



## Tourism in the COVID-19 context in mesotidal beaches: Carrying capacity for the 2020/2021 summer season in Pehuén Co, Argentina

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### ABSTRACT

As a result of the COVID-19 pandemic, there is an evident decrease in economic activity, especially in the tourism sector. On the southwest coast of the Buenos Aires Province (Argentina), coastal cities base their economy on 3S tourism. In this context, the analysis of social views is crucial for participatory coastal management. As well as the forecast of beach use areas in semi-diurnal mesotidal and low-slope beach conditions, wherein few hours the available beach can double or disappear. Therefore, our objective was to determine the beach's optimal use according to its tides, socio-environmental characteristics, and the perception of the interested parties about the 2020/2021 summer season in the pandemic context in Pehuén Co Beach. We employed camera images (January 2019 and 2020) to obtain the behaviour of normal, spring and neap tides, beach geomorphology, and daily and hourly beach use curves. Online surveys were also conducted with residents, second homeowners, and Pehuén Co visitors about their perception for the 2020/2021 summer season. With this analysis, we were able to divide the beach into four areas according to its potential carrying capacity. During low tide, users' maximum capacity on the beach, respecting sanitary distances, may be 6400 people. Meanwhile, at low tide, this number may rise to 34,000. This information is essential for coastal management after the COVID-19 irruption to ensure maximum efficiency in using the beach maintaining a safe social distance.

### 1. Introduction

The COVID-19 pandemic configures a unique and uncertain scenario for Sand-Sea-Sun (3S) tourism during the 2020/2021 summer season. Argentina has been undergoing a severe health crisis linked to the most extended period of quarantine worldwide. As of November 2020, more than 1,400,000 confirmed cases and more than 36,000 deaths were reported all across the country (Ministry of Health, Argentina<sup>1</sup>); and many provinces are facing the imminent collapse of their health systems.

The appearance of COVID-19 has brought the world to a standstill, and tourism activity is one of the most punished sectors in this "new normality" era (Baum and Hai, 2020; Gössling et al., 2020; Qiu et al., 2020; Neuburger and Egger, 2020; Yu et al., 2020). Most of the coastal areas of Argentina base their economy on 3S tourism and, as a

consequence, all the towns of the coast of Buenos Aires Province are trying to design specific protocols concerning hygiene in accommodation, restaurants, and, specifically, beaches to sustain the summer season in face of the COVID-19 pandemic.

Carrying capacity is defined as the maximum number of people who can visit a tourist destination at the same time, without destroying the physical, economic and socio-cultural environment, and without appreciable impairment of the visitor's recreational experience (WTO, 1981; Coccossis and Parpairis, 1992). Carrying capacity is a fundamental element when designing any activity carried out on a beach. There are different ways to calculate beach carrying capacity, but the methods have changed due to the emergence of COVID-19. Before, the user's comfort and the natural environment's sustainability were prioritised (Cifuentes et al., 1999; Huamantincio Cisneros et al., 2016;

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<sup>1</sup> <https://www.argentina.gob.ar/coronavirus/informes-diarios/reportes>.

Lucrezi et al., 2016; Corbau et al., 2019). Today, the preventive social distancing that averages 1–2 m between people (WHO, 2020) is the chief concern on a beach, where people spend a short time in a static position. For this reason, it is necessary to weigh other natural (i.e., tidal range, sedimentary dynamics, meteorological conditions) and social variables (i.e., social perception of residents and visitors, daily and hourly curve of use of the beach) to know the characteristics of each beach and, in this way, to avoid any harm to environmental sustainability or health and safety (Yepes, 2020a,b; Zielinski and Botero, 2020). In particular, the perceptions of people suffering in places where the economy depends on 3S tourism must be evaluated to anticipate their possible behaviour during the 2020/2021 summer season.

Tourism activity has been explored from the travellers' perspective (Sirgy et al., 2011; Nawijn et al., 2013; Deichmann and Frempong, 2016), from the residents' view (Williams and Lawson, 2002; Ribeiro et al., 2013; Sharpley, 2014; Bichler, 2019; Gursoy et al., 2019; Lee and Jan 2019; Kim et al., 2020), and from the management perspective (Han et al., 2003; Alexandrakis et al., 2015; Armenski et al., 2018; Bin et al., 2020). The increasing interest in understanding residents' attitudes towards tourism responds to the recognition that only mutually beneficial development can prevent latent conflicts and opposition to tourism (Bimonte and Faralla, 2012). Then, the opinions, perceptions, and feelings of both residents and visitors can help decision-makers (DM) to better guide tourism management according to what they consider

relevant, encouraging the successful development of the tourism activity (Dyer et al., 2007; Marin et al., 2009; Vargas et al., 2015).

In this context, we aimed to determine the beach's optimal use according to its tidal conditions, socio-environmental characteristics, and the perception of the interested parties about the 2020–2021 summer season in this pandemic context in the coastal town of Pehuén Co in Buenos Aires Province (Fig. 1), but also if the situation lasts in the future. Since most of the small localities in the Buenos Aires coast replicate a socioeconomic fabric entirely dependent on 3S tourism and, with an economic activity highly concentrated in the summer season, Pehuén Co becomes an excellent example to assess the standard situation for the rest of the province. In this context, we suggest that our findings can be immediately extrapolated to other towns with similar characteristics in this COVID-19 pandemic scenario.

