Canadian Technical Report of
Fisheries and Aquatic Sciences No. 2150

1997

Early life history of fishes in Long Point inner bay, Lake Erie

by

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Fisheries and Oceans
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Canadian Technical Report of Fisheries and Aquatic Sciences

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Fisheries and Oceans Pêches et Océans
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Cat. No. Fs 97-6/2150E ISSN 0706-6457

<u>Correct citation for this publication:</u>

Leslie, J.K., and C.A. Timmins. 1997. Early life history of fishes in Long Point inner bay, Lake Erie. Can. Tech. Rept. Fish. Aquat. Sci. No. 2150.

ABSTRACT

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Seasonality, distribution, and growth of the age 0+ fish assemblage in Long Point inner bay, Lake Erie, were determined for May-November, 1985. The study area is located in a World Biosphere Reserve, designated by UNESCO, and is characteristically shallow, protected, densely vegetated, and utilized intensively by humans for fishing and recreation. Fish larvae (N= 10201) were collected at the shore with a beach seine (0.4 mm mesh), and 0.4-m diameter, 0.4-mm mesh conical ichthyoplankton nets towed at the offshore margin of macrophytes. The age 0+ taxocene consisted of 12 families and 27 species in 8 reproductive guilds. Centrarchids (47% of total catch) and cyprinids (15%) dominated the assemblage. The most common and abundant taxa included *Lepomis gibbosus*, *Labidesthes sicculus*, *Perca flavescens*, and *Notemigonus crysoleucas*. Description and illustrations of age 0+ *Erimyzon sucetta* are given as an aid in identification of this "vulnerable" species.

RÉSUMÉ

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Nous avons étudié de mai à novembre 1985 le caractère saisonnier, la distribution et la croissance de l'assemblage des poissons d'âge 0+ au fond de la baie de Long Point, sur le lac Érié. La zone d'étude se trouve dans une réserve mondiale de la biosphère, désignée par l'UNESCO; elle se caractérise par des eaux peu profondes, protégées, à végétation dense, et fait l'objet d'une utilisation intensive par les humains pour la pêche et le loisir. Des larves de poissons (N = 10,201) ont été recueillies sur le littoral à la senne de plage (maillage de 0,4 mm), et à la marge extérieure des macrophytes à l'aide de filets coniques à ichtyoplancton d'un diamètre de 0,4 m et à maillage de 0,4 mm. L'assemblage taxinomique d'âge 0+ consistait en 12 familles et 27 espèces regroupées en 8 guildes reproductrices. Les centrarchidés (47 % des prises totales) et les cyprinidés (15 %) dominaient l'assemblage. Les taxons les plus communs et les plus abondants étaient *Lepomis gibbosus*, *Labidesthes sicculus*, *Perca flavescens* et *Notemigonus crysoleucas*. Nous présentons aussi une description et des illustrations de spécimens 0+ d'*Erimyzon sucetta* pour aider à identifier cette espèce "vulnérable".

INTRODUCTION

The ecosystem of Long Point has been subjected to unceasing European cultural interference for more than 200 years (Barrett 1981). Accordingly, its aquatic component has changed drastically (Whillans 1979), yet continues to support one of the oldest and most important recreational and commercial fisheries in Lake Erie. Whereas fisheries management has emphasized production of exploitable species (Reid 1978 and Halyk 1983 (OMNR unpubl. data); Hamley et al. 1983; OMNR 1993), and fish community structure has been investigated (Mahon and Balon 1977a,b), little is known of fish reproduction. Omission of this aspect of life history pervades fisheries biology in the Great Lakes. Nevertheless, knowledge of fish reproductive behaviour is prerequisite to understanding any species and thus the quality of its aquatic ecosystem (Leslie and Timmins 1994). Thus, a study was undertaken in 1985 to determine species composition, relative number, seasonality, and growth of age 0+ fishes in several different biotope types in the inner sector of Long Point Bay. This type of base study is especially important in consideration of the increasing intensity of industrial and cultural activities in the watershed.

Age 0+ lake chubsucker *Erimyzon sucetta*, a "vulnerable" species (Campbell 1996) seldom collected with ichthyoplankton samplers, were caught in small number in this study. Because hitherto, early development of this fish has not been described or illustrated for the Great Lakes basin, some basic external features are provided herein. This type of contribution to the systematics and taxonomy of age 0+ fishes in Ontario is rare, particularly of taxa whose ecological status is vulnerable, threatened, or endangered.

STUDY AREA

Long Point (42° 37'N; 80° 10'W), on the north shore of Lake Erie, is a narrow peninsula (Fig. 1) containing sandbars, dunes, lagoons, marshes, savannahs and forests. These support a rich and diverse avifauna, as well as terrestrial and aquatic plant and animal life (McCracken et al. 1981). As such, Long Point and environs are an especially important natural resource (Kreutzwiser 1981) in densely-populated southern Ontario. Indeed, in 1986, UNESCO designated Long Point a World Biosphere Reserve, one of just six in Canada.

The inner bay has a surface area of approximately 68 km^2, a drainage area of 947 km^2 (Whillans 1979), and a mean depth of 1 m. The bottom of the bay consists mainly of sand in most nearshore areas and silt in the centre. As the long axis of the inner bay and direction of prevailing southwest winds correspond, the water temperature regime at the shore is changed minimally by effects of meteorologic events, e.g., periodic upwelling and influx of water of low temperature. In 1926, a causeway was constructed between Long Point peninsula and the north shore of the inner bay. The main influent, Big Creek (mean daily flow for 1985 $\approx$ 10 m^3/s), flows under this causeway and deposits sediment at the western extremity of the bay. The north shore of the peninsula is extremely irregular and its slope shallow. Marshes, under public domain, encompass a cottage community. Except for the cottage community, where the shore has been stabilized, natural shoreline development varies annually according to the water level regime and effects of storms. In 1985, mean monthly water level decreased 12 cm between April and June, then an additional 24 cm to September (DOE 1985). A decrease in water level effects a gradual shift in nursery habitat for many fishes as the quantity of vegetative cover increases at the shore and macrophytes spread offshore. Aquatic vegetation covers about 90% of the bottom of the inner bay and is dominated by *Chara vulgaris, Vallisneria americana, Potamogeton friessii, Najas flexilis, Nitella sp.*, and *Myriophyllum spicatum* (Leach 1981; Bailey 1988). *Typha latifolia, Eleocharis elliptica*, and *Carex* spp., are common emergent macrophytes.

METHODS

Sampling took place mainly in the cottage community and adjoining Long Point Provincial Park. Sites were selected to provide maximum variety in fish habitat. Routine samples were taken with seines at five shore sites: a drainage ditch (~2 m wide, 300 m long, 0.5 m deep), a small (~0.5 ha) embayment, and areas adjacent to two recreational boat ramps. Collections were made at intervals of 1 to 3 wk between May 2 and July 24, 1985, then at least monthly from August to November. A fine-mesh (0.4 mm opening) beach seine 4-m long and 1-m wide was used for routine collections of age 0+ fishes whereas a larger seine (length 6 m, width 1 m, mesh opening 6 mm) was used for collecting juvenile and adult fishes. Seines were hauled parallel to shore (or up and down ditches) at maximum wading depth (~1 m) for a distance of approximately 10 m. As many as nine, but usually three, samples were collected with fine-mesh seines each date in each microhabitat. About 180 samples were thus obtained during the total sampling period. Occasionally, unlit activity traps (Murkin et al. 1983) were set on the bottom amongst macrophytes. In addition, two conical ichthyoplankton nets (diameter 0.4 m, length 2.5 m, mesh 0.4 mm) were hauled just under the surface on 8 dates (early May to late July) using a small boat. Depth over which collections were made did not exceed 1.5 m; all plankton net sampling took place at the offshore margin of macrophytes. An average of 9 hauls was made on each date. One net was pushed at the bow and the other towed simultaneously from the stern at an average speed of 0.9 m/s for 5 min. Sampler speed was monitored with a hand-held current meter. The location of net hauls shifted progressively lakeward in concert with seasonal spread of emergent vegetation. Although our study was essentially qualitative, densities of fishes collected with plankton nets were expressed as the total number of fishes in 100 m^3 of water filtered. Total volume of water filtered (100% efficiency assumed) was deduced by multiplying net mouth area by distance hauled and tow speed.

