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# EFFECT OF HIGH STORM TIDE LEVELS ON BEACH BURIAL OF JELLYFISH (SCYPHOZOA) AND OTHER ORGANISMS

Contents



## *1. Introduction*

Fossil jellyfishes or scyphozoans have been reported from the Cambrian to Recent strata (Moore, Lalicker and Fischer 1952). The process by which these delicate creatures have been preserved as three dimensional casts or molds (Harrington and Moore 1955, van Gundy 1951) is an intriguing question. Observation of jellyfish in present day seas may lead to a better understanding of preservation processes.

## *2. Observations*

In January of 1958, several days after a severe storm which had caused the waters in Aransas Pass, Texas, to rise 3.2 feet above normal high tide level, the authors observed a series of small depressions in beach sand at the end of Saint Joseph Island. Location of this area is shown in fig. 1. The impressions were most abundant in an area several feet above normal high tide level and more or less formed a band about 20 feet wide which extended almost the full length of the beach (figs. 2—4). Remains of the jellyfish *Stomolophus meleagris* L. Agassiz in various stages of decomposition were found in several depressions, and the remaining depressions were easily recognizable by their shape as having been formed by *Stomolophus* (figs. 5—18). This jellyfish occurs in large numbers seasonally in the vicinity of Port Aransas and because of its shape is commonly called "cabbagehead".

At first, all the depressions were thought to have been formed by jellyfish which had been partially covered by sand. Further inspection, however, revealed that many depressions were the result of a caving in of sand over jellyfish which had

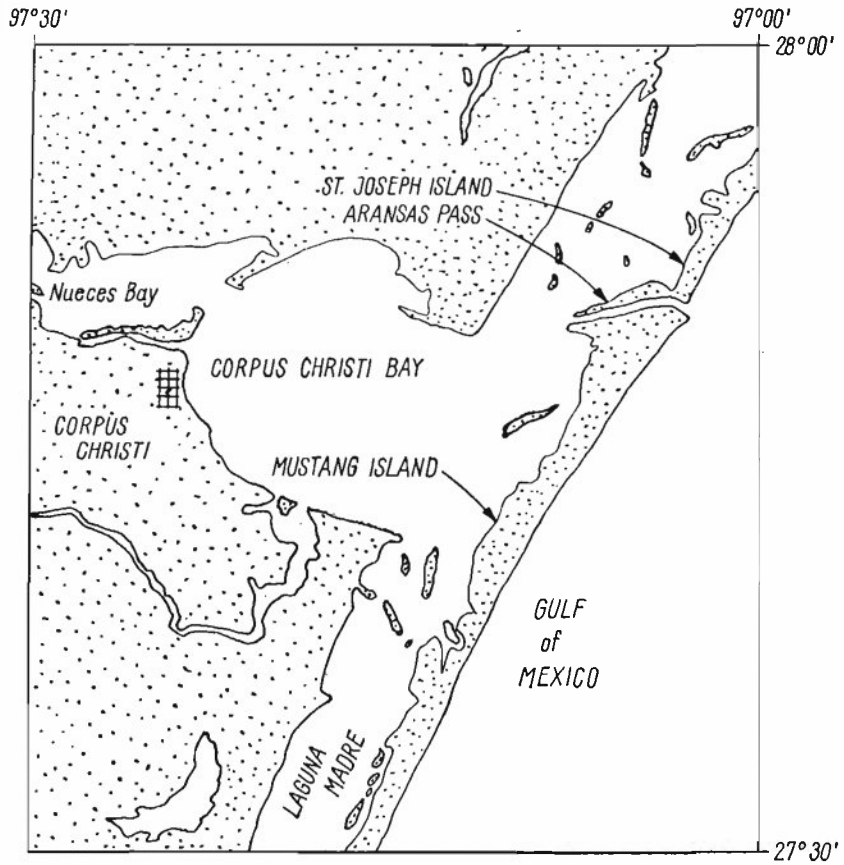



Fig. 1. Sketch map showing location of study area.

been completely buried by an inch or more of sand. Excavation of the sand within the 20-foot wide band revealed *Stomolophus*, whose presence was not indicated by surface depressions, buried 2—3 inches below the surface. Completely and partly buried jellyfish were also found at the water's edge. Surface depressions were not found either at the water's edge or in the shallow offshore water. Flattened films representing dehydrated remains of *Stomolophus* occurred on the beach above the band of depressions (figs. 15—16).

