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7 The Near-shore Macrobenthos of the Island Region of Western Lake Erie

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Many studies and reviews of the deep-water or lakeward areas of the western basin have chronicled in detail the dramatic changes in the macrobenthos during the past half century. This history has recorded the demise of the fauna dominated by *Hexagenia* mayflies, *Oecetis* caddisflies, and Unionidae clams and its virtual replacement by Oligochaete and Chironomidae typical of declining water quality (Wood and Fink 1984).

In contrast, the shore (0 to 1m depth) and near-shore macrobenthos around the islands have not been reported on in detail since the late 1920s and 1930s. Krecker and Lancaster (1933) and Shelford and Boesel (1942), from their respective studies in the summers of 1929, 1930, and 1937, reported the presence of a rich and largely loticlike fauna in the shallows around the Bass and nearby islands. The purpose of the present study was to investigate the condition of this fauna about forty years later. We concentrated our efforts on the macrobenthos living on flat and angular rubble in a 0 to 1m depth of water since that was the zone in which Krecker and Lancaster found the benthos to be richest in both variety and abundance (except for Chironomidae). We also investigated to a lesser degree the near-shore fauna in 1–9 m of water.

Methods

The shore zone (0 to 1m depth) was sampled qualitatively and quantitatively from twenty-three stations in the Bass Islands area (fig. 1) from May 28 to August 6, 1974. Flat and angular rocks were lifted from the water and attached organisms were picked or washed off. Roughly 2.0 m^2 of rock surface area from seventeen rocks was sampled quantitatively. The surface area of the rock was estimated by measuring *all* sides of each rock with a ruler.

Flat areas of large boulders and shelving rock (see Krecker and Lancaster for a description of different substrate types around the islands) were occasionally sampled by scraping with an aquarium net. Adult aquatic insects were sampled by aerial sweep netting and by picking up adults, attracted by nearby lights, that became attached to buildings and boats. Additional observations and collections for adult mayflies, using methods as noted above and also using our own light traps, were made on June 4 and 5, 1976, and May 30–June 3, 1985. Also on July 7–8, 1975, William L. Peters (pers. comm.) collected some *Hexagenia rigida* from the side of a building on South Bass Island. In an attempt to collect some larval *Psephenus herricki*, flat and angular rocks adjacent to Gibraltar Island by Alligator Bar and from Alligator Bar were sampled for thirty-five minutes on June 4, 1985.

A clam dredge 0.6 m in width with a fine mesh nylon bag was used to sample the near-shore zone, 1–9 m in depth, from thirty-five stations (fig. 1). Substrata varied from mud and sand to rubble and bedrock. The dredge was used sixty times.

Results and Discussion

The shore zone, 0 to 1m depth: similarities to the 1930s

Figure 2 is our attempt to compare as directly as possible the results of Krecker and Lancaster's and Shelford and Boesel's studies with ours. Limitations of such a comparison stem from different sampling methods and analysis of data and different levels of taxonomic identification employed in the three studies. Also the percentage abundance of the various taxa might be expected to vary, often greatly, from year to year depending on differing climatic patterns. In our study we tabulated the surface area quantitatively sampled as that of total rock

Fig. 7.1. Summer 1974 shore (0–1 m depth, circles) and near-shore (1–9 m depth, squares) macrobenthic sampling stations. B, Ballast Island; M, Middle Bass Island; N, North Bass Island; S, South Bass Island.

surface area of only those rocks we picked organisms from. In the other two studies in the 0 to 1m zone, quadrats were used (1 yd^2 and 0.1 m^2 for the above two studies respectively); thus the surface area sampled in these studies is not exactly comparable to our 1974 study. Despite the problems above, several important points are readily apparent from figure 2 and from qualitative data reported in the three studies.

In all three studies (fig. 2) the fauna is largely a lotic-like fauna dominated by Hydropsychidae caddisfly larvae and Chironomidae larvae. The most numerous Chironomidae included members of the genus *Cricotopus* of which *C. triannulatus* (MacQuart) (formerly *C. exilis* Johannsen) and *C. politus* (Coquillett) were the most abundant on hard rock substrata (Boesel 1983). In our 1974 study, the caddisfly larvae of *Symphitopsyche recurvata* (formerly *Hydropsyche recurvata*) and *Cheumatopsyche campyla* were often so abundant that their retreats literally covered the sides and bottoms of many rocks. These two species comprised 44 and 19% respectively of the total macrobenthos in the quantitative samples. *S. recurvata* was dominant in the early part of the summer while *C. campyla* was dominant from July on. Hydropsychidae larvae were also important members of the shore fauna of the Canadian shores of all the Great Lakes, and *Hydropsyche quttata* Pictet, *Symphitopsyche recurvata*, and *Cheumatopsyche campyla* were reported from the Canadian shore of the western basin (Barton 1976). Hydropsychidae caddisfly larvae were so prevalent in the summer of 1937 that Shelford and Boesel characterized this zone as the *Hydropsyche-Elimia* (as *Goniobasis*) zone. The snail *Elimia livescens livescens* was also very common in our study. However, we would not pick it to represent the shallow (0 to 1m depth) zone, since it clearly prefers quieter water in more protected locations (Krecker 1924; Wiebe 1926; Dennis 1928) such as protected docks; much of the flat and angular rock habitat in the 0 to 1m zone is exposed to the full force of the waves. In protected areas this snail could be found in very large numbers, often just below the water line.

