Canadian Technical Report of
Fisheries and Aquatic Sciences No. 2197

1998

Seasonality of fish in surf zone and tributary of Lake Erie: a comparison

by

J.K. Leslie and C.A. Timmins

Department of Fisheries and Oceans
Great Lakes Laboratory for Fisheries and Aquatic Sciences
867 Lakeshore Road
Burlington, Ontario L7R 4A6

Cat. No. Fs 97-6/2197E ISSN 0706-6457

Correct citation for this publication:

Leslie, J.K., and C.A. Timmins. 1998. Seasonality of fish larvae in surf zone and tributary of Lake Erie: a comparison. Can. Tech. Rept. Fish. and Aquat. Sci. No. 2197.

ABSTRACT

Leslie, J.K., and C.A. Timmins. 1998. Seasonality of fish larvae in surf zone and tributary of Lake Erie: a comparison. Can. Tech. Rept. Fish. Aquat. Sci. 2197.

Fish larvae were collected in the surf zone and at the mouth of a proximate tributary in western Lake Erie. Small mesh (0.4 mm and 3 mm opening) beach seines collected 38 taxa, of which 18 frequented both sites. Fish communities in each habitat were, however, quite distinctive. The assemblages in the surf zone was decidedly seral, dominated by emerald shiner *Notropis atherinoides*, spottail shiner *Notropis hudsonius*, and gizzard shad *Dorosoma cepedianum*. Peak densitiesof these species were low to moderate (<300 larvae/100 m^3). In the tributary, 25 species, representing 7 reproductive guilds, were dominated by fathead minnow *Pimephales promelas* and common carp *Cyprinus carpio*, characteristic fishes of shallow, turbid environments. Occasional reciprocal emigration of larvae occured between surf zone and tributary.

RÉSUMÉ

Leslie, J.K., and C.A. Timmins. 1998. Seasonality of fish larvae in surf zone and tributary of Lake Erie: a comparison. Can. Tech. Rept. Fish. Aquat. Sci. 2197.

On a recueilli des larves de poissons dans la zone de déferlement et à l'embouchure d'un tributaire voisin dans l'ouest du lac Érié. Au moyen de sennes de rivage à mailles fines (ouverture de 0,4 mm et 3 mm), on a recueilli 38 taxons, dont 18 étaient présents aux deux sites. Les communautés de poissons dans chaque habitat étaient toutefois assez distinctes. Les assemblages dans la zone de déferlement étaient nettement des assemblages de transition, dominés par le méné émeraude (*Notropis atherinoides*), la queue à tache noire (*Notropis hudsonius*) et l'alose à gésier (*Dorosoma cepedianum*). Les densités maximales de ces espèces étaient faibles à modérées (<300 larves/100 m^3).Dans le tributaire, 25 espèces, représentant 7 guildes de reproduction, étaient dominées par la tête-de-boule (*Pimephales promelas*) et la carpe (*Cyprinus carpio*), poissons caractéristiques des milieux turbides peu profonds. Une émigration occcasionnelle réciproque de larves a eu lieu entre la zone de déferlement et le tributaire.

INTRODUCTION

Low energy systems, such as sheltered embayments, marshes, and low gradient streams are often moderately or densely vegetated both by planktonic and rooted plants. As such, they provide food and sanctuary for fishes during early development . The high energy surf zone is, in contrast, devoid of vascular plants, burdened with detritis during wave events (Rounsefell 1975), and seemingly a hostile environment for fish larvae. Nevertheless, this zone is utilized by diverse and abundant ichthyofauna (Senta and Kinoshita 1985). Whereas numerous assessments of fish larvae have involved quiescent systems (Jude and Pappas 1992), the high energy shore biotope has been overlooked; certainly, no reports pertain to fishes in the Great Lakes basin, or freshwaters elsewhere in Canada.

We compared seasonality, frequency of occurrence, and density of fish larvae inhabiting the surf zone on an exposed shore and in a proximate tributary in western Lake Erie. This type of information is needed to better understand fish habitats in respect of conservation and rehabilitation in areas subject to human interference. In addition, a contribution is made to the modest fund of data on fish reproduction and early life history.