### 1.1. Study area

The coast of Buenos Aires Province is characterised by dissipative to intermediate sandy beaches backed by coastal dunes and Pleistocene cliffs, supporting the 3S tourism that constitutes the base of the economic activity in most of the coastal towns. To the North of the province, the urbanizations are well developed, while in the South the size and population of towns decrease. Pehuén Co is a small town located on the South-Western coast. It has an area of 18 km<sup>2</sup> and 2 km of urbanised

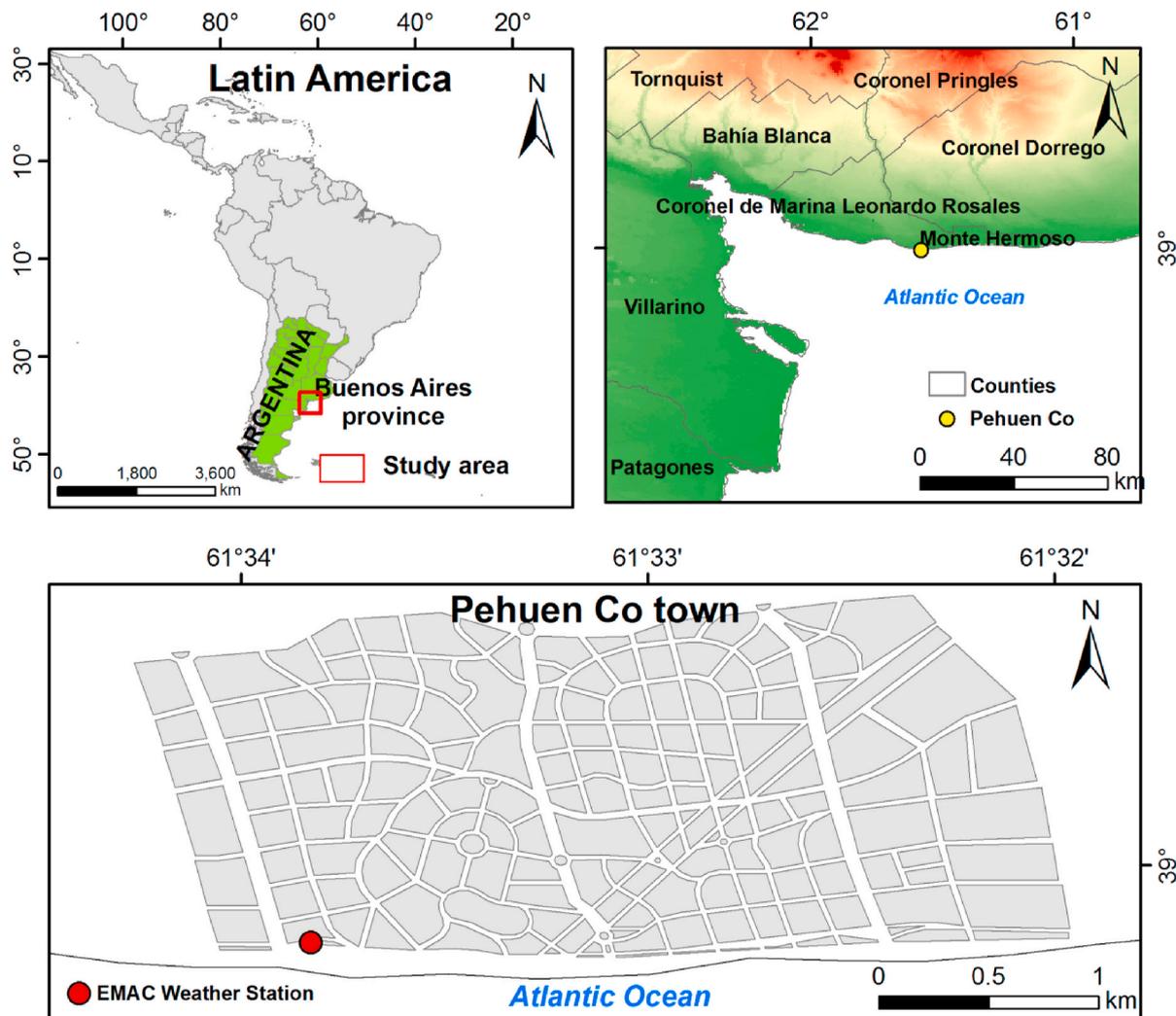


Fig. 1. Pehuén Co within the context of Argentina and South America. The red dot marks the EMAC weather station's site and the cameras employed in the present study. The EMAC tidal station (not shown) is located 4 km to the East of the cameras. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

coastline. The tides are semi-diurnal, with a mean high and low tide of 3.12 m and 0.76 m, respectively (SHN, 2020). The waves' dominant approach is from the South, with average heights of 0.8 m, and average annual seawater temperature is 13.8 °C (Bustos et al., 2016).

The climate is temperate with marked seasons. Temperatures in spring-summer have an average of 16.7 °C, while in autumn-winter, the average is 9.9 °C. The mean temperature in summer is 30 °C while the average water temperature in summer is 21 °C, making it the highest water temperature in Buenos Aires Province. The average annual rainfall in this area is 569 mm/year with alternating wet and dry periods. Typically, the rains are concentrated in spring-summer, decreasing in autumn, and becoming minimal in winter. The prevailing winds are from the N and NW. They have higher intensities in the spring and summer, mainly in December and January. Average annual speed is 25 km/h (Bustos et al., 2016). All these characteristics create a favourable environment for the development of 3S tourism.

Pehuén Co is famous worldwide for its two main attractions. Less than 17 km from the town, Charles Darwin made in 1832–1833 the discovery of the first Megatherium fauna, which provided the initial basis of his theory (Moorhead, 1980). At the beach, but most specifically at a paleontological and archaeological reserve, there is a significant number of well-preserved footprints of the typical Pleistocene fauna (i. e., Megatherium, macrauchenia, sabre tiger, deers, as well as many species of birds) estimated to be about 12,000 years old, but also human footprints dated 6000 BP, all corresponding to a shallow freshwater lake (Aramayo and Manera, 1996).