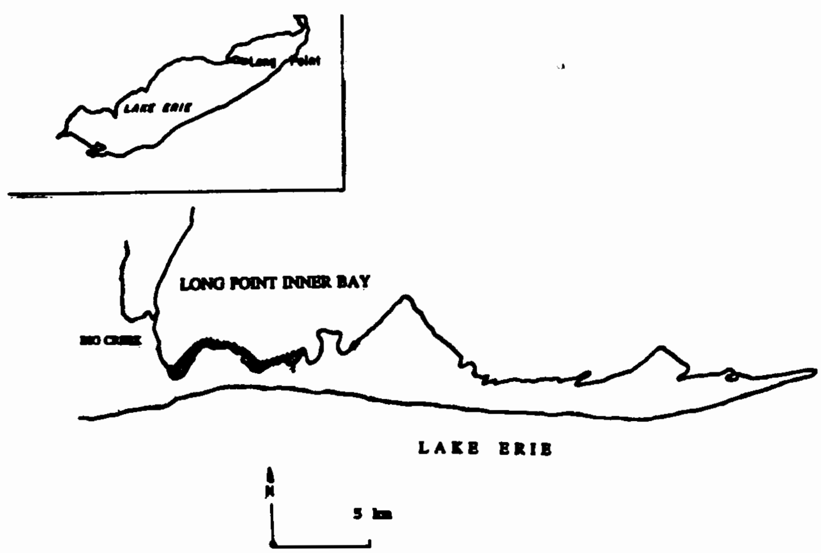


Fig. 1. Generalized map of area sampled for age 0+ fishes, 1985. Darkened shoreline denotes specific habitat investigated.

Fishes were fixed immediately in the field with 10% formalin and, within 3 months, transferred to a solution of Davidson's B. Adult and juvenile fishes (age 1+) were identified and counted on site, whereas age 0+ fishes were identified and counted in the laboratory. A small number (<0.01%) of fish was unidentifiable due to specimen damage during collection. Lengths of age 0+ fishes were expressed as total length (TL) measured to an accuracy of ±0.2 mm; fishes >30 mm TL were measured with a hand micrometer to an accuracy of ±0.5 mm. A percent coefficient of community (CC) (Whittaker and Fairbanks 1958) was used to compare co-occurrence of fish taxa at three microhabitats (embayment, drainage ditch, boat-launching areas) on each sampling date. This index tends to emphasize the occurrence of less common species, and this is appropriate to most general surveys of fish larvae in the lower Great Lakes, where only three or four species are common in a community of at least 30 fishes. CC = c.100/a+b-c, where a and b are the respective numbers of species at pairs of sites and c the number of species occurring in both. Arbitrarily, a CC <30 was indicative of dissimilarity in fish habitat.

The term "assemblage" refers to families which persist in highest numbers throughout the sampling season and which in general are most dominant fishes. Actually, the assemblage changes seasonally as species enter, and in some cases, leave the sampling area. Ecoethological guilds were utilized in classifying fishes ecologically (Balon 1975). Specimens were identified according to reference fish stored at the Great Lakes Laboratory for Fisheries and Aquatic Sciences, Burlington, Ontario, and a guide to larvae of Great Lakes fishes (Auer 1982).

Morphometric and meristic methods to describe lake chubsucker follow those of Leslie and Gorrie (1984). A camera lucida attached to a stereoscope was used to illustrate fish, with details added free-hand. Descriptions of lake chubsucker focus on external morphological and pigmentary features which we consider most useful for rapid identification.

RESULTS

COMMUNITY STRUCTURE OF AGE 0+ FISHES

Thirty-two fish taxa, representing 13 families and 8 reproductive guilds, were recorded for the south shore of inner Long Point Bay. Twenty-seven species of larvae and age 0+ juveniles (Table 1) were dominated numerically by centrarchids, cyprinids, and brook silverside *Labidesthes sicculus*. The age 1+ community was dominated by cyprinids and brook silverside. Emerald shiner *Notropis atherinoides*, common carp *Cyprinus carpio*, and spotfin shiner *Cyprinella spiloptera* were collected only as age 0+ fish, whereas white bass *Morone chrysops*, Iowa darter *Etheostoma exile*, smallmouth bass *Micropterus dolomieu*, yellow bullhead *Ameiurus natilis*, and logperch *Percina caprodes*, were collected only as age 1+ fish. Four taxa were found whose status in Canada is listed as vulnerable: grass pickerel *Esox americanus vermiculatus*, lake chubsucker, pugnose shiner *Notropis anogenus*, and yellow bullhead. These fishes appeared sporadically and occupied specific microhabitats. Notably, the eastern sand darter *Ammocrypta pellucida*, a "threatened" species in Long Point Bay (Holm and Mandrak 1996) was not collected in the inner bay.

Centrarchids represented 47% of the total catch of age 0+ fishes (10201) and cyprinids represented 15%. Highest catches of individual species were of pumpkinseed *Lepomis gibbosus* (41% of the total catch), brook silverside (17%), yellow perch *Perca flavescens* (13%), and golden shiner *Notemigonus crysoleucas* (7%). Reproductive guilds were verified for most taxa according to their initial appearance as free embryos or small larvae.

Non-guarding, open substratum phytophils formed the largest reproductive guild (13 species), in which fishes typically spawn when macrophytes first appear. These plants provide structure on which eggs may adher and develop above the substrate (Scott and Crossman 1973). Upon hatching, some members of this guild, e.g., esocids, bowfin *Amia calva*, and longnose gar *Lepisosteus osseus*, use a cement gland to attach temporarily to vegetation, rather than contact amorphous substrate. Although they represented 30% of the number of species assumed to have reproduced in the study area, guarding nest spawners contributed 51% to the total catch. Atypical species collected in marshes included the litho-pelagophil, gizzard shad *Dorosoma cepedianum* and a pelagophil (emerald shiner). Gizzard shad, often found in turbid water, probably originated in lower Big Creek, where turbidity is highest in the inner bay. Emerald shiner normally develops in open water, thus its presence at the shore suggests drift from offshore littoral areas.

Table 1. List of age 0+ fishes collected at the south shore of inner Long Point Bay. Reproductive guilds: Ph = Phytophil, Pl = Phyto-lithophil, Ps = Psammophil, Sp = Speleophil, Li = Lithophil, Po = Polyphil, Pe = Pelagophil, Lp = Litho-pelagophil. Numerical rank in parentheses. TL = total length of smallest specimen. nd = no data.

