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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 mega-drought 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 affectation of 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. Until July 2023, the communities have shared 350 photographs that have allowed analyzing the variability of the beaches, being able to quantify variations on average of up to 45 m wide in some of their beaches.

Keywords: Coastal erosion; CoastSnap; Citizen science, climate change

1. Introduction

Chile's coastal areas have undergone significant transformations due to extreme events, 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 the 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 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, anthropogenic interventions and contribute to the local management of coastal areas.

To achieve effective local monitoring, we have joined the Coastal Citizen Science

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(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 present dune fields [8]. Eight beaches were selected in the Valparaíso region that were tourist attractions, urban beaches, and beaches affected by plate tectonics, to monitor changes due to anthropic interventions and extreme events (Fig 1).

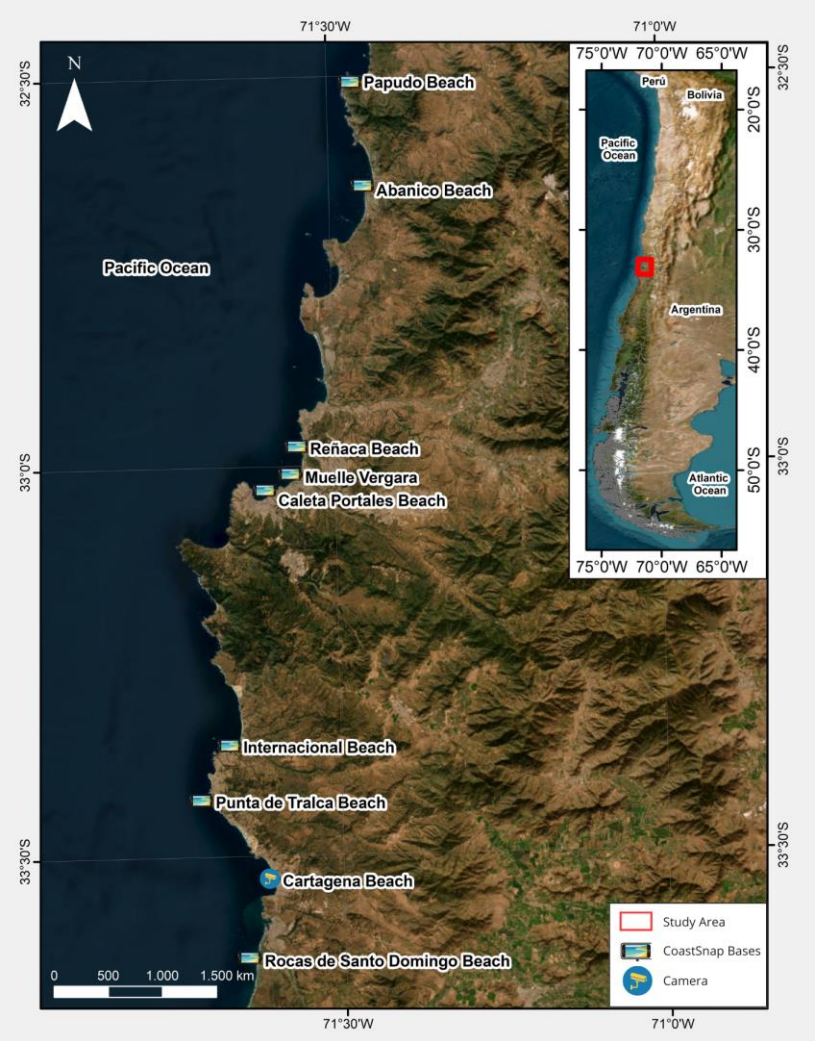

Figure 1. Study area. Located CoastSnap bases in Valparaíso region.

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 taking of angles that will define the direction (yaw) and inclination (pitch) of the cell phone to achieve the expected visual; (ii) request for permits to install the platforms to the councils; (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" and 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) [6, 9], (Fig 2) 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 to install the platforms to the councils; (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. .

Table 1 summarizes the parameters used 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	269765	6400912	3.9	114	10	40	70
Abanico	271567	6385477	4.3	50	10	40	70
Reñaca	262112	6348625	26.1	10	10	40	70
Muelle Vergara	261405	6344533	9.2	35	10	40	70
Caleta Portales	257584	6341986	9.0	67	10	40	70
Algarrobo	252596	6306039	5.3	330	10	40	70
Punta de Tralca	248640	6298134	9.3	20	10	40	70
Rocas de Santo Domingo	255607	6275562	17.5	191	10	40	70

3. Results and discussion

3.1. CoastSnap implementation in Chile

Eight CoastSnap platforms have been 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 located CoastSnap bases.

Figure 3. Located CoastSnap bases 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 is 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 analysis of changes in extreme events [5, 6]. Until July 2023, the communities have shared more than 350 photographs through social networks and the CoastSnap app. That has allowed us to know in some beaches the inter-daily variability of the beach, the high tide lines, and the impact of a coastal storm. This contributes to reducing the enormous gap of data and information existing in coastal areas, which benefits not only the scientific work for the understanding of hydro-morphodynamical processes but also enhances the development of indicators, and tools for decision-making that favors 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 starting in 2022, the response has been positive on most beaches. The highest number of photos shared by the community occurs in the summer seasons, with a significant increase in photos at each of the beaches from 10 to 50 photos during the season.

Figure 3 shows the preliminary results of the beach widths in some of the CoastSnap bases installed in the region, showing the weekly variability of the beach widths on average by Papudo beach de 40.5 m (Fig 3a-d,); 47.2 m by Caleta Portales beach; 90.8 m Punta de Tralca beach and 43.8 m Rocas de Santo Domingo beach.

The comparison of shorelines derived from photographs allows us to establish the areas with coastal erosion problems, as well as the volumes of sediments 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 recuperation of beaches before extreme events [6].

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

4. Conclusion

The CoastSnap initiative in Chile has provided a valuable data set for coastal monitoring. These complement the monitoring that is being carried out with satellite images, video monitoring, and in situ data. We expect that in the short term, the data by citizen science will be able to derive relevant metrics and indicators, which will allow analysis to support decision-making processes in relation to 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 of 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 centered on the summer seasons. Significant broadcasting of the program is required to increase the response of the communities and consolidate a database with daily records of the coastline.

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Conflicts of Interest: The authors declare no conflict of interest.

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