Coastal erosion narratives in the Gulf of Mexico: Implications for climate change governance

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Abstract

This article presents a study of coastal erosion narratives by the Mexican government, scientists, and local fishers in coastal communities in the Gulf of Mexico. It shows how plans to enroll fishing communities into programs to adapt to or to slow coastal erosion are based on simplified environmental narratives that rely on global climate change as the main cause of coastal erosion. They discount local processes and local explanations, as well as scientific studies that outline complex multi-scalar explanations for coastal erosion. Government narratives frame global climate change, as manifested in increased frequency and intensity of hurricanes and other hydrometereological extreme events and sea level rise, as the main causes of changes in coastal environments, including coastal erosion They fail to acknowledge other causes including the environmental degradation caused by the influential oil industry. In contrast, fishers' more complex and locally-embedded narratives are shaped by their long-term struggles against the state-owned oil company, whom they hold primarily responsible for coastal erosion in their communities. Scientists similarly emphasize the importance of local and regional processes, with climate change understood primarily as having significant impacts in the future, but less so in the recent past. Differences in temporal and geographical scaling among these narratives highlight the importance of considering how the translation of climate change adaptation programming from the global to diverse local situations would ideally consider site-specific power relations as well as community-based perspectives.

Keywords: Coastal erosion; climate change; environmental narratives; oil; participation

Résume

Cet article présente une étude des récits sur l'érosion côtière du gouvernement mexicain, des scientifiques et des pêcheurs locaux parmi les communautés côtières du Golfe du Mexique. Il montre comment les plans visant à faire participer les communautés de pêcheurs à des programmes d'adaptation ou de ralentissement de l'érosion côtière sont basés sur des récits environnementaux simplifiés qui considèrent le changement climatique mondial comme la principale cause de l'érosion côtière. Ils ne tiennent pas compte des processus locaux et des explications locales, ni des études scientifiques qui présentent des explications complexes et multi-scalaires de l'érosion côtière. Les récits gouvernementaux présentent le changement climatique mondial, tel qu'il se manifeste par une augmentation de la fréquence et de l'intensité des ouragans et d'autres événements hydrométéorologiques extrêmes, ainsi que par l'élévation du niveau de la mer, comme les principales causes des changements dans les environnements côtiers, y compris l'érosion côtière. En revanche, les récits plus complexes et ancrés localement des pêcheurs sont façonnés par leurs luttes à long terme contre la compagnie pétrolière d'État, qu'ils tiennent pour la principale responsable de l'érosion côtière dans leurs communautés. De même, les scientifiques soulignent l'importance des processus locaux et régionaux, le changement climatique étant considéré comme ayant des impacts significatifs dans le futur, mais moins dans le passé récent. Les

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différences d'échelle temporelle et géographique entre ces récits soulignent l'importance de considérer comment la traduction des programmes d'adaptation au changement climatique, du niveau mondial aux diverses situations locales, devrait idéalement prendre en compte les relations de pouvoir spécifiques au site ainsi que les perspectives communautaires.
Mots-clés: Érosion côtière; changement climatique; récits environnementaux; pétrole; participation

Resumen

En este artículo presentamos narrativas sobre erosión costera provenientes del gobierno, científicos, y de los pescadores de comunidades costeras ubicadas en el Golfo de México. En el artículo se muestra cómo programas gubernamentales sobre adaptación al cambio climático presentan narrativas ambientales simplistas, que se basan en narrativas sobre cambio climático como la causa clave para explicar el fenómeno de la erosión costera; estas narrativas también ignoran procesos y explicaciones a nivel local, y estudios científicos que subrayan complejos procesos de carácter multiescalar. Estas narrativas gubernamentales apuntan al cambio climático global - que se manifiesta en huracanes más intensos y frecuentes, en fenómenos hidrometereológicos extremos, y en el aumento del nivel del mar- como las principales razones que explican cambios ambientales incluyendo la erosión costera. Esta narrativa gubernamental pasa por alto otras causas de la erosión costera, incluyendo por ejemplo la degradación ambiental causada por la industria petrolera. En contraste, las narrativas de los pescadores muestran la complejidad de múltiples procesos locales, y se basan en el conflicto que históricamente las comunidades costeras de estudio han tenido contra la compañía paraestatal petrolera, a quienes los pescadores identifican como la principal causante de la erosión costera en sus comunidades. Los científicos por su parte también enfatizan la importancia de procesos locales y regionales para explicar la erosión costera en la región; integran el problema del cambio climático, pero principalmente en términos de sus impactos en el futuro más que el pasado reciente. Estas narrativas muestran diferencias en escalas temporales y geográficas, que son importante en señalar y tomar en consideración cuando se analizan programas de adaptación al cambio climático. Estos programas que se traducen del ámbito global a lo local, idealmente deberían de tener en consideración las relaciones de poder que se manifiestan a nivel local, y las perspectivas sobre cambios ambientales que emergen desde las comunidades costeras.
Palabras claves: erosión costera; cambio climático; narrativas ambientales; petróleo; participación

1. Introduction

This article presents a study of coastal erosion narratives by the Mexican government, scientists, and local fishers in coastal communities in the Gulf of Mexico. It is based on research in the coastal zones of Tabasco, one of the eight pilot sites that the Mexican government selected as part of an initiative funded by the World Bank – the Adaptation to Climate Change Impacts on the Coastal Wetlands in the Gulf of Mexico project (World Bank, 2008; 2011; Buenfil, 2009). This was a pilot project to design and implement measures to reduce the vulnerability of coastal wetlands to climate change (World Bank, 2008), and included provisions for enlisting the participation of coastal communities in slowing and reducing vulnerability to coastal erosion.

The Mexican government's program design followed a consensus found in scholarly and practitioner literature – that successful environmental and development planning interventions to reduce vulnerability to environmental and climate change effects need to take into account the local context, and require the participation of communities (Bindoff *et al.,* 2019; Bell *et al.,* 2013; Karlsson and Hovelsrud, 2015; Clarke *et al.,* 2019). Scholars also argue that different and sometimes incompatible perceptions of environmental issues constitute barriers to the implementation of good governance practices (Dewulf *et al.*, 2011). At the same time, rural and development research has shown how participatory practices and outcomes persistently fall well short of what is envisioned in the development programs that aim to be participatory (e.g., Cavanagh *et al*., 2017; Nagoda & Nightingale, 2017; Nagada, 2015; Few *et al.*, 2007). This includes programs that aim to facilitate adaptation to environmental change in coastal areas. The critical literature on these programs show that they often marginalize participation of communities in planning and implementation (Nijbroek, 2014), or fail to provide adequate resources for actions identified by communities (Shearer, 2012).

Recent critiques of community participation in adaptation programs in coastal zones often assume that coastal erosion is a central problem, and that this erosion is being caused by rising sea levels that are in turn primarily due to climate change. In contrast, this study describes a situation in which fisher communities view coastal erosion as less urgent than other environmental problems, especially those caused by offshore oil extraction, and where their explanations for coastal erosion identify multiple causes. In this article we build on the work of political ecologists to understand climate change adaptation and to incorporate multiple forms of knowledge to inform adaptation processes (Maldonado, 2014). We also draw on scholarship on environmental governance to echo arguments about the need for implementing agencies to be flexible and responsive to community input in addressing coastal erosion problems, rather than relying on standardized procedures and protocols (Shearer, 2012).

A political ecology of adaptation policies implies a focus on the power relations that shape them. Adaptation programs are conceived as sociopolitical processes that are structured within hierarchical political economies and discourses (Dunstan, 2019). Similarly, according to Bennett (2019), a political ecology of ocean and coastal zone governance should help us understand disjunctures and conflicts through the analysis of power and politics, environmental narratives across scales and over time, and with consideration of environmental justice and equity (Bennett, 2019: 68). The analysis of power, history, justice and equity draws our attention to history of resource booms in Tabasco, which have degraded coastal ecologies and undermined livelihoods while excluding local people from benefits. This history is the basis of community explanations for coastal erosion.