Family	Species	Common name	Guild	At first collection	
				Date	TL (mm)
Lepisosteidae	*Lepisosteus osseus*	Longnose gar	Ph	June 12	17.4
Amiidae	*Amia calva*	Bowfin	Ph	June 12	52
Clupeidae	*Dorosoma cepedianum*	Gizzard shad	Lp	May 29	nd
Umbridae	*Umbra limi*	Central mudminnow	Ph (8)	May 14	11.5
Esocidae	*Esox americanus vermiculatus*	Grass pickerel	Ph	June 12	40.3
	Esox lucius	Northern pike	Ph	June 26	60
Cyprinidae	*Notropis hudsonius*	Spottail shiner	Ps	Nov 14	45
	Notropis anogenus	Pugnose shiner	Li	Sept 11	32
	Notropis heterodon	Blackchin shiner	Ph (9)	June 12	8.9
	Notropis heterolepis	Blacknose shiner	Ps (6)	June 12	4.9
	Notropis atherinoides	Emerald shiner	Pe	July 4	5.1
	Notropis volucellus	Mimic shiner	Pl	June 26	5.0
	Pimephales notatus	Bluntnose minnow	Sp	June 12	5.4
	Notemigonus crysoleucas	Golden shiner	Ph (4)	May 29	5.3
	Cyprinus carpio	Common carp	Ph (10)	May 29	4.6
Catostomidae	*Erimyzon sucetta*	Lake chubsucker	Ph	June 12	7.0
	Catostomus commersoni	White sucker	Li	May 29	nd
Ictaluridae	*Ameiurus nebulosus*	Brown bullhead	Sp (7)	June 12	14.6
	Ameiurus natilis	Yellow bullhead	Sp	Oct 17	57
	Noturus gyrinus	Tadpole madtom	Sp	June 26	12.8
Cyprinodontidae	*Fundulus diaphanus*	Banded killifish	Ph	June 12	5.1
Atherinidae	*Labidesthes sicculus*	Brook silverside	Pl (2)	June 12	4.1
Centrarchidae	*Lepomis macrochirus*	Bluegill	Li	July 12	5.3
	Lepomis gibbosus	Pumpkinseed	Po (1)	May 29	4.9
	Ambloplites rupestris	Rock bass	Li	June 12	6.6
	Micropterus salmoides	Largemouth bass	Ph (5)	June 12	7.5
Percidae	*Perca flavescens*	Yellow perch	Pl (3)	May 2	5.0

SEASONAL SUCCESSION

Based on the occurrence of small larvae, we estimate that 86% of age 0+ fishes hatched in the study area and at least 61% utilized it as a nursery. Yellow perch was the sole species collected on May 2 (at 11.5°C; Fig. 2). Between late May and mid-June, golden shiner, pumpkinseed, brook silverside, common carp, blacknose shiner, largemouth bass, and banded killifish *Fundulus diaphanus* larvae as macrophytes developed. Offshore migration or shoreline movement of age 0+ fishes may take place in response to environmental changes, such as temperature, water quality, water level, amount of cover, quantity and quality of food, competition, and predation pressure. Any of these effects could thwart our attempts to determine seasonal succession of species. On May 14, for example, only 7 larvae were collected: one each of banded killifish and central mudminnow (12 mm) and five recently-hatched pumpkinseed (5 mm). Coincidentally, a diverse group of age 1+ fishes was collected (Table 2) in the absence of larvae.

Largest numbers of fishes (65% of total catch) appeared at all sites in mid-June. On the basis of their small size (<10 mm) and initial appearance in early to mid-July, taxa spawned latest included emerald shiner, blackchin shiner, and bluegill *Lepomis macrochirus*. Most species, either as newly-hatched larvae or age 0+ juveniles, were represented at the shore throughout the sampling period. Others, such as yellow perch, probably moved to deeper sectors of the littoral zone shortly after hatching, whereas brown bullhead and largemouth bass were rarely collected after first occurring (at 8 mm and 11 mm mean TL, respectively) in schools each of 200-500 at the margin of Eurasian milfoil and pondweeds. Brief occurrence of large broods of littoral fish probably helps prevent food depletion. Pumpkinseed, overall the most abundant and common age 0+ fish in the inner bay, were uncommon after late July, whereas bluegill appeared mainly in August and September. These centrarchids seldom co-occurred in any microhabitat.

SAMPLER PERFORMANCE

Static traps caught few larvae, and were not useful samplers. In comparison, plankton nets caught more species and a higher total number of fishes. However, numbers of larvae collected on each date varied considerably: the percent coefficient of variation (CV) of total catch in 3-10 successive hauls averaged 134% (range, 119-180% on 8 sampling dates). These data pertain mainly to collections of brook silverside, by far the dominant species in net hauls (Fig. 2A). The fine-mesh (0.4 mm) beach seine, on the other hand, collected a wide range of sizes and large numbers of fish larvae and juveniles of many species. Seines are especially useful for catching fishes in ditches, ponds, and narrow embayments, where their access to open systems is limited by physical factors.

HABITAT UTILIZATION

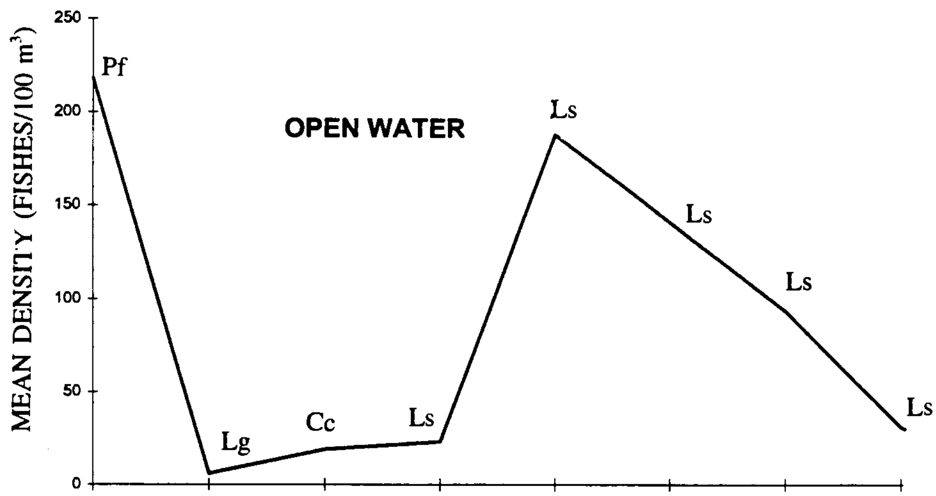
Few species coincided temporally at any two sampling sites. On June 12, for example, although 7 species were collected in the ditch and 17 at a boat ramp <0.5 km distant, these sites shared only 5 species: rock bass, lake chubsucker, blackchin shiner, grass pickerel, and central mudminnow. Throughout July, no fishes shared ditch and embayment or boat ramp habitats, i.e., between-site CC = 0. Boat ramps and embayment shared more taxa than did other sites used in paired comparisons, although the CC index was always low (range, 11-25).

Generally, spatial and temporal distribution of fishes indicated habitat specificity. Ten taxa, led numerically by blacknose shiner, were found in an embayment, 23 taxa, dominated by pumpkinseed and brook silverside, were collected in marsh and ramp areas, and 20 (chiefly golden shiner) in a drainage ditch. These microhabitats together contributed about 90% of the total catch of age 0+ fishes. Although 8 species were collected in open water, yellow perch and brook silverside were the only abundant fishes. Newly-hatched yellow perch (5.0-7.8 mm TL) were rarely collected with plankton nets after May 3, when they reached peak density (218/100 m^3), whereas brook silverside increased in June from 23 to 181 larvae/100 m^3, then steadily decreased to 31/100 m^3 in late July (Fig. 2A).

