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Environmental conditions and catch rates of predatory fishes associated with a mass mortality on the West Florida Shelf

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ABSTRACT

While conducting a standardized fisheries-independent longline survey in the northern Gulf of Mexico on August 20–21, 2014, dead and/or moribund fishes, estimated to number in the thousands, were observed within a well-defined area of the West Florida Shelf. Fishes from 15 families were identified; however, numerous individuals of relatively large-bodied serranid species were decomposed beyond a state that would allow for identification below the family level. Based on survey catch data from previous years and morphological characteristics associated with the decomposing fishes, it was determined that most of the large unidentified fishes were red grouper (*Epinephelus morio*). Water profiler cast data collected within the area demonstrated that when compared to previous years (1995–2013) bottom temperature and salinity were consistent with what would be expected; however, dissolved oxygen concentration was lower than normal, and in some cases, hypoxic and chlorophyll a and transmissivity values were anomalously high and low, respectively. Hypoxia, high chlorophyll a concentrations and low transmissivity are thought to have resulted from a bloom of *Karenia brevis*, which was documented to have occurred in close proximity to the sampling area. As necropsies were not performed, it was not possible to state a definitive cause of death as the effects of brevetoxins are species-specific. However, numerous individuals of most impacted species were observed floating incapacitated, yet alive, in normoxic surface waters suggesting that the impacts we observed were due to the neurotoxicological and/or hemolytic effects of a harmful algal bloom.

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1. Introduction

Occurrences of large-scale fish kills in the Gulf of Mexico have been widely documented with records of these events dating back to 1542 (Mitchell, 2003). While a number of causes, including hurricanes and seafloor volcanism, have been suggested over time (see Vargo, 2009 for a review), it is now understood that periodic wide-spread deaths of marine fauna in the region are the result of hypoxia associated with eutrophication and water column stratification or blooms of the toxic dinoflagellate *Karenia brevis* (Davis, 1948). The most well documented area in the Gulf of Mexico where hypoxia occurs with regularity is off the coast of Louisiana. Hypoxia within this region, often referred to as the Dead Zone, can persist from April through October and results from nutrient-rich, freshwater outflow of the Mississippi and Atchafalaya rivers during a time coincident with low wind speeds and water column stratification (Rabalais et al., 1991). These factors work in concert to create a system where decaying organic matter associated with phytoplankton blooms sink into bottom waters and deplete oxygen levels while vertical transport of oxygenated surface waters is prevented by a strong pycnocline (Boesch and Rabalais, 1991). While hypoxia-induced fish kills have been documented (Gunter and Lyles, 1979), Craig et al. (2001) report that fishes generally move from hypoxic areas into areas with intermediate, and thus habitable, oxygen levels. The avoidance behavior of these organisms to hypoxic water is perhaps best exemplified by “jubilees”, during which fishes beach themselves in advance of onshore movements of hypoxic waters (e.g. Loesch, 1960; May, 1973), or when abundance of fishes increases on the periphery of the hypoxic area (e.g. Rabalais et al., 1991; Bell and Eggleston, 2005) or into

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shallower oxygenated depths within the water column (e.g. Hazen et al., 2009).

While avoidance behavior is an effective survival strategy for fishes inhabiting areas prone to the formation of hypoxic conditions, brevetoxins associated with blooms of *K. brevis* cause a number of acute conditions, such as lethargy, loss of coordination, paralysis, and respiratory failure, ultimately leading to the death of fishes that have come in contact with the potent toxin (Landsberg, 2002). Exacerbating the deleterious impacts of these blooms is the potential formation of hypoxic conditions in areas where the bloom is occurring due to decaying *K. brevis* cells and dead organisms that succumbed to the harmful algal bloom (HAB) (Flaherty and Landsberg, 2011). Blooms of *K. brevis* are now commonly referred to as red tides and are known to occur almost annually off the southwest coast of Florida and less frequently in other areas within the northern Gulf of Mexico (Stumpf et al., 2003). How significant the impacts of red tides are to fish populations on the West Florida Shelf has been the source of some debate. For example, Gunter et al. (1948) reported a “catastrophic mass mortality” of marine organisms off the west coast of Florida and estimated over 500 million fishes died during a “phytoplankton bloom” in 1946–1947. However, Rounsefell and Nelson (1966) argued that the mortality estimate of Gunter et al. (1948) may “sound large, but it is actually not” when compared to yearly catches of some species.

Most studies examining the effects of red tides on fishes in Florida waters have been based on data collected from inshore habitats, such as estuaries and shallow coastal waters (e.g. Steidinger and Ingle, 1972; Gannon et al., 2009; Flaherty and Landsberg, 2011). Historically, the impacts of red tides on fishes at depths greater than 10 m have been documented based on anecdotal accounts provided by mariners and fishermen. For example, Feinstein et al. (1955) summarized numerous accounts of offshore fish kills related to red tides off the west coast of Florida from 1844 through 1955 but did not list species that were impacted. Of note, Smith (1975) compared the diversity and abundance of reef communities off Sarasota, Florida before and after a red tide event in 1971. The author stated that “red tides may result in the near-complete extirpations of shallow water (less than 40 m) reef biotas from extensive areas on the inner central-West Florida Shelf” and that as distance increased from shore so did mortality rates. Furthermore, Smith (1976a) reported 80–90% of fishes occurring on offshore reefs between depths of 18–30 m died as a result of the 1971 red tide, with 100% mortality for red grouper (*Epinephelus morio*) in the affected area with only small numbers of other groupers, such as gag (*Mycteroperca microlepis*), scamp (*M. phenax*) and goliath (*Epinephelus itajara*) groupers surviving.

