

Brown bullhead catfish (*Ameiurus nebulosus*) in Lake Taupo

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ABSTRACT

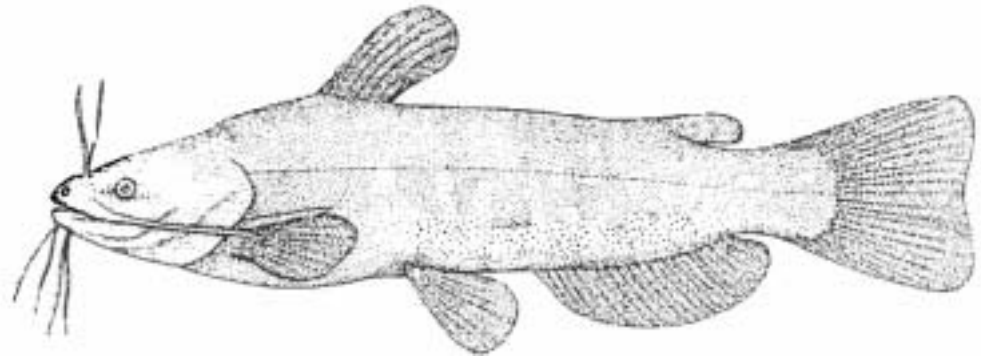
Brown bullhead catfish (*Ameiurus nebulosus*) were first discovered in Lake Taupo during the early 1980s and are believed to have originated from an illegal liberation into the southern end of the lake. A native of the southern and eastern states of America, these catfish have been in New Zealand since 1878 and are now widespread throughout the Waikato region. In 1995 the population structure, abundance, age, growth rate and diet of catfish in the littoral zone (<5 m deep) of Lake Taupo were examined by setting fyke nets overnight in three different habitat types. A total of 6247 catfish was caught from 269 fyke-net sets (mean CPUE 23 fish net⁻¹ night⁻¹). Catfish abundance was greatest in shallow, sheltered, macrophyte-dominated bays, where the population was skewed towards small catfish (<150 mm FL). Adjacent rocky headlands and escarpments supported populations of large fish (>150 mm FL) and small fish. Low numbers of catfish across all size classes were caught from exposed sandy sites. The diet of catfish was size and habitat dependent. Small catfish (<150 mm FL) fed predominantly on chironomids, Cladocera, gastropods, caddisfly larvae, plant material and detritus. Larger catfish were found to prey to a greater extent on koura (*Paranephrops planifrons*), fish and terrestrial invertebrates.

Keywords: brown bullhead catfish, catch rates, distribution, diet, Lake Taupo

1. INTRODUCTION

Brown bullhead catfish (hereafter catfish) are easily distinguished from other freshwater fish species in New Zealand by the presence of eight whisker-like barbels around the mouth and rigid spines in the dorsal and pectoral fins (McDowall 1990) (Fig. 1). Catfish are a thick-bodied fish with a broad, sloping, dorso-ventrally flattened head. The eyes are extremely small relative to body size (Scott & Crossman 1973), and the scaleless skin is dark brown to greenish olive, but paler on the sides and abdomen (McDowall 1990).

Figure 1. Brown bullhead catfish (*Ameiurus nebulosus*). FL = 330 mm (McDowall 1990).



In their native range, catfish occupy lakes and sluggish streams with muddy or weedy beds. Catfish are tolerant of a wide range of environmental conditions that may be limiting for other fish species, and can survive temperatures as high as 36°C and oxygen levels as low as 0.2 ppm (Scott & Crossman 1973). Though catfish normally reach a maximum length of 300–350 mm long, some may reach up to 500 mm in length and more than 3 kg in weight (Scott & Crossman 1973). In the Waikato region of New Zealand most catfish were 1–5 years old, but some reached up to 8 years of age (Patchell 1981).

Catfish are opportunistic generalists, feeding nocturnally on or near the bottom. The young feed mostly on chironomid larvae, cladocerans and amphipods (Scott & Crossman 1973). The adults are omnivorous with a diet composed of detritus, molluscs, invertebrate larvae, terrestrial insects, leeches, crustaceans, worms, plant material, fish and fish eggs (McDowall 1990).