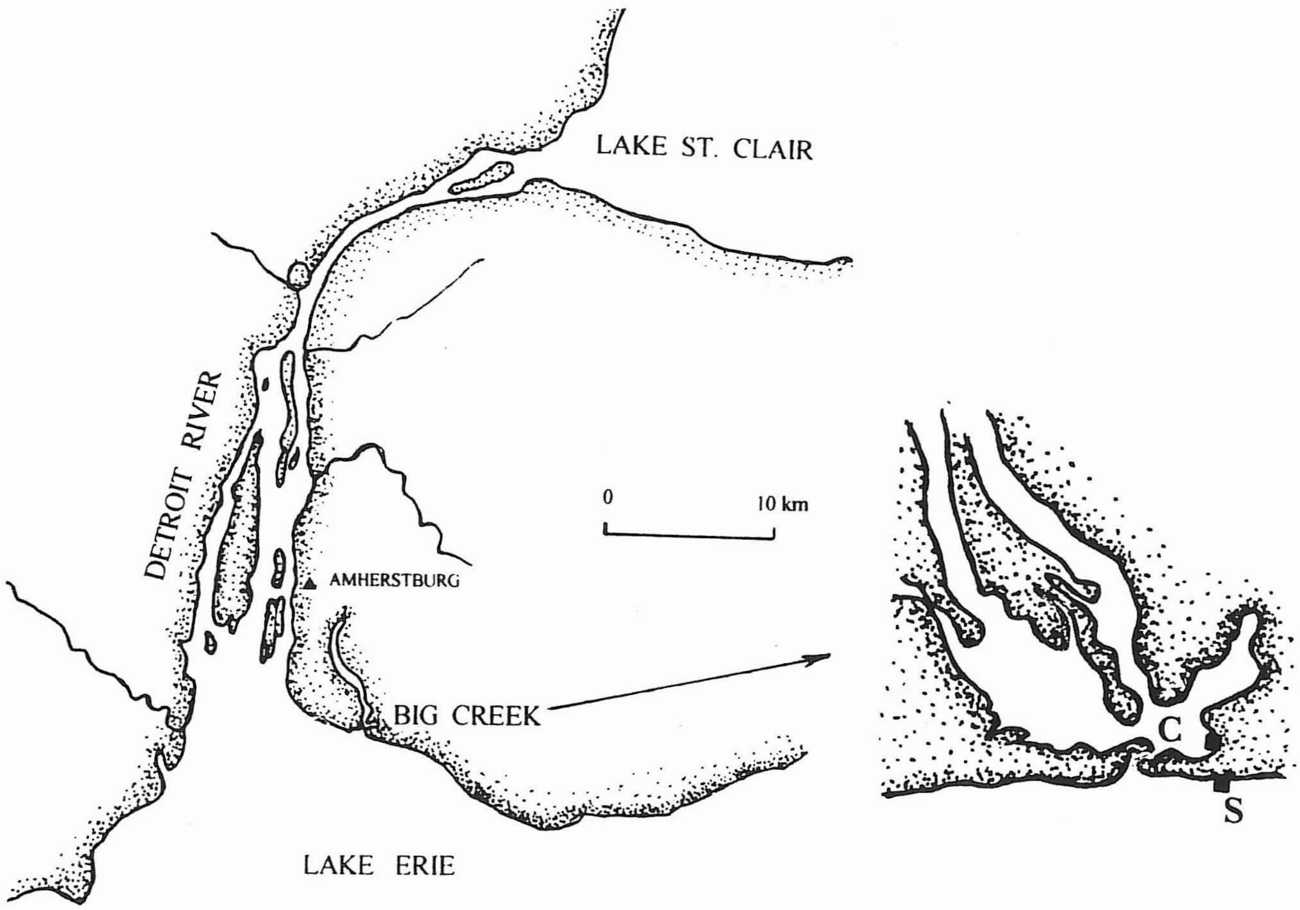

Fig. 1. Map of study area, showing sampling locations S (surf) and C (creek) for age 0+ fishes in 1994

SAMPLING SITES

The study area is located in the western extremity of Lake Erie (Fig. 1), bordered by the intensely-cultivated St. Clair clay plains of Essex County, Ontario. Detailed descriptions of physical, chemical, and biological environments for this area are given in Herdendorf (1987). Sampling sites are located on the north shore of the Detroit River estuary, 12 km south of the town of Amherstburg (Fig. 1). One site was an exposed sandy shore (fetch ~10 km). The surf zone, in which collections were made, contains detritus originating mainly from the Detroit River and Lake St. Clair. This site is located approximately 100 m south of the mouth of a tributary, Big Creek, in what is known as "Holiday Beach", in the Essex Region Conservation Authority. Fish collections were taken 2-3 m from shore, and were thus not in the surf *per se.*

Surface drainage in the extremely low gradient plains is effected by several streams, including Big Creek (Chapman and Putnam 1984). The other site was in Big Creek at the margin of a shallow (mean depth <1m) outlet basin in an acuate delta. Fish collections in Big Creek were hampered by debris (logs, roots, human detritus) and soft substrate of fine alluvium, which hindered seining efficiency. Because of high turbidity, rooted vegetation was absent at our sampling site, although patches of water lilies *Nuphar* and *Nymphae* and dense duckweed *Lemna minor* grew in areas protected from wind effects. Cattail *Typha* sp. and common reed *Phragmites australis* prevail at the margin of the shore. A small enclosure near the outlet of the creek basin is used for culture of common carp *Cyprinus carpio* and goldfish *Carassius auratus*.

MATERIALS AND METHODS

In Lake Erie and Big Creek, fish collections were made in mid-day each week from early May to mid-July. Thereafter, samples were taken once or twice monthly until early November. Because of high waves and turbulence, sampling in the surf zone was not possible on June 6. At each site, a larval fish beach seine (length, 4m; width 1 m; mesh opening 0.4 mm) and a coarse-mesh (3 mm) seine (6 m long, 1 m wide) were hauled parallel to shore at a depth of 1 m for a distance of 10 to 15 m. On each date, up to 6 (usually 2 or 3) seine hauls were made with both seines. Measurements of water temperature, pH, and conductivity were taken just below the water surface, and Secchi disc transparency was measured to a maximum depth of 1.5 m. Concurrently, weather conditions were noted with fish collections.

Collected fishes were immediately 'fixed' with formalin (concentration ~10%). In the laboratory, the catch was sorted to species using taxonomic keys (mainly Auer 1982 for fishes in general, and Fuiman and Witman 1979 and Fuiman et al. 1983 for catostomid and cyprinid species, respectively) and reference samples. All fishes were examined and the most abundant were measured for total length (TL; accuracy ±0.2 mm). Fishes larger than 30 mm were measured to an accuracy of ±1.0 mm TL, using a hand micrometer. Representative samples were then preserved with a solution of Davidson's B or a mixture of 80% ethanol and glycerin (90:10 v/v). Density of most-abundant fishes were estimated, and expressed as number/100 m^3 of water filtered, assuming a catch efficiency of 100%. Fishes encountered at least 46% of sampling dates were arbitrarily considered "common", whilst those found on 29 to 41% of sampling dates were "uncommon.

RESULTS

Environmental characteristics

Mean temperature was 2°C higher in the creek than in the surf zone during May and June. Mean values of conductivity in the creek were more than twice those in the surf zone (Table 1), and accrue to relative differences in nutrient supply to respective waters, one from farming and urban activities, and the other from influent mainly from the Detroit River. Secchi disc transparency in the creek basin was extremely low on all sampling dates.

Table 1. Environmental variables at Holiday Beach, May 11-Nov. 3, 1994.
Values shown with ±SD. N = number of measurements.

		Surf (Lake Erie)	Big Creek
Temperature (°C);		N = 17	N = 16
	Minimum	7.5 Nov. 3	7.5 Nov. 3
	Maximum	27.0 July 6	29.0 July 6
	Mean	19.7 ±4.9	20.9 ±9.0
Conductivity (µS/cm);		N = 16	N = 15
	Minimum	90	175
	Maximum	250	540
	Mean	179 ±51	394 ±126
Secchi depth (m);		N = 12	N = 15
	Minimum	0.2	0.05
	Maximum	1.5	0.2
	Mean	0.6 ±0.4	0.1±0.05
pH			
	Range	7.1-7.8 (N = 3)	7.2-7.6 (N = 2)

Surf zone species occurrence and density

Twenty-eight species (10 families) of age 0+ fishes (Table 2) were found in the surf zone. Except for 9 taxa considered either uncommon or common, most fishes were rarely encountered. Alewife *Alosa pseudoharengus*, gizzard shad *Dorosoma cepedianum*, spottail shiner *Notropis hudsonius*, emerald shiner *Notropis atherinoides*, and white bass *Morone chrysops* were common, whereas brook silverside *Labidesthes sicculus*, white perch *Morone americana*, and yellow perch *Perca flavescens* were uncommon. Open substratum spawning lithophils and phyto-lithophils (Balon 1975) dominated the assemblage, represented by 7 reproductive guilds. Not surprisingly, only 4 phytophils were found in the surf, only one of which (common carp) contributed more than a trace (>0.5%) to total catch (2793 fishes, Table 2).

