Nat Hazards
DOI 10.1007/s11069-010-9528-3

SHORT COMMUNICATION

Reply to "Rip Current Misunderstandings"

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Received: 10 March 2010 / Accepted: 17 March 2010

We welcome the opportunity provided by the comments of Mr. B. Chris Brewster on his interpretation of the results found in our article titled "An Examination of Rip Current Fatalities in the United States." We argue below that the commenter's points of contention appear guided largely by assumptions, which lead to the misinterpretation of our research focus and associated conclusions. We appreciate the chance to illuminate our results on rip current mortality in relation to the commenter's statements.

First, we would like to clarify that our data were not simply derived from "media reports", as the commenter suggests. Our data were collected primarily from the National Climatic Data Center's *Storm Data*, which is the chief source of hazard data used by scientists for determining the number of casualties produced by weather and climate-related events. Because there are some known caveats associated with these data (e.g., see our discussion and references in the article), we supplemented rip current mortality information from *Storm Data* with mortality data acquired from *Lexis Nexis*, as well as information from a National Weather Service employee who specializes in rip current hazards. These supplemental data were used to (1) illustrate the best possible hazardscape of rip currents *as represented by rip current mortality* and (2) reveal any inadequacies in *Storm Data*'s rip current fatality reporting.

We initially examined the USLA dataset recommended by the commenter during our early investigation into rip current mortality, but determined subsequently that these data did not meet our research standards. There were many reasons why we chose not to incorporate USLA rip current mortality and/or rescue data into our analysis—some of these reasons include: (1) the major focus of our study was on mortality, not rescues; (2) major discrepancies appeared to exist between the USLA and *Storm Data* databases; (3) USLA rip current rescue and mortality data is not available for the entire United States; and (4) USLA data are reported *voluntarily* by local lifeguarding agencies annually with little, if any, metadata [the USLA states that "this is not a comprehensive list of all statistics generated by all beach

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Published online: 07 April 2010

lifeguard agencies" (http://www.usla.org/Statistics/public.asp)]. As an example of the USLA's dataset issues, in 2002 and 2003 (relatively high-frequency rip current fatality years; see our Fig. 3), the USLA dataset suggests that 22 fatalities during this two-year period were caused by rip currents. This is far less than the 80 fatalities found in *Storm Data* alone and, we claim, indicative of major reporting issues in the USLA database. Furthermore, if one were to query regional statistics from USLA, that person would find that no rip current fatalities were reported in the Great Lakes over the entire period of record. This subset of discrepancies illustrates data quality concerns and, therefore, we chose not to include USLA data in our investigation.

Nowhere in our manuscript do we state that we "developed a relative level of risk posed by rip currents" based solely on mortality, as incorrectly assumed by the commenter. Furthermore, we do not posit, as suggested by the commenter, that higher mortality in certain areas is due to "stronger or more hazardous rip currents". There are many variables that commingle to cause a rip current death; relative strength and frequency of rip currents are only two of those many variables that could be examined.

Next, the commenter contends that rip current *rescues* should be examined to assess the "actual" level of rip current risk across the United States. As illustrated in the title of our manuscript, we sought to examine solely rip current fatalities in the United States. We encourage any interested readers to examine the rip current rescue data; however, we urge caution in employing the USLA database since the organization only supplies data that were *voluntarily* provided by beach and lifeguard agencies (i.e., the relative completeness of the dataset is unknown) and because of the lack of useful metadata (i.e., date, location, gender, age, etc.). While we do not deny that rescues are an important component to rip current mitigation and may be used to assess the level of hazard, we do disagree with the commenter's argument that rescues across the entire United States is an accurately "quantifiable" variable at this time.

We concur with the commenter's position that California records, according to the USLA dataset, more rip current rescues on any given year than Florida (again, the completeness of these data is in question) and, therefore, the risk of rip currents *may be* higher in California than in Florida. However, we argue that risk alone does not determine whether a hazard results in a fatality, which, of the various assessments of a hazard's impact, was the focus of our study. Human and physical vulnerability comingle with risk to result in any hazard casualty. Our study did not solely highlight risk and we do not recommend that fatalities are to be used as the solitary variable in the examination of rip current risk.

