Gulf of Mexico Science

Volume 31
Number 1 *Number 1/2 (Combined Issue)*

Article 7

2013

Mass Mortality of the Sea Stars *Luidia clathrata* and *Luidia alternata alternata* on the Alabama Coast, December 2013

James B. McClintock
University of Alabama at Birmingham

Luke M. McClintock
University of Alabama at Birmingham

John M. Lawrence
University of South Florida

DOI: 10.18785/goms.3101.07

SHORT PAPERS AND NOTES

Gulf of Mexico Science, 2013(1–2), pp. 74–78

MASS MORTALITY OF THE SEA STARS *LUIDIA CLATHRATA* AND *LUIDIA ALTERNATA ALTERNATA* ON THE ALABAMA COAST, DECEMBER 2013.—Mass mortalities among echinoderms are known to occur worldwide and can be of biotic or abiotic origin. Despite the importance of these observations, the vast majority of these catastrophic events are noted only anecdotally. Documentation of mortality events can provide important insights into the biology of the individuals involved, their ecological roles in communities, and the general health of marine ecosystems, as well as information of paleontological relevance (reviewed in Lawrence 1996). Among those mass mortality events documented and published in the literature, the majority have focused on sea urchins (e.g., *Lytechinus variegatus*: Beddingfield and McClintock, 1994; *Paracentrotus lividus*: Girard et al., 2012; *Strongylocentrotus purpuratus*: Hendler, 2013; reviewed in Lawrence, 1996). Fewer studies have documented mass mortality in sea stars. Eckert et al. (2000) reported significant mortality from ''sea star wasting disease'' in *Pisaster giganteus* and *Patiria miniata*, and to a lesser degree nine other species of common Pacific coast sea stars in a study conducted in the California Channel Islands in 1997. A similar epidemic of sea star wasting disease is currently underway along much of the Pacific coast of North America (J. S. Pearse, pers. comm.). Shorter-term sea star mass mortality events that are not density dependent or often as widespread as those caused by disease have been attributed to a host of abiotic factors including low seawater temperature (e.g., *Astropecten irregularis*: Crisp, 1964; Moyse and Nelson-Smith, 1964), rapid smothering by sediments (e.g., *Asterias rubens, Astropecten irregularis*: Schäfer, 1972), high currents and waves (e.g., *Luidia senegalensis*: Tiffany, 1978; *Asterias rubens*: Menge, 1979), low tide emersion (e.g., *Patiriella, Coscinasterias, Pentagonaster*: Hodgkin, 1959), low salinity exposure (e.g., *Asterias rubens* (as *Asterias vulgaris*): Smith, 1940), hypoxia (e.g., *Luidia clathrata*: Osborne 1979), anchor ice and ice scour (e.g., *Odontaster validus*: Dayton et al., 1970), and oil spills (e.g., *Asterias rubens, Marthasterias glacialis*: Smith, 1968). Moreover, there have been numerous anecdotal observations of sea stars washing up on beaches. For example, a recent 24 Jan. 2014 news headline in the web-based *London Daily Mail* read ''Thousands of dead starfish wash up on Lincolnshire Beach following stormy weather.'' The ensuing news article and photograph reported a mass mortality of what was identified by a local expert to be *Asterias rubens* presumably caused by strong storm-generated currents (Reynolds, 2014).

Herein we report a mass mortality of the sea stars *Luidia clathrata* and *Luidia alternata alternata* as indicated by hundreds of dead individuals discovered littering the tide line of a high-energy sand beach in Orange Beach, AL, on 27 Dec. 2013.

Methods.—In order to document the mass mortality event, individuals of both *L. clathrata* and *L. a. alternata* were exhaustively hand-collected along a continuous 1.125-km stretch of beach immediately to the east of the East Jetty of Perdido Pass that opens into Perdido Bay, Alabama (30°16′14″N−87°33′11″W). The sea stars were separated into their respective species and the radius (R) of the longest arm was measured to an accuracy of 1 mm for all individuals. Two individuals of each species were preserved as voucher specimens (Fish and Wildlife Research Center, Saint Petersburg, FL). In order to evaluate the size classes of individuals that were most impacted in the mass mortality event, the size frequency of all the individuals collected from the shoreline were determined for each species. Moreover, the mean body size (R) of *L. clathrata* and *L. a. alternata* were statistically compared.

