on pelagic and benthic zone in the Sea of Marmara (Balkıs-Ozdelice *et al.* 2021; Savun-Hekimoğlu and Gazioglu 2021). There have seen three mucilage outbreaks since the 1990s in the Turkish Straits System (TSS). Former events appeared in 1996 (Uğurlu 2021) and 2007 (Aktan *et al.* 2008), followed by the heaviest mucilage of 2021, creating more serious ecological problems for the first time in corals and some other marine invertebrates such as tunicates, bivalves, sponges, coralligenous and algae. Pelagic mucilage responsible for the 2021 event became intensive in time, sank and massed rapidly on numerous areas on the bottom in the Çanakkale Strait, leading to severe mortality in gorgonian corals at the first stage of BM, which was still effective in many sites until the end of July. Due to BM worsening in the strait later than 31 December 2020, the time known as the first massive coral mortality event in the region, some sponges and soft coral species also started to die since they could not feed and breath. Because of this condition of mucilage aggregates, several sponge facies living in the biodiversity hotspots of the Çanakkale Strait have been devastated. The aim of the current study is to describe the mortality of benthos due to mucilage since December 2020.

Materials and Methods

During the period between 3 March 2021 and 12 July 2021, the thickness of BM was regularly monitored by scientific diving team of COMU using Scuba and technical diving equipments at seven stations in the Çanakkale Strait. An underwater ruler was used for *in situ* measurements of mucilage aggregates and the mean value of three randomly-collected data at each station was calculated (Figures 1 and 2).

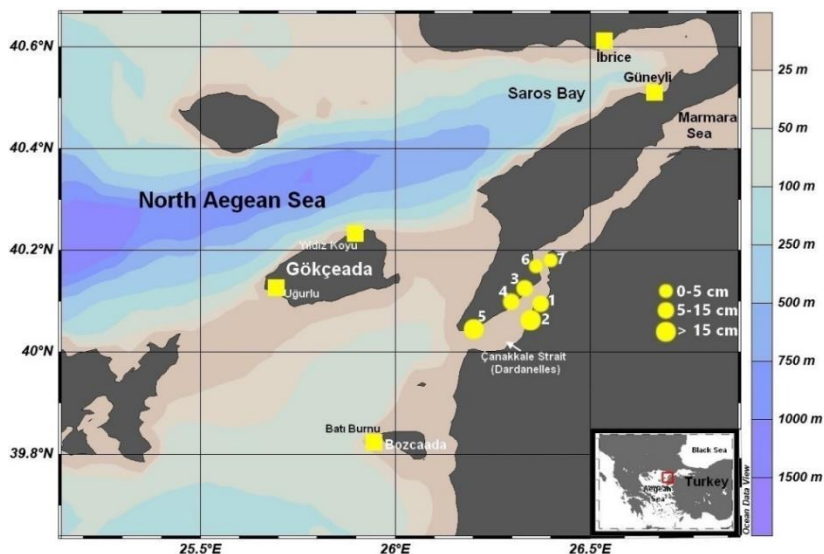


Figure 1. Survey sites in the Çanakkale Strait (circles) and the North Aegean Sea (squares) and the thickness of mucilage on the bottom in the Çanakkale Strait recorded between April 29-July 12, 2021

Monitoring stations for blanket type mucilage: 1: Dardanos, 2: Güzelyalı, 3: Baykuşfener, 4: Kesikfener, 5: Seddülbahir (Morto Bay), 6: Eceabat, 7: Nara

