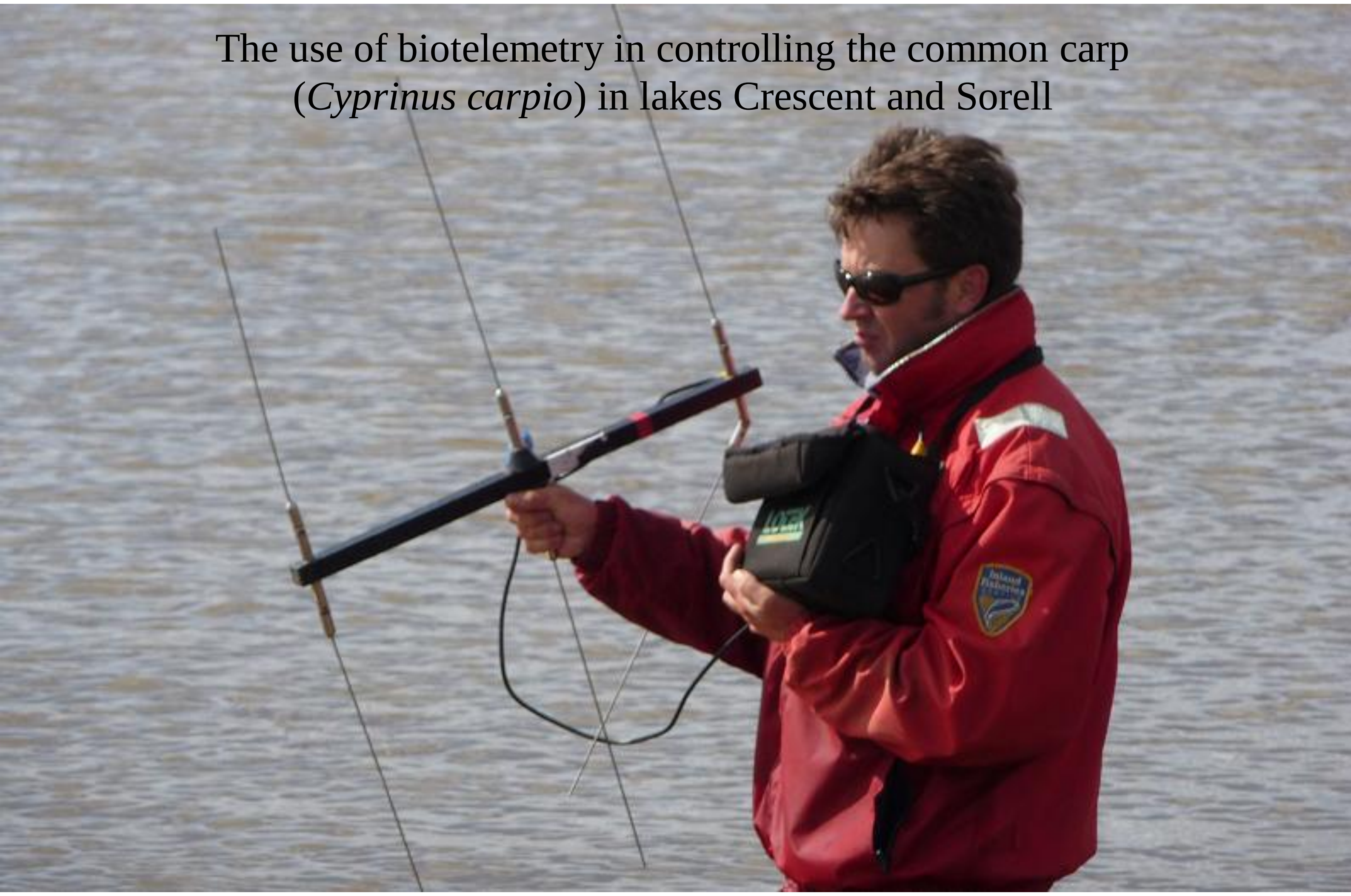
Inland Fisheries Service

Tasmania

The use of biotelemetry in controlling the common carp (*Cyprinus carpio*) in lakes Crescent and Sorell



Technical Report No. 1.

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Carp Management Program

Inland Fisheries Service 2003 (Revised 2011).

Tasmania

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This report is part of a series of documents, which provide information and details of carp eradication efforts in lakes Sorell and Crescent as part of the Lakes Sorell and Crescent Carp Management Project.

The aim of the project is to control the spread of carp within the state of Tasmania, with a view to their eradication.

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Contents

1.0 Introduction

Biotelemetry provides a means to monitor the location, behaviour and physiology of animals in uncontrolled environments, both terrestrial and aquatic. Biotelemetry or 'radio tracking' involves the transfer of information in the form of radio signals from radio transmitters, (which are attached or implanted into animals), to a remote receiver system.