The mass mortality event also provided an opportunity to evaluate the first documentation of the incidence of arm regeneration in field populations of both *L. clathrata* and *L. a. alternata* along the northern Gulf of Mexico. Arm regeneration was defined as only those arms that showed discernable regenerative growth, not simply arms that had freshly broken off presumably due to damage caused by being cast on to the shore. Both the incidence of individuals with at least one regenerating arm was determined for each species (frequency of arm regeneration within the population), and the number of arms regenerating in individuals displaying regeneration (degree of regeneration within individuals) were recorded. The frequency of arm regeneration and the numbers of arms regenerating among individuals were statistically compared between the two species.

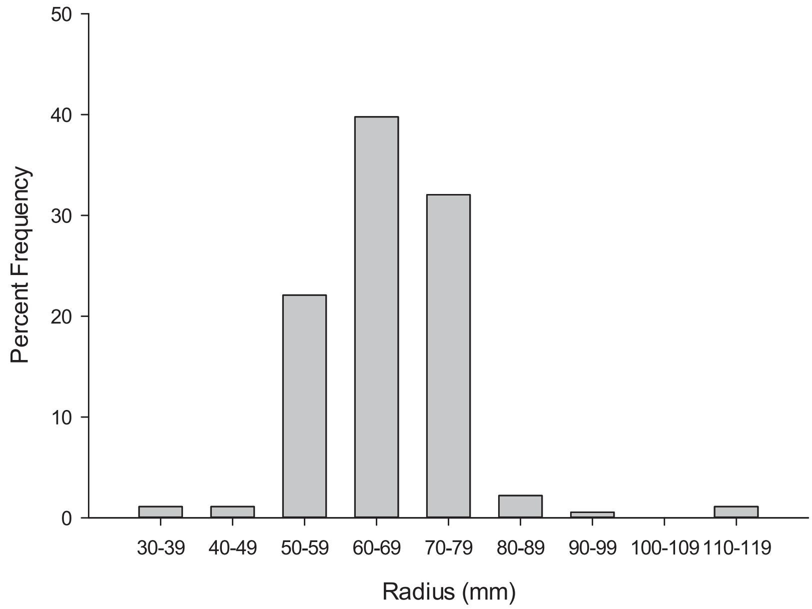

Fig. 1. Size frequency (radius) histogram of individuals of *Luidia clathrata* collected from the shoreline of Orange Beach, AL, following a mass mortality event observed on 27 Dec. 2013 (n = 195).

Results and Discussion.—The total number of *L. clathrata* and *L. a. alternata* collected were 195 and 226 individuals and their density along the shoreline sampled was 0.17 and 0.20 individuals m^{-1}, respectively. Dead individuals were found all along the shore but were not spread evenly and often were found clumped together with up to as many as ca. 10 individuals aggregated in a tight pile. This was likely the result of repeated strandings of dead individuals in zones of higher currents or surf. There appeared to be no pattern of differential distribution of the two species along the shore, but rather they generally occurred mixed together.

The vast majority of individuals of both species fell into large size classes (*Luidia clathrata*: 90% > 50 mm R; *L. a. alternata*: 100% > 50 mm R). Individuals of both species collected along the shore had unimodel size frequency distributions (Figs. 1, 2) indicating that either juveniles were not present in the populations impacted by the mass mortality event, or were less susceptible to stranding. *Luidia clathrata* has an annual reproductive cycle and spawns in the spring (Lawrence, 1973; Dehn, 1980; Watts and Lawrence, 1990; Pomory and Lares, 2000). If this were always the case, then early juveniles would have the potential to be represented in the impacted populations, but annual recruitment is known to be sporadic in echinoderms as it is dependent upon a number of biotic and abiotic variables (Mercier and Hamel, 2009, 2013). Despite the overlap of the size frequencies of the two species, individuals of *L. clathrata* were significantly smaller than those of *L. a. alternata* (mean R ± 1 SD: 64.2 ± 0.79 mm [n = 132] and 98.3 ± 0.87 mm [n = 173] for *L. clathrata* and *L. a. alternata*, respectively; $P < 0.001$, two-sample Student's t-test, t = 28.971, df = 418). The fact that *L. clathrata* were on average one-third smaller than *L. a. alternata* is more likely a consequence of species-specific differences in maximum body size rather than size-specific differences in susceptibility to the factor (or factors) that caused the mass mortality.