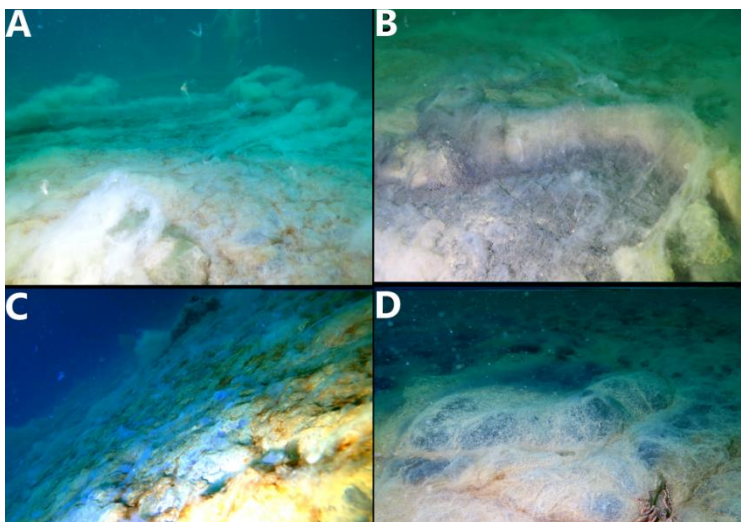


Figure 2. Blanket type mucilage (BM) in the benthic zone at four stations in the Çanakkale Strait (A: 38 m depth at Seddülbahir as the southernmost part of the Turkish Straits System; B: 21 m depth at Kesikfener; C: Inclined benthos and BM between 19-26 m depth at Seddülbahir; D: 35 m depth at Güzelyalı)

The total number of dead individuals of invertebrates, such as corals and sponges, on two transects, one horizontal and the other vertical, as 10 m and 50 m long, respectively, were counted using quadrat 1m x 1m for determining abundance. For the evaluation of mortality rate on invertebrate fauna, all species discovered at the stations were photographed and recorded with a video camera. The geographical distribution in relation to the thickness of BM and underwater photos at different stations in the strait are also presented.

Results and Discussion

As a result, the highest mean thickness of BM was measured as 16.26±5.97 cm at Station 5 (Seddülbahir) (Table 1). The second highest mean thickness was 11.7±2.98 cm in diameter at Station 2 (Güzelyalı). The thickness data of BM at Stations 1 and 4 resulted in 5.33±0.28 cm and 5.13±2.73 cm, respectively. Due to severe impact of mucilage that has been ever-expanding and becoming thick on the bottom, some species of invertebrates were heavily damaged as the mucilage aggregates fully covered over the individuals suspending their breathing and feeding activities.

Table 1. Thickness of blanket type mucilage (BM) monitored in seven stations in the Çanakkale Strait (TFb: Mean thickness of BM; sd: standart deviation)

Station	Current*	TFb±sd (cm)	min-max (cm)	Depth (m)	Date
ST1	Medium	5.33±0.28	5-5.5	18-21	May 2, 2021
ST2	Medium	11.7±2.98	9.5-15.1	29-34	May 22, 2021
ST3	Strong	3.6±0.17	3.5-3.8	20	May 12, 2021
ST4	Strong	5.13±2.73	2-7	23-24	Apr 28, 2021
ST5	Weak	16.26±5.97	9.5-20.8	32-39	July 12, 2021
ST6	Very strong	1.66±0.28	1.5-2	5-11	Apr 29, 2021
ST7	Very strong	3.5±0.86	2.5-4	19-25	May 6, 2021

Note: TFb was a mean value of three randomly collected data at each station

Current*: very strong: > 4 knots; strong: 2-3 knots; medium: 1-2 knots; weak: < 1 knot

The highest rate of mortality was detected in soft coral *Pteroeides spinosum*, belonging to Pennatulidae. A total of 77 individuals of *P. spinosum* observed in horizontal position on sandy bottom rather than their natural vertical position, has been found dead in an area of 500 m² at depths between 21-38 m in the largest habitat of the species in Güzelyali region (Station 2). Moreover, 34 individuals of the gorgonian coral *Eunicella singularis* at two stations, 20 in Station 3 and 14 in Station 4, were dead with massive BM on their branches, turning the color of the corals from white to brown.

