An Ornithological Radar

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Preliminary evaluation of an inexpensive, portable, short-range radar for ornithological study

Radar has recently become an important tool in ornithological research. While designed primarily for the detection of storms, aircraft, and ships, radar is also able to record the movements of flying birds. With radar it is possible to observe a bird migration from distances as great as 120 miles and to follow the movements of birds beyond the limits of human vision. Radar observations have revealed that the greatest part of bird migration occurs at night, at altitudes up to 20,000 feet, and that birds may even migrate through clouds or in fog. An excellent review of this work may be found in Eastwood (1967).

With few exceptions ornithologists wishing to study bird migration with radar have had to rely upon large aircraft control or weather radars. Observations of bird activity are thus, by necessity, restricted to existing radar sites, and in most cases the ornithologist must accommodate his schedule to that of the other operations at the radar site. Exceptions to this rule have been scientists who have been able to use small portable radars, usually of the type designed to direct anti-aircraft guns (Bellrose and Graber, 1963, Gehring, 1967, Schaeffer, 1968, Bruderer, 1971, and Griffin, in press). Even these units usually require at least a well trained technician to keep them in good operating condition. The units are not easily moved and require a powerful electric generator to run them.

We believed that there was a need for a small, lightweight radar which could be taken anywhere an automobile could go, which would not require a great deal of electric power, and which could be operated without a technical knowledge of radar. Schaeffer (1970) suggested that small marine radars might be modified to detect birds at airports. Following his suggestions we examined a number of small marine radars and decided upon the Decca 101. (The specifications of the Decca 101 are as follows: Wavelength 3.2 cm. Peak transmitter power 3kW pulse length $0.08\mu s$ Vertical beam width 30° Horizontal beam width 2.5° antenna gain 24db. Power supply 170W at 12 V d.c.) For use as an ornithological radar, it was necessary to insert a rotatable joint between the transmitter-receiver and the antenna so that the radar could be set to "look" up into the sky rather than scan the horizon. The radar was mounted on top of a small "Econoline" van, as shown in figure 1. Power was supplied from the 12v automotive system.

During a relatively brief period of trials in the fall of 1971, we have been able to detect bird migration to a range of 1.3 miles, to differentiate between flocks and single bird targets, and to follow the paths of birds moving through falling snow. The primary advantages of the radar are its great mobility (which in part makes up for its poor range), and its ability to detect closely spaced targets and targets close to the radar. In this paper we will briefly report some of our preliminary observations with the unit and some of the techniques for using this instrument.

To operate the radar we park the truck in an area where the radar picks up a minimum amount of interference, or clutter, from low buildings and other objects near the ground. Clutter appears on the radar screen (Plan Position Indicator or PPI) as non-moving, luminescent spots. These station-

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ary targets are removed from the displays of airport radars by a complex circuit known as a moving target indicator (MTI). The Decca marine radar, however, is designed specifically to pick up targets such as buoys, lighthouses and rocky coastlines. It is designed to do this in stormy weather on a small boat rolling and pitching in heavy seas. Thus, even if the antenna is pointed upward at an angle of 45° above the horizon, the radar will still pick up most objects which project more than a few inches above the surface of the earth. This can almost completely obliterate the PPI display out to a range of 1 mile making it impossible to see birds. In order to minimize this ground clutter we depend upon the fact that the radar energy which is emitted from the antenna must travel in straight lines and cannot bend around an object. Thus, if the truck is parked in a forest clearing, between two buildings, or behind sand dunes, the radar cannot "see" through these nearby objects and will only detect objects above this "radar fence". Under these conditions the radar picks up almost no ground clutter and we can concentrate on targets flying through the air.

Figure 1: The ornithological radar and a view of the radar console in use.

With ground clutter thus reduced to a minimum, a number of moving targets can be easily seen on the radar screen. Each time the radar antenna revolves (at 36 RPM), it shows the target in a slightly different position on the screen. The large targets which we have observed moving more than 100 miles per hour were identified as aircraft. Birds appeared as small targets moving between 10 and 50 miles per hour.

We record the paths of moving targets in one of two ways. The simplest is to record the position of the target directly on the face of the screen with a wax pencil. This would be impossible to do with a large airport radar because such radars detect large numbers of migrating birds and it would be extremely difficult to follow any single track. We, however, usually have less than three or four targets on the screen at a time. After plotting a number of tracks, we transfer the data to tracing paper, and remove the wax from the screen so that new tracks can be followed. If we want to record data from the radar over a long period of time, we use a modified super 8 mm movie camera which, with a timer, automatically takes one frame of film for each revolution of the radar. These time lapse films can then be projected at normal speed to review an entire night's migration in a few minutes. A single frame from one of these films is shown in figure 2.

