# A Program to Develop Aerial Photo Technology for Assessment of Surface Fish Schools

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**Abstract**

Current research at the Bureau of Commercial Fisheries Exploratory Fishing and Gear Research Base, Pascagoula, Mississippi, is concerned with developing remote sensor technology for the detection, identification and quantification of pelagic schooling fishes from high altitude aircraft and examining potential space applications. Studies have been undertaken to evaluate available photo technology for a basic format. Preliminary altitude, target size and imagery resolution trials have indicated this to be a feasible approach. Film evaluations to date have included selected spectral bands with some early indications that Ektachrome Infra-red Aero film will provide a suitable standard for detailed study. Imagery evaluations are being made through microdensitometry which will, in turn, be subjected to spectrographic analysis for those properties that could lead to identification and quantification.

THE USE OF AIRCRAFT by the fishing industry has become wide-spread over the past twenty years, and a technology of sorts has been developed by highly specialized commercial fish spotters. Some of our major fisheries have reached a point of near dependence on this technology—the menhaden fishery, for example, and to an extent the tuna fishery.

The use of aerial spotting techniques in fishery research is best exemplified by the extensive coastal survey flights of the California Department of Fish and Game. More recently, the development of air-borne radiometers has come to play a significant role in fishery environmental studies. There are other similar aerial applications.

The present study was initiated in 1963 as a limited reconnaissance project attempting to establish a monthly pattern of menhaden school movements during the off-season period of October to April in the eastern Gulf of Mexico. The flights were continued through 1965 when attempts to treat the observation data indicated that the best approximations of school content were far too subjective to have any significant meaning. Photo records of intense schooling concentrations of mixed species, photographed at oblique angles from the plane window, proved to be of no quantitative value whatever. Ground truth values obtained by gill-net sampling in these schooling areas provided, at very best, confirmation of the presence of given species. Assistance from professional fish spotters added just a little to the reliability of observation values. Literature review through this period has shown that others attempting similar school assessment procedures had ended their studies in the same dilemma.

At this point we became convinced of an obvious need to develop a factual data-yielding aerial survey technique. The resultant program to accomplish this goal was essentially:

1. To employ civil engineering vertical photo survey techniques. This would provide standard horizontal area measurements and other reliable point-to-point horizontal references.

2. To coordinate simultaneous horizontal scanning sonar and vertical depth recorder target profiling with the aerial photography.

3. To employ commercial purse seiners to provide quantitative values on the volume and weight of the school, the number and sizes of individuals, and species identification.

It was hypothesized that by following this approach the most rapid progress could be made in interpreting and evaluating the photographic images. It has been further hypothesized that, if reliable qualitative and quantitative imagery factors could be derived, it should be technically feasible to transfer these parameters to rapid-scan sensors such as a video screen, which in turn could be programmed for instantaneous telemetry to the laboratory, the fishing base, or even the fishing vessel.

For the past year major effort has been spent on the study of film suitability, to determine with what film types and under what conditions maximum target resolution can be achieved, and how maximum target environment contrast can be enhanced. Early simple multi-spectral photography has shown that color infra-red (Ektachrome IR Aero) has provided maximum values for both of these criteria. Broad spectrum black and white film has provided minimum values. Various standard positive color films have yielded intermediate values. Multi-spectral photographic coverage of the Florida west coast area, obtainable through the cooperation and assistance of NASA, will provide data to reach some early estimations on the usefulness of restricted spectra on black and white film and on the potential for determining spectral signatures that could be used for species identification.

It is interesting to point out here that Barringer Research, Inc., has already demonstrated, by the use of absorption spectroscopy, unique absorption characteristics in the oils of each of many fish species examined to date. These characteristics are found in the day-light ultra-violet region between 2800 A° and 4000 A°. These studies have also indicated sharply resolved spectra of fish oils in the infra-red region.

So we have some preliminary indications that fish schools, once detected and delineated, exhibit characteristics within either the visible spectrum or the invisible ends of the spectrum and possibly in all three areas, that would assist in species identification.

