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Temporal and spatial distribution of pelagic larval fishes of Dauphin Lake, Manitoba

by

Kenneth Dale Rowes

A thesis

Submitted to the Faculty of Graduate Studies

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KENNETH DALE ROWES

A Thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements for the degree of

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DEDICATED

To my parents

Nillie Ethyl Maud (Keenes) Rowes and Joseph Kelly Rowes

whose gentle prodding and guidance

encouraged me in my studies

and

To my sweet daughter Anna Lee

and

loving son Ryan Joseph

who had to share time from Dad while writing this thesis

for your love and understanding I am forever indebted.

ABSTRACT

The distribution of larval fish was investigated in Dauphin Lake (51° 17'N, 99° 48'W) 283 km northwest of Winnipeg, Manitoba from May - August, 1984 and 1985. Larvae were sampled using dual fine mesh conical nets with non-porous mouth-reducing cones. Twelve species of larval fish were found, of which four species dominated in 1984: *Notropis atherinoides*, *Perca flavescens*, *Etheostoma nigrum*, and *Percopsis omiscomaycus*. *Percina caprodes* replaced *P. omiscomaycus* in 1985. Species composition varied, with *P. omiscomaycus* dominating in late May and early June, *P. flavescens* and *E. nigrum* in late June and early July, and *N. atherinoides* mid July to early August. CPUE was greatest in the clay-silt habitat associated with rivers and lowest in the sandy and cobble habitats. Habitat type and temperature were major environmental factors influencing species distribution. Abundance of fish increased in close proximity to river mouths in early spring, and in mid-water during mid-summer. The hypothesis that the timing of appearance of pelagic larval fish in Dauphin Lake is temperature controlled was supported. I found that (a) the time of appearance of larvae in early spring reflected the cold water (<15.0 °C) spawning preference of benthic spawners using near-shore spawning grounds before and during ice breakup; (b) the timing of occurrence of larvae in early summer was attributed to the cool water (16.0-20.0 °C) spawning preference of other benthic species; (c) the timing of occurrence of larvae in mid-summer reflected pelagic warm water (21.0-23 °C) spawners. The hypothesis that the spatial distribution of the major species of larval fish is attributed to habitat type and in-lake environmental variables such as lake mixing and water currents was also supported by species abundances in each location during each sample period.

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INTRODUCTION

The early life history of freshwater fishes has been studied from a number of different perspectives: embryology (Balon 1985), functional morphology of larval structure, larval features applied to taxonomic and systematic studies, ecology of eggs and larvae (Fish 1932, Norden 1961, Flittner 1964, Mansueti and Hardy 1967, May and Gasaway 1967, Pflieger 1975, Ahlstrom and Moser 1976, Hogue et al. 1976, Snyder et al. 1977, Konrad 1985, Simon 1985, Sifa and Mathias 1987). Larval stages have also been used to address fisheries-related problems such as assessment of spawning stocks and recruitment success (Houde 1969, Houde and Forney 1970, Fuiman 1979, Fuiman and Witman 1979, Kendal et al. 1984, Gaboury 1985, Harbicht and Franzin 1988, Harbicht 1990, Schaap 1989, Mathias et al. 1992). The term 'early life history' is used in this study to include the primary stages of pro-larva, post-larva I and post-larva II as defined by Mathias and Sifa (1982), Kendall et al. (1984), and Konrad (1985).

As part of an enhancement and rehabilitation program on Dauphin Lake, Manitoba, a larval fish survey was initiated by the Canadian Department of Fisheries and Oceans, Central and Arctic Region. The goal of this enhancement program was to stock genetically identifiable 3-4 day old larval walleye and, in alternate years, to stock 60 to 90 day old juveniles in order to increase the walleye population which had declined. Dauphin Lake's commercial fishery was a "Walleye-Cisco" fishery in the 1940's but now is a "Pike-Sucker" fishery (Dauphin Lake walleye rehabilitation pilot project). The walleye production during the past 25 years has averaged 20000 kg, one-tenth that of the 1960's (Gaboury 1985).

Several aspects of the Dauphin Lake basin have been studied previously. Weir (1960) studied the geography of the lake and its basin. The general biology of the lake was surveyed by Stewart-Hay (1951), and fishes utilizing major tributary streams were studied by Harbicht and Franzin (1988). Hydrology, including stream characteristics and improvements was studied by Newbury and Gaboury (1988), and stream channelization by Chapman (1987a,b). Lake chemistry was studied by Babaluk and Friesen (1990) and Schaap (1987). The life histories, distribution, and production of the burrowing mayflies *Hexagenia limbata* (Serville) and *Ephemera simulans* (Walker) in Dauphin L. were studied by Heise (1985). Lake zooplankton was studied by Friesen and Mathias (1990). The ecology of the quillback, *Carproides cyprinus* (Lesueur) (Catostomidae), in Dauphin Lake was studied by Parker (1987), and the ecology of the shorthead redhorse, *Moxostoma macrolepidotum* (Lesueur) (Catostomidae), was studied by Harbicht (1990). The sports fishery of northern pike, sucker, walleye, and yellow perch was described by Babaluk et al. (1984) and stocking walleye fry was evaluated by Mathias et al. (1992).