Since 1997, the Carp Management Program, under the Tasmanian Inland Fisheries Service (IFS) has employed the use of biotelemetry technology to identify the movements of carp (*Cyprinus carpio*) in lakes Crescent and Sorell, Tasmania.

Carp were discovered in these lakes in 1995 and since then considerable resources have been allocated to reduce their abundance and maintain overall low numbers with an ultimate goal of total eradication. However, initial attempts to reduce the population by electro-fishing and netting were inefficient and destructive to non-targeted fish species. This was because fishing efforts were random and with a combined surface area of 74.7 square kilometres at full supply (Uytendaal 2003), random effort is hindered by the physical size of both lakes.

Carp can inflict major environmental and economic costs on both the private and public sectors by reducing water quality and degrading aquatic habitats (Koehn *et al* 2000). Carp have been implicated in macrophyte destruction, through direct grazing and physical uprooting of plants, increases in water turbidity and nutrient loads by continually resuspending sediments and reductions in invertebrate biomass and composition through predation. In addition to this, they compete with native and other desirable species for both food and space (Fletcher *et al* 1985. Brumley 1991. Koehn *et al* 2000).
The tendency for carp to aggregate for breeding and feeding was identified early in the Tasmanian program as a behavioural trait that could be exploited to quickly remove large numbers of fish. However, the location of carp aggregations was only possible when carp created visual disturbances by

moving into shallow water to spawn. Aggregations in deeper water were unpredictable and infrequently discovered by random fishing efforts.

The use of biotelemetry technology has enabled greater efficiency in the detection of carp movement and activity. The tendency for carp to aggregate during feeding and breeding episodes has been identified in other water bodies (Johnsen and Hasler 1977) and is the principle underlying the use of this technology. Carp are first captured then measured and weighed to ascertain whether they are large enough to carry a radio- transmitter inside their gut cavity (transmitter $\leq$ 2% body weight in air). If suitable, the carp are surgically implanted with radio transmitters and released back into the lakes. Their movements are tracked from a boat using a radio telemetry receiver attached to a directional antenna. Transmitter-implanted carp or 'tracker fish' are regularly located and used as indicators of carp activity, movement and range. This enables IFS fishing operators to target fish aggregations through netting and electro-fishing with a higher degree of efficacy. In doing so, the impacts on non-target species are also reduced.

This report outlines the equipment used and the procedures employed in the IFS Carp Management Program. Methodology for the surgical implantation of transmitters into carp is also outlined.

2.0 Telemetry Equipment

2.1 Transmitters

The IFS carp program uses internal ultrasonic transmitters, which are surgically implanted into the abdominal cavity of carp. Initially the program attempted to source transmitters with long battery life and signals strong enough to transmit through water depths up to three metres in depth (maximum depth in Lake Sorell). Transmitters need to be small enough to be implanted into the body cavity of the carp. It was decided that terrestrial transmitters would be suitable for use in Lakes Sorell and Crescent due to the shallow average depths across both lakes. The most suitable transmitters for these requirements were found to be terrestrial transmitters coated with epoxy resin to ensure the unit would be completely waterproof. The first transmitters (model TX2-ICP-1) were supplied by Bio-Telemetry Tracking Australia (Biotel) with a 12-month battery life and a straight wire (whip) antenna. The transmitters are tuned to operate between 150 and 152 MHz. These frequencies were chosen as they fall within permitted operating frequencies covered by a radio-communications class licence (low interference potential devices) under the *Commonwealth Radio Communications Act, 1992*. The signal emitted is a short "ping" with variable signal interval depending on the model of transmitter used. Most transmitters used have a pulse interval rate of approximately 55 cycles per minute but variations between 40-60 have been used when battery longevity is required.

