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CoastSnap Valparaíso Region: An Experience of Citizen Science in Chile †

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Abstract: The coastal areas of Chile are undergoing major transformations associated with changes in the frequency and intensity of coastal storms, alterations in the rainfall regime with a megadrought of more than 10 years, and variations in ocean currents, which have generated a series of impacts related to beach erosion, the alteration of coastal wetlands and the effects on coastal cities. Faced with this problem, it is necessary to incorporate multiple monitoring methodologies that are complementary to existing ones, and that promote the incorporation of communities as fundamental axes in data collection. In this paper, we present the CoastSnap initiative implemented in Chile, whose results have been notorious, despite the short implementation time. Up to July 2023, the communities had shared 350 photographs that have allowed for analysis of the variability of the beaches, allowing for the quantification of variations on average up to 45 m wide in some of their beaches.

Keywords: coastal erosion; CoastSnap; citizen science; climate change

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1. Introduction

Chile's coastal areas have undergone significant transformations due to extreme events, the intensification of tidal waves, and anthropogenic actions that have deepened coastal erosion [1,2]. Currently, erosion rates in the Valparaíso region are irrefutable, with some beaches reaching −1.5 m/year and others, such as Algarrobo Bay, up to −4.5 m/year [3]. Given this scenario, beach monitoring poses excellent challenges for quantifying and projecting changes in sandy coastlines. Therefore, rigorous monitoring is required, based on low-cost, high-quality, and accurate data, involving the participation of coastal communities as fundamental axes in data capture [4].

Recently, the increasing accessibility of open-source tools, digital data, social networks, and the growing visibility of citizen scientists has enabled progress not only in data collection but also in processing and integrating [4]. Currently, although satellite systems are becoming more and more robust in their spatial resolutions, access to them is costly. At the local scale in coastal areas, it is necessary to have tools that allow the continuous and sustainable monitoring of sandy coastlines, which not only allows for analysis of the inter-daily variability of coastal dynamics but also for understanding, monitoring, and quantifying the transformations caused by extreme events and anthropogenic interventions and contributing to the local management of coastal areas.

To achieve effective local monitoring, we have joined the Coastal Citizen Science (CoastSnap) program [5]. At present, there is a need to capture coastal data that will contribute to long-term coastal protection and management. It is hoped that the body of data collected will allow for a more detailed study of the interrelationships between social uses and values and the biophysical conditions of the coastal zone [6].

The main objective of the paper is to present the citizen science initiative for monitoring the beaches of the Valparaíso region in Chile from CoastSnap.

2. Material and Methods

2.1. Study Area

The Valparaíso region has ~180 km of coastline, of which less than 55% is sandy coastline. The beaches of the region are a national and international tourist attraction [7]. Its coastal morphology is controlled by plate tectonics, configuring an irregular coastline where rocky cliffs, resistant to marine erosion, coexist and form prominent rocky protrusions, sandy beaches, and ancient and contemporary dune fields [8]. Eight beaches were selected in the Valparaíso region, including tourist attractions, urban beaches, and beaches affected by plate tectonics, to monitor changes due to anthropic interventions and extreme events (Figure 1).