The key analytical concept in this article is what political ecologists have labelled environmental narratives (Fairhead and Leach, 1995, 2000; Forsyth, 2003; Forsyth and Walker, 2008; Hajer, 1995; Leach and Mearns, 1996; Bennett, 2019), embedded in power relations and historical political economies (Forsyth, 2003). Our focus is on the narratives that explain coastal environmental change; we do not take up the operation of the development programs themselves, except to analyze their documents for environmental narratives. This helps us understand how different actors create, contest, or legitimate different accounts of natural processes and environmental problems (Bennett, 2019; Gordon, 2008; Kelman 2018). It allows us to question whose environmental knowledge counts, how knowledge is constructed (Nijbroek, 2014), and whose rationalities predominate (Lindegaard, 2020) when governments design coastal erosion adaptation initiatives.

We identify three significant and distinct environmental narratives on coastal erosion in the study area: the development narrative produced by Mexican government agencies (national and provincial); the narrative articulated by fishers living in coastal communities in the Gulf of Mexico; and finally, that produced in scientific publications. We show how the explanations given by fishers and scientists differ from government narratives in three important respects: problem definition; the identification of the main drivers in the emergence of local environmental changes; and the attribution of responsibility for addressing the problem. We also draw attention to how these narratives differ in terms of the temporal and spatial scaling of problem definition, and the causes of environmental change (for example: Boucquey, 2020; Lyle, 2015; Tynkkynen, 2015).

An important feature of the fishers' narrative is the significance they give to the state-owned oil industry, which they argue has been responsible for coastal environmental changes. Scientists similarly propose that there are diverse explanations for coastal changes that include the impacts of coastal development due to oil extraction. This contrasts with the way that the government's development narrative emphasizes global climate change as the sole or main cause of coastal erosion, and assumes that communities adapt to that climate-induced environmental change. Our argument is in no way intended dismiss the significance of what is appropriately being called the climate emergency, and the major impacts climate change will have in coastal areas including Tabasco. At the same time, it is important to address the ways that climate change impacts work through local environmental processes that have increased vulnerability to future climate change effects, and to engage with community assessments of the environmental problems that are most important to them and to the sustainability of their livelihoods.

2. Methods

The five coastal communities in this study are located in the southern Mexican State of Tabasco, on the Gulf of Mexico (Figure 1). The province includes the deltas of two important rivers, as well as extensive

wetlands and lagoons. Tabasco is considered one of the poorest provinces in Mexico (CONEVAL, 2012), with 51% of its population classified as living in poverty in 2018 (SEDESOL, 2018). The state was ranked below national average in social development indicators including social security, housing, social services, food access, and income (Ibid).

Figure 1. Study area and the two regions of the Province of Tabasco, Mexico (shaded). Source: The original uploader was Celay at Spanish Wikipedia https://commons.wikimedia.org/wiki/File:Regions_of_tabasco-Es.png

In these communities, small-scale artisanal fishing with small boats has been practiced for many generations. At the time of the field research, government authorities reported the existence of more than two thousand fishers in the Carmen-Pajonal-Machona lagoon system (Figure 2), although they recognized that these numbers are not accurate since only legally registered fishers appeared in the data (Vazquez, 2017), and many fishers are not registered. The majority of fishers exploit resources in the lagoons, but fishers who have motorboats and nets also fish in the sea. Fishers also exploit estuaries, rivers, streams and marshlands (Mendoza-Carranza *et al*., 2013).

Local fishers have virtually no alternative economic activity, and depend on fishing to survive. In interviews, they reported that they were full-time fishers, although some fishermen engage in other additional temporary livelihood activities such as small-scale agriculture and livestock farming for their own consumption. Many but not all fishers in the municipalities that are part of the lagoon system (Cárdenas, Paraíso and Comalcalco) are members of the thirty-two fishing cooperatives, including nine in the study communities (below). Fishers who are organized in cooperatives exploit mainly oysters, while others also fish for shrimp, crab, clam, winkle, nook, tilapia, sea bream, sea bass, shark, and dogfish (Vazquez, 2017). The Gulf of Mexico contributes 93.4% of national oyster production, and the country is the sixth largest oyster producer in the world (Pérez *et al*., 2012: 134). Tabasco is the second most important oyster (Crassostrea virginica) producer in the Gulf of Mexico, and the Carmen-Pajonal-Machona lagoon system used by the fishing communities in this study is Mexico's most important oyster producer (Vazquez, 2017).

This article draws from a broader qualitative study in which the first author employed a multi-method fieldwork approach during 2011-2012. The author conducted semi-structured interviews with 98 fishers in the five study communities, and 14 with government officials from different organizational levels – national and provincial, and with 13 scientists working on the Gulf of Mexico. In addition, she analyzed government archival materials and planning documents. The data for the analysis of the government narratives are drawn largely from studies and reports authored by the federal Ministry of the Environment and Natural Resources (SEMARNAT), with interviews providing a contextual background. Specifically, we examined planning documents (CICC 2012a, 2009b, 2007) and reports (CICC 2012b, 2009a, 2006, 1997) authored by the Climate Change Intersectoral Commission (CICC for its acronym in Spanish); as well as other knowledge mobilization material (e.g. public presentations by the Federal government in Tabasco) (SEMARNAT, 2008). At the provincial level, we analyzed a climate change planning instrument authored by the Ministry of Natural Resources and Environmental Protection (SERNAPAM, 2011, 2007). We examined these documents for their implicit and explicit understandings of coastal erosion and of climate change adaptation programming. For scientists, we based our analysis primarily on journal articles and the IPCC's fourth report, focusing on explanations of coastal erosion with particular attention to the role of climate change.

3. Background: Resource booms and coastal erosion

Throughout its history, Tabasco has been a territory bearing contradictory meanings for state actors, fishers, peasants and scientists. It has often been described as backward and isolated, and a place where modernity – economic production, roads, infrastructure, and progressive ideas – has struggled to settle. For the national government, Tabasco has provided the ground for "high modernist" projects – well-intended utopian social engineering schemes to improve the human condition (Scott, 1998; Lanzas, 2020). Through these projects the government aimed "to remedy the social ills – poverty, sickness, and illiteracy – which had resulted from Porfirian [dictatorial] rule" (Ridgeway, 2001: 138). At the same time, the history of Tabasco has been one of resource and crop booms, much like other parts of Latin America (Bunker, 1985). Key resources and crops have included mahogany and other tropical woods, cacao, coffee, pepper, indigo, sugar cane, and vanilla (Arrieta, 1994; Martinez, 1979). In the 1920s, the province was one of the largest banana-producing provinces in the country, forming part of the banana boom in Mexico – "the new green gold" (De Giussepe, 2011). The decline of the banana boom was followed by another structural transformation of the natural landscape promoted by the state: the "conquest" of swamplands through massive deforestation to enable agricultural and livestock farming during the 1940s (Tudela, 1989). Finally, since the 1950s, Tabasco has become one of the most important oil and gas producing regions in Mexico (INEGI, 2009). Most of these resource booms took the form of enclave economies, designed to target external markets, while transforming the natural and social space by implementing new organizational forms of production and modes of extraction that remade land rights, land-use, and ecosystems (Bunker, 1985).

The most recent and ongoing boom is the offshore extraction of oil. The oil industry arrived in this region during the 1950s and expanded during the 1970s after the discovery of extensive offshore and onshore oil and gas fields. The oil boom has reinforced Tabasco's enclave economy, since it was not used to support and diversify other economic activities that could potentially support regional development (Bunker, 1985; Hall, 2011). At the same time, this industry has radically impacted the quality of life of local fishers and farmers, transformed the provincial economy, and degraded the wetland ecosystem.[2] Scholars have argued that oil-related activities have displaced peasants through both the expropriation of their lands and the pollution of land and water (Negrete, 1984; Tudela, 1989; Velázquez, 1982). The outcomes for peasants have been the abandonment of agriculture and livestock activities (Negrete, 1984), and a "violent abandonment of their way of life" (Velázquez, 1982: 170).