The species composition of the pelagic larval fish community of Dauphin Lake has not been documented, nor is the role of these larval fishes in Dauphin Lake understood. A useful knowledge of the dynamics of lacustrine environments requires knowledge of life histories and the ecology of organisms at each trophic level (Flittner 1964). In this lake, knowing which species make-up the pelagic larval fish community and by how much including their distribution in time and space would be be useful in understanding their inter-relationships for management purposes.

My objectives in this thesis were: 1) to examine the ecological relationships of the pelagic species of larval fish in Dauphin Lake, Manitoba in terms of their distribution over time and space, habitats used, degree days of lake water above 10°C to first appearance and date of greatest abundance, and diet, and 2) to suggest factors which affect these distributions.

The major larval pelagic fish species observed in Dauphin Lake are the emerald shiner, *Notropis atherinoides* (Rafinesque)(Family Cyprinidae), yellow perch, *Perca flavescens* (Mitchill), logperch, *Percina caprodes* (Rafinesque), Johnny darter, *Etheostoma nigrum* (Rafinesque), (all Family Percidae) and trout-perch, *Percopsis omiscomaycus* (Walbaum) (Family Percopsidae) (Figures 1-5). The following is a review of their spawning and early life history.

These fish larvae are planktophagic, ingesting plankton at first feeding (Clady 1978). Emerald shiners are classified as pelagophilic, trout-perch and johnny darters as lithophilic and yellow perch as phyto-lithophilic in habitat preferences (Clady 1978).

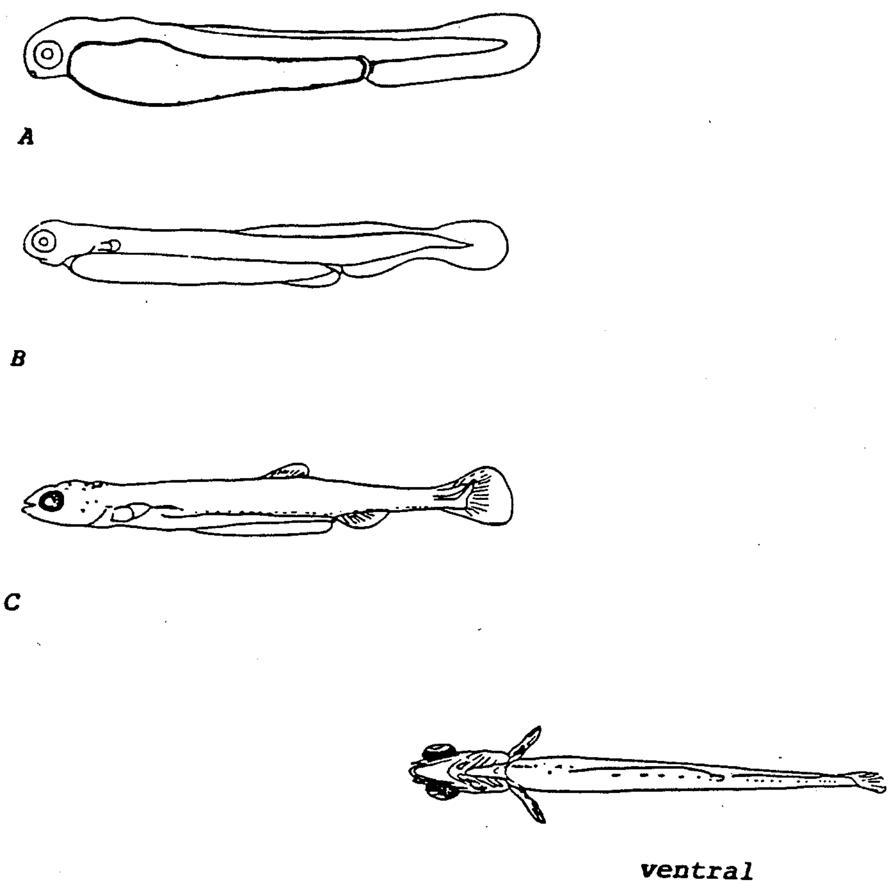
Emerald Shiner

The emerald shiner is the most abundant minnow in L. Erie , L. Simcoe (Scott and Crossman 1973) and in Dauphin Lake (Schaap 1987, Rowes this study). It tolerates a wide range of turbidity and inhabits the epipelagic zone in deep lakes. It can also be found in streams, in low current habitats (Flittner 1964).