Individuals of both species with one or more regenerating arms were relatively common and the incidence of regeneration was significantly higher in *L. clathrata* than in *L. a. alternata* (32.3% vs 23.4%, respectively; $P = 0.0426$; two-by-two contingency table, chi-square uncorrected = 4.113). Moreover, the mean number of arms regenerating was also significantly greater in *L. clathrata* than in *L. a. alternata* (mean ± 1 SD: 1.83 ± 0.79 (n = 63) and 1.45 ± 0.75 (n = 53), respectively; $P = 0.004$, Mann–Whitney U-test). Both the higher incidence of arm regeneration in the population and the greater number of arms regenerating in a given individual indicate a higher susceptibility of *L. clathrata* to arm loss and has implications for allocations of material and energy to regenerating body components (Lawrence et al., 1986; Lawrence and Ellwood, 1991; Lawrence, 1992). Pomery and Lares (2000)

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DOI: 10.18785/goms.3101.07

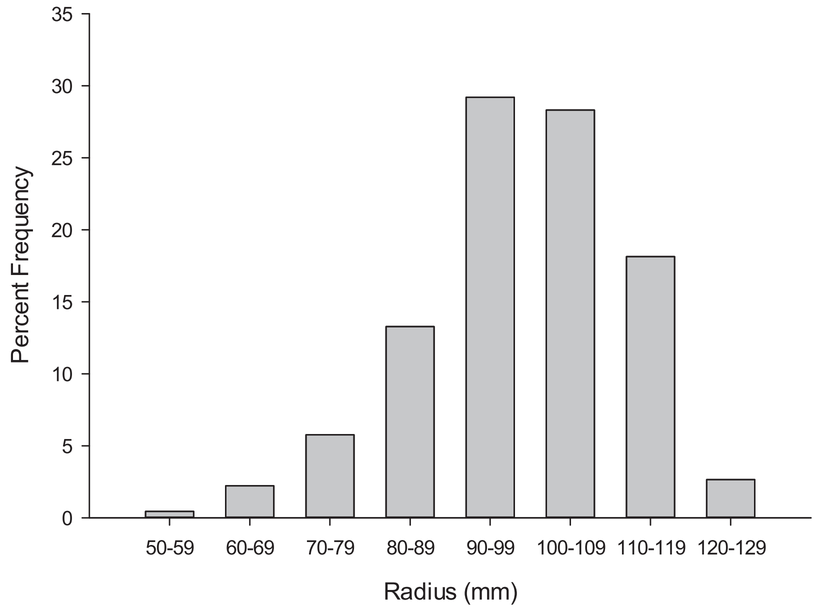

Fig. 2. Size frequency (radius) histogram of individuals of *Luidia alternata alternata* collected from the shoreline of Orange Beach, AL, following a mass mortality event observed on 27 Dec. 2013 (n = 225).

attributed arm loss in *L. clathrata* to predation and recorded an even higher incidence of arm regeneration (60%) in a field population in Old Tampa Bay, FL. There are several possibilities that could explain the species-specific differences in the incidence and degree of arm regeneration. One is that the tissue and ossicles are arranged such that the body wall of arms of *L. clathrata* is inherently weaker than that of *L. a. alternata*, rendering individuals more susceptible to predation. This is supported by the anecdotal observation that fresh arm breakage was not uncommon in *L. clathrata* but almost nonexistent in *L. a. alternata* collected from the high-energy shoreline (J. B. McClintock, pers. obs.). It is also possible that *L. a. alternata* is less prone to predation because of a chemical defense or some behavioral attribute such as a higher incidence or degree of burial in soft sediments.

The causative agent (or agents) for the mass mortality of sea stars observed in Orange Beach, AL, and documented in the present study are unknown. However, it seems unlikely that disease was a factor. Individuals cast on the shore, although all dead, appeared in good condition with no evidence of tissue necrosis that might be attributable to an infectious agent such as that causing sea star wasting disease (Eckert et al., 2000). Among abiotic factors, sediment burial, low salinity, emersion, and hypoxia would seem unlikely to have caused mortality. Although Orange Beach was the recipient of oil released during the April 2010 Deepwater Horizon oil spill in the Gulf of Mexico, and residual oil is known to occur in beach sediments that are coincident with the nearshore habitat of *Luidia* spp. in the Gulf of Mexico (Hayworth et al., 2011), it seems unlikely that hydrocarbons would have caused this mass mortality event as it occurred over such an abrupt time frame. Local tidal conditions for the week leading up to the mass mortality event reflect a moderate tidal cycle. However, data from a National Weather Service (NWS) ground station in Pensacola, FL, indicate that wind speeds were relatively high during several days of the week leading up to the recorded mass mortality (e.g., mean wind speeds of approximately 24–32 km h^{-1} and gusts up to 47 km h^{-1}). It is possible that winds contributed to strong currents. The day the sea star mortality event was documented, 27 Dec. 2013, there was a very strong long-shore current. A 113-g fishing weight repeatedly cast approximately 25 m from the beach directly offshore was rapidly swept by in a westerly direction and beached within a 1- to 2-min period (J. B. McClintock, pers. obs.). Daily marine weather data from NWS Orange Beach buoy station 42102 (30°3′55″N 87°33′19″W) indicated that sea surface temperature had declined to 20°C by 11 Dec. 2013, and had remained in the 18–20°C range until the 27 Dec.

