








Corinth Gulf Story Map: Enhancing Public Awareness in Natural and Anthropogenic Environment using Interactive GIS Applications

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Abstract: Story maps are widespread as an interactive tool used for science and spatial data communication, information and dissemination. A web-based application using story mapping technology is presented here to highlight places of interest around Corinth Gulf (Greece), a new addition in Natura 2000 areas. A tailored story map that combines thematic webmaps and scenes (3D webmaps) generated through a Geographic Information System (GIS) having a great impact on web-based visual presentations with narrative text and multimedia content was created to highlight the geological and cultural environment of the area around Corinth Gulf.

1 INTRODUCTION

Recent improvements in Geographic Information Systems (GIS) technologies can provide new opportunities for immersive and wide engaging public audiences with complex multivariate datasets.

Story Maps can provide support for scientific storytelling in a compelling and straightforward way (Antoniou, et al., 2019) using multi-media assets (e.g. photos, videos, 3D representations) and narrative text for visualizing spatial data effectively.

Thereby, Story Maps can be used in order to disseminate and understand scientific findings to broader non-technical audiences (Janicki et al., 2016; Wright et al., 2014).


In this paper biodiversity (unique flora and fauna) and geodiversity (geological formations, major active faults, sea level changes), cultural and recreation areas environment on both shorelines of the Corinth


Gulf, are presented through a narrative map, as it is now included in Natura 2000 site areas.


2 STUDY AREA


Corinth Gulf is a small, long, semi-enclosed and significantly deep gulf, formed between Central Greece and Peloponnese, starting from the Ionian Sea to the west and ending up to the Isthmus of Corinth to the east (Fig. 1).


It is an elongated basin of 105km length with a WNW-ESE direction and 10-15km width representing one of Europe's most active seismic areas. The central part of the gulf is characterized by a flat area of 800-870m depth, with a length of 40km and a width of 9km to the west up to 12km to the east. Its southern part is characterized by the existence of many submarine canyons in the NE-SW direction,


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while its northern part is mild up to 400m depth and then with steep slopes up to 800m (Nomikou et al., 2011). Of the total of 2,336km² of its surface, 23% is deeper than 100m, while 38% has 400-800m depth.



Figure 1: Screenshot showing the geographic location of the Corinth Gulf. It constitutes a video frame, part of the video that has been created using ArcGIS Desktop – Pro version¹, in order to highlight the study area.

It is surrounded by 4 Districts, 6 Prefectures and 15 Municipalities (Fig. 2) while the total population is approximately 584.000 (2017) citizens occupying mostly with tourism, industry and fishing activities.

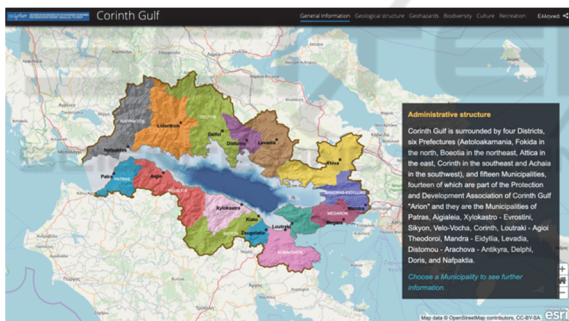


Figure 2: Screenshot presenting the administrative structure of the area.

Being recently a part of Natura 2000 site areas, Corinth Gulf foster an unusually high biodiversity and productivity of marine habitats due to its high depths in combination with the particular geomorphological, oceanographic and environmental conditions. Specifically, the habitats as well as genus and species that can be found in the gulf are reported at Natura 2000 official site².

Furthermore, in the wider area, visitors meet the “Helmos – Vouraikos” geopark belonging to the UNESCO Network of European Geoparks and the

¹ <https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview>

World Geoparks Network³, as well as the Parnassus National Park.

From the geological point of view, Corinth Gulf basin is a tectonic half-graben to an asymmetric graben with a strong differentiation of its two sides. Thus, in the North Peloponnese there is a large tectonic uplift, which has raised the first post alpine sediments of the gulf at an altitude of 1200-1400m creating an intense topographic relief. Their age is very young, ranging from the Upper Pliocene to the Lower-Middle Pleistocene (3.6-0.78mya). In contrast to the south side of the Gulf, the north side along the coast of Central Greece, is subsided or it is relatively stable and consists of alpine rocks mainly of Mesozoic - Lower Cenozoic (250-23mya). Responsible for this, are the major normal marginal faults, with WSW-ENE direction, which border the different geodynamic-environmental units and at the same time constitute the main seismic sources of the gulf (Fig. 3).