The larvae and adults of *Stenelmis crenata* riffle beetles were common and omnipresent components of the macrobenthos in the 1930s and 1970s (and 1985) as well as Heptageniidae mayfly larvae (fig. 2). Shelford and Boesel reported *Stenonema femoratum* (as *S. tripunctatum* Banks) and *S. pulchellum* as the two most abundant Heptageniidae. Jenkins (1939) from adult collections (June 15 to September 1, 1938, and part of this period in 1939) found *S. femoratum* (as *S. femoratum*, *S. tripunctatum* and *S. scitulum* Traver), *Stenacron interpunctatum* and *Stenonema pulchellum* to be the most abundant Heptageniids in that order of decreasing abundance. The most abundant Heptageniid larva collected in our survey was *S. pulchellum* at 4.0/m^2, and we also collected a few specimens of *S. femoratum* and *Stenacron gildersleevei*. *S. pulchellum* was also the most common Heptageniid larva collected along the mainland Canadian shores of Lake Erie (Barton 1976). Krecker and Lancaster found *Heptagenia* to be the second most abundant mayfly in 1929–30. Most of these specimens probably include the *Stenonema* and *Stenacron* species listed above, since both these genera were included in *Heptagenia* until Traver (1933) erected the genus *Stenonema* and Jensen (1974) erected *Stenacron* from several *Stenonema* species. However, at

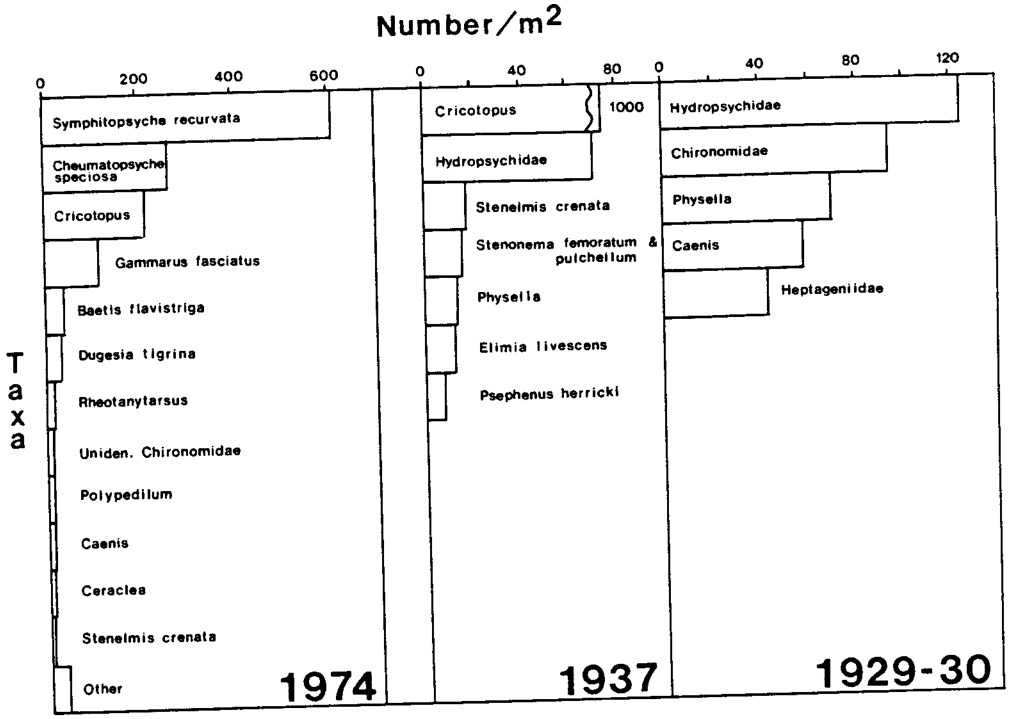

Fig. 7.2. Comparison of benthic surveys in the shore zone (0–1 m depth) of the Bass islands area of the western basin of Lake Erie. 1974, present study; 1937, data from Shelford and Boesel (1942); 1929–30, data from Krecker and Lancaster (1933).

least two species of *Heptagenia, H. hebe* McDunnough and *H. maculipennis* Walsh, were collected from the Canadian shore of the western basin in 1974 (Barton 1976). Jenkins also collected these two species in addition to two other *Heptagenia, H. aphrodite* McDunnough and *H. juno* McDunnough.

The most abundant mayfly larva in 1974 was *Baetis flavistriga* (formerly *B. phoebus* McDunnough), which was also the fifth most abundant macroinvertebrate in our quantitative collections at 39.5/m^2 (fig. 2). Strictly a shallow shore-zone resident, *B. flavistrige* was found to be abundant at depths of 0–15 cm but rare at depths greater than 15 cm in Douglas Lake, Michigan (Lyman 1955). *Caenis* was the second most abundant mayfly and tenth most abundant macroinvertebrate in 1974 at 12.5/m^2 (fig. 2). In 1929–30, *Caenis* accounted for 15% of the fauna (Krecker and Lancaster) (fig. 2). *Caenis* spp. were also well represented in adult collections of 1938–39 (Jenkins).

The planarian *Dugesia tigrina* at 33.9/m^2 was very common in 1974 (fig. 2), and was one of the few invertebrates that could occur abundantly on smooth rounded rocks and boulders. This planarian was present in the 1930s as well (Krecker and Lancaster) and was probably as common then.

Chironomidae other than *Cricotopus* were also very common in 1974 (table 1), especially members of the genera *Rheotanytarsus* and *Polypedilum* (fig. 2). Snails of the genus *Physella* (formerly *Physa*) were important constituents of the macroinvertebrate fauna in the 1930s (fig. 2) and in 1974. *Physella gyrina* and *P. integra* were abundant in 1974, but generally in quiet protected areas, where numbers could reach 200/m^2 or more. In addition, *Fossaria* (formerly *Lymnaea*) snails were common in such areas. *Bithinia tentaculate* snails, formerly abundant in the lakeward area of the western basin (Wood and Fink 1984), were found in some numbers at two North Bass Island shore stations.

Important caddisflies other than hydropsychidae included *Ceraclea* (10.5/m^2) and *Neureclipsis* (1.0/m^2) which were both common, and *Ceraclea* (10.5/m^2) and *Neureclipsis* (1.0/m^2) which were both common, and *Oecetis* which was occasional in the shallow shore zone. *Ceraclea* was also common in Krecker and Lancaster's study. We did not collect any specimens of *Molanna* since we did not sample in its preferred habitat of sand and mud (Wiggins 1977), except with the relatively inefficient clam dredge in deeper water offshore. Krecker and Lancaster and Shelford and Boesel reported this species, as well as Marshall (1939) from light-trap collections in 1937.