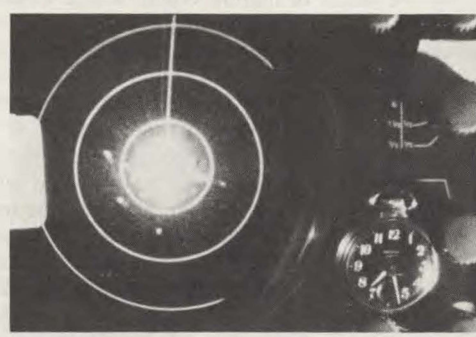

Figure 2: A single frame from the time lapse 8 mm film of the radar display. Birds show as elongated targets followed by a series of dots of decreasing intensity showing the bird's previous position.

During the fall of 1971 observations were made at two sites: in Chincoteague, Virginia, and on the campus of the State University of New York at Buffalo. In Virginia we were also observing migration with the NASA long range tracking radars at Wallops Island. In Buffalo simultaneous observations were made at the Buffalo International Airport radar (an ASR-6).

The ornithological radar observes bird migration at altitudes between ground level and about 5000 feet (depending on antenna elevation). This should be a useful range since it covers the range between the limits of human vision and the lower limits of most large radars. Our preliminary observations indicate that bird migration at these levels does not differ markedly in direction and numbers of birds from migrations observed by other techniques. During the fall of 1971 the heaviest migrations were detected at night, with falling temperatures and with north to northwest winds. Rising temperatures and southerly winds were accompanied by weak movements often with birds flying in many different directions. John Richardson (1972) discusses similar results from observations with large search radars and our own observations with large radars mentioned above agreed with the smaller radar in direction and numbers of migrating birds. During the day the ornithological radar does see movements of birds not clearly seen by most large radars but familiar to visual observers. Along the shore of Virginia we could watch the circling flights of shorebirds and waterfowl near the Chincoteague National Wildlife Refuge and of gulls moving between the fishing piers in Chincoteague and their resting areas. In Buffalo we observed the movements of domestic pigeons and gulls around the buildings of the university. Such observations in clear weather offer little new information. Under conditions of fog, rain or snow even local movements of birds may reveal something of their orientational abilities.

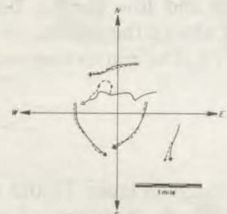

Figure 3: Tracks of targets showing splitting and reforming of a single target on the radar screen.

Although this marine radar is very poor at detecting distant objects, and we have not been able to track birds at distances greater than 1.3 miles, the unit clearly distinguishes near objects which are relatively close together. Most large radars cannot differentiate two objects, unless they are at least 1500 m apart in range. Our radar theoretically is able to separate objects only 24 m apart in range. This has allowed us to determine whether or not some birds were flying in flocks. Figure 3 shows five tracks from the screen of the radar in which a single target separated into two targets and then reunited. We also observed two targets flying side by side on three occasions. Waterfowl were migrating during this time of year and these targets may have been pairs of ducks or geese. Larger flocks appeared on the radar screen in the following way: on November 21 we observed for 15 minutes, seeing only three or four birds; then suddenly 10 or 20 targets crossed the screen in less than 30 seconds.

We have also been able to detect with the radar, birds flying through the rain or snow. Rain is a common occurrence in coastal waters, and the Decca marine radar is provided with a circuit which minimizes echoes from rain or snow, without greatly reducing echoes from larger targets. We found that this "anti-rain" circuit reduced our maximum range for detecting birds to about ½ mile, but we could get useful information on bird migrations even in a blizzard. Under these conditions migration was very light, as might be expected, since few birds attempt to fly on such nights, and those birds that were sighted, produced more erratic tracks than the birds flying in clear weather.

In summary, we find that it is possible to obtain a radar which is useful for ornithological work for a cost of less than $4000. Such a radar is limited in range, but has great resolving power for short range work. In particular it appears very useful for discriminating flocks of birds, for detecting their movements in rain or snow, or for use in remote locations beyond the range of fixed radar installations.

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