Regarding the mortality of Scleractinian corals in the study sites, 9 colonies of the hard coral *Polycyathus muelleriae* were found dead, while twelve were healthy (21 in total) under a rock overhang at Station 4 in 28 m depth. Sponge species, *Aplysina aerophoba* and *Sarcotragus spinosulus*, also known as common species at many sites of the strait, showed the highest rate of mortality. Ten individuals

of *A. aerophoba*, three of which were partially healthy with some live lobes and 28 individuals of *S. spinosulus* were found dead at Station 5 and Station 6, respectively (Figure 3). The highest mean abundance of *S. spinosulus* determined at 7 m depth on a 10m long horizontal transect set on the largest habitat was 1.7 ind/m² in Station 6. Additionally numerous biodiversity hotspots, caverns, fish assemblages, algae beds and other invertebrate facies were also under negative effects of mucilage formations (Figure 4).

BM may be accepted as a very serious phase of mucilage phenomenon and it has mostly been linked to mortality in marine animals due to its long-lasting characteristic and morphological features such as stiffness which prevents them from breaking up in small pieces even in strong currents. Thus, it is sometimes responsible for ecological destruction in marine environment.

Although the first mucilage event of 2021 in the Çanakkale Strait (Dardanelles) started on 31 December 2020 and even affected the Turkish islands in the North Aegean Sea, massive formation of mucilage aggregates subsiding fastly by time from surface as it increases intensity are still effective mainly at depths deeper than 18 m despite strong current regime and threatening the sustainable life of sessile fauna. Its ever-thickening coherent structure having a steady characteristic on the bottom could not be dispersed for 5 months, thus there is high risk of mortality in many other species. However, active swimmers such as fish, crabs, lobsters, shrimps and some other benthic invertebrates like sea cucumbers, sea stars, polychaetans look healthy and no mortality related to mucilage has been reported from the region.

Though mucilage is known as a natural and recurrent event occurring in almost all aquatic habitats in the world (Fonda Umani *et al.* 2007; Flander-Putrlle and Malej 2008), its intensity and prevalence have recently increased abnormally due to human-induced changes in ecosystems like pollution and climate change (Lorenti *et al.* 2005; Danovaro *et al.* 2009). Humans understand that nature can only be sustainable, provided that we can save the balance between human and environment. The 2021 mucilage event in the Turkish Straits System has lasted for seven months in the surface waters, also affecting the Turkish islands in the North Aegean Sea and yet the accumulated mucilage on the bottom has serious impact on marine sessile species. Since massive mucilage aggregates cannot disappear naturally and continue accumulating in various areas, the mucilage-based mortality has been rapidly increasing, causing a catastrophic state in marine habitats. Formerly mucilage caused mortality in the gorgonian corals in the region (Özalp 2021). Following the unexpected loss of coral habitats, massive mortality was also recorded in some soft coral, sponge and tunicate species, also representing the first records of *S. spinosulus* and *P. mammillata* from the region, in time as presented in the current study.