The shape of the depressions indicated that most of them had been made by *Stomolophus* deposited on their sides. However, in some cases specimens had apparently been buried in an upright or inverted position. Buried and partially buried jellyfish in various stages of decomposition were also found in all attitudes, but mostly on their sides. Orientation of the jellyfish which was not random (fig. 21) was probably a consequence of current direction.

Partly decomposed jellyfish occurred in distorted heaps several feet from impressions they had formed. Bird tracks around the impressions indicated that this was done by gulls. Edges of these molds were broken. This probably took place when the gulls pulled at the interred jellyfish (fig. 17).

The beach on which these observations were made was approximately 50 feet wide at the time of measurement. During the storm, water had apparently completely covered the beach for sand dunes at the back of the beach had been recently eroded. An approximately 3 foot drop in level occurred from the base of the sand dune to the water's edge, an average slope of about 3 degrees. The slope of the beach was not uniform, being steeper both above the depression zone and seeward of a berm which was locatet about 10 feet from the water's edge. A thick wrack of seaweed formed the crest of the berm. The wrack was composed largely of the "seagrass" *Diplanthera wrightii*, and algae such as *Gracilaria blogettii*, *Gracilaria crassissima*, *Gracilaria folifera*, *Digenea simplex*, *Laurencia poitei*, and *Spyridia aculeata*. These species are common in the bays of this region.

A sample of sand from the depression zone was analyzed mechanically and had characteristics typical of beach sands along the Gulf of Mexico (Table 1).

Table 1. Parameters of Beach Sand from Depression Zone on Saint Joseph Island[1])

| | |
|---|---|
| Mean Size: 2.95 ø | (fine sand) |
| Standard Deviation: 0.35 | (well-very well sorted) |
| Skewness: 0.00 | (symmetrical) |
| Kurtosis: 0.50 | (Mesokurtic) |

[1]) Analysis made by Harvey Blatt, University of Texas.

The beach was revisited about two weeks after the initial observation on a day following a heavy rain. Depressions were no longer in evidence. All that remained to indicate the location of former depressions were greenish patches where algae were apparently being nourished by the decomposition products of the jellyfish.

### *3. Discussion*

Two conditions which increase the probability of an organism being preserved in the geologic record are for the organism to occur in large numbers, and to be quickly buried after death. These conditions are much more important for soft bodied organisms such as jellyfish than for animals with hard parts such as clams and brachiopods.

The abundance of jellyfish in present day seas is probably not realized by many paleontologists. These animals at times occur in phenomenal numbers, e. g. HEDGPETH (1954, p. 277) estimated *Stomolophus meleagris* to be drifting through Aransas Pass at the rate of 2 million an hour on September 20, 1948. According to

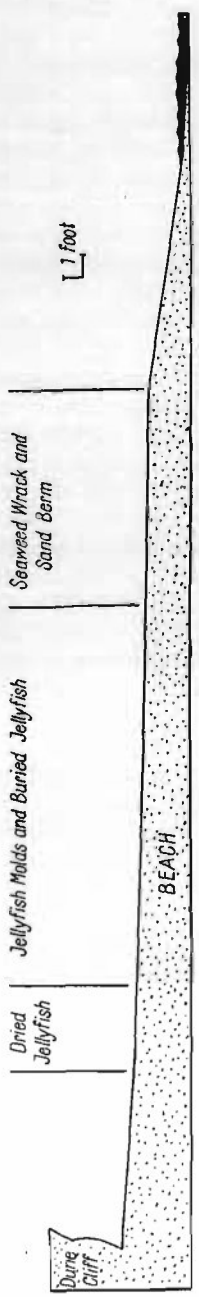



Fig. 2. Sketch of beach profile perpendicular to waters edge showing zone of dried jellyfish, zone of jellyfish molds and buried jellyfish, and location of seaweed wrack and sand berm.

HEDGPETH, "The bobbing white domes of jellyfish seemed to be packed almost solidly across the 800-yard width of the channel". Occasionally, *S. meleagris* is caught by the ton in shrimp trawls in the Gulf of Mexico (HEDGPETH 1954, p. 277) and has been sufficiently abundant off the west coast of Florida to interfere with commercial fishing (HELLIER 1958, personal communication). *Stomolophus meleagris* is not restricted to the Gulf of Mexico but is also abundant in bays and lagoons along the Texas coast. This species is also common along the coast of North and South Carolina, Georgia, and Florida, and is found along the northern coast of South America (MAYER 1910, p. 711). The occurrences of jellyfish as fossils, although scarce, probably indicate that they were also very abundant in the geologic past.

