An examination of the selectivity of fishing equipment in relation to controlling the common carp (*Cyprinus carpio*) in Lakes Crescent and Sorell.

Technical Report No. 2

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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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Abbreviations

CMT – Carp Management Team

CPUE – Catch Per Unit Effort

TFL – Total Fork Length

IFS – Inland Fisheries Service

Definitions

Biotelemetry	The use of radio telemetry to ascertain the position of male carp which have been implanted with transmitters.
Galvontaxis	Swimming artificially induced by a constant continuous current.
Tetany	State of muscular rigidity
Voltage	The rate at which energy is drawn from a source that produces a flow of electricity in a circuit; expressed in volts
Frequency	The number of occurrences within a given time period
Amplitude	The maximum displacement of a periodic wave

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INTRODUCTION

The physical removal of fish is by far the most popular and successful technique for managing fish populations worldwide. For this reason there is a very large body of empirical and theoretical literature on the effects of removal on fish population dynamics (Thresher 1997). Essential to the success of controlling fish populations by physical removal, is the ability to target fish populations using equipment designed to selectively target specific species.

The selectivity of fishing equipment is governed by the gear itself and also by differences in behaviour between individual fish, differing in age or biological state within the target species (Nikolskii 1969). The efficiency of gear to catch more fish per unit effort are inherent objectives in population control (Jester 1977). A sound knowledge of selectivity is therefore needed to ensure fishing equipment used obtains the maximum yield, while protecting non-target species (Kennedy 1950, Peterson 1954, McCombie 1961, Jensen 1972).

For carp management and population control within lakes Sorell and Crescent, being able to efficiently capture carp within an aggregation or net set, is vital to the overall success of the program. In order to optimise these catches, it is essential to have an understanding of the selectivity of each piece of fishing equipment as well as the habits of the carp at each stage of development.

Initially when carp were discovered in Lake Crescent in 1995, it was impossible to ascertain the number and size range of fish in the population. This meant that the fishing was often random and the efficiency of the equipment used was less than optimal.

Over time, as the carp management team (CMT) captured more fish, they were able to refine their techniques and obtain a better understanding about the number, size range and ages of cohorts being targeted. Now that the population of carp is low (in comparison to 1995), and the approximate numbers and size ranges of fish are well known, the CMT has a good understanding of what fishing equipment is able to best capture fish in a given circumstance.

The one piece of equipment that is essential to the entire carp removal program is biotelemetry or radio tracking. This equipment does not capture fish directly, but is vital in locating individual fish and aggregations of carp.

Biotelemetry provides a means to monitor the location, behaviour and physiology of animals in uncontrolled environments, both terrestrial and aquatic. Biotelemetry 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 CMT has employed the use of biotelemetry technology to identify the movements of carp. A detailed account of radio-tracking equipment and methods employed are outlined in a technical report titled “The use of biotelemetry in controlling carp” (Macdonald 2003).

The use of telemetry can only indicate the presence of the implanted/transmitter fish. However, as these fish are among the largest male specimens in the population, their movements and grouping activity give a good indication of the carp population as a whole. In addition to this, as it is the largest male specimens that are thought to dominate any spawning activity within an aggregation, the exact location of these fish becomes a valuable tool in locating and limiting spawning carp.

In relation the selectivity of the biotelemetry equipment, it is fair to say that it is unselective toward any particular size of fish, but tends to lead the CMT to predominantly large sub-adult and adult specimens. This is simply due to the fact that it is this age range that the large male carp tend to associate with.

This technical report reviews the fishing equipment commonly used by the CMT and discusses its selectivity on the carp as well the situations in which it has proved most effective.

ELECTRO-FISHING EQUIPMENT

The behaviour of a fish in an electric field depends essentially on; the length of the fish's nervous elements; its orientation in the field; the difference in electrical potential between tail and head and the manner of locomotion of the animal concerned (Vibert 1967). Essentially, the electric current acts upon the sensory nerve endings beneath the skin surface and in muscle tissue. When the electric current stimulates these nerves, it causes a reflex/contraction of the muscle fibres which produces movement of the fish toward the anode. This artificially induced swimming is called galvanotaxis.

As the galvanotaxis draws the fish closer to the anode, the fish reaches a threshold that induces a state of unconsciousness where the fish becomes immobile and in a state of muscular rigidity or tetany. At this stage, the fish will either float or sink depending on the species and can be removed from the water easily. Once removed from the electric current or the stimuli turned off, the fish recovers in a short period of time and usually has no long-term effects.

The larger the fish, the more susceptible to electro-fishing it becomes. This is essentially due to its greater body mass in contact with the water and therefore a lower electric current is required to cause galvanotaxis. This suggests that the electro-fishing equipment should have selectivity toward the larger specimens in a population and it is important that this selectivity is understood if the equipment is to be used to its full potential.

In relation to the carp program, the electro-fishing equipment is seen as vital, not only to directly capture carp, but also to drive carp into surrounding nets. The CMT uses two types of electro-fishing equipment, each with a slightly different application and selectivity.