According to the last census, Pehuén Co had a permanent population of 681 inhabitants (INDEC, 2010), although municipal authorities assert that the current number could reach 800. The town also holds a significant number of homes belonging to non-resident owners, hereafter second homeowners (SHO), which is estimated at 2,200, mostly belonging to inhabitants of other towns of Coronel Rosales and the neighbouring counties of Bahía Blanca and Coronel Dorrego (Fig. 1). Although these SHO visit Pehuén Co periodically all along the year, the major affluence of tourism occurs during the summer season. However, in the last 5–10 years, the number of visitors in other seasons has increased steadily. Such affluence of tourists becomes the main driver of the local economy: the authorities estimate 300,000 visitors arrive each summer season (40,000 in December; 160,000 in January, 100,000 in February). Consequently, the town is entirely prepared to host a large number of visitors, offering accommodation and gastronomic facilities to support tourism activity.

## 2. Methodology

We followed two lines of research and then cross-referenced their results. Our estimates were submitted to the local authorities to establish more specific protocols, guiding their time and space efforts. First, we characterized the beach and its conditions to receive the expected number of visitors adequately. Then, we explored the socio-environmental aspects of the beach and the perception of the stakeholders regarding the 2020/2021 summer season.

### 2.1. Socio-environmental aspects

The summer seasons of 2018/2019 and 2019/2020 were characterised by ca. 300,000 tourists each, mostly concentrated in January. For that reason, and due to data availability, we based our study on this month's description, when the tourists' affluence makes the management more necessary in this pandemic context.

First, it was necessary to determine the usable beach area along the day. We calculated the area of the beach hourly from the foredune to the water level. Since the tides are semi-diurnal with a mesotidal range, the usable area varies significantly. Sometimes, the maximum influx may coincide with the largest area, but the situation reverses in others. Therefore, different strategies must be employed depending on the

available beach. To determine the height of the tides measured and observed in Pehuén Co, photographic images were used, obtained by two permanent monitoring RGB Cameras located at the EMAC weather station tower (20 m height). They point to the West (CW) and East (CE), respectively (Fig. 2). Photos were taken every 30 min. The procedure for each photo is as follows: the camera takes two pictures per second (2 Hz) for 2 min, then a microcomputer at the tower makes an average of each pixel's RGB values. Therefore, the image we employed is a 2-min average of the beach. The ground-true area was delimited with at least 5 points defined with a differential GPS RTK within the range of the camera, and simultaneously marking the position of these points in the camera's frame buffer, according to the procedure adopted by Huamantincó Cisneros et al. (2016) (Fig. 3a and b). In each image, we mapped the waterline using colour change detection algorithms (Fig. 3c). We obtained reprojected images from the polygon formed by the georeferenced points and used a two-dimensional projective transformation that allowed us to establish a meter/pixel scale (Fig. 3d). Using this scale, we calculated the distance between the mapped water line and the georeferenced point in the foredune, allowing the beach area calculation. To estimate the area Available per User (ApU), every 60 min, we calculated the actual available area and divided it for the number of people on the selected area.

In the images, a rectangle 120 m wide by 87.5 m long was delimited considering the intertidal zone (Fig. 3a and b). Also, with the images, we analysed the days of spring and neap tides. Photographic data was correlated with the information about tides obtained from the EMAC station located on the beach at 4 km to the East of the study area, complemented with the tidal prediction for the area from the Argentina Servicio de Hidrografía Naval (SHN, 2020). To observe the influence of beach geomorphology, the tides' behaviour was analysed based on the space available for beach users. In this way, we compared the predicted and measured rise and fall of spring and neap tides. We considered the tides of January 2019 that coincided with a weekend day at or close to spring or neap tides.

This type of analysis is needed because the beaches along the SW of Buenos Aires Province have, in most cases, low slopes (on average 1–3°). Therefore, the tides play a significant role in the beach's effective area that can be employed by the beach users along the day. Also, we compared the days where climatic conditions were similarly based on data obtained from the EMAC weather station (Fig. 2).

As in any natural environment, especially on semi-diurnal, mesotidal beaches, there are no fixed lines that can delimit an area and, consequently, how many users can be at both low and high tide situations. Therefore, we analysed data from the images of weekends (Friday to Sunday) and, as a representation of the week, Wednesdays. In this way, we identified accesses to the beach that could be enabled, usable areas of the beach, state of the foredune, and maximum load capacity, taking into account the tides and a fix area of 6 m<sup>2</sup>/person to include circulation corridors and accesses to the beach, among others. With the images, we determined the hourly and daily occupancy curves in the last two summer seasons.

### 2.2. Social perception

In order to assess the perception of residents (R), SHO, and visitors (V) of Pehuén Co, we performed a semi-structured questionnaire survey for each of the groups. The questionnaire contained both close-ended or categorical, and open-ended questions, allowing respondents to express freely their opinions and suggestions about the topics. The anonymous survey was conducted between July 31 and September 7, 2020 completely on-line due to the quarantine measures. In order to reach maximum diffusion, we shared the questionnaire, designed on Google Forms, on the most popular social networks (Facebook and Instagram) repeatedly during such period, using both personal and institutional accounts to disseminate the survey as widely as possible. In parallel, we sent the questionnaire via e-mail to key stakeholders who contributed to



Fig. 2. Coastal Environmental Monitoring Station - EMAC (for its acronym in Spanish). Image A shows the tower in which the EMAC is located; Image B shows the permanent monitoring cameras to the E (CE) and W (CW). Image C is the meteorological station.