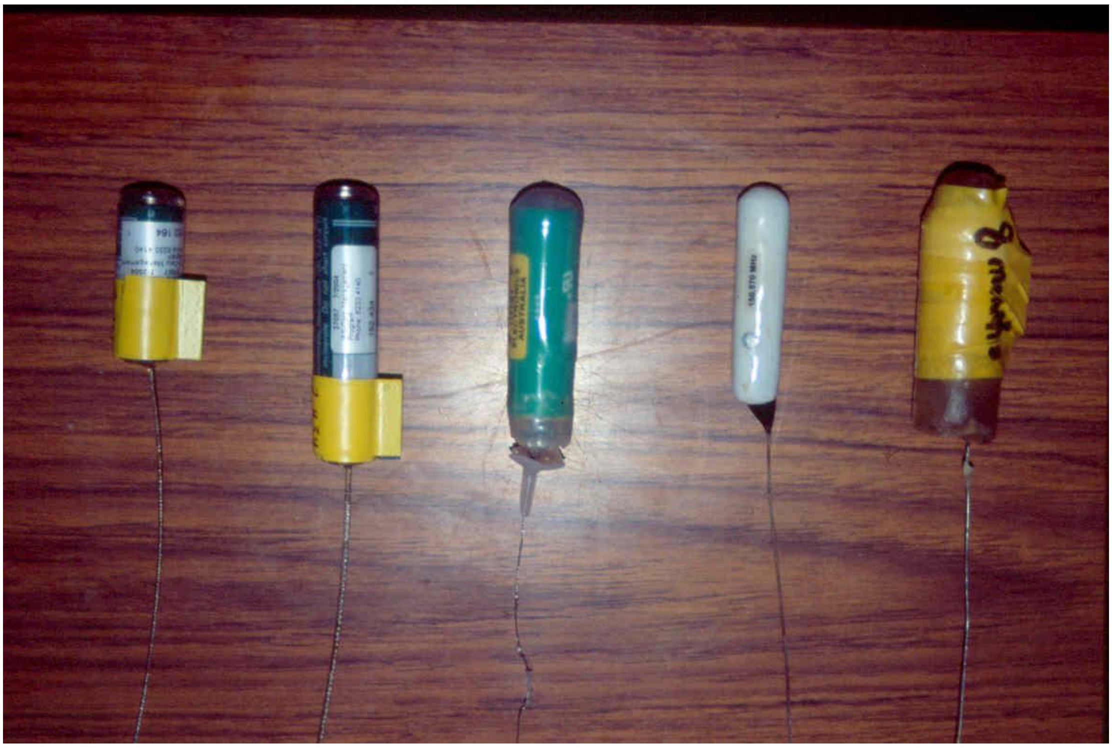


Figure 1. A variety Bio-Telemetry Transmitters with aerial.

Since the inception of the IFS carp biotelemetry program, different transmitter suppliers have been sourced and trialed. The CMP has found that Advanced Telemetry System (ATS) transmitters can provide a range of transmitter variations to suit different fish sizes and provide a reliable long battery life. The most commonly used transmitter has been the F1835 with trailing whip antenna. This transmitter weighs 20 grams and is suitable for fish >1kg but has been found to have greater retention success in fish >1.4kg The CMP is currently running the 7 gram ATS F1815 in juvenile carp >350 gram.

Other transmitters from various suppliers are constantly being sourced, trialed and evaluated. In general different transmitters are being trialed with a view to sourcing a transmitter that maximises battery life, durability, size, signal output and price. Other transmitter suppliers currently being utilised are outlined in table 1.

Manufacturer	Series model	Length (mm)	Diameter (mm)	Weight (grams in air)	Duty cycle	Battery life (months)
Bio-Telemetry Tracking Australia	(model TX2-ICP-1)	30	15	15	24hrs	4
Bio-Telemetry Tracking Australia	(model TX2-ICP-1)	50	20	24	24 hrs	12
Sirtrack Wildlife Tracking Systems	FRT conventional pulse transmitter	48	16	16.3	12hrs on / 12 hrs off	18
Sirtrack Wildlife Tracking Systems	FRT conventional pulse transmitter	40	14	10.3	12hrs on / 12 hrs off	9
Titley Electronics	F1850 prototype series	50	20	24	12hrs on / 12 hrs off	18
Titley Electronics	F1850 prototype series	20	12	11	12hrs on / 12 hrs off	9
ATS Advanced Telemetry Systems, INC	F1835 crystal controlled 2 stage series.	42	17	14	12hrs on / 12 hrs off	30
ATS Advanced Telemetry Systems, INC	F1855 crystal controlled 2 stage series.	68	17	25	12hrs on / 12 hrs off	44

Table.1 - Specifications for transmitters used over time in Lakes Sorell and Crescent

Transmitter implant surgical procedures are based on those outlined by Johnsen and Hasler (1977). Unlike this study, the IFS carp program avoids holding fish captive for long periods both prior to, and after implant. This is due to an observed improvement in transmitter retention and fish survival when handling times are reduced as much as possible.

Since the inception of the biotelemetry within the CPM in 1997, between 6 and 15 active transmitters have been maintained in each lake. The larger Lake Sorell has required more active transmitters. This range has proven adequate for detecting aggregations and scanning frequencies effectively at a moderate boat speed. When transmitter batteries approach their expiry date, implanted fish are retrieved. Their transmitters are then removed and the fish either destroyed or re-implanted with new transmitters. In some cases, if the transmitter is cleanly removed, the fish will be sewn up and placed in a holding pen for observation in the hope that it will fully recover and be available for future implantation.