Table 2. List of fishes collected at the exposed shore of western Lake Erie ("Surf") and in an adjoining creek (Big Creek). % No. = numerical contribution to total catch (N). tr = trace (<0.5% of total catch). f = percent frequency of occurrence for 17 sampling dates. A = collected only as age 1+ fish.

Species	Surf zone (N = 2793) Occurrence	No.	Frequency (%) f	f	No.	Creek habitat (N = 2307) Occurrence
Lepisosteus osseus	Jun 23	tr	6	6	tr	Jun 23
Alosa pseudoharengus	Jun 14-Nov 3	12	59	18	tr	Jun 14-Oct 3
Dorosoma cepedianum	Jun 23-Oct 3	19	53	41	tr	Jun 6-Sep 7
Coregonus clupeaformis				6	tr	May 30
Osmerus mordax	Sep 7	tr	6			
Umbra limi				12	tr	May 11/Jun 28(A)
Notropis hudsonius	May 29-Oct 3	19	59	59	5	May 30-Oct 19
Cyprinus carpio	Jun 14/Jun 27	2	12	94	15	May 11-Oct 19
Pimephales promelas	Jul 6/Jul 6	tr	12	94	42	May 11-Aug 15
Carassius auratus				59	5	May 11-Oct 19
Notropis atherinoides	Jun 23-Nov 3	32	65	29	tr	May 11-Aug 3
Luxilus cornutus				6	tr	Jun 14(A)
Notropis anogenus				6	tr	Sep 7
Pimephales notatus	Jul 6-Aug 3	tr	18	6	tr	May 11(A)
Notropis volucellus	Jun 23-Sep 7	tr	18	12	tr	Aug 3/Nov 3
Cyprinella spiloptera	Jul 6/Sep 7	tr	12			
Opsopoeodus emiliae	Jun 23	tr	6			
Catostomus commersoni	May 29/Jun 14	tr	12	24	12	May 30-Jun 23
Carpiodes cyprinus	May 29-Jul 6	1	29	29	5	May 30-Jul 11
Moxostoma erythrurum	Jun 23-Jul 10	2	18	12	tr	Jun 28/Jul 6
Moxostoma macrolepidotum	Jul 6	tr	6	6	tr	Aug 3
Moxostoma carinatum	Jul 6	tr	6			
Moxostoma sp.	Jul 6	tr	6			
Hypentelium nigricans	Aug 3	tr	6			
Ictiobus cyprinellus				6	9	Jun 3
Ameiurus nebulosus				35	1	Jul 6-Sep 7
Ameiurus melas				6	tr	Aug 15
Labidesthes sicculus	Jun 23-Oct 3	1	41			
Percopsis omiscomaycus	Aug 3/Oct 3	tr	12			
Morone americanus	Jun 23-Oct 3	2	29	12	tr	Jul 6/Sep 20
Morone chrysops	Jun 14-Nov 3	8	47	12	tr	Jun 14/Aug 15
Lepomis cyanellus				18	tr	May 11-Sep 7
Lepomis macrochirus	Jun 23/Jun 27	tr	12	6	tr	Nov 3
Lepomis humilis				12	tr	Sep 7/Oct 3
Ambloplites rupestris	Aug 3	tr	6	6	tr	Jul 20
Micropterus salmoides	Aug 3	tr	6			
Perca flavescens	May 17-Jun 14	1	41	71	3	May 30-Nov 3
Percina caprodes	Jun 14	tr	6			

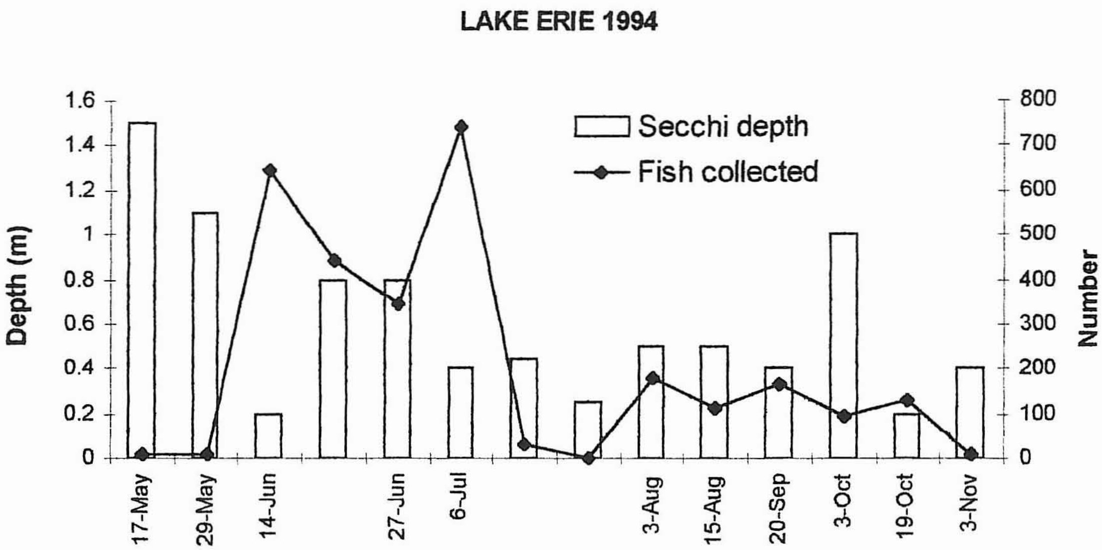

Fig. 2. Seasonal Secchi disc transparency and total number of age 0+ fishes collected in the surf zone.

In the surf zone, several taxa occurred, at least sporadically, in habitat in which they are not usually found. For example, a 156-mm longnose gar *Lepisosteos osseus,* appeared in late July, and common carp and fathead minnow *Pimephales promelas* in mid-June and early July, respectively. These fishes are usually associated with wetlands, rather than exposed coastal areas devoid of rooted plants.

Few fish species occurred in the surf zone in successive weeks or repeatedly throughout the sampling period. Emerald shiner numerically dominated the total catch (Table 2). Spottail shiner was a consistent member of the assemblage in the surf zone. Highest numbers of recently hatched spottail shiner were collected in mid-June, whereas small juveniles were abundant in late summer. Yellow perch appeared earliest (mid-May), then white sucker *Catostomus commersoni*, spottail shiner, and quillback *Carpiodes cyprinus* in late May, followed by logperch *Percina caprodes* (N = 1), emerald shiner, alewife (mid-June at 23°C), gizzard shad, brook silverside, and several catostomid species at 21 to 27°C. Two post-yolk sac rainbow smelt (29 and 32 mm TL) were collected on September 7. Emerald shiner, centrarchids, and ictalurids were collected in highest numbers during early July. A single pugnose minnow *Opsopoeodus emiliae,* was collected on June 23.