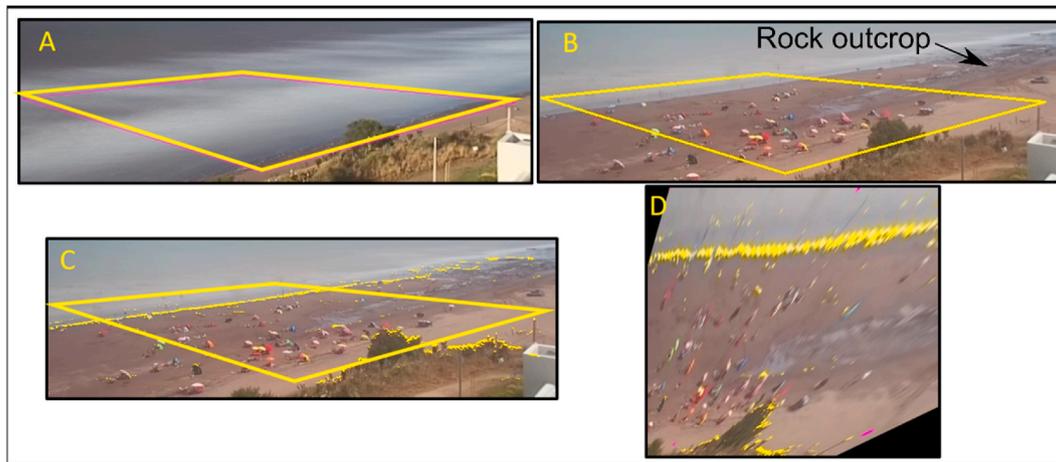


Fig. 3. Example of the type of photographs taken by the CW camera, the yellow square delimits the sampling area. Examples of high (A) and low (B) tidal stages. Yellow line identifies the waterline (C) rectification to obtain the meter/pixel scale on the plane (D). Although difficult to see in these images, there are some small rock outcrops in the low-tide (B) photo. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

disseminate it, such as the Pehuén Co Neighbourhood Association, the civil group “Defensa del Médano Costero”, and other social references of the town. Although, we did not reach such a high sample size, we consider that the obtained answers are valid to infer social perception, mainly considering the selection bias related to the only spread strategy suitable in the pandemic context. Furthermore, based on previous surveys made by our group, we had much higher responses than from those experiences (Waylen et al., 2015; London et al., 2017) with the same population.

In sum, the questions sought to address the main issues raised in the COVID-19 pandemic scenario, such as how the beach should be opened, how people will react in case of taking some measures to diminish the risk of contagion, and who must be in charge of deciding how the beach should be managed next summer seasons.<sup>2</sup> Once processed, we related the information to the available environmental data and used it to guide better our suggestions on managing the beach in Pehuén Co during the 2020/2021 summer season with COVID-19.

### 3. Results

#### 3.1. Environmental conditions

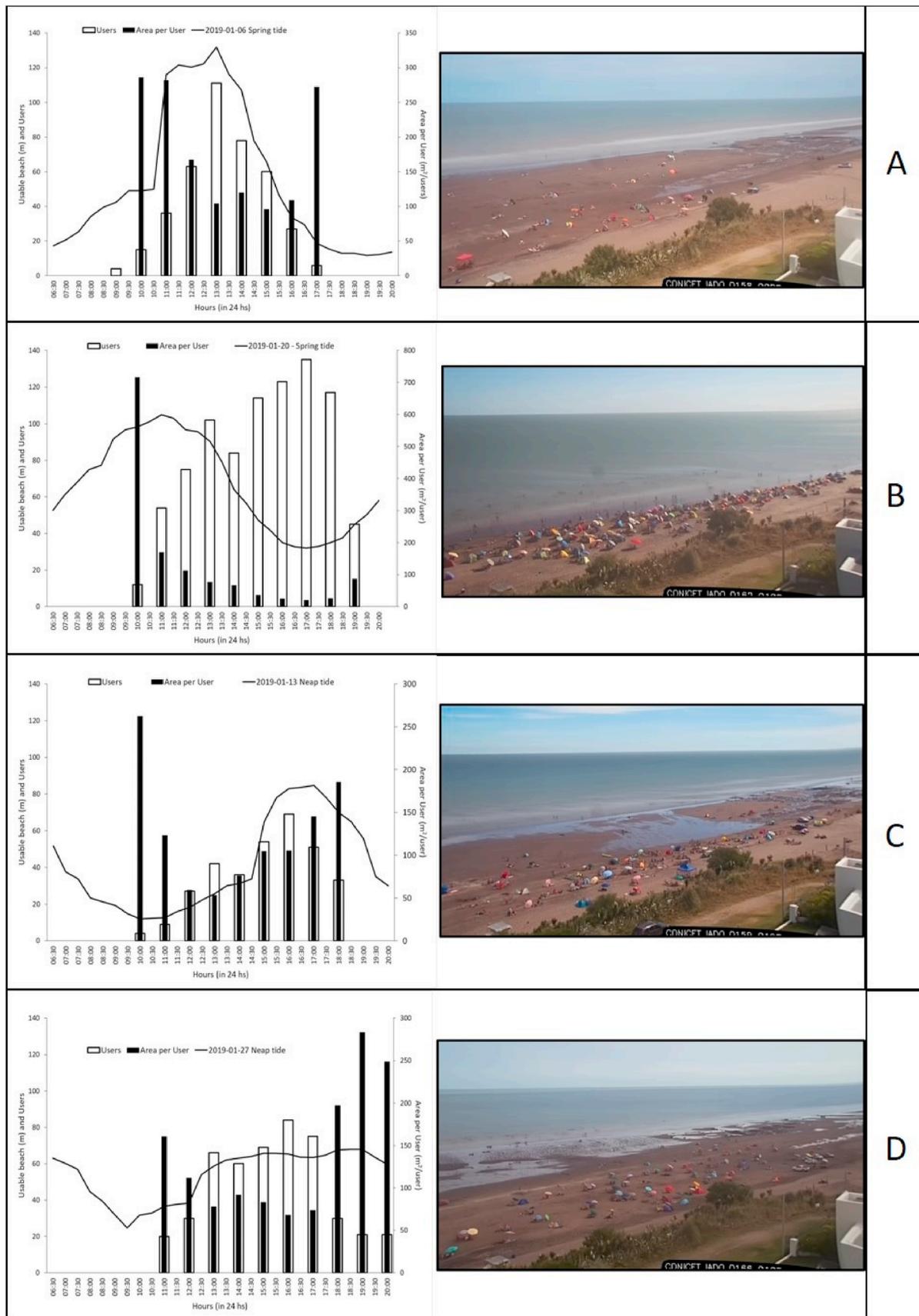
To establish adequate beach usage strategies, we need to have in-depth knowledge of the beach’s geomorphologic and dynamic conditions. Low slope beaches with significant tides need completely different

management strategies than, for instance, reflective microtidal beaches. Also, the characteristics of the town, including the distributions of streets, beach accesses, parking facilities are, among other issues, essential in defining those strategies.