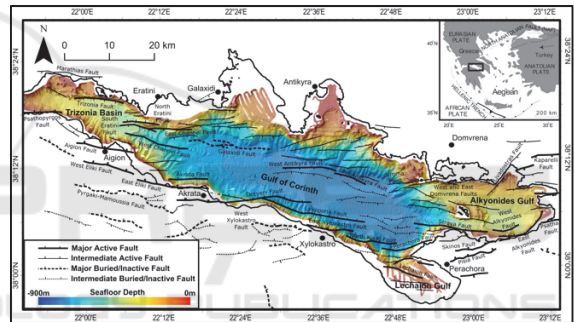


Figure 3: Structural map of the Corinth Rift with the major marginal faults (active and inactive). The bathymetry was obtained through multibeam mapping systems (Nomikou et al., 2011). Offshore faults by Nixon et al., 2016, Taylor et al. 2011, Bell et al., 2009. Onshore faults by Fold et al., 2007, 2013 and Skourtsos and Kranis 2009.

The timing of the opening of the present-day Corinth Gulf is not accurate but is generally estimated in the Upper Pliocene (3.6My). Its evolution is characterized by a migration of tectonic activity from south to north. Today, Corinth Gulf is under continuous subsidence with a constant depth of central area at 800m.

In the wider area of Corinth Gulf, natural phenomena can occur due to geodynamics of the region, seismicity and the peculiar terrain they generate. As it exhibits strong seismic activity and high seismicity, being one of the most active seismic

² <http://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=GR2530007>

³ <http://www.hellenicgeoparks.gr>

regions in the world (Ambraseys & Jackson 1990, 1997; Papazachos & Papazachou 1989, 1997; Papadopoulos 2000), Corinth Gulf constitutes a seismic laboratory for Greece. During the last 150 years strong earthquakes have resulted in the loss of many human lives or even the destruction of entire cities. Geological studies have revealed many main active faults that have spectacular surface appearances, making populated cities such as Corinth and Athens vulnerable to seismic hazard (Papadopoulos et al. 2000).

Tsunamis have also been reported due to earthquakes of low focal depth and coastal landslides, while the pre-existing evidence of submarine mounds interruptions indicates the possibility of a tsunami with a maximum wave height of 1.04 - 4.04m and a maximum wavelength of 4.52 - 6.25km (Stefatos et al. al., 2006).

Also, flash floods, as well as forest fires events can be observed due to the morphology, on both sides of the Gulf. Finally, the coastline is in widespread erosion at a percentage of more than 65%, while its southern coast is in full recession.

3 METHODOLOGY

In order to meet the challenge of creating the Story Map of Corinth Gulf, which focuses on presenting the bio- and geo-diversity as well as the anthropogenic environment of the broader area, different types of datasets have been compiled (historical, geological, topographical, etc. data together with geospatial data from open source portals). Moreover, multiple field trips have taken place for data collection, such as photos and videos for each site of interest to enrich the existing knowledge.

The Story Map of Corinth Gulf has been created in an ArcGIS platform, although other free software is also available (e.g. StoryMapJS⁴, Google Earth Outreach⁵). The selection was based on the fact that all available data as well as the necessary tools and apps, exist into the same platform without the need to use different software to achieve the same result and without the need for programming.

Thus, all the available vector and grid spatial data, along with descriptive data, was first collected, homogenized and organized into a geodatabase via

ArcGIS Pro v.2.4 software. Moreover, the geodatabase also contained the necessary feature layers to be used during field work for data collection.

Geodatabase was then uploaded in ArcGIS online platform⁶ and the available information layers were used to create a webmap.

To ensure the accuracy of the geographic location of the sites and to collect real time data, a web application, available in ArcGIS Online, was created using the afore mentioned webmap and Collector for ArcGIS⁷, an application both compatible for Android and iOS devices, which gives the opportunity, to collect and update spatial and descriptive data through mobile devices (tablets or smartphones). Accordingly, during field work, points that correspond to sites of interest were collected using the map or the GPS signal, while descriptive text and photos completed the fields available in the attribute table of the corresponding layer as attachments.

