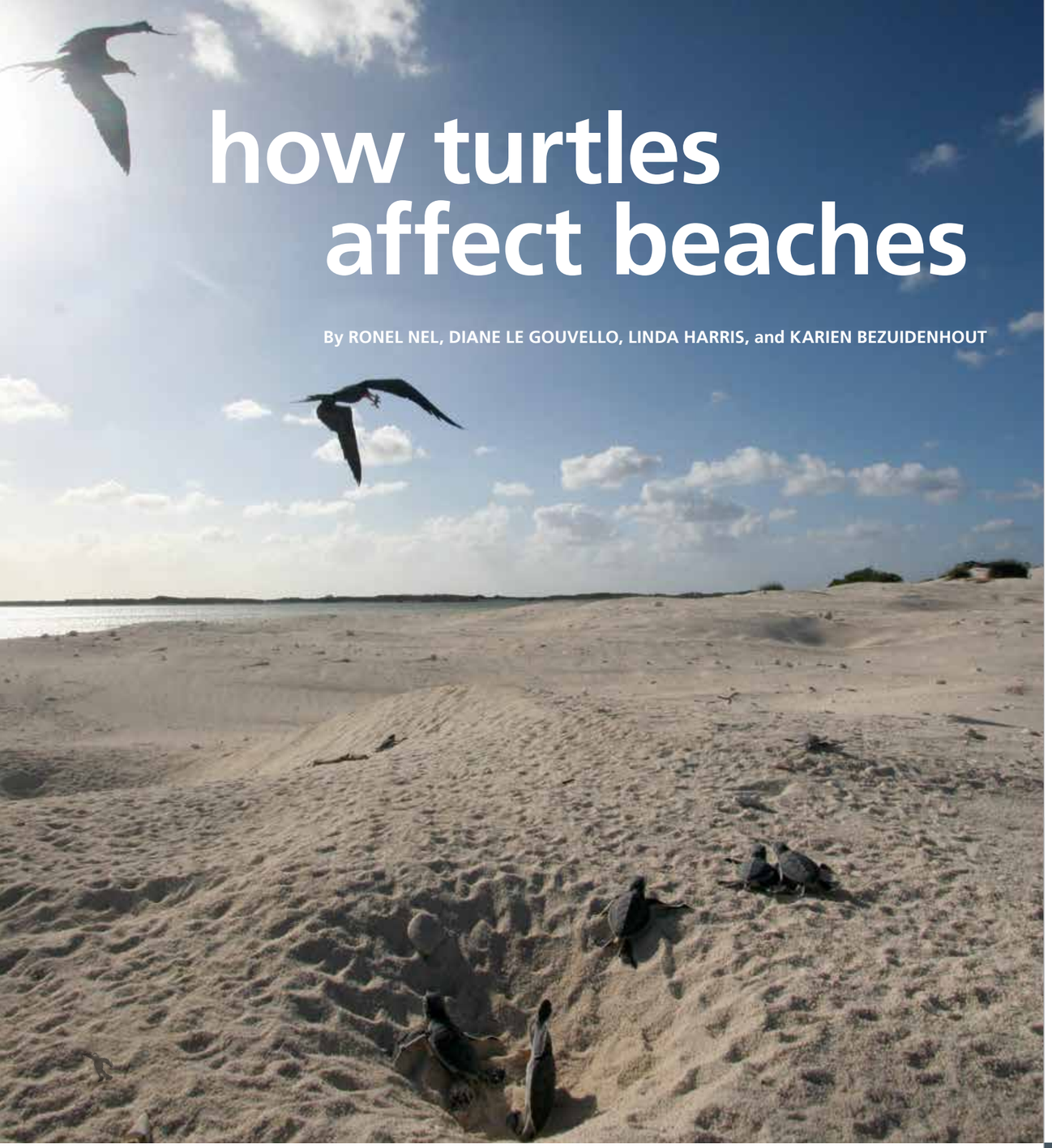

how turtles affect beaches

By RONEL NEL, DIANE LE GOUVELLO, LINDA HARRIS, and KARIEN BEZUIDENHOUT

Research attention has recently shifted toward understanding the complex ecological roles of sea turtles as transporters of nutrients, hosts for epibionts, and sustainers of healthy seagrass beds and coral reefs. Although those relationships are undeniably important, to date we have not been successful at fully quantifying all of them or uncovering the interdependencies between them. One such set of unanswered questions pertains to the functional value of sea turtles to intertidal beach ecosystems. Researchers have long recognized the strong relationship between beaches and turtles, but past research typically has focused only on the beach conditions required to ensure successful incubation. We rarely ask the inverse: What is the value of sea turtles and the nutrients they bring to sandy beach ecosystems? Although pioneer sea turtle scientists such as Karen Bjorndal have investigated nutrient budgets for turtles and dunes, the relationship between turtle-derived nutrients and beach and nearshore ecosystems remains a mystery.

