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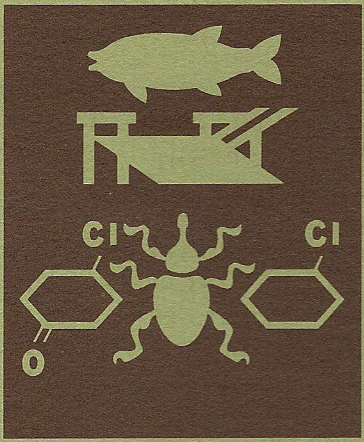

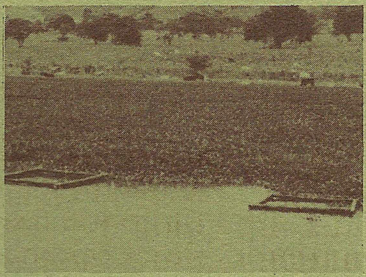

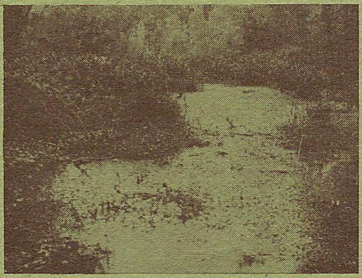

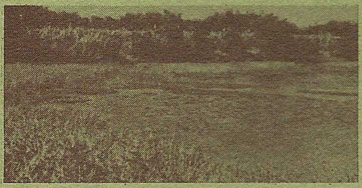

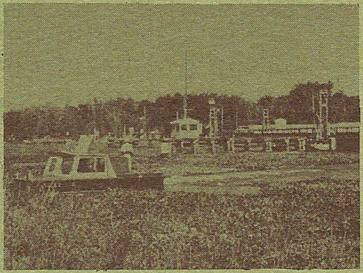

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# AQUATIC PLANT CONTROL RESEARCH PROGRAM

*Information Exchange Bulletin*

## RADIOTELEMETRY TRACKING AT LAKE CONWAY

BY MALCOLM P. KEOWN

As part of the Aquatic Plant Control Research Program, the U.S. Army Engineer Waterways Experiment Station (WES) is conducting research to develop biological methods for control of problem aquatic plants. A Large-Scale Operations Management Test (LSOMT) was initiated in 1976 at Lake Conway, Florida (Figure 1), to evaluate the use of the white amur fish (*Ctenopharyngodon idella*) as an operational control method for the excessive growth of hydrilla (*Hydrilla verticillata*).

The white amur, also called the "Asian grass carp," is a species native to eastern Asia that has been introduced into various other parts of the world as a food fish and for controlling aquatic plants. Exclusively vegetarian, the white amur feeds greedily and has shown a decided preference for hydrilla. The LSOMT was designed not only to test the value of the fish as an agent for controlling hydrilla but also to assess its effects on various components of the Lake Conway ecosystem. Monosex fish were used so that they would not reproduce, and precautions were taken to prevent the escape of the fish from Lake Conway.

The effects of the introduction of the white amur into Lake Conway are being monitored by various agencies with WES serving as project manager-coordinator. The aquatic plant/fish and herpetofaunal studies described in this article were performed by the Florida Department of Natural Resources (DNR) and the University of South Florida, respectively.

The tracking system described in this article is considered to be a technological breakthrough in the state-of-the-art of tracking live fish. The radiotags were designed to emit signals for a much longer time than heretofore possible. Performance during the Lake Conway LSOMT indicates that they will be useful for up to 4 years—their maximum design life is estimated to be 58 months. The antenna system developed for this project is unique; because of its highly directional characteristics, accurate locations of the fish tags can be obtained easily and rapidly. In addition, the pursuit method of locating the tagged fish by passing over them with the antenna-instrumented boat rather than location by triangulation is also thought to be a new development. The pursuit method was perfected by Messrs. Larry E. Nall and Jeffrey D. Schardt of the Florida DNR.

