GREAT LAKES FISHERY COMMISSION

Project Completion Report[1]

The effect of velocity barrier construction in the McIntyre River on the fish and lamprey community

by:

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Introduction:

Low head barrier dams (LHBD) constructed by the Great Lakes Fishery Commission since the 1970's block the upstream migration of sea lamprey (*Petromyzon marinus)* while enabling jumping salmonids to pass over the structure on their spawning migrations. However, LHBDs also block the spawning migrations of non-jumping teleosts, such as walleye (*Stizostedion vitreum*), white sucker (*Catostomis commersoni*) and lake sturgeon (*Acipenser fulvescens*) which limits the streams available for barrier construction. The velocity barrier was designed to pass non-jumping migratory fish while blocking sea lamprey runs by exploiting the perceived superior swimming performance of teleosts. The barrier functions by accelerating water down an instream chute. The water velocity in the chute exceeds the swimming performance of the lamprey, blocking their upstream migration but does not exceed the swimming performance of larger teleost fish.

The swimming performance of fish is positively correlated with body length and negatively correlated with water velocity. Consequently, smaller individuals of migratory species (eg white suckers) may not be able to negotiate the velocity barrier, causing a decline in recruitment of young-of-the-year (YOY). In addition, the instream movements of small resident fish (<300 mm) may result in them being trapped downstream of the barrier. The effect of velocity barrier construction could impact on fish species richness as well as the relative abundance of some species.

The primary function of the velocity barrier is to block the upstream migration of sea lamprey. However, the concept of blocking the upstream movements of spawning lamprey with a velocity barrier had not been field tested. We monitored nesting activity and larval abundance upstream of the barrier, before and after construction to evaluate the effectiveness of the velocity barrier at blocking sea lamprey spawning runs. A secondary purpose of most barriers is to evaluate the magnitude of spawning runs by trapping or "fishing up" lamprey at the barrier site. Lamprey runs were evaluated using mark and recapture at a trap installed in the velocity barrier.

The velocity barrier was constructed in the fall of 1993. We evaluated the effectiveness of the velocity barrier at blocking sea lamprey spawning runs and its effect on the fish community by comparing collections of teleost fish and lamprey in the year prior to construction (1993) and in the two years following construction (1994-95). Our objectives in this study were three-fold:

1) To evaluate the size of the spawning run of sea lamprey in the McIntyre River,

2) To determine the effectiveness of the velocity barrier blocking the spawning runs of sea lamprey, and

3) To evaluate the impact of the velocity barrier on migratory and resident fish populations.

Materials and Methods

Spawning run evaluation:

The size of the spawning run was determined using the Petersen mark and recapture method (Ricker 1975). Lamprey were captured in a trap built into the face of the velocity barrier. Water flowing through the trap entrance from the upstream side of the dam attracted lamprey to the trap. We marked all healthy spawning sea lamprey with a fin punch, using a code to identify the week of capture. Marked lamprey were released upstream of the confluence of the McIntyre River with the Neebing-McIntyre floodway (Figure 1). Recaptured animals and those not used in the marking study were destroyed.

Effectiveness at blocking sea lamprey:

i) Sea lamprey nest survey - The primary spawning area in the McIntyre River was identified as the 2 km of stream between the proposed velocity barrier site and the Lakehead University dam (Figure 1). Survey crews walked this section of the river two to three times per week, from June until mid-July when water temperatures averaged 14°C to 20°C. Sea lamprey nests were marked with rocks numbered with fluorescent paint and mapped. Nests were sampled to determine if eggs were present by excavating for a small number of eggs.

ii) Larval sea lamprey surveys - Sea lamprey larvae were sampled once or twice each year from 1993 to 1995. Two sampling stations measuring 30 m in length were established both upstream and downstream of the velocity barrier site. Sea lamprey larvae were live captured from other Lake Superior tributaries with electrofishing gear and were marked by squaring the tail with a scalpel. Marked lamprey were released into the study areas one to two days prior to sampling in the study area. Larvae in the study areas were sampled using electrofishing gear at a rate of approximately 1.0 to 1.5 $min \cdot m^{-2}$. Abundance was determined using the modified Peterson method (Ricker 1975), and density was estimated from the area electrofished. Captured larvae were preserved in formalin for subsequent identification, and length and weight measurements in the laboratory.