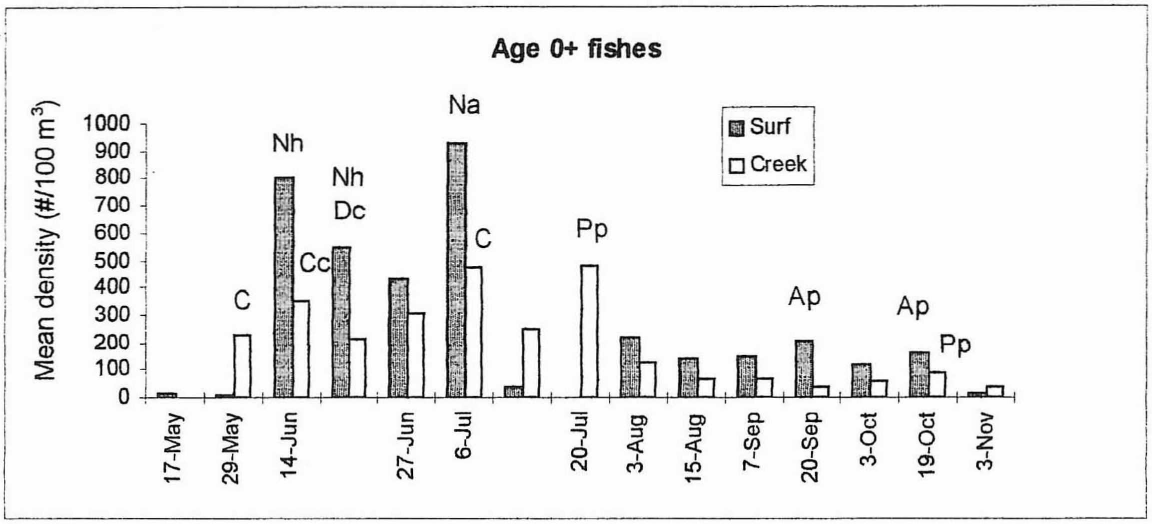

Fig. 3. Mean density of age 0+ fishes collected on exposed shore (Surf) and tributary (Creek) of Lake Erie, 1994. Occurrence of most-abundant species: C = *Cyprinus carpio*, Nh = *Notropis hudsonius*, Dc = *Dorosoma cepedianum*, Na = *Notropis atherinoides*, Cc = *Catostomus commersoni*, Pp = *Pimephales promelas*, Ap = *Alosa pseudoharengus*.

Seasonal composition of dominant fishes in the surf zone changed as successive taxa entered and departed the assemblage. With few exceptions, their appearance was not linked to surf turbulence. On June 14 and July 6, highest catches coincided with lowest water clarity, just as lowest catches occurred (on May 17, and May 29) when water clarity was highest (Fig. 2). There was no direct relationship between these variables, although wind-driven currents may have forced species toward the shore. In late spring, spottail shiner (324/100 m^3) and gizzard shad (214/100 m^3) were more abundant than other taxa. Emerald shiner continued to dominate catches until late summer, when alewife larvae appeared in relatively large numbers. Henceforth, total mean densities remained moderate to low (Fig. 3). High total density of larvae (802/100 m^3) was observed on June 14, when wind was onshore (~10 km/h) and waves were approximately 1 m, and on July 6 (925/100 m^3), when emerald shiner attained their highest density (779/100 m^3).

Calm conditions (no surf) occurred on three dates, when total densities ranged from 144 to 551 larvae/100 m^3, and assemblages were dominated by spottail shiner, clupeids and white bass. Lowest catch (2 fishes) was on July 20, when the surf was very turbulent. Fish species richness and mean total densities in surf and creek basin (Fig. 3; Fig. 4) were neither related ($r_s = 0.289$; Spearman's rank correlation) nor in synchrony. Species richness was highest between late June and early August (Fig. 4), but the assemblage was unstable, as half the number of species were transients.

Big Creek age 0+ fish seasonality and density

Fishes in the creek basin were generally available to samplers more frequently than were those in the surf (Table 2), but few taxa were abundant. For example, yellow perch contributed just 3% to the total catch while appearing on 71% of sampling dates. Likewise, the combined catch (<2% of the total) of spottail shiner, emerald shiner, and gizzard shad was realized on fewer than half the sampling dates (f =

43%). Emerald shiner, which contributed <0.5% to the total catch, probably originated in Lake Erie, since the shallow, turbid creek basin is unlikely nursery habitat for a pelagophil at any stage of development. No apparent relationship existed between Secchi disc depth and number of fishes collected (Fig. 5).

Numbers of age 0+ species (25), families (9), and guilds (7) represented in Big Creek were similar to those in the Lake Erie surf zone, although assemblages, occurrences, and densities differed considerably (Table 2; Fig. 3; Fig. 4). Further, all of the most-abundant fishes that were found in the surf zone appeared sporadically and in low number in Big Creek. Similarly, dominant taxa in Big Creek were numerically insignificant in the surf zone. In general, occurrences of abundant fishes in Big Creek were characteristic of species found in shallow, turbid locales. Common carp and fathead minnow, goldfish, yellow perch, and spottail shiner were numerically dominant fishes in Big Creek, and of these, only fathead minnow (42%) and common carp (15%) were collected in large number. Yellow perch and goldfish were frequent components of the assemblage, but their combined contribution to the total catch was moderate (8%). Typically, however, individuals as well as schools of fish appeared in spates on only one or two occasions.

Species rarely collected outnumbered common or uncommon fishes, of which there were nine. Common shiner *Luxilus cornutus*, bluntnose minnow *Pimephales notatus*, and central mudminnow *Umbra limi* were represented by a small number of adults but not by their larvae. Adfluvial white sucker larvae (12% of total catch) were collected at 18-23 mm TL; their appearance coincided with a dense bloom of phytoplankton in mid-June at 25°C. Gizzard shad, brown bullhead *Ameiurus nebulosus*, quillback, and emerald shiner together contributed fewer fish (6%) to the total catch than did bigmouth buffalo *Ictiobus cyprinellus* (9%). Two "vulnerable" nonindigenous species, bigmouth buffalo and the orangespotted sunfish *Lepomis humilis*, were found once, as was a native "vulnerable" pugnose shiner *Notropis anogenus* (Campbell 1996).