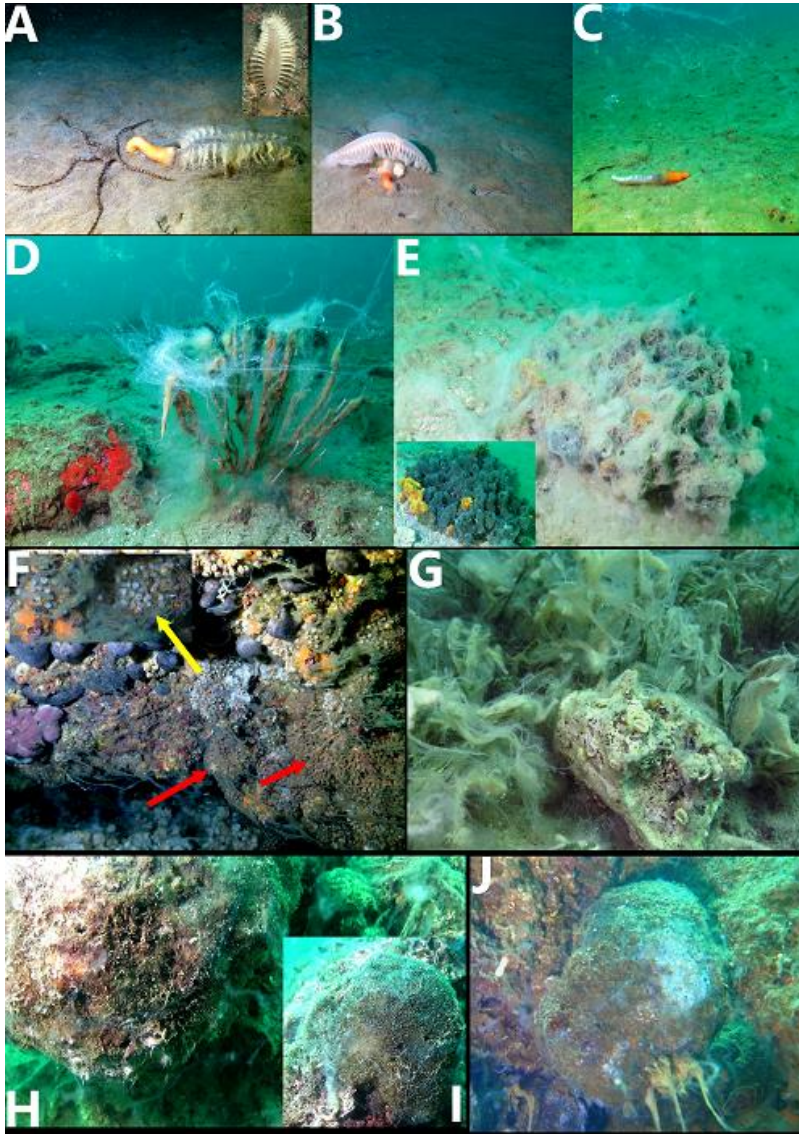


Figure 3. Dead and threatened individuals of marine invertebrates and algae due to massive coverage of mucilage formation recorded in the Çanakkale Strait after May 2021 (A: Dead and live (upper photo) individuals of *Pteroeides spinosum* at Station 2 in 38 m depth; B, C: Dead individuals of *P. spinosum* at Stations 3 and 4; D: Dead individual of *Eunicella singularis* at Station 3 in 21 m depth; E: Partial mortality in *Aplysina aerophoba* at Station 5 in 14 m depth (lower photo: the same individual in complete black color after taking out mucilage); F: Dead colonies of *Polycyathus muellerae* (white ones); G: BM on *Posidonia oceanica* meadow at Station 1 in 8 m depth; H, I, J: Dead individuals of *Sarcotragus spinosulus* at Station 6 in 4 m depth)