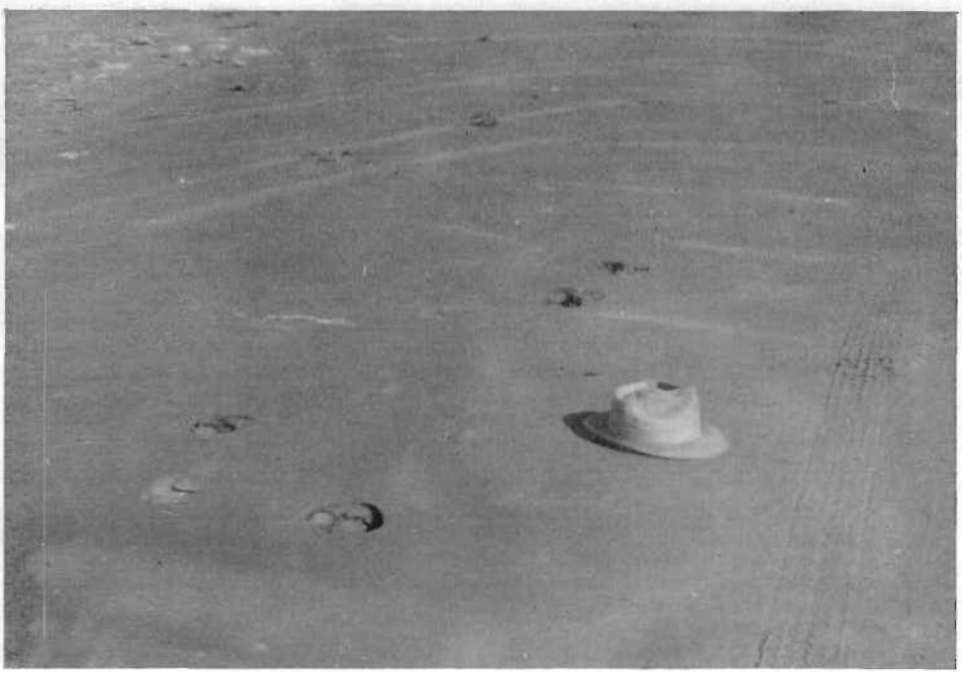
*S. meleagris* like many jellyfish are free-swimming and are capable of moving against, as well as with, water currents. If they should, however, venture into very shallow water where they are partly exposed and touch bottom, they are unable to navigate and are at the mercy of currents. A situation such as this exists on sand beaches where stranded jellyfish have been reported from many parts of the world (SCHÄFER 1941). Receding tidal waters often leave jellyfish behind to decompose on the beach. BRONGERSMA-SANDERS (1948, p. 974—989) in her comprehensive catalogue of mass mortalities which have taken place at sea lists stranding by receding tides and by being cast upon the beach by severe storms as two causes of mass mortalities of fish and mollusks. It is quite likely that drifting jellyfish also accumulate on beaches in especially large numbers after severe storms.

It is evident that so far as abundance of individuals is concerned jellyfish have good probability of being preserved, and that they occur perhaps in greatest abundance along beaches. The second condition necessary to increase the probability of preservation, that of quick burial, has been shown by the observations reported above to have occurred on a beach during or immediately after a severe storm. The process by which the jellyfish may have been buried will be discussed in a following section. To summarize, on a Saint Joseph Island beach after a severe storm jellyfish were abundant and were being buried, thus fulfilling two conditions which increase the probability organisms being preserved.

A third condition which increases the probability of an organism becoming a fossil is that the sediment in which the organism has been buried remains intact, that is, not reworked before lithification. In this regard, a sand beach rates very low as a situation favorable for fossilization. As expressed by SHEPARD (1948, p. 80), "Few things give as false a concept of permanence as a broad beach on a calm summer day". Beach sands are continuously being reworked by both wind and water currents and, therefore, are unlikely places for fossil formation. A point in favor of the beach as an environment where organisms might be preserved is its ubiquity. Sand beaches form much of the periphery of oceans and seas which have transgressed and regressed on and off the continents many times during the

Fig. 3 (above). Photograph of beach showing seaweed wrack. Molds were present in their greatest abundance in zone between seaweed wrack and strand line evident in upper left corner of photograph.