Effect on the fish community

Fish were sampled twice each year (1993-95) in the spring and the fall, water levels permitting near the sampling stations used in the larval lamprey surveys. An additional sampling station was located on the Neebish River as a reference station. We placed seine nets across the width of the river at the upstream and downstream limits of the sampling stations. Sampling crews electofished the area between the nets two to three times on each sampling day. The fishing effort was recorded as the total time spent fishing on all electrofishing runs. Fish were identified to species on site and returned to the stream.

Results and Discussion

Spawning Run Evaluation

In 1994 and 1995, 65 and 51 spawning phase sea lamprey were caught in the trap, respectively. The spawning runs were estimated as 545 in 1994 (95% C.I.: 282-1146) and 225 in 1995 (95% C.I.: 131-423) lamprey. Trap efficiency, defined as the ratio of seasonal catch to the population estimate was 12% in 1994 and 23% in 1995 (x=17.5%). Trap efficiency at other barriers with built in traps averages 60%. We can not explain the relatively low trap efficiency at the McIntyre barrier other than to speculate that seiche downstream of the barrier may have effected the upstream migratory behaviour of spawning lamprey.

Effectiveness in blocking sea lamprey runs

i) Sea lamprey nest survey - Prior to construction, we observed 73 nests in the 2 km between the velocity barrier site and the dam at Lakehead University. Following construction, nest building decreased to 3 nests in 1994 and 0 nests in 1995. On June 17, 1994, a severe rainstorm in the Thunder Bay area resulted in increased discharge in the McIntyre River, completely inundating the barrier for three to four days during the lamprey spawning run. We believe that during this period, lamprey were able to swim upstream of the barrier, accounting for the three nests in 1994. In 1995, the velocity barrier was functional throughout the spawning run and no lamprey nests were observed. The barrier appears effective at blocking upstream lamprey migrations at discharges less than those which innundate the barrier. Continued monitoring will determine the frequency of floods that exceed design discharge range during the spawning runs.

ii) Larval sea lamprey surveys - Our electrofishing gear was ineffective at collecting young-of-the-year (YOY) larvae and YOY data are not included in the analysis that follows. Prior to construction, sea lamprey density was similiar upstream and downstream of construction (Figure 2). Density of 1^+ and older larvae ranged between 1.6 larvae·m^{-2} at the downstream location to 2.0 larvae·m^{-2} upstream of the barrier site prior to construction. Size distribution of larvae downstream of the barrier site ranged from 35 to 121 mm in length, while lamprey upstream of the barrier site ranged in length from 34 to 150 mm. These data indicate the upstream and downstream stations were suitable stations for comparing larval populations because of similiar densities and size distributions. The McIntyre River was treated with TFM in July, 1994. Larval surveys conducted in the week prior to treatment indicated the density had declined from 1993 (Figure 2), however density and size distribution of larvae was not significantly different among sampling locations. Post-treatment surveys did not yield any 1^+ or older larvae at either location. However, we collected sea lamprey larvae of the 1994 year class upstream and downstream of the velocity barrier in all 1995 surveys(Figure 2). In September 1995, larval density was not significantly different upstream and downstream of the barrier although densities were 35% of pre-construction densities. Larvae ranged in size from 38 -110 mm downstream of the barrier and 40 - 73 mm upstream of the barrier. These data indicate that spawners which moved upstream of the barrier following the rainstorm in June 1994, spawned successfully upstream of the barrier. In addition, despite the relatively low spawning activity in 1994 (based on only 3 nests observed in 1994), our sampling detected a relatively strong year class of larval lamprey.

