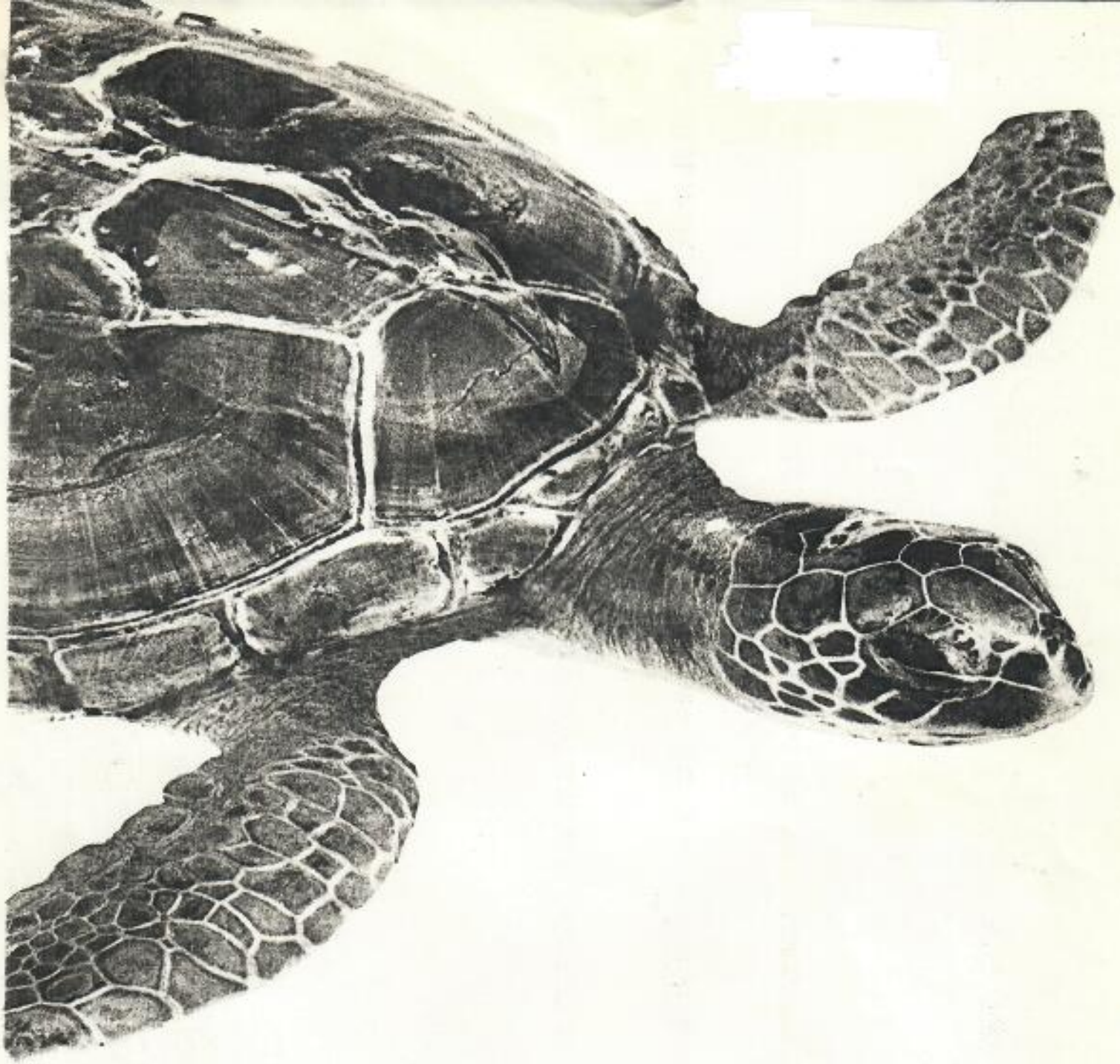

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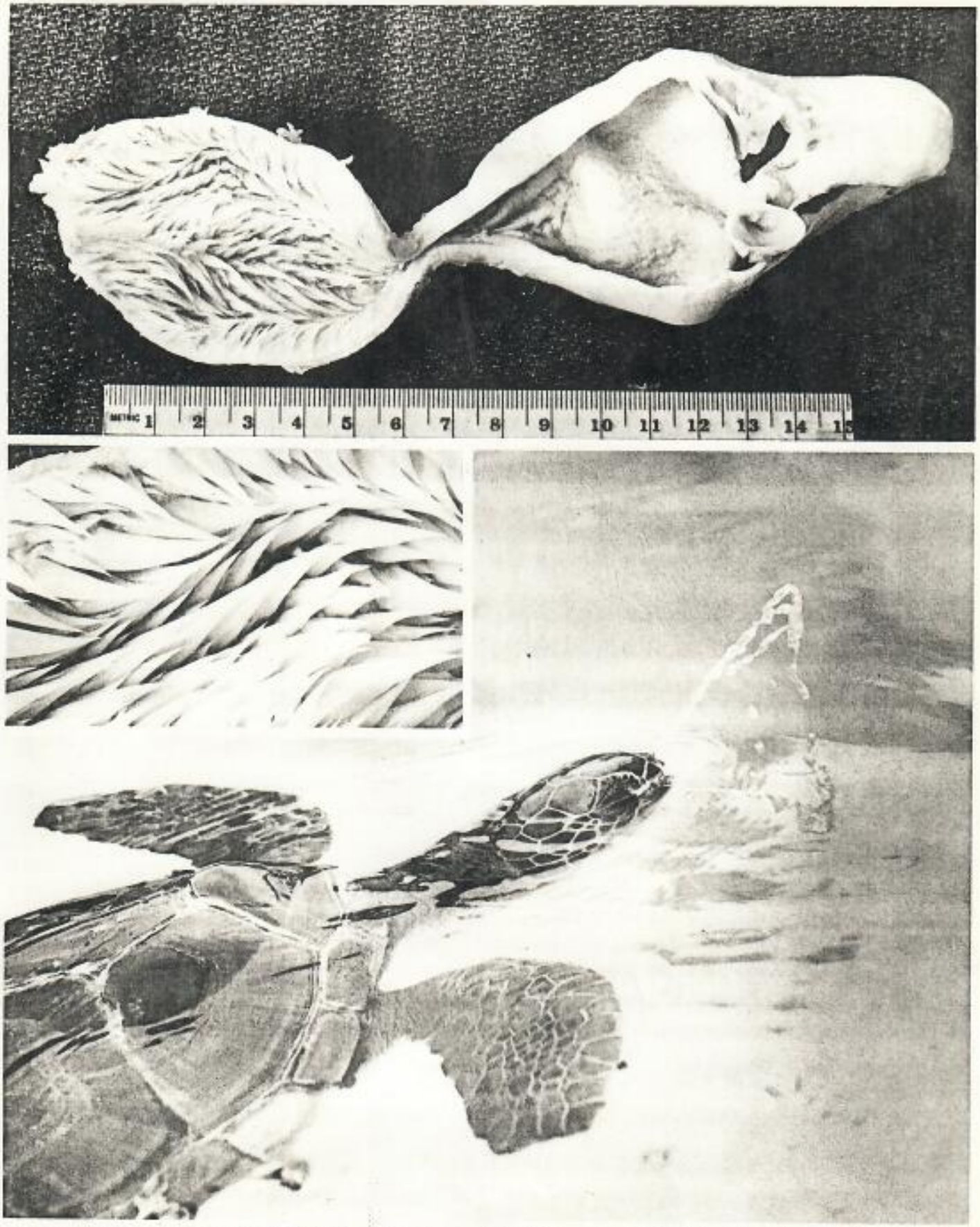
Scripps Institution of Oceanography

Annual Report 1983

University of California, San Diego



F. N. WHITE

Top: The esophagus and stomach of a sea turtle. The esophageal spines (middle left) serve to retain food when the esophagus contracts to expel seawater. A series of pumping cycles propels food to the stomach and forces the water out through the nostrils (below). The system functions in a manner similar to the baleen of whales and minionizes saltwater ingestion when food is swallowed.

PHYSIOLOGICAL RESEARCH LABORATORY

Scientists in the Physiological Research Laboratory concentrate on the physiological and biochemical adaptations of aquatic and terrestrial animals. The biology of free-ranging aquatic birds and mammals is the focus of Dr. Gerald L. Kooyman's group. Field studies were completed by the group on foraging and nurturing behavior of female Peruvian fur seals, in collaboration with West German and Peruvian scientists. This study, held during an El Niño condition, showed there was widespread mortality to both fur seals and sea lions, which appears related to the unavailability of food.

A marine bird receiving an intravenous infusion of 1 mol NaCl/kg H_2O at 0.4 ml·min^{-1} will secrete the salt from its nasal salt glands at the same rate and concentration. Dr. Harold T. Hammel and James E. Maggert find that including the naturally occurring hormone angiotensin II with the infusate at the rate of 10^{10} mol·min^{-1}·kg^{-1} fully inhibits the secretion during the period of the infusion. This rate of infusion is well below the minimum rate affecting heart rate and blood pressure. However, it does cause a measurable increase in amount of NaCl eliminated by the kidneys. The amount of salt infused in 90 minutes will be secreted by the salt glands immediately after the infusion containing angiotensin II is discontinued. These results suggest that angiotensin may be involved in controlling the rate of salt-gland secretion in marine birds.

