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Short communication

The 2010 tsunami in Chile: Devastation and survival of coastal small-scale fishing communities

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ABSTRACT

In 2010, a tsunami generated by a magnitude 8.8 earthquake struck the central-south zone of Chile. This short communication reports the direct impacts on the small-scale artisanal fishing capacity and coastal livelihoods along approximately 600 km of the coastline. Despite the magnitude of the catastrophe, the absence of official warnings, and the failure of telecommunication networks only 8 fisher victims were reported out of a total death toll of more than 170. Results show that this trend is explained by socio-cultural assets and a natural hazard subculture. This highlights the need to integrate contextual and behavioural approaches in disaster management and rehabilitation policies.

1. Introduction

On February 27th, 2010, at 3:34 AM, a magnitude 8.8 earthquake, the fifth largest instrumentally recorded, struck the central-south zone of Chile [1]. Major tsunami waves hit the coast in the following 14 min–2 h [2], devastating coastal villages and fishing coves *caletas* along 600 km of coastline (33°36′S–38°28′S). The tsunami was particularly destructive for the artisanal small-scale fishery sector, in an area that accounts for around 27% of the artisanal workforce and 47% of the national artisanal catch [3]. The devastation and environmental modifications pose great social, economic, and policy challenges for a sustainable rehabilitation of the activity. Surprisingly, despite the magnitude of the catastrophe (Fig.1), the absence of early official evacuation warnings [4], and the failure of communication networks [1], out of an estimated population of 75,000–80,000 artisanal fishers and their close relatives, only 8 fisher victims were reported (Table 2). This suggests well-established responding capacities in these fishing communities at times of unpredictable natural hazards. Here, immediate impacts on the small-scale fleet, gear, and equipment are first reported; second, the survival of inhabitants of fishing communities, and finally the role and effectiveness of natural warning signals (for example, earthquake shaking), human-made warning systems (for example, emergency alert systems), and socio-cultural assets (for example, place based knowledge and social networks) on fishers' tsunami preparedness/responsiveness are analysed. Insights are expected to inform the post-tsunami fishery rehabilitation process, and design broader warning systems and disaster management policies in Chile.

2. Methods

Grassroots information about the impacts, behavioural response, and relevance of different warning systems was gathered between the second and eighth week after the tsunami event. The sample was obtained based on extensiveness criteria and the goal was to cover as many cases as possible in a short time (Table 1). In a first step, more than eighty fisher leaders from fifty-nine coastal

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fishing villages were surveyed about human victims and material damages by a team formed by the Confederación Nacional de Pescadores Artesanales (CONAPACH)—Corporación para la Educación, Desarrollo e Investigación de la Pesca Artesanal de Chile (CEDIPAC) and academics from the Pontificia Universidad Católica. Later, forty-one of them were interviewed (either personally or telephonically) by the research team to explore key factors of fishers' rapid evacuation. This was based on a semi-structured questionnaire that openly asked first "how did you know that a tsunami may occur and that you had to escape?". Then, interviewees were asked to score (in a Likert type scale) the relevance of a list of factors initially identified on the field (for instance, the observation of the sea, informal warnings, and local official alerts).

3. Impacts on the small-scale fishing capacity

Artisanal fisheries in Chile are highly heterogeneous in terms of target resources, equipment, and gear. Moreover, despite the existence in Chile of an Artisanal Fishery Register, including fishers, boat owners, and vessels (small, medium, and larger size boats or "lanchas") [5], specific information about fishing gear and other equipment, such as nets, out/in-board engines, air compressors, diving suites, and GPS, is unavailable. Thus, an accurate assessment of the net impacts of tsunami on the small-scale artisan fishing gear and equipment is difficult. Nevertheless, based on the destruction of artisan vessels, the tsunami damages represented between 50% and 60% of the fishing capacity within the tsunami affected zone (Table 2). But a detailed field assessment shows multiple regional specific realities and is worthwhile to be highlighted:

- The impacted coastal zone of the Chilean VI Region [5] of O'Higgins is intensive in inshore seaweed gatherers (such as luga/*Mazzaella laminarioides*, chasca/*Gelidium* spp., and cochayuyo or bull-kelp, *Durvillaea antarctica*) [6]. The activity is based on coastal seasonal settlements, called *rucos*. Critical material losses in the region consist of these temporary homes, diving suites, and the latest ready-to-sell harvests.
- The impacted coastal zone of the Chilean VII Region of Maule concentrates a large number of fishers in two categories of vessel: out-board engine boats (less than 8–10 m), targeting demersal species (for example, merluza or Chilean hake/*Merluccius gayi* and in-board engine "lanchas" less than 18 m long [5], targeting pelagic species (for instance, reineta or southern rays bream/*Brama australis*, bacalao or patagonian toothfish/*Dissostichus eleginoides*, congrios or cusk-eels/*Genypterus* spp., and albacora or swordfish/*Xiphias gladius*). Here, critical fishing material damages were vessels, engines, and fishing nets.
- The impacted coastal zone of the Chilean VIII Region of Bio Bio is one of the most important and diverse fishing zones of Chile, with more than 60% of the national artisanal catch of fish and 45% of benthic invertebrates. The region has an important labour-intense artisanal pelagic fleet (maximum length of 18 m and 50 gross tons), targeting species like sardina común or pilchard/*Sardinops sagax,* anchoveta or anchovy/*Engraulis ringens*, jurel, or jack mackerel/*Trachurus symmetricus*. In this region, massive damages affected all categories of vessels (particularly small boats), fishing nets, longlines, and diving equipment.