2.2 Telemetry Receiver Systems

Radio-transmitter implanted fish are individually identified by a unique radio frequency. The frequencies are programmed into a telemetry receiver and scanned continuously for approximately three seconds per frequency. The three second interval can be shortened or lengthened accordingly however the CMP has found a three second frequency interval most appropriate. When the receiver registers a programmed frequency, an audible "ping" sound will be heard through an in-built speaker system. The receiver can then be paused on that particular frequency so that an exact location of the tracker fish can be ascertained using a directional antenna. Therefore, in a typical tracking situation where 10 tracker fish are known to be functioning within a lake, it will take a telemetry receiver approximately 30 seconds to travel through an entire scan. This time period must be taken into account when choosing an appropriate boat speed to effectively radio track an area. As fish are located the boat speed can be increased as the number of transmitters are removed from the receivers scan

The CMP uses a Lotek Suretrack STR 1000 to locate transmitter-implanted carp from the runabout and the smaller Lotek Bio-tracker for honing in on fish while wading. Each receiver is programmed with a particular frequency ranging between 150 and 152 megahertz.

The Lotek receivers has proved most suitable because they could be programmed to automatically search for up to 20 transmitters in each of up to four separate frequency (memory) partitions. Therefore, a theoretical limit of 80 transmitters is possible for use with the Lotek receiver. Separate partitions are used to store active transmitter frequencies for each lake.

The Lotek receiver scans the partition by sequentially sampling each frequency in the partition. If the sample period for each frequency is set at 3 seconds this is long enough to sweep a receiving aerial in a 180 degree arc and hear at least one of the “pings” which identifies a particular tracker fish in the vicinity. When a tracker frequency is located, the receiver can be locked onto that frequency so operators can move closer and accurately ascertain the tracker fish location. After location, the tracker frequency can be removed from the overall scan partition thereby shortening the overall scan time and increasing the efficiency of locating the other tracker fish.

Fig 2 . LOTEK Suretrack STR 1000 Telemetry Receiver.

2.3 Receiving Transmitter Signals

To receive signals, an antenna is attached to the LOTEK receiver using a flexible cable jack connecter. The CMP uses a directional antenna or 'yagi'. The yagi antenna derives its name from one of the two Japanese inventors, Yagi and Uda, who developed the first directional antennae in the early 1920's. For radio-tracking on lakes such as Sorell or Crescent, the yagi is boat mounted to an aluminium mast with a rubber non-conducting slip to isolate the antenna. The yagi is mounted approximately 2 metres above the water surface for a number of reasons: adequate elevation can significantly increase signal strength, elevating the antenna can assist in dampening interference from outboard motors and also keeps the antenna out of the boat operators way. The new four stroke motors offer far less interference to the transmitter signal. When tracker fish are located near to the lake-shore, a hand held yagi can be connected to the receiver and an exact location of the tracker fish can be found on foot.

Due to the directionality of the yagi, the strongest signals are received when the antenna is pointed directly towards the implanted fish. However, depending on the distance between the transmitter and receiver, an audible signal may be heard with the yagi pointed at more than 90 degrees from the direction of the transmitter. Because of the polarising effect on radio-waves of the water-air interface (Velle *et al* 1980), the strongest signal is received when the plane of the aerial is mounted perpendicular to the waters surface.

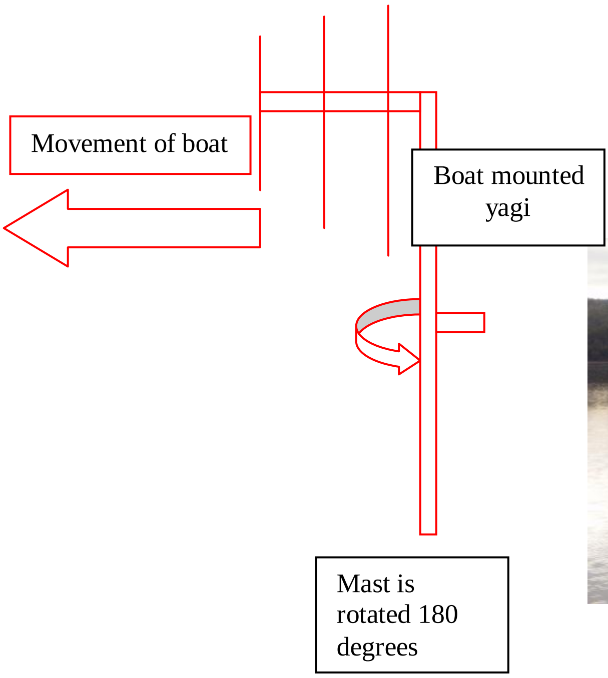


Fig 3. Radio tracking from boat using mast-mounted yagi.