Effect on the fish community

i) Species richness - We collected 22 species of fish from the three sampling locations during the study. The catch was dominated by dace (*Rhinichthys cataractae* and *R. atrahulus*), sculpins (*Cattus spp*), darters (*Etheosloma spp*) and white suckers (*Catostomus commersoni*). We observed no seasonal trend in species richness (Figure 3). However, we did observe a decline in species richness in all sampling stations from approximately 9 species·station^{-1} to 5 species·station^{-1} over the study period. The decline in species richness can be attributed to the loss of salmonids (*Oncorhynchus tschawytscha* and *Salmo mykiss*) and other rare species from the catch. We attribute the decline in species richness to natural variation rather than the construction of the velocity barrier because the decline occurred at all stations, including the reference station on the Neebing River.

ii) Species abundance - Large runs of spawning white suckers have been observed in the McIntyre River during May and early June, before and after construction of the velocity barrier (M. L. Chase, University of Guelph, pers. comm). YOY white suckers begin to migrate downstream approximately one month after spawning (Scott and Crossman 1973). We expected white suckers to be seasonaly abundant, with dominant catches in July and relatively low abundance in October collections. However, young-of-the-year (YOY) white suckers were relatively rare in our collections at all stations prior to the construction of the velocity barrier (Figure 4). White suckers were also rare at the Neebing River throughout the study period. At the upstream station on the McIntyre River, YOY white suckers increased in abundance following construction. The highest abundance occurred in July, 1995 upstream of the barrier (Figure 4). Suckers were moderately abundant at the upstream station in October 1995. The only significant collection of white suckers downstream of the velocity barrier occurred in October 1994. These data suggest not all of the YOY white suckers migrated to the lake soon after spawning. The velocity barrier appeared to have no impact on the white sucker population since YOY abundance upstream of the velocity barrier increased following construction.

The dominant forage species collected included dace, darters and sculpins. Dace were relatively common at both McIntyre River stations in 1993 and 1994

(Figure 5), with mean abundance of $16.5 \cdot hour^{-1}$. In 1995, abundance increased to over $100 \cdot hour^{-1}$ at both locations (Figure 5). At the Neebing River, dace were less abundant, averaging less than $5 \cdot hour^{-1}$ throughout 1993-94, and $23 \cdot hour^{-1}$ in 1995. In both rivers, the abundance of dace increased by approximately by five-fold. No seasonal trend in dace abundance was observed.

The abundance of darters showed the reverse trend than that of the dace. Prior to construction, the abundance of darters at the McIntryre stations averaged $49.6 \cdot hour^{-1}$ (Figure 6). Following construction in 1994, abundance of darters decreased upstream of the barrier to $6.0 \cdot hour^{-1}$ while abundance downstream of the barrier remained relatively high at $61.0 \cdot hour^{-1}$. In 1995, abundance remained relatively constant at $7.5 \cdot hour^{-1}$ while abundance downstream of the barrier decreased to $24 \cdot hour^{-1}$. Darters were not collected at any time from the Neebing River and we observed no seasonal trend in darter abundance.

Sculpin abundance was relatively constant downstream of the velocity barrier, with average CPUE of $13 \cdot hour^{-1}$ (Figure 7). However, sculpin abundance varied dramatically upstream of the velocity barrier. Prior to construction, CPUE averaged $15 \cdot hour^{-1}$ (Figure 7). In July 1994, abundance peaked at $73 \cdot hour^{-1}$ but fell to less than $3 \cdot hour^{-1}$ in July 1995. However, sculpin abundance recovered to $64 \cdot hour^{-1}$ in October, 1995 upstream of the barrier. Abundance in the Neebing River was relatively constant at $22 \cdot hour^{-1}$ throughout the study period (Figure 7). No seasonal variation was observed in sculpin abundance.

We observed considerable variation in the abundance of the dominant forage species in the McIntyre and Neebing rivers. However, this variation can not be attributed to the construction of the velocity barrier. While the relative abundance of darters declined following construction, dace and sculpin abundance remained constant or increased during the same period. In addition the pattern in abundance of dace and sculpins in the McIntyre followed that of the Neebing

River, suggesting that these changes were not related to the construction of the velocity barrier.

