Underwater Biotelemetry: Useful for the Study of Mekong Fish?

Fishermen release a Mekong giant catfish, *Pangasianodon gigas*, as part of a pilot study of the migratory behaviour of this species. Note tag on base of tail.

Preliminary tests of two biotelemetry systems for tagging fish, radio telemetry and ultrasonic telemetry, indicate that biotelemetry is a tool for the study of fish migrations and fish habitat use in the Mekong River Basin. The study was conducted in the Tonle Sap River during October and November 2001. Five types of transmitters (two radio, two ultrasonic, and one combined radio/ultrasonic) and two types of receivers (radio and ultrasonic) were tested. Ultrasonic transmitters outperformed radio transmitters in tests of transmitter range. Signals from ultrasonic transmitters were audible at a distance of over two kilometres whereas the range of radio transmitters varied between 500m and one kilo metre. Careful consideration of the study design and methodology (e.g. transmitter type, receiver type, study site, study species and sample size) can optimise the effectiveness of biotelemetry research. Biotelemetry equipment is now available (through the Management of the Freshwater Capture Fisheries of Cambodia Component) for fisheries research.

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Over the past five years, the study of fish migrations has emerged as a key area of fisheries research in the Mekong River Basin (Baird et al. 2001, Hogan et al. in press, Lenormand 1996, Lieng et al. 1995, Poulsen et al. 2000, Singhanouvong et al. 1996). Many recent studies have focused on the migrations of Mekong species, using a combination of local knowledge and catch data to infer the movements of fish throughout the Basin (Baird op. cit., Poulsen op. cit.). As a result of these studies, fisheries experts have begun to describe the patterns of fish movement in the Mekong River Basin. Based on these descriptions of migratory behaviour and habitat use, one option for future research is the direct measurement of these migrations, including species-specific data on fish movements, by tagging fish using underwater biotelemetry.

Underwater biotelemetry provides direct measurement of fish location, movement and habitat use (Winter 1996). Although biotelemetry has not been applied to the study of wild fish migrations in the Mekong River Basin, the technique may prove useful if applied with careful consideration of the study species and objectives. While transmitter range and high cost potentially limit the effectiveness and widespread use of biotelemetry in the Basin, focused use of this technique can yield valuable information on the life history patterns of a variety of migratory Mekong species.

The optimal telemetry system (radio, ultrasonic or satellite) for Mekong research depends on the objectives, project budget, and the environmental conditions of the area of interest. Traditionally, radio telemetry is used in freshwater environments, especially rivers. However, high conductivity limits the effectiveness of radio transmitters. Ultrasonic telemetry is normally required in environments of high water conductivity or in applications where the typical water depths exceed 12-15 metres. Combined Acoustic (ultrasonic)/Radio Tags (CART) are hybrid tags that transmit both radio and ultrasonic signals. Theoretically, CART transmitters enable researchers to track fish in a variety of aquatic environments, including deep and shallow water, freshwater, brackish water and even salt water.
Tags and Transmitters

Satellite transmitters (tags that transmit data to a satellite) may be an option for very specialised research, but technological constraints limit their applicability to studies of Mekong species. Two types of tags exist: Pop-up Archival transmitters (PAT) and data storage transmitters. PAT transmitters are designed to track long-distance migration and behaviour of (typically) marine organisms. The PAT transmitter releases from the study animal at a pre-set date. The transmitter then floats to water's surface and transmits the stored data to a satellite. Unfortunately, pop-up satellite transmitters have not been developed for freshwater conditions. To use satellite transmitter technology in freshwater, researchers must use data storage transmitters. Data storage transmitters are similar to PAT transmitters in that they provide direct measurements of geographical position at regular intervals over many months. However, in order to retrieve the information the transmitter must be recovered from the fish. Transmitter recovery normally requires an intensive recapture operation dependent on commercial and recreational catch returns.

Equipment Tested in the Tonle Sap River

The maximum range of radio and ultrasonic transmitters was tested in the Tonle Sap River, Cambodia. Both the maximum distance (metres along the water surface from the transmitter to the receiver) and maximum depth (distance from a submerged transmitter to a receiver at the water surface) were measured. The maximum surface range was measured by positioning the transmitters one metre below the water surface and then monitoring the strength of the radio/ultrasonic signal at successively greater distances from the transmitters. The maximum depth range was measured by positioning the receiver a metre above the water and then monitoring the strength of the radio/ultrasonic signal as the transmitters were lowered to greater and greater depths. Five types of transmitters and two types of receivers were tested.