After having gathered and processed all the data for the area, a decision had to be made as a follow-up: the template of the Story Map. ESRI provides a number of open source templates⁸ which can be used either as they are (or with minor CSS code modifications in ArcGIS Online Assistant⁹) through ArcGIS Online or can be downloaded through GitHub, modified and then served through a private server (Antoniou & Vassilakis, 2019). The first approach was followed during the deployment of this Story Map, not only due to the large number of users expected to visit the application, but also due to the lack of a private server capable of managing them.

As far as the visual output is concerned, a template called Cascade Story Map¹⁰ was implemented, to present the available information, as it resembles an easily accessible for the end user webpage. Furthermore, due to the large variety of information that are supposed to be presented, it has been decided that the guided linear narration through immersive scrolling is more effective for the users, than the one that allows jumping from one tab to another without sequence.

Finally, the Cascade Builder, accessed also with a free, non-commercial ArcGIS public account, was used to combine narrative text with webmaps, images, and multimedia content in an engaging, full screen scrolling experience, as described in the following chapter.

⁴ <https://storymap.knightlab.com>

⁵ <https://www.google.com/earth/outreach/>

⁶ <http://doc.arcgis.com/en/arcgis-online/>

⁷ <https://www.esri.com/en-us/arcgis/products/collector-for-arcgis/overview>

⁸ <https://storymaps-classic.arcgis.com/en/app-list/>

⁹ <https://ago-assistant.esri.com/>

¹⁰ <https://storymaps-classic.arcgis.com/en/app-list/cascade/>

4 THE STORY MAP

In the Story Map created for Corinth Gulf¹¹, webmaps, narrative texts, images, tables, multimedia content and scenes, which correspond to 3D presentation of data, were used. Additionally, through ArcGIS Desktop – Pro version 3D animations using the available spatial data were created, while web apps were embedded into the main application.

The thematic maps which are presented in the application, were created directly in ArcGIS Online¹², based on the collected data, fieldwork and literature review, depicting the most important and unique points. In every webmap, the individual parameters for each of the information layers, e.g. its symbol, the appearance or not of pop-up menus, reference scale, etc., have been determined (DiBiase et al. 1992; Newman et al. 2010). Although the use of this template does not require the knowledge of language programming, ArcGIS Assistant was used, to perform modifications in CSS coding.

Before using the Cascade Builder, all available information was grouped into six categories covering (a) the natural and anthropogenic environment: general information for the wider area, (b) its geological structure, (c) the geohazards that might occur in it, (d) its biodiversity, (e) cultural information and (f) recreation and outdoor activities through tourism information across the involved Municipalities around Corinthian Gulf. For each category, webmaps or scenes were created using corresponding data as mentioned below.

User's first experience entering the web application is a representative picture of the area (Fig. 4) as well as, a way to navigate through the desired language. The narrative starts giving general information about the broader area, as its geographic location, the onshore-offshore morphology of the area, the administrative structure of the Municipalities bordering the Gulf and concludes giving information for the anthropogenic environment. Each narrative text is accompanied with a webmap showing the spatial distribution of the data presented using Imagery, OpenStreetMap or Light Gray Canvas as basemap, while pop-ups give further information. In addition, a video, in MP4 format, a combination of successive thumbnails of spatial distribution of feature layers along with an imagery basemap animating the location and a multibeam bathymetric map of the Corinth Gulf with 20m isobaths (Nomikou et al, 2011) were used to enhance the narration (Fig. 5).

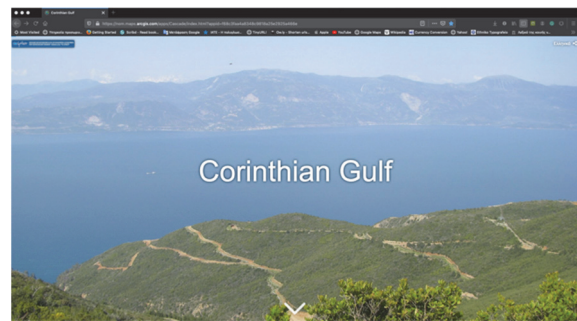


Figure 4: Screenshot showing the home page of Corinth Gulf Story Map. In the upper right part, users can select the desired language for the narration.