A variety of other macroinvertebrates were encoun-

Table 7.1 Macrobenthos of the Shore (0–1 m) and Near-shore (1–9 m) Areas of the Bass Islands, Summers 1974–76, and 1985

Taxon	[a]*#/m*^{2}
Ephemeroptera	(56.0)
[b]*Baetis flavistriga* McDunnough	39.5
Caenis	12.5
Stenonema pulchellum (Walsh)	4.0
[c]*Stenonema femoratum* (Say)	
[d]*Stenacron interpunctatum* (Say)	
[e]*Stenacron gildersleevei* (Traver)	
[f]*Hexagenia limbata* (Serville)	
[f]*Hexagenia rigida* McDunnough	
[f]*Ephemera simulans* Walker	
Trichoptera	(888.0)
[g]*Symphitopsyche recurvata* (Banks)	610.5
Cheumatopsyche campyla Ross	263.5
Neureclipsis	1.0
Cyrnellus fraternus (Banks)	
Polycentropus	
Ceraclea [*cancellata* (Betten), *transversa* (Hagen), *tarsipunctata* (Vorhies)]	10.5
Oecetis	0.5
Nectopsyche	
Hydroptila	0.5
Orthotrichia	
Diptera-Chironomidae	(277.0)
Cricotopus	216.5
Psectrocladius	2.5
Trichocladius	0.5
Dicrotendipes	4.5
Glyptotendipes	3.5
Microtendipes	1.5
Parachironomus	1.0
Cryptochironomus	
Polypedilum	14.0
Chironomus	
Pseudochironomus	0.5
Rheotanytarsus	17.5
Tanytarsini	
Procladius	
Tanypodinae	
unidentified larvae	15.0
Amphipoda	(113.5)
Gammarus fasciatus Say	113.5
Isopoda	(3.0)
Asellus intermedius Forbes	3.0
Asellus racovitzai racovitzai Williams	
[b]*Helicopsyche borealis* (Hagen)	
Leptoceridae pupae	0.5
unidentified larvae	1.0
Coleoptera	(9.0)
Stenelmis crenat (Say) larvae	5.0
adults	1.5
Nacronychus glabratus Say	
Lutrochus laticeps Casey	2.0
Anchytarsus bicolor (Melsheimer)	0.5
Ectopria nervosa (Melsheimer)	
[i]*Psephenus herricki* (De Kay)	
Lepidoptera	(0.5)
[i]*Petrophila*	0.5
Odonata	
Enallagma exsulans (Hagen)	
Hemiptera-Corixidae	
Diptera	(6.0)
Antocha	1.0
Tipulidae	3.0
Empididae	
Simuliidae	0.5
Hemerodromia ?	
unidentified larvae	1.5
[m]*Elimia livescens livescens* (Menke)	
Bithynia tentaculata (Linnaeus)	
Ferrissia	
Gyraulus deflectus (Say)	
Valvata	
Pelecypoda	
[n]Unionidae (12 live and 13 dead collected by dredge)	
Quadrula pustulosa (Lea)	[1,0]
Amblema costata (Rafinesque)	[1,0]
Fusconaia flava flava (Rafinesque)	[2,0]
Anodonta grandis grandis Say	[2,0]
Obliquaria reflexa Rafinesque	[1,0]
Proptera alata (Say)	[1,4]
Obovaria subrotunda (Rafinesque)	[0,1]
Leptodea fragilis (Rafinesque)	[0,1]
Ligumia nasuta (Say)	[0,1]
Ligumia recta (Lamarck)	[0,1]
Lampsilis radiata siloquoidea (Barnes)	[3,3]
Lampsilis ovata ventricosa (Barnes)	[1,2]
Sphaeriidae	
Platyhelminthes	(33.9)
Dugesia tigrina (Girard)	33.9

Table 7.1 continued

Taxon	[a]*#/m²*	*Taxon*	[a]*#/m²*
Decapoda	1.0	Hydracarina	
Gastropoda	(2.5)	Cnidaria	
[k]*Physella* [*gyrina gyrina* (Say), *integra integra* (Haldeman)]	1.5	*Hydra*	
[l]*Fossaria*	1.0	Bryozoa	
Hirudinea	(1.0)		
Erpobdella punctata punctata (Leidy)	0.5		
Helobdella			
unidentified	0.5		
Oligochaeta			
Nais pseudobtusa Piguet			
Nais bretscheri (Michaelsen)			
Nais elinguis Müller			
Nais communis Piguet			
Nais variabilis Piguet			
Nais barbata Müller			
Chaetogaster diaphanus (Gruithuisen)			
Branchiura sowerbyi Beddard			
Tubificidae			

[a] Counts from 17 rocks totaling approximately 2.0m² (all sides), taxa without numbers are from qualitative collections.
[b–e,g,i–m] These taxa were formerly: b, *Baetis phoebus* McDunnough; c, *Stenonema tripunctatum tripunctatum* (Banks); d, *Stenonema interpunctatum* (Say); e, *Stenonema gildersleevei* Traver; g, *Hydropsyche recurvata* Banks; i, *Psephenus lecontei* (Le Conte); j, *Paragyractis*; k, *Physa gyrina* Say, *Physa integra* Haldeman; l, *Lymnaea*; m, *Goniobasis livescens* (Menke).
[f] Collected as subimagoes or imagoes, or cast final instar larval exuviae.
[h] Only one empty larval case collected.
[n] In [ ], the first number refers to the number of live individuals collected, the second number refers to the number of dead individuals collected (both valves collected intact).