Several fishes were found precisely in habitat characteristic of each species (Scott and Crossman 1973). For example, longnose gar larvae were found in slightly turbid water at the margin of early emergent macrophytes adjacent to boat ramps, whilst bowfin, grass pickerel, and tadpole madtom *Noturus gyrinus* almost exclusively occupied a ditch. These taxa did not appear to migrate extensively. Central mudminnow and grass pickerel could be found throughout early ontogeny in the upper section of a drainage ditch. Golden shiner and banded killifish were usually abundant and common in submersed and floating plants, e.g., *Chara* and *Potamogeton,* but were uncommon in open water (mean densities 1 fish/100 m^3).

AGE 0+ FISHES, LONG POINT 1985

A)



B)

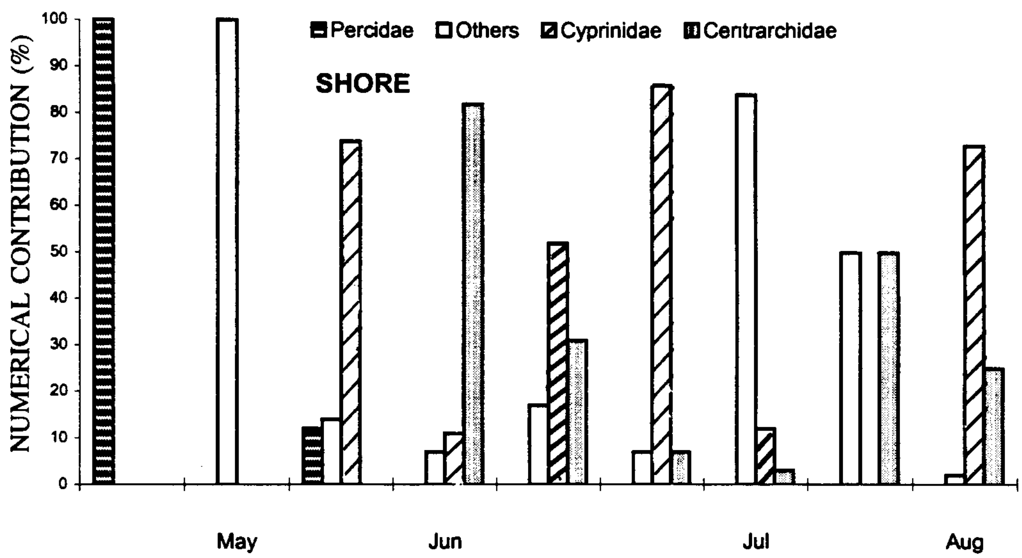


Fig. 2. Seasonal mean density of age 0+ fishes collected at the offshore margin ("open water") of emergent macrophytes (A), and percent contribution, according to family, of total catch at the shore (B), Long Point inner bay, 1985. Dominant taxa in open water: Pf = *Perca flavescens*, Lg = *Lepomis gibbosus*, Cc = *Catostomus commersoni*, Ls = *Labidesthes sicculus*. Contribution of "Others" in mid-May consisted of 6 fish (*Umbra limi*) and in mid-July, 340 fishes (mainly *Labidesthes sicculus*).

Table 2. Species of age 1+ fishes found at the shore of inner Long Point Bay, 1985. An asterisk (*) denotes most numerous species in collection.

Date	Species collected	Habitat occupied-
May 2/3	*Fundulus diaphanus**, *Notemigonus crysoleucas**, *Notropis heterodon**, *Notropis heterolepis*, *Notropis anogenus*, *Notropis atherinoides*, *Pimephales notatus*, *Cyprinella spiloptera*, *Labidesthes sicculus*, *Perca flavescens*, *Percina caprodes*, *Etheostoma exile*, *Ambloplites rupestris*	Boat ramps; no vegetation; thick detritus
May 14/15	*Fundulus diaphanus**, *Notropis heterolepis*, *Notropis volucellus*, *Notropis stramineus*, *Labidesthes sicculus*	Boat ramps; vegetation sparse
	Lepomis gibbosus, *Notropis heterodon*, *Notemigonus crysoleucas*, *Esox americanus vermiculatus*, *Pimephales notatus*, *Etheostoma exile*	Drainage ditch; submersed vegetation
May 29/30	*Fundulus diaphanus*, *Notropis volucellus*, *Notropis heterodon*	Marshes; *Eleocharis*
	Notropis heterolepis, *Labidesthes sicculus*, *Etheostoma exile*, *Perca flavescens*, *Erimyzon sucetta*	Boat ramps; *Carex*
	Notemigonus crysoleucas, *Umbra limi**, *Noturus gyrinus*, *Esox americanus vermiculatus*, *Micropterus salmoides*, *Lepomis macrochirus*	Drainage ditch; *Carex*
June 12/13	*Fundulus diaphanus**, *Cyprinella spiloptera*, *Notropis heterodon*, *Notropis heterolepis*, *Erimyzon sucetta*, *Pimephales notatus*, *Micropterus salmoides*	Boat ramps; *Potamogeton*
	Esox lucius, *Esox americanus vermiculatus*, *Lepisosteus osseus*, *Perca flavescens*, *Ambloplites rupestris*	Drainage ditch; *Carex*
June 26/27	*Pimephales notatus*, *Notropis heterolepis*, *Lepomis macrochirus*, *Ameiurus nebulosus*, *Notemigonus crysoleucas*, *Perca flavescens*	Embayment, ramps; *Nymphaea*, *Potamogeton*
July 4/5	*Micropterus salmoides*, *Notemigonus crysoleucas*, *Notropis heterodon*, *Notropis heterolepis*, *Noturus gyrinus*, *Ameiurus nebulosus*, *Umbra limi*, *Esox americanus vermiculatus*	Embayment; *Chara*, *Carex*, *Nymphaea*
July 11/12	*Esox americanus vermiculatus*	Drainage ditch; *Carex*, detritus
	Erimyzon sucetta, *Ameiurus nebulosus*, *Lepomis macrochirus*, *Labidesthes sicculus*	Boat ramps; *Typha*, submersed vegetation
July 23/24	*Noturus gyrinus*	Drainage ditch
August 8	*Notemigonus crysoleucas*, *Labidesthes sicculus*, *Micropterus dolomieu*	Embayment; *Carex*, *Chara*, *Nymphaea*
September 11/12	*Umbra limi*, *Notemigonus crysoleucas*, *Notropis heterolepis*, *Etheostoma exile*, *Noturus gyrinus*	Drainage ditch; *Carex*, detritus
	Labidesthes sicculus, *Morone chrysops*, *Notropis atherinoides*	Boat ramps; *Typha*, senescent submersed vegetation

Table 3. Number of taxa occurring seasonally at the south shore of inner Long Point Bay. Both = complement of age 0+ and 1+ fishes.