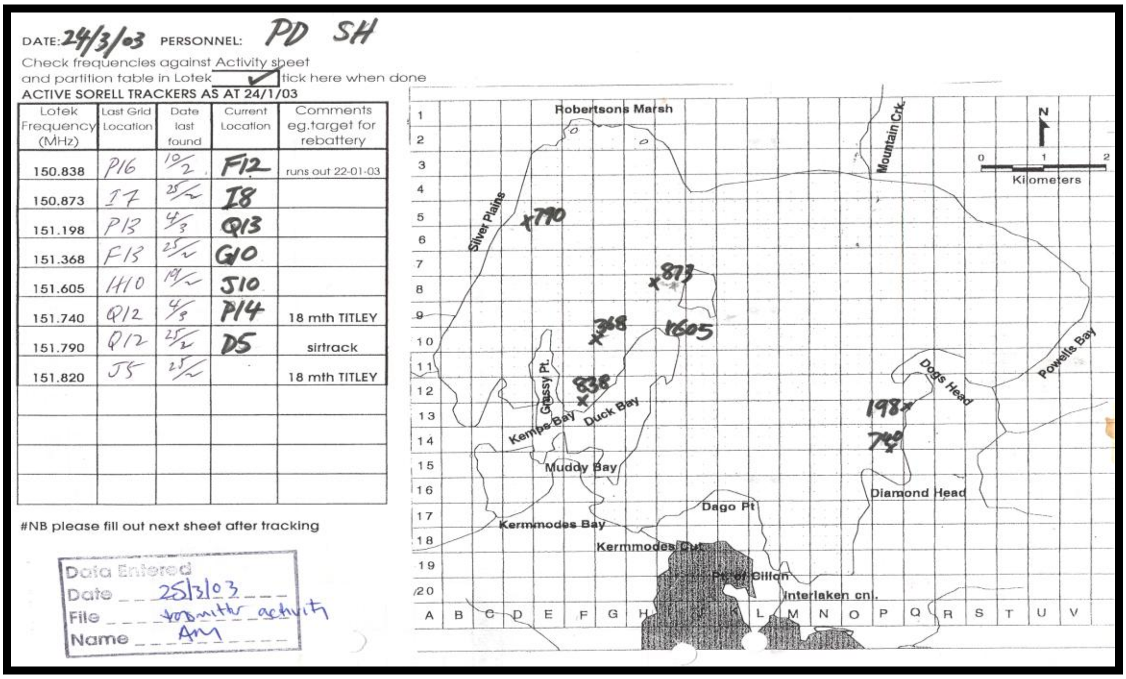
Fig 4. Radio tracking an implanted carp using a hand held yagi

As illustrated in figures 4 and 5, the Carp Management Program uses 3 element, collapsible directional yagi antennas. Care must be taken to protect the elements of the antennas against bending and connection failure. Any damage to an antenna can negatively affect frequency receiving strength and therefore tracking effectiveness.

Originally the yagi antenna came with 50 Ohms flexible cable jack connectors. Once these wore out they were replaced with 75 Ohms flexible cable jack connectors. Recently, the Carp Management Team has been advised to use the 50 Ohms flexible cable jack connectors again. The 75 Ohms connectors are for TV only and create too much static interference making it difficult to hear the 'ping' noise, which identifies a particular tracker fish in the vicinity. The 50 Ohms flexible cable jack connectors will reduce the amount of static interference and increase reception efficiency of the Lotek receiver.

3.0 Radio Tracking Techniques

Peak spawning times for carp have been identified as the warmer months from September through to March when water temperatures are higher (Drori 1994) During this period, the Carp Management Program undertakes daily monitoring of the lakes depending on weather conditions. As the lake is tracked, each transmitter fish that is located is given an approximate grid location. This is recorded on a prepared data sheet showing all operating tracker fish frequencies, their implant details and their last recorded position, (refer figure 5). Each data sheet is then entered into a computer database, when linked to ArcGIS can map the movements of carp over time.



DATE: 24/3/03 PERSONNEL: PD SH

Check frequencies against Activity sheet and partition table in Lotek ✓ tick here when done

ACTIVE SORELL TRACKERS AS AT 24/1/03

Lotek Frequency (MHz)	Last Grid Location	Date last found	Current Location	Comments eg.target for rebattery
150.838	P16	10/2	F12	runs out 22-01-03
150.873	I7	25/2	I8	
151.198	P13	4/3	Q13	
151.368	F13	25/2	G10	
151.605	H10	19/2	J10	
151.740	Q12	4/3	P14	18 mth TITLEY
151.790	Q12	25/2	D5	sirtrack
151.820	J5	25/2		18 mth TITLEY

#NB please fill out next sheet after tracking

Data Entered
Date 25/3/03
File transmitter activity
Name AM

Fig 5. A biotelemetry field record data sheet for Lake Sorell, March 2003.

Between 10 and 15 tracker fish has proven to be a large enough sample of the population to detect aggregations in each lake. As the number of frequencies scanned increases, so does the chance of missing a signal due to passing the range of the signal before the frequency is scanned (10 frequencies takes approximately 30 seconds to scan). For larger frequency partitions, the boat speed and scan interval can be reduced to avoid these problems. For each scan, the mounted yagi is manually rotated through a 180^0 arc. Because the yagi picks up frequencies approximately 90 degress from its centre, this will effectively cover a 360 degree scan if direction of travel is constant over an entire frequency scan period.