In August of 2014, NOAA Ship *Oregon II* was conducting operations on the West Florida Shelf during the annual National Marine Fisheries Service, Southeast Fisheries Science Center, Mississippi Laboratories Bottom Longline Survey. This survey utilizes standardized gear and has been conducting fisheries-independent surveys on the West Florida Shelf annually since 1995. During the 2014 survey, a large-scale fish kill was observed coincident with a *K. brevis* bloom in the area (Florida Fish and Wildlife Conservation Commission, 2014). The objective of this report is to 1) describe abiotic conditions in the area where dead or moribund fishes were observed, 2) provide a list of species affected based on shipboard observations of dead and moribund fishes, and 3) compare catch per unit effort (CPUE) values for selected shark and grouper species during the fish kill to those from previous years within the area impacted by the 2014 event.

2. Material and methods

From 1995 to 2014, standardized bottom longline gear was set at depths ranging from 9 to 366 m on the West Florida Shelf. Locations were randomly selected using a stratified-random sampling design with proportional allocation and strata defined by water depth with stratum size determined by continental shelf area. Sampling did not occur during all years due to logistical constraints or adverse weather. Longline gear consisted of 1852 m of 4 mm diameter monofilament mainline and 100 gangions, which were constructed with a snap, 3.7 m of 3 mm diameter monofilament leader and a hook. Hook type varied, with No. 3 J-hooks (Mustad, Model No. 34970D) used from 1995 through 1998 and 15/0 circle hooks (Mustad, Model No. 39960D) used from 2001 to 2014; during 1999 and 2000 both hook types were used. Soak times were limited to 1 h unless circumstances dictated otherwise (mechanical difficulties, adverse weather, etc.). All captured fishes were identified and body length measurements obtained. Additionally, a Seabird SBE-911 water profiler (CTD) equipped with sensors to measure temperature (°C), salinity (practical salinity scale), dissolved oxygen (DO, mg/l), transmissivity (% transmissivity) and fluorescence at 650 nm (mg/m^3) was deployed at each station to obtain an environmental profile of the water column from surface to bottom. In some cases, not all sensors were operational; therefore, the full suite of environmental variables was not collected at all sampling sites. However, environmental data gaps were limited and all measures were obtained for all stations in 2014.

While transiting between survey stations during the 2014 survey, a large mass of dead and/or moribund fishes was observed approximately 50 km off the west coast of Florida (Fig. 1). Because of the large number of fishes floating on the surface in proximity to the ship, it was not possible to quantify or obtain a reliable estimate of the number of dead or moribund individuals. A list of impacted species was compiled by collecting floating specimens with dip nets both from the ship and a small launch. Additionally, while the ship was at idle speed during longline retrieval, visual observations of morphologically distinct fishes (e.g. *Lachnolaimus maximus*, *Ogcocephalus* sp., *Pterois* sp.) were recorded.

To assess the impact of the 2014 event on fishes, data were compared from that year to data collected in the same area from 1995 to 2013 (hereafter referred to as composite years). Three approaches were used in aggregate to determine the area impacted by the 2014 event. First, the ship's track line was plotted and locations where dead and/or moribund fishes were observed were indicated (Fig. 1). Second, visual comparisons of interpolated maps of temperature, salinity, dissolved oxygen, transmissivity and chlorophyll a concentrations encountered during 2014 and composite years were made and anomalous areas in 2014 were identified. Maps were generated with the mapping software Surfer (version 11.5.1069, Golden Software, Inc.), using a point kriging function and semi-variogram model with a linear component, anisotropy angle of 0 and anisotropy ratio and variogram slope of 1. Finally, data were provided by personnel with the National Oceanic and Atmospheric Administration's Harmful Algal Blooms Observing System (HASBOS) to determine if a *K. brevis* bloom was detected during monitoring of the West Florida Shelf for dates ranging from August 1,–August 20, 2014 (NOAA, unpublished data). A bloom was considered to be present when *K. brevis* cell counts exceeded 10^4 cells l^{-1} (Cannizzaro et al., 2009).

After identifying the impacted area, environmental data collected at the seafloor from composite years were statistically compared to those collected during 2014 (i.e. affected area only). In all cases, seafloor environmental data were homoscedastic; however, despite applying multiple transformations, data were not normally distributed. Therefore, median values and sample distributions for each seafloor environmental variable between composite years and 2014 were examined using Mann–Whitney (Wilcoxon) W tests and Kolomogorov–Smirnov tests, respectively.