LIKE WHALERS of old, the crew scans the horizon, searching for a glimpse of fins cutting the water. Then comes a cry from the starboard observer, "I've got dolphins at 37°!"

The crew swings into motion, glad for some action after hours of staring at an empty skyline. The action for this crew involves not longboats and harpoons, but high-powered binoculars and computers. These are research scientists out to answer a difficult question: "How many dolphins live in the 5 million square miles of the eastern tropical Pacific?" Environmentalists, biologists, and tuna fishermen would all like to have an accurate answer, for each of these groups has a stake in the "numbers game" that governs dolphin conservation practice.

5 million square miles=13 million square kilometers

In 1972, dolphin conservation was initiated as part of the Marine Mammal Protection Act (MMPA), a federal law that imposed a moratorium on taking and importing marine mammals or their products, with exceptions, in the United States.

One of the major exceptions is the dolphins. Because some species of dolphins often travel in association with schools of commercially valuable yellowfin tuna, dolphins are some-

PREVIOUS PAGE: EXPLODING *into action, these spinner dolphins (*Stenella longirostris*) leap from the water in apparent* joie de vivre. *Their characteristic runs of long low jumps punctuated with high leaps and midair spins allow these dolphins to be easily identified and counted.*

M. Scott Sinclair/NMFS

HIGH-POWERED BINOCULARS *are used to scan the sea for schools of dolphins. This vigil continues from sunup to sundown as* David Star Jordon *crisscrosses the eastern tropical Pacific. Two bottlenosed dolphins (*Tursiops truncatus*) are sighted and recorded in the log.*

Stephen B. Reilly/NMFS
Far right: M. Scott Sinclair/NMFS

times the incidental victims of tuna purse-seine operations. The MMPA acknowledges this tuna-dolphin relationship, and permits a limited amount of dolphin "take" — accidental death or serious injury — by the tuna fishermen.

Reduced mortalities

Great effort on the part of the U.S. tuna fishermen and the development of specialized gear and fishing techniques have combined to decrease the number of dolphin deaths: in 1977, more than a quarter of a million dolphins were killed or seriously injured during the tuna-fishing operations of U.S. boats; by 1979, the number of deaths had dropped to around 25,000, and has remained near 20,000 over the last several years.

While the take of dolphins by U.S. fishermen has declined dramatically, there is still concern among a number of scientists and environmentalists that the survival of some species and stocks of dolphins may be threatened if *any* incidental killing is allowed. The MMPA therefore designates certain species and stocks of dolphins as depleted and prohibits the killing or collecting of these animals.

The job of determining which dolphin stocks should be classified as depleted, and what the limit on take levels should be, falls to the Department of Commerce (DoC). Acting on information provided by research sci-

entists of the National Marine Fisheries Service (NMFS), DoC officials set annual limits on the number of dolphins that can be incidentally killed by fishermen, collected by research scientists, or permanently removed from the wild by commercial groups for public display.

To make their recommendations, NMFS researchers must first determine how many dolphins there are and how fishing and removals have affected the size of the dolphin populations. Counting the number of dolphins in an area the size of the eastern tropical Pacific has posed an ongoing challenge to scientists from the NMFS Southwest Fisheries Center at La Jolla, California. For the past six years, the scientists studying dolphin population size have been developing and refining their assessment techniques, trying to find the best method for counting the animals.

Computerized binoculars

In summer 1983, the La Jolla scientists "road-tested" their latest development, a method known as Computer Assisted Sighting Technique (CAST). CAST combines two sets of high-powered binoculars (strong enough to sight dolphins up to 6 miles away), a group of experienced dolphin observers, and a shipboard computer to form a system designed to give scientists the most accurate data yet available on dolphin distribution and population size.