### FISH TRACKING

Since the stocking of Lake Conway with white amur in September 1977, aquatic plant sampling operations by the Florida

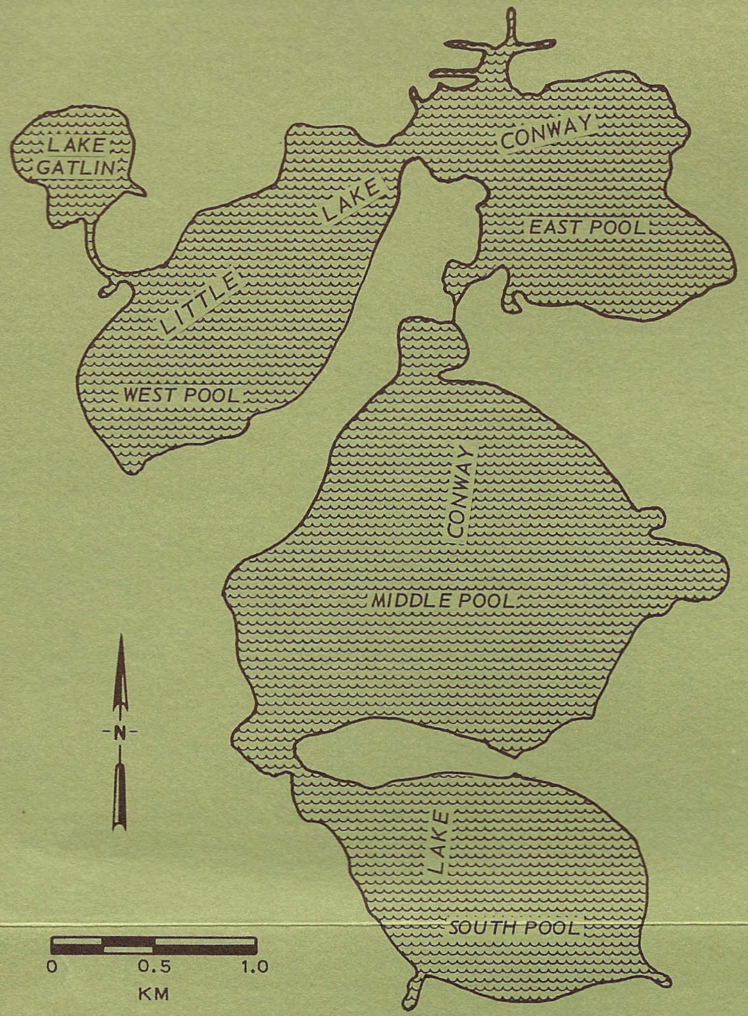


**Figure 1. Sketch map showing chain of five bodies of water that comprise the Lake Conway system**

DNR indicated a definite reduction of the hydrilla populations resulting from the fish's presence. What could not be determined from the observations was a correlation between fish movement within the lake system and the decline or occurrence of the macrophytes as a function of time. The examination of this problem indicated that tracking fish movements at comparable time intervals to the other data-collection efforts would provide the needed information. WES was responsible for developing and providing the tracking equipment to be used by the Florida DNR.

Radiotracking experiments to locate fish have been conducted on frequencies ranging from 27 to 164 MHz. The two dominant factors affecting the propagation of radio signals through water in this part of the electromagnetic spectrum are the electrical conductivity of the propagation medium (water) and the radiation efficiency of the underwater antenna.

The value of electrical conductivity is dependent on the quantity of electrolyte present and the transmission frequency; an increase in either parameter raises the conductivity. An increase in conductivity shortens the propagation path length over which communications can be maintained for a given transmitter/antenna and antenna/receiver configuration. Conversely, as the frequency is raised, the dimensions of the antenna in a fish radiotag become larger with respect to the transmission wavelength, thus promoting a more efficient transfer of energy from the tag to the propagation medium. Because of these opposing factors, a trade-off must be made to establish an optimum operating frequency. Experiments have shown that the use of frequencies in the 30-50 MHz band represents a good compromise between the high conductivities experienced at short wavelengths and the improvements in antenna radiation efficiency that results when a shorter wavelength is used.

**Signal Propagation**

As a radio signal travels away from a tag toward an above-water receiving antenna, attenuation is experienced over three distinct parts of the propagation path: through the water, at the air/water interface, and through the air (Figure 2).