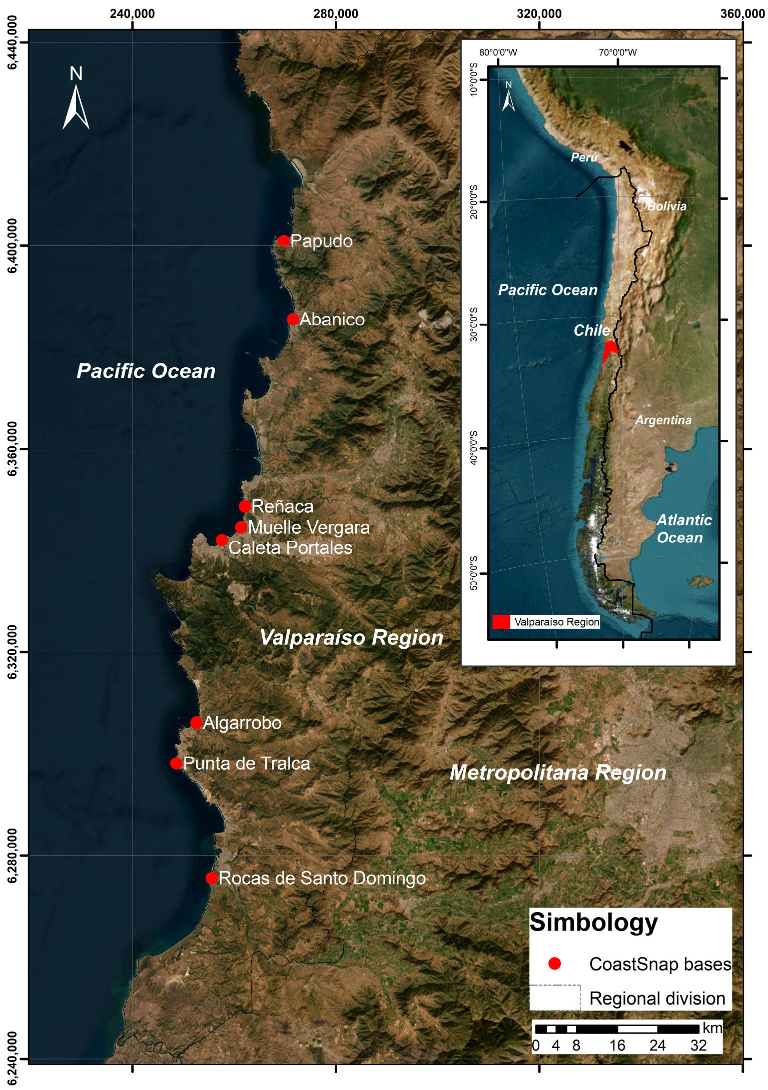

Figure 1. Study area. Locations of CoastSnap bases in Valparaíso region. Source: World Imagery—Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. The Universidad Mayor has Esri Arcmap 10.8.2 and ArcGIS-Pro licenses for teaching and research.

2.2. Methodology

The implementation of the CoastSnap program in Chile has been carried out in the following phases: (i) selection of the installation sites and measuring of angles that will define the direction (yaw) and inclination (pitch) of the cell phone to achieve the expected visual; (ii) requests for permits from the councils to install the platforms; (iii) design, signaling, and construction of the platforms; (iv) taking of control points (v) installation of the platforms; (vi) inauguration and start-up, and (vii) extraction and processing of shoreline, from open-source codes available at "https://github.com/Coastal-Imaging-Research-Network/CoastSnap-Toolbox. (accessed on 10 October 2023)"; other free tools can also be downloaded from the CIRN profile (https://github.com/Coastal-Imaging-Research-Network). It is recommended to install Routines (https://github.com/Coastal-Imaging-Research-Network/Support-Routines) (accessed on 10 October 2023)" [6,9]; (Figure 2) which summarizes the workflow for the implementation of CoastSnap Chile.

Figure 2. Workflow CoastSnap implementation in Valparaíso region, Chile. (**a**) Selection of the installation sites; (**b**) request for permits from the councils to install the platforms; (**c**) design, signaling, and construction of the platforms; (**d**) control points with GPS; (**e**) installation of the platforms; (**f**) inauguration and start-up; and (**g**) extraction and processing of shoreline, from open-source code. Source (b image creative commons from canvas for educational).

Table 1 summarizes the parameters used as measurements relative to the point where the base is to be fastened.

Table 1. Parameters used for the location of CoastSnap bases.

Beach	West (m)	North (m)	Elevation (m)	Yaw (°)	Pich (°)	Min FOV	Max FOV
Papudo	269,765	6,400,912	3.9	114	10	40	70
Abanico	271,567	6,385,477	4.3	50	10	40	70
Reñaca	262,112	6,348,625	26.1	10	10	40	70
Muelle Vergara	261,405	6,344,533	9.2	35	10	40	70
Caleta Portales	257,584	6,341,986	9.0	67	10	40	70
Algarrobo	252,596	6,306,039	5.3	330	10	40	70
Punta de Tralca	248,640	6,298,134	9.3	20	10	40	70
Rocas de Santo Domingo	255,607	6,275,562	17.5	191	10	40	70

3. Results and Discussion

CoastSnap Implementation in Chile

Eight CoastSnap platforms were installed in the Valparaíso region on beaches (Papudo, Abanico, Reñaca, Muelle Vergara, Caleta Portales, Algarrobo, Punta de Tralca and Rocas de Santo Domingo). Figure 3 shows the locations of the CoastSnap bases.