BACKPACK SHOCKERS:

The backpack electro-shockers used by the CMT are Smith-Root (model 12B) units. These units have voltage, frequency and amplitude settings that can be adjusted to suit the conductivity of the water. The CMT uses these backpack units to target carp aggregations behind set nets to either catch the carp directly or drive/frighten the carp into the surrounding nets. As these units are used predominantly on aggregations, both feeding and spawning, the entire size range of the carp come into contact with this method.

Figure 1 shows the size range of the carp caught using backpack electrofishing equipment from 1995 – July 2003. This plot clearly shows the backpack units are not selective toward any particular size of fish, instead they appear to be a useful tool on the carp population as a whole with all but the smallest fish being captured.

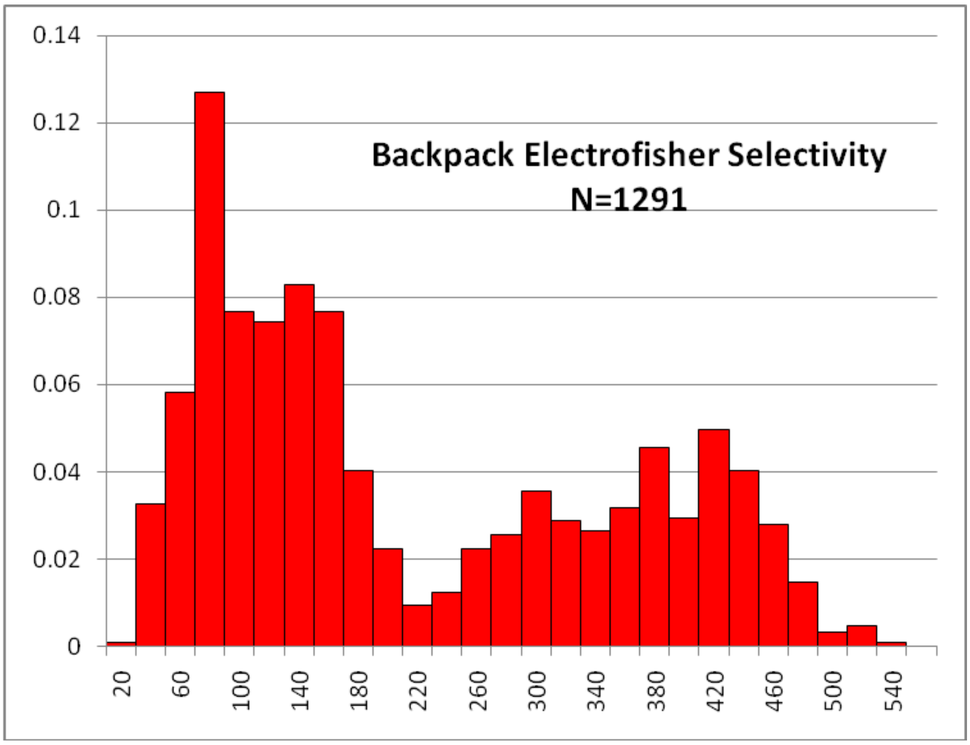

FIGURE 1: Selectivity plots showing all the carp captured in lakes Sorell and Crescent using Backpack electro-shocking equipment from 1995 – July 2011.

Larval sized fish (6-20mm) are poorly represented in figure one due to the fact that the electro-shocking equipment has little effect on this size class. Also, the ability of operators to recognise and collect this size of fish is low and is further compounded by poor water clarity in lakes Sorell and Crescent.

ELECTRO-FISHING BOAT:

The CMT uses a Smith-Root (SR18-EB) electrofishing boat as part of its fishing effort to remove carp from lakes Sorell and Crescent. This boat is capable of fishing in depths over about 30cm.

The electro-fishing boat is used to capture and/or move fish using an electrical field behind set nets usually in deeper water where the use of backpack units is limited. Often in shallow water the use of backpack units is preferred as it enables the operators to place nets close together and intensely fish small areas ensuring an almost 100% efficiency.