The attenuation $A_1$ through water in decibels per metre can be estimated from:

$$A_1 = 0.1635 \left( \frac{\sigma}{\sqrt{\epsilon_r}} \right) \qquad (1)$$

where $\sigma$ = electrical conductivity of water at signal frequency, micromhos/cm

$\epsilon_r$ = dielectric constant of water (varies from 87 at 1.5° C to 78 at 25° C for frequencies from 10 to 100 MHz)

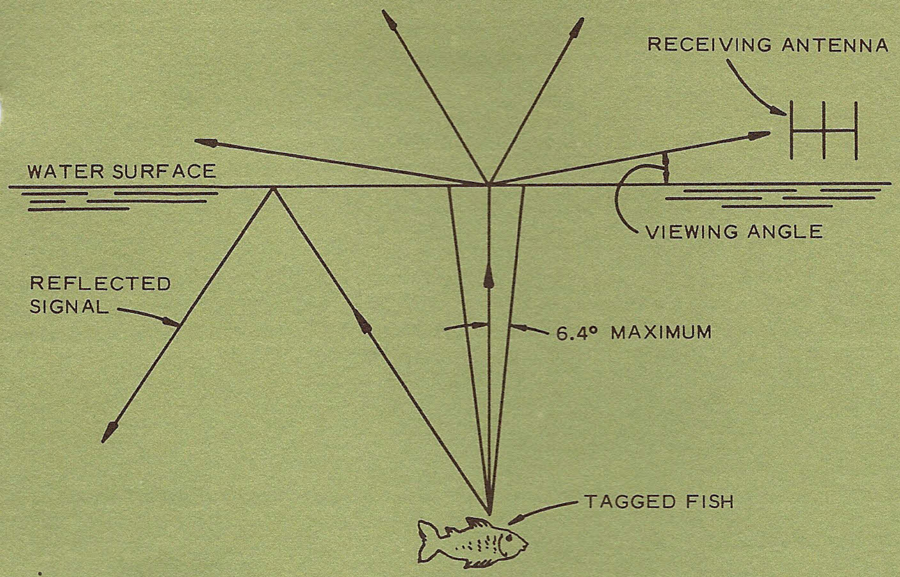


**Figure 2. Signal propagation path from tagged fish to receiving antenna**

As the radio signal approaches the air/water interface, only the portion of the incident signal that makes an included angle of 6.4 deg or less with the water surface normal is propagated across the interface (Figure 2). The remainder of the signal is reflected back into the water; thus, less than 0.5 percent of the power radiated from the tag is available to be transmitted across the interface, exclusive of the losses incurred due to water attenuation between the tag and surface. Once the signal has crossed the interface, the remaining energy is distributed into vertically and horizontally polarized components spread through the radiation hemisphere.

The signal loss at the air/water interface is a function of the dielectric constant of the water and the viewing angle in air (Figure 2); i.e., the included angle between the water surface and the path between the source of radiation (the location of the interface where the signal is being radiated from) and the receiving antenna. Measurements by other investigators have shown that this loss is 27-30 db for viewing angles of 10 to 5 deg.

Once the signal has crossed the air/water interface, it suffers further attentuation through air until the receiving antenna is reached. This signal attentuation $A_2$ in decibels per metre can be computed from:

$$A_2 = \frac{1}{d}\left[22 + 10 \log_{10}\left(\frac{d^2}{\lambda^2}\right)\right] \quad (2)$$

where d = length of propagation path over which attenuation is being measured, m

λ = wavelength of radio signal in air, m

**Mobile Tracking Unit**

A mobile unit was assembled by WES at Lake Conway in May 1979 for tracking tagged fish. The dual Yagi antenna system shown in Figure 3 is termed a null-peak array. When the Yagi transmission lines are the same length, the signals are additive, resulting in a 3-db gain over a single Yagi. When a simulated half-wave section is added to one of the transmission lines (with a phase-shift unit, see Figure 4), the signals are 180 deg out of phase with each other, resulting in a deep null in the array radiation pattern. The null azimuth, which is determined by a minimum reading of the receiver's signal-strength meter, occurs at the same azimuth as the azimuth toward the signal source. Typical azimuthal