<table>
<thead>
<tr>
<th>Distance</th>
<th>5m</th>
<th>384m</th>
<th>813m</th>
<th>1.4km</th>
<th>2.2km</th>
<th>3.4km</th>
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<tbody>
<tr>
<td>Transmitter</td>
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<td>S</td>
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<td>FIS-550 (radio)</td>
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<td>MCFT-7E (radio)</td>
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<td>CART 16-3 (radio)</td>
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<tr>
<td>CART 16-3 (ultrasonic)</td>
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<tr>
<td>CHP-87-L (ultrasonic)</td>
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<td>S</td>
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<tr>
<td>DT-97 (ultrasonic)</td>
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</tbody>
</table>

Results Are Promising...

The maximum range (surface distance) of each of the five transmitters is provided in Table 2 (see next page). The maximum range of the radio transmitters varied between 384m-813m. The maximum range of the ultrasonic transmitters varied between 1.4km-2.2km. The observed maximum ranges of the radio transmitters were lower than the maximum ranges of ultrasonic transmitters. The signals of two radio transmitters could not be detected from 813m, a distance roughly equal to the width of the narrowest sections of Mekong River during the high water season. The signal of one of the ultrasonic transmitters was detected from a distance of 2.2km.

The maximum depth range (distance underwater) of each of the five transmitters is provided in Table 3. The maximum depth ranges of the radio transmitters varied between 20-24m. The maximum ranges of the ultrasonic transmitters were not tested, because the ultrasonic signal remained strong at a depth of 24m—the maximum depth of the river at the test site. Both the radio and ultrasonic signals remained strong up to a depth of 20m. At depths greater than 20m, the radio signals weakened rapidly, whereas the signals of the ultrasonic transmitters remained very strong.
Designing a Telemetry Study

The results of these preliminary tests indicate that underwater biotelemetry is a viable tool for the study of fish migrations and habitat use in the Mekong River. While the utility of radio telemetry remains in question, these tests show that ultrasonic telemetry is a sufficiently powerful tool to detect tagged fish, even at distances of over 2km or at depths greater than 24m. Ultrasonic transmitters may enable fisheries researchers to locate and track fish in the deepest pools (some thought to be more than 100m deep) and widest stretches (theoretically any single channel of width not greater than 4.4km) of the Mekong River. Nonetheless, it was noticed that the signal strength of all transmitters varied from day to day and from site to site. Curiously, the transmitter range appeared to be greater in the Tonle Sap River than in the Mekong River. Although we were not able to determine the cause of this variability, stratified water of different temperatures, wave action, boat noise and equipment condition have all been shown to impact signal strength (Winter 1996). Therefore, the transmitter ranges listed here should be considered as the maximum ranges under optimal conditions. The actual range of each transmitter may vary.

Observed signal strength depended not only on system type (radio or ultrasonic) but also on transmitter type. The choice of transmitter must be carefully considered, based on study design and species, tracking needs, and budget.

Airplanes Can Track Radio Tagged Fish

The performance of radio transmitters may be improved by increasing the size of the antenna or by lowering the frequency of transmission. The radio transmitters in this study emitted signals in the 148-150 mHz range. Lower frequencies attenuate less when travelling through water. The use of airplanes to track radio tagged fish may also improve the performance of radio telemetry systems in the Mekong River Basin. Winter (1996) reports that airplane monitoring is an excellent way to track highly mobile species. Airplanes cover large areas quickly and provide two to three times greater detection range than boat mounted receivers.

For this test study, uncoded transmitters and a manual receiver were used. Uncoded transmitters and manual receivers are less expensive than coded transmitters and scanning receivers. Typically, uncoded transmitters and manual receivers enable researchers to track between 20 and 100 fish at one time. Each uncoded transmitter is programmed with a signal of slightly different frequency, thus allowing for the identification of individual fish. However, for studies involving more than about 20 fish, coded transmitters and scanning receivers enable researchers to identify individual fish much more quickly and easily. Instead of using unique frequencies for each transmitter, the coded transmitter system relies on information encoded in the signal to identify the fish. In this way, many fish can be tagged with transmitters emitting signals of the same frequency.

