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Physical-ecological consequences of some indicators of climate change on fisheries in marine and continent capture

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The average annual daily extreme precipitation (AADEP) in the Core North American monsoon (*CNAM)* can be caused by the occurrence of positive anomalies of the Pacific decadal oscillation (+ *PDO*) simultaneously with negative anomalies of the Atlantic multidecadal oscillation (− *AMO*) given the convective activity from monsoons caused by a strong land–sea thermal contrast and surface heating of moist air along the western slope of the Sierra Madre Occidental (Giovannetone and Barros, 2008). Given the issues raised, the goal of this work was to estimate trends and return periods of *AADEP* in the *CNAM* and examine the role of anomalies in Sea Surface Temperature (SST_{an}), surface temperature ($Stemp_{an}$), Pacific decadal oscillation and Atlantic multidecadal oscillation (PDO_{an} vs AMO_{an}), geopotential height to 500 mb ($Z500_{an}$), outgoing longwave radiation (OLR_{an}) and average relative moisture ($Mrel_{ave}$) before and during the beginning of Tropical Cyclones (*TC)* events in the northeastern Pacific and its association with decreases in the volume of fisheries in the Pacific because fisheries have always been affected by climatic variations, especially by rare and extreme events such as hurricanes and floods.

To identify and quantify the non-parametric trend of the contribution and intensity of 95th percentile (*P95*), in coastal and mountain sites, the Mann-Kendall methods were applied using the PAleontological STatistics (PAST) software version 3.08, and Sen's slope method using Microsoft Excel version 2013. To examine the role played by SST_{an} at the beginning of *AADEP* events, optimal data interpolation was used on the weekly and satellite *SST* merged dataset (OISSTV2) (Reynolds *et al.*, 2002), with a resolution of one degree for data available since 1981. In addition, anomalies of surface temperature ($Stemp_{an}$), geopotential height to 500 mb ($Z500_{an}$), outgoing longwave radiation (OLR_{an}) and average relative moisture ($Mrel_{ave}$) were analyzed. These were obtained from the (NCEP-NCAR) (Kalnay *et al.*, 1996) for the period 1981–2000, which was constructed of compounds of average daily atmospheric variables NOAA/CDC (http://www.cdc.noaa.gov/Composites/Day).

The results of the increases of the Surface Temperatures of the Sea were associated with the increase of the intensity of the Tropical Cyclones which in turn were related to the occurrence of decreases in the volume on fisheries in marine and continent capture production in live weight of main species (clam [Mercenaria mercenaria; *Spisula solidissima*], tuna [*Thunnus thynnus*], shrimp [Giant tiger prawn; *Penaeus monodon*], dogfish [Combtooth dogfish; *Centroscyllium nigrum*], lisa [*Mugil lebranchus*], mojarra [Chicawa; *Gerres equulus*], oyster [*Pacific oyster*], sardine [California pilchard, Pacific sardine and Sardina Monterrey; *Sardinops sagax caerulea*], sawfish [Largetooth sawfish; *Pristis pristis*] and shark [Tiger shark; *Galeocerdo cuvier*). Results of Tropical Cyclones and fisheries for the period 1981-2000; they were obtained from CONAGUA (National Water Commission) and CONAPESCA (National Commission of Aquaculture and Fisheries) databases, respectively.

TC compounds that can generate events of *P95* in southern Mexico are observed three days before the onset of extreme precipitation. They are generally observable in the configuration made for the contribution to events of high positive anomalies of $Z500_{an}$ and negative anomalies of OLR_{an} (Figures 1a and 1b). From the results, it is clear that the system of *TC*'s produces subsidence over the southwestern United States (partially reflected in the positive $Z500_{an}$ pattern) and cooling in the eastern Pacific off the coast of Mexico (Figure 1c), thus increasing the magnitude of land–sea thermal contrast, which in turn increases the availability of moisture (Figure 1d) for a distribution of storms along the Mexican Pacific. The positive anomalies of $Stemp_{an}$ (> 0.5 °C) in northwestern Mexico suggest a positive land–sea thermal contrast (Hasanean and Almazroui, 2017) (Figures 1e and 1f). The synoptic conditions of Figure 1 intensify the land–sea thermal contrast near the Gulf of California (Figure 1b), which generates convective systems and heavy precipitation in the *CNAM*. In the central region of the *CNAM*, the highest number of frequencies of *P95* associated with *TC's* occurred in September, which originated when the intensity of the SST of the Western Hemisphere warm pool (WHWP) showed maximum anomalies of SST_{an} > 28.5 °C (Figure 1c) (Wang and Enfield, 2003).