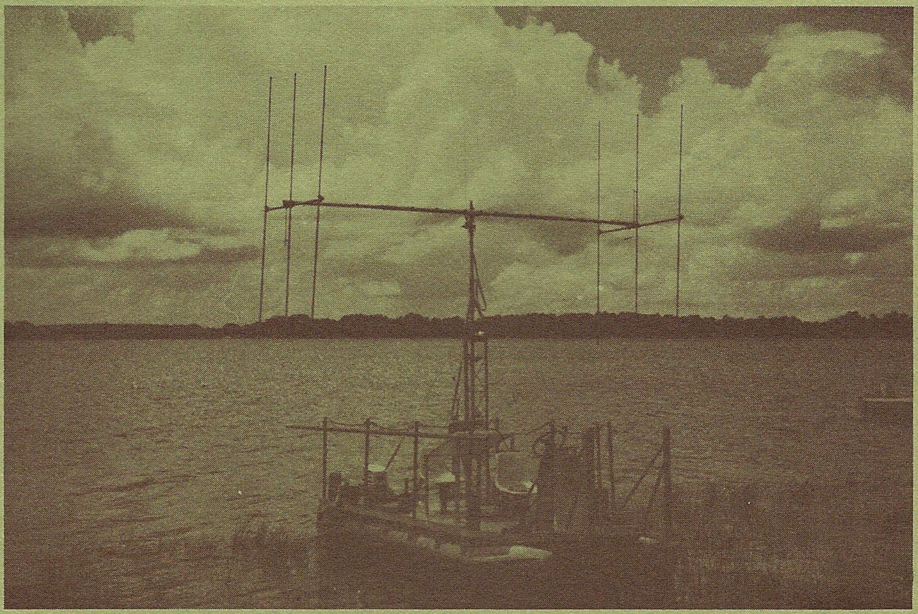

**Figure 3. Mobile tracking unit at Lake Conway**

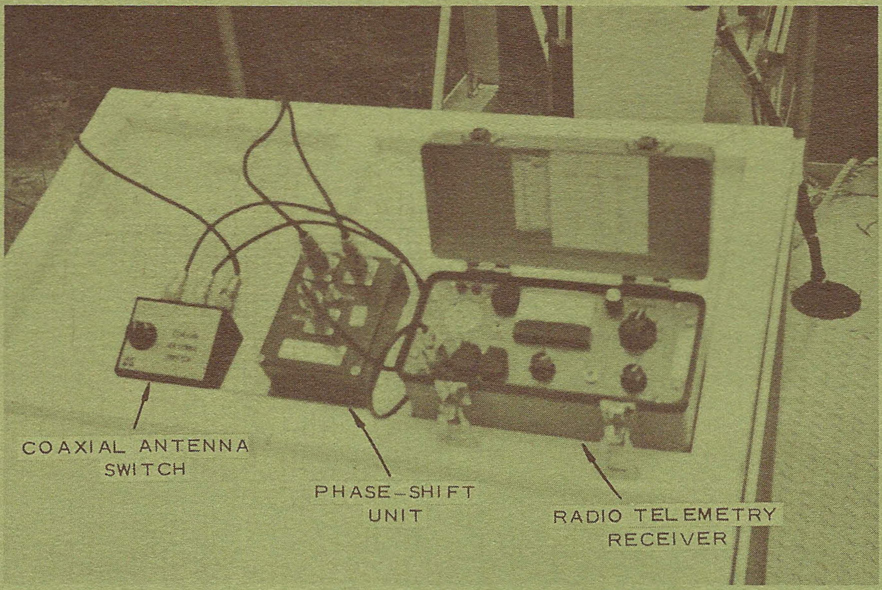


**Figure 4. Receiving equipment used at Lake Conway**

error with the Yagis in phase is 10 deg and is 3 deg when they are 180 deg out of phase.

### Fish Tagging

Since the beginning of the radiotelemetry tracking effort at Lake Conway in May 1979, more than twenty white amur have been tagged and tracked by DNR personnel. The tags are approximately 11 cm in length, 3 cm in diameter, weigh an average of 61 g (less than 1 percent of the average weight of the tagged fish), and have a design life of 4 years. Only fish weighing between 13 and 18 lb were tagged, thus representing the average size in Lake Conway.

Tags were implanted into the lowest point of the abdominal cavity of anesthetized fish; no ill effects of this procedure have been observed. The details of the tag implantation procedure are given in another article in this bulletin.

### Fish Location

Two methods have been used to locate the tagged fish: simple triangulation and the pursuit method.