2013 mass mortality event. *Luidia clathrata* in Old Tampa Bay have little locomotor activity in winter when the seawater temperature is ca. 20°C (Watts and Lawrence, 1986). The most parsimonious hypothesis for the mass mortality appears to be stress associated with exposure to relatively low seawater temperature combined with strong onshore currents that swept individuals of *L. clathrata* and *L. a. alternata* from the shallow soft-bottom benthos onto the shore.

Acknowledgments.—We thank Ferne and Jamie McClintock for assistance in collecting sea stars. Bill and Lynn Carter kindly provided access to Carters' Way on Ono Island, AL, where sea star measurements were conducted. JBM thanks the University of Alabama at Birmingham for providing support through an Endowed Professorship in Polar and Marine Biology.

Literature Cited

Beddingfield, S. D., and J. B. McClintock. 1994. Environmentally-induced catastrophic mortality of the sea urchin *Lytechinus variegatus* in shallow seagrass habitats of St. Joseph's Bay. Bull. Mar. Sci. 55:235–240.

Crisp, D. J. 1964. Mortalities in marine life in north Wales during the winter of 1962–1963. J. Anim. Ecol. 33:190–197.

Dayton, P. K., G. A. Robilliard, and R. T. Paine. 1970. Benthic faunal zonation as a result of anchor ice at McMurdo Sound, Antarctica, p. 244–258. *In:* Antarctic ecology. Vol. 1. M. W. Holgate (ed.). Academic Press, London.

Dehn, P. F. 1980. The annual reproductive cycles of two populations of *Luidia clathrata* (Asteroidea). I. Organ indices and occurrence of larvae, p. 361–367. *In:* Echinoderms: past and present. M. Jangoux (ed.). Balkema, Rotterdam, Netherlands.

Eckert, G. L., J. M. Engle, and D. J. Kushner. 2000. Sea star disease and population declines at the Channel Islands, p. 390–394. *In:* Proceedings of the Fifth California Islands symposium. U.S. Mineral Management Service Publication 99-0038, Santa Barbava, California, USA.

Girard, D., S. Clemente, K. Toledo-Guedes, A. Brito, and J. C. Hernandez. 2012. A mass mortality of subtropical intertidal populations of the sea urchin *Paracentrotus lividus*: analysis of potential links with environmental conditions. Mar. Ecol. 33:377–385.

Hayworth, J. S., T. P. Clement, and J. F. Valentine. 2011. Deepwater Horizon oil spill impacts on Alabama beaches. Hydrol. Earth Syst. Sci. 15:3639–3649.

Hendler, G. 2013. Recent mass mortality of *Strongylocentrotus purpuratus* (Echinodermata: Echinoidea) at Malibu and a review of purple sea urchin kills elsewhere in California. Bull. South. Calif. Acad. Sci. 112:1–19.

Hodgkin, E. P. 1959. Catastrophic destruction of the littoral fauna and flora near Fremantle January 1959. West Aust. Nat. 7:6–11.

Lawrence, J. M. 1973. Level, content, and caloric equivalents of the lipid, carbohydrate, and protein in the body components of *Luidia clathrata* (Asteroidea: Platyasterida) in Tampa Bay. J. Exp. Mar. Biol. Ecol. 11:263–274.

———. 1992. Arm loss and regeneration in Asteroidea, p. 39–52. *In:* Echinoderm research 1991. L. Scalera-Liaci and C. Canacatti (eds.). Balkema, Rotterdam, Netherlands.

———. 1996. Mass mortality in echinoderms from abiotic factors, p. 103–137. *In:* Echinoderm studies. Vol. 5. M. Jangoux and J. M. Lawrence (eds.). Balkema, Rotterdam, Netherlands.