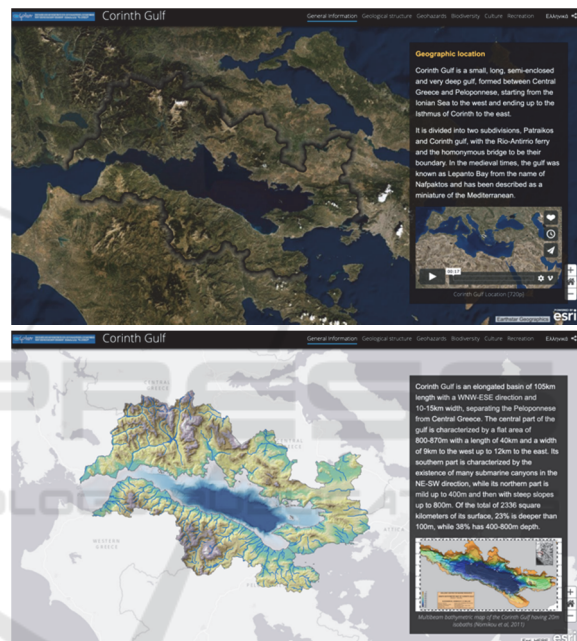


Figure 5: Screenshots showing the boundary (up) and onshore-offshore morphology of the area (down).

The geological – tectonic structure of the area is subsequently presented using Ocean basemap. Starting with a 3D representation of the spatial distribution of geological formations, which are distinguished in alpine and post-alpine, a narrative text using multimedia content describes the evolution of the gulf. Users can use the tools on the right bottom of the map, to zoom in and out or right-click anywhere on the scene to tilt and rotate (Fig. 6). Due to the geodynamics of the area, further information is given about the geohazards that might occur in the area: earthquakes, tsunamis, landslides, floods, coastal and soil erosion and forest fires. Apart from maps showing the spatial

¹¹ <https://nom.maps.arcgis.com/apps/Cascade/index.html?appid=f68c3faa4a8348c9818a25e2925a466e>

¹² <https://www.arcgis.com/home/index.html>

distribution of these phenomena, representative photos of the area also enhance the narration.

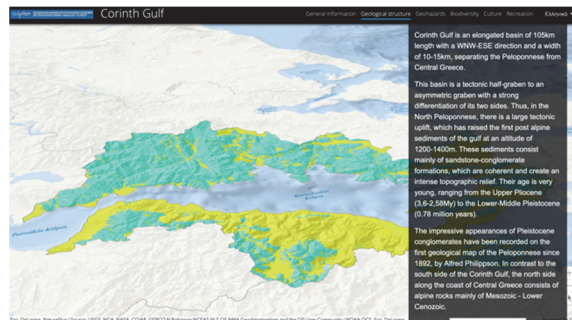


Figure 6: Screenshot showing the three-dimensional distribution of alpine and post-alpine formations of the area.

To better understand the high seismicity of the area, an interactive dashboard was created showing the earthquakes that occurred with in the period 2008-2018 and their distribution. Filters can be applied to minimize the results in every panel, using depth, magnitude, year and area of event, while statistical data present the result as a total number of earthquakes and as a diagram with their distribution according to magnitude (Fig 7).

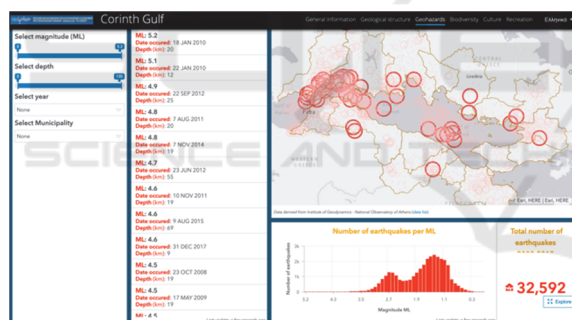


Figure 7: Screenshot showing a dashboard where the high seismicity of the area is presented. Users can modify the data displayed according to earthquake’s magnitude and depth, as well as the year and area of occurrence.

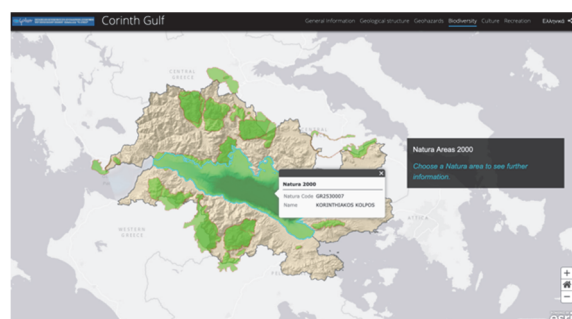


Figure 8: Screenshot showing the spatial distribution of Natura 2000 areas around Corinth Gulf.