tered in our study (table 1). The leech *Erpobdella punctata* was commonly seen while collecting and could reach populations locally as high as 8/m². In order to quantify this fast-swimming species accurately, enclosed quadrats have had to be employed in order to prevent escape. Krecker and Lancaster also recorded this species as common in shallow water amongst angular rubble, and they were also common around the Bass islands in 1926 (Miller 1929). Naididae oligochaetes of the genus *Nais* were occasionally taken in great numbers in rock detrital scrapings. The coelenterate *Hydra* was taken in many collections, and gemmules of Bryozoa were often taken. Water mites (Hydracarina) were abundant but no attempt was made to quantify and identify these interesting arachnids. Two species of isopods were collected. *Asellus racovitzai racovitzai* was uncommon in our shallow-water collections and Barton and Hynes (1976) collected only one specimen in all their Great Lakes shore collections. This species has been considered the dominant Great Lakes isopod (Williams 1976), but in offshore and sheltered areas (Barton and Hynes). Kerr (1978) sampled from fifty-two deep-water stations in the western and central basins in 1975 and found *A. r. racovitzai* predominantly in the central basin with the western basin specimens largely restricted to the Bass Island area and areas south of Point Pelee. The reason for this distribution is unknown (Kerr 1978). *Asellus intermedius* was occasionally taken in our collections and was the most abundant isopod along the Canadian shores of Lakes Erie and Ontario (Barton and Hynes 1976). Until the summer of 1974 this species had not been reported from the Great Lakes (Barton and Hynes 1976).

The near-shore zone, 1–9 m deep

Where flat and angular rubble occur offshore we should expect much of the same fauna as found in the shallows, although in reduced numbers. Although the clam dredge was inefficient in sampling the rocky near-shore habitat and other habitats, certain species appeared to prefer this area as compared with life in 0–1 m of water. These species will be reported on in this section.

Stenacron interpunctatum (Heptageniidae) was the dominant, or at least most noticeable, adult mayfly swarming around the Bass Islands in the summer (subimaginal and imaginal collections July 3–August 7, 1974; June 4–5, 1976; May 30–June 3, 1985). Swarms often reached such abundant proportions that they became clouds of dancing male imagoes, and many matings were witnessed. Subimagoes and imagoes also were often found in abundance attached to buildings and boats, especially where the adults were initially attracted by lights. However, despite the abundance of the adults, we collected very few larvae in our study. Lyman (1955) found that *S. interpunctatum* was most abundant in water 1–2 m deep and much less numerous closer to shore in Douglas Lake, Michigan. Lamp and Britt (1981) investigated the comparative ecology of *Stenonema pulchellum* and *Stenacron interpunctatum* in Big Darby Creek, Ohio. They found that *S. pulchellum* occurred on stones in swift water while *S. interpunctatum* lived on stones in a slower current. Thus, in Lake Erie *S. pulchellum* and *S. interpunctatum* occur in habitats that parallel their stream microenvironments. The wave-washed zone approximates the conditions of a swift stream current, while the 1 to 2m (or greater) zone approximates the conditions of a much slower current.

Some of the caddisflies appeared to prefer the near-shore environment. *Cyrnellus fraternus* and *Polycentropus* were generally collected by dredge off rocks at 2- to 7-m depth.

The near-shore environment also harbors sand-gravel and mud habitats, since the greater depth allows these finer substrate particles to accumulate. Unionidae clams are important members of sand and mud substrata around the islands. Brown et al. (1938) collected 481 clams in 24 species from approximately one acre in Fishery Bay. *Elliptio dilitata* (Rafinesque) and *Lampsilis radiata siliquoidea* were the two most abundant clams at 134 and 84 secimens respectively. Shelford and Boesel also found *L. r. siliquoidea* to be the dominant Unionid clam on shifting sand bottoms surrounding the islands and south mainland shore. Like Brown et al. (1938), we found the clam dredge to be inefficient around the islands, but high water precluded locating clams by wading barefoot as they had done. We collected only 12 live clams in 60 dredgings (table 1) but only about 33 dredgings were in suitable mud-sand habitats. *L. r. siliquoidea*, the dominant lakeward clam (Wood and Fink), was the most numerous clam at three specimens. The percentage of dead shells (both valves intact) from all species of 52% compares favorably to the lakeward areas of 79% (Wood and Fink). We also collected several specimens of very recently dead or alive *Leptodea fragilis* which were washed onto the shores of the Bass islands.

Spectacular emergences of *Hexagenia* mayflies were once common in the western basin (Langlois 1951), but these mayflies were essentially extirpated from the lakeward areas of the western basin since the catastrophic calm of the summer of 1953 allowed the depletion of oxygen in the larva's mud substrate to lethal levels (Wood 1973). *Hexagenia* larvae have not been reported from the lakeward areas of the western basin after 1965 (Britt et al. 1973, 1980; Veal and Osmond 1968. While the great *Hexagenia* emergences may never occur again in the western basin, it is likely that populations exist in muddy areas close to shore where wave action is sufficient to maintain minimum oxygen levels without washing away the mud. On July 28, 1974, a number of *H. limbata* subimagoes were attracted to the lights of a ship moored in Squaw Harbor, South Bass Island, and on July 7–8, 1975, W. L. Peters collected some *H. rigida* from the side of a building on South Bass Island. These imagoes may, however, have come from nearby Terwilliger's Pond where *Hexagenia* larvae have been collected (Schooley 1983) and even stocked (Britt, pers. comm.).

Britt (1962) from 1948 to 1953 collected and conducted comprehensive life history studies of two additional burrowing mayfly species, *Ephemera simulans* and *Ephoron album* (Say), from gravel-sand shoals around the Bass islands, especially from Alligator Bar (between Gibraltar Island and Oak Point of South Bass Island). Although we did not search for larvae in their habitats, large populations of *Ephemera simulans* still exist around the islands. *E. simulans* imagoes were collected on June 30 and July 7, 1974; and an especially large emergence of *Ephemera* was indicated on June 4–5, 1976, by an abundance of subimagoes and imagoes on buildings and at light trap, large aerial swarms, and many final instar larval exuviae were collected from Fishery Bay. A large mating swarm was also observed on May 31, 1985.

