rock bass numbers correlated negatively with current velocities in four instances and positively with temperature in two instances. Total number of species and total weight had several positive associations with temperature. Associations with temperature were most common and those with current velocities the least common. The substrate with which the four species were most commonly associated was sandy, with or without vegetation.

For a summary analysis, we determined mean catch and weight of all species combined, total number of species collected, mean catch of yellow perch, rock bass, hornyhead chubs, and spottail shiners associated with six sediment-vegetation combinations. The highest and lowest catches and diversity (number of species) were then listed with the various sediment-vegetation combinations (Table 48). For example, the highest mean catch of hornyhead chubs per net set was highest in sandy areas in vegetation and lowest in non-vegetated rubble areas. We also found that low current velocities were associated with fine sediments and faster currents with coarse material. Vegetation tended to be in areas with slower currents. Yellow perch were collected most often in vegetation, regardless of sediment type; rock bass were taken over rubble without regard to vegetative cover; and hornyhead chubs and spottail shiners were most often caught over fine sediments in vegetated areas.

DISCUSSION

DISTRIBUTION AND ABUNDANCE OF MACROZOOBENTHOS

The number of taxa of macrozoobenthos listed in this study (160) exceeded that in any work on SCDRS, including that of Hiltunen (1980), Hiltunen and Manny (1982), Ontario Ministry of the Environment (1979), Thornley and Hamdy (1984), and Thornley (1985). The number of such taxa reported for any aquatic system depends primarily on the level of taxonomic treatment and the timing and extent of the sampling program. In the present study, we attempted to identify most specimens at least to genus (which potentially lengthened our list relative to those in the other published works), but we also limited our sampling to near-channel areas and to spring and fall (which potentially shortened the list). Our list (Appendix C) was also made somewhat longer than those in earlier works by the inclusion of Copepoda and Cladocera. However, our list might have exceeded 300 species, if we had identified all specimens to species, particularly within the Chironomidae, Ephemeroptera, Trichoptera, Odonata, and Oligochaeta, and added the other remaining taxa.

Our collections contained all of the major taxa listed in past studies in SCDRS but did not include several less abundant taxa such as Crangonyx, Dolichopodidae (Hiltunen 1980), and Pseudocleon (Ontario Ministry of the Environment 1979). In addition, we collected several common chironomid genera (Robackia, Chernovskiia, and Lopescladius) that had not been reported from the system. These chironomids were common in the less productive sand-gravel sediments and their abundance may have been underestimated because their thin body form and small size allowed them to escape through the sieve (this is a common problem

Table 48. Fish catches and associated environmental conditions in the St. Clair and Detroit rivers in 1983-1984.

Physical characteristics and catch	Vegetation					
	Absent			Present		
Bottom type	Silt-clay	Sand	Rubble	Silt-clay	Sand	Rubble
Mean depth (ft)	4.3	4.0	5.0	4.4	4.0	4.7
Mean current (ft/s)	0.6	1.1	1.1	0.4	1.1	1.1
Catch						
Mean wt, all species		Lowest	Highest			
Mean catch, all species					Highest	Lowest
Diversity		Lowest				Highest
Catch of hornyhead chub			Lowest		Highest	
Catch of yellow perch			Lowest		Highest	
Catch of spottail shiner		Lowest			Highest	
Catch of rock bass					Lowest	Highest

with "rare" taxa, which often are merely not adequately sampled).

Comparison of zoobenthos diversity in large river systems is difficult because taxonomic detail is usually inadequate. The following studies are exceptions. Barton (1980) collected 114 taxa of benthic macroinvertebrates from the Athabasca River in northern Alberta, Canada. Hudson and Nichols (In Press) recorded 206 taxa from the Savannah River, South Carolina-Georgia. The list of 334 taxa from the wave-zone habitat (0 to 2-m depth zone) of the exposed shores of the Canadian portion of the Great Lakes (Barton and Hynes 1978) surpassed that for SCDRS. Although several taxonomic groups (e.g. oligochaetes, chironomids) were treated at different taxonomic levels in the two studies, the overall similarity was striking. The higher diversities of mayflies and stoneflies in the wave-zone and clams and leeches in SCDRS are noteworthy exceptions. Barton (1980) pointed out the greater diversity of sand-dwelling animals in rivers connecting ancient bodies of water with waveswept shores, such as those of Lake Baikal, Black Sea, and Caspian Sea, and stated that there are no ecological equivalents in glaciated North America. Barton used mollusks and malacostracans as examples of relict fauna not found in glaciated North America, but SCDRS may be an exception because both groups are well represented.