The natural environment, biodiversity and ecosystems available in the area were presented through a webmap showing the spatial distribution of Natura 2000 areas (Fig. 8) around the gulf, using Light Gray Canvas basemap, while photos and narrative texts describe the unique flora and fauna of the area.

The two following sections present the cultural environment as well as recreation and outdoor activities in the area. Due to the large number of sites available, it was decided to present the five most important for each Municipality. Cultural environment section provides information about archaeological sites – museums, cultural heritage monuments and sport facilities available in the area. For each category a webmap has been created visualizing the spatial distribution of the data using the morphology of the area as basemap. Selecting a site of interest, further information is given through text and photos in a pop-up format. The same approach is adopted for the different kinds of recreation and outdoor activities, which provides information about fishing shelters, diving centers, bathing waters, walking paths and religious sites (Fig. 9).

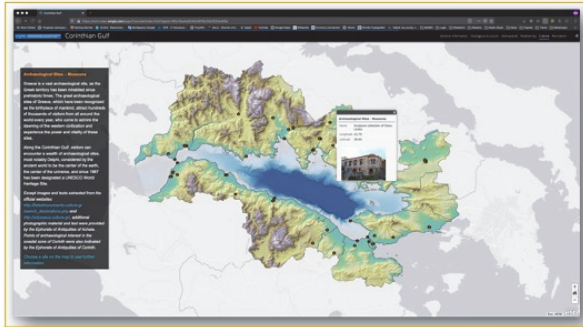
All the available information (texts, multimedia, etc.) that was used in this interactive GIS application, is properly mentioned, along with the research team responsible for its creation, at the end of the story map.

5 DISCUSSION

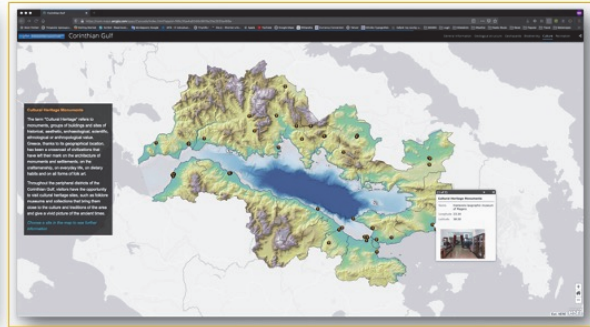
In the demonstrated application the aim was to highlight, bio- and geo-diversity as well as cultural and recreation sites, around Corinth Gulf. Using Story Maps, a relatively new geographical approach, and having open source code, provide many possibilities, due to the simplicity of use, both from the aspect of the developer and the end user. It allows integration of new functions combining many scientific fields, in a way that scientific knowledge is received and comprehended by a broader audience. Furthermore, it is responsive, and it can also be as interactive as the developer wishes.

As shown in figure 10, the developed application has already reached a number of users in a very small period of time. Furthermore, having in mind previous attempts (Antoniou, at al., 2018, 2019), this can be an interactive way for presenting geological, geomorphological and cultural contents of any