Emerald shiners have a protracted spawning period. In the Great Lakes, spawning occurs from early April to mid-August (Auer 1982, Smith 1985) and in the Missouri River they spawn from late May through to early

Figures 1-5. Drawings of the dominant pelagic larval fish species found in Dauphin Lake, Manitoba during open water trawling 1984-85. *Notropis anthrinoides*, *Perca flavescens*, *Percina caprodes*, *Etheostoma nigrum*, *Percopsis omiscomaycus* are shown in lateral view for each of the pro-larvae, post-I and post-II larval stages. Distinquishing characteristics in pigmentation are included in ventral view where they occur. Mean total length ranges are included for size comparison between species. Drawings are modified from Auer, 1982.

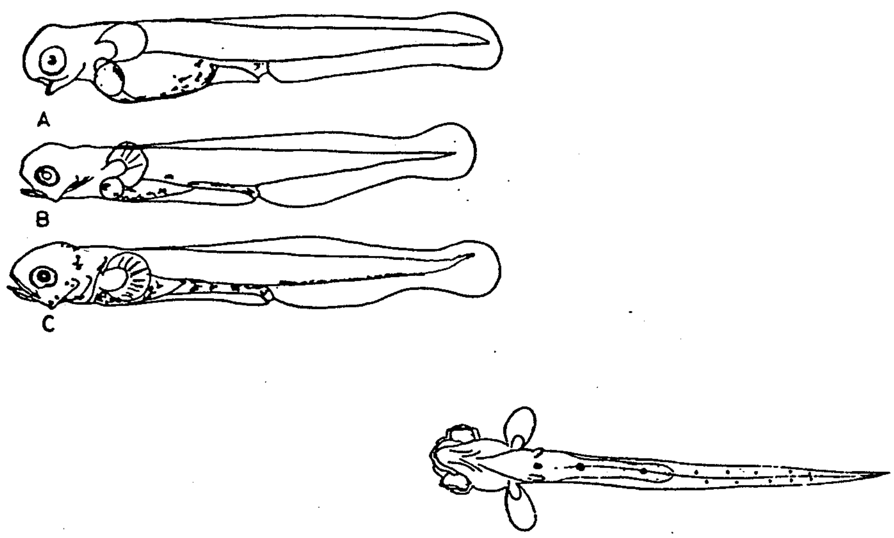
Notropis atherinoides



A	*pro-larva*	*3.40-5.81 mm*
B	*post-larva I*	*6.43-7.63 mm*
C	*post-larva II*	*9.39-13.07 mm*

Figure 1.

Perca flavescens

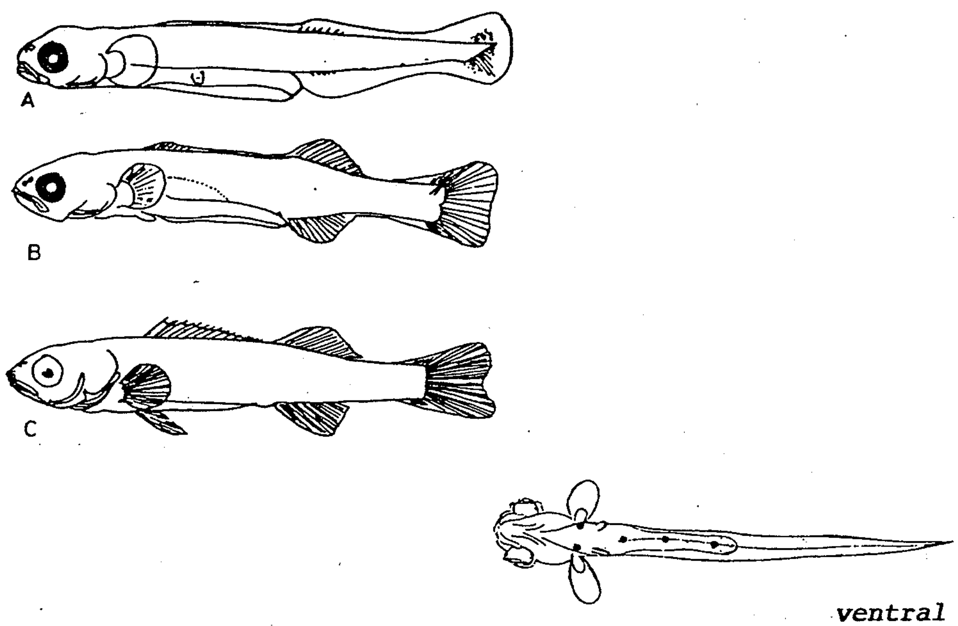


ventral

A	*pro-larvae*	*mm*
B	*post-larvae I*	*6.79-7.65 mm*
C	*post-larvae II*	*7.60-9.52 mm*

Figure 2.