[2] The operation and impact of offshore oil extraction has been extensively documented; see Allub, 1985; Buenfil, 2009; Botello *et al.*, 1983; De la Cruz*et al.*, 2017; Lezama, 1987; Negrete 1984; Olguín *et al.*, 2007; Pinkus-Rendón and Castro, 2012; Pinkus-Rendón and Contreras-Sánchez, 2012; Ponce and Botello 2005; Reyes and de la Cruz, 2017; Rodríguez *et al*., 1995; Rosas *et al*., 1983; Town and Hanson, 2001; Tudela, 1989; Vázquez-Luna *et al*., 2010; Velázquez, 1982 and Wilson and Ryan, 1997).

One of the most important impacts of the oil industry in the study communities is associated with the building of an artificial opening to connect the lagoon system to the sea in 1975 (Figure 2). At that time, the oil industry was opening new sites for oil extraction in the region, and the artificial channel allowed the introduction of machinery and the transportation of oil. Scientists have documented how this opening altered the lagoon ecosystem by allowing for increased saltwater flow to the lagoons (Resendis, 1980). The opening also affected the livelihoods of many people through flooding of land, and decreased oyster production. Fishers were also affected by the disappearance of native fresh water fish, mammals and chelonians (Pérez *et al*., 2012; Resendis, 1980). Even though the oil industry compensated some peasants for the loss of their lands and production, community members were still demanding justice for this damage during 2011-12 when the first author completed the fieldwork for this article.

Figure 2: Study area and the Carmen-Pajonal-Machona Lagoon System. Tabasco, Mexico. Source: INEGI, Mapa Digital de Mexico, 2014. http://www.inegi.org.mx/geo/contenidos/mapadigital

In our interviews, fishers described the many impacts the oil industry brought to their communities, not only in terms of their life, livelihood and health, but also through the reconfiguration of social and political relations. As Quist and Nygren (2015: 44) explain, there has been a "fierce competition for offshore space between fishers, the oil industry and government authorities in Tabasco." For example, regulations enacted in the late 1990s prohibited fishing close to offshore oil fields, fields that had functioned as artificial reefs for fishers (Zalik, 2009). This eliminated a potential unintended benefit of oil extraction for fisheries, increased production costs and time for fishers who worked in the Gulf, and exposed them to more risks since they needed to travel farther offshore (Quist and Nygren, 2015; Vázquez, 2017). These long-term conflicting relationships

between the fishers and the oil industry form a backdrop to how coastal erosion and other processes were experienced by inhabitants of the coastal communities in our study.

The rates and impacts of coastal erosion for the Mexican communities we studied are startling. Between 1993 and 2003 scientists reported the minimum coastal retreat during this period was 10 to 20 meters in some areas, and a maximum as 60 to 87 meters in others (Hernández *et al.*, 2008). Dozens of homes and public buildings, including a school, have been destroyed (Figure 3). People have been displaced from their houses and have had to find other places to live, without government or community support. They have also been isolated due to the destruction of roads and bridges (Figure 4). In interviews with fishers and local authorities, they reported that this isolation has had economic impacts as well, since they are now paying more for staple goods and services such as transportation. Some local inhabitants expressed the view that their communities will disappear sooner or later.

The rapid changes in the coastal landforms are clear to everyone: on this there is agreement among government officials, fishers and scientists. The differences arise in their assessments of the relative importance of coastal erosion in relation to environmental changes more broadly, in their understandings of the causes of erosion, and in who should take action to address this problem. There are also some differences in whether changes in the coastline should be understood as an irreversible process of coastal erosion, or as the most recent manifestation of what has always been a dynamic coastal landform. The next section analyzes these differences through the concept of environmental narratives.

Figure 3: Coastal erosion impacts on housing in the study sites.

Figure 4: Coastal erosion impacts roads and oil infrastructure in the study sites.

4. Narratives of coastal erosion

In this section we analyze government, fishers' and scientists' narratives of coastal erosion. These are also summarized in Table 1.

Government narratives: Coastal erosion as a climate change impact

Government narratives on climate change adaptation draw on the conceptual frameworks produced by what has been called the international climate change regime (Lindegaard, 2020; Okereke *et al.,* 2009). These climate change narratives (Kelman, 2018) are a point of departure for diverse locally situated policy responses to climate change (Bravo, 2009: 258). At the same time, they recognize the diversity of socioeconomic and environmental factors that determine the degree of vulnerability of the country to climate change impacts.

Specifically in relation to the coast, the government narratives highlight climate change impacts due to sea level rise over the medium and long term (CICC, 2012a), also due to increased frequency of extreme weather events. In the analysis of future scenarios, sea-level rise is linked to coastal erosion, coastal flooding, and coastal zone loss (CICC, 2009,1997; SEMARNAT, 2008). The documents explain that even though sea-level rise is a long-term process, it is already being manifested and therefore impacting coastal erosion (CICC, 2009). Government narratives also refer to beach erosion that has already resulted from an increase in the number and intensity of hurricanes in the Gulf of Mexico and the Caribbean Sea, which is associated with the rise of sea temperatures (CICC, 2006).

Actors/ Narratives	Problem	Causes	Scale		Attribution of Responsibility
			Temporal	Spatial	
Government	Coastal changes (coastal flooding, beach and coastal erosion)	Climate change – due to sea level rise caused by melting of glaziers - and increased intensity and frequency of hurricanes and other extreme hydrometereological events	Future and present	Global	Mexican and global populations
Fishers	Coastal erosion	Oil infrastructure	1970s to present	Local (artificial opening in the lagoon)	Oil industry
	Coastal erosion	Lack of planning: Coastline housing and deforestation, industrial infrastructure such as oil pipes and urban infrastructure such as roads.	1970s to present	Local	Local and provincial governments
	There is no problem, coastal erosion has always been part of fishers' lives	It is a natural phenomenon	Cyclical, seasonal, long term historical	Local	It is a natural phenomenon, no one is responsible
Scientists	Coastal erosion	Oil and urban infrastructure	1940s (when data was available) to present	Local/Regional	Do not point out any specific actor
	Coastal erosion	Urban infrastructure, lack of planning	1970s to present	Local	Do not point out any specific actor
	Coastal erosion	Storms, hurricanes	1970s to present	Regional/Global	Do not point out any specific actor
	It is not a problem in the first place, it becomes a problem when there is no room to accommodate natural cyclical coastline variations	Natural cyclical processes of erosion and accretion	Geological	Local/Regional	Do not point out any specific actor
Scientists (IPCC)	Coastal erosion and flooding	Storms and sea level rise (in interaction with local environmental changes)	Future based on future climate change scenarios	Regional and Global	All actors who contribute to greenhouse gas emissions

Table 1: Coastal erosion narratives in the Gulf of Mexico.

The Mexican National Climate Change Program highlighted potential climate change impacts as changes in the shoreline, and coastal erosion and flooding. The program document explained these as due to sea level rise and the recurrent incidence of increased extreme hydrometereological events (CICC, 2009b). It identified the protection of coastal ecosystems as a key goal, which will be met by identifying and designing adaptation measures in four pilot sites in the Gulf of Mexico, one of which was the study site of this research in Tabasco.

According to national government documents the province of Tabasco is highly vulnerable to two types of hydrometeorological climate change effects: floods and sea-level rise (CICC, 2006; SERNAPAN, 2011). Based on the sea level rise projections of scientists in Mexico, the CICC explained that if sea level rises one meter, eight percent of the territory would be affected (CICC, 2012a: 50). The study area for this article – the Carmen-Pajonal-Machona lagoon system – is identified as one of five regions in the Gulf of Mexico with high risk of floods due to sea level rise (CICC, 2007).

The provincial government of Tabasco presents coastal erosion in the study communities as an example of the vulnerability of Tabasco's coastal ecosystems to the effects of climate change (SERNAPAN, 2011). The Tabasco Climate Change Plan was partially produced by Mexican scientists whose narratives we discuss later. In this plan, the urgency of addressing climate change impacts is also illustrated with data produced by geographers who have studied coastal erosion in the region since the 1940s. In relation to the vulnerability of the Tabasco's coast to sea level rise, the plan explains that among the impacts are shoreline retreats and coastal flooding. The scientists who authored the document explain that there are other factors that are contributing to the "shoreline retreats and loss of land along the coasts" such as geological subsidence associated with hydrocarbon extraction, among other factors (SERNAPAN, 2011: 114). Nevertheless, coastal erosion in the study sites is due primarily to sea level rise, according to this plan. In sum, in the Tabasco Plan scientific data on coastal erosion is subsumed into a climate narrative, so that coastal erosion becomes an impact of climate change.