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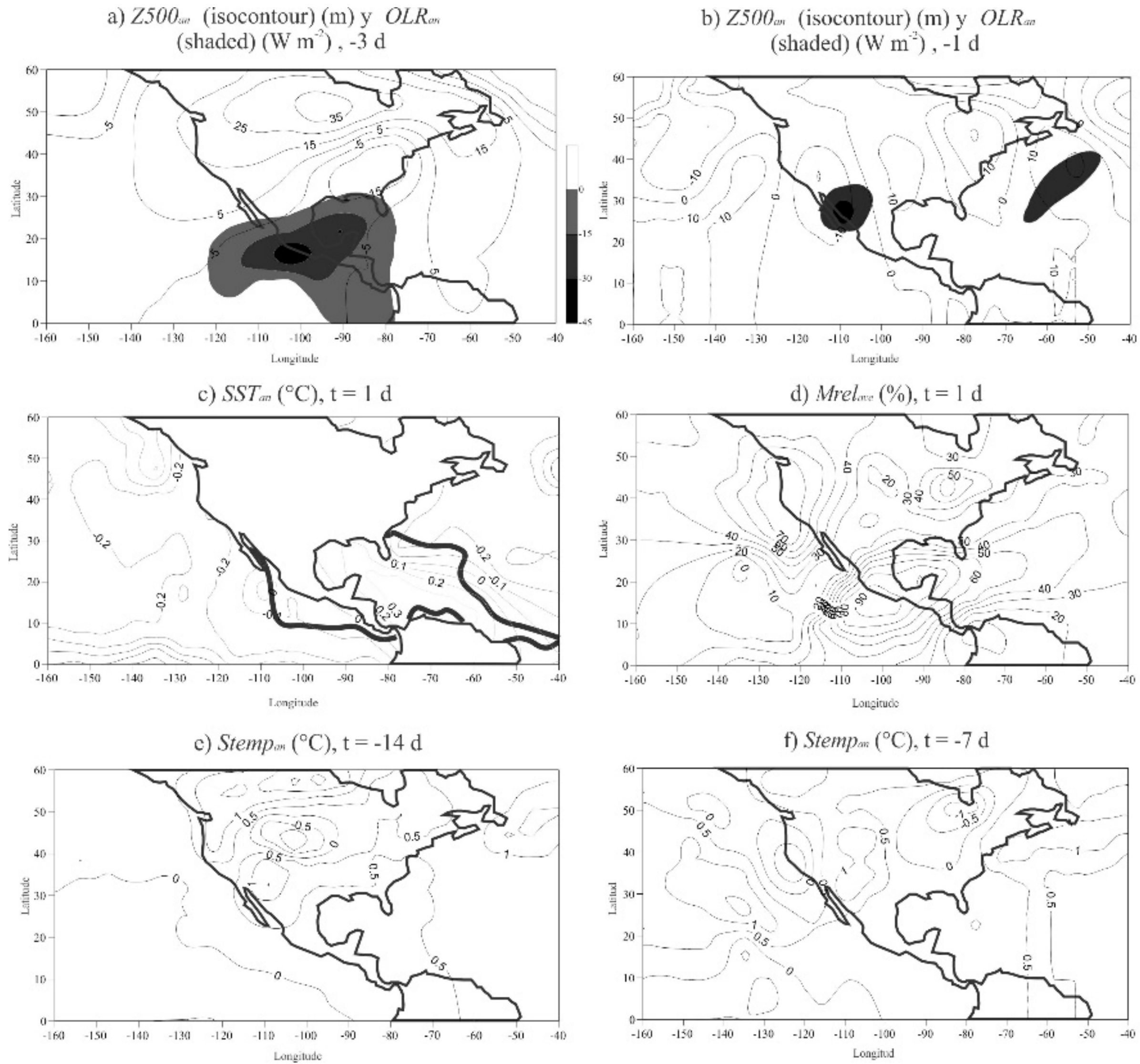