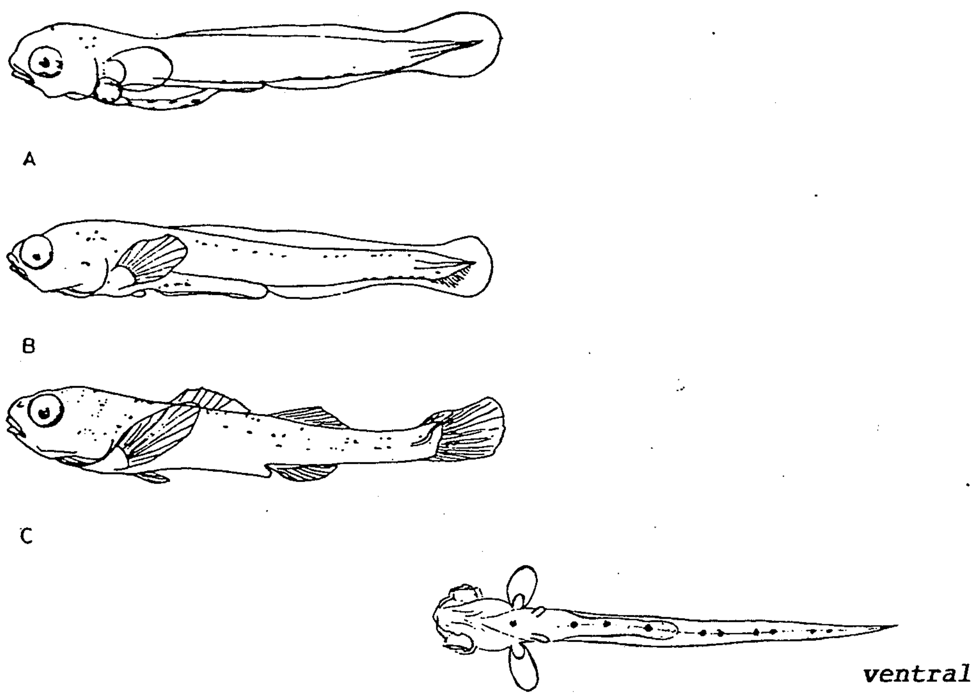
Percina caprodes



A	*pro-larvae*	*5.40- 7.69 mm*
B	*post-larvae I*	*7.39- 9.10 mm*
C	*post-larvae II*	*7.98-13.47 mm*

Figure 3.

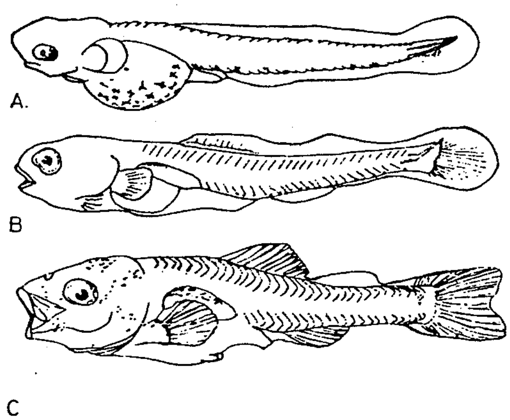
Etheostoma nigrum



A	*pro-larvae*	*4.29-5.69 mm*
B	*post-larvae I*	*5.41-6.47 mm*
C	*post-larvae II*	*6.25-11.50 mm*

Figure 4.

Percopsis omiscomaycus



A	*pro-larvae*	*5.77- 6.72 mm*
B	*post-larvae I*	*7.00- 9.00 mm*
C	*post-larvae II*	*10.00-11.10 mm*

Figure 5.

July. In Lake Erie, spawning is usually at night, just beneath the surface in shallow water, over sandy or firm mud substrate (Pflieger 1975). Temperatures at spawning are 23°C in New York (Smith 1985), or beginning at 22°C (Auer 1982) in the Great Lakes. Spawning has been noted in near-shore areas of lakes over depths of 3 m with hard sand and mud substrates, free of detritus.

Eggs are non-adhesive, lack oil globules and sink to the bottom where they are moved by currents. Hatching occurs in 24-36 hours (Flitter 1964). Fry remain on the bottom 4 or more days then swim up and congregate at the surface in schools (Flitter 1964, Pflieger 1975, Smith 1985).

Pro-larvae have a total length (TL) of 4-5 mm (measured from the tip of the snout to the tip of the caudal fin, Figure 11). Post-I and II larvae are 6-14 mm TL with 23-26 pre-anal and 10-15 post-anal myomeres. The myomere counts of adults are 25 pre- and 14 post-anal (Flitter 1964, Auer 1982).