We illustrate that nearly half of all reported fatalities from 1994 to 2007 occurred in Florida, while the commenter highlights that California reports a far greater share of rip current rescues. This statistical discrepancy in rip current mortality versus rescues is likely caused by lifeguard (in)accessibility, underlying human and physical vulnerability, as well as risk. Further, perhaps lifeguard density is higher, or beach agency reporting of statistics, is better in California versus Florida? To our knowledge, data comparing the density of lifeguards and how this impacts rescues and, in turn, the rip current hazardscape is unknown. How would the possibility of better rescue reporting by California lifeguard agencies in comparison to Florida's agencies influence the statistics? How do differing lifeguard agency definitions of what constitutes a rescue (versus a non-drowning "assist" or a "prevent" act) assessed and accounted for in the USLA database? These questions illustrate the problems with using a dataset that is constructed from information that is voluntarily provided and metadata deficient.

Additionally, the commenter states, "Since the USLA has determined, based on reported causes, that approximately 80% of rescues at surf beaches are attributable to rip currents, it can be surmised that there were approximately 4,771 rescues from rip currents in Florida in

2008 and 46,905 in California." We see little evidence of this 80% value and argue its validity. Examining the USLA's own data from 2000 to 2009 suggests that of the 933,301 rescues voluntarily reported by lifeguard agencies in the United States, 340,223 were due to rip currents—i.e., roughly 36.5% of the reported rescues were due to rip currents.

Next, the commenter's opinion on the impacts of *local* weather conditions (or lack thereof, in his personal judgment) may be suitable for some California beaches where he has lifeguarded; however, the broad brush assumption that local weather conditions do not have an impact on rip current development and vulnerability is likely inappropriate for all locations that experience rip currents. For example, the studies by Lushine (1991a, b) and Kent (2008) suggest that local wind direction and speed is highly correlated with southeastern U.S. rip current events. In our work, we suggest that favorable beach weather (e.g., the conditions found under or near surface high pressure) may lead to an increased beach presence and, therefore, vulnerability. As we argued earlier, risk alone does not determine mortality rates. Further, we remind the commenter that we examined the *large-scale* (so-called "synoptic scale") features that provided the underlying weather conditions for rip current development and vulnerability; we did not focus on "local" (so-called "mesoscale" to "microscale") weather conditions in our study. The discussion of these scale issues, and uncertainty involved, are provided in our Section 3.3. We do agree with the commenter's concluding statement that "predictive models for rip currents must be adaptive to a wide variety of causations"; nowhere do we suggest that our *large-scale* examination of weather patterns contributive to rip current fatalities is the only variable or primary variable that should be employed when developing forecasting tools for rip current event and vulnerability patterns. In fact, we suggest that local natural (e.g., wave forcing, sand bars, shelf bathymetry), man-made structures (e.g., piers, groins, jetties), and/or human behavior, characteristics, and abilities (e.g., use of alcohol, gender, swimming ability, beach visitations/tourism) can overwhelm the larger-scale weather influences to magnify rip current hazards and associated casualties. To reiterate, to discount weather conditions impacts on rip current risk and vulnerability across the United States is a mistaken and unsafe assumption. A reader may ask why the National Weather Service is required to issue rip current potential forecasts if weather has "little impact" on rip current development, as the commenter suggests?

In conclusion, the purpose of our research was to provide a spatiotemporal analysis of U.S. rip current *mortality*, and dissect the large-scale, surface meteorological conditions associated with these deadly events. We do not deny that lifeguard and Good Samaritan rescues, in many cases, successfully mitigate rip current mortality. We stand by the conclusion that Florida possesses a unique comingling of rip current risk and vulnerability that results in its relatively high rate of fatalities. We anticipate that the commenter, as well as readers, can agree that future rip current mitigation efforts should be focused where mortality has consistently been the highest.

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