Gulf Research Reports

Volume 6 | Issue 3

January 1979

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DOI: 10.18785/grr.0603.14

Gulf Research Reports, Vol. 6, No. 3, 305–307, 1979.

NOTES ON SEA BEACH ECOLOGY. FOOD SOURCES ON SANDY BEACHES AND LOCALIZED DIATOM BLOOMS BORDERING GULF BEACHES

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ABSTRACT Food production along sandy beaches is much different from that of rocky beaches. No large algae grow on sand beaches. Small filamentous green algae find footholds upon molluscs, mole crabs, strands of *Leptogorgia* and logs. Basic food along the sand beach is made up of diatoms, bacteria, unicellular algae and detritus; diatoms are probably the most abundant autotrophic organism; the beach bacteria are largely heterotrophic. Most food on sandy beaches comes from the sea. The sandy shore seems to be barren, but it swarms with plant and animal life. Food production has a seasonal aspect. Food strands more abundantly on sandy beaches because the force of water returning to the sea is much less than that coming in. Beach materials are concentrated in a strand line. All organic materials are returned to the food cycle. Beached animal remains are consumed immediately until their breakdown products ooze away to enrich the sand substrata. The material of logs may not be redistributed until a number of years have passed. Food producing algae are diatoms, green algae, peridinians and blue-greens. Many of them are quite small and must be detected by bacteriological methods. They are probably quite significant. Food production from autotrophic algae appears to be relatively steady compared to drifting materials, which may vary enormously. Various types of food drift in as a result of dinoflagellate blooms, catastrophic cold kills and stranding cetaceans. Seasonal drifting materials such as sargassum, *Leptogorgia* and jellyfish come in at particular times of the year. The river mouth floods bring in material. The artificial jetsam of ships washes up on the beaches.

Nutrients and salts are also concentrated on beaches from organic remains. As a result, a type of beach-hugging planktonic bloom has been noted on the Texas coast when the sea is calm following heavy rains. It consists of a yellowish-brown conglomeration of diatoms of the species *Chaetoceras* sp., 15 to 20 feet wide along the shore for many, many miles. It follows heavy rains and the event is parallel to some aspects of the Florida red tide which occurs in calm weather, often following heavy rains, which are thought to bring chelating substances from the land.

There are variations in time both in production of food on beaches and that washing in from the sea. Quantitative studies have not been made; nevertheless, certain nonquantitative observations and distinctions can be made.

Food production and the sources of food for animals living along sand beaches are considerably different from those of rocky beaches. In contrast to rocky shores, no large algae grow on sand beaches except for filamentous green varieties which find small footholds upon certain molluscs such as *Donax*, the mole crab *Emerita*, strands of the alcyonarian coral *Leptogorgia*, and other beached objects such as logs. They occur only in negligible amounts. Thus the basic food along the sand beach is microscopic plants, chiefly diatoms, bacteria, various other unicellular algae and detritus. The diatoms are probably the most abundant autotrophic organisms produced on the beach. Presumably the beach bacteria are largely heterotrophic. Most of the food consumed on sandy beaches comes from the sea. Pearse et al. (1942, p. 137) have made similar comparisons before and their words are worth quoting, "A marine sandy beach seems like an inhospitable place for plants and animals to become established. On a rocky, wave-beaten headland, where storms rage and intertidal areas are exposed alternately to cool, surging water and hot or cold desiccating air, there may be an abundant biota of attached seaweeds, hydroids, barnacles, clams, etc. The rocks may be literally carpeted with living things. On the other hand a shifting, sandy beach is usually without much apparent life. There may be seen an occasional scuttling crab, a school of little fishes wiggling into the shallows, or a solitary sandpiper drilling holes with his long beak. In general a sandy shore seems to be a barren, clean place – admirable for bathing, but unpromising as a habitat where a biologist may collect or study animals. But appearances are deceiving. Marine littoral sands swarm with plant and animal life."

Along both rocky and sandy beaches food production has a seasonal aspect on temperate coasts, and the total production or peaks change from year to year. Nevertheless, this process has aspects of steadiness and regularity. Possibly the same thing holds for drift of planktonic materials from the sea, but information on that point is lacking.