The gain function of the receiver allows the operator to adjust the audibility of the signal and the level of background noise. Under normal circumstances, the Carp Program has found that a gain of around 80 dB set in the Lotek enables an audible signal to be detected over the background noise. With gain set at between 80 and 85 dB, a tracker fish can be detected up to 800m, and sometimes beyond 1200 metres, from the antenna depending on climatic conditions. As the distance to the transmitter is decreased, the gain can be reduced which improves the directionality of the yagi. This allows operators to determine the location of a tracker fish with a greater degree of accuracy. Experienced operators can, with very high precision, estimate *distance* to transmitter fish by the signal strength emitted at low gains. However, signal strength at a given gain can be influenced by several variables; water depth, turbidity and conductivity (Winter, 1979, Velle *et al* 1980) The height of the yagi and substrate topography will also effect the radio reception of transmitter frequencies travelling from water into air.

Diagram 1 illustrates how radio tracking can monitor the development of aggregations for immediate benefits and for future research and trend identification.

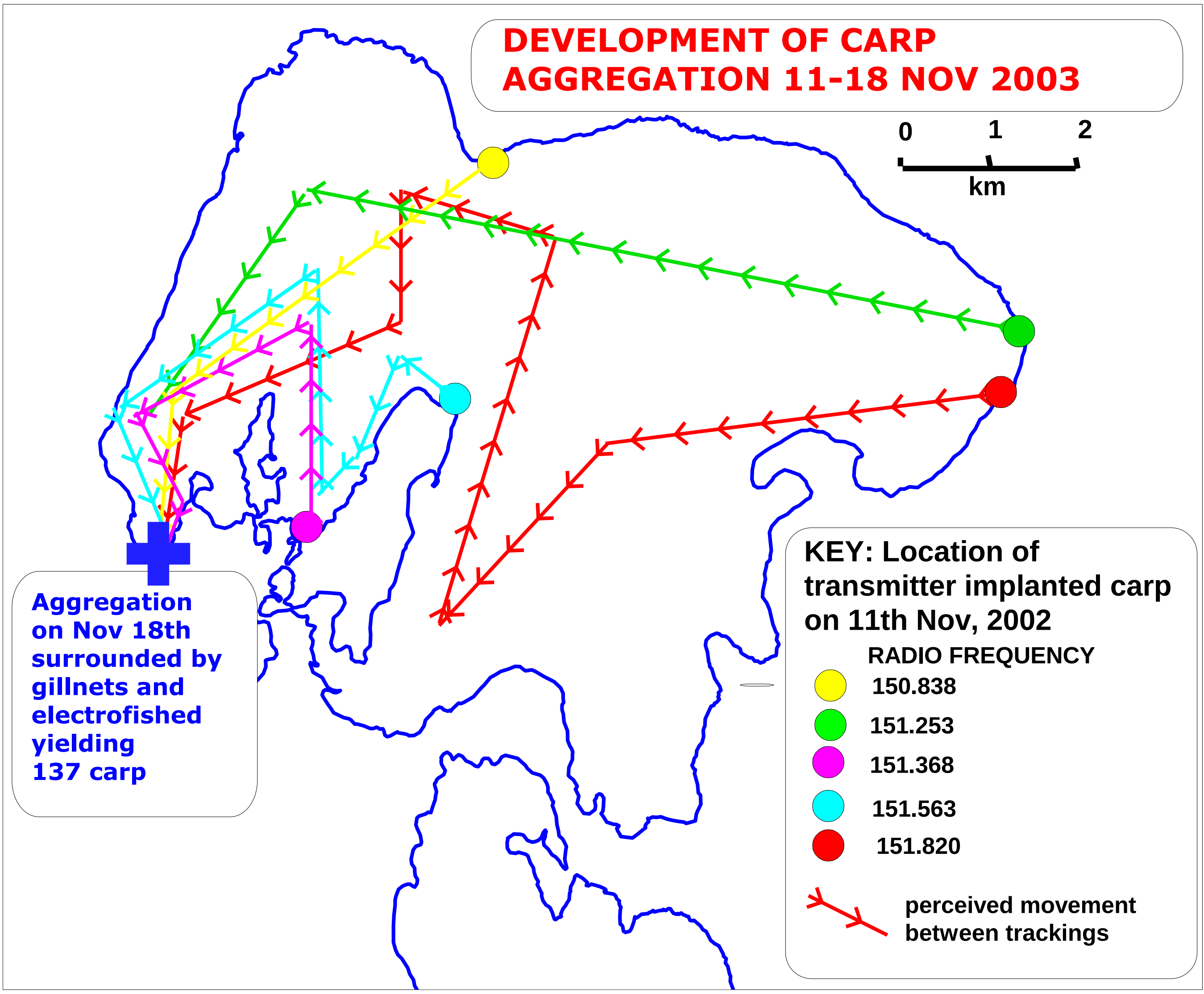


Diagram 1. Development of a carp aggregation in Lake Sorell, 2002

4.0 Surgical Implant Techniques

4.1 Introduction

Surgical implantation of radio transmitters into fish has been carried out on several species: chinook salmon, *Oncorhynchus tshawytscha* (Adams *et al* 1998); coho salmon, *Oncorhynchus kisutch* (Burger 1980); flathead catfish, *Pylodictis olivaris* (Hart and Summerfelt 1975); channel catfish, *Ictalurus punctatus* (Marty and Summerfelt 1986; Summerfelt & Mosier 1984); Colorado squawfish, *Ptychocheilus lucius* (Tyus *et al*. 1984); common carp, *Cyprinus carpio* (Johnsen and Hasler 1977; Berry 1982).

