Ocean & Coastal Management 93 (2014) 37–50

Contents lists available at ScienceDirect

Ocean & Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

Review

Vulnerability to climate change of hypersaline salt marshes in the Northern Gulf of California

H. Morzaria-Luna [a,*], Peggy Turk-Boyer [a], Alyssa Rosemartin [b,c], Victor F. Camacho-Ibar [d]

[a] Centro Intercultural de Estudios de Desiertos y Océanos, A.C. Edif. Agustín Cortes, s/n. Puerto Peñasco, Sonora CP 83550, Mexico
[b] National Coordinating Office, USA National Phenology Network, 1955 East Sixth Street, Tucson, AZ 85721, USA
[c] School of Natural Resources and the Environment, University of Arizona, Tucson, AZ 85721, USA
[d] Instituto de Investigaciones Oceanológicas, Universidad Autónoma de Baja California, Apdo. Postal 453, Ensenada, Baja California CP 22860, Mexico

ARTICLE INFO

Article history:
Available online 28 March 2014

ABSTRACT

The ecosystem functions and environmental services provided by coastal wetlands are threatened by climate change and other anthropogenic impacts. Assessing the degree of vulnerability and the nature and extent of probable impacts of climate change on coastal wetlands is necessary to develop adaptation strategies. Here we review and synthesize existing scientific information to examine climate change impacts on physical and biotic processes of hypersaline salt marshes in the Northern Gulf of California, Mexico. In this region, negative estuaries provide nursery and refuge for migratory species and sustain important fisheries. We found marshes in the Northern Gulf may be susceptible to the effects increased CO_2, sea-level rise, storm frequency and intensity, changes in ambient temperature, and ocean physical changes, including elevated sea temperature, and acidification. The responses of coastal marshes to these climate change effects will likely be interactive and hard to predict; climatic interannual variability (i.e. El Niño-Southern Oscillation) will play an important role in determining the strength and directionality of the impacts. Given the uncertainty of climate change effects, it will be important to continue ongoing monitoring programs and implement new ones that help separate natural variability from the effects of climate change. Management actions and adaptation plans will be needed that consider uncertainty, are flexible, and encourage ongoing learning. Our study is a first step toward understanding vulnerability of coastal wetlands in the Northern Gulf of California to climate change.

1. Introduction

Climate change, resulting from increased atmospheric concentrations of greenhouse gases, is expected to lead to higher global average temperature, changes in precipitation and freshwater inputs, variations in extreme weather and climate events, and a rise in average sea level (IPCC, 2013a). These climate change effects are expected to affect the environmental features and biotic assemblages of terrestrial and aquatic ecosystems, including coastal wetlands (Gillanders et al., 2011). The spatial and temporal variabilities of subsequent physical and ecological responses are expected to be substantial and include considerable uncertainty (Simas et al., 2001).

Coastal wetlands are some of the most valuable ecosystems in the world, due to the ecological functions and the ecosystem services they provide (Tabot and Adams, 2013). These wetlands are highly susceptible to significant and irreversible damage from climate change impacts (Parry et al., 2007). Because of their unique position in the marine–terrestrial interface, where they are subject to both tidal inundation and exposure to air, coastal wetlands can be affected by variations in freshwater quality and quantity, thermal and CO_2 fluxes and water, and changes in relative sea level and tidal range (Day et al., 2008; Erwin, 2009). These wetlands may then show a variety of ecomorphological responses such as changes in elevation, distribution of the wetland–terrestrial interface, spatial extent, and sediment composition, which could then cause complex outcomes involving biotic processes (Gedan et al., 2009). Other responses might include reduced biodiversity, altered primary and secondary productivity, altered nutrient cycling, increased prevalence of invasive species and disease vectors, and predominance of short-lived opportunistic species (Erwin, 2009)

* Corresponding author. Tel.: +52 206 5224132.
E-mail address: hmorzarialuna@gmail.com (H. Morzaria-Luna).