Changes since the 1930s

In contrast to the lakeward areas, the shore-zone macrobenthos have been relatively stable since the 1930s because oxygen depletion of the water cannot occur due to constant mixing by wave action, even on calm days. However, several important changes have apparently occurred.

One of the most intriguing changes in the island region is the recent apparent demise of the burrowing mayfly *Ephoron album*. Britt (1962) found from 1948 to 1953 abundant populations of *E. album* in the same habitats and localities as *Ephemera simulans*, another burrowing mayfly (most collections in the vicinity of Alligator Bar). Considerable sampling effort by Britt and his aquatic entomology classes in the 1960s failed to procure any *Ephoron* larvae, although *Ephemera* larvae were still found. Only an occasional flying adult was observed in the late 1950s and early 1960s and none in later years (1960s–1982, according to Britt pers. comm.). We did not collect any adults or final instar larval exuviae, but we probably missed the peak of the emergence period which occurs in late July to September (Jenkins 1939; Britt 1962). However, *E. album* larvae were collected from the northern shore of the western basin in 1974 but were found at only one of three stations (Barton 1976) and were considered rare (Barton and Hynes 1978a). Reasons for the apparent decline of *E. album* from the island region await further research.

The distinctive caddisfly *Helicopsyche borealis* may now be absent from the western basin. Apparently Krecker and Lancaster found this species in some numbers in 1929–30 (see their table 2, p. 89), and Shelford and Boesel (1942) also reported it. Marshall (1939) considered the adults to be abundant around the islands in late June–early July of 1937; she collected 694 females and 2,209 males at light from June 15 to September 9. Britt in the late 1950s and 1960s collected large numbers of larvae near the concrete wall at Oak Point, but none were found in later years. These larvae appeared to disappear at the same time as *Ephoron album* at the same locality (Britt, pers. comm.). In 1974 we found only a single empty case and Barton found no larvae in the western basin (Barton 1976) and considered it rare along the Canadian shore of the entire length of Lake Erie (Barton and Hynes 1978a). *H. borealis* larvae were also rare along the Canadian shores of Lake Ontario and Georgian Bay, but were common in Lakes Huron and Superior (Barton and Hynes 1978a). In the early 1970s we collected good numbers of *Helicopsyche borealis* from the mouth of a stream entering into the middle of the eastern basin, but we did not, unfortunately, look for them in the lake. Reasons for the disappearance of *H. borealis* are unknown.

The caddisfly genus *Ceraclea* remains an important component of the shore macrobenthic fauna, but in the 1930s ten species were collected [although three species were uncommon (Marshall 1939)] compared with only four today (table 2). The reasons for the apparent disappearance of more than half of the *Ceraclea* species are unknown. It is possible that sponges, food of some *Ceracles* (Resh 1976), were reduced since the 1930s, perhaps by the proliferation of *Cladophora*. However, both *C. transversa* and *C. resurgens* occur today and both were considered by Resh (1976) to be obligate sponge feeders at least at some point in their life cycle.

The waterpenny *Psephenus herricki* was one of the most abundant shoreline taxa in Shelford and Boesel's study (fig. 2). In shallow water they state that *P. herricki* was " . . . more often present . . . " than either Hydropsychidae larvae or *Elimia livescens*. Britt found that *P. herricki* was quite abundant during most of the years between the 1940s until recent years (1970s?) when numbers appeared to decline since considerably more effort was necessary to procure specimens for his aquatic entomology classes (Britt, pers. comm.). In 1974 we did not collect a single specimen, although we did collect a small number of larvae of the waterpenny *Ectopria nervosa*, and in 1985 collected one specimen of *P. herricki* after a 35-minute search for it on suitable substrata on Alligator Bar adjacent to Gibraltar Island. No specimens were collected along the north shore of Lake Erie, and this species was rare in Lakes Ontario, Huron and Superior and in Georgian Bay (Barton and Hynes 1978a). The adults of *P. herricki* require emergent moist wave-splashed rocks for mating and access to oviposition sites, and the pupae require rocky areas just above the water line where they will not be inundated by water (Murvosh 1971). High water levels since 1972 (see macrophyte paragraph below) may have reduced the *Psephenus* population by reducing the number of wave-splashed rocks and pupation sites.

Table 7.2 *Ceraclea* Species Collected in the Bass Islands Area: 1930s–1970s

Reference: / Collection date:	Marshall (1939) May 25–Oct. 12, 1937		Horwath (1964) summers 1962 and 1963	*Resh and Unzicker (1975) Dec. 1972	Fink and Wood summer 1974
Species	No. males	% of total			
transversa (Hagen)	1053	35.8	[a]P	P	P
cancellata (Betten)	860	29.3	P	P	P
resurgens (Walker)	324	11.0	P	P	
tarsipunctata (Vorhies)	250	8.5	P	P	P
albosticta (Hagen)	195	6.6			
erulla (Ross)	127	4.3			
ancylus (Vorhies)	73	2.5			
submacula (Walker)	49	1.7			
diluta (Hagen)	7	0.2			

erratica (Milne): Common in 1930s (Resh and Unzicker 1975).

*Larval collections made on one day in December 1972 in Put-in-Bay (Resh, pers. comm.).
[a]P, present.

Krecker and Lancaster collected some Plecoptera larvae (Perlidae) where they were most abundant on flat and angular rubble in 1–6 inches of water. Crowell (1960) collected seven Perlidae adults by light-trapping on Gibraltar Island from June 25 to July 16, 1954. During this same time period, however, 225 mayfly, 314 Hydropsychidae, and 128 Odonata adults were also collected. Thus Plecoptera larvae may not have been particularly abundant. Britt in the early summer of 1940 found many *Acroneuria* (Perlidae) adults attracted to lighted windows at night at F. T. Stone Lab on Gibraltar Island, as well as hiding between the window screen and frame and also in crevices in the bark of trees during the day. Britt found greatly reduced populations in the late 1940s and early 1950s, and between the 1970s and 1982 neither Britt nor his aquatic entomology students found any larvae or adults (Britt, pers. comm.). In 1974 we did not collect any larvae despite intensive qualitative collections through much of June and July. Barton and Hynes (1978a) did not collect any Plecoptera larvae from the Canadian shores of Lake Erie in the summer of 1974. We have no explanation for the disappearance of these insects.