Another fundamental factor on the beaches of the Argentine coast is the tide. The beach width difference between high and low tides can exceed 100 m (in some places maybe even 200–400 m). Wind conditions tend to be relatively strong, which may induce significant changes both in height and time of occurrence of the tide, compared to those forecasted (Perillo and Piccolo, 1991). The beach’s geomorphology also plays a significant role in how it can be used by the tourist. Beaches tend to widen or shrink frequently due to storm or fair-weather conditions, changing the area available for some activities. For instance, days with strong winds could be perfect for those interested in windsurf, but sun-bathing tourists usually find them inadequate for their purpose. Another geomorphologic factor, which is common in many beaches of Argentina, is rock outcrops (Fig. 3b). Those sectors reduce the potential area for user location. Since the size of the rock outcrops also varies with the dynamic conditions, the usable areas’ actual values may also change. Therefore, the strategies provided to the authorities require continuous surveillance of the beach features as well as decisions taken as conditions vary.

When we analysed these factors, in the days we did our study, there were no winds that exceeded 40 km/h for more than 2 or 3 h; thus, there was no significant influence on the tides. Spring tides took place on January 6 and 20 (Fig. 4a and b). According to the tidal forecast on the former day, the difference between high and low tide was 2.6 m, and the observed maximum distance between the water levels was 119 m. On

<sup>2</sup> Full questionnaire available under request.



**Fig. 4.** Graphs showing the width of the beach available for use (m), number of beach users per hour and area (m<sup>2</sup>) ApU in Pehuén Co (A) on January 6, 2019, Image: January 6 at 1 p.m.; (B) on January 20, 2019, Image: January 20 at 5:30 p.m.; (C) on January 13, 2019, Image: January 13 at 4 p.m.; (D) on January 27, 2019, Image: January 27 at 4 p.m.

this day, the time of maximum space for the beach's use coincided with the one with the largest number of V to the beach (1 p.m.), so the average area ApU was 104 m<sup>2</sup> (Fig. 4a). On the contrary, on January 20, high tide coincided with the maximum number of users (5:30 p.m.), but the beach's distance was only 30 m (Fig. 4b). Which gave an ApU of only 21 m<sup>2</sup> (Fig. 4b).

Neap tides occurred on January 13 and 27. Both days coincided with a Sunday (Fig. 4c and d). On January 13, the difference between predicted high and low tides was 2.4 m and the maximum available beach width was 73 m (Fig. 4c). The ApU was always high because at high tide the users were just beginning to reach the beach, and the most significant influx was at low tide with more beach availability and an average ApU of 124 m<sup>2</sup> (Fig. 4c). On January 27, the tide was influenced by geomorphology. The forecast of the tidal difference for that day was 3.6 m. However, the high tide did not rise as expected. It occurred in the morning without users on the beach, so it did not influence the beach's use (Fig. 4d). Meanwhile, during low tide a wide channel prevented users from enjoying all the potential areas (Fig. 4d). In the hours of the greatest influx of beach users, coinciding with low tide, the average ApU was 68 m<sup>2</sup> per user. One of the lowest due to the little available area left by the low tide (Fig. 4d).

Another significant issue in defining how many users are at the beach at a specific moment is the climatic conditions. In summer, Pehuén Co (as well as many coastal towns) is affected by strong sea breezes between 1 and 4 p.m., with winds sometimes higher than 20 km/h from the SE (Huamantín Cisneros and Piccolo, 2011; Bustos et al., 2011). Similarly, being a temperate region, weather conditions can change rather abruptly along the day from sunny to stormy in a matter of hours. Both conditions occurred on January 13 and 27, which affected the number of users even for days in which typically one expects very high numbers to tourists.

Clearly, beach geomorphology combined with the tidal range and time of high and low tide, affects significantly the ApU values that one can estimate. Climatic conditions in such a place where changes may occur rather suddenly are factors in designing strategies for the best way to use the beach during pandemic situations.

### 3.2. Social conditions

When we analysed the hourly and daily use curve of Pehuén Co Beach (Fig. 5) we found that 37% of the V went on Sunday, followed by Saturday (31%) and Friday (25%). We did not account for weekdays for this study because they represented only 7% of total visits. Through Fig. 5, we estimated the hourly occupation curve of the beach. The beaches remained empty between 6 and 9 a.m. Starting at 9 a.m., would commence a slow arrival of the people until 11 a.m. In this period, mostly single individuals were observed, with low occupation density, grouped in a maximum of three people.

After 11 a.m. and until approximately 4 p.m., a significant arrival of people was observed. People began to group into five or more individuals, reducing the effective occupation area. Usually, they were grouped under tents or umbrellas. For each of them, we estimated an average of 3–5 people. The increase in density coincided when the ApU being reduced due to the rising tide.

The maximum occupancy occurred at 4 p.m., except on Fridays where the average curve flattened, and the maximum occurred at 5 p.m. This curve (Friday) showed the highest visitor arrivals after lunchtime, probably because V worked Friday morning. They stayed until sunset (Fig. 5).