Beyond the mentioned impacts on the fishing capacity itself, severe damages on basic port infrastructure and services were also reported by national authorities (Dirección de Obras Portuarias, DOP), such as docks, dams, landing platforms, and cranes. Moreover, many fisher organizations in the tsunami hit zone lost their offices, storage lockers, stores, and restaurants. As in other massive tsunami, such as Sri Lanka's 2004 [7], artisanal fishing communities were among the most affected coastal groups. In summary, in Chile following the tsunami of February 2010, the livelihoods of more than 24,000 fisher households were directly or indirectly affected.

Fig. 1. Post-tsunami scene in Caleta Loanco, VII Region of Maule.

4. Key triggers and factors of effective tsunami evacuation

Results show that human-made warning systems, such as authorities' and radio alerts, failed drastically at the time of the tsunami catastrophe (Fig. 2). Formal emergency training by the national emergency agency (Oficina Nacional de Emergencia, ONEMI), the navy, or municipalities at coastal localities was considered important by 42% of interviewees. In general, human-made warning systems were considered less important for tsunami evacuation than natural warning signals and socio-cultural assets (Fig. 2). These results suggest that the triggering factors for tsunami escape were natural phenomena, specifically, the earthquake magnitude and the observation of sea level changes. Additionally, the presence of a full moon was a fortuitous facilitating factor. Moonshine allowed people to observe the sea receding from the shore and the clarity facilitated evacuation. As Patricio, a seaweed gatherer in Las Quizcas, declared *"In a cloudy or moonless night the story would have been different; many more would have died"*.

Table 1
Coverage of fishing villages in the tsunami zone.

	VI Region O'Higgins (no.)	VII Region Maule (no.)	VIII Region Bio Bio (no.)	Total impacted zone (no.)
Fishing villages	8	14	65	87
Surveyed fishing villages	8	13	35	59
Surveyed leaders (telephone and personal)	6	16	19	41

Table 2
Tsunami impacts on artisanal fishers, fleet, fishing equipment and gear.

	VI Region O'Higgins (no.)	VII Region Maule (no.)	VIII Region Bio Bio (no.)	Total impacted zone (no.)	Estimated damages on fishing capacity (%)
Human health					
Losses	2	2	4	8	–
Injured/sick	–	21	101	122	–
Vessels					
Boats (8–10 m) and lanchas (less than 18 m)	41	236	996	1273	55
Off board engines	28	214	805	1047	–
Gear and equipment					
Diving gear	85	181	289	555	33
Fishing nets	728	8804	2986	12,518	–
Longlines	4	3	1214	1221	–
Tramps			340	340	–
Winchers	2	122	85	209	–
Air compressors	3	42	384	429	–