Distinqishing features used for identifying larvae were: a small body shape with an inferior mouth; pigmentation lacking in pro-larvae, especially in the eyes; single series of chromatophores along underside of stomach to vent that continued with smaller spots from vent to caudal along the ventral ridge (Fig. 1).

Siefert (1972) found that first feeding emerald shiner larvae selected rotifers and copepod nauplii. The items eaten by all feeding larvae were rotifers, copepod nauplii, *Cyclops bicuspidatus*, Cladocera, calanoid copepods, algae, protozoa, and chironomid larvae. Emerald shiners begin feeding at day 6, as post-I larvae swimming near the surface and exhibiting sharp avoidance responses to tactile and visual stimuli such as approaching zooplankton. Feeding larvae are known to drift 10 to 12 miles (Flitter 1964), but it was not clear over what period of time.

Yellow Perch

Yellow perch are phyto-lithophilic, preferring a stony, vegetated habitat and are ranked as a dominant small fish in lake communities. Spawning requires 1.5-3.0 m water depth over sand, gravel and vegetation. Spawning has been reported from April - May at 7-10.5 °C in New York (Smith 1985), into July in Canada (Scott and Crossman 1973) and can last for 6 days at 14-20 °C to 51 days at 5.4 °C (Auer 1982). Spawning of *P. flavescens* has been observed over 14 days to 8 weeks in England (Craig 1987).

Eggs are semi-demersal, with a single oil globule and a thick elastic capsule with radial striations. The eggs are connected in accordion-folded strands 0.6 - 2.0 m in length (Scott & Crossman 1973, Auer 1982, Craig 1987). They are heavier than water and the strands adhere to vegetation or substrate.

Larvae are 5-7 mm TL as pro-larvae, with 17-24 pre- and 13-20 post-anal myomeres, 7-10 mm TL as post-I larvae with 18-20 pre- and 17-21 post-anal myomeres and 11-20 mm TL as post-II larva with 20-24 pre- and 13-14 post-anal myomeres (Norden 1961, Scott and Crossman 1973, Lippson and Moran 1974, Auer 1982).

Distinguishing features used for identifying larvae are: a dorsal fin fold origin at base of head; two or more large, light-coloured stellate chromatophores along the bottom of the yolk sack and an uneven small line along ventral ridge from vent to caudal; PI and PII larvae with 3 ventral spots along ventral stomach and a non-paired series of spots from vent to caudal on opposite sides of ventral ridge (Fig. 2).

First feeding larvae select the rotifer *Polyarthra* and cyclopoid copepods (Siefert 1972). Food organisms eaten by all feeding larvae were copepod nauplii, rotifers, copepods, cladocerans, and some algae.

Logperch

Logperch are lithophilic (Clady 1978), preferring the silt-free, gravel bottom of wave-swept shores (Pflieger 1975). They are bottom dwellers which can be found at depths up to 40 m (Auer 1982).

Spawning occurs during April - May in Missouri (Pflieger 1975), and late June to early July in Michigan (Auer 1982), at temperatures of 10-15°C. Spawning adults bury in the bottom sand and gravel where eggs are laid and fertilized (Pflieger 1975). Incubation varies from 5-6 days at 21-23°C to 8 days at 16°C (Auer 1982).

Newly hatched pro-larvae are 4-6 mm TL and the post-I and II larvae are 7-19 mm TL with myomere counts of 20 pre-anal and 17-18 post-anal as prolarvae and 23 pre-anal and 18 post-anal as post-II larva (Auer 1982).

Distinguishing features used to identify species: 3 black spots along ventral surface of stomach with the last spot located near the anus similar to johnny darters and contrary to yellow perch. One large black spot at the ventral base of each pectoral fin and a faint single series of black specks along ventral ridge from vent to caudal fin (Fig. 3).

Johnny Darter

Johnny darters are also lithophilic, living in stony habitats of streams and lakes that are not excessively turbid and silty but with high or continuous flow. They prefer riffles (Pflieger 1975, Smith 1985). They inhabit a wide variety of aquatic habitats and have been recorded to depths of 40.0 m in Lake Erie (Scott and Crossman 1973).

Spawning dates are generally April to May, and they spawn over sandy-gravel substrate. Spawning is well described by Scott and Crossman (1973).

The eggs are demersal and adhesive with a single large oil globule (Auer 1982). Eggs are very adhesive and usually clustered. They are deposited on the underside of rocks or other objects on the bottom. Incubation varies from 5.5-8.0 days at 22.0 - 24.0 °C to 16 days at 12.8 °C (Auer 1982).

Larvae are 5 mm TL as pro-larvae, 5-7 mm TL as post-I larvae and 8-10 mm TL as post-II larvae (Auer 1982). No myomeric counts are available for larvae, but adults have 37 pre- and 39 post-anal myomeres (Auer 1982).