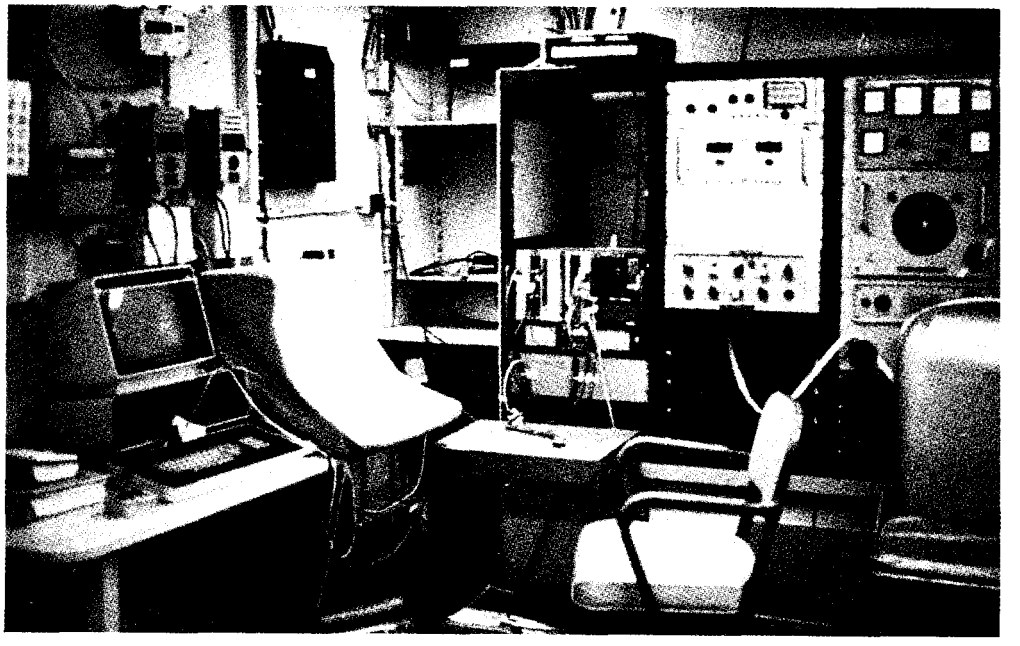
Researchers on board the National Oceanic and Atmospheric Administration ship *David Starr Jordan* spent three months in the eastern tropical Pacific using CAST to collect precise measurements of the position of dolphin schools. Each morning, just after first light, the six observers would begin their search, taking turns on the binoculars throughout the day. The observers were responsible for identifying the species of dolphins that made up each school sighted (there are more than 15 dolphin species in the area), as well as the approximate size of the school and its position. Using a statistical formula known as the line-transect method, scientists can "plug in" this information to calculate the population density in a given area.

At one point in the trip, 20 dolphin schools were seen in a single day, while at other times hours would pass without a sighting. The researchers assume a patchy distribution of dolphin schools when making their final calculations of population density. Because they choose the survey area without respect to dolphin distribution, the scientists assume that they are measuring a set of events — dolphin sightings — that accurately represent a bigger picture—total dolphin population size and distribution. They can thus survey a small, randomly chosen section and use the sightings made in the survey area to project population figures for a much larger region.

As the research ship travels along a predetermined track line, or transect, observers using CAST record each sighting of a dolphin or school of dolphins. To calculate the density of the population, the researchers need to know three things: the number of dolphins found along the track line