Fig. 4 (below). Photograph of zone containing greatest abundance of molds and buried jellyfish. Jellyfish were distributes in the manner shown in photograph throughout an area about 20 feet wide paralleling the waters edge.



Above: fig. 3; below: fig. 4

geologic past. Geographical areas that were not at one time or another the location of a beach are probably extremely rare. This situation increases the probability of organisms buried in beach sands being occasionally preserved.

During severe storms organisms may be deposited and buried above the normal high-tide level, e. g. the buried jellyfish described in this paper. Organisms buried at this level of the beach are less likely to be disturbed by normal tide levels. This increases somewhat their chance to be preserved.

The hypothesis is here advanced that fossils of jellyfish and other soft-bodied animals, including the remains of whole fish, might be relics of organisms buried in a beach environment. The fact that severe storms cause both high water and mass mortalities, which supply an abundance of organisms subject to burial above the high tide level, is considered to strengthen this hypothesis.

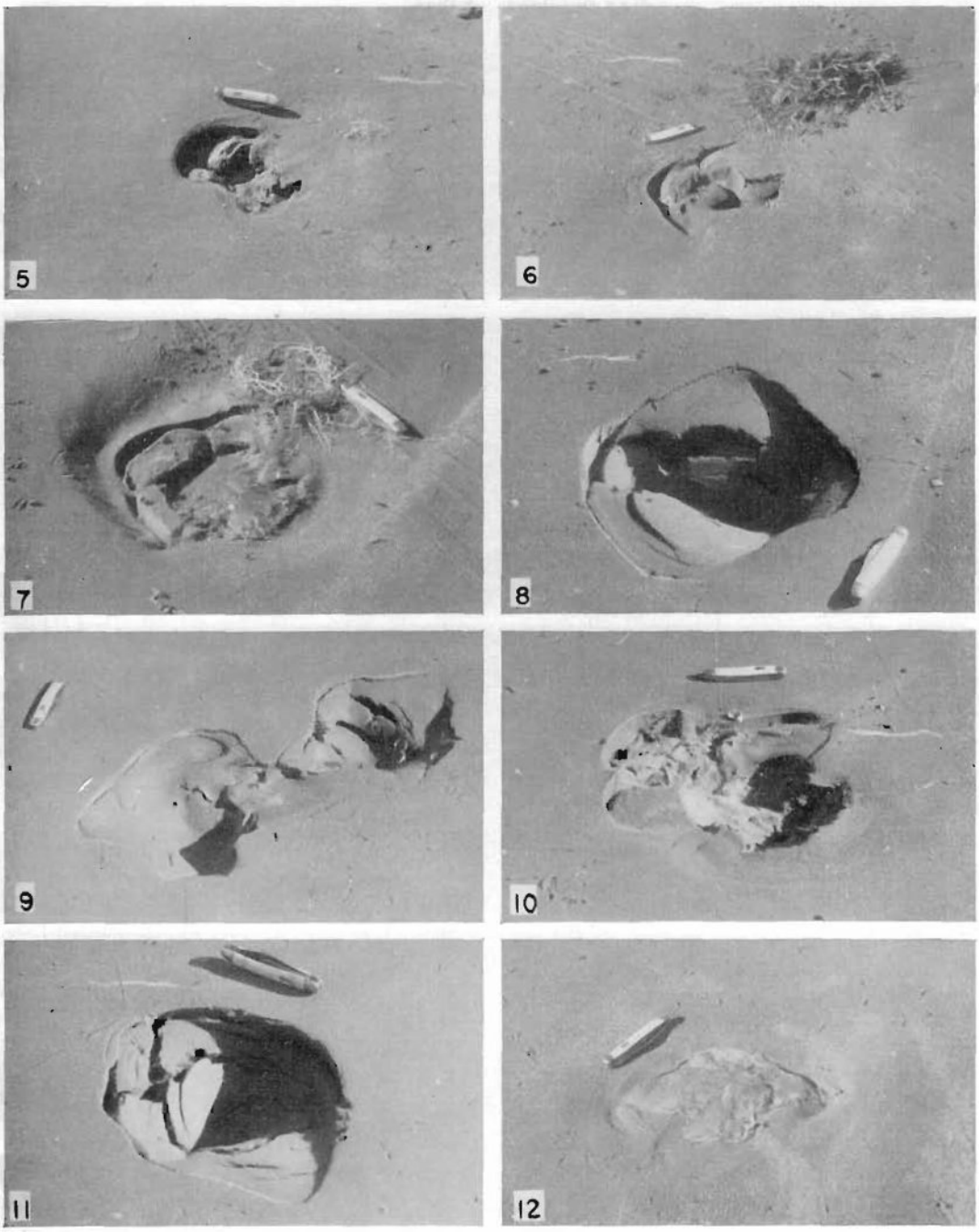
### *4. Burial Process*

MENARD and BOUCOT (1951) describe a mechanism by which shells may be buried in sand. In essence, a water current scours sand from around the shells and the shells settle into the scoured hole (see fig. 19). If erosion of sand prevails, the shell remains exposed, whereas if deposition prevails, it is covered. The process by which the *Stomolophus* were buried appears to be similar to the above account of shell burial. Although jellyfish were observed