In 1974 the amphipod *Gammarus fasciatus* was the fourth most abundant macroinvertebrate species in our quantitative collections at 113.5/m^2 (fig. 2) and was one of the most visible components of the shore macrobenthos. This highly adaptable species may be found on all substrata at all depths [although now largely extirpated from the lakeward area of the basin (Wood and Fink)] but reaches its largest populations on *Cladophora glomerata* (Linnaeus)-covered substrata, where the filaments offer abundant attachment sites and a rich source of food in terms of attached epiphytes (Lowe et al. 1982; Stevenson and Stoermer 1982). Barton and Hynes (1976) estimated peak densities at over 10,000/m^2 on *Cladophora*-covered substrata. Krecker and Lancaster state that *C. glomerata* largely occupied the 0- to 6-in-depth zone where it could thickly cover the substrata, and in this zone *G. fasciatus* reached its greatest abundance. Today *Cladophora* thickly covers the substrata from the water line to 2–4 in depth where it becomes light-limited (Lorenz and Herdendorf 1982). *G. fasciatus* probably existed in similar numbers in the *Cladophora* zone in the 1930s but with the proliferation of *Cladophora* to greater depths the total numbers of *Gammarus* have certainly increased around the islands and mainland shores of the western basin.

Researchers conducting studies in the 1920s and 30s commented on the presence of rich macrophyte beds in the harbors between South Bass Island and Gibraltar Island (Kennedy 1922; Krecker 1924, 1939; Dennis 1928; Tiffany 1937; Brown et al. 1938). In 1974 the macrophyte fauna in protected harbors was greatly reduced. In 1940 much of Squaw Harbor was a cattail marsh so dense that paths had to be mowed through the cattails to allow rowboats access to the open water (Britt). Stuckey (1971) documented the loss of 20 of the 40 species present in Put-in-Bay Harbor in 1898, and that only three of those were common or abundant in 1970, along with two other species not recorded in the 1897 survey. The loss of the plants can be attributed largely to human activities. Algal blooms in the warm season due to eutrophication and siltation from agricultural and other land development activities have greatly limited the amount of light available for photosynthesis at greater depths. Dredging, building of retainer walls and docks, and recreational boating have also taken their toll of the macrophytes (Stuckey 1971; Taft and Kishler 1973). High water levels since 1972, with an all-time record high in 1973, have probably further reduced the macrophyte fauna (Farney and Bookhout 1982).

Ten of the fifteen species of snails collected by Dennis (1928) in the summer of 1927 occurred on or were associated with aquatic plants and thus may have been reduced in numbers (see Stein 1979). Krecker (1939) showed the importance of aquatic macrophytes as substrata for a large variety of macroinvertebrates. Three of the plants collected by Krecker in the summers of 1935–36 were still common in 1970 (data from Stuckey 1971), and Krecker found that two of these plants, *Myriophyllum exalbescens* Fernald and *Potamogeton crispus* Linnaeus, possessed an average of 1,442 and 1,139, respectively, of attached macroinvertebrates per 10 linear feet of plant. We do not know if the significantly higher water levels in 1973 and 1974 further reduced aquatic macrophytes from the levels of Stuckey's (1971) study conducted in 1967–70. We occasionally pulled up some *Ceratophyllum demersum* Linnaeus, common in Stuckey's study, from Put-in-Bay Harbor by the clam dredge in 1974. In a small north Florida lake this plant and water hyacinth roots were richly populated with *Caenis* and *Callibaetis* mayflies, caddisflies, damselflies, and snails (Fink and H. M. Savage, unpublished data). *Baetis, Caenis, Callibaetis, Cloeon* (a small number of adult specimens reported by Jenkins in 1939), and *Centroptilum* (reported by Shelford and Boesel 1942) mayfly larvae may utilize macrophytes as a substrate and thus may now be reduced in number. More work needs to be done in Put-in-Bay Harbor on the relative abundance of the macrophytes and their attached macroinvertebrates.

Future Research

The shore-zone macrobenthos are an important component of the fauna of the lake that occurs not only around the Bass islands but also around the other islands, along the many shallow reefs and shoals (see Herdendorf and Braidech 1972, including table 10 on p. 16 which contains data from Baker 1967 on macrobenthic organisms inhabiting bedrock and rubble habitats of Niagara, Crib, and Toussaint reefs), and also along the Canadian and U.S. shores throughout the Lake. The macrobenthos are also important to the success of artificial reefs as fish habitats.

Changes in the shore macrobenthos are likely to be subtle and difficult to detect without more intensive study. While the highly turbulent waters of this zone ensure high oxygenation of the water and thus prevent degradation of the fauna through anoxia, trace element and chemical pollution directly or indirectly could affect the fauna, and local climatic changes could affect population levels. For example, cold air temperatures during a short emergence season of the terrestrial adult stage of some aquatic insects could reduce reproductive success. In the previous section some changes or possible changes were noted, and more study would be necessary to clearly confirm and to determine why these changes have occurred.

Many things could be done to enhance our knowledge of the benthos. These include year-round sampling to determine seasonal population changes, determining all groups to species, detailed life-history studies to look at species-specific requirements and interactions, and sampling from all substrata, including sand and small pebble beaches. Barton and Hynes (1978b) have discovered in the central basin, through on-, off- and alongshore drift samples and through on- and offshore substrata samples, that some shallow shore benthos move offshore to avoid late fall and early spring storm and ice scour of the easily erodible shore sediments of this region. More of this kind of research would determine where other organisms spend the winter and how different substrate types and lake currents (see Barton 1981) affect seasonal movements.