Sampling date 1985	Temp. (°C)	Number of taxa age 0+	age 1+	both	Abundant age 0+ fishes
May 2	12	1	13	13	*Perca flavescens*
May 14	21	3	11	12	none
May 29	22	8	14	17	*Notemigonus crysoleucas*
June 12	22	16	12	19	*Lepomis gibbosus, Micropterus salmoides, N. crysoleucas*
June 26	22	14	6	16	*Notropis heterolepis, Lepomis gibbosus*
July 4	29	13	8	17	*Notropis heterolepis*
July 11	24	9	5	9	*Labidesthes sicculus, Notropis heterolepis*
July 23	24	5	1	6	*Labidesthes sicculus*
August 8	23	10	3	10	*Notropis heterodon*
September 11	22	10	8	18	*Notropis heterodon*
October 16	14	6	9	15	none
November 16	8	0	4	4	none

Although density was not calculated for fishes collected with seines, numbers caught per unit effort were generally much higher than in open water. Species composition and contribution to the overall catch of age 0+ fishes differed according to sampling method used and habitat sampled (Fig. 2). Whereas few species were found in open water, and only brook silverside persisted as a dominant taxon, at least several fishes were represented in seine collections (Fig. 2B). Thus, the "assemblages" at the shore and in open water were usually dissimilar. For example, collections with a seine indicated that in general, cyprinids (chiefly golden shiner) and centrarchids (mainly pumpkinseed) were the most abundant fishes in the inner bay between late May and early August. Brook silverside dominated catches simultaneously in open water and at the shore (see "others" in Fig. 2B) in mid-July, marking the sole occasion when relative abundances were similar at the shore and in open water.

OCCURRENCE OF AGE 1+ FISHES

In addition to age 0+ fishes, age 1+ cyprinids and centrarchids, juvenile and adult banded killifish, Iowa darter, brook silverside, rock bass *Ambloplites rupestris*, and grass pickerel were collected. Most fishes were usually <85 mm TL, although 2 yr-old grass pickerel (105-145 mm; N = 15) were captured in dense submersed plants. These fish inhabited a small drainage ditch, which had become a closed system during low water level in November. Temporally, age 0+ and 1+ fishes utilized shore microhabitats asynchronously, as the number of spawning fish peaked in May and June, whilst the largest number of species hatched about 2 wk later (Table 3). Fewest adult fishes occupied shore areas between late June and early August, when water temperatures were highest and vascular plants most abundant. As temperature decreased and vegetation senesced, the number of taxa increased from three in early August to nine in late October (Table 3). By mid-November, however, few viable submersed macrophytes remained to provide cover for fish. Consequently, just four taxa were found: brook silverside, spottail shiner *Notropis hudsonius*, golden shiner, and grass pickerel.

SEASONAL GROWTH IN LENGTH

Growth in common taxa (Table 4) was difficult to determined, possibly due to the occurrence of two or more cohorts, and in most cases, insufficient specimens of any given species available to samplers on successive dates. Overall variability in length was highest in brook silverside (mean CV = 32%), pumpkinseed (28%), and blacknose shiner (21%), and least in largemouth bass (8%) and central mudminnow (11%). During July, mean lengths of pumpkinseed, brook silverside, and blackchin shiner suggested co-occurrence of at least two cohorts of each species (Table 4). Mean length of central mudminnow increased an average of 0.4 mm/d between late June and late July, when maximum growth rate was probably achieved. Among centrarchids, mean total length of pumpkinseed was 27.1 mm on August 8, whilst mean length of largemouth bass was 66.5 mm in mid-September. At this time, pugnose shiner (N = 4), blackchin shiner (N = 26), and bluegill (N = 9) all averaged 32-34 mm, and age 1+ brook silverside were 94.1 mm (range = 90-98 mm; N = 9). These fish may represent record length for brook silverside in Ontario (Scott and Crossman 1973).

Table 4. Growth in total length (± SD in millimeters) of selected age 0+ fish taxa in inner Long Point Bay, 1985. Number of specimens measured in parentheses.

	Mean length ± SD						
Species	June 12	June 26	July 4	July 11	July 24	Aug 11	Sept 11
Lepomis gibbosus	6.0 1.0 (63)	8.6 2.6 (20)	8.6 3.0 (9)	6.7 2.6 (9)		27.1 5.3 (21)	
Umbra limi		28.6 3.0 (25)	32.7 3.6 (12)	32.6 2.9 (13)	37.2 3.0 (31)		37.4 6.9 (17)
Labidesthes sicculus	4.7 0.5 (24)			6.9 2.9 (40)	25.7 11.5 (25)		
Micropterus salmoides	8.1 0.5 (20)	28.9 4.4 (15)	35.8 4.7 (8)		49.5 4.5 (8)	56.2 (2)	66.6 4.6 (5)
Erimyzon sucetta		14.3 3.9 (19)	19.1 1.6 (17)		28.8 1.5 (5)		
Notemigonus crysoleucas	6.8 2.0 (22)	18.4 2.2 (19)	27.1 1.5 (5)				
Notropis heterodon				7.4 (3)		22.4 5.5 (26)	33.0 4.3 (26)
Notropis heterolepis	7.6 1.4 (15)	13.0 2.0 (22)	11.0 3.1 (17)	7.4 1.8 (24)			43.5 (2)

DESCRIPTION OF *Erimyzon sucetta*

All age 0+ lake chubsucker (N = 48) were collected in a vegetated drainage ditch when water temperatures were high (24-28°C). The first two fish (7.0 and 12.5 mm) were caught on June 12, and the remainder in late June and early July. On June 26 and July 5, fish were 12.5 to 19.1 mm (N = 25) and 16.9 to 23.2 mm in length (N = 17), respectively. According to the length of smallest specimens, lake chubsucker were estimated to have been spawned in late May (at ~20°C) and hatched in early June. Adult fish were caught in vegetation at a boat ramp on May 29, June 13, and July 12. Table 5 gives morphometric and meristic data, and together with illustrations (Figs. 3 and 4), provides details that may help in rapid identification of this fish.

Table 5. Morphometric and meristic data for age 0+ *Erimyzon sucetta.* Mean value and range (lower line) are expressed as percent TL of N fish measured in four size groups (12.1-14.9; 15.1-17.8; 18.1-21.0; 22.7-29.2 mm). Ranges (in parentheses) refer to percentage TL. PD = predorsal, PA = preanal, PO = postanal, H = Head, E = eye, Body = >depth. Fins: D = dorsal, A = anal, Pel = pelvic, Pec = pectoral, C = caudal.

							Myomeres			Fin rays				
N	TL	PD	PA	H	E	Body	PA	PO	Total	D	A	Pel	Pec	C
18	13.7	39	63	23	7	16	27	9	36	9-12	6-7	5-6	4-7	17
	0.7	37-41	61-64	21-24	7-8	15-18	27-28	8-9	35-37					
11	16.8	39	61	23	7	18	27	9	36	11	7	8	10	18
	0.8	37-40	59-63	21-23	7-8	17-19	27-28	8-9	35-37					
11	19.2	38	60	22	7	19	27	9	36	11	7	8	10	18
	0.7	37-39	58-61	22-24		18-20	26-28	8-10	35-37					
6	27.0	38	60	24	7	20	28	9	36	11	7	8	10	18
	2.4	37-40	59-61	22-25	6-7	18-21	27-28	8-9	36-37					

Morphological features

12.1-14.9 mm: body form superficially similar to blacknose dace *Rhinichthys atratulus*. Eye large; mouth small, terminal; origin of dorsal fin slightly anterior to pelvic fin origin (Fig. 3B); maxilla extends to centre of nare; dorsal finfold barely evident, exists from dorsal fin insertion to base of caudal fin; ventral finfold obvious from mid-gut to anus; urostyle flexed upward; caudal fin slightly forked. Standard length 83% (81-85%) TL; peduncle depth 7% (6-7%) TL; eye diameter 33% (30-36% head length, HL); swim bladders (2), 20-22% TL.