in all stages of burial, a complete burial from start to finish was not observed. The probable order of events leading to complete burial is as follows: 1. A jellyfish drifts into shallow water where it is partly emergent. At this point the effective weight of the jellyfish is increased so that further movement requires larger currents; 2. Water currents concentrate at the edges of the jellyfish and scour a hole around and under the jellyfish and it settles into the hole (figs. 22, 23); 3. Sand eroded from the upper beach or sand dunes in back of the beach is deposited on top of the jellyfish causing complete burial.

### *5. Mold and Cast Formation*

In order to gain insight as to whether the molds may also have been present under the off-shore water, a large *Stomolophus* was cut in half and each half buried in a jar of sand. The sand was collected from the Saint Joseph Island beach where so many jellyfish had been found buried. One jar was filled with water, whereas the other was left in the original damp condition. The jellyfish covered with water took about 10 days to collapse completely. As it slowly shrunk in size, sand from around the specimen filled in the space left by the jellyfish. At the end of 10 days only a slight, inverted cone-like depression at the surface of the sand markes the former location of the jellyfish. Slight agitation of the water caused the surrounding sand to fill up the depression so that there remained no evidence of the animal's former position except for a blackening of the sand which lasted several months. The half of *Stomolophus* buried in damp sand completely collapsed in about 3 days, but a mold reflecting the original shape and