Conclusions

1) Velocity barrier construction had little or no impact on the dominant forage species or YOY white sucker populations.

2) The velocity barrier was effective at blocking sea lamprey spawning migrations during normal operating conditions. However, a significant year class of larval lamprey was established from a small escapement of spawners upstream of the barrier when it was inundated.

3) The trap at the velocity barrier was effective at collecting spawning lamprey but trap efficiency was low compared to other barriers.

Literature Cited

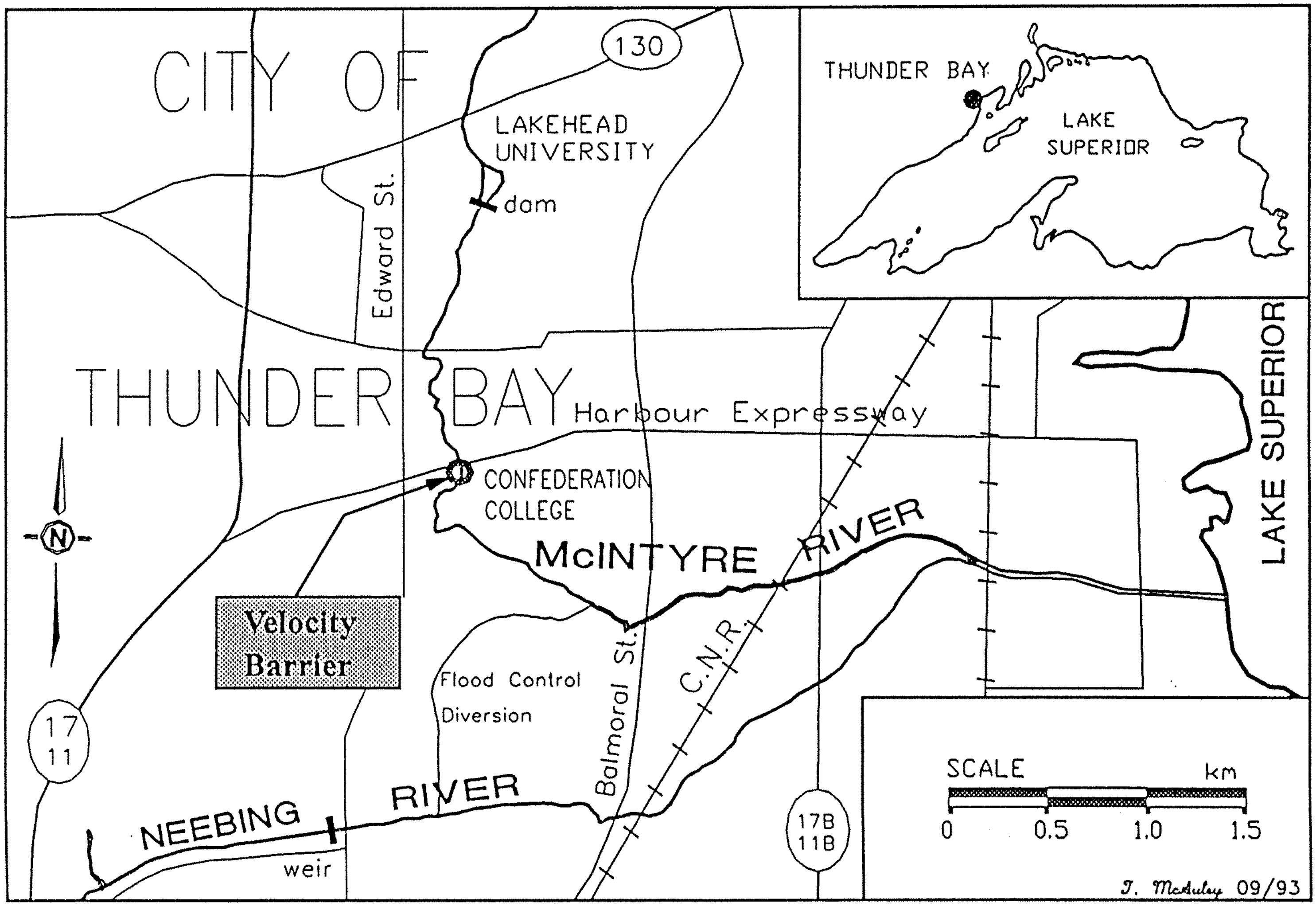
Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Department of the Environment Fisheries and Marine Service Bulletin 191. 382p.