FIGURE 1. Anomalies associated with 95 Percentile (P95) of Tropical Cyclones (TCs) in the period 1961–2000. a) Geopotential height (*$Z500_{an}$*) (m) and outgoing longwave radiation (*OLR_{an}*) (W m^{-2}) starting at −3 days, b) as a), but starting at −1 day, c) anomalies of Sea Surface Temperature (*SST_{an}*) (°C) starting at 1 day, d) Relative moisture (*$Mrel_{ave}$*) (%), starting at 1 day, e) Surface temperature (*$Stemp_{an}$*) (°C), starting at −14 days and f) as e), but starting at −7 days.

According to the results of the fisheries of the period 1981-2000 of Figure 2a, the decline of the fishery in the years 1982, 1987, 1992, 1993, 1994 and 1997 was associated with the occurrence of tropical cyclones of high intensity (hurricanes of category I, II and III), which stimulated large-scale changes of Pacific affecting the species distribution mentioned in this paper (Figure 2b, Miller, 2007). It is also widely known that temperature changes in the Pacific islands can result in a spatial redistribution of tuna resources to higher latitudes in the Pacific Ocean and that this may lead to conflicts over tuna stocks among industrial fleets and national fleets (Daw et al., 2009). It is also widely known that temperature changes in the Pacific islands can result in a spatial redistribution of tuna resources to higher latitudes in the Pacific Ocean and that this may lead to conflicts over tuna stocks among industrial fleets and

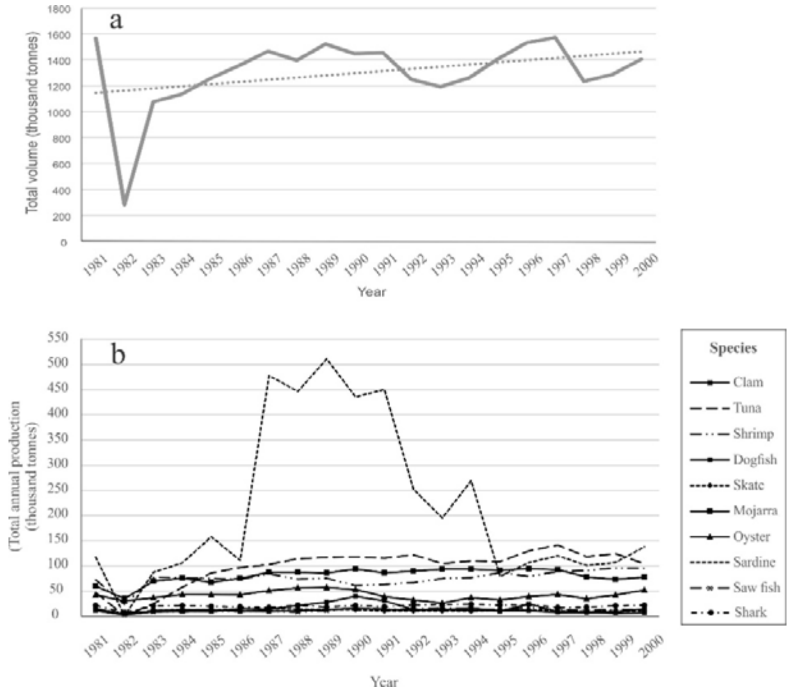

FIGURE 2. Annual variation (1981-2000) of fisheries data for the study area from CONAGUA and CONAPESCA a) total volume of fishery production in live weight (tonnes), b) fishery production total annual per species harvested (thousand tonnes).

national fleets (Daw et al., 2009). After the hurricanes Katrina and Rita (generated in 2005) struck the center of commercial and recreational fishing along the Gulf of Mexico coast, which produces 10% of the shrimp and 40% of the oysters consumed in the United States. Initial losses to seafood production from Katrina including sardine were estimated at $1.1 billion for Louisiana and may exceed $200 million for Alabama, exclusive of infrastructure; Mississippi losses are comparable to those of Alabama. Additional damages from Hurricane Rita may bring Louisiana losses to nearly $2 billion (Buck, 2005).

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AUTHOR CONTRIBUTIONS

All authors discussed the original idea; MNC, PMS, NHM, HJPG, MJPC and RDEG collected the field data; OLlC lead the writing.

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