6 miles = 9.6 kilometers

Stephen B. Reilly/NMFS

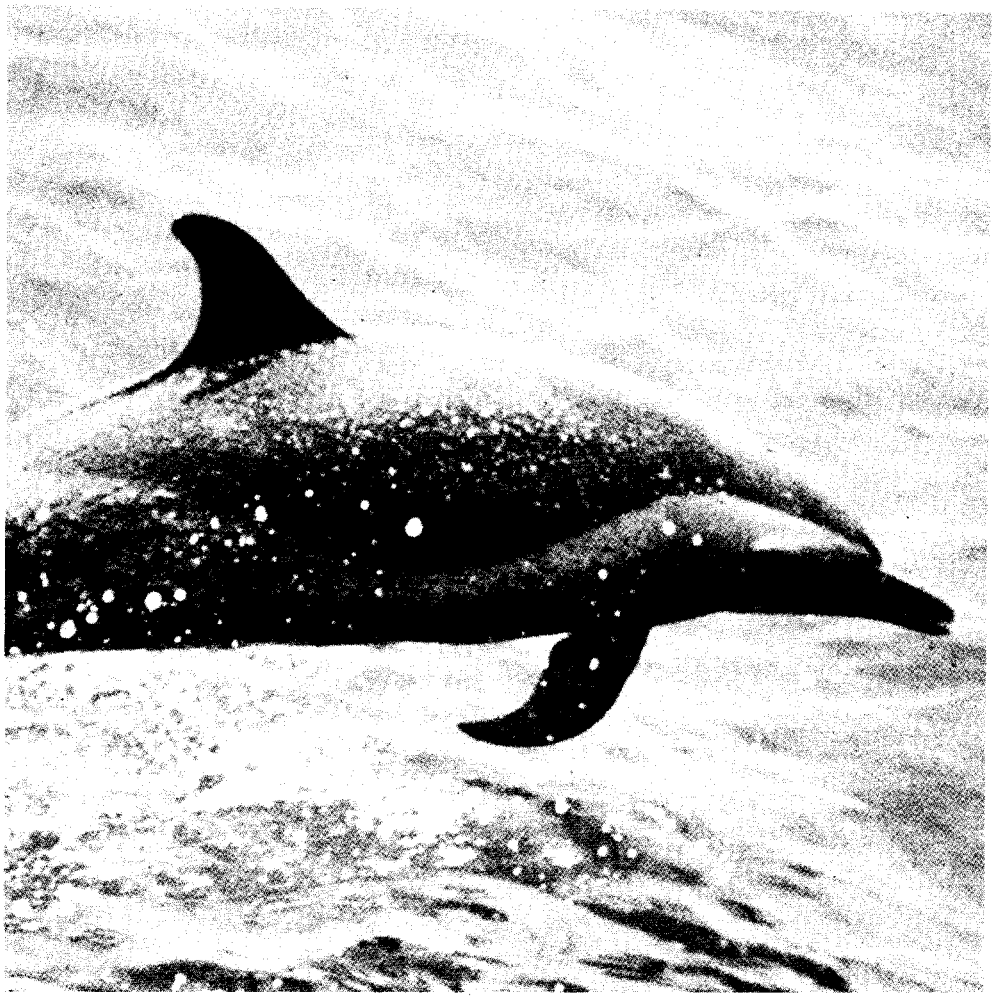


SOPHISTICATED COMPUTER *equipment aboard the ship instantaneously records the position of each dolphin school when either observer on deck indicates a sighting. The area of sea actually searched by the observers is also calculated.*

itself, the number of dolphins found at some distance from the track line and, in these cases, when the dolphins are not on the track line, the perpendicular distance from the position of the animals to the track line. The scientists can calculate that perpendicular distance if they know the sighting angle, defined as the angle between the ship's line of travel and the line of sight to the dolphins' position at the moment that the animals are detected by an observer, and the direct distance from the ship to the school.

The line-transect method is not a new technique—biologists have been using it for years to calculate everything from the number of trees per acre of forest to the number of duck nests per acre of marsh. But measuring the density of a dolphin population presents some unique challenges.

"One problem is that dolphin schools don't sit still," says Dr. Rennie Holt, one of the scientists involved in the dolphin-counting project. "We've therefore had to modify the line-transect technique, and measure a number of sighting angles to take into account the movement of the animals; using the resulting 'family' of lines, we can back calculate to get an accurate initial sighting angle," explains Holt. This sighting angle is the key to the formula — knowing the



PLAYFUL ACROBATICS *and distinctive markings of the common dolphin (*Delphinus delphis*) allow for easy recognition. The spotted or bridled dolphin (*Stenella attenuata*) is usually seen swimming near the surface rather than jumping high into the air.*

M. Scott Sinclair/NMFS

sighting angle means being able to calculate population densities.

In the past, measuring the sighting angle was a fairly crude procedure. "We used to collect angles and distances by just eye-balling the measurements, using the horizon as our guide," says Holt. "Then we went to a system where a notched washer was mounted on the binocular stand, and the observers would count off the clicks made by the swiveling binoculars as they panned away from the track line; the number of clicks gave an indication of the sighting angle. CAST uses an electronic encoder, again mounted on the binocular stand, which monitors the movement of the binoculars and feeds that information into the ship's computer. When the observer makes a sighting, he or she pushes a button, and the computer records the angle of the sighting by measuring the position of the binoculars. We can get very precise calculations of sighting angles that way."

The computer monitors not only the sighting angle, but the actions of the observers themselves. According to Holt, density measurements depend on observers seeing every animal located on the track line. As the observer pans out from the line, chances of spotting all the dolphins in the area decrease, a factor that the line-transect formula takes into account. The two observers, one on the port binoculars and one on the starboard set, are supposed to search only on their side of the track line. A formula in the computer determines whether or not the observers are actually looking where they are supposed to look.

The computer can also screen out the interference caused by the movement of the ship as sighting angle measurements are being taken. The computer records the number of degrees that the ship moves up or down (pitch), or from side to side (roll), then eliminates those changes to give an accurate reading of the sighting angle.

Months of analysis

Analyzing the computer data from the most recent monitoring cruise will take a number of months, but Holt is confident that CAST will provide the best information ever collected on dolphin population density.

In 1985, DoC officials will establish a new set of regulations on dolphin conservation practices for 1986 and beyond. The development and use of the CAST system represent an important advance in providing scientists with the most complete and accurate data on which to base an assessment of the status of the dolphins in the eastern tropical Pacific. □