Accordingly, there is much literature describing surgical procedures of radio transmitter implantation. Despite this, several practical refinements to these surgical techniques have been developed during the long-term use of biotelemetry by the CMP.

Most carp are implanted during colder months when water temperatures are low. This is to reduce infection rates after surgery and to ensure that an ample period of recovery time is available before carp attempt to aggregate for spawning purposes. Through 14 years of observation the carp team has concluded that implanted carp return to 'normal' behaviour patterns in a relatively short space of time after successful implantation. The very fact that tracker fish are located in spawning and feeding aggregations only days after implantation supports these observations.

4.2 Surgical Equipment

General surgical equipment includes:

- stainless steel kidney dishes
- stainless steel scissors

- tweezers
- scalpels
- locking and needle nosed forceps
- suture needles
- cotton wool
- ethanol for sterilisation
- sterilised surgical gloves
- cotton gloves for holding the carp in place
- Antibiotics (Engemycen)
- AquiS

All surgical operations were performed in a purpose-built mesh cradle designed to fit over a plastic fish bin. The cradle is a simple wooden frame supporting a cloth mesh (figure 6). During surgery, the bin is filled with water and the cradle is positioned over the bin. The carp is held in an upside down position so that the surgical area is exposed but the head is emersed sufficiently to irrigate the gills. Observation has also shown that holding the carp in an upside down position, with a wet cloth covering its eyes, appears to pacify the carp to some degree. Cotton or neoprene gloves are used to hold the fish during the procedure.

A variety of sutures have been trialed, with varying success. Silk thread with pre-threaded needles proved to be adequate. However, a relatively inexpensive alternative is light (6 lb) mono-filament nylon fishing line. This material is strong, has good knot strength and is equally effective as silk. Dissolving sutures were also trialed but their use was aborted due to a high rate of suture failure. The suture needles determined to be most effective were size 6-8 flat point needles.

4.3 Sterilisation and fish handling procedures

Immediately prior to surgery, all surgical equipment is placed in a kidney dish and emersed in 100% ethanol. Excess ethanol is then decanted and the remaining ethanol and surgical tools “flamed” to remove residual ethanol and augment the sterilisation process. Heat sensitive equipment such as transmitters and sutures are emersed in ethanol and air-dried instead of flamed. In earlier implants, wounds were irrigated with iodine solution (Betadine) which is hypo-allergenic and non-toxic. However, the current consensus amongst operators is that wound irrigation is not necessary, as seepage from bleeding and mucous secretions appears to reduce infection.

Sterile practices are adopted in the field where practical. However, it appears that reducing stress is probably an equally important factor in reducing fish mortality, post-operative infection and the loss of transmitters through ruptured wounds. Keeping holding times to a minimum prior to, during, and after implant surgery is crucial in reducing stress. In earlier procedures, fish were captured and detained for up to a week in a holding pen and transported to shore based facilities for implant when required. Over time, it was recognised that less handling time improved the recovery process and decreased mortality rates. The procedure has been refined to reduce handling, holding and procedural time, therefore reducing overall stress on the carp.

Also important in stress minimisation is ensuring that all equipment is ready for surgery and that the transmitter to be implanted is operational. In addition, the transmitter should be tuned in to the receiver and the serial number recorded to ensure that the fish frequency is recorded correctly.

4.4 Anaesthesia

' AquiS ' is a solution consisting of clove oil and is commonly used as a fish anaesthetic. Prior to surgery, carp are placed in a 20 litre tub of fresh water which has been diluted with AquiS at a rate of 0.3 mg/l. The carp is observed until it is unable to right itself for any period of time and its swimming function is lost. At this point the carp is removed from the anaesthetic and placed on a cradle partly submerged in fresh water ready for surgery. After surgery the carp is placed into a 20 litre tub of aerated fresh water and kept under observation until fully recovered and ready for release.

4.5 Surgical Procedure

Fish chosen as implant recipients are of a size suitable for the transmitter that is to be implanted. The larger the fish the more receptive they appear to holding the transmitter. This is because for successful implantation, it is recommended that fish should not be implanted if the weight of the transmitter is greater than 2% of the actual body weight of the fish when weighed in air (Winter 1979). Prior to implant surgery, if mature the sex of fish is ascertained by gentle hand stripping and the details recorded.