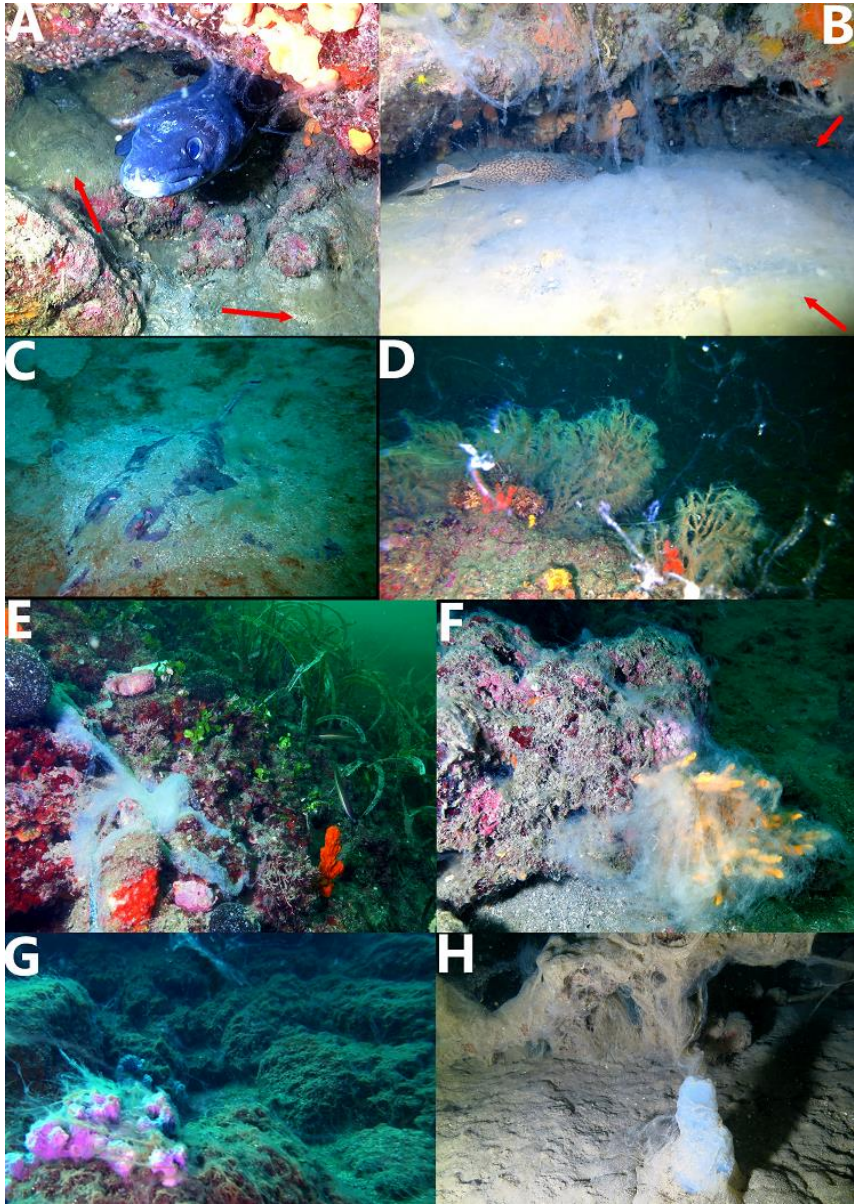


Figure 4. Marine life and cave habitats affected by massive BM in the Çanakkale Strait (A, B: Two caverns of about 5 m² as home for *Conger conger* and *Torpedo torpedo*, C: *Dipturus oxyrinchus* surrounded by BM at Station 4 in 24 m depth; D: *Scorpaena scrofa* around the habitat of *Savalia savaglia* at Station 6 in 40 m depth; E: Coralligenous facies around *Posidonia* beds; F: Healthy *Axinella cannabina* at station 4 in 35 m depth; G: *Dysidea avara* at Station 3 in 19 m depth; H: *Phallusia mammillata* recorded in massive BM at Station 2 in 34 m depth)

Additionally, although the main affected areas were the Sea of Marmara and the Çanakkale Strait, the aggregations were also observed in the North Aegean Sea (Saros Bay, Bozcaada, Gökçeada) due to catastrophically massive and tightly packed mucilage formation in the area which has never recorded in such a scale in the Turkish seas. Five species of sponge, two octocorals, a mollusc and two echinoderms were also affected by the mucilage event of 2021 in the North Aegean Sea (see Table 2 and Figure 5). BM at an offshore station of Yıldız Bay (Gökçeada), which represents the deepest monitoring site, numerous blanket and cloud types of mucilage were detected on the bottom at between 45-54 m depths (Figure 6). In Bozcaada Island, where the mucilage has been observed since April 2021, the main affected locations were recorded as Batı Burnu (Ponente), Killik and Çayır Beach. BM was recorded only in the coastal area of Çayır Beach and the rate of accumulation regarding thickness of BM was < 5 cm in shallow water between 0-2 m depth. Additionally, *P. oceanica* meadows in the southern parts of the island (Bozcaada Harbour, Baklataş, Habbele, Sulubahçe) were also affected by massive creamy surface layer, macrofloc and stringer type of mucilage during May and June 2021. In spite of its massive spreading in Bozcaada and Gökçeada Islands, such an extreme mucilage formation similar to the BM monitored since December 2020 in the Çanakkale Strait has never been observed during the marine surveys conducted in the North Aegean Sea.