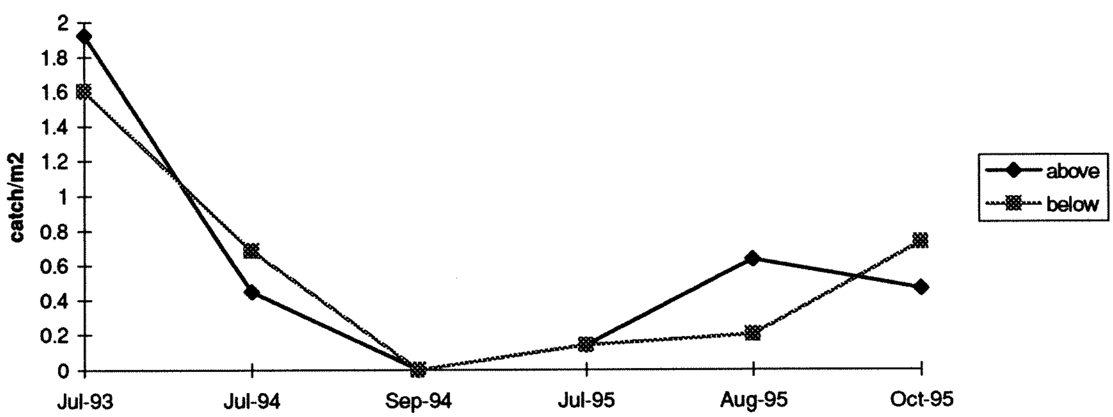
Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada. Bulletin 184. 966p.

Tables

Species	Above	Below	Neebing
Lampetra appendix	P	P	P
Petromyzon marinus	P	P	P
Oncorhynchus tshawytscha	P	P	P
Oncorhynchus mykiss	P	P	P
Misc dace	A	A	P
Phoxinus neogaeus	P	A	A
Rhinichthys cataractae	P	P	A
Rhinichthys atratulus	P	P	P
Semotilus atromaculatus	A	A	P
Margariscus margarita	A	A	P
Notropis heterolepis	P	P	A
Notropis hudsonius	A	A	P
Catostomus catostomus	A	P	A
Catostomus commersoni	P	A	P
Culaea inconstans	P	P	P
Cottus spp.	P	P	P
Cottus bairdi	P	P	P
Cottus cognatus	P	A	P
Ambloplites rupestris	A	P	A
Etheostoma spp.	A	A	A
Etheostoma nigrum	P	P	A
Etheostoma exile	P	P	A
Percina caprodes	P	P	A

Figures


CITY OF
THUNDER BAY
130
LAKEHEAD UNIVERSITY
dam
Edward St.
Harbour Expressway
CONFEDERATION COLLEGE
McINTYRE RIVER
Velocity Barrier
Flood Control Diversion
Balmoral St.
C.N.R.
17
11
17B
11B
NEEBING RIVER
weir
N
LAKE SUPERIOR
THUNDER BAY
LAKE SUPERIOR
SCALE
km
0
0.5
1.0
1.5
J. McAuley 09/93