With respect to the oil industry, the CICC explains that in the Gulf of Mexico the oil industry infrastructure is highly vulnerable to climate change, and that there is a need to protect its infrastructure from rising sea levels, coastal erosion and increasingly frequent storms (CICC, 2012a: 64). The CICC thus casts the oil industry as a victim of global climate change processes, including the coastal erosion that is attributed to climate change.

Finally, in government narratives the responsibility for addressing coastal erosion falls differently on citizens, communities, universities, and on local, provincial and national government agencies. In an interview, a provincial government official stated that it is fishers' responsibility, for example, to adopt sustainable productive practices or to develop adaptation practices to face climate change impacts. It is the responsibility of government agencies and universities to design and implement adaptation projects. But the government also recognizes that in order to successfully carry out these initiatives, local people need to participate and be engaged in these actions (CICC, 2012a).

Fishers' narratives: Coastal erosion is a human-made and multi-causal problem

For residents in coastal communities, coastal erosion is perceived primarily as a human-made problem. Most fishers said that coastal erosion has been caused by the oil industry, especially by the building of infrastructure to support the state oil company, Petroleos Mexicanos (Pemex). As a fisher stated, "Pemex is responsible for changing or altering ocean currents, not nature, as people think." They argued that the origin of this problem dates to 1975, when Pemex opened the artificial connection between the sea and the lagoon that we mentioned above – the Boca de Panteones (Figure 2). They often blamed this opening for coastal erosion as well as the degradation of fisheries and land. During interviews, the fishers from these communities raised this argument over and over. Fishers also linked other activities by the oil extraction industry to coastal erosion: for example, some fishers argued that they suffer coastal erosion due to the fact that Pemex built a deepwater port in a nearby city, Dos Bocas, to the east. Fishers claimed that the extraction of sand from some of their coasts – used by Pemex to refill swampland and expand its infrastructure – was changing coastal profiles.

A second cause of coastal erosion mentioned by some fishers was migration and settlement in the coastal area. In this narrative, migrants who arrived in their communities in the 1950s caused mangrove deforestation in this coastal area, which was regarded as important for their villages since the mangroves functioned as a natural barrier against hurricanes and storms and protected them from coastal erosion. A third narrative held that coastal erosion was not really taking place. Fishers in two of the five communities said that coastline changes are part of a natural dynamic; they notice that after storms their beaches are eroded by the effect of storm waves, but that the sediments that were eroded were transported to other areas along the coast. Along this line, some fishers also stated that coastal erosion has always been present in their communities. Fishers have been aware of coastal erosion for decades: people recall having to walk long distances from their villages before they could reach the sea. At the same time, fishers in their fifties remember that their grandparents told them that the shoreline was once closer to their villages than it is now. Many fishers thus believe that the coastline is constantly changing, an interpretation that shapes local risk perceptions around erosion and flooding as well. Finally, one fisher speculated that coastal erosion may be the result of the extraction of water and oil from the subsurface, so causing a sinking of the ground, and therefore, erosion. This narrative coincides with the scientific narrative outlined next. It was not clear where the fisher heard this explanation, but it shows a complex way of thinking about coastal erosion and also exemplifies fishers' place-based explanations.

Fishers saw the responsibility for dealing with coastal erosion as belonging primarily to the government. In these examples, the fishers do not regard themselves as responsible for dealing with the problem, mainly because they do not have the material or financial resources to do so. They wanted the government to supply materials such as sandbags to place at the coastal edge. They also doubted the effectiveness of government programs to stop coastal erosion, reporting that past efforts by the government to build protection through seawalls have largely been ineffective, and that the government needed to better understand ocean currents before investing in these kind of infrastructure.

Scientists' narratives: Coastal erosion is a multi-causal, non-linear, socio-natural phenomenon

We include in the scientific narrative the explanations for coastal erosion produced by diverse scientists including coastal ecosystem sciences, coastal sciences, earth sciences, geology, and environmental management and planning. Scientists explain that coastal ecosystems are one of the most dynamic on the planet (Marchand, 2010; *Ruiz et al*., 2010); they are evolving complex systems that "show non-linear morphological responses to change" (Nicholls *et al*., 2007: 320). Scientists state that processes of erosion and accretion have always co-existed, evolving through large-scale redistribution of sediments, and that they are not always in equilibrium (Ortíz *et al.*, 2010). Understanding coastal erosion thus requires both insight into all the complex factors that interact along a coast, and an awareness of different time scales (Marchand, 2010: 6). These include both 'natural' and human-induced factors that operate at different geographic scales (Doody *et al*., 2004).

Among the factors that cause erosion that scientists understand as natural are storms, altered wind patterns, higher waves, ocean and near-shore currents, vertical land movement, sea-level changes, and surge levels (Doody *et al*., 2004; Nicholls *et al*., 2007; van Rijn, 2011). Anthropogenic activities that directly affect the delivery of sediments to the coasts include the damming, channelization, and diversions of coastal waterways. Other types of infrastructure can reduce the availability of sand and alter natural sediment transport pathways. These include the construction of ports, the installation of pipelines, or the building of harbors and sidewalks along the coast (Alejo *et al.*, 2005; Carranza *et al.*, 2010; Fernández *et al.,* 2005). Land subsidence induced by the extraction of groundwater, gas and oil, land claims, dredging, sand mining, mangrove deforestation, and diverse engineering works, are also among the identified human-induced factors that cause coastal erosion (Hernández *et al*., 2008; Ortíz, 1992; Ortíz *et al.*, 2010; Ortíz and Méndez, 1999).

Sea-level rise resulting from global warming is considered a major threat by scientists. But they recognize that they lack knowledge and certainty about the effects of sea level rise, given the complexity of both coastal systems and climate change, as well as the importance of local processes. The fourth IPCC report was published during the period when the government narrative described above was being produced. In this report, Chapter 6 on coastal systems and low-lying areas emphasized that "sea-level rise is not necessarily the primary driver" promoting erosion (Nicholls *et al*., 2007: 318; see also Kelman, 2018: 154). The IPCC scientists

explained that due to natural coastal variability, it is "difficult to identify the impacts of climate change" on coastal erosion, and that the direct impacts of human activities have been more important than impacts that can be attributed to climate change (Nicholls *et al*., 2007: 318). At the same time, the authors predicted that sea-level rise "will exacerbate" beach erosion in the future, in combination with other human induced processes such as land subsidence and increasing intensity of storms (Nicholls *et al*., 2007: 324). They stated that "few studies have unambiguously" quantified the relationships between coastal land loss and sea-level rise", and discussed the challenge of determining whether coastal changes are resulting from climate change, given the complex, non-linear, morphological responses to changes in response to both short-term disturbances (such as changes in the behavior or frequency of storms), or to human drivers like shore protection infrastructure, or to changes in sea level (Nicholls *et al*., 2007: 318-320).

The more recent 2019 IPCC Special Report on the Ocean and Cryosphere (Bindoff *et al*., 2019) does not change these observations significantly: it states that subsidence caused by human activities is currently the most important cause of relative sea level rise in many deltas, and that consideration of local processes is critical for sea level rise projects at local scale – all at a 'high confidence' level – while also projecting with medium confidence that by the end of the century, the global mean sea level (GMSL) will rise between 0.43 meters and 0.84 meters relative to 1986-2055, if the long term temperature goals set out in the Paris Agreement are achieved, and that sea level will continue to rise for centuries thereafter.

Outside of the IPCC reports, some scientists cite studies showing that "coastal protection strategies and changes in the behavior or frequency of storms may be more important than the projected acceleration of sea-level rise in determining future coastal erosion rates" (Marchand, 2010: 9). While the IPCC reports are clear that scientists expect that sea level rise will have a major impact on coasts, this argument is presented largely in the future tense. Scientists also predict considerable regional variability in relative (local) sea level change, depending on shifts in atmospheric pressure, changes in ocean currents, local winds, and rainfall (Bindoff *et al*., 2019; Komar and Enfield 1987).