The catfish in New Zealand originated from fresh and brackish waters in North America, where their native range is east of the Rocky Mountains from southern Canada to Central America. They have been extensively introduced throughout the United States and are now well established as far east as California (McGammon & Seeley 1961; Sinnot & Ringler 1987). Catfish were released into Germany in the early 1900s and have been widely moved from there to many other European countries, including England and the former Soviet Union (Scott & Crossman 1973).

Catfish were released into New Zealand in 1877, and the first consignment of 140 live catfish were released into St Johns Lake, Auckland (McDowall 1990). Since that first release, catfish have been distributed intentionally and accidentally into many lakes and rivers of the North Island. Catfish are now widespread throughout the Waikato River catchment, occurring as far upstream as Lake Aratiatia. More recently, catfish have become naturalised in Lake Taupo, where they are concentrated around the southern bays of the lake.

Catfish are thought to have been in Lake Taupo since approximately 1980, although their presence was not documented until 1985 when an initial survey of Motuoapa Bay was undertaken by the Wildlife Service of the Department of Internal Affairs (Fechney 1986). In 1995 the Department of Conservation funded a study of the biology and general ecology of catfish in Lake Taupo, and their potential effects on the trout fishery. This study evaluated spatial and seasonal feeding behaviour of catfish, their abundance, fecundity, growth and habitat use—primarily within the southern bays of Lake Taupo (Barnes 1996a).

2. STUDY AREA

Lake Taupo is a large (623 km²), deep (mean depth 97 m, maximum 164 m), steep sided, oligotrophic lake in the centre of the North Island of New Zealand (38°44´S, 175°55´E). It is a large caldera formed from multiple eruptions of the Taupo volcano since the early Pleistocene (Grange 1937). Lake Taupo is warm and monomictic, stratifying between November and May to a minimum depth of 25–35 m (Hutchinson 1957; Vincent & Forsyth 1983). Peak phytoplankton biomass is during winter (Jolly 1968; Viner & White 1987) with low nutrient concentrations limiting phytoplankton growth during summer (Vincent & Forsyth 1983).

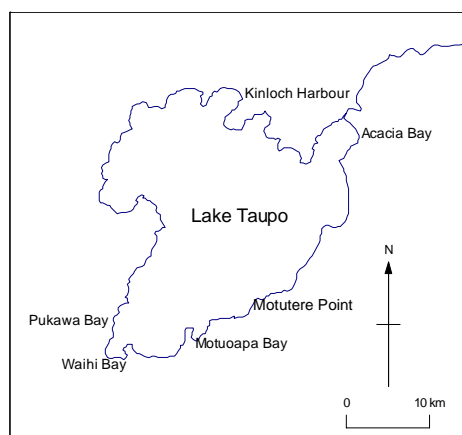
The shoreline of Lake Taupo is characterised by rocky cliffs and escarpments and extensive areas of exposed sandy beaches. Only 7% of Lake Taupo's total area provides suitable conditions within the depths to which macrophytes can grow (Rae et al. 2000), and it has been estimated that only 37% of this suitable area has actually been colonised (Howard-Williams & Vincent 1983). Introduced weeds (*Lagarosiphon major* and *Ceratophyllum demersum*) dominate the macrophyte community, with remnant native communities consisting of *Myriophyllum triphyllum*, *Isoetes kirkii*, *Ruppia polycarpa*, *Potamogeton ochreatus* and *P. cheesmanii* (Howard-Williams & Vincent 1983).

The indigenous fish fauna of Lake Taupo is depauperate, and consists of koaro (*Galaxias brevipinnis*) and common bully (*Gobiomorphus cotidianus*). Common smelt (*Retropinna retropinna*) were introduced to the lake as forage fish for rainbow trout (*Oncorhynchus mykiss*; Stephens 1983). Brown trout (*Salmo trutta*) and goldfish (*Carassius auratus*) are present in addition to catfish.