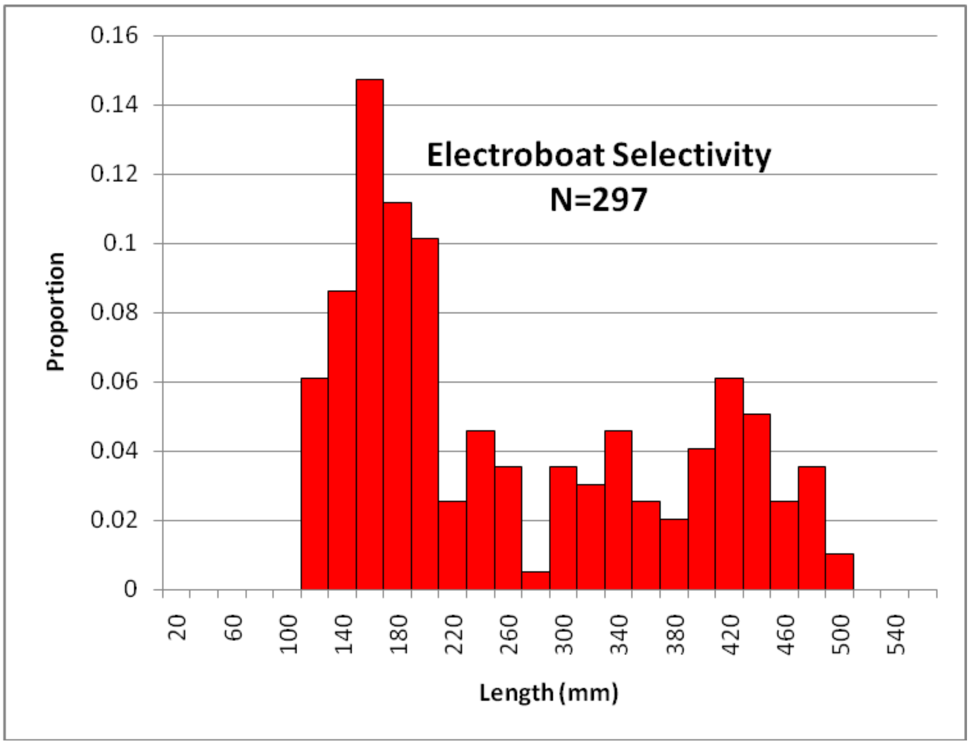

FIGURE 2: Selectivity plots showing all the carp captured in lakes Sorell and Crescent using the electro-boat equipment from 1995 – July 2011.

Figure 2 shows that the selectivity of the electro-boat is toward the juvenile,sub-adult and adult end of the population, with little representation of juveniles below 100mm overall catch. This is due to the electro-boat being used predominantly in deeper water where the current is required to draw the fish toward the anode from depth. Smaller juveniles are usually in the shallow marshes before they disperse. Also, the water clarity/quality in lakes Sorell and Crescent is at times very poor making the spotting and netting of small specimens difficult. The chances of missing these fish is much greater than larger fish.

GILL NETS

Gillnets are widely used as a research tool to sample fish populations, but they are highly selective. Baranov (1948) states that in general; few fish are caught whose length differs from the optimum by more than 20%.

Clark (1960) listed as factors most important to gillnet selectivity; mesh size, elastic stretching of the net (including knot stretching), strength and flexibility of the twine, visibility of the twine, shape of the fish and degree to which fish are meshed at parts of the body other than the pectoral area.

The gill nets used by the CMT for eradication efforts on carp, range in mesh size from 2.5 – 6 inches (6.35 – 17.78cm). The nets are all made from monofilament mesh (line 5 – 0.37mm) hung on 7mm blue polypropylene rope with lead net weights. The drops on these nets range from 12 mesh depth to 32 mesh depth.

When carp were first discovered in lakes Sorell and Crescent, the CMT had little information of what size range of fish existed or what mesh-sized nets should be fished for the optimum CPUE. Initially, mesh sizes ranged from 2.5" to 7”, however, setting this size range of nets (often randomly) was labour intensive and often did not adequately target the range of fish in the population. Now that the CMT has more information about the remaining population, the number of nets and mesh sizes fished can be optimised to those that give the best chance of catching the remaining carp.

Barnov (1914 – as cited in Hamley 1975) recognised that fish mesh into the nets in three main ways. They can be wedged – held tightly by the mesh around the body, gilled – prevented from backing out of the net by a mesh caught behind the operculum, or tangled – held by projections, usually spines in the mesh. This piece of information is important as it suggests that a gillnet may catch a few carp outside the optimum range for that net, through tangling of the dorsal spine. However these can be potentially discounted when looking at selectivity of the nets as these captures are more by chance than correct gear selection.

Figure 3 shows the selectivity of the 2.5” (6.35cm) gillnets. This mesh size is only fished once a new cohort of juvenile fish has been discovered. Figure three shows that the 2.5” mesh selects carp mainly between 120mm – 240mm total fork length (FL).