Most mammals regulate their body temperature within a narrow range by central integration of input from temperature receptors located in the skin, body core, and within the central nervous system. Dr. Martha E. Heath is investigating the contribution of these sites in driving the heat production response in the rat. The contribution of extrahypothalamic core temperature receptors exceeds that of either the skin receptors or receptors in the hypothalamus. Dr. Heath also noted that input from the skin serves to increase the sensitivity to changes in the hypothalamic and extrahypothalamic core temperature, which indicates that the nature of the input from the skin is quite different from that of the body core.

Dr. Edvard A. Hemmingsen is studying the formation of bubbles in cells and organisms under conditions of gas supersaturation in order to better understand the early etiology of decompression sickness.

Dr. Jeffrey B. Graham and his colleagues investigated the function of the pericardioperitoneal canal, a structure unique to sharks and rays. These primitive fishes depend upon the maintenance of a negative pericardial pressure to ensure cardiac filling by aspiration. The canal provides a route for the ejection of fluid into the peritoneum and permits adjustments in pericardial operating pressure and volume. The system may represent a mechanism for control of heart volume and output in these fishes.

Studies in the laboratory of Dr. Fred N. White are concerned with the cardiorespiratory physiology of lower animals and its relationship to temperature and metabolism. Dr. White and associates demonstrated the presence of a circadian rhythm in which CO_2 is retained during the resting phase of the diurnal cycle. The CO_2 (or its influence of pH) is responsible for a significant reduction in metabolism during rest. Dr. Philip E. Bickler demonstrated that this "acidic" phase of the activity-rest cycle is also accompanied by an intracellular acidosis.

A cooperative investigation between Dr. White and colleagues at the UC San Diego School of Medicine revealed that the hypothermic mammalian heart remains more electrically stable when the acidity of the blood is maintained at a more alkaline level than classically sustained during hypothermic human surgery.

Dr. White and graduate student Giuseppe N. di Sciara have noted the presence of long fingerlike projections in the esophagus of several species of sea turtles. The tips of the papillae are oriented toward the stomach. Studies of esophageal pressure of sea turtles during swallowing of food demonstrated that swallowing is powered by a hydraulic pump; when the esophagus relaxes, seawater is taken into the mouth and propels the food into the esophagus, where it is retained by the papillae. Several pumping cycles move the food toward the stomach. Following each ingestion of a bolus of seawater, a strong contraction of the esophagus expells the water; however, the food progressively moves to the stomach. The result is separation of food from seawater. (Ingestion of seawater in large quantities may be fatal to these reptiles.) The adaptation is similar in function to the baleen of whales.

The research of Dr. A. Aristides Yayanos focuses on high-pressure and radiation biophysics. The role of hydrostatic pressure as an ecological factor was investigated in deep-sea bacteria. The rate of reproduction of such bacteria, studied over the range of atmospheric pressures to 1,200 atm, was accelerated at pressures slightly less than the pressures at which the organisms originated. Deep-sea bacteria, when kept at the preferred pressure, exhibit ultrastructural characteristics similar to other bacteria. However, graduate student Roger A. Chastain found a strain from the Marianas Trench that dies at atmospheric pressure and exhibits profound degenerative morphological changes in the process of death. Other studies confirmed that bacteria from the cold deep ocean are strictly adapted to low temperature and are more so the greater the depth of habitation.

Dr. Yayanos also investigated the cause of the Cretaceous-Tertiary mass extinctions, proposing that thermal neutrons irradiated seawater, fresh water, and the plants on the surface of the earth. Such irradiation would have killed many organisms; however, the selective formation of radioactive calcium, sulfur, and phosphorus in the environment appears to be of greater significance. Organisms incorporating radioactive calcium from the environment would thus be irradiated. This hypothesis seems to explain how marine organisms were more susceptible to extinction than those living in fresh water; and how organisms making silicates (e.g., radiolarians) were spared, compared to those making calcite (e.g., coccolithophores). Thus the hypothesis indicates how the patterns in the extinctions occurred.

VISIBILITY LABORATORY

Research at the Visibility Laboratory includes studies of the oceanic and atmospheric optical environment, digital image processing, and optical remote sensing of the oceans.

The spectral nature of the reflectance and attenuation properties of ocean waters were the focus of several major field expeditions. On these cruises Gerald D. Edwards and Jeffrey W. Nolten measured vertical profiles of the downwelling and upwelling natural light fields in the upper 200 m of the water column. From these measurements the depth dependence of the spectral attenuation properties of natural daylight, together with the spectral reflectance of the surface waters, was determined. These studies, under the direction of Roswell W. Austin, support a variety of research programs in remote sensing of the oceans, optical communications, and modeling of image and radiative propagation.

Benjamin L. McGlamery continued his studies and computer simulations of compensated imaging systems. The performance of these sophisticated adaptive optical systems in correcting wavefront distortion induced by atmospheric turbulence has been successfully modeled on the laboratory's Image Processing Computer System. The effect of system modifications and the effect of various subsystems' failure can be rapidly and inexpensively examined.