In triangulation, the location of the mobile tracking unit was determined initially by triangulating with at least three known points on the shoreline. An observation site and a compass rose attached to the mast of the antenna array were used to determine the relative angles between these known points. This location was then plotted on a map of the particular pool using a swing-arm protractor. The azimuth to a tagged fish from the mobile tracking unit was initially determined by rotating the antenna in the general direction of maximum signal amplitude with the Yagis in phase; the measured azimuth was then determined by switching in the simulated 180-deg phasing line with the phase-shift unit and then rotating the antenna until the null in the radiation pattern was obtained. The orientation of the antenna array was then the same as the azimuth from the tracking unit to the fish. This azimuth was laid out on the pool map from the previously plotted location of the tracking unit. After completing this procedure from at least three locations, the location of the fish was estimated to be at the intersection of the azimuths.

The triangulation method of acquiring data was somewhat slow. A quicker and probably more accurate method was developed as a result of field experience. Using the second approach, termed the pursuit method, the antenna array is oriented broadside with the direction of travel of the mobile tracking unit. The driver of the craft then proceeds in the direction of maximum signal amplitude. As the tracking unit passes over the location of a tagged fish, there is a drastic reduction in signal strength; this reduction is explained by the fact that the front-to-back ratio of the antenna array is in excess of 20 db. After passing over the fish, the craft then circles back to the estimated position of the fish to verify the location. If the boat is maneuvered rapidly, the wake forms an "x" at the estimated location of the fish. When the location is close enough to shore, the position of the fish can be plotted directly on a pool map from visual observation. When the fish is far from land, its location can be determined by triangulating with known points along the shoreline.

### Preliminary Findings

Use of the mobile tracking unit in conjunction with the pursuit method has proven to be a reliable technique to determine the surface location of a tagged fish. Comparisons of estimated locations with known locations have indicated that the difference is generally less than 5 m.

Preliminary comparison of fish sitings with known vegetated areas indicate that the white amur are concentrating in these areas (Figure 5) and that most of the sitings are at locations where the water depth is 1 to 3 m.

The examination of sequential sitings (May-November 1979) for various individuals indicates that the fish demonstrate a wide variation in behavior. Some fish remain in a given area for a period of time and then move to a new location; others regularly move between the same locations; and still others tend to wander. One fish is known to have traveled nearly 2 km in a 24-hr period.

After completion of the data-collection phase of the LSOMT, a study will be initiated to correlate the aquatic macrophyte data with the location history of the tagged fish. Interrelated topics to be covered by this study include preference for specific areas or depth zones; preference for food type; relationship between time of day, water temperature, and/or cultural impacts on feeding and other activities; travel between the five pools of the Lake Conway system; variability in individual behavior; and gregariousness of individuals. The findings, as well as monitored changes in the aquatic macrophyte community's species composition, biomass, and spatial distribution, will be used to determine if the introduction of white amur into a lake system is an effective and environmentally compatible aquatic plant control method.

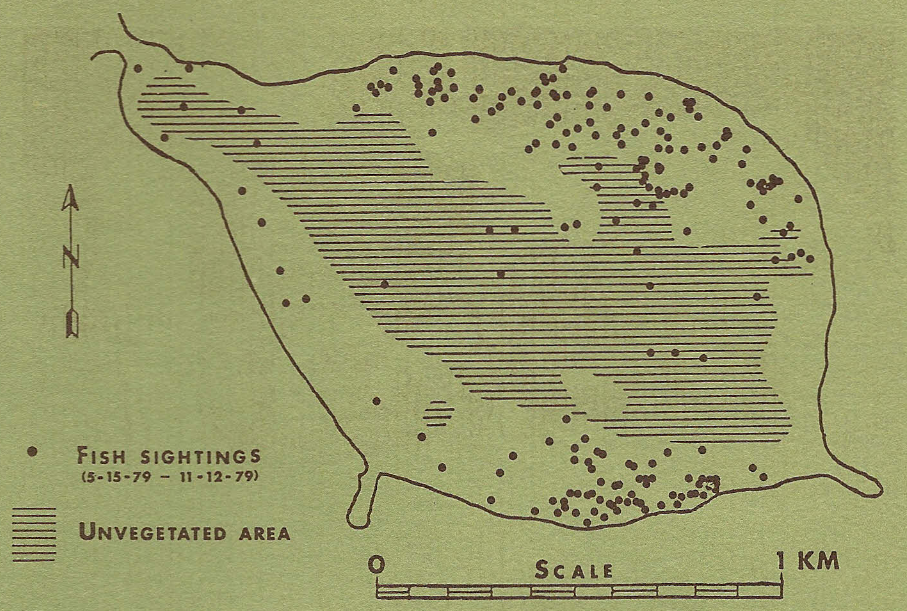


Figure 5. Cumulative tagged fish sitings in the Lake Conway South Pool from 15 May through 12 November 1979