People living on temperate shores are familiar with phenomena such as the salmon run, in which entire ecosystems emerge from winter hibernation, starving for nutrition and desperately waiting for the salmon to arrive. Hungry bear cubs and their mothers, along with a whole suite of predators and scavengers ranging from other fish to birds and even insects, await the seasonal nutrient pulse as an opportunity to gorge themselves on adult salmon, their eggs, and fry. Fish-derived nutrients are enormous drivers in the terrestrial, freshwater, and coastal ecosystems where salmon runs occur.

Sea turtle nesting is no different; it creates a massive nutrient pulse into otherwise nutrient-poor beach ecosystems. Unlike the riparian vegetation or conifer forests of salmon habitat, however, intertidal beaches have no noticeable primary production. In fact, sea turtle nesting typically occurs on the backshores of tropical beaches, areas that are devoid of vegetation and adjacent to clear, nutrient-starved seas. Temperate beaches contain long-term diatom accumulations, and nutrient inputs also are maintained by washed-up algal wrack or cast-up kelp, which breaks down and is recycled through the beach systems. In the absence of plants or algae on most turtle beaches, however, intertidal systems rely solely on outside inputs, such as those brought by sea turtles, to drive ecosystem processes.

Turtle-derived nutrients provide a rich, albeit unpredictable, source of carbon and nitrogen to beaches and dunes. Although turtle eggs typically are deposited above the high-tide mark, fauna traverse the beach, feeding on eggs and hatchlings both above and below the high-tide line, thereby moving those nutrients widely. Such fauna include vertebrates, such as monitor lizards, snakes, honey badgers, birds, and other regionally specific species, and larger invertebrates, such as ghost crabs. Decaying nests are also invaded by ants and other insects and by meiofauna, such as nematodes (see images below), and are processed by microbes and bacteria, thus releasing nutrients into the groundwater that ultimately leach back into nearshore environments.

A recent investigation in South Africa aimed to untangle and quantify some of those complicated relationships. Even though South Africa hosts modest sea turtle populations, years of study have yielded a good deal of knowledge about beach ecosystems. The investigation surveyed the dependence of invertebrate macrofauna (creatures greater than one millimeter in diameter, e.g., ghost crabs) and the responses of meiofauna (creatures no more than one millimeter in size that move between the sand grains, e.g., nematodes) with regard to turtle nutrients. Ghost crabs, plough snails, and mole crabs were collected from high- and low-density turtle nesting areas, and tissues were analyzed using stable isotopes to assess their overlap with turtle hatchling and egg signatures. Carbon and nitrogen isotopes generally indicate trophic level, following the principle of "you are what you eat" (see *SWOT Report*, vol. IX, pp. 28–29).

The results showed a strong, direct correlation between turtle nutrients and meiofauna living in the sand. The abundance of nematode worms, for example, rose by several orders of magnitude within a few days of a nesting occurrence, with densities increasing from 10–100 nematodes per sample to a peak of 100,000–1,000,000 in just 10 days. Stable isotope analysis also confirmed that ghost crabs feed on sea turtle eggs and hatchlings, but not exclusively. Surprisingly, even plough snails, scavengers that live buried in the sand on the low shore, incorporate some sea turtle in their diet. Nutrient pulses are short lived, and their processing is rapid; nests that are preyed on seem to be processed within about 10 days of the eggs being broken when dug up or when punctured by ghost crabs and ants.

Combining all that information confirms that beach and dunes act as a unit and that turtle nutrient inputs in the form of eggs or hatchlings are important to the functioning of both. Turtle-induced nutrient pulse was detectable even on long, highly dynamic beaches in South Africa that had modest turtle densities. Those types of responses would be even more important and pronounced on shorter, less energetic beaches, such as are found on islands, or on beaches with higher nest densities, such as those of ridley turtle arribadas.

Knowing that natural predation on turtle eggs and processing by interstitial fauna are important ecosystem processes has strong conservation implications. Sea turtle protection programs avidly protect turtle nests to maximize hatchling production and to ensure hatchlings' safe passage to the water. That protection is understandable because sea turtle populations are depleted and the mortality rate, especially for younger turtles, is high. Conservation endeavors also are critical to right the wrongs of human interference. On reasonably pristine beaches, however (such as iSimangaliso Wetland Park, South Africa), where human interference with the environment is minimal, natural predation must be recognized as an important ecosystem process and should be allowed to function normally if possible.

To most sea turtle conservationists witnessing the destruction of turtle nests or the capture of hatchlings by predators, realizing that turtle-derived nutrients are an essential food source in beach ecosystems may be only a small consolation. The survival gauntlet on the beach, however, is no more forgiving on the predator-rich African savannahs or in open ocean systems. Nature is cruel, but it is also balanced. We need those interactions to maintain healthy coastal ecosystems. ■

Microscope images of nematode worms (pink) in beach sand following the predation of a sea turtle nest reveal how meiofauna benefit from the nutrients that sea turtles bring to the beach. © DIANE LE GOUVELLO; AT LEFT: Frigatebirds prey on hatchling green turtles in the Éparses Islands. The important roles that sea turtles play in beach ecosystems are not yet fully understood. © JÉRÔME BOURJEA