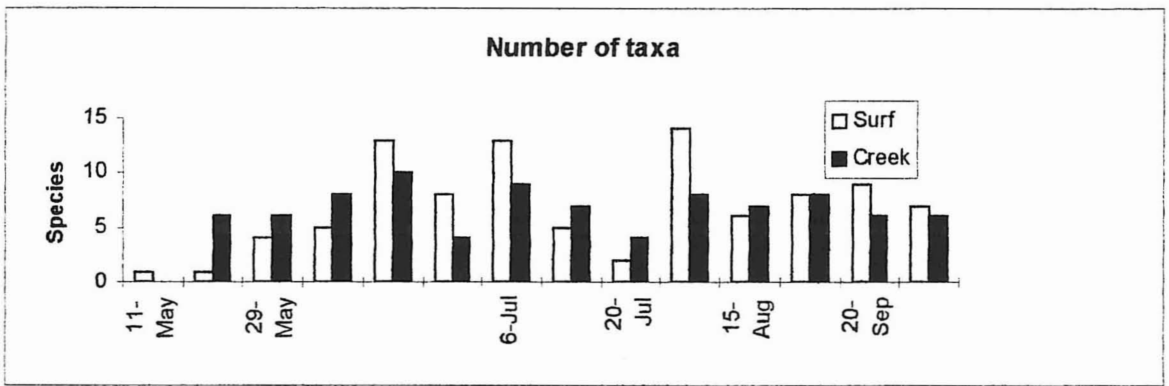

Fig. 4. Number of age 0+ fish species collected in the surf zone and creek basin, Lake Erie, 1994.

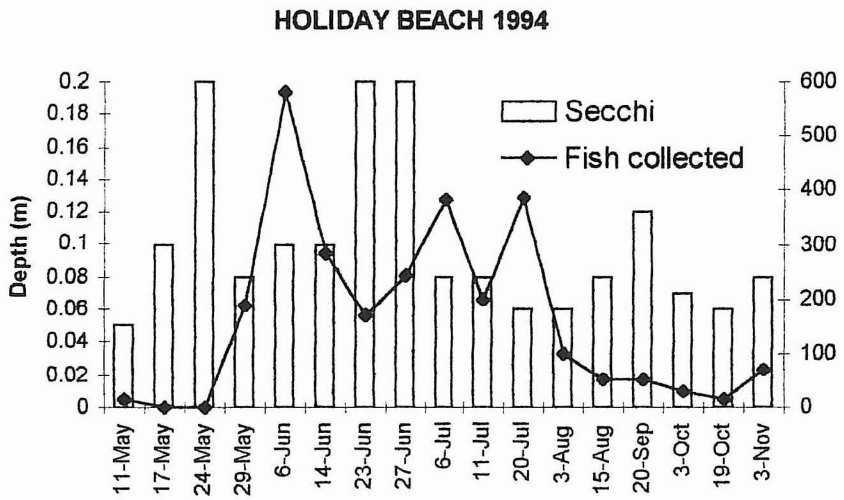

Fig. 5. Secchi disc transparency and total number of fishes collected in Big Creek basin, 1994.

Total fish densities fluctuated according to the number of recently hatched species entering or left the assemblage locally or from the Detroit River. Lithophils were represented by the largest number (11) of taxa, but averaged only 1.6 occurrences. Phytophils were found on an average of 5.8 dates, and phyto-lithophils on 4.4 dates, mediated mostly by regular occurrences of small numbers of yellow perch. On all but four sampling dates, mean density of total species was higher in the surf zone than in the creek basin. Fathead minnow dominated all fishes in Big Creek on 8 dates, common carp on 5 dates, and white sucker once. Fathead minnow, the most abundant fish (253 larvae/100 m^3) in Big Creek, reached maximum density on July 20, common carp (184/100 m^3) on July 6, and white sucker (220/100 m^3) on June 14. Mean total densities were more or less stable after July 20 (Fig. 3).

First year growth in age 0+ fishes in the surf zone

End of year growth in alewife appeared to have been achieved by mid-August, as compared with late September to mid-October in white perch, white bass, gizzard shad, and emerald shiner (Table 3). Two separate groups of alewife were caught on September 20. Alewife exhibited highest variation in mean TL (CV = 24-27%) in late summer, when largest larvae appeared in onshore migrations. Sampler selectivity played a role in these collections. For example, smaller fish (28 mm) were collected with a fine mesh (0.4 mm) seine, whilst 48-mm fish were caught with a 3 mm mesh seine. Brown bullhead ranged in length from 27 to 72 mm (N = 16) in August, whereas goldfish were 22-65 mm (N = 6) in September. Rate of growth in white bass (~0.8 mm/d) was at least twice that in white perch, emerald shiner and gizzard shad.

Table 3. First year growth (TL, mm) in several common fishes collected with fish larvae beach seine in Lake Erie surf zone, 1994. Mean values ± SD are given for each species. N = number of fish measured.

Species	Date	Total length Mean		Range	N
Alosa pseudoharengus	Aug 15	46.1	11.0	28-67	10
	Sep 7	38.9	10.4	23-63	59
	Sep 20	27.8	5.3	22-37	58
	Sep 20*	47.5	4.4	40-57	14
Morone chrysops	Aug 3	55.5	7.0	47-66	11
	Aug 15	61.0	8.1	47-73	31
	Sep 7	83.6	14.6	66-98	7
Dorosoma cepedianum	Aug 15	45.7	5.5	40-56	15
	Sep 20	58.2	8.0	48-91	26
	Oct 3	63.3	3.3	60-70	7
Morone americana	Aug 3	53.8	7.7	45-65	8
	Sep 7	61.1	11.7	42-88	14
	Sep 20	67.6	12.5	52-83	9
	Oct 3	63.3	12.0	43-85	49
Notropis atherinoides	Aug 3	32.9	5.1	27-44	53
	Sep 20	42.4	9.9	30-62	21
	Oct 3	51.5	10.4	30-66	15
	Oct 15	55.0	10.1	26-66	14

*collected with 3 mm-mesh seine

Growth in common carp and fathead minnow in Big Creek

Water temperatures were within the normal spawning range of common carp (Scott and Crossman 1973) throughout spring and much of the summer. Most intense spawning activity was observed at 26°C on June 6. Reproduction probably ceased when water temperature reached 29°C in early July. The first common carp yolk sac larvae (5-7 mm) were collected on May 11. They were subsequently collected in increasing numbers until early June, although peak density occurred in early July, when larvae were 22.9 mm mean TL. At least two cohorts appeared in our collections (Fig. 6), so that their separation was not possible on the basis of total length. Relatively few fish were collected after September, when common carp averaged 73 mm. The largest common carp (155 mm) were collected with our fine-mesh beach seine in early October. Undoubtedly, larger age 0+ fish were present in deeper, unsampled areas.