Distinguishing features used to identify species: very large pectoral fins that extend beyond yolk sack; no marking on ventral surface of yolk sack, but 4 large spots, the first originating between pectoral fin bases, then a series of equally spaced spots along ventral surface of stomach, the last located near anus, in PI and PII larvae; a series of 3 paired spots in single file from vent to caudal fin (Fig. 4).

Trout-perch

Trout-perch are also lithophilic, favouring the stony, sand or gravel bottom of streams or lakes having permanent flow of moderately clear water. They occur from the shallows down to depths of 60 meters, avoiding rooted aquatic vegetation (Smith 1985). According to Pflieger

(1975), trout-perch are nocturnal feeders in shallow water and hide among debris in deeper water during the day.

Spawning of lake populations is preceded by movements of breeding adults into tributary streams or onto beaches in lakes (Pflieger 1975). These fish have a prolonged spawning period from May to August (Pflieger 1975, Smith 1985), even into September in Lake Michigan (Auer 1982). Spawning has been observed on beaches and in streams over sandy-gravel substrates (Auer 1982).

Eggs are demersal, and adhesive, with a single oil globule. Auer (1982) stated that incubation to hatch can be 6.5 days at 20-27 °C. Spawning has occurred at 4.4-10.0 °C and 15.6-20.0 °C (Auer 1982).

No information is available on the diet of larval trout-perch. Larvae are 5.3-6.0 mm as pro-larvae. There is no information on myomeric counts of pro-larvae. Post I larvae are 6.0-7.0 mm TL, with 14 pre- and 18-20 post-anal myomeres, and post-II larvae are 7.0-12 mm TL, with 14-16 pre-anal and 17-20 post-anal myomeres (Auer 1982).

Distiguishing features used to identify species: a distinct prolonged snout with a small inferior mouth; dosrsal fin fold originates at the 7th or 8th myomere; many black pepper-like stellate melanophores over the yolk sack and along ventral surface from vent to caudal fin (Fig. 5).

MATERIALS AND METHODS

1. Study Area

Dauphin Lake, Manitoba (51° 17'N , 99° 48'W) (Figs. 6 and 7) is situated 283 km northwest of Winnipeg, Manitoba, in a broad level valley bounded by the Duck Mountains, 45 km northwest and the Riding Mountains, 6 km southeast. This valley slopes gently downward to the north and east toward Lakes Winnipegosis and Manitoba.

Dauphin Lake is a shallow water body occupying a depression in glacially compressed limestone, with clay and silt comprising most of the lake bottom. It has a surface area of 532.3 km^2, which is 7.4 % of the total area of its watershed, (App. IV). Heise (1985) divided the lake bottom into three zones following the nomenclature of Shepard (1954), based on the sand-silt-clay particle size ratio. I have divided the lake into four habitats using these zones, but adding tributary influences. These are described in Table 1. No significant thermal stratification of the lake was observed in summer. Dauphin Lake is characteristically mesotrophic (Table 2), although it receives fertile soils from a channelized drainage basin within a vast area subject to intensive agriculture (Penner and Oshoway 1982, Chapman 1987). The dominant inorganic ions controlling Dauphin L. are Ca^{+2} and SO_4^{-2}. During 1982, Dauphin Lake had a specific conductivity of 310-770 $\mu S.cm^{-1}$, a maximum summer chlorophyll-a of 0.1 to 35.3 μg^{-1} and a dissolved oxygen concentration range of 6.4-20.5 $mg.L^{-1}$ (Babaluk and Friesen 1990). In 1984-85 chemical conditions were within the above ranges; specific conductivity 374.0-494.5 $\mu S cm^{-1}$, chlorophyll-a 2.2-35.3 $\mu g l^{-1}$, and dissolved oxygen

Figure 6. Drainage features of the Dauphin Lake watershed.