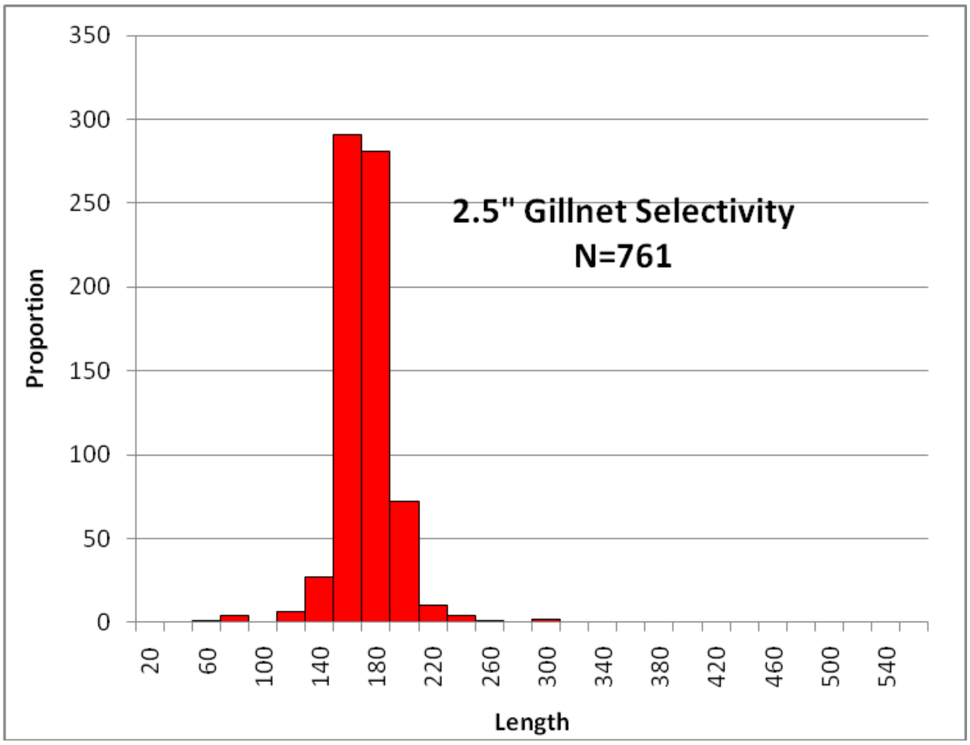

FIGURE 3: Selectivity plots showing all the carp captured in lakes Sorell and Crescent using 2.5” Gillnets from 1995 – July 2011.

The 3” (7.62cm) gillnets have a selectivity that overlaps neatly with the 2.5” nets. Figure four shows that the 3” nets have selectivity that catches fish between 170mm - 330mm FL. As with the 2.5” mesh, the CMT has found the use of fyke nets, seine nets and electrofishing equipment has a better CPUE than the 3” gillnets. It has been found however, that carp of this size range tend to remain in schools away from the adult population. This can make them difficult to locate using the methods employed. However, when they are found, the catch rates are usually high.

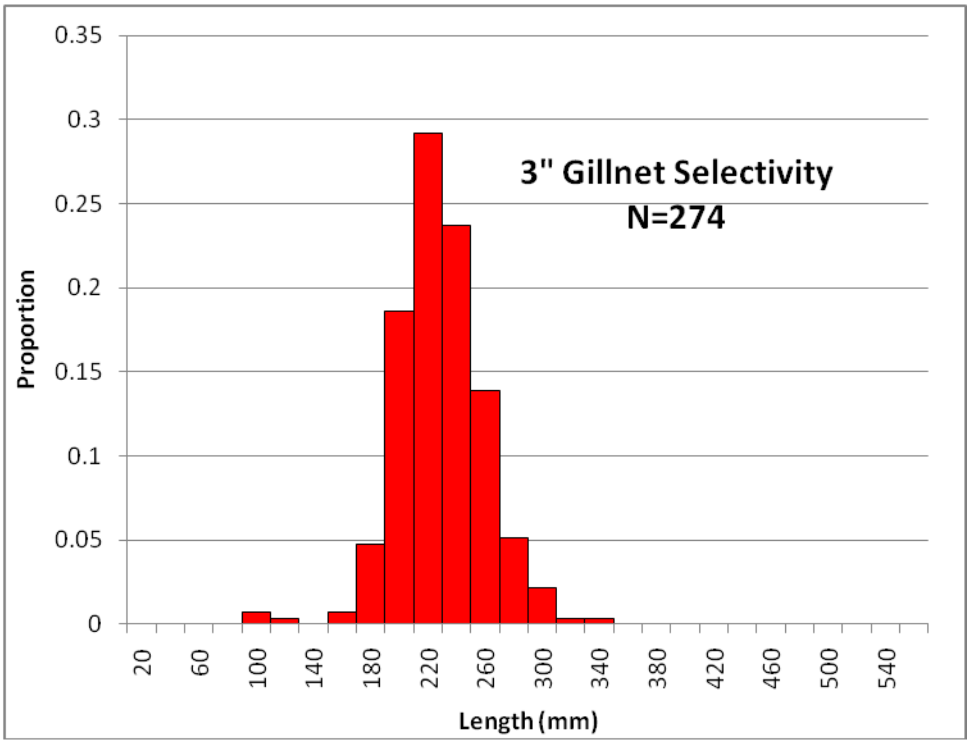

FIGURE 4: Selectivity plots showing all the carp captured in lakes Sorell and Crescent using 3" Gillnets from 1995 – July 2011.

The most efficient nets used by the CMT for catching carp are the 4", 5" and 6" mesh sizes. This is due to the fact that the carp in lakes Sorell and Crescent grow into the 4" (10.16cm) mesh category by the time they are 2.5 – 3 years of age and are still being taken by the 6" (15.24cm) mesh when they are greater than 10 years old. The reason for this is that initially, juvenile fish put all their energy into rapid growth, but by the time they are three years old they begin to develop gonad and growth rate slows significantly. A technical report examining the age and growth rates of carp has been produced by Donkers (2003) and details the variable growth rates and maturity rates of carp in lakes Sorell and Crescent.