Scientists studying coastal erosion in the Tabasco delta plain agree that there are many complex causes explaining erosion. However, they state that on Tabasco's coasts the main driver of coastal erosion, at least until very recently, has been land subsidence due to sediment compression and oil and gas extraction (Ortíz, 1992; Ortíz *et al*., 2010; Ortíz and Méndez, 1999). Scientists have also pointed to variation in how the coastline has changed over time and along the coast, and they concluded that processes of erosion and accretion have always co-existed in the Tabasco delta plain (Ortíz *et al*., 2010), although more recently rapid retreat is the dominant process. They have thus studied historic retreat rates to understand the vulnerability of Tabasco's coasts to climate change. Hernández *et al*. (2008) argued that in order to evaluate sea level rise impacts in the region, there is a need to produce spatial analysis and modeling studies focused on the particularities of the Tabasco's morphology. Other scientists state that the specific topographic characteristics of the Tabasco delta make its coasts especially vulnerable to sea level changes. Even minor sea level rises will affect vast continental regions of the Gulf of Mexico (Torres *et al*., 2010), with special intensity in the Tabasco plains. The overall conclusion is thus that sea level rise does matter; that until over a decade ago, sea level rise due to global warming was a 'complementary factor' (Ortíz *et al*., 2010, p. 322) to the more significant human activities described above in explaining coastal erosion. The state could see major changes flooding and changes in the coastline if or when sea level rise accelerates.

5. Discussion: Simplified versus complex and multi-causal narratives

Our findings show a contrast between simplified explanations for coastal erosion in government narratives compared to the more complex, multi-causal, and non-linear explanations offered by both fishers and scientists. Despite these differences, these narratives do not actually engage or contest each other (Leach and Fairhead, 2000), in that they rarely mention or acknowledge the existence of the other two.

Fishers' and scientists' explanations of coastal erosion are distinct from the environmental orthodoxies that shape government narratives in relation to problem definition, the identification of the main drivers of local environmental changes, and how they attribute responsibility to solve environmental problems. Environmental orthodoxies are simplified explanations of environmental change that persist despite contradictions with both

scientific research and the stories told by people who live in these environments. The government narrative can be described as an environmental orthodoxy because it is based on limited participation in problem definition (Forsyth and Walker, 2008); and because it includes selected sources of knowledge (selecting only some elements from climate change science) and knowledge producers (e.g. climatologists) while excluding other relevant information (scientific and local explanations for coastal erosion) and knowledge producers (e.g., fishers).

Provincial climate change planning documents include data on erosion rates in the region since the 1940s, and they draw on the work of scientists who conduct research on erosion. But these documents do not fully explore the factors highlighted by scientists. For example, scientists have concluded that land subsidence due to sediment compression and oil and gas extraction has been the main driver of coastal erosion in Tabasco, and that other human activities such as coastal infrastructure may also have shaped erosion rates. These are sometimes mentioned but not discussed, or they are downplayed and data is instead used to emphasize and evaluate the vulnerability of the coasts to sea level rise and increased storm intensity.

Drawing on a political ecology approach to environmental narratives that highlight their embeddedness in power relations, we have shown how fishers' perceptions of coastal erosion emerged from the political economic context forged in this region over time. It is in the context of fishers' conflict-ridden relationship with the state-owned oil company that they developed their understanding that their problems are caused by the Mexican government working through the state-owned oil industry, rather than natural processes or climate change. Fishers' positions make evident that vulnerability to climate change impacts are the product not only of climatic events, but of "conditions and systemic power relations on the ground" (Farbotko and Lazrus, 2012: 382). As we have argued elsewhere (Vazquez, 2017), fishers' accounts illustrate that for them, any potential adaptation plan is not neutral but an inherently political project: "a question of governance – of managing people, land and resources" (Lindegaard, 2020).

We also found that scientists and some fishers question the very definition of erosion as "a problem" in itself. Scientists and fishers agree that coastal erosion is a natural phenomenon in the sense that it is part of a natural coastal variability. For some fishers, erosion is part of the life of their communities, and they recall their ancestors' testimonies about shoreline variation over time. These ideas also shape fishers' perceptions of environmental risks. For other fishers, erosion is not dangerous; they have always lived with it. As a fisher said during an interview: "maybe we are going to move from our places when we have the water up to our knees." Scientists and fishers pointed out that coastal erosion becomes a problem only when there is not enough room to accommodate ecosystem changes.

Our findings contribute to political ecology analyses of how scaled, political rationalities are based on historical dynamics, and inform climate change adaptation framings (Lindegaard, 2020). Tynkkynen (2015: 204) explains that "[s]cale framings defining environmental problems influence the responsibility-sharing, right level of decision-making and resources needed… [and] can thus be used to legitimize inclusion or exclusion of certain actors and arguments in policy processes." We have shown how the three environmental narratives exhibit distinct spatial and temporal scaling for problem definition, proposed solutions, and attribution of who is responsible for implementing solutions (Scoones, 1997; Tschakert *et al.*, 2013; Tynkkynen, 2015). The different scale framings emerge from the various types of knowledge each actor (governments, scientists, fishers) draw on to narrate the problem. By framing the cause of coastal erosion at the scale of global climate change, government narratives pose the cause as external to local conditions. This scale enables the omission of local actors (especially the oil industry) in explanations of coastal erosion, and it passes over any discussion of other local governance processes – e.g., urban and coastal planning, forest management – as potential explanations. Temporally, government narratives pick up the scientists' future projections in which climate change will interact with local processes to shape coastal processes, and apply these to the present and recent past, while overlooking the question of how global processes interacting with local processes might contribute to coastal erosion. These findings echo research that analyzes international narratives about change in the Arctic, which shows that "the problem of climate change is being defined in ways that may unintentionally eclipse the problems facing communities" (Shearer, 2012, p. 174). This in turn has implications "for assessing differing levels of responsibility and need", and for overlooking inequalities of access to climate change adaptation-related support (Ibid).

Fishers' understanding of environmental change is based on their knowledge of the many changes along the coast over many decades, highlighting the relevance of integrating environmental history perspectives to understand local perceptions on environmental changes (Scoones, 1997). Finally, the scientists' narrative is produced in conversation with a broader global community of scientific knowledge producers whose studies inform each other. Out of this conversation a consensus has emerged that local level processes are important for understanding coastal erosion, in combination with current and future global environmental changes, including intensifying storms and future sea level rise. The latter, however, cannot be projected as occurring uniformly across the globe, due to the strong influence of local processes on sea levels, which are also changing. The scientific temporal scale thus projects into the future, to predict that global climate change processes will interact with local processes to influence coastal erosion – while noting that it is difficult to sort out whether and how these interactions have already begun.

Another example of how scale framing defines who and what is visible or not in problem definition involves how the different narratives frame the oil industry. The government is able to frame the oil industry as a victim, rather than a cause, of coastal erosion, because the government narrative scales the cause as global, so that all local actors are victims. As a result, a discussion of the industry's role in contributing to coastal erosion, not to mention climate change, is omitted in the provincial and federal climate change adaptation plans. This move enables the government narrative to avoid addressing the double inequity between responsibility (in this case the role of the oil industry producing both coastal erosion and climate change) and vulnerability to climate change and coastal erosion (fishers, coastal communities).

This study provides an illustration of the notion of "perverse resilience" as it applies to the fossil fuel industry worldwide, a sector that arguably remains resilient in the context of climate change (Dunstan, 2019). Dunstan (2019) explains that "perverse resilience" identifies the process by which "one sub-component's adaptations can weaken an entire system, but also how the act of maintaining one aspect of society's resilience through adaptation may actively victimize and produce new burdens upon the well-being of other aspects or actors within society" (p. 707). In other words, it illustrates "how resilience policy, and adaptation mechanisms in particular, for one entity might harm another" (Dunstan, 2019: 708).