3. METHODS

The principal sampling sites were located at Motuoapa, Pukawa and Waihi Bays in the southern part of Lake Taupo (Fig. 2). Additional sites used to determine the distribution of catfish were located at Acacia Bay, Motutere Point and Kinloch Harbour. From each principal site three sub-sites were chosen corresponding to a dominant habitat type of sandy, rocky, or weedy bottom (Barnes 1996a).

Figure 2. Location of the sampling sites in Lake Taupo, North Island, New Zealand.



Fishing for catfish was carried out seasonally from February 1995 to December 1995 (Barnes 1996a). Sampling in each season was conducted over four nights during which four fyke nets were set at each different habitat type, just prior to dusk, and left to fish overnight. Each fyke net comprised 25-mm stretched mesh and three interconnected funnels, with a total length of 6 m, including a 4-m-long wing extending

from the net mouth. The nets were set within 200 m of the lake edge in water less than 5 m deep.

All fish captured were weighed to the nearest 0.1 g, fork length (FL) was measured to the nearest mm and sex was determined. The stomachs of every tenth fish were retained for dietary analysis. Gonads and vertebrae of some fish were retained for fecundity and age analysis, respectively.

4. RESULTS

A total of 6247 catfish were caught from 269 fyke nets set within the principal sites combined, equating to a mean catch per unit effort (CPUE) of 23 fish net⁻¹ night⁻¹ ± 95% confidence interval. Catch rate varied by habitat and season (Table 1). Mean CPUE in rocky sites increased from 5.5 fish net⁻¹ night⁻¹ in late summer to 44 fish net⁻¹ night⁻¹ in winter. In weedy sites, mean CPUE decreased between summer and winter, with catch rates peaking at 92.1 fish.net⁻¹.night⁻¹ in December. During this sampling, one net alone captured 639 catfish (Fig. 3). Catch rates at sandy sites were consistently low with no catfish caught at either site sampled during winter. Waihi Bay accounted for the largest catches amongst the weedy sites sampled, with a spring mean CPUE six times higher than that at Pukawa or Motuoapa Bays. Motuoapa Headland was the most productive rocky site sampled.

Small catfish (<130 mm FL) dominated the catfish population numerically at all weedy sites sampled. In Motuoapa and Waihi Bays, age 2 fish (110–130 mm FL)

TABLE 1. CATCH RATES OF CATFISH CAUGHT AT WEEDY, ROCKY AND SANDY SITES BETWEEN FEBRUARY AND DECEMBER 1995. (–,nets not set.)

SITE TYPE	MEAN CATCH PER UNIT EFFORT (FISH NET ⁻¹ NIGHT ⁻¹)				
	LATE SUMMER	AUTUMN	WINTER	SPRING	EARLY SUMMER
Weedy	19.6	26.9	6.0	22.6	92.1
Rocky	5.5	39.0	44.0	23.5	34.3
Sandy	2.0	0.8	0.0	3.0	–

Figure 3. Two fyke nets containing 10% of the catfish caught during the study.



made up 70% of the fish caught. Conversely, the range of size classes encountered at the rocky sites was generally even with no obvious mode, except during winter and spring at Motuoapa Headland when age 2 catfish were numerically dominant.

The abundance of catfish in the northern sites was low with a total of 27 fish caught from 39 nets set. Two fish were caught from Acacia Bay, 11 at Motutere and 14 at Kinloch Harbour, resulting in a mean CPUE of 0.15, 0.84 and 1.08 fish net⁻¹ night⁻¹, respectively.

Catfish at both rocky and weedy sites appeared to be opportunistic omnivores, with the dominant food items reflecting relative prey abundance. Indicative of this indiscriminate feeding were the stomach contents of a catfish caught in Waihi Bay, which contained a chicken thigh bone, potatoes, peas and carrots.