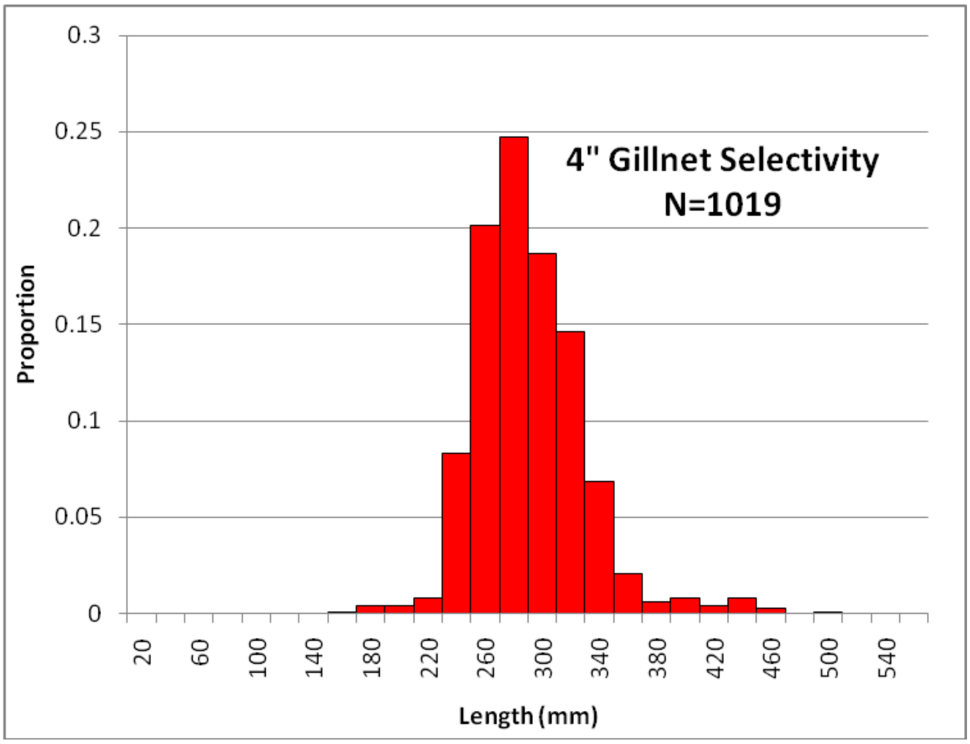

FIGURE 5: Selectivity plots showing all the carp captured in lakes Sorell and Crescent using 4” Gillnets from 1995 – July 2011.

Figure 5 shows the selectivity of the 4” (10.16cm) mesh gillnets. This plot suggests that these nets select for fish between 160mm FL and 460mm FL. The plot also shows that although the net can catch a wide size range of fish, the mesh significantly favours (>95% of total catch) fish between 220mm and 360mm.

Compared to 2.5” and 3” mesh size, 4” has a significantly higher CPUE. The reason for this is due to the fact that fish of this size begin to associate with the adult population on a regular basis and are therefore more susceptible to fishing methods utilising the tracking equipment. Additionally, when carp were discovered in 1995 the vast majority of fish in the population were large sub-adult and adult specimens, biasing the catch rates toward the larger sizes.

Figure 6 shows the selectivity of the 5” (12.7cm) mesh gillnets and clearly shows that these nets select fish between 260mm FL and 500mm FL. The number of fish caught in the 5” mesh is relatively high at 1833 fish. The reasons for this are the same as outlined for the 4” mesh nets above.