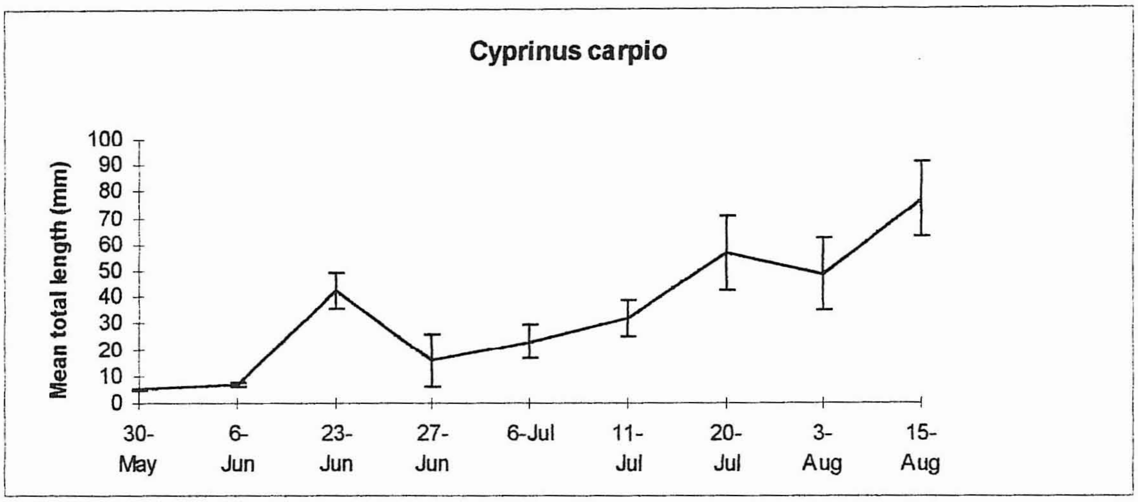

Fig. 6. Growth in length (±1 SD) of age 0+ *Cyprinus carpio* in Big Creek, 1994.

According to the presence of yolk-sac larvae throughout this period, fathead minnow apparently spawned from May to August. First cohorts grew rapidly (0.3 mm/d) during the first week of June and probably attained maximum length by late July (Fig. 7). On September 20, fish were larger (mean TL = 46.4 mm) in an area densely vegetated with water lilies, pondweeds *Potamogeton* spp., and Eurasian watermilfoil *Myriophyllum spicatum,* than at our regular sampling site, where they were 36.7 mm.

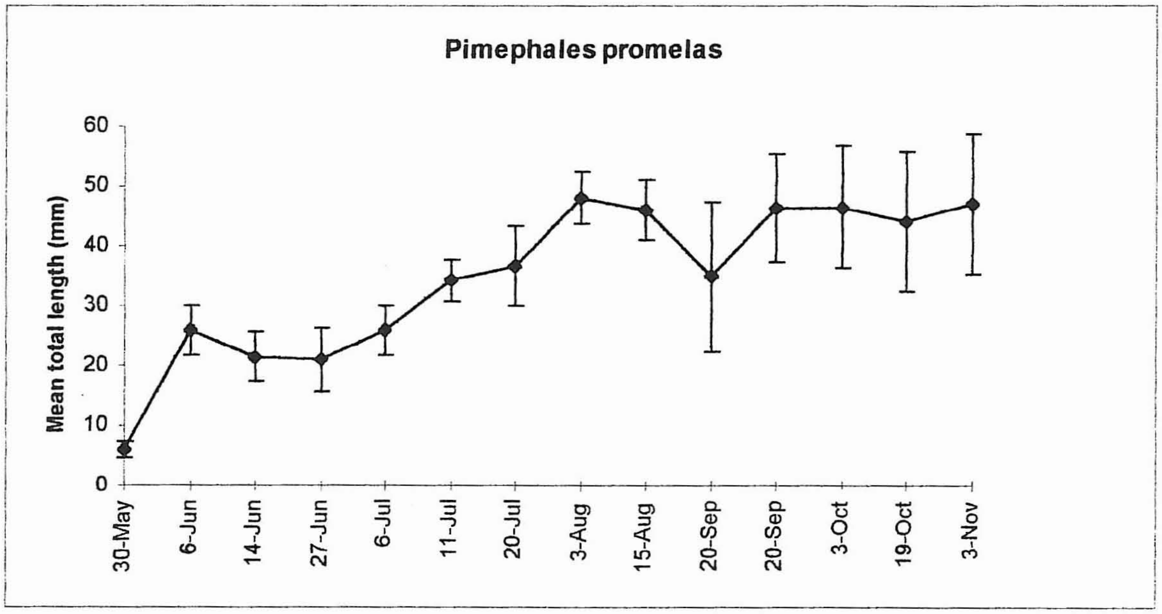

Fig. 7. Growth in length (±1SD) of age 0+ *Pimephales promelas* in Big Creek, 1994.

Age 1+ fishes in the study area

Age 1+ and age 0+ fishes were often caught together throughout the sampling period. Age 1+ common carp, fathead minnow, emerald shiner, central mudminnow *Umbra limi,* and green sunfish *Lepomis cyanellus* were the first species collected (May 11) in Big Creek. Whereas fathead minnow were abundant throughout autumn, common carp became increasingly scarce. Transient channel catfish *Ictalurus punctatus* and freshwater drum *Aplodinotus grunniens* were observed in Big Creek in early June, although larvae were not represented. The first age 1+ fishes collected in the surf zone included emerald shiner, yellow perch, white bass, spottail shiner, and pumpkinseed *Lepomis gibbosus.* The fish assemblage in the surf zone remained essentially constant until early autumn, when logperch (55-71 mm) and alewife replaced the prevailing dominants, emerald shiner, spottail shiner, and white bass. Nevertheless, these species, as well as white perch, persisted until November.

DISCUSSION

The importance of the estuarine littoral area lies in its role as a fish nursery (Rounsefell 1975), whereas tributary streams serve as sources of energy for larger biological sinks, such as the western basin of Lake Erie. Water quality and hydrologic factors effectively separate the two systems ichthyologically, as exemplified by different assemblages of age 0+ fishes. In the surf zone, two cyprinids (emerald shiner, spottail shiner), two clupeids (gizzard shad, alewife), and white bass predominated, whereas common carp and fathead minnow were the sole dominant components of the fish community in the creek basin. Common carp and fathead minnow utilize various environments, but tend to favour shallow standing or slow-flowing turbid waters with clay or organic-rich substrate (Herdendorf 1987). Common carp, fathead minnow, goldfish, central mudminnow, and brown bullhead were among a small suite of taxa that prevailed throughout early ontogeny in Big Creek.