There is a second fundamental difference between the sand beach and the rocky beaches in that the rougher and more abrupt the beach, the less organic materials, especially large particles or bodies, tend to strand and add their increment to the food of the shoreline. This holds true for two reasons. Rocky beaches are generally not wide and the water from waves and tide is channeled into quite strong currents returning to the sea. Floating objects may bump or bounce against rocks, which act as more or less pointed bodies, and be swirled out to sea again long before they ground on relatively level bottom. This is not to imply that stranding does not take place on rocky coasts, for it sometimes does and the total frequency may even be high, but the tendency is less than on an even-bottomed sand beach. The amount of food stranding on rocky coasts will

Manuscript received April 9, 1979; accepted April 19, 1979.

be at a maximum on gravelly or cobblestone beaches, which are not greatly different from sand beaches, and decreases with increasing roughness of the substrate and size of the rocks. On the bluff-like rock walls which prevail on some coasts, nothing strands except negligible scraps in small clefts and cracks.

In contrast, everything which drifts into the surf of a sandy beach finally strands. The writer has pointed out before that returning currents are much weaker than those driving in from the sea and that all floating materials become beached where they drag bottom (Gunter 1946). Another factor which serves to further reduce the ability of breaking waves to carry flotsam (and sediments) seaward again was pointed out by Dr. David DeVries (personal communication). This is because part of the water from any breaking wave train percolates into the beach, to return slowly to sea level at that particular stage of the tide. This percolation (or loss of water) on the foreshore portion of the beach is most effective in reducing energy of return flow for the more gently slopping, sandy beaches. Stranding holds true for whale carcasses and other large objects and for microscopic animals and plants as well. Subsequent higher tides may move beached objects higher up on sandy beaches, but they are not carried back to sea. Thus there is an aspect of finality about the stranding or beaching process. This is especially true of the wide Gulf beaches, where, except for a few days a month, tides are negligible and occur only once a day. Hedgpeth (1957, pp. 590–591) discussed the sorting action of strong and weak currents of incoming and outgoing waves with regard to sand, beached organisms and "the usual flotsam." It is only reversed by extreme flooding from land or actual cutting away of the beach by currents, both of which are rare occurrences. Beaching has been so commonly observed that it has given rise to a descriptive term, i.e., the strandline. The flotsam of the ocean, extending as a line down the beach, is characteristic of this environment all over the world. Thus, although sand beaches are harsh environments fitted only for the hardier organisms, they are not poor in food. To the contrary, food materials from a wide area are concentrated there within a narrow band.

It goes without saying that all organic materials drifting into the beach are returned in some manner to the food cycle. Even the logs and grass stems are slowly broken down by bacteria, while the more edible products are consumed directly and immediately, both by permanent beach dwellers and certain land animals which remove organic materials away from the beach cycle. In this latter category the various birds probably play the greater part.

Food-producing algae, according to Humm (Pearse et al. 1942), aside from the few macrophytes, are diatoms, green algae, peridinians and blue-greens. Some are only 3 microns in size and are seldom abundant enough to be seen. However, they are to be found everywhere by bacteriological methods and Humm states that they are probably more "significant in the economy of the beach than previously supposed."

Food production on the beach is relatively steady from autotrophic algae while that from drifting materials varies enormously in abundance. This matter has not been noted particularly in the literature and it is worth some attention. One group of drifting materials may be called sporadic or irregular. There are many examples over the world but only certain ones which have been observed personally will be mentioned.

During the various cases of catastrophic mortality in the sea, huge numbers of animals, chiefly fishes, drift onto the beach. Photographs relating to dinoflagellate bloom or the red tide in Florida (Gunter et al. 1948) and others connected with cold kills on the Texas coast (Gunter and Hildebrand 1951) have been published. Although the latter are of bay beaches, the writer (Gunter 1941) has noted that numbers of molluscs and fishes also wash up on the outside of beaches after the heavy cold kills. When these catastrophic mortalities come, and they are fairly common in widely spaced places on earth, the beach fauna receives a vast superabundance of food.

It is well known that carcasses of cetaceans commonly come ashore. Numbers of locality records derive from such instances. Some species are prone to stranding in large numbers while alive and large porpoises of the genus *Globicephala* are especially noted for this characteristic. Lowery (1943) published photographs of 49 of these animals that had become beached on the Louisiana coast following a hurricane. There are several other examples in the literature. Animals such as the ghost crabs *Ocypode* gather around such carcasses and dine upon the rich fare until the liquefying remains ooze away into the sand.