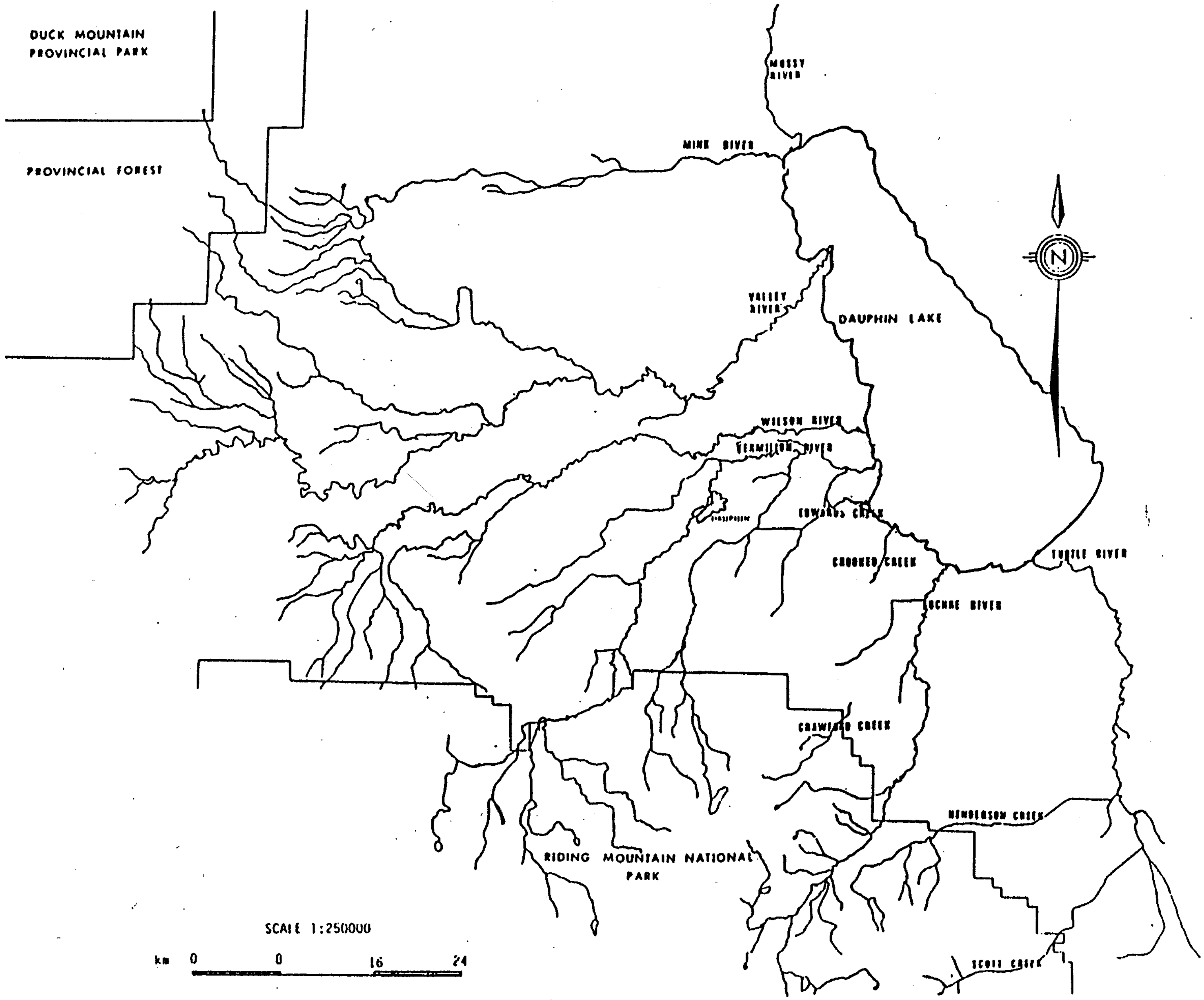

DUCK MOUNTAIN PROVINCIAL PARK
PROVINCIAL FOREST
MOSSY RIVER
MINK RIVER
VALLEY RIVER
DAUPHIN LAKE
WILSON RIVER
VERMILION RIVER
EDWARDS CREEK
CROOKED CREEK
TURTLE RIVER
OCHRE RIVER
CRAWFORD CREEK
HENDERSON CREEK
RIDING MOUNTAIN NATIONAL PARK
SCOTT CREEK
N
SCALE 1:250000
km 0 0 16 24

Figure 7. Bathymetry of Dauphin Lake in contour form. Sampling locations show the divisions for lake trawling. The double line indicates the arbitrary division of the north basin from the south basin.