There were differences between the curves for the three days on the weekend. On Fridays, the maximum occurred at 5 p.m., but the occupation curve's flattened from 12 a.m. to 6 p.m. On the other hand, on Saturdays and Sundays, there were two maximum arrivals, the first, between 12 a.m. and 1 p.m. (coinciding with lunch) and the second and more significant at 4 p.m. Normally it is the time that younger people go to the beach. The shorter stay time of V was more visible on Sundays (4 h) than on Fridays and Saturdays (5 h). The shorter stay on Sundays, particularly for the daily V, is due to severe traffic congestion that happens those days since many other towns along the coast use the same highway to return home. Therefore, many people try to avoid long hours on the route.

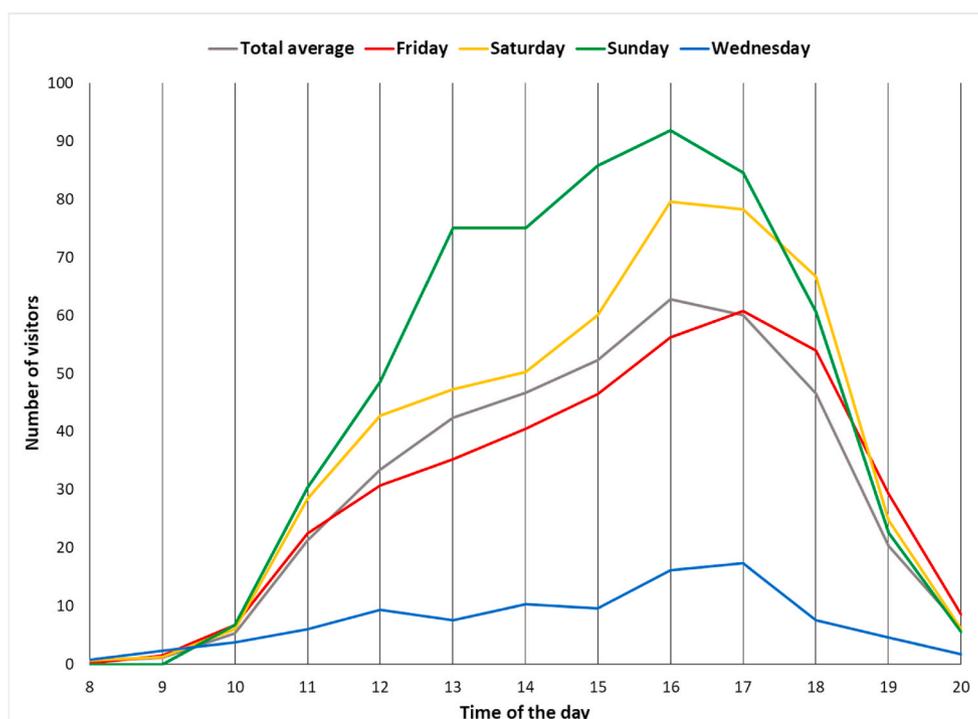


Fig. 5. Hourly and daily use curve of Pehuén Co Beach for Wednesdays, Fridays, Saturdays, and Sundays of the last two summers.

### 3.3. Perception analysis

Regarding SHO and V, decisions about controlling their entrance to Pehuén Co and the beach will be the cornerstone of the 2020/2021 summer season. Up to December 2020, the access was forbidden for R of the Bahía Blanca county (unless they are SHO), origin of most V and SHO, which was at such moment facing a challenging health situation in terms of COVID-19 contagion. In this sense, the pandemic's growth in the near localities will be crucial for developing the town's summer season.

The survey was answered by 61 R, 205 SHO, and 217 V. More than 80% of the SHO lived permanently in Bahía Blanca (49%) and Punta Alta (34%), the head city of the Coronel de Marina Leonardo Rosales county. These cities also concentrate 80% of the V (64 and 16%, respectively), so the health situation there is critical in determining their possibility to visit Pehuén Co.

The three groups shared a very similar profile, mostly dominated by women (59, 53, and 64% for R, SHO, and V, respectively). Regarding age, almost 40% of R's sample was more than 61 years old, 33% was between 41 and 60, and 28% was between 21 and 40. This distribution varied slightly in the sample of SHO and the V's sample. R and SHO were asked about the dependence of their jobs on tourism activity. The results indicate that the employment of 69% of R and 89% of SHO was not related to tourism. In comparison, 21 and 5% had employment indirectly related, and only 15% of R and 5% SHO directly depended on tourism activity.

Asked about the upcoming summer season (2020/2021), only 7% R and 5% V believed that beaches should be closed, while 21% R, 42% SHO, and 38% V suggested that beaches should be opened normally. The intermediate solution of allowing access to the beach with distance limitations was the more selected option among R (64%), SHO (49%) and V (47%). Finally, the opening of only specific areas was less preferred (25, 14 and 14%, respectively for each sub-sample). These results suggest that, despite the COVID-19 persistence, most of the respondents supported the idea of opening the beach in the 2020–2021 season as well as implementing measures to diminish the affluence of tourists to minimize the risk of contagion. Logically, these results could be subject to sudden changes in public perception related to the evolution of the COVID-19 pandemic itself, which is nearly unpredictable. Nevertheless, knowing that people are willing to visit the coast, in this particular context, constitutes a vital starting point to encourage authorities to design and propose protocols to make the beaches safe places to visit during the 2020/2021 summer season.

Besides the opinion about the ideal beach management according to users' perception, the survey also asked about their willingness to go to the beach in any proposed management scenarios. In Pehuén Co, 15% R, 4% SHO, and 8% V answered that they would not go to the beach under any circumstance. These numbers are slightly higher than those for people who answered that beaches should be closed, which indicates that no matter how the beach is managed, a small percentage of people would not visit the beach anyway. Once again, most respondents would be willing to go to the beach if distance restrictions were imposed (61% R, 58% SHO, and 51% V), while opening the beach only in certain areas was a markedly less selected option.