Several Remote Tracking Stations

For non-migratory species with small home range size (e.g. fish that never leave the deep pools of the Tonle Sap River) a manual, mobile receiver is adequate. For migratory species, however, several remote-tracking receivers positioned at strategic points along the river will yield better data. A remote receiving station consists of a receiver, a hydrophone, and a small computer. Remote receiving stations automatically record the date, time, and fish identification number as the fish passes the receiving station. This information can then be downloaded onto a laptop computer. The combined use of several remote tracking stations enables fisheries researchers to track the movement of a fish as it moves past each station.

The use of remote tracking stations increases the efficiency and cost effectiveness of telemetry studies. A large investment in several remote stations may yield proportionally more benefit (data) than a small investment in a single manual receiver, since the study of several fish or many species is very difficult.

<table>
<thead>
<tr>
<th>Distance</th>
<th>1m</th>
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<th>5m</th>
<th>7m</th>
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<td>FIS-550 (radio)</td>
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<td>MCFT-7E (radio)</td>
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<tr>
<td>CART 16-3 (radio)</td>
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<tr>
<td>CART 16-3 (ultrasonic)</td>
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</table>

Table 3. The maximum depth range for five types of radio and ultrasonic transmitters. S indicates a strong signal. W indicates a weak signal. A signal was considered as strong if it could be heard easily over background noise. A signal was considered as weak if it could not be heard easily over background noise. Weak signals might be difficult to follow using manual tracking techniques. A dash indicates no signal was detected.

The Sonotronics USR-96 narrow band tracking ultrasonic receiver with a Sonotronic DH-4-10 directional hydrophone.

The Mekong Fisheries Network Newsletter
using a single, mobile receiver. Moreover, a manual tracking receiver is limited because it is only capable of monitoring one area at a time and only for as long as the researchers remain in the field.

Small sample sizes make it difficult to relocate fish in the field, and so costly field surveys may not yield new information. If, on the other hand, a large number of fish are tagged, the chance of relocating some fish during each survey is increased. A small sample size also limits the validity of population-level inferences about fish behaviour. By increasing the number of fish tagged, multi-species studies are possible as well.

**Possible Study Sites**

Based on the results of these preliminary tests, study sites appropriate for ultrasonic telemetry include deep pools, narrow and undivided stretches of the Mekong River, its tributaries and specific focal sites such as weirs, dams, important channels (e.g. Hou Sahong, Khone Falls, Lao PDR), spawning grounds, etc. Examples of such sites include the Tonle Sap River, the narrowest sections of the Mekong River below the Khone Falls, the deep pools of the Tonle Sap and Mekong Rivers, the tributaries of the Mekong River in north-east Cambodia (Sekong, Srepok, Sesan), Lao PDR (Nam au), and Thailand (Songkhram, Loei, Mun), and most of the Mekong River upstream of Vientiane. For instance, a series of stations placed (1) in the Tonle Sap River, (2) in a narrow stretch of the Mekong River at Kratie, (3) at Stung Treng at the mouth of the Sekong River, and (4) in the Mekong River between Stung Treng and the Khone Falls would provide information about movement out of the Tonle Sap Lake and upstream to the Khone Falls and the tributaries of north-east Cambodia.

Since many species are believed to migrate between the Tonle Sap Lake and upstream habitats, the study of such migrations is critical to measuring this important link between spawning grounds and lowland and flooded habitats. Alternatively, stations could be placed in the Tonle Sap, Bassac and Mekong Rivers at the Quatre Bras area of Phnom Penh in order to monitor the movement of fish in and out of the Great Lake, downstream toward Viet Nam and upstream toward the Lao PDR.

Study sites that might be considered inappropriate for ultrasonic studies include the widest sections of the Mekong River, flooded forest habitats, huge expanses of open water (e.g. the Tonle Sap Lake), and multi-channel sections of the Mekong (e.g. Siphandone wetlands in southern Lao PDR).

**Summing Up**

This study shows that biotelemetry, and especially acoustic biotelemetry, can be used effectively within the Mekong River Basin. Biotelemetry systems provide direct measurements of fish movement and habitat use, thus enabling fisheries researchers to test current ideas on fish migrations, locate spawning and feeding grounds, and describe important seasonal habitats. In a large, multi-species ecosystem such as the Mekong River, careful study design is critical to the success of telemetry studies.

**News Flash!**

One of the River Catfish tagged by us with an ultrasonic tag on 30 November 2001 in the Tonle Sap River near Phnom Penh (Dai row 2, unit C) was recaptured on the border of Kratie and Stung Treng Provinces on 5 February 2002. The species is *Pangasianodon hypophthalmus* (Khmer: *tray pra*). The fish was caught by hook and line.

**References**