A second group of drifting materials may be called seasonal. On the Texas coast during the spring, vast windrows of *Sargassum* pile up on the beach. In certain years this drift is much greater than in others. In 1950 a band approximately 15 yards wide and 1 foot deep lined the Texas coast for over 300 miles. The weights involved must have been of the order of several thousand tons. During the summer the alcyonarian coral, *Leptogorgia setacea* (Pallas), rolls ashore in large masses and to such an extent that some thoughts have been given to the possibility of commercial use of the central horny core as a source of iodine. Still later in the year, when the winds blow from the north, thousands of the jellyfish *Stomolophus meleagris* Agassiz are sometimes beached. It should also be mentioned that *Physalia* and *Velella* move steadily into the strandline throughout the summer, but are relatively scarce in winter.

Certain beaches around river mouths, such as those of the Louisiana coast, receive influxes of material from land following the annual spring high-water periods. The amounts are greatly increased in flood years. These materials consist largely of plant remains, such as logs and the water hyacinth. The logs and dead trees sometimes make the beaches virtually impassable.

In addition to the purely natural causes of organic deposition upon the beach, there are certain artificial ones, some of which have a seasonal character. Beaches near ship lanes or in the vicinity of coastwise traffic receive certain amounts of garbage. Trash materials from commercial fishermen's catches seasonally drift up on some beaches. Near Port Aransas, Texas, certain fishes, chiefly tarpon, drift ashore in considerable numbers in summer due to the sport fishing industry of that town.

Food materials drifting onto beaches may be roughly divided into two categories on a basis of whether their availability is immediate or deferred. Most animal remains are immediately available to the beach animals. On the other hand, plant remains must first be subjected to bacterial action and, in some cases, it may be years before they become totally available. Even the most edible animal bodies are not all consumed before part of them oozes away into the sand. These factors tend to have a damping or time-spreading effect upon the amounts of food available to beach animals following mass beachings; part of the food may become available over a time spread of a few weeks, months or even years after mass strandings.

Humm (Pearse et al. 1942) made a particular study and found that the various bacteria species that destroy the celluloses and hemi-celluloses are quite common. They slowly destroy logs many years after their stranding. Chitinoclastic bacteria have been found abundant on both Atlantic and Pacific beaches.

It is clear that organic material drifting into the beaches varies enormously from time to time and this variation may be seasonal or completely sporadic, with some instances being years apart. Seasonal drifts usually cover a few hundred miles. The sporadic cases may relate to a few hundred miles of beach, but certain others, such as the strandings of cetaceans are entirely local. In any case, the concentration of organic materials in a narrow band on the shores of the seas is impressive.

Pearse et al. (1942, p. 176) concluded "Sand beaches are not barren wastes, as they appear at first glance, but are swarming with life, and continually digest and furnish food to plants and animals."

The shifting sands of the seashore are probably not good sites for the process of fossilization. Nevertheless, the mere fact that the beaches are points of concentration makes them worthy of consideration in this respect. Fossils of open-sea animals have been described from beach deposits. It is obvious that remains of land animals and plants might also be found along old beach lines.

It seems probable that nutrient salts are also concentrated upon beaches, as would be expected from concentration of organic remains. This is suggested by a type of plankton bloom which occurs along the Texas coast. When the water of the Gulf is relatively calm, following heavy rains, a narrow band of diatoms sometimes forms along the Gulf shore of Mustang Island, extending from the water's edge out 15 or 20 yards. The writer has seen it running along the shore without break for a distance of 16 miles, which was as far as it was traced, and extending on out of sight. The organisms were so thick they gave the water a yellowish-brown appearance somewhat like tea. The phenomenon has been observed two or three times and the organisms in one instance were collected in a plankton net by the late David Kramer (personal communication). He found that the water contained a perfectly uniform population of billions of *Chaetoceras* sp., which is commonly looked upon as an open-sea genus. Presumably, this diatom bloom takes place next to the beach when the common nutrient salts are leached out by rainwater and remain concentrated in the calm sea right next to shore, or they may wash down a chelating agent from land, as has been suggested for the Florida red tide. In any case, the parallel of blooms following rains and calm weather is suggestive.

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