Figure 3. Locations of CoastSnap bases in the Valparaíso region. (**a**) Papudo beach; (**b**) Abanico beach; (**c**) Reñaca Beach; (**d**) Muelle Vergara; (**e**) Caleta Portales Beach; (**f**) Algarrobo beach; (**g**) Punta de Tralca beach; and (**h**) Rocas de Santo Domingo.

The installation of CoastSnap bases has given communities living in coastal municipalities the opportunity to participate in the collection of high-quality data that are used by researchers and coastal managers to monitor beaches, detect critical areas, and analyze the vulnerability of the coast to coastal hazards [6]. The datasets provided by citizens are reliable and useful for coastal management, geomorphological studies, and the analysis of changes in extreme events [5,6]. As of July 2023, the communities had shared more than 350 photographs through social networks and the CoastSnap app. That has allowed us to know the inter-daily variability of some beaches, the high tide lines, and the impact of a coastal storm. This contributes to the reduction in the enormous gap of data and information existing in coastal areas, which not only benefits scientific work for the understanding of hydro-morphodynamical processes but also enhances the development of indicators and tools for decision making that favor a sustainable and safe development of these areas.

Currently, beach monitoring has been carried out with conventional techniques (GPS, in situ topography) [3,10–13] and recently with satellite images (MONCOSTA, SIMONA Coastal video monitoring). The different methods of coastal measurement are compatible and complementary to each other. For example, MONCOSTA uses optical satellite images that are affected by the coastal trough, which makes monitoring impossible when there are clouds; CoastSnap and SIMONA, the former from images shared by citizens and the latter from video monitoring, can monitor beaches when cloudy conditions do not allow it. Although the CoastSnap initiative was installed in Chile in 2022, the response has been positive on most beaches. The highest number of photos shared by the community occurred in the summer seasons, with a significant increase in photos at each of the beaches from 10 to 50 photos during the season.

Figure 4 shows the beach width results from 4 CoastSnap bases installed in the region, showing average weekly variability: (Figure 4a) Papudo beach 40.5 m; (Figure 4b) Caleta Portales beach 47.2 m; (Figure 4c) Punta de Tralca beach 90.8 m; and (Figure 4d) Rocas de Santo Domingo 43.8 m. At the time of writing, the platform installed in Algarrobo was severely damaged by the coastal storms of August 2023. The remaining platforms are only available for the summer season.

The comparison of shorelines derived from photographs allows us to establish the areas with coastal erosion problems and the volumes of sediment displaced. The results show the coastal dynamics in short periods of time; in this case, one year since the installation in Chile. The images shared by citizens contribute to the construction of data collections that provide necessary information for integrated coastal management and improve the understanding of long-term littoral dynamics, monitoring the changes in land uses, impacts of tidal waves, and the recuperation of beaches before extreme events [6].