Quantitative sampling would yield the best information. Enclosed quadrats where organisms could be washed off the substrata and sucked up by some kind of vacuum system (e.g., Barton and Hynes 1978a) would probably yield the best data. In deeper areas scuba would be essential for accurate sampling, especially for charting the distribution of clams and burrowing mayflies in mud, sand, or sand-gravel shoal habitats which may be interspersed among rocks and boulders. These habitats cannot be sampled adequately by remote dredges. Aquatic plants would probably also be best surveyed and collected by scuba. However, turbid water during the warm spring and summer months would make even sampling with scuba difficult.

Daily quantitative light-trapping and serial net-sweeping during the flight period could help monitor seasonal and yearly population levels of aquatic insects whose serial adult stage is readily attracted by light or whose swarms are readily reachable by a net. Adult collections are exceedingly less tedious and time-consuming to sort and analyze than substrate collections and they essentially sample from a much wider area, thus often yielding a greater number of individuals with the greater chance of picking up rare and uncommon species. Light-trapping (bright mercury vapor and black lights would be best) and sweeping have worked or would work well with many caddisflies (Marshall 1939), mayflies (Jenkins 1939), and Chironomidae. Emergence traps, including large malaise traps, would also be very beneficial and would locate the area of immature habitat. Vandalism, however, would be a problem with traps which could not be monitored continuously. Jenkins (1939) collected approximately 37 species of adult mayflies, including many rare or uncommon species which were not collected as larvae in our 1974 study. Future adult collections would provide informative comparisons with Jenkin's study. Similarly adult collections of Trichoptera would also provide important comparisons with Marshall's (1939) and Horwath's (1964) studies. A synoptic series of specimens collected should also be deposited in a suitable museum for study and comparison by later workers (contact the senior author of this essay for the eventual location of such a synoptic series from the present study).

Probably some of the most interesting research would involve an investigation of the causes of the loss or reduction of *Ephoron album* mayflies, *Helicopsyche borealis* and some *Ceraclea* spp. caddisflies, Perlidae stoneflies, and *Psephenus herricki* waterpennies (Coleoptera). One approach would be to conduct in situ and in the laboratory bioassays with the above taxa collected from nearby areas and with taxa still present or common in the near-shore zone. A particularly interesting study would be to reintroduce *Ephoron album* into its former localities, and to compare its success with its former *Ephemera simulans* "neighbors." This could also be attempted in the lab. Certainly, much research remains to be done in the island area of Lake Erie.

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References

Baker, C. T. 1967. Walleye spawning area study in western Lake Erie: Ohio Div. Wildlife Progress Rept. F-35-R-5.

Barton, D. R. 1976. A study of the wave-zone macrobenthos along the Canadian shores of the St. Lawrence Great Lakes. Ph.D. diss. University of Waterloo, Ontario.

———. 1981. Effects of hydrodynamics on the distribution of lake benthos. *In* M. A. Lock and D. D. Williams (eds.), Perspectives in running water ecology, pp. 251–63. Plenum Press, New York.

Barton, D. R., and H. B. N. Hynes. 1976. The distribution of amphipoda and isopoda on the exposed shores of the Great Lakes. J. Great Lakes Res. 2:207–14.