Although people agreed with re-opening the beach next summer, the authority in charge of deciding about beach management is not completely clear in this context. From the beginning of the mandatory quarantine, which was ordered at the national level, a wide range of measures was implemented at the provincial and local level, according to the faculties that national authorities were granting to lower levels of governments, to adjust the restrictions to each particular health situation at the local level. The unprecedented quarantine duration in Argentina also generates the overlap of norms, problems related to mobility restrictions among different jurisdictions, and a certain degree of confusion about each DM's role in the pandemic management. Asked about who should decide how to manage the beach on the 2020/2021

summer season, 77% R, 73% SHO, and 67% V considered that municipal authorities should be in charge of designing measures, followed by experts and scientists (70, 52 and 67%, respectively). The role of R as DM becomes particularly interesting in this context, in which the opinion of local populations should be especially considered to decide about the next steps for managing the beach. Nevertheless, just a small portion of the sample consider that the R should decide the beach management strategy in isolation (5% R, 2% SHO, and 3% V). This result is also valid for the case of only experts and for the combination of experts and scientists plus R (which also exclude any governmental level in the decision-making process), strengthening the government authorities' role in this pandemic context.

The results of our perception analysis reinforces the need to developing a specific beach management strategy for the 2020/2021 summer season in Pehuén Co. Not only the willingness to visit the beach despite the COVID-19 situation, but also the stakeholders' expectations about the participation of the scientific community in the decision-making process, reveal a clear social demand for an adequate beach management based on environment conditions for using the beach as safely as possible.

### 3.4. Beach carrying capacity for the 2020/2021 summer season

Based on the exposed results, we identified beach sectors with similar characteristics and inter-tide beach areas (Table 1) where we integrated the data for easy visualisation. Although, as already demonstrated, the intertidal area depends on several conditions, it is necessary to have an average number to design strategies. Therefore, from Google Earth images and data from previous studies (Bustos et al., 2011; Bustos et al., 2016), we estimated that, on average, the distance from high tide to low tide is 60 m along the whole town. We then divided the areas where the average high tides left a distance from the foredune to the water <5 m, 5–10 m, 11–20 m and >21 m. Towards the W of the town (Fig. 6) there are some incipient neighbourhoods with little urban development that do not concentrate significant numbers of V to the beach. Towards the E, after the last urban descent, the area of the Provincial Natural Reserve begins.

With this information, we estimated that, during high tide, the whole beach could support a maximum of 6400 users with insufficient spacing and corridors for movement. The beach area with less than 5 m is socially and naturally sensitive, and beach users should not be allowed to stay there due to the narrow width. As for areas with lengths of 6–10 m, these should be restricted to a single user line. With 10 or more meters of the usable beach during high tide, it could be opened to a larger number of users, giving priority to groups of 5 or more members. In low tide hours, the maximum capacity rises to 35,000 users (Table 1).

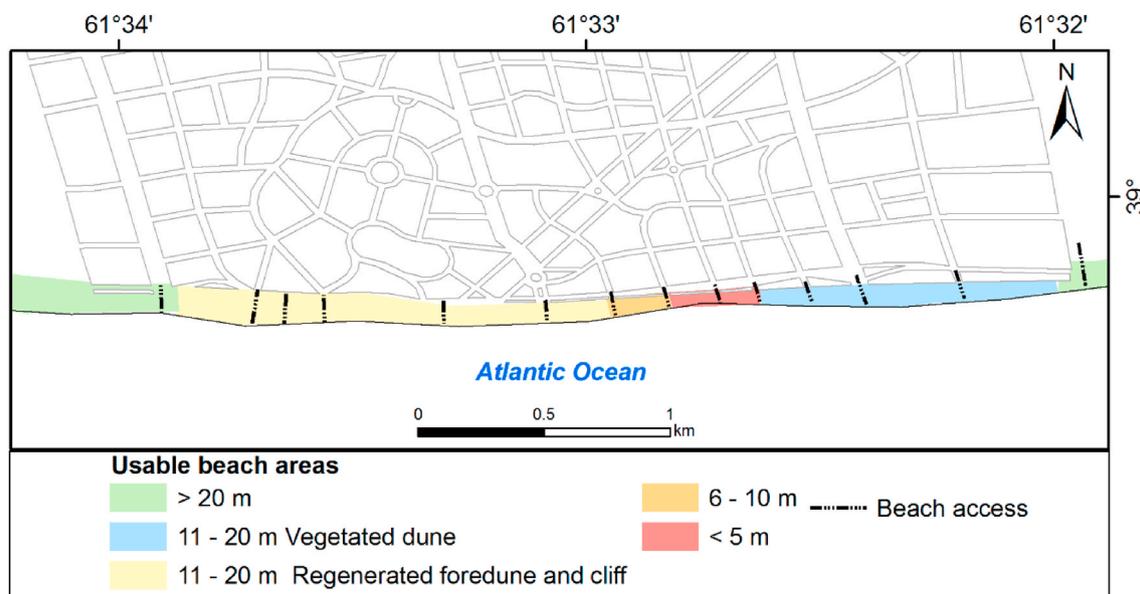
## 4. Discussing contributions for the management of beach use

From the perception analysis, we conclude that, despite the COVID-19 pandemic situation, most R, SHO, and V of Pehuén Co were willing to visit the beach during the 2020/2021 summer season, therefore, designing safety protocols became an urgent need. Also, a high percentage responded that the beach should be opened without any type of restriction. Such actors could hinder the compliance of the health protocols: the V who consider that the measures are unnecessary and the tourism providers. The latter face an evident conflict of interests between the costly implementation of COVID-19 measures and their need to increase the income along the season, after suffering enormous economic losses due to the extensive lockdown period. In this context, the challenge before the launch of the first summer season with COVID-19 was twofold: designing health protocols to manage the beach according to environmental conditions and searching mechanisms to guarantee adequate enforcement of such measures.