## HERPETOFAUNAL STUDIES

Parallel with the aquatic macrophyte sampling and white amur tracking efforts, the University of South Florida (USF) is conducting a study to determine the impact of the introduced white amur on the resident herpetofaunal species. A major part of this effort is the development of a typical movement history for the predominant herpetofaunal species such that variations in these movement patterns can be detected as the amur reduce the amount of vegetation available for consumption in the lake system.

During the initial phase of this study, 200 adult Chrysemys (painted turtles) were mechanically tagged; of this number, only 2 were recaptured. This led to the conclusion that radiotagging and tracking of several individuals would considerably enhance the final product of the herpetofaunal study.

Analysis of the project funding schedule indicated that radiotagging would be economically feasible only if the existing mobile tracking unit could be utilized. The dual Yagi antenna array was resonated at 49.8 MHz (mid-point of the 49.61-49.99 band) for the fish-tracking study. Ideally, the herpetofaunal studies should be conducted on an adjacent band in order to avoid confusion of fish tag signals with herpetofaunal tag signals. A band (46.61-46.99 MHz) was available 3 MHz below the fish-tracking band; however, in order to use the same mobile tracking unit (but with a different receiver), the resonant frequency of the dual Yagi antenna array had to be shifted to 48.3 MHz in order to accommodate the frequency bands for both studies. The resonant frequency was lowered by changing the Yagi elements to lengths calculated from conventional equations for a 48.3-MHz array. No apparent degradation in antenna performance has been noted on either band since the resonant frequency modification.

The radiotags purchased for this study are described in the tabulation on page 6.

Stinkpots, mud turtles, and painted turtles were tagged by fixing the tag to the rear of the shell with dental acrylic (Figures 6 and 7). Two of the five tags purchased for the aquatic salamander were implanted in this species; in addition, one tag each was implanted in an

| Herpetofauna | | | Radiotag | | | |
|---|---|---|---|---|---|---|
| | | | Design | Max | Max Dimension, cm | |
| Species | Common Name | No. Tagged | Life Months | Weight g | Diameter | Length |
| *Sternotherus odoradus/ Kinosternon subrubrum* | Stinkpot/ mud turtle | 7/3 | 3 | 6.5 | 1.5 | 2 |
| *Chrysemys floridana/ Chrysemys nelsoni* | Painted turtle | 12 | 50 | 80 | 3 | 10 |
| *Siren lacterina* | Aquatic salamander | 2 | 6 | 5 | 1.7 | 3.5 |

**Figure 6. Painted turtle with radiotag attached**

*Amthiuma means* (two-toed salamander) and a *Nerodia cyclopion* (green water snake). The general method used for the implantation was to anesthetize the individual with chlorotone, insert the tag through an incision into the body cavity, and suture the incision.

The design life for the battery used in the stinkpot/mud turtle tags is only 3 months (because of maximum tag weight considerations); thus, the batteries must be replaced on a regular basis if the time-history of an individual is to be continued past 3 months; 9 out of 10 batteries were successfully replaced by USF in February 1980. After locating and removing a tagged turtle from the lake, the acrylic around the battery compartment was dissolved with acetone; when the battery was exposed, it was removed and replaced with a fresh cell. Acrylic was then applied to the tag to restore it to the original condition. No apparent stress or damage was suffered by the turtles during this procedure.