Fig. 5. Jellyfish mold, St. Joseph beach. Fig. 6. Jellyfish mold, St. Joseph beach. Fig. 7. Jellyfish mold containing decomposing jellyfish, St. Joseph Island beach. Fig. 8. Jellyfish buried in sand, St. Joseph Island beach. Fig. 9. Two jellyfish buried in sand, St. Joseph Island beach. Fig. 10. Partly buried jellyfish, St. Joseph Island beach. Fig. 11. Buried Jellyfish, St. Joseph Island beach. Fig. 12. Decomposing jellyfish partly buried in sand near waters edge, St. Joseph Island beach.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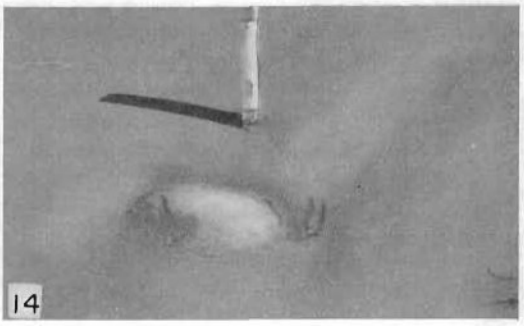
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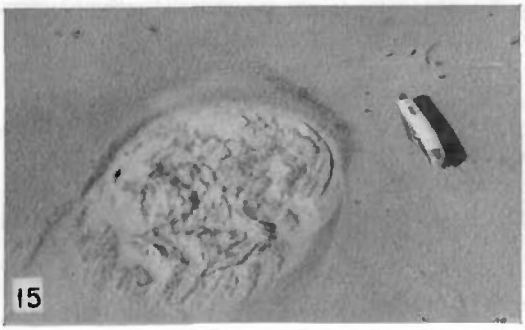
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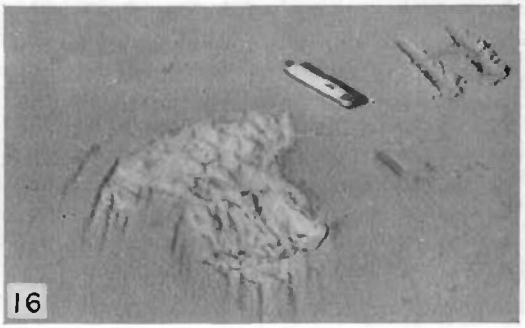
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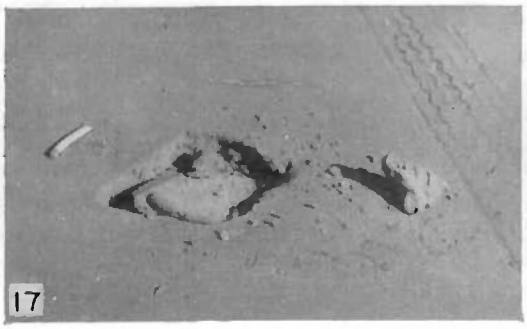
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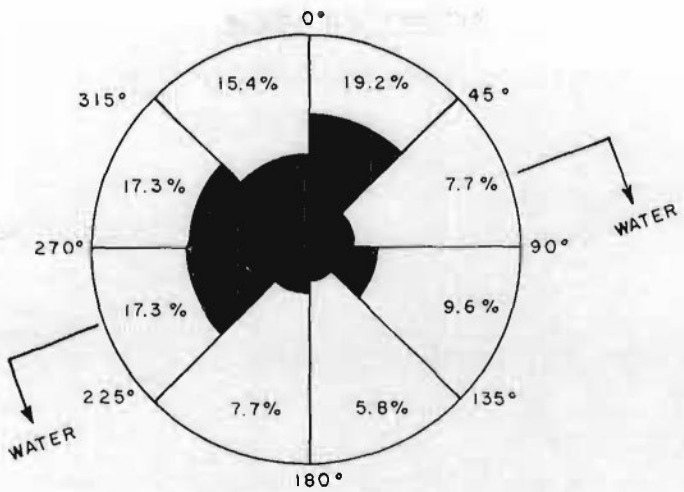