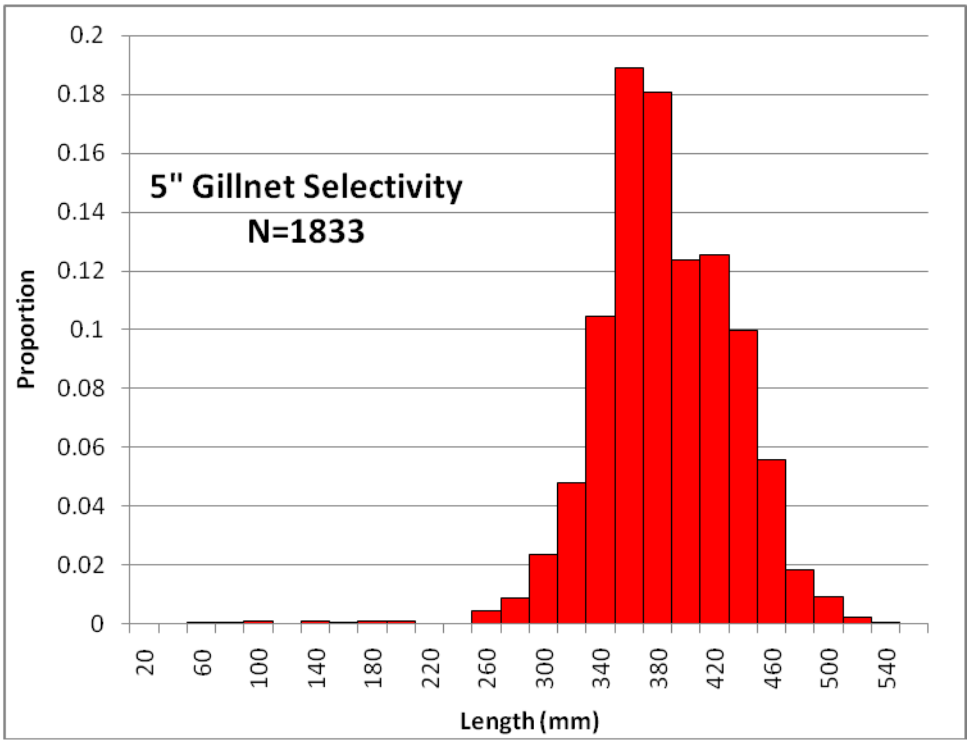

FIGURE 6: Selectivity plots showing all the carp captured in lakes Sorell and Crescent using 5" Gillnets from 1995 – July 2011.

Figure 7 shows the selectivity plot for 6" (15.24cm) mesh nets in lake Sorell and Crescent between 1995 and July 2003. This plot indicates that greater than 70% of the nets catch has been fish between 400mm and 460mm FL.

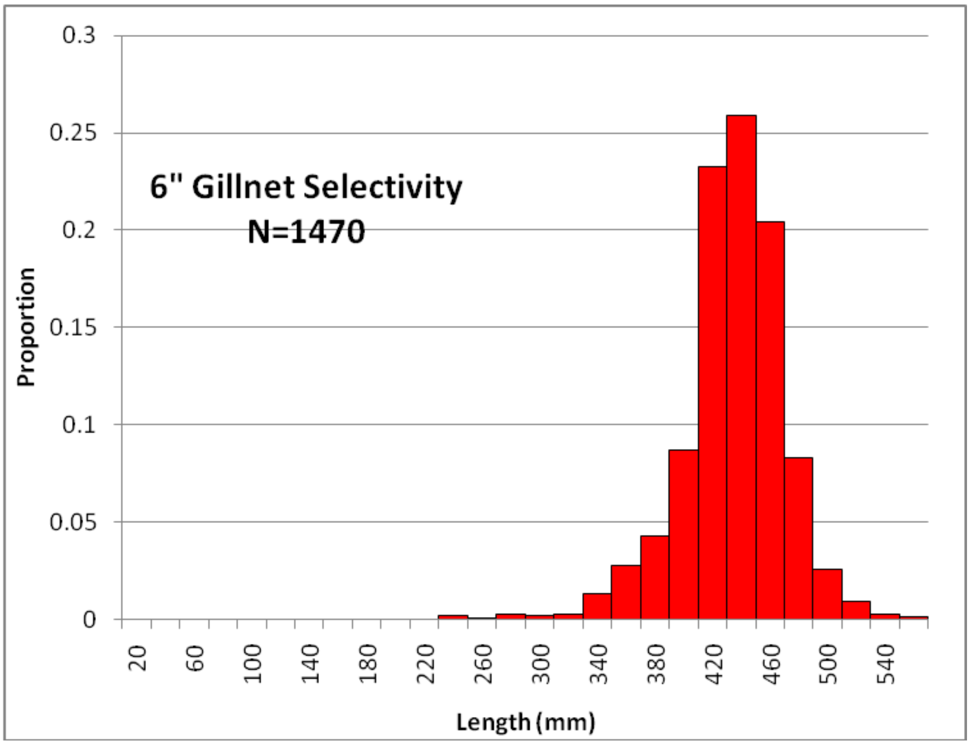

FIGURE 7: Selectivity plots showing all the carp captured in lakes Sorell and Crescent using 6" Gillnets from 1995 – July 2011.

This range is relatively narrow when compared to the other net sizes used. However, if both the 5” and 6” nets are compared, the reason becomes clearer. The selectivity overlap between these two mesh sizes is large with the size ranges being 260 - 500mm (5” mesh) and 360 - 520mm for the 6” mesh.

Considering these two mesh sizes are often set in combination around an aggregation (6” on the inside and 5” on the outside) and the area thoroughly electro-fished, it is clear that the vast majority of sub-adult and adult fish will be susceptible to entanglement.

FYKE NETS

Fyke nets are a valuable tool in surveying the carp population for juvenile specimens. In general, juvenile fish will not associate with adults for extended periods until they are in their third year. Prior to this, they are thought to remain schooled up away from the adult population, usually in deep water. This makes any juvenile fish inaccessible to the fishing efforts for the majority of time.

The CMT has found that schools of juvenile fish do often move into shallow water overnight to feed. It is these shallow-water feeding activities that are targeted with fyke nets.