The usefulness of photographic images for basic data values has been greatly enhanced by the recent development of instruments for evaluating and interpreting high-sensitivity film. In regard to the second objective of school quantification, we have begun imagery study using microdensitometry. This technique measures variations in film emulsion thickness—portrayed as variations in grey levels—which can be enlarged up to 1000 times and printouts rendered through an isodensitracer. Emulsion variations as fine as one micron can be detected and then traced or plotted. This provides a degree of sensitivity evaluation far beyond the limitations of the human eye and eliminates the distracting problem of photographic grain.

Assistance in this aspect of the study has been provided through access to equipment in use by the Lunar Mapping Program, NASA, Houston, Texas. To date it has been possible to determine the presence of a wide range of quantitative values in the photographic imagery—particularly those fish school targets recorded on Ektachrome IR Aero film. It appears that, even under great magnification, we have an emulsion density range of between 10 and 50 microns within a given target in which variations cannot be noted by the naked eye. In our early estimation, this very likely represented variations in school configuration in fish density and school thicknesses which ultimately should relate to quantitative factors of the school.

The difficulties in obtaining underwater three-dimensional values for fish school configuration studies that can be related to photographic imagery have now become grim realities in this phase of the program. Sonar applications are presently being evaluated and have already yielded some correlative observations. However, presently available sonar technology is designed primarily for target detection and tracking with little capability for target delineation.

Under design at Pascagoula is an experimental narrow-beam multi-sectional scanning sonar (2½° beam 200 kc) that will provide three level horizontal and vertical school cross-sectional profiles that can be recorded simultaneously with aerial photographs. Hopefully the three-dimensional models that can be constructed from such sonar sectioning will provide an interpretive linkage to densitometer patterns of school shape and density.

From the beginning of this study the question of feasibility of such a technology for space applications has been given consideration. Interestingly enough, the question most frequently posed is that of target detection and resolution from orbital altitudes. In employing relatively unsophisticated commercial photographic equipment we have found a resolution relationship between target size and camera focal length. Through extrapolation, this would indicate that a target of 20 to 100 feet in diameter could be photographically recorded at altitudes of 100 to 500 miles with sufficient detail to permit identification. Further, sets of photographs of subsurface fish (presumably menhaden) taken at an altitude of 2 miles were furnished to IBM Corporation for evaluation in an Earth Sighting Simulator. The resultant tests indicated that fish schools such as these could be optically identified as such from orbital altitudes for target sizes as small as 30 feet in diameter.

We assume from these preliminary evaluations that the detection and recording of quantifiable data on surface and near-surface fish schools can be accomplished within the parameters of existing technology. The next step is to establish data criteria that can be used in the studies we hope will lead to spectral signatures for identification and quantification.

Obviously, the application of photography to fish school survey and assessment has a number of limitations when the numerous practical realities are considered. Aside from the photographic problems caused by the varying atmospheric interferences of cloud cover and ground haze, and sea surface interferences of turbidity, wave action and sun angle, the time consuming mechanics of analyzing and processing film do not provide for timely transmission of fishing information to an interested industry.

An air-to-ground or space-to-ground link will undoubtedly require some application of video technology. This, however, does not appear to be an insurmountable problem. The real problem is: What are the spectrographic and density signatures that will identify and quantify surface schooling species?

If these cannot be determined at relatively low altitudes under relatively ideal conditions, there is little hope of solving the problem from orbital altitudes.

## SUMMARY

1. Visual observations have relatively little quantitative value in fish school reconnaissance surveys.

2. Oblique photography can document visual observations, but it gives no quantitative values at the present time.

3. High altitude vertical photography, especially with infra-red film, offers promise of qualitative spectral signature values. It also offers maximum depth penetration and absolute ground truth values.

4. Assuming that such signatures can be determined, programming these through aircraft or possibly spacecraft video/computer instrumentation would provide a potentially practical means of transmitting data to the fishing industry.