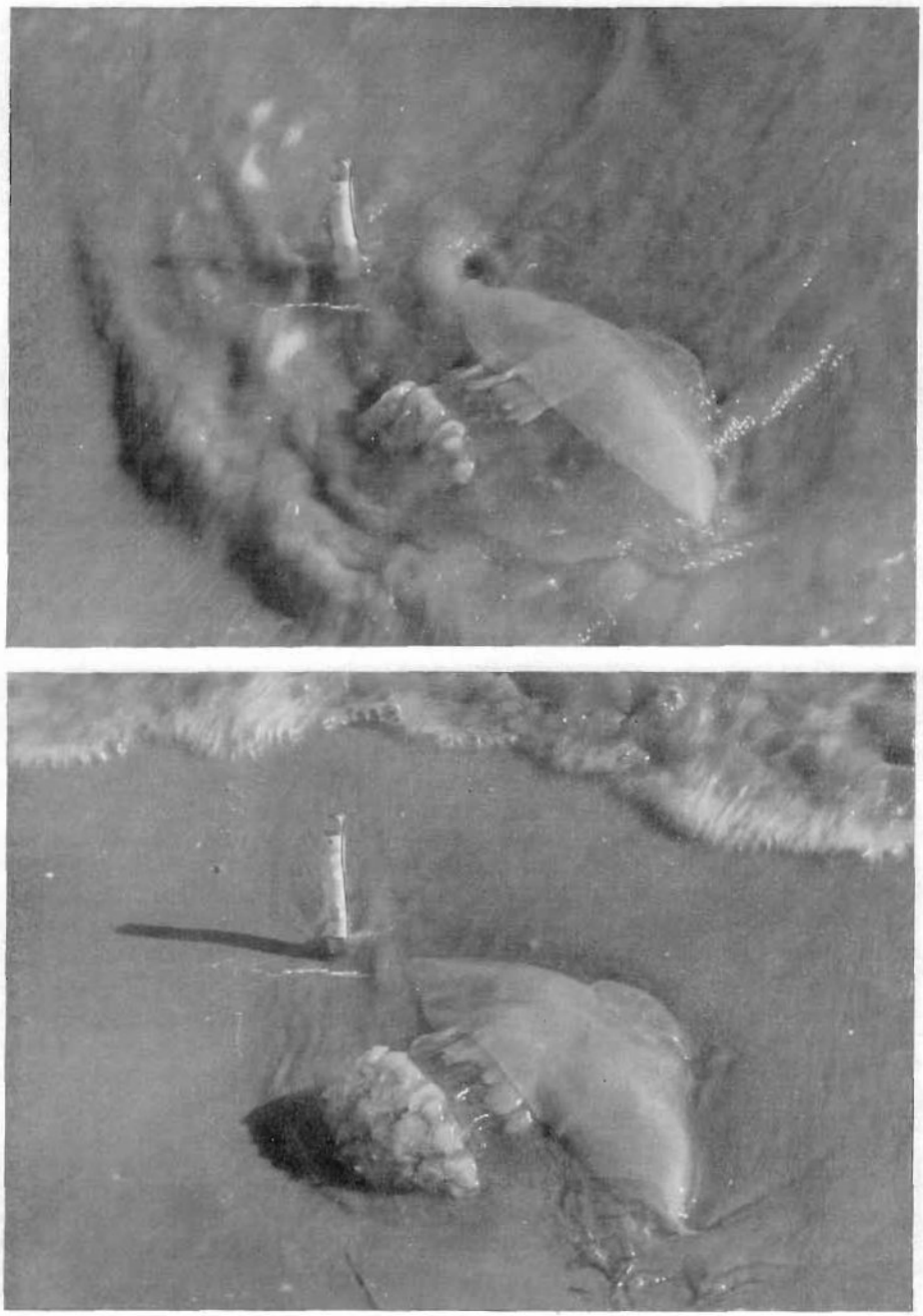

Fig. 21. Diagram showing orientation of jellyfish molds in 20 foot zone on St. Joseph Island beach. Radius of darkened portion of diagram represents spercentage of jellyfish umbrellas pointing in given compass direction. N = 52.

size of the jellyfish remained (fig. 24). This suggests that mold formation by jellyfish does not occur in sand covered by water, but further experiments are needed before stronger conclusions may be drawn.

Measurements of pH made by Dr. CARL OPPENHEIMER showed the pH of the beach sand to be about 8.2 and the buried jellyfish about 6.7 (fig. 20). In one pH profile taken from the surface of the sand down to a specimen of *Stomolophus* buried 4 cm below the surface the pH was 7.5 at the surface, 7.0 at ½ cm below the surface, 7.1 at 2.0 cm below the surface, and 6.0 at the jellyfish. Surface pH was 8.6 at a distance 13 cm away from the buried jellyfish. Measurements of pH made on a specimen of *Stomolophus* which had recently drifted into the beach and was collected from the water's edge showed the pH at the surface of the umbrella to be 7.5, tentacles 7.0, beneath mantle 6.9, inside of jellyfish 6.9. A specimen of a jellyfish belonging to the genus *Aurelia* had a surface pH of 7.5 and internal pH of 6.5. The low pH of the buried jellyfish may play some part in cementing the surface of the mold; however, no cementation was observed by microscopic examination in the sand forming the surface of several molds examined. Slime from the organism might also add rigidity to the mold.

Three dimensional fossils of jellyfish often occur as casts as well as molds. TWENHOFEL and SCHROCK (1935, p. 94) suggest some of these to be mud fillings

Fig. 13. Partly buried jellyfish near waters edge, St. Joseph Island beach. Fig. 14. Jellyfish almost completely covered at waters edge, St. Joseph Island beach. Fig. 15. Desicated jellyfish on upper part of St. Joseph Island beach. Fig. 16. Desicated jellyfish on upper part of St. Joseph Island beach. Fig. 17. Mold of jellyfish partly destroyed probably by bird, St. Joseph Island beach. Fig. 18. Partly buried jellyfish whose tentacles have been pulled away from umbrella probably by birds. Fig. 19. Gastropod on Laguna Madre beach partly buried by wave action. Fig. 20. Photograph of method of taking pH measurement of buried jellyfish, St. Joseph Island.