Figure 4. *Cont.*

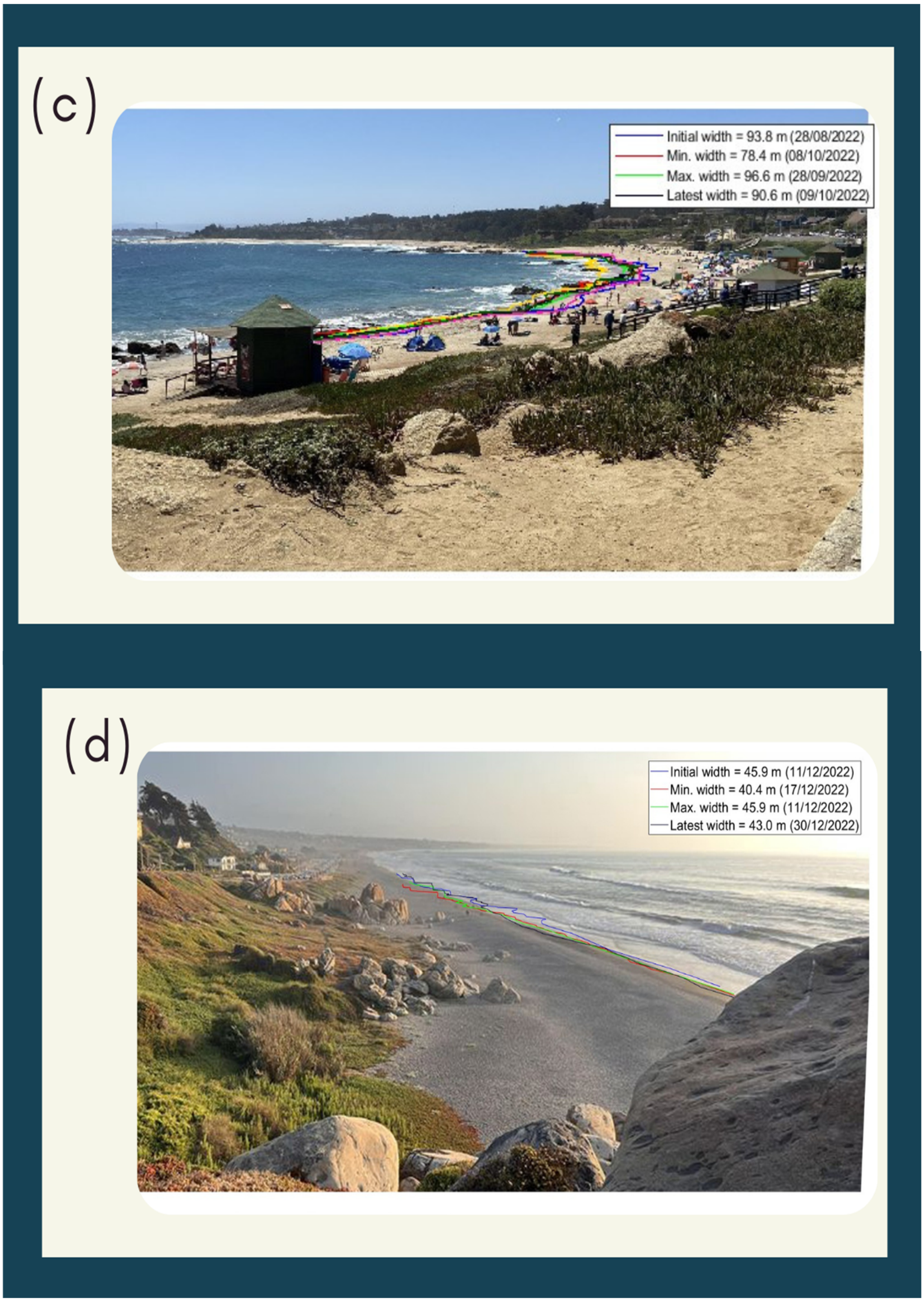

Figure 4. Width of beaches according to CoastSnap. (**a**) Papudo Beach; (**b**) Caleta Portales Beach; (**c**) Punta de Tralca Beach; and (**d**) Rocas de Santo Domingo beach.

4. Conclusions

The CoastSnap initiative in Chile has provided a valuable data set for coastal monitoring. These data complement the monitoring carried out with satellite images, video monitoring, and in situ data. We expect that in the short term, the data from citizen science will allow us to derive relevant metrics and indicators which will allow analysis to support decision-making processes in relation to the integrated management of coastal areas.

Citizen science from the CoastSnap initiative is presented as a long-term data collection method that involves citizens, local governments, and researchers. Although the limited data collection period is approximately 1 year since the first base was installed, the data collected provides robust, accurate, and valuable information for all researchers, local governments, and citizens.

The highest participation is centred on the summer seasons. Significant broadcasting of the program is required to increase the communities' response and consolidate a database with daily records of the coastline.

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