In Pehuén Co, like several localities on Buenos Aires' coast, erosion is a fundamental problem. In recent years, various techniques have been

**Table 1**  
Usable beach areas, characteristics, and the maximum carrying capacity for Pehuén Co beach.

Distance foredune to water at high tide	# of accesses	Foredune condition	Extension (m)	Average width Usable beach at high tide (m)	Usable beach area (m <sup>2</sup> )	Maximum carrying capacity (individual per 6 m <sup>2</sup> )	Average width usable beach at low tide (m)	Usable beach area (m <sup>2</sup> )	Maximum carrying capacity (individual per 6 m <sup>2</sup> )
>21 m	2	natural dune	200	30	6000	1000	90	18000	3000
11–20 m	9	vegetated dune	700	12	8400	1400	72	50400	8400
	7	regenerated foredune and cliff	1400	15	21000	3500	75	105000	17500
10 to 6 m	3	vegetated foredune and tourist trade	450	7	3150	525	67	30150	5025
<5 m	1	rebuilt foredune	170	0	0	0	60	10200	1700
<b>TOTAL</b>	<b>22</b>		<b>2920</b>		<b>38550</b>	<b>6425</b>	<b>364</b>	<b>213750</b>	<b>35625</b>



**Fig. 6.** Access to the beach and usable beach areas in Pehuén Co.

implemented to mitigate its impact in this locality and in other areas of the province (Diez et al., 2007; Merlotto et al., 2016, 2017; Isla et al., 2018). In Pehuén Co, specifically, the mitigation of the foredune’s erosion is decisive for the beach evolution. The beach’s impact and recovery after storms are better where there are well-developed foredunes with vegetation cover and very slow where there are pedestrian crossings perpendicular to the beach over the dune (Bustos et al., 2016). Therefore, users cannot use the foredune, and the access point must also be controlled. Some private owners have recently made stairs and ramps across the foredune in the most vulnerable to trampling impacts areas. The municipality should add more of these access points to the beach along the entire coast.

The methodology applied here can be readily transferred to different beaches, knowing the particular behaviour of users and their natural characteristics of each beach sector, especially those where the beach’s width is not enough for large numbers of users. In the same locality, the coast must be zoned according to its characteristics. Pehuén Co must control users’ maximum capacity per zone, doubling the reinforcement of rules on Fridays and Saturdays, and tripling them on Sundays, especially between 11 a.m. and 6 p.m. People have shown confidence in municipal government decisions and will, therefore, be more pleased with the measures they impose. Furthermore, R, SHO, and V agree on the significance of the scientific opinion for supporting beach management decisions in this specific context and always hand in hand with governmental authorities and not in isolation. This finding appears in

line with the idea of co-production of knowledge promoted by Pohl (2008), Cummis and McKenna (2010) and Cornwell and Campbell (2012), among many others. Such developments reinforce the role of transdisciplinary research as the driving force of the decision-making process behind beach management.

The total influx of V to the Argentinean beaches will probably be higher in the 2020/2021 than in other seasons because people who used to make international trips have mostly decided to travel inside the country. As the travel risk perception studies affirm, it is essential to develop safety and health measures in domestic tourism, so that tourists feel safer and, in this way, reduce their perception of risk (Neuburger and Egger, 2020; Prideaux et al., 2020). Undoubtedly, all these factors should be widely considered in any effort to manage the beach as safely as possible in this new health context, minimizing the risk of contagion and granting security to R and V about the accomplishment of health and hygiene protocols against the COVID-19 spread (Neuburger and Egger, 2020).

In February of 2021, still over the course of the first summer season post-COVID-19 appearance, we still do not have access to reliable data about the results of distance restrictions and other measures imposed due to the COVID-19 advance. In spite of this, and besides the evolution of the pandemic, our recommendations about the use of the beach can be useful to guide the beach management in Pehuén Co also for future seasons.

## 5. Conclusions

Pehuén Co's coast holds a particular environment, a specific type of tide, and a single social dynamic, which is replicated over many coastal towns of the Buenos Aires Province. The influence of tidal range and beach geomorphology can significantly impact the management decision about how many users can be simultaneously at each specific sector of the beach. In this sense, our findings can be useful for other localities also dependent on tourism activity sharing similar characteristics.

Aimed to determine the optimal use of the beach during the first post-COVID-19 irruption, we explored the social perception of R, SHO and V of Pehuén Co about the season, their willingness to visit the beach under different management scenarios, and their opinion about who must be in charge of deciding the beach management in this unprecedented context. Our results indicated that 64% of R, 49% of SHO, and 47% of V who completed the questionnaire consider that the beach should be opened with distance limitations. In comparison, 61%, 58%, and 51%, respectively, affirm that they will visit the beach in case of facing distance measures. Moreover, 77% R, 73% SHO, and 67% V considered municipal authorities to be in charge of designing measures, followed by experts and scientists (70, 52, and 67%, respectively). Thus, while the government authorities' role becomes critical in this pandemic context, the scientific community's support seems necessary to design a management strategy aimed to minimize the risk of COVID-19 contagion.

Regarding environmental conditions, guaranteeing a carrying capacity invariable in time and space is complex in mesotidal beaches. Both the geomorphology and the range and time of occurrence of the tides affect the beach's width and, consequently, the area available for users throughout the day. After analysing camera images from previous seasons, and the tidal range, we estimated the beach carrying capacity in Pehuén Co, respecting social distance, resulting in a maximum of 6400 users at high tide and 35,000 users at low tide. In addition to the access points to the beach and the greater vulnerability of the foredunes in some areas, it was possible to divide the town's coastal area into areas of greater, lesser, and no user entry capacity.

Undoubtedly, finding strategies to managing the beach safely was an urgent need previous to the first summer season with COVID-19. Nevertheless, we generate the information to guide decision-makers and beach users to make more sustainable use of the coastline henceforth, beyond the persistence of the pandemic context.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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