The human-induced causes for the mucilage in 2021, reported for the first time in the Turkish Straits System at such an extreme level, should be examined in detail to find a definite solution to prevent it from recurring, as it is destructive for marine environment and ecosystem, reported formerly in many studies (Conti 1996; Deserti *et al.* 2005; Aktan *et al.* 2008; Danovaro *et al.* 2009; Savun-Hekimoğlu and Gazioğlu 2021; Öztürk and Şeker 2021). Sea water in the region is warming, which has become an environmental cause to mucilage events. The changes in sea water temperature in the Sea of Marmara, supported with trend analyses, may also be linked to global climate change (Bengil and Mavruk 2019; Altıok *et al.* 2021) and marine pollution has also a severe impact on the balance of natural processes in environment. The recent mucilage phenomenon in 2021, which is still ongoing in the bottom of the Turkish Straits System as BM, has actually been a critical alarm to us, meaning the ecological destruction of marine life. Unless serious measures are taken to protect nature from our harmful activities on ecosystems, the state of mass mortalities of marine species recorded in the Çanakkale Strait and Aegean Sea, also termed as an ecological destruction of marine life in the region, will have much more consequences that may not be compensated in the future.

Removal of the mucilage from gorgonian species with careful and gentle handling, despite its difficulty in application, may be one of the targets in future mucilage events. However, since this recommended technique is very difficult apply at seas, more feasible removal methods should be developed and a guideline is needed for all invertebrate species in marine environment.