catch/m2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jul-93
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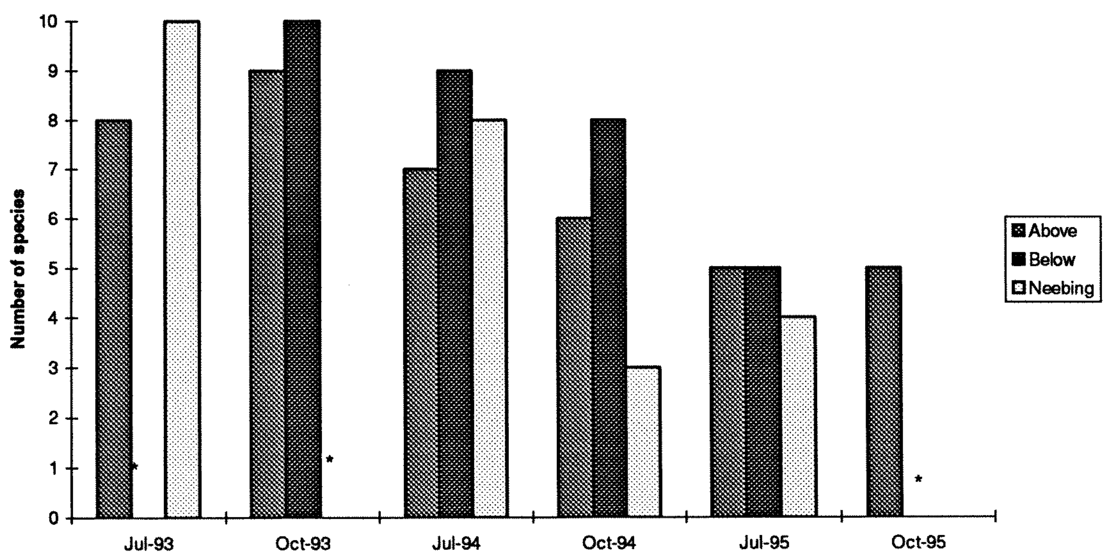
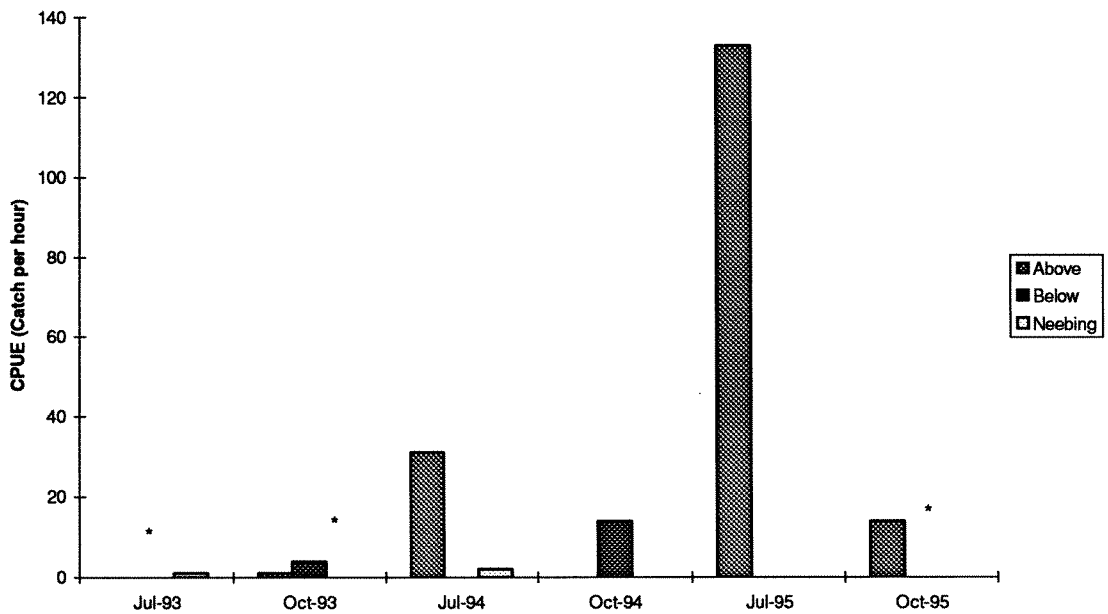
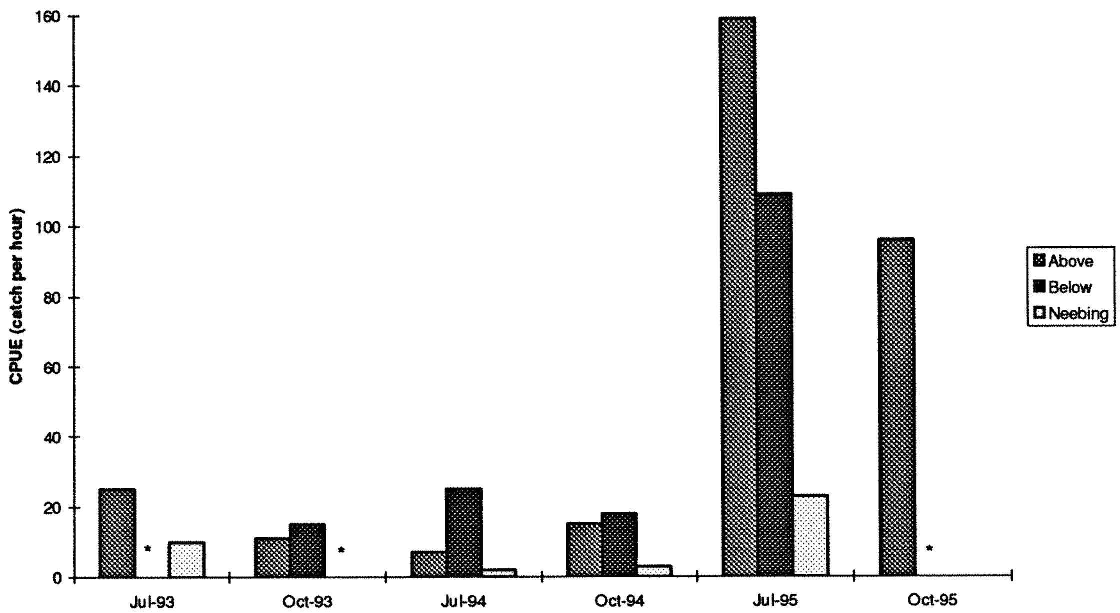
Sep-94
Jul-95
Aug-95
Oct-95
above
below