http://dx.doi.org/10.1016/j.ocecoaman.2014.03.004
0964-5691/

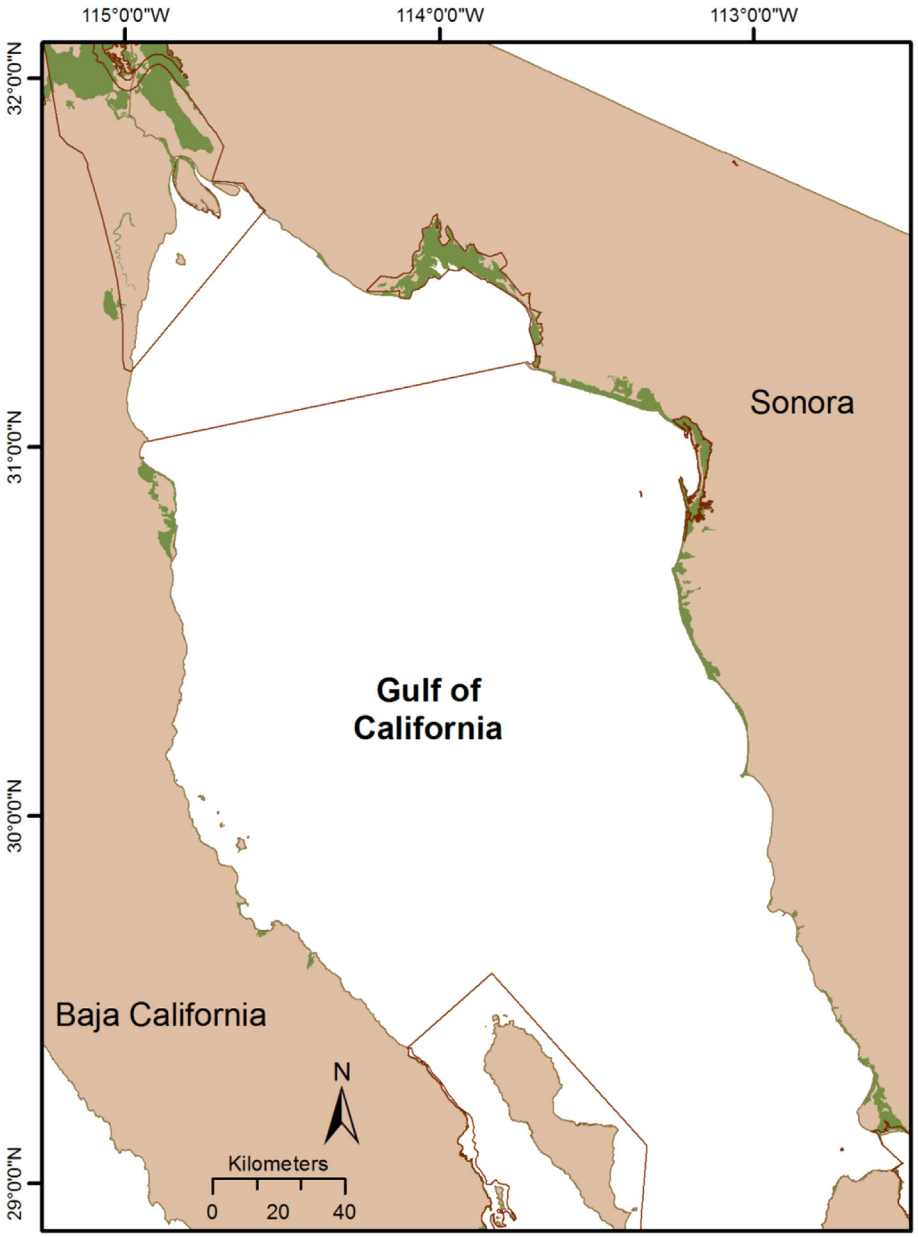

Fig. 1. Wetlands in the Northern Gulf of California above 29° N. Red lines indicate Marine Protected Areas and Ramsar sites. Data: INE- CONABIO, (Sierra and Chamberlain, 1999). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

and could alter the essential ecological functions and environmental services provided by coastal wetlands (Turner et al., 2000). Additionally, climate change impacts could interact with other anthropogenic stressors in coastal areas including pollution, habitat fragmentation, land use change, and invasive species, resulting in cumulative effects with large economic costs and societal consequences (Ruckelshaus et al., 2013).

Coastal wetlands in the Gulf of California, Mexico are considered vulnerable to climate change. The Gulf of California is one of the world's most productive and biodiverse marine ecosystems (Enriquez-Andrade et al., 2005). Here, fishing activities generate about 50% of Mexico's fishery production and support over 50,000 jobs (Cinti et al., 2010). Coastal wetlands sustain fisheries production by providing refuge, nursery, and/or feeding grounds for many commercial species (Aburto-Oropeza et al., 2008). In response to increases in climate-related risks, the Mexican government has developed a national policy on climate change that aims to develop strategies that preserve coastal wetlands, their communities, and the environmental services they provide (SEMARNAT, 2013). Information on the vulnerability of coastal wetlands is therefore urgently needed.

In this paper, we review and synthesize existing scientific information to critically examine possible climate change impacts on physical and biotic processes of coastal wetlands in the Northern Gulf of California (north of 29°N). This paper sets a foundation to understand the degree of vulnerability and the nature and extent of probable impacts of climate change for coastal wetlands in the Northern Gulf, in order to develop adaptation strategies. We focus on the effects of climate change on hypersaline negative estuaries found north of 29°N, dominated by salt marsh vegetation (Glenn et al., 2006). Mangroves predominate in the Central and Southern Gulf (Brusca et al., 2006). Salt marsh and mangrove wetlands have