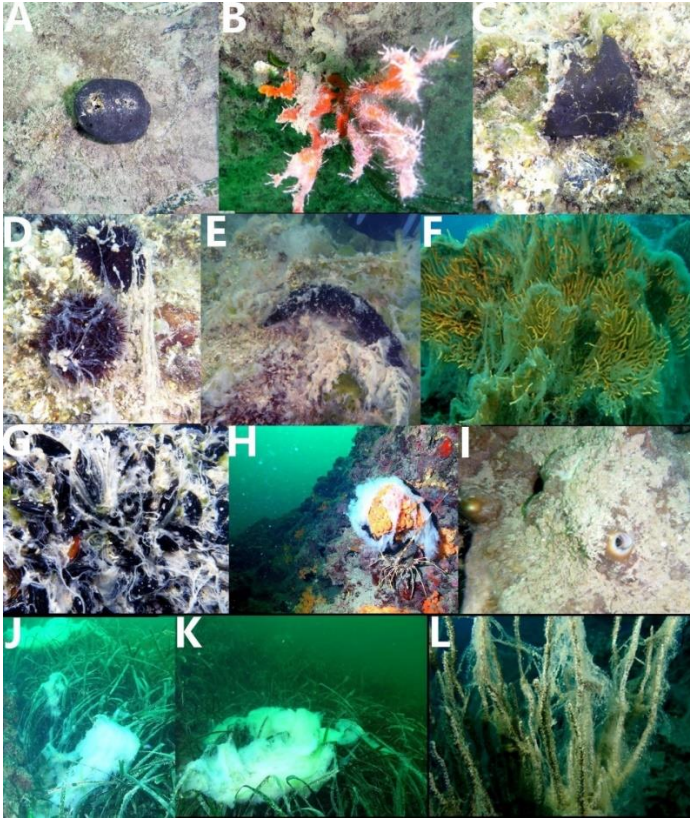


Figure 5. The mucilage-affected species recorded in the Northern Aegean Sea (Bozcaada, Gökçeada, Saros Bay) (A, C: *Ircinia oros*, B: *Axinella cannabina*, D: *Paracentrotus lividus*, E: *Holothuria tubulosa*, F: *Eunicella verrucosa*, G: *Mytilus galloprovincialis*, H: *Agelas oroides* associated with *Palinurus* sp., I: *Cliona viridis*, J, K: *Posidonia oceanica*, L: *Eunicella singularis* (Photos: B. Özalp for H, J, K; B. Öztürk for A, B, C, D, E, F, G, I, L)

Table 2. Species affected by the mucilage event of 2021 in the North Aegean Sea

Species name	Depth (m)	Location
<i>Axinella cannabina</i>	20	Güneyli/Saros Bay
<i>Agelas oroides</i>	36	Gökçeada/Yıldızkoy
<i>Ircinia oros</i>	20	İbrice/Saros Bay
<i>Aplysina aerophoba</i>	15	Bozcaada
<i>Ciliona viridis</i>	15	Güneyli/Saros Bay
<i>Mytilus galloprovincialis</i>	5	Gökçeada/Ugurlu
<i>Eunicella verrucosa</i>	25	İbrice/Saros Bay
<i>Eunicella singularis</i>	30	İbrice/Saros Bay
<i>Paracentrotus lividus</i>	4	Gökçeada/Yıldızkoy
<i>Holothuria tubulosa</i>	2	Gökçeada/Yıldızkoy
<i>Posidonia oceanica</i>	8-14	Gökçeada/Yıldızkoy



Figure 6. Blanket-type mucilage observed on the sea bottom in 45-54 m depth, Gökçeada Island (8 July 2021)

A long-term monitoring study is needed covering the entire area of both the Sea of Marmara and North Aegean Sea in order to predict the next mucilage outbreaks and potential damages on marine life and habitats. Finally regional cooperation is also important for joint actions in monitoring and preventing mucilage in the Aegean and Mediterranean Sea.

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Çanakkale Boğazı ve Kuzey Ege Denizi'nde meydana gelen 2021 yılı deniz salyası olayının bazı bentik türlerin kitlesel ölümleri üzerine bir ön değerlendirme

Öz

Deniz salyası (müsilaj) olayları, denizel yaşamda ciddi ölümlere sebep olarak bu çevrede yaşam süren bentik fauna ve flora canlılarını olumsuz etkileyebilir. Bu çalışma, 2021 yılında Kuzey Ege Denizi ve Çanakkale Boğazı'nda gerçekleşen geniş çaplı müsilaj olayını incelemektedir. Denizel bentosu etkileyen ve bazı bölgelerde ekolojik yıkım meydana getiren örtü tipi müsilaj, Çanakkale Boğazı'nda Mart ve Temmuz ayları arasında 5 ay varlığını devam ettirmiştir. Saroz Körfezi, Gökçeada, Bozcaada ve Tavşan adalar (Mavriya) bölgesi de bu büyük çaplı müsilaj olayından etkilenmiştir. Elde edilen verilere göre, örtü tipi müsilajın en yüksek kalınlık değeri ortalaması 16.26 ± 5.97 cm, en düşük 3.5 ± 0.86 cm olarak ölçülmüştür. Denizel omurgasızlarda müsilaj bazlı mortaliteye ilişkin olarak, Pennatulacea takımına ait *Pteroeides spinosum* mercan türünde 77 ölü birey tespit

edilmiştir. Müsilajın substratta oluşturduğu kalınlık verilerini içeren bu çalışma, Türkiye deniz araştırmaları envanterinde ilk kez rapor edilmektedir.

Anahtar kelimeler: Müsilaj, omurgasız, kitlesel ölüm, Çanakkale Boğazı, Ege Denizi

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