15.1-17.8 mm: mouth terminal, not protrusible, but slightly suctorial (Fig. 4B); ventral finfold remnant exists only between pelvic fins and anus; scaled dorsally and dorso-laterally between nape and caudal fin. Standard length 82% (81-83%) TL; peduncle depth 8% (7-9%) TL; eye diameter 33% (30-35%) HL.

18.1-21.0 mm: increased scaling, especially dorso-laterally, but not obvious ventro-laterally. Mouth terminal, lower lip invaginated. Depressed pelvic fins extend just beyond mid-way between pelvic insertion and anus. Standard length 81% (80-83%) TL; peduncle depth 8% (8-9%) TL; eye diameter 31% (29-32%) HL.

22.7-29.2 mm: mouth protrusible, slightly suctorial and inferior; pupil situated higher than mouth opening (Fig. 4C). Standard length 81% (79-84%) TL; peduncle depth 8% (8-9%) TL; eye diameter 29% (25-32%) HL.

Pigmentation

12.1-17.8 mm: a. dorsal aspect - head slightly pigmented between nares and interorbital area, nape and origin of dorsal fin; dorso-lateral series of interspersed large round and small chromatophores extending to mid-caudal peduncle, thence, single line of small chromatophores to caudal fin, where pigment concentrated (Fig. 3A,B).

b. lateral - chromatophores on both jaws; wide, dark stripe on snout continues (barely discernible) through eye, thence to caudal fin, pigmentation widest and most concentrated mid-body; pigment becomes slightly flared at base of caudal fin (Fig. 3B). Essentially devoid of obvious pigmentation above and below body-length stripe; posterior portion of intestine has large surface chromatophores (Fig. 3B). All fin rays, except pelvic, at least partially pigmented. Slight concentration of minute pigment "spots" on dorsal margin of 6-8 procurrent caudal fin rays; large round single chromatophores between origin of pelvic fins and anus; 17 mm - except 3-4 inferior rays on pelvic and pectoral fins, all rays pigmented.

c. ventral - posterior margin of lower lip pigmented, several dark-brown "dashes" at gut; triangular subsurface gular patch (Fig. 3C, 4A,B). Single, irregular series between gut and anus; barely-perceptible double line between anus and caudal fin.

18.1-29.2 mm: a. dorsal aspect - minute chromatophores on first 2 or 3 interradial membranes of dorsal fin; thin line of pigment extends between dorsal fin insertion and procurrent rays of caudal fin (Fig. 3D).

b. lateral - increased blending of pigment on dorso-lateral aspect; essentially pigment-free ventro-laterally (Fig. 3E); generally, pigmentation more extensive at 20 mm than at smaller sizes; edges of all fin rays outlined.

c. ventral - pigment on isthmus, gular region, intestine, and anus fading with increase in length of fish; otherwise, generally unpigmented, including posterior of anus (Fig. 3F).

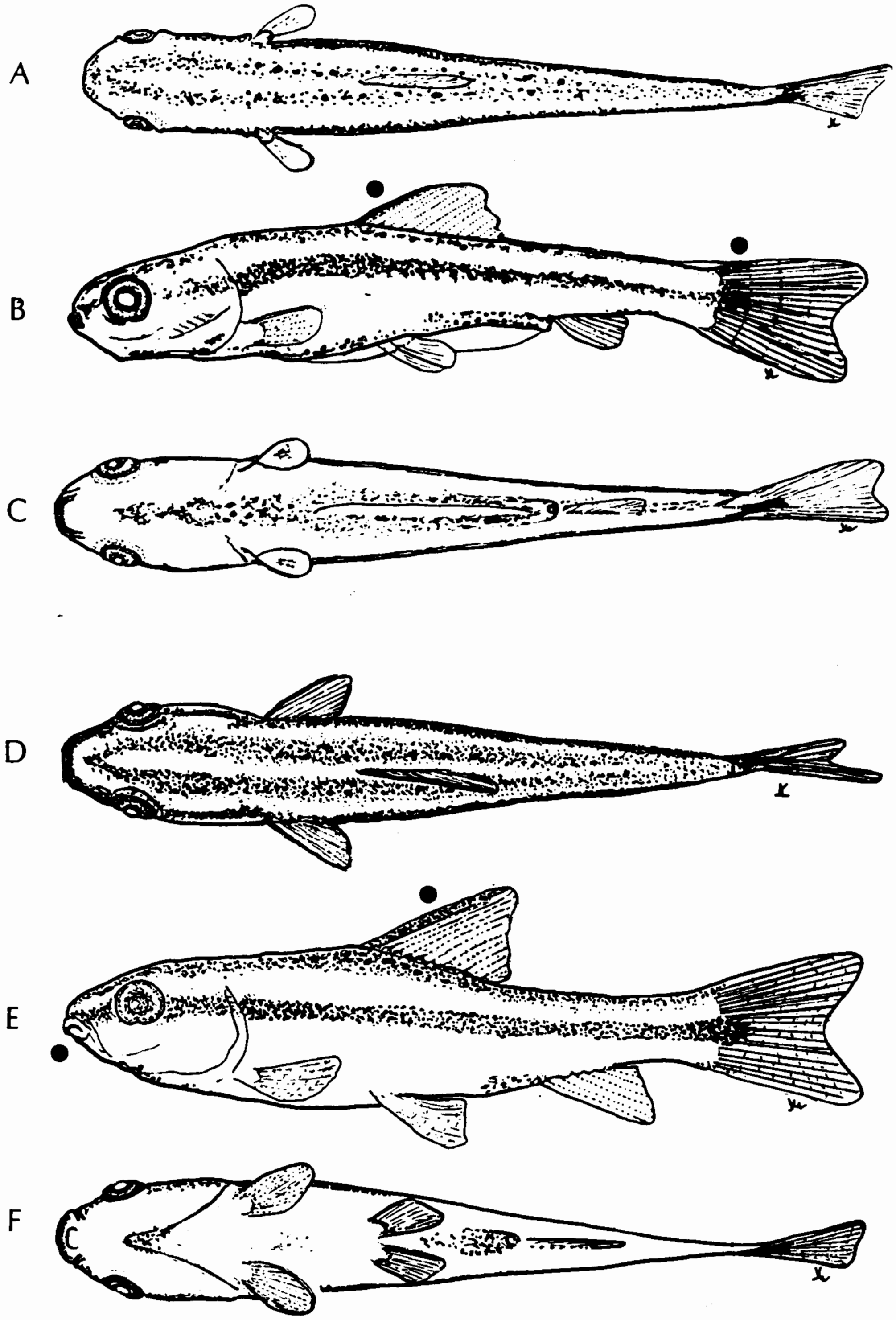


Fig. 3. Dorsal (A), lateral (B), and ventral (C) view of *Erimyzon sucetta* at 13 mm TL, and respective views (D, E, F) at 25 mm. Dots denote location of main distinguishing features.

d. head - pigmentation more concentrated and defined, lateral aspect (Fig. 4C) than in smaller fish (Fig. 4A,B); stripe through eye at 17 mm fades with growth (Fig. 4B,C).