———. 1978a. Wave-zone macrobenthos of the exposed Can

dian shores of the St. Lawrence Great Lakes. J. Great Lakes Res. 4:27–45.
———. 1978b. Seasonal variations in densities of macrobenthic populations in the wave-zone of north-central Lake Erie. J. Great Lakes Res. 4:50–56.
Boesel, M. W. 1983. A review of the genus *Cricotopus* in Ohio, with a key to adults of species of the northeastern United States (Diptera, Chironomidae). Ohio J. Sci. 83:74–90.
Britt, N. W. 1962. Biology of two species of Lake Erie mayflies, *Ephoron album* (Say) and *Ephemera simulans* Walker. Ohio Biol. Surv. Bull. New Ser. 1(5).
———. Unpublished. Personal communication.
Britt, N. W., J. T. Addis, and R. Engel. 1973. Limnological studies of the island area of western Lake Erie. Ohio Biol. Surv. Bull. New Ser. 4(3).
Britt, N. W., A. J. Pliodzinskas, and E. M. Hair. 1980. Benthic macroinvertebrate distributions in the central and western basins of Lake Erie. *In* C. E. Herdendorf (ed.), Lake Erie Nutrient Control Program. An assessment of its effectiveness in controlling lake eutrophication, pp. 294–330. U. S. Environmental Protection Agency, EPA–600/3–80–062.
Brown, C. J. D., C. Clark, and B. Gleissner. 1938. The size of certain naiades from Western Lake Erie in relation to shoal exposure. Am. Midl. Nat. 19:682–701.
Crowell, R. M. 1960. The taxonomy, distribution and developmental stages of Ohio water mites. Ohio Biol. Surv. Bull. New Ser. 1(2).
Dennis, C. A. 1928. Aquatic gastropods of the Bass Island region of Lake Erie. Contrib. No. 8. Franz Theodore Stone Lab. Ohio State University.
Farney, R. A., and T. A. Bookhout. 1982. Vegetation changes in a Lake Erie marsh (Winous Point, Ottawa County, Ohio) during high water years. Ohio J. Sci. 82:103–7.
Fink, T. J., and H. M. Savage. Unpublished data. Aquatic insect-aquatic plant relationships in Meginnis Arm, Lake Jackson, Florida.
Herdendorf, C. E., and L. L. Braidech. 1972. Physical characteristics of the reef area of western Lake Erie. Ohio Dept. Natur. Resources. Div. Geol. Surv. Rep. Invest. 82.
Horwath, A. B., 1964. Insects of Gibraltar Island in relation to their habitats. MS thesis. Ohio State University, Columbus.
Jenkins, D. W. 1939. The mayflies of the west end of Lake Erie. MA thesis. Ohio State University, Columbus.
Jensen, S. L. 1974. A new genus of mayflies from North America (Ephemeroptera: Heptageniidae). Proc. Entomol. Soc. Wash. 76:225–28.
Kennedy, C. H. 1922. The ecological relationships of the dragonflies of the Bass Islands of Lake Erie. Ecology. 3:325–36.
Kerr, J. R. 1978. Some aspects of life history and ecology of the isopod *Asellus r. racovitzai* in western and central Lake Erie. Ohio J. Sci. 78:298–300.
Krecker, F. H. 1924. Conditions under which *Goniobasis livescens* occurs in the island region of Lake Erie. Ohio J. Sci. 24:299–310.
———. 1939. A comparative study of the animal population of certain submerged aquatic plants. Ecology 20:553–62.
Krecker, F. H., and L. Y. Lancaster. 1933. Bottom shore fauna of western Lake Erie: a population study to a depth of six feet. Ecology 14:79–93.
Lamp, W. O., and N. W. Britt. 1981. Resource partitioning by two species of stream mayflies (Ephemeroptera: Heptageniidae). Great Lakes Entomol. 14:151–57.
Langlois, T. H. 1951. The mayfly crop of 1951. Ohio Conserv. Bull. 15:15 and 32.
Lorenz, R. C., and C. E. Herdendorf. 1982. Growth dynamics of *Cladophora glomerata* in western Lake Erie, North America, in relation to some environmental factors. J. Great Lakes Res. 8:42–53.
Lowe, R. L., B. H. Rosen, and J. C. Kingston. 1982. A comparison of epiphytes on *Bangia atropurpurea* (Rhodophyta) and *Cladophora glomerata* (Chlorophyta) from northern Lake Michigan, USA. J. Great Lakes Res. 8:164–68.
Lyman, F. E. 1955. Seasonal distribution and life cycles of Ephemeroptera. Ann. Entomol. Soc. Am. 48:380–91.
Marshall, A. C. 1939. A qualitative and quantitative study of the Trichoptera of western Lake Erie (as indicated by light trap material). Ann. Entomol. Soc. Am. 32:665–88.
Miller, J. A. 1929. The leeches of Ohio. Contrib. 2. Franz Theodore Stone Lab. Ohio State University.
Murvosh, C. M. 1971. Ecology of the water penny beetle *Psephenus herricki* (DeKay). Ecological Monographs 41:79–96.
Peters, W. L. Unpublished. Personal communication.
Resh, V. H. 1976. Life cycles of invertebrate predators of freshwater sponge. *In* F. W. Harrison and R. R. Cowden (eds.), Aspects of sponge biology, pp. 299–314. Academic Press, New York.
———. Unpublished. Personal communication.
Resh, V. H., and J. D. Unzicker. 1975. Water quality monitoring and aquatic organisms: the importance of species identification. J. Water Poll. Control Fed. 47:9–19.
Schooley, R. 1983. Benthic organism habitat associations in Terwilliger's Pond. *In* C. E. Herdendorf and A. M. Wilson (eds.), Limnological investigations of Terwilliger's Pond and adjacent areas of Lake Erie, South Bass Island, Ohio, pp. 251–58. Franz Theodore Stone Lab. Res. Rept. No. 1.
Shelford, V. E., and M. W. Boesel. 1942. Bottom animal communities of the island area of western Lake Erie in the summer of 1937. Ohio J. Sci. 42:179–90.
Stein, C. B. 1979. Aquatic gastropods of the Bass Island region of western Lake Erie: a half century of change. Abstract in Ohio J. Sci. 79:5.
Stevenson, R. J., and E. F. Stoermer. 1982. Seasonal abundance patterns of diatoms on *Cladophora* in Lake Huron, North America. J. Great Lakes Res. 8:169–83.
Stuckey, R. L. 1971. Changes of vascular aquatic flowering plants during 70 years in Put-in-Bay harbor, Lake Erie, Ohio. Ohio J. Sci. 71:321–42.
Taft, C. E., and W. J. Kishler. 1973. *Cladophora* as related to pollution and eutrophication in western Lake Erie. Proj. Compl. Rep. 332x, 339x. Water Resources Center, Ohio State University.
Tiffany, L. H. 1937. The filamentous algae of the west end of Lake Erie. Am. Midl. Natur. 18:911–51.
Traver, J. R. 1933. Mayflies of North Carolina. Part III. The

Heptageniinae. J. Elisha Mitchell Sci. Soc. 48:141–207.
Veal, D. M., and D. S. Osmond. 1968. Bottom fauna of the western basin and near-shore Canadian waters of Lake Erie. Proc. 11th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res. 1968:151–60.
Wiebe, A. H. 1926. Variations in the freshwater snail, *Goniobasis livescens*. Ohio J. Sci. 26:49–68.
Wiggins, G. B. 1977. Larvae of the North American caddisfly genera (Trichoptera). University of Toronto Press, Toronto.
Williams, W. D. 1976. Freshwater isopods (Asellidae) of North America. U.S. Environmental Protection Agency, Water Poll. Contr. Res. Ser. 18050 ELD05/72 (second printing),
Wood, K. G. 1973. Decline of *Hexagenia* (Ephemeroptera) nymphs in western Lake Erie. *In* W. L. and J. G. Peters (eds.), Proceedings of the first international conference on Ephemeroptera, pp. 26–32. Brill Publishers, Leiden, Netherlands.
Wood, K. G., and T. J. Fink. 1984. Ecological succession of macrobenthos in deep- and shallow-water environments of western Lake Erie: 1930–1974. *In* V. Landa, T. Soldán, and M. Tonner (eds.), Proceedings of the fourth international conference on Ephemeroptera, pp. 263–79. Institute of Entomology, Czechoslovak Academy of Sciences, České Budějovice, Czechoslovakia.