Fyke nets are the only net type that is able to be left unattended, as they pose minimal risk to other non target species. Fish that come into contact with the net wing (a fine mesh cotton net), are not caught in it as they are with gillnets, but instead forced to move along the net to try and move around the structure. On the end of the net is a tapering cylindrical structure that contains a series of funnels, so once fish enter they cannot get back out. The cod-end of this cylinder is fitted with a polystyrene buoy and is raised on a stake 300mm out of the water. This is so platypus or other animals (eg. native hens, water rats) that enter the net can get access to air and are not drowned during the survey. The buoy acts as a backup to the stake being blown or washed over, by keeping the cod-end above the water surface.

Fyke nets are set in multiple teams of up to six nets usually starting in the shallows and set at right angles to the shore. The wings of each net are positioned to slightly overlap the net in front, there by creating a single wall out from shore with up to five cylindrical funnel traps throughout.

A second type of fyke net has two wings, one either side of the cylindrical funnel. The CMT uses these nets as part of its surveys but have found that they do not have a better catch rate than single winged fykes. For the purposes of this report, both types of fyke net have been considered together as they are composed of the same materials and do not have a difference in selectivity. However, it must be noted that double wing fyke nets are more suitable for use in drains and canal situations where longer wing length and directional trapping focus can be of benefit.

Figure 8 shows the selectivity plot for the fyke nets used as part of the carp eradication efforts in lakes Sorell and Crescent. These nets are used on an annual basis, for one week every month from October to January each year. One lake is surveyed for a week period and the following week the other lake is surveyed. The CMT try and keep the number of nets as well as their placement in the lakes the same each month, as a means of control to the surveys. Fyke nets are set in all habitat areas in an attempt to cover a cross section of the habitat available to the juvenile fish.

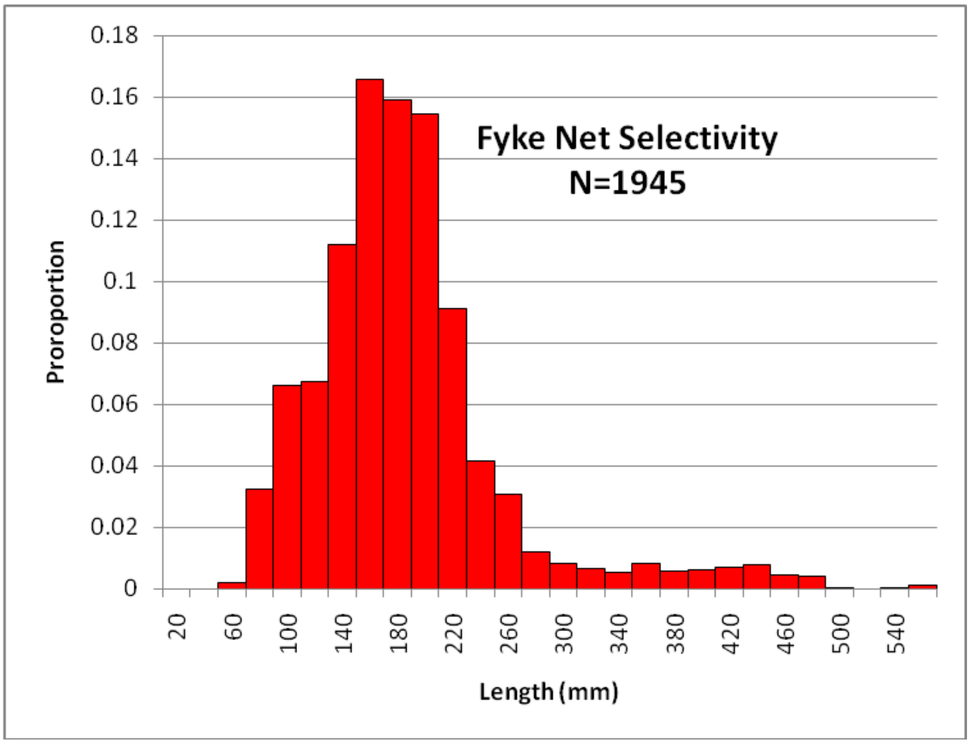

FIGURE 8: Selectivity plots showing all the carp captured in lakes Sorell and Crescent using fyke nets from 1995 – July 2011.

Figure 8 shows that the fyke nets do not have distinct size selectivity, instead catching nearly all sizes of fish in the population. The plots do show however, that fykes tend to favour smaller fish which are difficult to catch using other methods. This is probably due to the fact that fyke nets provide a dark sheltered area for juvenile fish to hide, as well as the fact that these small carp are schooling and tend to be caught in large numbers when they come into contact with fyke nets.

SEINE NETTING:

Seine nets used by the CMT are 100m long and have 9 ply cotton rope mesh attached to a top and bottom rope. The mesh ranges in size from 30mm to 50mm depending on the fish being targeted. The nets are fished using two long ropes attached to each end of the seine. Stainless steel rings attached to the bottom of the net assist in keeping the net close to the bottom and prevents the net rolling up on obstructions. The net is waded or paddled out from shore around the intended fishing area and back to shore. The ropes are then pulled in a slow and continuous manner.

