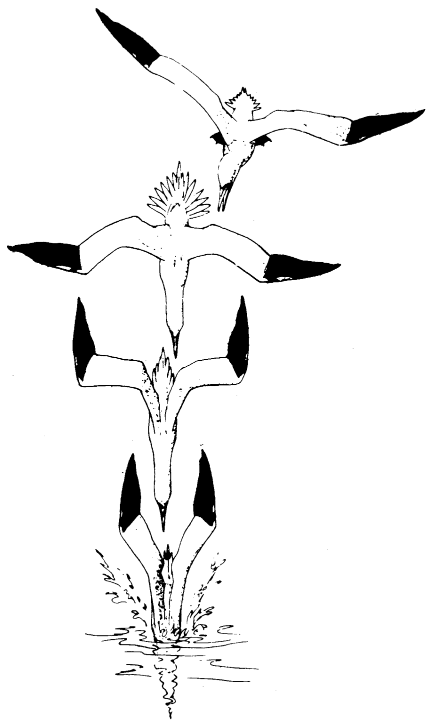
Diving for fish: The eyes have it



B. Nelson, *The Gannet*. Poyser, Berkhamsted, 1978

A large seabird hovers high above the ocean. It sights its prey and plunges down with wings half open. Then just before hitting the water, it starts to fold its wings so that its body is streamlined for entering the water.

The gannet's *(Sula bassana)* fish-catching behavior is a beautiful example of finely timed activity. From a height of 30 meters, the bird will hit the water at about 25 meters per second (55 miles per hour). How does the gannet so precisely time the folding of its wings in preparation for entering the water?

David N. Lee and Paul E. Reddish of the psychology department at the University of Edinburgh report in the Sept. 24 NATURE the results of a film analysis of the gannet's dive and use the evidence to support a theory of how actions are visually timed. They believe the theory is applicable to a variety of activities, including, for example, how a tennis player gets to the right place at the right time to play a shot.

The theory is based on the idea that whenever the head moves relative to its environment, the pattern of light at the eye constantly changes. This time-varying pattern is called the optic flow field. As an object gets closer to the eye, it produces an expanding optic flow pattern on the retina.

Lee has defined an optical parameter, which is the ratio of the distance as a function of time to the velocity as a function of time, to characterize the optic flow pattern. In the case of a constant-velocity approach, this simply specifies the time to contact. Lee predicts that the gannet waits until this parameter reaches a particular critical value before closing its wings.

Early film analysis showed that the bird did not fold its wings at a specific time after the start of the dive or at a specific height above the water. Instead, the gannet seemed to base its judgment on information about its time away from the water. For example, in a 12-meter dive, the bird started to fold its wings when it was about 5.5 meters above the water, whereas in a 4-meter dive, the wing folding started at a height of about 2.3 meters. The wing folding started earlier for the higher dive. The time away from the water, however, was similar in both cases.

The bird seems to determine when to fold its wings on the basis of visual information picked up during its dive. By waiting until a particular visual cue, the bird also avoids the problem of the wind's effect on its motion.

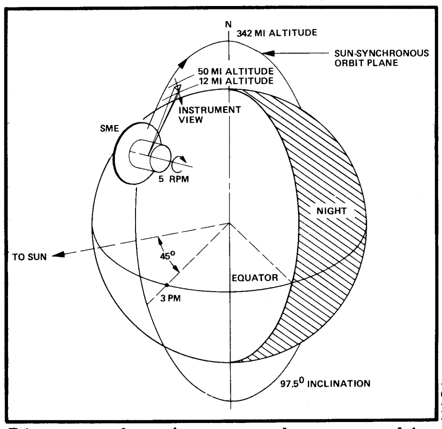
In their model, Lee and Reddish assumed the bird moved with constant acceleration. They plotted theoretical curves for time-to-contact (from the beginning of wing-folding) versus the duration of the dive for several possible strategies and then the data from observations of 55 dives. The results favored the optical parameter strategy. The birds were clearly not streamlining at a constant time-to-contact, a constant height or a constant time-from-start.

Reddish and Lee are now investigating whether people also time their actions according to an optical parameter strategy in conditions of constant acceleration. They are looking at high diving and leaping to punch a dropping ball. □

An ozone-oriented orbiter

In the years since concern developed about the condition of the earth's protective ozone layer, numerous satellites have been launched with a sensor or two included to study various aspects of the situation. On Oct. 6, however, the National Aeronautics and Space Administration launched what project scientist Charles Barth of the University of Colorado calls "the first all-ozone satellite." Every instrument aboard the Solar Mesosphere Explorer (SME) is designed to collent data on properties ranging from concentrations of ozone itself to the various atmospheric constituents and solar ultraviolet radiations that contribute to its destruction.

Planned for up to three years of operation, SME has been placed in a near-polar orbit that is "sun-synchronous"—aligned so that the satellite can observe any spot on the planet at the same relative local time each day, providing a clear record of day-to-day changes in ozone-related processes. The northbound equator-crossings will always take place at about 3 p.m.—a time, says Barth, when "the ozone chemistry has settled down."



NASA

Diagram of SME's sun-synchronous orbit.

The satellite's observations are concentrated on the upper stratosphere and mesosphere, a region extending from about 30 to 80 kilometers above the surface, where most of the UV-driven photochemistry responsible for ozone's production and destruction takes place. Ozone is created when solar UV radiation breaks down oxygen molecules (O_2) into atoms (O_1) that then combine with additional molecules to form ozone (O_3). The same energy source, however, also runs the other end of the cycle by breaking down atmospheric water vapor into atomic hydrogen (H_1) and hydroxyl radicals (OH) that can catalytically destroy ozone. It produces similar destroyers from nitrogen dioxide (NO_2) and other species, including the halogen-containing propellants that find their way into the atmosphere from spray cans.

One of SME's first goals will be to find out which parts of the solar UV spectrum are responsible for most of the photodissociation. One instrument will do nothing but monitor changes in the sun's UV output, which will then be compared with changes in ozone concentrations around the earth in search of a correlation with certain spectral bands that may be more influential than others. "We should have an answer," says Barth, "in about three months."

A longer-term study will seek out seasonal patterns, by comparing seasonal changes in H_2O and NO_2 concentrations with variations in the amount of ozone. Overall, the researchers hope to develop improved models of ozone behavior on a global scale, by combining simultaneous measurements of ozone and its destroyers with data on temperature, pressure and UV — all taken at the same times and (except for the UV sensor, which looks sunward) places over the earth.

Understanding of earth's ozone situation has also been aided by studies of other planets, notes Barth. Mars, he says, provides a simplified test chamber because water vapor is virtually its sole ozone destroyer, while Venus introduced many researchers to the role of chlorine, once common in spray can propellants. □