Species composition in the Lake Erie surf zone changed more frequently than in Big Creek, as no individual fish retained numerical dominance more than a few weeks. Thus, the age 0+ fish community may be considered “seral” (Guillory et al. 1979) at the exposed shore of an estuary. Lasiak (1984) found a similar situation in adult fishes, both over the short and long term, in the surf zone of Algoa Bay, South Africa, as did Senta and Kinoshita (1985) of ichthyoplankton in the surf zone of western Japan. Distribution of species at the shore is variously determined abiotically by wind direction and velocity, fetch, shore currents, beach slope and proximity to tributary discharges. In particular, wind speed over the preceding 12-48 h may be the primary abiotic variable in distribution and abundance of nearshore fishes (Lasiak 1984). In some instances, the presence of detached macrophytes in the surf zone are related to food requirements of fishes (Lenanton and Caputi 1989). As the study area is located in an estuary, and fragmented vascular plant matter is abundant, the occurrence of age 0+ fishes may be indirectly related to this source of food. However, our field data were much too scant to link this factor, or wind history with distribution of any particular species in Lake Erie. Total fish seasonal abundances in the surf zone also fluctuate according to wax and wane in individual abundances (Senta and Kinoshita 1985), diurnal and diel dispersal patterns, presence of predators, and age-related distributional factors, such as ontogenetic changes in feeding mode (e.g. lake whitefish, gizzard shad, catostomids).

Seasonal onshore migration of fishes occurs from the limnetic zone, while sporadic reciprocal movement takes place between Lake Erie and Big Creek. Quillback *Carpiodes cyprinus* was the only fish whose frequency of occurrence and abundance were similar in both habitats. Its appearance in the surf zone may stem from excursions from “preferred” habitat (Trautman 1981) in Big Creek. As expected, age zone may stem from excursions from "preferred" habitat (Trautman 1981) in Big Creek. As expected, age 0+ ictalurids were not found in the surf zone, probably because of their intrinsic association with macrophytes in clear or slightly turbid conditions, rather than exposed shore. Gizzard shad larvae occur where water clarity ranges from clear to extremely turbid (Leslie and Timmins 1990), but not in overblooming plankton. In the study area, gizzard shad were much less abundant in the dark-brown and green water of the creek than at the lake shore. This suggests that food (plankton) was more abundant at the shore, or that gizzard shad select against darkly-turbid waters. Highest densities of this fish in the St. Clair plains region are found in "milky" water of agricultural drainage systems (Leslie and Timmins 1990). Alewife and white bass larvae are usually found in waters of medium clarity. More than any species, these phyto-lithophils and the pelagophil, emerald shiner, were expected in the surf zone.

Resource diversity for age 0+ fishes was clearly lacking at both sampling sites, although the creek basin contains contiguous marshy areas and backwaters that provide spawning and rearing habitat. Save for wave-induced turbidity, exposed shores provide minimal protection for larvae, as sand and debris in the surf abrade delicate age 0+ fishes. As well, turbulence reduces visual acuity for prey and predator alike (Rounsefell 1975), reduces photosynthesis and consequently the supply of planktonic food. Sporadic occurrence of redhorse (*Moxostoma* spp.) in the surf zone was undoubtedly the result of fishes hatched in Lake St. Clair and the Detroit River (personal observation), and possibly Big Creek. Planktivorous fishes were most abundant in the surf zone, where several species occasionally co-occurred, although peak densities of each were temporally staggered. For example, spottail shiner, gizzard shad, and alewife spawn at approximately 18-20°C (Scott and Crossman 1973), several weeks before emerald shiner and white bass reproduce at 14-21°C. Of these taxa, only gizzard shad and spottail shiner were co-dominants (Fig. 3).

A feature of fish assemblages, both in Lake Erie and Big Creek, was the almost complete absence of predators, the small number of centrarchids, and absence of yolk-sac rainbow smelt. A single largemouth bass *Micropterus salmoides* (55 mm TL) collected in the surf zone, and a longnose gar in both habitats, were the only piscivores found in the study area. Age 0+ predatory species are unlikely occupants of the surf zone for the same reasons that other fish larvae and small juveniles tend to avoid it. Further, because centrarchids are strongly dependent on rooted vegetation for spawning, feeding, and refuge, they favoured neither surf zone nor outlet basin. Centrarchids are cover-oriented fishes, thus, they probably originated in vegetated subhabitats of Big Creek. More centrarchid and ictalurid species (if not representatives of other families) probably would have been encountered had we established numerous sampling sites (Leslie and Timmins 1994; 1997) spanning a range of niches. Although Hatcher and Nester (1983) identified rainbow smelt spawning habitat in the lower Detroit River, no newly-hatched larvae were dispersed into our surf site in Lake Erie. As dispersal of these small larvae is typically sporadic and brief, the hatch of rainbow smelt may have occurred in the surf zone exclusive of our sampling "window".

In open systems, (e.g., Lake Erie) accurate determination of density and growth in fish larvae are often beyond the reach of ichthyoplanktologists. This accrues from complex synergistic factors, habitat site selection, and temporal and spatial considerations, not to mention sampling bias. Moreover, in recent years, food chain dynamics in Lake Erie have been affected by enormous populations of recently invading nonindigenous mussels *Dreissena* spp. (Dermott and Kerec 1997), which influence food availability and growth in all biota, including age 0+ fishes. Unfortunately, comparative data are scarce on fish larvae growth and diet during the pre-mussel invasion (as well as contemporarily) in the Great Lakes.

Fish length at the "end" of first year growth may provide a crude indication of the ecological status of a water body and hence the success expected of the year class (Schiemer et al. 1991). As fish growth varies annually within and between ecosystems, this aspect of fish ecology often confounds models. For example, alewife were 18-19 mm long in eutrophic Bay of Quinte and Hamilton Harbour (Leslie and Moore 1985; Leslie and Timmins 1992a), 32 mm in mesotrophic Severn Sound (Leslie and Timmins 1994; 1997), and 28-48 mm in the present study. Similarly, gizzard shad (63 mm) in the surf zone were generally larger than their counterparts in Hamilton Harbour (26 mm) (Leslie and Timmins 1992a), but slightly smaller than in the Bay of Quinte (71 mm) (Leslie and Moore 1985). White bass, on the other hand, were relatively small (66-98 mm) compared with those reported of Lake Erie fish (Trautman 1981) and 127-200 mm in central Ontario (Scott and Crossman 1973). The disparity between occurrence and total catch in the surf zone and Big Creek precluded comparison of seasonal growth and mean density of any taxon.

Peak densities of most species were generally low (<50/100 m^3), whether of larvae in the surf zone or in the creek basin. While gizzard shad was one of the most abundant fish in the surf zone, peak density reached 214 larvae/100 m^3, which is much lower than observed (20,169/100 m^3) in agricultural ditches in the St. Clair flats (Leslie and Timmins 1990). They were similar to densities in the Bay of Quinte (100-263/100 m^3) (Leslie and Moore 1985), however, as were densities of white perch and spottail shiner. Density estimates of post-yolk sac common carp probably were not realistic because our samples were collected in shallow water at the margin of the creek basin, from which common carp move shortly after hatching. Further, our collections are increasingly inaccurate as fish become more elusive. In any case, this taxon is a challenge to collect accurately, since it often occupies habitat that is inaccessible to active samplers. Accordingly, our estimates of peak density in Big Creek (184/100 m^3) were probably conservative.