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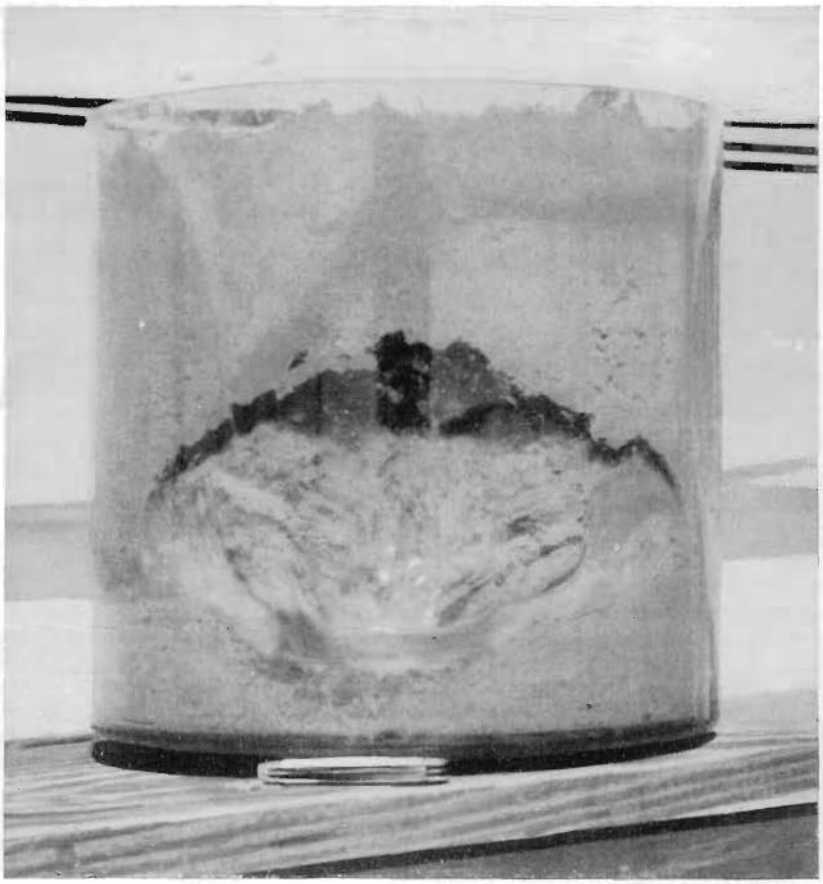

Fig.24. Mold of jellyfish formed after decomposition of jellyfish. Sand was obtained from St. Joseph Island and was slightly damp.

of the gastric pouches. KING in HARRINGTON and MOORE (1955) described two fossil jellyfish from the Upper Pennsylvanian of Kansas each of which adhere to "a subcylindrical or subconical mass of rock consisting of roughly stratified fragments of brachiopod spines, ostracode valves, and other organic remains in a matrix of sand or clay firmly cemented with calcium carbonate". Both specimens weathered out of shale. KING suggests that, "the rock mass attached to the jellyfish specimens might represent the filling of a burrow dug by some other animal, in which the medusoid was trapped and died or into which it was washed soon after

Fig. 22 (above). Photograph of current action around jellyfish at waters edge at St. Joseph Island. The water's edge is at lower left corner of photograph. Water is in process of goingout. Note turbity of water on downstream side of jellyfish caused by sand being excavated from under and around jellyfish.

Fig. 23 (below). Photograph of jellyfish shown in fig. 22 after water has passed. Note that jellyfish is partly embedded in sand.

death". An alternate explanation might be that a mold formed by jellyfish buried in a manner described in the present paper was filled in by sediment from above. In this case the "subcylindrical mass of rock" would be lithified sediment which filled the "neck" formed by caving in of the mold roof.

### *6. Summary*

Jellyfish belonging to the species *Stomolophus meleagris* L. Agassiz were deposited on a beach of Saint Joseph Island, Texas, above the normal high tide level during a severe storm. After the water had receded many individuals were found buried as deep as 2—3 inches in the sand of the beach. Decomposition of buried and partly buried specimens had resulted in many molds in the sand.

It is suggested that the jellyfish may have been partly buried by sand being scoured from around and under the jellyfish, and completely buried by deposition of sand eroded from the upper beach or sand dunes in back of the beach.

A hypothesis is advanced that some fossils of jellyfish and other soft-bodied animals might be evidence of organisms buried in the beach environment after having been deposited above high-tide level during a severe storm.

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