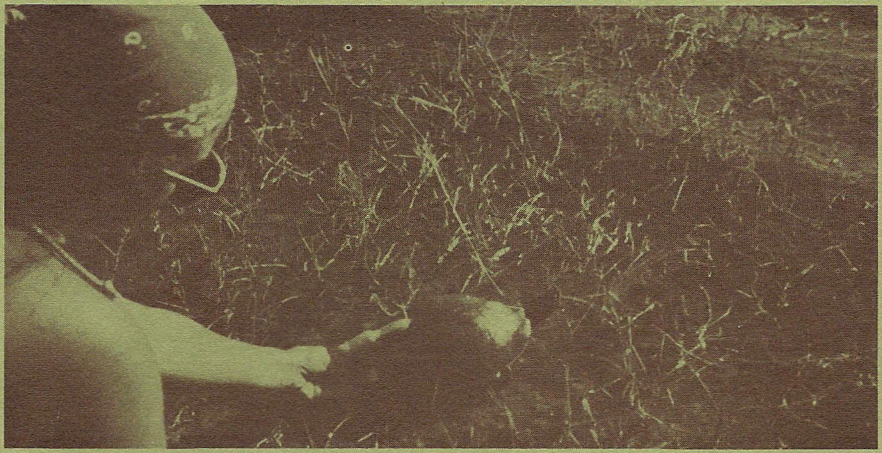

**Figure 7. Release of tagged turtle**

## Preliminary Findings

Initial tracking by USF through March 1980 has indicated that the painted and stinkpot turtles have very large home ranges and often travel distances greater than one km in a day or two. Most of the adults spend their time in open water and rarely frequent the shallows, thus explaining the low recapture rate for these species at permanent USF shoreline sites. On the other hand, the three tagged mud turtles appear to be rather sedentary with some tagged individuals remaining in a 10-m-sq area during the entire tracking period. No initial conclusions are available yet for the other tagged species.

## FURTHER EQUIPMENT DEVELOPMENT

The procedures described to track fish, turtles, and other species can only be used to determine the surface location of a tagged individual. As part of the LSOMT, an attempt is being made by WES to develop a technique to estimate tag depth, which would give an X, Y, and Z coordinate location.

# FISH TAG IMPLANTATION

***by MALCOLM P. KEOWN***

Larry E. Nall and Jeffrey P. Schardt of the Florida DNR developed a successful method for implanting radiotags in the white amur in the Lake Conway LSOMT. This method was adapted from methods used with catfish and other species previously used by Hart and Summerfelt at Oklahoma State University and by other workers.

The fish to be tagged were initially placed in a holding tank and anesthetized in a 4-ppm quinaldine solution. This aided in handling during weighing and transfer to the surgical tank which consists of a V-shaped trough in an aerated 80-ℓ aquarium. The trough allowed positioning of the fish ventral side up with the gills submersed. The concentration of quinaldine solution used in the surgical tank ranged from 4 to 15 ppm, depending on the amount necessary to prevent fish movement.

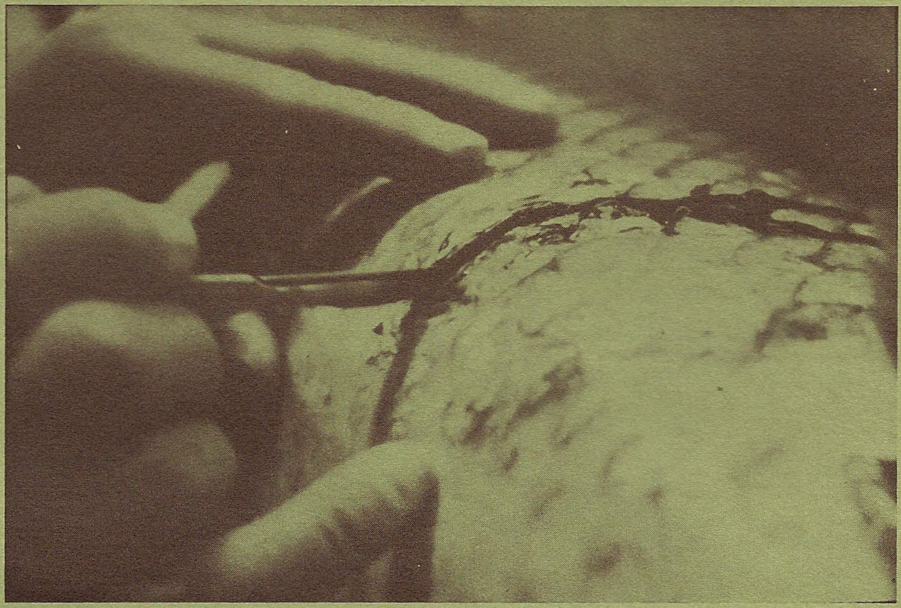

**Figure 1. Incision made to implant radiotag (photograph courtesy of the Florida DNR)**

Once anesthetized, two or three rows of scales were removed around the incision site. A 5- to 7-cm incision was then made vertically just anterior to the pelvic fin girdle (Figure 1). The lower end of the incision terminated 2 to 3 cm from the midventral line. This incision site was chosen over a longitudinal midventral incision site because the tag and viscera would probably place a strain on the sutures of a longitudinal incision and thus possibly open the wound.