Seine nets are used to sweep large areas of shore and remove carp inside the net. This is only possible in areas where the shore is uniform and few rocks, sticks and other snags are present. In lakes Sorell and Crescent there are only a few areas where the use of seine nets is possible. These areas are the sandy beach shores in both lakes as well as the silty marsh areas in Lake Crescent when lake-levels are low.

If an aggregation is identified, gillnets are initially deployed to contain the aggregation. A seine net is then used inside these gill nets to sweep the area and remove any fish on the inside of the net. Seine nets are used in these areas only when an aggregation occurs or tracker fish show a tendency to remain in the area over an extended period of time.

Figure 9 shows the selectivity plot for the seine nets in both lakes. This plot clearly shows that seine nets are not selective toward any size of fish. There are however, three distinct peaks at about 100mm and again at 350mm and 450mm FL.

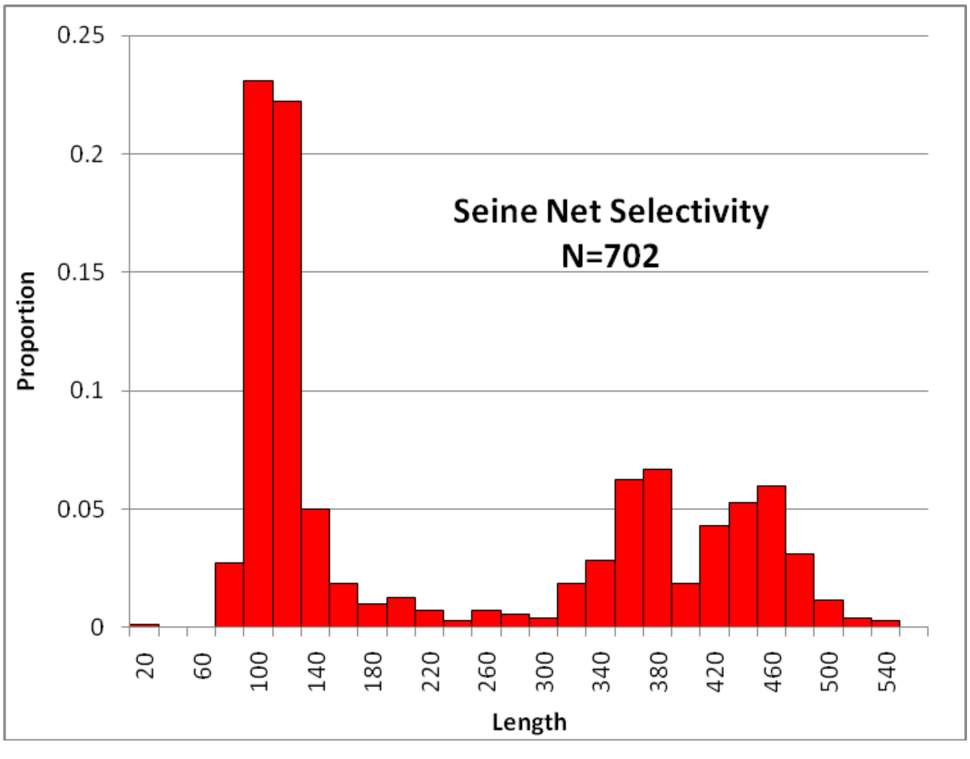

FIGURE 9: Selectivity plots showing all the carp captured in lakes Sorell and Crescent using seine net hauls from 1995 – July 2011.

This pattern is not due to net selectivity but instead is a function of when the CMT choose to use the net, and what size fish are being targeted. The large peak at around 100mm FL is when the CMT targeted juvenile carp that were aggregated in Duck Bay (where they were spawned) prior to these fish dispersing into the lake itself. The other major grouping of fish was a spawning aggregation in Lake Crescent where the size range of fish were limited to spawning adult fish, hence the perceived gap in the 150 – 300mm size range. The seine net by its construction will remove all fish present, providing the fish cannot get under, over or around the net.

DISCUSSION

In order to eradicate carp from lakes Sorell and Crescent a good understanding of the carp population dynamics and structure within the two lakes is required. In addition to this it is essential that when an opportunity arises to target a carp aggregation, whether it be feeding or spawning, that the correct equipment is deployed and a high catch rate be secured. It is essential therefore to have a good understanding of the selectivity of each piece of fishing equipment used.

Obviously the gillnets are highly selective in the size range of fish that each mesh will capture. Given that the carp population in each lake is now low and the CMT have a good understanding of the remaining cohorts, their approximate numbers and size, the CMT can ensure the correct gill nets are carried and deployed at each aggregation. When the correct mesh size gillnets are combined with non-selective techniques such as boat or backpack electro-fishing the result is a high percentage of aggregated fish being captured.

Given the range and quantity of fishing equipment utilised by the CMT, it is not possible to have all gear out on the water at any one time. It is an important skill therefore to predict what is likely to be encountered on a daily basis and make sure the correct equipment is carried. This is not always possible, however with years of experience within the team in catching carp the knowledge base ensures that the majority of situations can be effectively handled.

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