Interviews with government officials show that those located in national agencies were not aware of the existence of views about causes of environmental change differing from their climate change narratives. In the government definition of the problem, communities including coastal fishers are conceived as victims of a global process, along with the oil industry. At the provincial level, some officials, when they were informed by the interviewer about fishers' views, indicated awareness of fishers' critiques of the oil industry, but they did not demonstrate awareness of a fisher-based narrative that explained coastal erosion. Instead, they dismissed the fishers' criticism of the oil industry. Thus one officer stated that fishers "have always complained about everything, that their only concern is to blame the oil industry and to look for strategies so they can get economic resources from the oil company." At the same time, government officials included villagers in their conception of responsibility to solve problems, in that they were asked to collaborate and change their local practices (where to live, how to live) in order to better face climate change impacts.

6. Conclusions

These findings engage with political ecology analyses that highlight the problems arising from "universalizing accounts of climate change adaptation" (Lindegaard, 2020: 105). These narratives overlook the existence and significance of situated knowledge (Maldonado, 2012; Kelman 2018) as well as the various historical factors accounting for environmental changes. We also contribute to explaining why development programs to promote climate change often fail in their efforts to promote community participation. At the same time, as scientists have argued, climate change will likely have an increasing role in shaping coastal erosion in the future, so that programing that addresses this future is necessary. We argue that government adaptation programs in the study area would be more successful in involving communities if they acknowledged the multi-causal and locally-embedded narratives found in both the fishers' and scientists' narratives. This would, however, mean confronting the powerful oil industry, and we are not confident that this can happen in the current political economy of Mexico.

A political ecology approach directs our attention to unequal power both in the production of environmental narratives, and in programming to address environmental problems. In the case presented here, a key obstacle to an approach to tackling erosion that is more grounded in scientific studies, and that includes local communities in problem definition as well as responsibility to act, is the unequal power relations on the coast, which are the manifestation of a long history of resource booms and extractive economies in the region. What is generalizable about our study to other coastal regions is the way that explanations of coastal erosion are likely to avoid accounting for how the activities of influential actors contribute to it. This is done by shifting the spatial scale to the global level, and applying future projections of sea-level rise to current and recent coastal erosion. In other coastal sites, simplifying narratives that locate the causes of environmental degradation at the global scale may also conceal influential processes and actors promoting environmental changes. Both scenarios can lead to a failure to account for the complex factors shaping coastal environments as well as the diverse and locally-embedded perspectives on the nature and causes of coastal environmental change, which could be a successful basis for community participation in adaptation programs.

References

Alejo I., Costas, S., & Vila-Concejo, A. (2005). Littoral evolution as a response to human action: The case of two sedimentary systems in a Galician Ría. *Journal of Coastal Research* 49: 64-69.

Allub, L. (1985). Polarización de clases y conflicto social en regiones petróleras. *Estudios Sociológicos* 3(8): 351-370. https://doi.org/10.24201/es.1985v3n8.1205

Arrieta, P. (1994). *La integración social de la chontalpa: Un análisis regional en el trópico mexicano*. Gernika.

Bell, E., Seidel, B., & Kilpatrick, S. (2013). Climate change: How scientism has neutralised health policy effectiveness for rural communities. *Journal of Rural Studies* 32: 365-374. https://doi.org/10.1016/j.jrurstud.2013.09.001

Bennett, N. J. (2019). In political seas: Engaging with political ecology in the ocean and coastal environment. *Coastal Management* 47(1): 67-87. https://doi.org/10.1080/08920753.2019.1540905

Bindoff, N. L., Cheung, W. W., Kairo, J. G., Arístegui, J., Guinder, V. A., Hallberg, R., ... & Williamson, P. (2019). Changing ocean, marine ecosystems, and dependent communities. *IPCC Special Report on the ocean and cryosphere in a changing climate*, 477-587. https://www.ipcc.ch/srocc/chapter/chapter-4-sea-level-rise-and-implications-for-low-lying-islands-coasts-and-communities/

Botello, A., Gofii, J., & Castro, S. (1983). Levels of organic pollution in coastal lagoons of Tabasco state, Mexico; I: Petroleum hydrocarbons. *Bulletin of Environmental Contamination and Toxicology* 31: 271-277.

Boucquey, N. (2020). The 'nature' of fisheries governance: narratives of environment, politics, and power and their implications for changing seascapes. *Journal of Political Ecology* 27(1): 169-189. https://doi.org/10.2458/v26i1.23248

Bravo, M. T. (2009). Voices from the sea ice: the reception of climate impact narratives. *Journal of Historical Geography*, 35(2), 256-278. https://doi.org/10.1016/j.jhg.2008.09.007

Buenfil, J. (2009). Executive summary. In J. Buenfil (Ed.), *Adaptación a los impactos del cambio climático en los humedales costeros del Golfo de México* (pp. 25-34). México: SEMARNAT.

Bunker, S. (1985). *Underdeveloping the Amazon: Extraction, unequal exchange, and the failure of the modern state.* Chicago: University of Chicago Press.

Carranza , A., Marín, A., & Rosales, L. (2010). Problemática ambiental en la gestión costera-marina. In I. Evelia Rivera-Arriaga, Azuz-Adeath, L. Alpuche & G. J. Villalobos-Zapata (Eds.), *Cambio climático en México un enfoque costero-marino* (pp. 89-100). México: Universidad Autónoma de Campeche.

Cavanagh, C. J., Chemarum, A. K., Vedeld, P. O. and Petursson, J. G., 2017. Old wine, new bottles? Investigating the differential adoption of 'climate-smart' agricultural practices in western Kenya. *Journal of Rural Studies* 56: 114-123. https://doi.org/10.1016/j.jrurstud.2017.09.010

Clarke, T., McNamara, K. E., Clissold, R. and Nunn, P. D., 2019. Community-based adaptation to climate change: lessons from Tanna Island, Vanuatu. *Island Studies Journal* 14(1). https://doi.org/10.24043/isj.80

CICC (Comisión Intersecretarial de Cambio Climático). (1997). Primera comunicación nacional ante la convención marco de las Naciones Unidas sobre el cambio climático. México, SEMARNAT.

CICC. (2006). Tercera comunicación nacional ante la convención marco de las Naciones Unidas sobre el cambio climático. México, SEMARNAT.

CICC. (2007). Estrategia nacional de cambio climático. Comisión Intersecretarial de Cambio Climático. México, SEMARNAT.

CICC. (2009a). Cuarta comunicación nacional ante la convención marco de las Naciones Unidas sobre el cambio climático. México, SEMARNAT.

CICC. (2009b). *Programa especial de cambio climático 2009-2012*. México, SEMARNAT.

CICC. (2012a). *Adaptación al cambio climático en México: Visión, elementos y criterios para la toma de decisiones*. México, SEMARNAT.

CICC. (2012b). Quinta comunicación nacional ante la convención marco de las Naciones Unidas sobre el cambio climático. México, SEMARNAT.

CONEVAL (Consejo Nacional de Evaluación de la Política de Desarrollo Social). (2012). *Informe de pobreza y evaluación en el estado de Tabasco, 2012.* México, CONEVAL.

De la Cruz, M. Á. P., Alcántara, A. G., Sánchez, A. J., & Maurice, M. J. E. (2017). Pérdida de humedales y vegetación por urbanización en la cuenca del río Grijalva, México. *Investigaciones Geográfica* 68: 151-172. https://doi.org/10.14198/INGEO2017.68.09

De Giuseppe, M. (2011). El Tabasco racionalista frente a lo indígena: Entre laboratorio social y experimentación cultural (1922-1934). *Historia Mexicana* 61(2): 643-706.

Dewulf, A., Mancero, M., Cárdenas, G., & Sucozhanay, D. (2011). Fragmentation and connection of frames in collaborative water governance: A case study of river catchment management in Southern Ecuador. *International Review of Administrative Sciences* 77(1): 50-75. https://doi.org/10.1177/0020852310390108

Doody, P., Ferreira, M., Lombardo, S., Lucius, I., Misdorp, R., Niesing, H., … & Smallegange, M. (2004). *Living with coastal erosion in Europe sediment and space for sustainability. Results from the Eurosion study*. European Union.