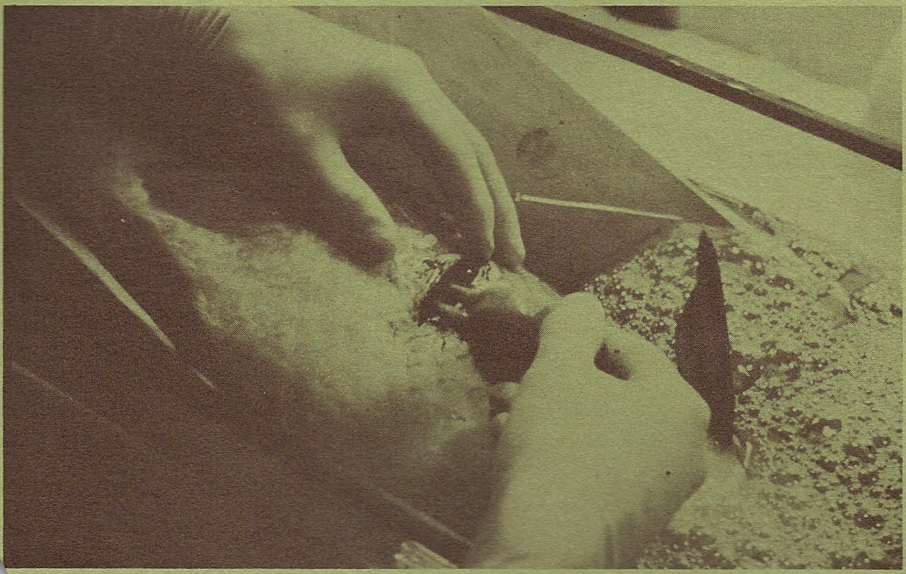

**Figure 2. Radiotag being implanted into white amur (photograph courtesy of the Florida DNR)**

The tag was implanted into the abdominal cavity and positioned at the lowest point (Figure 2). Incision closure was accomplished using 000 Type C Chromic Gut suture material. Four to six deep stitches were made through the body wall using a 6-D half-circle cutting suture needle. Five to seven shallower stitches were then made through the epidermis using a smaller 8-D half-circle cutting needle, which ensured a tight closure.

After completion of the closure, 10 ml of injectable terramycin solution, which contained 50 mg/ml oxytetracycline hydrochloride, was administered intramuscularly. This represented a dosage of approximately 55 mg of oxytetracycline per kilogram of body weight. Intraperitoneal injections and antibiotic ointment applied directly to the incision were considered but rejected because of the possibility of dissolving the suture material prematurely.

No ill effects of this procedure have been observed. The details are given here because of the lack of success reported by other investigators.

## APCRP Publications

Guillroy, Vincent. 1979. "Large-Scale Operations Management Test of Use of the White Amur for Control of Problem Aquatic Plants; Report 1, Baseline Studies; Volume II, The Fish, Mammals, and Waterfowl of Lake Conway, Florida," WES Technical Report A-78-2, prepared by the Florida Game and Fresh Water Fish Commission for the Environmental Laboratory.

Haller, William T., and Tag El Seed, Mirghani. 1979. "Study of Waterhyacinths Showing Possible Resistance to 2,4-D Chemical Control Programs," WES Miscellaneous Paper A-79-8, prepared by the University of Florida Department of Agronomy for the Environmental Laboratory.

Long, Katherine S. 1979. "Remote Sensing of Aquatic Plants," WES Technical Report A-79-2, Environmental Laboratory.

Pemberton, Robert W. 1979. "Exploration for Natural Enemies of *Hydrilla verticillata* in Eastern Africa," WES Miscellaneous Paper A-80-1, prepared by the U. S. Department of Agriculture, Agricultural Research Service, Southern Region, for the Environmental Laboratory.

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