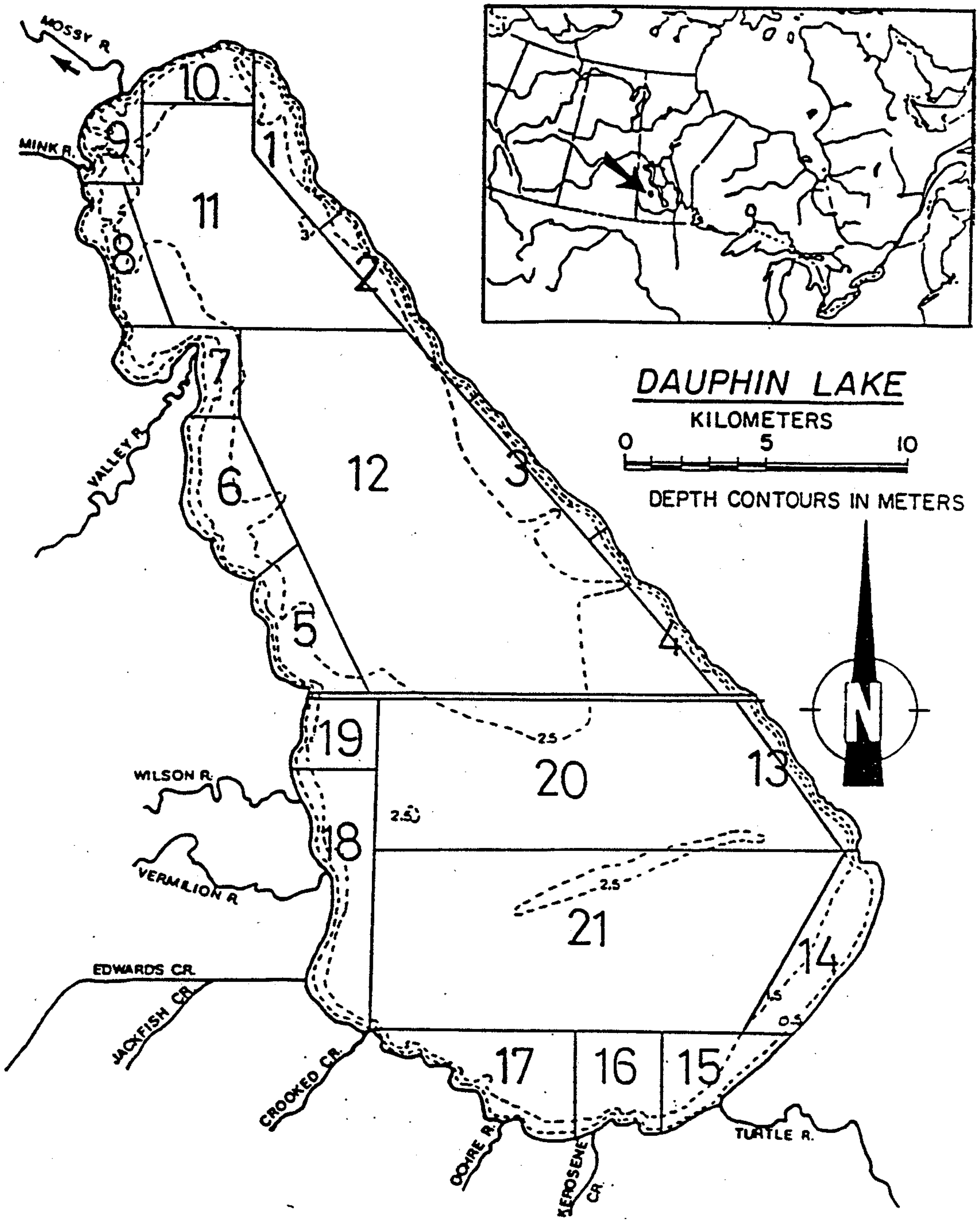

DAUPHIN LAKE
KILOMETERS
0
5
10
DEPTH CONTOURS IN METERS
N
MOSSY R.
MINK R.
VALLEY R.
WILSON R.
VERMILION R.
EDWARDS CR.
JACKFISH CR.
CROOKED CR.
OCHRE R.
KEROSENE CR.
TURTLE R.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
2.5
0.5

Table 1. Sample locations within the four habitat types presented with coordinates for Dauphin Lake, Manitoba, 1984-1985.

HABITAT	A	Bottom = Cobble	NO RIVERS (very little vegetation)
Location			
1	51°27'N	99°54'W	NNE shore
2	51°22'N	99°49'W	NE shore
3	51°19'N	99°44,W	Mid NSE shore
4	51°16'N	99°40'W	Mid E shore
HABITAT	B	Bottom = Sand	**NO RIVERS** (some vegetation close to water-line)
Location			
13	51°12'N	99°35'W	SE shore
14	51°10'N	99°35'W	S shore
HABITAT	C	Bottom = Clay-silt	**RIVERS**
	(vegetation in protected bays 50 to 100m out from the water-line at depths of 0.5 - 1.5m)		
Location			
5	51°16'N	99°51'W	Mid SW shore
6	51°19'N	99°55'W	Mid W shore
7	51°22'N	99°54'W	Valley River
8	51°24'N	99°57'W	NW shore
9	51°26'N	99°58'W	Mink R. and Dauphin L. **OUTLET**
10	51°27'N	99°55'W	North shore
15	51°08'N	99°39'W	Turtle River
16	51°08'N	99°41'W	Kerosene Creek
17	51°08'N	99°45'W	Ochre River
18	51°13'N	99°50'W	Vermilion River - Wilson River
19	51°15'N	99°50'W	SW shore
HABITAT	D	Bottom = Clay-silt	**OPEN MID-LAKE**
Location			
11	51°24'N	99°54'W	Mid North Basin
12	51°19'N	99°50'W	Mid Centre North Basin
20	51°14'N	99°43'W	Mid Centre South Basin
21	51°10'N	99°42'W	Mid South Basin