Caddisfly larvae were the most abundant food item in small catfish (<150 mm FL) from weedy sites, followed by the gastropods *Physastra* sp., *Potamopyrgus* sp., *Lymnaea* sp., *Sphaerium* sp. and *Gyraulus* sp., chironomids, and cladocerans (*Simocephalus* sp.) in relatively equal amounts (Table 2). No fish, koura (*Paranephrops planifrons*), dragonfly larvae, detritus or plant material was found from stomachs sampled.

In large catfish (>250 mm FL) sampled from weedy sites a greater range of food items were found. Gastropods were a similar percentage of total food items to that found in small catfish, but there were fewer caddisfly larvae and chironomids and no cladocerans. In contrast to small catfish, common bullies and koura were 9% and 15%, respectively, of the diets of large catfish from weedy sites. Plant material and detritus were a significant component of the diet of large catfish in weedy sites, occurring in 23% of stomachs sampled.

The diet of catfish from rocky habitats was similar to that of catfish sampled from weedy sites. Apart from the absence of cladocerans, the stomachs of small catfish (<150 mm FL) contained a similar percentage of food items to that observed for catfish of a similar size from weedy sites. Koura occurred in 64% of the stomachs of the large catfish (>250 mm FL) from rocky sites. As observed in

TABLE 2. PROPORTION OF STOMACHS ANALYSED CONTAINING ONE OR MORE PREY TAXA IN CATFISH OF TWO SIZE CLASSES, CAUGHT IN LAKE TAUPO BETWEEN FEBRUARY AND AUGUST 1995.

Figures expressed as a percentage of all stomachs containing one or more food items. (–, prey items not found.)

PREY ITEM	PERCENTAGE OF STOMACHS CONTAINING ONE OR MORE FOODS			
	WEEDY BOTTOM		ROCKY BOTTOM	
	50–149 mm	>250 mm	50–149 mm	>250 mm
Snails	27	25	13	12
Damselfly larvae	–	13	–	4
Caddisfly larvae	30	7	36	–
Zooplankton	15	–	–	–
Chironomid larvae	24	8	23	4
Koura	–	15	4	64
Fish	3	9	–	8
Detritus	–	12	4	2
Plant material	1	11	18	6

weedy sites, common bully were found in 8% of stomachs from large catfish. Surprisingly, considering the low plant abundance around rocky sites, plant material was found in the stomachs of 18% of small catfish and 6% of large catfish from rocky habitats.

Though no direct observations of nest building were observed during the present study, ovarian development suggested that spawning occurred between September and December, a time of high catfish density in the weedy areas of Motuoapa and Waihi Bays. Motuoapa and Waihi Bays therefore may provide important juvenile rearing habitat.

5. DISCUSSION

Different ecological and physical site characteristics appear to account for the variations in catfish abundance around Lake Taupo. Catfish were most abundant in rocky and weedy habitats and least abundant at exposed sandy sites. Rocky and weedy areas are likely to provide sheltered refuge (during Taupo's frequent strong wind events), protective juvenile rearing habitat, abundant food supplies and a habitat type similar to that occupied by brown bullheads in their native range. Catfish density was seasonally variable both within and between habitats, probably because of their largely gregarious behaviour.

The shoreline of Lake Taupo is characterised by cliffs (c. 25%) and sandy, exposed beaches (Lister 1978). Areas that support dense macrophytes are restricted to the southern and northern bays of the lake. Catfish are known to invest considerable time and energy in nest building and guarding and manipulation of eggs, larvae and juveniles (Stranahan 1910; Blumer 1986). Blumer (1985) found male catfish to be aggressively territorial while guarding the nest from predators and other catfish. This territorial nature may limit the total number of nesting adults within prime nesting habitat and thus the availability of sheltered, macrophyte-dominated areas within Lake Taupo may be a limiting factor determining total catfish population.

A comparison was made of length frequency data from Lake Taupo with other studies within New Zealand (Patchell 1977; Fechny 1986; Kane 1995). The size of catfish from the Waikato River Basin was normally distributed and dominated by large individuals within a single mode (250 mm FL). Catfish in Hamilton Lake in 1993–94 had a similar size distribution, with a population dominated by large individuals with low numbers of juvenile fish (Kane 1995). This is in contrast to the littoral of Lake Taupo that was numerically dominated by small catfish (<130 mm FL). The dominance of catfish populations in Lake Taupo by small individuals was similarly observed in Waikato drains (Bannon 2001).