Dunstan, A. (2019). Victims of "adaptation": Climate change, sacred mountains, and perverse resilience. *Journal of Political Ecology* 26(1): 704-719. https://doi.org/10.2458/v26i1.23167

Fairhead, J., & Leach, M. (1995). False forest history, complicit social analysis rethinking some West African environmental narratives. *World Development* 23(6): 1023-1035. https://doi.org/10.1016/0305-750X(95)00026-9

Fairhead, J., & Leach, M. (2000). Desiccation and domination: Science and struggles over environment and development. *The Journal of African History* 41(1): 35-54. https://doi.org/10.1017/S0021853799007641

Farbotko, C., & Lazrus, H. (2012). The first climate refugees? Contesting global narratives of climate change in Tuvalu. *Global Environmental Change* 22: 382–390. https://doi.org/10.1016/j.gloenvcha.2011.11.014

Fernández, Y., González, J. M., Martínez, J. E., & Sánchez-Lizaso, J. L. (2005). Evaluation of the effects produced by the construction and expansion of marinas on *posidonia oceanica* delile meadows. *Journal of Coastal Research*, 49, 94-99.

Few, R., Brown, K. and Tompkins, E. L., 2007. Public participation and climate change adaptation: avoiding the illusion of inclusion. *Climate Policy* 7(1): 46-59. http://doi.org/10.1080/14693062.2007.9685637

Forsyth, T. J. (2003). *Critical political ecology: The politics of environmental science*. Routledge.

Forsyth, T. J. & Walker, A. (2008). *Forest guardians, forest destroyers. The politics of environmental knowledge in northern Thailand*. University of Washington Press.

Gordon, F.D. (2008). *Freshwater resources and interstate cooperation: Strategies to mitigate an environmental risk*. State University of New York Press.

Hajer, M. A. (1995). *The politics of environmental discourse: Ecological modernization and the policy process*. Cambridge University Press.

Hall, D. (2011). Land grabs, land control, and Southeast Asian crop booms. *The Journal of Peasant Studies* 38(4): 837-857. https://doi.org/10.1080/03056244.2011.582753

Hernández, J. R., Ortíz, M. A., Méndez, A. P., & Gama, L. (2008). Morfodinámica de la línea de costa del estado de Tabasco, México: Tendencias desde la segunda mitad del siglo XX hasta el presente. *Boletín Del Instituto de Geografía* 65: 7-21.

Instituto Nacional de Estadística y Geografía (INEGI). (2009). Sistema de cuentas nacionales de México. Producto interno bruto por entidad federativa, 2005-2009. Retrieved 4 Mov. 2022, from http://cuentame.inegi.org.mx/monografias/informacion/tab/economia/default.aspx?tema=me&e=27#sp

Instituto Nacional de Estadística y Geografía (INEGI). (2014). Mapa digital de Mexico. Retrieved 4 Nov. 2022, from https://www.inegi.org.mx/temas/mapadigital/#Descargas

Karlsson, M., & Hovelsrud, G. K. (2015). Local collective action: Adaptation to coastal erosion in the Monkey River Village, Belize. *Global Environmental Change* 32: 96-107. https://doi.org/10.1016/j.gloenvcha.2015.03.002

Kelman, I. (2018). Islandness within climate change narratives of small island developing states (SIDS). *Island Studies Journal* 13(1): 149-166. https://doi.org/10.24043/isj.52

Komar, P. D., & Enfield, D. B. (1987). *Short-term sea-level changes and coastal erosion*. The Society of Economic Paleontologists and Mineralogists.

Lanzas, G., (2020) From water abundance to water scarcity: the case of the Chontalpa, Mexico, *Journal of Political Ecology* 27(1), 263-278. https://doi.org/10.2458/v27i1.23214

Leach, M., & Fairhead, J. (2000). Fashioned forest pasts, occluded histories? International environmental analysis in West African locales. *Development and Change* 31(1): 35-59. https://doi.org/10.1111/1467-7660.00146

Leach, M., & Mearns, R. (Eds.) (1996). *The Lie of the Land: Challenging received wisdom on the African environment.* James Currey.

Lezama, J. L. (1987). Migración y petróleo en Tabasco. *Estudios Demográficos y Urbanos*, 2(5), 231-256. https://doi.org/10.24201/edu.v2i2.627

Lindegaard, L. S. (2020). A historical, scaled approach to climate change adaptation: the case of Vietnam. *Journal of Political Ecology* 27(1): 105-124. https://doi.org/10.2458/v27i1.22049

Lyle, G. (2015). Understanding the nested, multi-scale, spatial and hierarchical nature of future climate change adaptation decision making in agricultural regions: a narrative literature review. *Journal of Rural Studies* 37: 38-49. https://doi.org/10.1016/j.jrurstud.2014.10.004

Maldonado, J. K. (2014). A multiple knowledge approach for adaptation to environmental change: lessons learned from coastal Louisiana's tribal communities. *Journal of Political Ecology* 21(1): 61-82. https://doi.org/10.2458/v21i1.21125

Marchand, M. (2010). *Concepts and science for coastal erosion management. CONCISE report for policy makers*. Deltares.

Martínez, C. R. (1979). *El laboratorio de la revolución. el Tabasco garridista*. Siglo XXI Editores.

Mendoza-Carranza, M., Wendi, A. F., & Emilio, I. D. (2013). Common pool resources dilemmas in tropical inland small-scale fisheries. *Ocean & Coastal Management* 82: 119-126. https://doi.org/10.1016/j.ocecoaman.2013.06.004

Nagoda, S. (2015). New discourses but same old development approaches? Climate change adaptation policies, chronic food insecurity and development interventions in northwestern Nepal. *Global Environmental Chang* 35: 570-579. https://doi.org/10.1016/j.gloenvcha.2015.08.014

Nagoda, S., & Nightingale, A. J. (2017). Participation and power in climate change adaptation policies: Vulnerability in food security programs in Nepal. *World Development* 100: 85-93. https://doi.org/10.1016/j.worlddev.2017.07.022

Negrete, M. E. (1984). Petróleo y desarrollo regional: El caso de Tabasco. *Demografía y Economía* 18(1): 86-109. https://doi.org/10.24201/edu.v18i01.1602

Nicholls, R. J., Wong, P. P., Burkett, V., Codignotto, J., Hay, J., McLean, R., ... & Saito, Y. (2007). Coastal systems and low-lying areas. Chapter 6 in Working Group II: *Impacts, Adaptation and Vulnerability, IPCC's Fourth Climate Change Report*. https://ro.uow.edu.au/scipapers/164

Nijbroek, R. P. (2014). Mangroves, mudbanks and seawalls: whose environmental knowledge counts when adapting to sea level rise in Suriname? *Journal of Political Ecology* 21(1): 533-550. https://doi.org/10.2458/v21i1.21150

Okereke, C., Bulkeley, H., & Schroeder, H. (2009). Conceptualizing climate governance beyond the international regime. *Global Environmental Politics* 9(1): 58-78. https://doi.org/10.1162/glep.2009.9.1.58

Olguín, E. J., Hernández, M. E., & Sánchez-Galván, G. (2007). Contaminación de manglares por hidrocarburos y estrategias de biorremediación, fitorremediación y restauración. *Revista Internacional de Contaminación Ambiental* 23(3): 139-154.

Ortíz, M. A. (1992). Retroceso reciente de la línea de costa del frente deltaico del río San Pedro, Campeche, Tabasco. *Boletín del Instituto de Investigaciones Geográficas* 25: 7-23.

Ortíz, M. A., Cervantes, I., & Oropeza, O. (2010). Criterios para estimar la vulnerabilidad física de las costas de barrera ante los impactos hidrometeorológicos. In E. Rivera-Arriaga, I. Azuz-Adeath, L. Alpuche & G. J. Villalobos- Zapata (Eds.), *Cambio climático en México un enfoque costero-marino* (pp. 101-124). Universidad de Campeche.

Ortíz, M.A., Hernández-Santana, J.R., Figueroa Mah Eng, J.M., & Gama Campillo, L. (2010). Tasas del avance transgresivo y regresivo en el frente deltaico Tabasqueño: en el periodo comprendido del año 1995 al 2008. In A.V. Botello, S. Villanueva-Fragoso, J. Gutiérrez, y Rojas Galaviz, J. L. (Eds.). *Vulnerabilidad de las zonas costeras mexicanas ante el cambio climático* (pp. 305-324). SEMARNAT-INE, UNAM-ICMYL, Universidad Autónoma de Campeche.