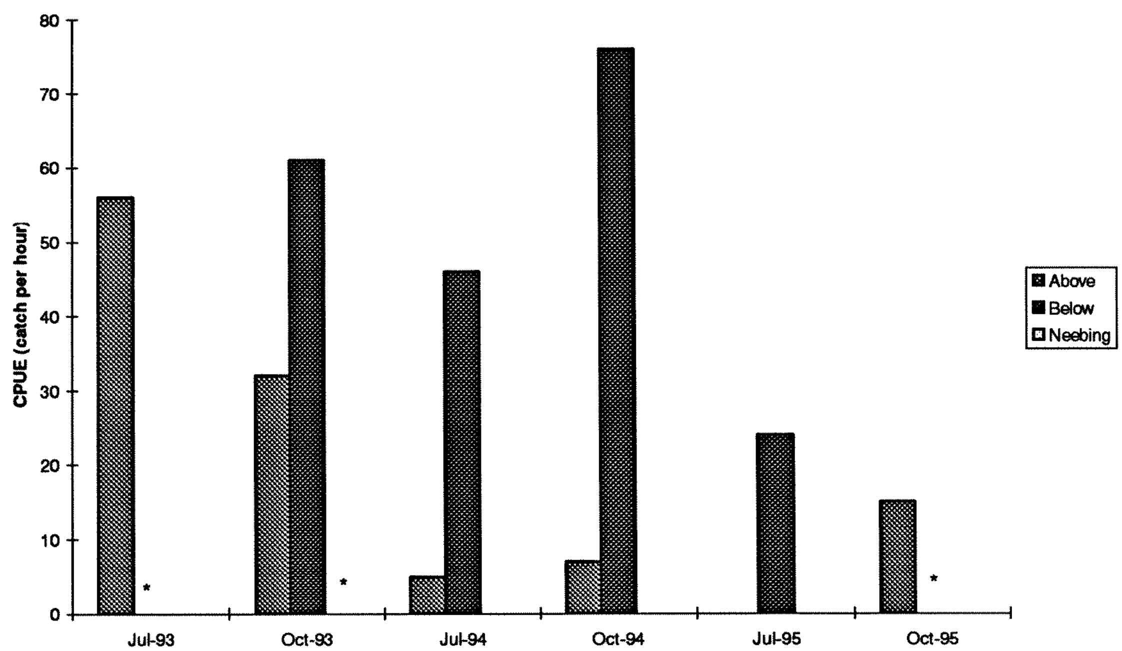
Number of species
10
9
8
7
6
5
4
3
2
1
0
*
*
*
Jul-93
Oct-93
Jul-94
Oct-94
Jul-95
Oct-95
Above
Below
Neebing