———, and A. Ellwood. 1991. Simultaneous allocation of resources to arm regeneration and to somatic and gonadal production in *Luidia clathrata* (Say) (Echinodermata: Asteroidea), p. 543–548. *In:* Biology of Echinodermata. T. Yanagisawa, I. Yasumasu, C. Oguro, N. Suzuki, and T. Motokawa (eds.). Balkema, Rotterdam, Netherlands.

———, T. S. Klinger, J. B. McClintock, S. A. Watts, C.-P. Chen, A. Marsh, and L. Smith. 1986. Allocation of resources to body components by regenerating *Luidia clathrata* (Say) (Echinodermata: Asteroidea). J. Exp. Mar. Biol. Ecol. 102:47–53.

Menge, B. A. 1979. Coexistence between the seastars *Asterias vulgaris* and *A. forbesi* in a heterogeneous environment: a non-equilibrium explanation. Oecologia 41:245–272.

Mercier, A., and J.-F. Hamel. 2009. Endogenous and exogenous control of gametogenesis and spawning in echinoderms. Adv. Mar. Biol. 55:1–320.

———, and ———. 2013. Reproduction in Asteroidea, p. 51–58. *In:* Starfish: biology and ecology. J. M. Lawrence (ed.). The John Hopkins Univ. Press, Baltimore, MD.

Moyse, J., and A. Nelson-Smith. 1964. Effects of the severe cold of 1962–1963 upon shore animals in south Wales. J. Anim. Ecol. 33:183–190.

Osborne, S. W. 1979. The seasonal distribution of *Luidia clathrata* (Say) in Charlotte Harbor with reference to various physical-chemical parameters. Unpubl. M.S. thesis, Florida State University, Tallahassee, FL.

Pomery, C. M., and M. T. Lares. 2000. Rate of regeneration of two arms in the field and its effect on body compartments in *Luidia clathrata* (Echinodermata: Asteroidea). J. Exp. Mar. Biol. Ecol. 254:211–220.

Reynolds, E. 2014. Thousands of dead starfish wash up on Lincolnshire Beach following stormy weather. Available at: http://www.dailymail.co.uk/news/article-2267632/Thousands-dead-starfish-mysteriously-wash-Lincolnshire-beach-following-stormy-weather.html. Accessed: 1 Jan. 2014.

Schäfer, W. 1972. Ecology and paleoecology of marine environments. Univ. Chicago Press, Chicago.

Smith, G. F. M. 1940. Factors limiting distribution and size in starfish. J. Fish. Res. Board Can. 5:84–103.

Smith, J. E. (Ed.) 1968. 'Torrey Canyon' pollution and marine life. A report by the Plymouth Laboratory of the Marine Biological Association of the United Kingdom. Cambridge University Press, Cambridge, UK.

https://aquila.usm.edu/goms/vol31/iss1/7
DOI: 10.18785/goms.3101.07

Tiffany, W. J., III. 1978. Mass mortality of *Luidia senegalensis* (Lamarck, 1816) on Captiva Island, Florida, with a note on its occurrence in Florida gulf coastal waters. Florida Sci. 41:63–64.

Watts, S. A., and J. M. Lawrence. 1986. Seasonal effects of temperature and salinity on the organismal activity of the seastar *Luidia clathrata* (Say) (Echinodermata: Asteroidea). Mar. Behav. Physiol. 12: 161–169.

———, and ———. 1990. The effect of reproductive state, temperature and salinity on DNA and RNA levels and activities of metabolic enzymes of the pyloric caca in the sea star *Luidia clathrata* (Say). Physiol. Zool. 63:1196–1215.

James B. McClintock, Luke M. McClintock, and John M. Lawrence, *(JBM) Department of Biology, University of Alabama at Birmingham, Alabama 35294; (LMM) Department of Physics, University of Alabama at Birmingham, Alabama 35294; (JML) Department of Integrative Biology, University of South Florida, Tampa, Florida 33620.* Send reprint requests to JBM.

Note Added in Proof— Since the December 2013 starfish mortality event reported in the present study, there have been three reports of additional mortality events in the area, all in March 2014; at Bon Secour National Wildlife Refuge, Alabama (both *Luldia clathrata* and *L. a. alternata*), at Alabama Point, Alabama (*L. a. alternata* only) and at Perdido Key, Florida (both *L. clathrata and L. a. alternata*).