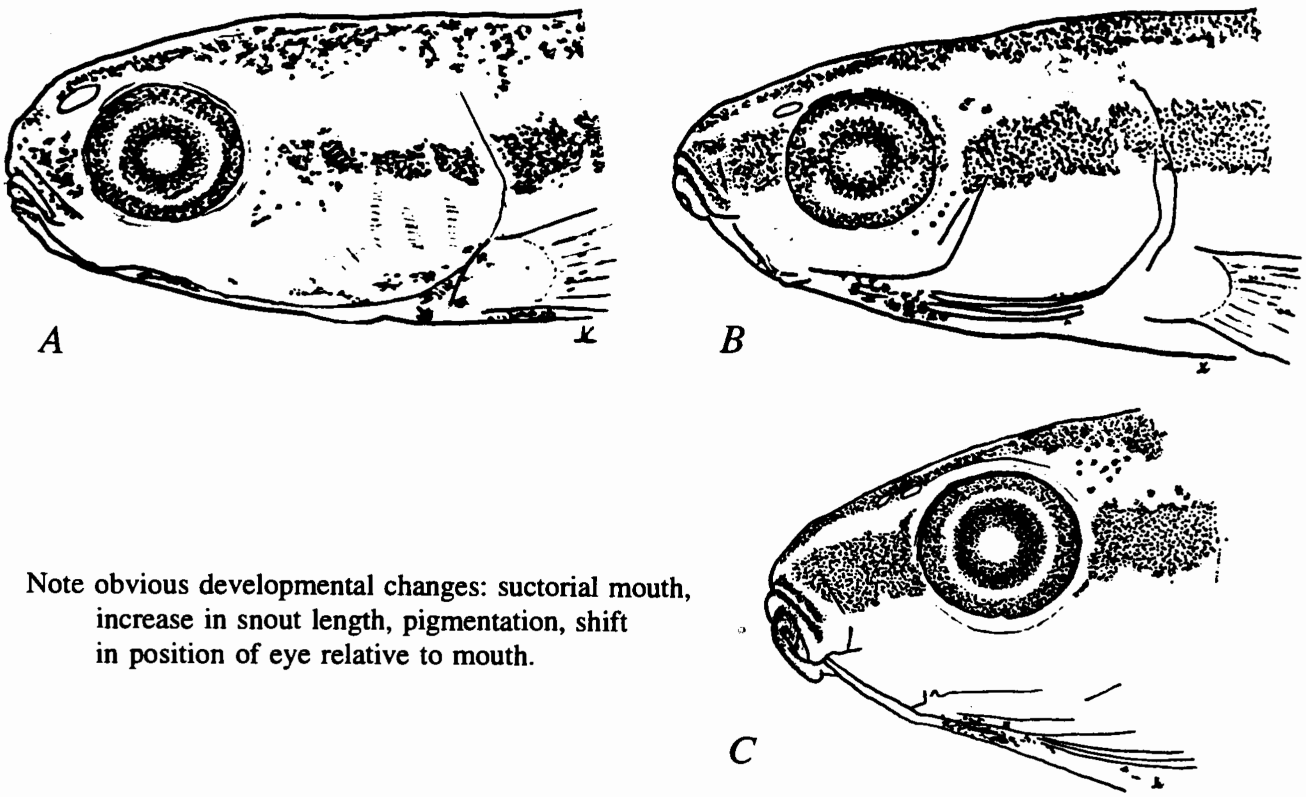


Fig. 3. Development of head in *Erimyzon sucetta* at 13 mm (A), 17 mm (B), and 25 mm (C).

DISCUSSION

Fishes representing 8 of a total of 13 ecoethological guilds in Ontario were found at the south shore of Long Point inner bay. The total fish taxocene (32), which consisted of 27 age 0+ and 28 age 1+ species, utilized numerous microhabitats, including those resulting from human activities. Indeed, fish species diversity was highest in these areas, and lowest where the environment is influenced mainly by natural phenomena. Non-guarding open substratum spawners dominated the assemblage, consistent with their reproductive requirement for freshly-flooded live or dead plants or debris, and sandy bottom. Guarding open substratum spawners were represented mainly by centrarchids, which contributed about half the total number of fish caught. As expected, the age 0+ assemblage in our collections closely parallel age 1+ fishes found in ponds and marshes on Long Point peninsula and the inner bay (Reid 1979 and Halyk 1983 (OMNR unpubl. data); Mahon and Balon 1977a). Seasonal occurrence of newly hatched larvae confirms this shore as a natal area for many species.

The assemblage of fishes in the inner bay probably prevails because it has access to diverse spawning and interconnecting nursery habitats. During ontogeny, many species require a variety of habitat types that accommodate changing needs for food and cover. For such fishes, survival depends on access within and between littoral areas. Although ecosystems in watersheds near or adjoining Long Point Bay are open hydrologically, they are restricted or effectively closed biologically. For example, watersheds in the Toronto (Lake Ontario) area suffer severance of biotic exchanges that seriously affect functioning of associated coastal wetlands (Lemay and Mulamoottil 1984). Urbanization is the root cause of what may be termed "fractionized" fish habitat. As a result, only 64% of the community of fish species utilize wetlands for spawning (Stephenson 1990), as opposed to at least 86% in the inner bay. Similarly, the age 0+ assemblage in Hamilton Harbour, a deep embayment of Lake Ontario, is dominated by transient clupeids that emigrate several weeks after hatching. Littoral species there are hindered from exploiting the open system because of lack of food and cover in the harbour. Low habitat diversity thus necessitates concentration of many fishes within a relatively small littoral zone (Leslie and Timmins 1992). This contrasts with diverse microhabitats available to fishes in the open system of the inner bay.

The percid-centrarchid-cyprinid assemblage in the inner bay is typical of ecosystems in which human interference is moderate or subtle. Such assemblages are found in open systems of Mitchell Bay, eastern Lake St. Clair (Leslie and Timmins 1993) and bays in southeastern Severn Sound, Lake Huron (Leslie and Timmins 1994, 1995). However, where vascular plants are relatively sparse, clupeids and cyprinids are co-dominants, as was observed in shallow Muscote Bay (Leslie and Moore 1985) and low gradient waters in the St. Clair River delta (Leslie and Timmins 1991). Whereas percids typically dominate early assemblages (if any), they emigrate from shore within 2-3 wk of hatching, giving way to centrarachids and cyprinids as new vegetation appears. Centrarchids are often the dominate fishes in densely vegetated closed, or confined waters, such as West Marsh, Lake Erie (Petering and Johnson 1991), St. Clair National Wildlife Area, Lake St. Clair (Leslie and Timmins 1990), and Pentwater Marsh, Lake Michigan (Chubb and Liston 1986).

Pumpkinseed was chronologically the first, and bluegill the last, centrarchid to appear as newly-hatched fish, the former emerging from nests near patches of new growth of, for example, *Najas* and *Vallisneria,* and the latter near established submersed and floating-leaved macrophytes, such as *Ceratophyllum* or *Nymphaea*. Successive cohorts of pumpkinseed larvae throughout late spring and summer confirms its status as a multiple, extended spawner (Scott and Crossman 1973). Migration in July of larger age 0+ pumpkinseed larvae to offshore littoral areas may explain low catches at the shore in mid-summer. This movement may be in response to numerous factors, including high prevailing water temperatures, low water levels, low dissolved oxygen, insufficient food, or predation. It may also accrue in part to an inherent sampling bias toward capture of smaller fish (Leslie and Timmins 1993). In contrast, age 0+ bluegill tend to respond positively to increased stem density (Hayse and Wissing 1996) and generally favour vegetated habitat (Werner 1967; Keast 1980; Conrow et al. 1990), whilst adults avoid dense vegetation (Trautman 1981; Keast 1984). A serotinous shoreward movement of age 1+ largemouth bass and age 0+ bluegill in the inner bay suggests that a direct predator-prey relationship may exist between these species (Trautman 1981).