Ortíz, M. A., & Méndez, A. P. (1999). Escenarios de vulnerabilidad por ascenso del nivel del mar en la costa mexicana del Golfo de México y el Mar Caribe. *Boletín del Instituto de Investigaciones Geográficas*, 39, 68-81.

Pérez, E., Galmiche, A., Zapata, E., Martínez, A., & Meseguer, R. (2012). Contexto de vulnerabilidad de las mujeres desconchadoras de ostión (crassostrea virginica), del Ejido Sinaloa, Primera Sección, de Cárdenas, Tabasco. *Agricultura, Sociedad y Desarrollo*, 9(2), 123-148.

Pinkus-Rendón, M. J. P., & Castro, J. P. (2012). Expectativas sociales y deterioro ambiental por el petróleo. Caso de Cárdenas, Tabasco, México. *Cuadernos de Antropología* 22: 1-22.

Pinkus-Rendón, M. J. P., & Contreras-Sánchez, A. (2012). Impacto socioambiental de la industria petrolera en Tabasco: El caso de la Chontalpa. *LiminaR* 10(2): 122-144.

Ponce, G, and Botello, A. V. (2005). Niveles de hidrocarburos en el Golfo de México. In Botello, A. V., Rendon-von, J., Gold-Bouchot G. and Hernández, C. A. (Eds.). *Golfo de México. Contaminación e impacto ambiental: Diagnóstico y tendencias* (pp. 681-695). Instituto Nacional de Ecología.

Quist, L. M., & Nygren, A. (2015). Contested claims over space and identity between fishers and the oil industry in Mexico. *Geoforum* 63: 44-54. https://doi.org/10.1016/j.geoforum.2015.05.015

Resendis, A. (1980). Hidrología de un sistema de lagunas costeras del sur del Golfo de México, en un período comprendido entre 1977/1978. *Boletim do Instituto Oceanográfico* 29(2): 337-342. https://doi.org/10.1590/S0373-55241980000200067

Reyes, R. R., & de la Cruz, M. Á. P. (2017). Modelación del cambio de uso del suelo en Comalcalco, Tabasco, México. *Revista de Urbanismo* 37: 1-17. http://doi.10.5354/0717-5051.2017.47986

Ridgeway, S. (2001). Monoculture, monopoly, and the Mexican revolution: Tomas Garrido Canabal and the Standard Fruit Company in Tabasco (1920-1935) *Mexican Studies* 17(1): 143-169. https://doi.org/10.1525/msem.2001.17.1.143

Rodríguez, E., Jiménez, I. S., & Valenzuela, M. (1995). *Contaminación acuática generada por la producción de hidrocarburos en Tabasco.* Universidad Juárez Autónoma de Tabasco.

Rosas, I., Báez, A., & Belmont, R. (1983). Oyster (*crassostrea virginica*) as indicator of heavy metal pollution in some lagoons of the Gulf of Mexico. *Water, Air, and Soil Pollution* 20: 127-135. https://doi.org/10.1007/BF00279623

Ruiz, G., Mendoza, E., Silva, R., Posada, G., & Mariño, I. (2010). La geomorfología como herramienta para el análisis de las formaciones costeras y sus alteraciones de largo plazo. aplicación a la Península de Yucatán. In Rivera-Arriaga, E., Azuz-Adeath, I., Alpuche, L. & Villalobos- Zapata, G. J. (Eds.), *Cambio climático en México: Un enfoque costero-marino* (pp. 125-158). Universidad de Campeche.

Scoones, I. (1997). The dynamics of soil fertility change: Historical perspectives on environmental transformation from Zimbabwe. *The Geographical Journal* 163(2): 161-169.

Scott, J. C. (1998). *Seeing like a state. How certain schemes to improve the human condition have failed*. Yale University Press.

SEDESOL (Secretaría de Desarrollo Social). (2018). Informe anual sobre la situación de pobreza y rezago social 2018. Subsecretaría de Planeación, Evaluación y Desarrollo Regional. Secretaria de Desarrollo Social. Accessed on 4 Nov. 2022 https://www.gob.mx/cms/uploads/attachment/file/288970/Tabasco.pdf

SEMARNAT (Secretaría de Medio Ambiente y Recursos Naturales). (2008). *Actividades de cambio climático del Instituto Nacional de Ecología / Programas Estatales de Cambio Climático*. *Primer foro: Cambio climático en el estado de Tabasco*. SEMARNAT.

SERNAPAM (Secretaría de Recursos Naturales y Protección Ambiental del Estado de Tabasco). (2007). *Plan estatal de acción ante el cambio climático de Tabasco*. SERNAPAM.

SERNAPAM. (2011). *Programa estatal de acción ante el cambio climático*. SERNAPAM.

Shearer, C. (2012). The political ecology of climate adaptation assistance: Alaska Natives, displacement, and relocation. *Journal of Political Ecology* 19(1): 174-183. https://doi.org/10.2458/v19i1.21725

Titus, J. G. (2005). Sea level rise, effects. In Schwartz, M. L. (Ed.), *Encyclopedia of coastal science* (pp. 838-845). Springer.

Torres, R., Márquez, A., Bolongaro, A., Chavarria, J., Díaz, G. E., & Márquez, E. (2010). Tasa de erosión y vulnerabilidad costera en el estado de Campeche debidos a efectos del cambio climático. In A.V. Botello, S. Villanueva-Fragoso, J. Gutiérrez, y Rojas Galaviz, J. L. (Eds.). *Vulnerabilidad de las zonas costeras mexicanas ante el cambio climático* (pp. 325-344). SEMARNAT-INE, UNAM-ICMYL, Universidad Autónoma de Campeche.

Town, S., & Hanson, H. (2001). Oil at the grassroots: Report from Tabasco. *NACLA Report on the Americas* 34(4). https://nacla.org/article/oil-grassroots-report-tabasco

Tschakert, P., van Oort, B., St. Clair, A. L., & LaMadrid, A. (2013). Inequality and transformation analyses: A complementary lens for addressing vulnerability to climate change. *Climate and Development* 5(4): 340-350. https://doi.org/10.1080/17565529.2013.828583

Tudela, F. (1989). *La modernización forzada del trópico: El caso de Tabasco*. El Colegio de México.

Tynkkynen, N. (2015). Baltic Sea environment, knowledge and the politics of scale. *Journal of Environmental Policy & Planning* 17(2): 201-216. https://doi.org/10.1080/1523908X.2014.936582

Van Rijn, L. C. (2011). Coastal erosion and control. *Ocean & Coastal Management* 54: 867-887. https://doi.org/10.1016/j.ocecoaman.2011.05.004

Vázquez, L. M. (2017). Implementation challenges of climate change adaptation initiatives in coastal lagoon communities in the Gulf of Mexico. *Maritime Studies* 16(1): 14. https://doi.org/10.1186/s40152-017-0068-2

Vázquez-Luna, D., Manzanares, P. A., Cruz, J. Z., Acosta, E. H., Maurice, M. E., & de Celis Carrillo, R. (2010). Impacto de la industria petrolera sobre el desarrollo equitativo en cuatro zonas de Huimanguillo, Tabasco. *Naturaleza y Desarrollo* 8(2): 6-22.

Velázquez, M. G. (1982). Afectaciones petroleras en Tabasco: El movimiento del Pacto Ribereño. *Revista Mexicana De Sociología* 44(1): 167-187.

Wilson, M., & Ryan, D. A. (1997). International issues and perspectives in wildlife management. *Wildlife Society Bulletin* 25(1): 57-64.

World Bank (WB). (2008). *Environmental framework for proposed grant from the special climate change fund (SCCF) in the amount of USD {US$4.5} million for the benefit of Mexico through BANOBRAS for the adaptation to climate change impacts on the coastal wetlands in the Gulf of Mexico*. (No. E2081). World Bank.

Zalik, A. (2009). Zones of exclusion: Offshore extraction, the contestation of space and physical displacement in the Nigerian Delta and the Mexican Gulf. *Antipode* 41(3): 557-582. https://doi.org/10.1111/j.1467-8330.2009.00687.x