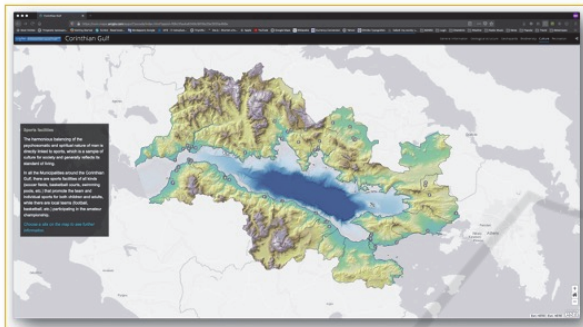
Archaeological sites - Museums



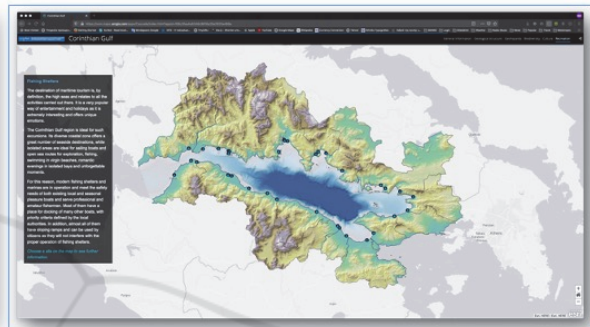
Cultural heritage monuments



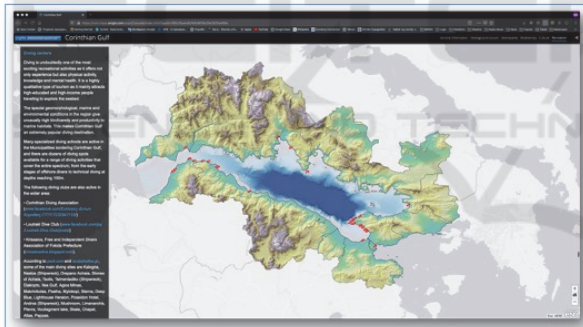
Sports facilities



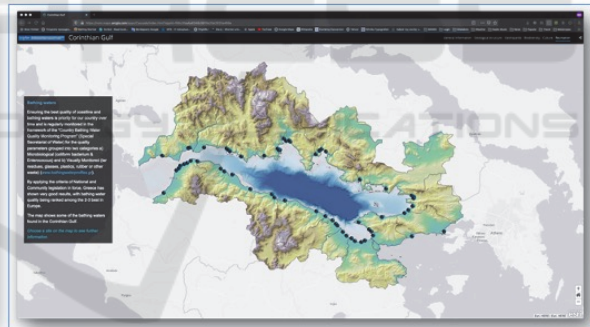
Fishing shelters



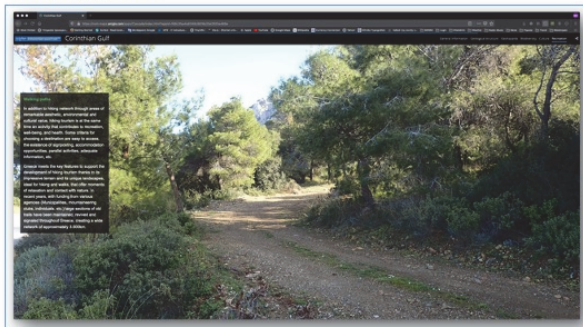
Diving centers



Bathing waters



Walking paths



Religious sites

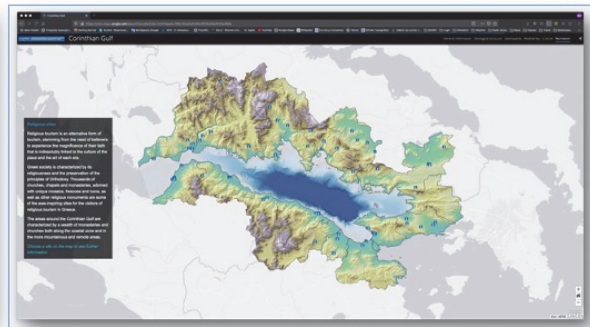


Figure 9: Screenshots showing the spatial distribution of cultural environment and recreational and outdoors activities. Also, representative photo is used to present general information about the walking paths of the area.

significant area, especially places which can be characterized as geotopes or protected areas worldwide.

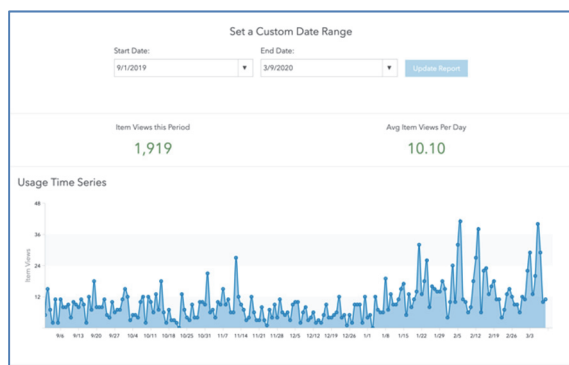


Figure 10: Screenshot showing accessibility statistics for a 6-month period.

Finally, as Corinth Gulf portrays a Natura 2000 area, this application provides a quick access of all useful data to a wide audience, attracting interest and possibly motivating people to learn more and visit the area.

ACKNOWLEDGEMENTS

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