Seasonal growth in common carp and fathead minnow reflect protracted spawning in Big Creek and/or infiltration of fish into our sampling zone from various nursery areas. In the present case, separation of cohorts on the basis of size is therefore problematic. Additionally, size frequency of fish of both species was probably skewed negatively because of increasing escape capability with size (Taber 1969), the affect of decreasing collection efficiency as fish grow (Stott and Russell 1979) and too few replicate samples (Leslie 1986; Allen et al. 1992; Leslie and Timmins 1992a, b, c).

As our survey was preliminary, future research may include a more thorough examination of fish communities in the creek proper, throughout the creek outlet basin, the Lake Erie littoral zone, and shore north of Big Creek (Fig. 1). This would provide a clearer understanding of seasonal contribution of fish species to the surf zone (and Big Creek) from Lake Erie and the Detroit River.

ACKNOWLEDGEMENTS

We are grateful to Drs. O. Johannsson and J.R.M. Kelso, whose reviews improved the quality of the manuscript.

REFERENCES

Allen, D.M., S.K. Service, and M.V. Ogburn-Mathhews. 1992. Factors influencing the collection efficiency of estuarine fishes. Trans. Amer. Fish. Soc. 121: 234-244.

Auer, N.A. (ed.). 1982. Identification of larval fishes of the Great Lakes basin with emphasis on the Lake Michigan drainage. Great Lakes Fisheries Commission, Ann Arbor, MI 48105. Special Pub. 82-3: 744 pp.

Balon, E.K. 1975. 1975. Reproductive guilds of fishes: a proposal and definition. J. Fish. Res. Board Can. 32: 821-864.

Campbell, R.R. 1996. Rare and endangered fishes and marine mammals of Canada: COSEWIC fish and marine mammal subcommittee status reports: X. Canadian Field-Nat. 110:454-461.

Chapman, L.J., and D.F. Putnam. 1984. The physiography of southern Ontario; Ontario Geological Survey, Special Volume 2. 3rd edition. Toronto. 386 p.

Dermott, R., and D. Kerec. 1997. Changes to the deepwater benthos of eastern Lake Erie since the invasion of *Dreissena*: 1979-1993. Can. J. Fish. Aquat. Sci. 54: 922-930.

Fuiman, L.A., and D.C. Witman. 1979. Descriptions and comparisons of catostomid fish larvae: North Atlantic drainage species. Trans. Amer. Fish Soc. 108:560-603.

Fuiman, L.A., and five co-authors. 1983. State of the art of identification for cyprinid fish larvae from eastern North America. Trans. Amer. Fish. Soc. 112:319-332.

Guillory, V., M.D. Jones, and M. Rebel. 1979. A comparison of fish communities in vegetated and beach habitats. Florida Scientist. 42:113-122.

Hatcher, C.O., and R.T. Nester. 1983. Distribution and abundance of fish larvae in the St. Clair and Detroit Rivers. Great Lakes Fish. Lab. Admin. Rept. 83-5. USFWS-GLLFL/AR-83-5. 41 p+app.

Herdendorf, C.E. 1987. The ecology of the coastal marshes of western Lake Erie: a community profile. U.S. Fish Wildl. Serv. Biol. Rep. 85(7.9).

Jude, D.J., and J. Pappas. 1992. Fish utilization of Great Lakes coastal wetlands. J. Great Lakes Res. 18:651-672.

Lasiak, T.A. 1984. Structural aspects of the surf-zone fish assemblage at King's Beach, Algoa Bay, South Africa: long-term fluctuations. Estuarine, Coastal and Shelf Sci. 18: 459-483.

Lenanton, R.C.J., and N. Caputi. 1989. The roles of food supply and shelter in the relationship between fishes, in particular *Cnidoglanis macrocephalus* (Valenciennes). and detached macrophytes in the surf zone of sandy beaches. Exp. Mar. Biol. Ecol. 128: 165-176.

Leslie, J.K., and J.E. Moore. 1985. Ecology of young-of-the-year fish in Muscote Bay (Bay of Quinte), Lake Ontario. Can. Tech. Rep. Fish. Aquat. Sciences 1377. 63 p.

Leslie, J.K. 1986. Nearshore contagion and sampling of freshwater larval fish. J. Plankton Res. 8: 1137-1147.

Leslie, J.K., and C.A. Timmins. 1990. The community of young fish in drainage ditches in southwestern Ontario. Arch. Hydrobiol. 118:227-240.

Leslie, J.K., and C.A. Timmins. 1992a. Distribution and abundance of larval fish in Hamilton Harbour, a severely degraded embayment of Lake Ontario. J. Great Lakes Res. 18: 700-708.

Leslie, J.K., and C.A. Timmins. 1992b. Enhancement of ecological studies of freshwater larval fish: shore sampling. J. Appl. Ichthyol. 8:214-221.

Leslie, J.K., and C.A. Timmins. 1992c. Beach seine collections of freshwater larval fish at the shore of lakes. Fish. Research 15:243-251.

Leslie, J.K., and C.A. Timmins. 1994. Habitat distribution in relation to sample collections of young-of-year fishes. Pol. Arch. Hydrobiol. 41: 301-310.

Leslie, J.K., and C.A. Timmins. 1997. Early life of fishes in Penetang Harbour, an Area of Concern in Severn Sound. Can. Tech. Rep. Fish Aquat. Sci. No. 2188.

Rounsefell, G.A. 1975. Ecology, utilization, and management of marine fisheries. The C.V. Mosby Co., Saint Louis, MO. 516 pp.

Schiemer, F., T. Spindler, H. Wintersberger, A. Schneider, and A. Chovanec. 1991. Fish fry associations: important indicators for the ecological status of large rivers. Verh. Internat. Verein. Limnol. 24: 2497-2500.

Scott, W.B., and E.J. Crossman 1973. Freshwater fishes of Canada. Bull. Fish. Res. Board Can. 184: 966 pp.

Senta, T., and I. Kinoshita. 1985. Larval and juvenile fishes occurring in the surf zones of western Japan. Trans. Amer. Fish. Soc. 114: 609-618.

Stott, B., and I.C. Russell. 1979. An estimate of a fish population which proved to be wrong. Fish. Mgmt. 10: 169-171.

Taber, C.A. 1969. The distribution and identification of larval fishes in the Buncombe Creek arm of Lake Texoma with observations on spawning habits and relative abundance. Ph.D. Diss., Univ. Oklahoma, Norman OK.

Trautman, M.B. 1981. The fishes of Ohio. Ohio State Univ. Press, Columbus, OH. 782 p.