The relatively small size of catfish in our study suggests several testable hypotheses. First, Lake Taupo may not support catfish of large sizes, though this seems unlikely. Secondly, the population may have been undergoing a rapid expansion, characterised by high survival of small catfish that then migrate and expand their range within the lake. Recent work by Dedual (pers. comm.) has shown little further expansion of the area occupied by catfish which suggests that this is also unlikely. Thirdly, our study may have focused too narrowly on the shallow areas that were primarily used as rearing areas by small fish, with

larger catfish occupying deeper areas that we did not sample. Considering Dedual's findings of diel vertical migrations, and migrations from deeper regions to the littoral zone, this hypothesis seems the most likely.

Earlier lines of evidence indicated that catfish in Lake Taupo are recent arrivals, still spreading throughout the lake. Keen (1981) hypothesised that in established stable populations, large body size might be an important factor controlling recruitment of juvenile fish, as adults efficiently exploit limited food resources. Consistently low capture rates of juvenile fish in the Waikato River Basin and Hamilton Lake may be consistent with Johnson's (1994) theory that in unexploited populations, length-frequency distributions of stable fish populations indicate an almost complete absence of young fish which results from the dominance conferred by large individuals. In an exploited or recently established population such as Lake Taupo, where large individuals are absent or low numbers exist, a population dominated by juvenile fish is expected. This could support the alternative views that the catfish population within Lake Taupo is either still spreading into new habitat or that sheltered, macrophyte-dominant areas are important juvenile rearing sites.

Catfish were more abundant in the southern bays of Lake Taupo than in the exposed eastern shores and northern harbours, which again could indicate a population still increasing its range. Kinloch Harbour and other bays along the northern portion of Lake Taupo provide shelter from the prevailing wind and support considerable beds of aquatic macrophytes, providing seemingly ideal catfish habitat. However, more intensive sampling of this area is recommended before strong conclusions are drawn regarding catfish population dynamics in the northern parts of Lake Taupo.

Catfish are generally considered obligate omnivores (Scott & Crossman 1973), often consuming the most abundant prey encountered (Barnes 1996b). The size-related diet change, from preying principally on small abundant food items to consuming larger, energetically more rewarding prey, is indicative of an adaptive feeding strategy and is likely to be an important influence on the maximum size obtained by catfish in Lake Taupo.

There is potential for direct competition between large catfish and large rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*). Large trout of both species are known to consume greater proportions of common bully and koura than juvenile trout. Koura were found in 50% of stomachs sampled in large rainbow trout (>550 mm FL) in Lake Taupo (Stephens 1983). Brown trout are a known predator that occupy the littoral zone in Lake Taupo and eat common bully and koura. Catfish greater than 250 mm FL consume a high proportion of koura and therefore could be in direct competition with both rainbow trout and brown trout. However, this is considered unlikely for rainbow trout given their largely pelagic feeding behaviour.

6. CONCLUSION

The large abundance of catfish within weedy and rocky areas of the sheltered southern bays in Lake Taupo suggests these areas are important habitats for juvenile catfish and to a lesser extent, large adult catfish. The limited areas where macrophytes are able to establish within the lake may be an important factor controlling the reproductive potential of catfish, preventing the population from reaching high levels throughout the lake. There appears to be potential for the catfish population to increase within the northern bays of Lake Taupo in areas such as Kinloch Harbour, where the population appeared to be relatively low despite ideal habitat.

The diet of catfish was related to size and habitat, with the diet of small fish generally consisting of different prey items to that of large catfish. The size-related diet change observed in large catfish may impact on the biomass of koura and common bullies if the present catfish population increased to an extent where those prey items became limiting. Although this is considered unlikely, further research is required to determine if it is possible and, if so, what the possible impacts on the rainbow trout and brown trout populations within the lake are.

7. ACKNOWLEDGEMENTS

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