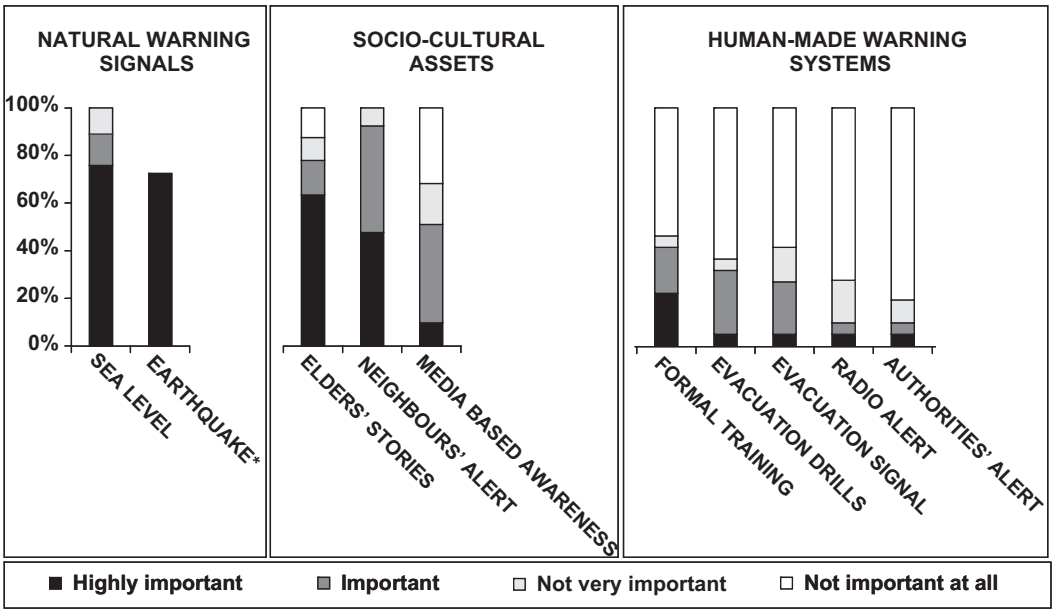

Fig. 2. Factors and triggers of the evacuation in Chile's 2010 tsunami; * in figure represents percentage of mentions based on the openended question: "How did you know that a tsunami may occur and that you had to escape?".

Complementarily, the effective evacuation is explained by a natural hazard subculture [8]. Fig. 2 shows the experiences of past tsunamis, transferred primarily through elders' stories, and the neighbours' alerts informally empowered communities for a desirable behavioural response. The heuristic rule of thumb "*if an earthquake is so strong you cannot stand up and walk, you must run to the hills*" proved a fundamental strategy. This knowledge is orally transmitted through social networks formed in coastal towns through daily life activities. Knowledgeable neighbours raised the alarm and helped each other for a quick evacuation. Dubious individuals were forced to run away. This is also how numerous tourists survived. In Taucú, for example, a fisher, risking his life, ran to a camping site and saved 30 inexperienced vacationers. In Chile, as in the Pandang tsunami in 2007, more than 50% of survivors said to have received the critical warning through the social network [9].

Results suggest that, as in other parts of the world, efficiency in times of tsunami is related to a local natural hazard subculture [8]. Everyday life constraints would reduce people's vulnerability and induce individuals' behaviour in the face of the tsunami [10]. Thus, it is fundamental to integrate contextual and behavioural approaches in disaster management. Unlike random factors, such as the moon cycle or time of the day [11], or human-made warning systems that are prone to fail after massive earthquakes, socio-cultural mechanisms can be developed and enhanced by bottom-up risk management policies. Because long times between tsunamis can erase memories of how to survive them [12], highlighting cultural, social, and economic contexts determining responses become cornerstones for preparedness.

5. For whom the bell tolls?

Unfortunately, many people did not survive the 2010 tsunami. More than 120 tsunami victims and 56 missing persons have been reported to date [13]. According to the interviewees in Pelluhue, Curanipe, Constitución, Dichato, Quidico, and Isla Mocha, the victims of the waves were mostly tourists. The events occurred in

the last weekend of the summer vacation. Risky or inappropriate behaviours at the time of the tsunami include: (1) no evacuation; (2) delayed evacuation due to the attempt to collect personal belongings; (3) massive car evacuation that generated traffic gridlocks in small villages; (4) evacuation to high-risk zones (for instance, to the beach, through sea-level roads); and (5) early return to risk areas as a consequence of misleading information from local authorities. In the absence of effective human-made warning systems, outsiders lacked the place-based response capacities that saved coastal dwellers. The bell tolls mostly for them.

6. Conclusion

The post-tsunami rehabilitation of Chilean small-scale fisheries demands special attention of the multiple faces of the artisanal activity. Only focusing on the recovery of vessels would exclude thousands of coastal gatherers and divers with different gear and equipment needs. In addition, the distribution of financial aid and other resources calls for special consideration of local social dynamics and organization. An effective and fair distribution of public and private support should draw from existing fisher organizations or unions, without excluding non-organized fishers. Second level fisher associations, such as regional federations, and regional fisheries authorities (SERNAPESCA) can play key coordination roles [14] when they count on fishers' legitimacy and trust. Collaboration at all levels becomes a key condition for the rehabilitation process.

Tsunamis are likely to strike Chilean coasts again, and thus preventive policies should be implemented and reinforced. Cultural and social assets of communities, or "social capital", are resources that resource and disaster managers must draw upon and enhance [15]. Initiatives should be drawn from and consider the experience and knowledge from the 2010 tsunami survivors, fishing, and coastal communities that proved to possess well-established responding capacities to unpredictable hazards. Community preparedness provides strong basis for tsunami-resilient communities [16]. The critical task is to design and implement integrated human-made and social network-based response systems to offer safer places to dwell and visit. In fact, the rehabilitation of the fishery in many devastated localities is also reliant on the recovery of tourism. Among the greatest challenges for fishers, coastal dwellers, and the authorities is the definition of where and how housing areas, *caletas*, and services are to be reconstructed.

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