Centrarchids, most cyprinids, esocids, ictalurids, central mudminnow, bowfin, longnose gar, and brook silverside are typical wetland-dependent fishes (Herdendorf 1987) occurring in our study area. With the exception of incidental high densities of brown bullhead and largemouth bass, no fish was collected consistently in large number. Seasonal density of yellow perch and brook silverside in open water each peaked at about 200 larvae/100 m^3, whilst other taxa were either collected in small number or appeared sporadically. Brook silverside usually occurs in highest density in shallow bays where larvae have clear access to open water. For example, in Mitchell Bay, Lake St. Clair mean densities of brook silverside usually peaked at 300-500/100 m^3 (diurnal) (Leslie and Timmins 1993), whereas nocturnal peak density in a drowned river-mouth wetland on Lake Michigan averaged only 19 during a 3-yr study period (Chubb and Liston 1986). Similarly, in distributary channels of the St. Clair River, mean density of brook silverside peaked at 3/100 m^3 (Leslie and Timmins 1991).

Seasonal persistence of several taxa in a particular area of the bay indicated habitat preference. Brook silverside frequented the offshore fringe of bluejoint grass *Calamagrostis canadensis*, bluestem grasses *Andropogon* spp., and Cyperaceae in clean sand, whereas grass pickerel were located almost exclusively in disturbed areas, such as drainage ditches in the cottage community and provincial park camping areas. Age 1+ grass pickerel were rare in lagoons on Long Point (Mahon and Balon 1977a), or in *Typha* and *Carex* marshes of the inner bay and Big Creek marsh (Halyk 1977 and Reid 1978 (OMNR unpubl. data)). Reproductive habitat for grass pickerel in Long Point inner bay therefore appears to depend somewhat on continuance of sanctuaries resulting from human activities. Congenor northern pike were rare in these habitats, probably because they inhabit deeper water than do grass pickerel at comparable developmental stages.

The ecological status of brook silverside and blackchin shiner, until recently considered vulnerable in Canada (Campbell 1996), does not appear of immediate concern, at least based on ubiquity in coastal marshes (e.g., see Leslie and Moore 1985; Leslie and Timmins 1991; 1992; 1993; 1995). On the other hand, the classification of pugnose shiner as "vulnerable" in Canada seems justified. This taxon requires habitat found extensively along the north shore of Long Point peninsula, i.e., clear, vegetated areas where sand substrate predominates (Scott and Crossman 1973). However, only four age 0+ fish were collected in our sampling area. We attribute the small catch to our sampling habitats that were perhaps marginal for pugnose shiner. The quantity of habitat is limited for other vulnerable fishes in the study area. For example, grass pickerel, central mudminnow, and lake chubsucker usually frequent shallow embayments, floodplains, and ditches where substrate consists of decumbent vegetation and detritus. All, except central mudminnow, tend to migrate if water level decreases to the extent that submersed vegetation begins to appear. Central mudminnow gulps air (Scott and Crossman 1973) to accomplish anaerobiosis in stagnant, oxygen-deficient waters, such as as exist in ditches and shallow, vegetated ponds in Long Point.

Given the high variability in annual abundance of fish larvae, comparisons of growth in fishes originating in different ecosystems provide limited insight into their ecology. This is especially true of collections in single year surveys. Nevertheless, data on growth of age 0+ fishes may indicate relative differences in trophy of water bodies and approximate size of recruits. Unusually high water levels in 1985 may have induced early spawning as a result of increased availability of flooded vegetation. Consequently, many taxa grew faster than usual, thus enhancing survival. In mid-August, mean length of pumpkinseed in Long Point inner bay was 27.1 mm, slightly longer than fish in Mitchell Bay (14.9-25.3 mm) (Leslie and Timmins 1993) and Lake Opinicon, Ontario (24.9 mm) (Keast and Eadie 1984). Overall growth in pumpkinseed was much greater than observed of larvae (8.2-13.9 mm) developing in lower temperatures in Penetang Harbour (Leslie and Timmins 1994). Brook silverside, 25.7 mm in late July, were larger than in four coastal habitats in southeastern Lake Huron, where this fish was relatively small (4.9-17.7 mm) in mid-July (Leslie and Timmins 1994). Length data on central mudminnow are scarce, but fish in the inner bay were 37 mm mean TL in September, assumed the end of growth in the first year. This length approximates that of age 0+ fish (25-53 mm) in New York state (reported in Scott and Crossman 1973). Finally, in Long Point inner bay, blackchin shiner (22-33 mm) were approximately 8 mm smaller in August and September than those collected in Lake Opinicon, whilst bluegill were about the same size (Eadie and Keast 1984).

Little is known of the life history of lake chubsucker in Canada because it is considered of little "beneficial" use to humans, and therefore ignored. However, its potential as a commercial bait fish may be high (Bennett and Childers 1966; Shireman et al. 1978). This fish has been found in ecotone "islands" in southern Ontario, such as Long Point and Rondeau Bay (Lake Erie), sections within the St. Clair watershed, and the Old Ausable Channel on the southern shore of Lake Huron (Mandrak and Crossman 1996). As these habitats are seldom sampled in contemporary fish surveys, lake chubsucker may be more widely distributed than past studies suggest. Nevertheless, its power of dispersal seems limited. Our surveys for fish larvae in remnant wetlands in the lower Great Lakes have located lake chubsucker in only one ecosystem other than Long Point. Adults, approximately 120 mm in length, were found on the Walpole Island in a roadside ditch connected intermittently to the St. Clair River. These specimens, collected at 4°C in early January, were taken from under a layer of leaves in water about 10 cm deep (Leslie and Timmins unpubl. data 1990). The occurrence of these fish therefore updates information provided by Mandrak and Crossman (1996), who reported that lake chubsucker were last recorded in Canada in 1983.

Our description of lake chubsucker, while limited, serves to fill a small gap in taxonomy of the early life history of Great Lakes fishes. Rather than defer this work until the improbable availability of a complete collection of eggs, embryos and larvae, we have described fish at sizes most likely encountered in the field. Fuiman (1979) described 12 specimens (6.8-35.7 mm) of lake chubsucker taken from Singletary Lake, North Carolina and compared them with eastern creek chubsucker *Erimyzon oblongus*. There are no known congeners of *E. sucetta* presently in Canada. Apparently, lake chubsucker prefers vegetated ponds, ditches, and various static open or closed systems, whilst other members of the family (except quillback *Carpiodes cyprinus*) are more often found in lotic systems or in deeper water. As the amount of spawning habitat declines in the face of increasing land use in the Great Lakes, the ecological status of lake chubsucker seems eventually destined to be downgraded to "threatened" (see Campbell 1996).

In conclusion, despite the intuitive nature of ichthyoplankton surveys (Leslie and Timmins 1994), and the small area surveyed, collections confirmed that most species found in our survey reproduced in Long Point inner bay. High species diversity is related to unhindered access between nursery ecotones, including those resulting from human activities. Indeed, at least two species (lake chubsucker and grass pickerel) may benefit from minor environmental disturbances created by humans. Ultimately, survival of the community of fishes depends on our moral imperative in respect to perpetuation of Long Point as a World Biosphere Reserve.

ACKNOWLEDGMENTS

Steve King and James E. Moore helped in field and laboratory. J.D. Fitzsimons and D. Graham improved the manuscript. M.J. Keir and R. Kiriluk assisted with sundry aspects of the study.

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