The surgical process requires at least two personnel: one to perform the surgery and another to hold the fish in an inverted position in the cradle. The latter person secures the fish with both gloved hands; one hand around the tail and the other placed around the pectoral girdle whilst ensuring that the gill opercula are not held shut.

When the fish is firmly secured, the incision site is prepared by removing scales along a 50-70 mm line (dependant on size of transmitter) slightly offset on either side of the mid-ventral line, posterior to the pelvic fin and anterior to the anus (see figure 6). Incisions along the mid-ventral line are possible but the risks if cutting the gut or a major blood vessel are high. Abrasion with the substrate and possible infection can also occur if the incision is made at the mid-ventral line.

With a scalpel, the first incision should be shallow without penetrating the inside of the body wall. The length of the cut should be between 30 to 40 mm and just large enough to permit transmitter insertion (refer figure 7).

Using tweezers and grasping one side of the incision, lift the wall away from the gut. This reduces the chance of cutting visceral organs or gonad. Complete the incision through the body wall whilst exercising caution not to sever any viscera. At this stage, the sex of the fish and the stage of gonadal maturation can be established (if uncertain). Under normal circumstances, there will be a small to moderate amount of bleeding. This may be beneficial by irrigating the wound, thus expelling pathogens and promoting the healing process.

Figure 6 Removing scales and making the first incision

Holding the fish firmly with the transmitter aerial trailing posteriorly, push the transmitter into the body cavity. Initially, angle the blunt end down then gently push the end towards the head angling the leading edge outward toward the body wall to avoid disturbing the organs (refer figure 8). Continue until the transmitter lies neatly within the body cavity. To secure the transmitter in place, the antenna is then threaded on to a suture needle and is sewn through the gut wall, exiting through the body wall on the posterior end of the incision. Alternatively, needle nosed forceps can be used to push the aerial through the gut wall with the aid of a very small incision made with a scalpel.

Figure 7 Implanting the transmitter into body cavity

Figure 8 Transmitter being positioned in body cavity

Several 200 mm lengths of mono-filament should be prepared and pre-threaded onto suture needles. Using locking forceps to hold the suture needle, each suture is started about 5 mm on either side of the wound. The needle is passed through the skin and through the muscle, exiting from the side of the incision at about half the thickness of the body wall. The incision is then closed by entering the muscle on the other side of the wound and again, at about half the thickness of the body wall, then out through the skin about 5 mm from the edge of the incision. The suture is then tied off using a standard locking knot.

Figure 9. The implanted transmitter securely sutured and ready for release.

The sutures are repeated about 5-7 mm apart until the wound is sutured completely shut. The tails of each suture should be trimmed back to about 2 mm from the knot. To further identify fish, number-coded T-bar tags that are implanted beside the dorsal fin of each fish. This is useful for two reasons: firstly, fish can be individually identified when recaptured without using the receiver and secondly; if the transmitter is “dropped” and the fish recaptured at a later date, the fish can still be identified.

Prior to release the fish is then injected with the antibiotic oxytetracycline 100mg per kg as long acting formulation via intramuscular injection (10% engimycen) at a rate of 0.1ml/kg of body weight. This will help control infection and assist with transmitter retention

5.0 Discussion

Currently, there are carp eradication and research programs operating in all states of Australia. However in most cases other than Tasmania, biotelemetry is used as a means to monitor movement, range and growth of a carp population (Stuart and Jones 2002). The Tasmanian CMP is unique in that it

uses biotelemetry as a primary tool in the removal of carp during spawning and feeding aggregations.
Radio tracking has also identified certain trends and key habitat areas, which have been frequented by different tracker fish over long periods of time. This information has allowed the carp program to monitor these areas closely and in some cases to build static carp traps.

These traps have captured carp with no direct fishing effort required. In addition to this, large areas of habitat in Lake Sorell have been fenced off due to repeated spawning aggregation attempts. In this case biotelemetry has greatly assisted in identifying these areas. The fencing off of these areas forces future carp aggregations into marginal habitat areas where spawning success will be reduced and aggregations will be more vulnerable to fishing efforts.

The ability to use radio tracking to locate key aggregations of carp and remove a large percentage in one fishing session, has increased fishing efficiency and lowered catch per unit effort markedly. The chance to remove large numbers of carp during these events allows the Carp Management Program team to maximise the use of equipment and personnel at pivotal times rather than trying to spread these resources randomly across an entire season. There certainly exists ambiguity in relation to which fishing efforts are directly related to radio tracking location events or indirectly related to radio tracking trends and patterns observed over time. To adequately illustrate this, it would be useful to examine the direct relationship biotelemetry has on catch effort and fishing efficiency more closely in a separate document.

As the population of carp becomes lower, random fishing techniques over such a large surface area obviously become much less effective. For this reason, the CMP has relied on biotelemetry more heavily as the population of carp is further reduced.

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