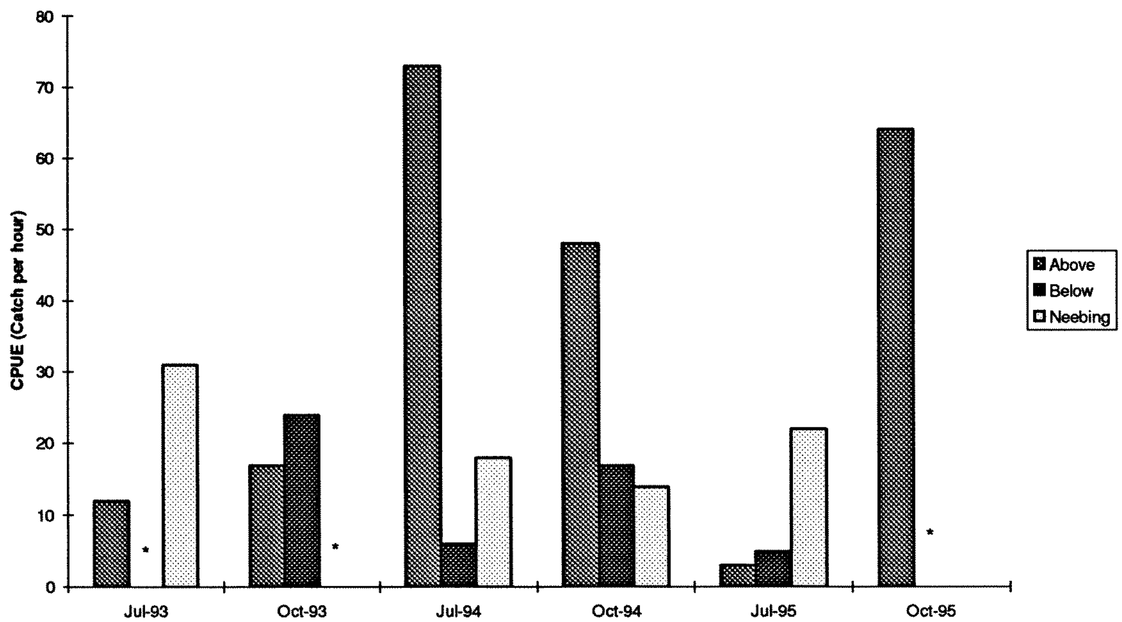
CPUE (Catch per hour)
140
120
100
80
60
40
20
0
Jul-93
Oct-93
Jul-94
Oct-94
Jul-95
Oct-95
Above
Below
Neebing



160
140
120
100
80
60
40
20
0
CPUE (catch per hour)
*
*
*
Jul-93
Oct-93
Jul-94
Oct-94
Jul-95
Oct-95
Above
Below
Neebing



CPUE (catch per hour)
80
70
60
50
40
30
20
10
0
Jul-93
Oct-93
Jul-94
Oct-94
Jul-95
Oct-95
Above
Below
Neebing
*
*
*



80
70
60
50
40
30
20
10
0
CPUE (Catch per hour)
Jul-93
Oct-93
Jul-94
Oct-94
Jul-95
Oct-95
*
Above
Below
Neebing