Variability in type of gear and sieve size, plus the great seasonal variability in numbers of small individuals or instars, makes the value of numerical comparisons of abundance between investigations dubious. This becomes immediately obvious when one realizes that our densities were at least 10 times higher than those reported by Thornley (1985) for SCDRS. Some of the differences may reflect an increase in macrozoobenthos numbers and diversity over time as a result of pollution abatement measures that occurred in the 1960's and 1970's. However, differences in the amount and distribution of sampling effort and in sampling and processing techniques all probably contributed to the difference--which points out clearly the need for standardization. Other gross differences in density between areas may reflect differences in productivity. Barton and Lock (1979) suggested an average density of benthic organisms of about 2,000/m^2 in the Athabasca River, as well as many other streams. Barton and Smith (1984) provided estimates of total invertebrates for a variety of rivers in the world that ranged from 17/m^2 in the Danube River (Bulgaria) to 40,000/m^2 in certain areas of the Athabasca River. Spring and fall densities we measured in SCDRS averaged 24,000/m^2. Assuming a sampling efficiency of only about 50% (Barton and Smith 1984) due to the large mesh size of the sieves we used, the densities in SCDRS may have exceeded those in most rivers of the world.

However, one can usually make confident quantitative comparisons of biomass, which are affected less from presence or absence of large numbers of small individuals, and by comparing selected species such as Hexagenia. Biomass estimates for large rivers (Barton and Smith 1984) ranged from 0.1 to 8.6 g/m^2 and our value of 1.33 g/m^2 for the SCDRS equals or exceeds values for six of the eight rivers listed. The mean biomass for SCDRS is higher than most

listed for rivers below impoundments (Walburg et al. 1983), and is nearly identical to that reported for the St. Lawrence River (1.4 g/m²) by Mills et al. (1981). Densities of Hexagenia in spring in SCDRS (235/m²) were higher than those reported by Hudson and Swanson (1972) for a Missouri River reservoir (140/m²), but somewhat lower than those reported by Hiltunen and Schloesser (1983) for the St. Marys River (361/m²). Densities of Hexagenia at transect VI in the St. Clair River in October 1984, which ranged from 3,600 to 6,730/m², are among the highest densities reported in the literature, and exceed the maximum density (50/m²) recorded by Thornley (1985) in the St. Clair River in 1968 and 1977.

Large within-year and between-year variations in abundance of macrozoobenthos can typically be traced to life cycle patterns. Most invertebrates complete several generations a year, causing population structure to shift in a matter of weeks from one dominated by large mature individuals to one of mainly small, immature specimens. Because density of most taxa in SCDRS is higher in fall, we might assume that age structure in fall is dominated by young individuals that are subject to overwinter mortality. In contrast, populations with maximum densities in spring may be cold-adapted forms that overwinter with little mortality or grow at low temperatures, and were recruited to our No. 30 mesh screen by May. Several genera of chironomids have this adaptation to low temperature. Of the 24 taxa we analyzed in detail, 19 had maximum densities during the same month in successive years, and differences in densities between years were usually less than 30%. Hydra, Oligochaeta, Manayunkia, Chironomidae, and Acarina were the only taxa with large, erratic seasonal and yearly changes in density. Hiltunen (1980) noted large fluxes between years in the oligochaete population in the St. Clair River. These large changes in density were probably due to the life history of oligochaetes, to differences in behavior of the multiple species in this large group or both.

Of the abundant taxa, 75% were most numerous at the shallower off-channel stations. The relative difference in densities between off-channel and channel stations is probably a true reflection of the life history requirements of each taxon, whereas the absolute difference between stations is probably a sampling artifact. Channel stations in particular are characterized by higher current velocity and coarser sediments. The Ponar dredge is inefficient in fast currents, and in the hard clay or rubble substrate, that is characteristic of the channel bank stations. Many taxa (e.g. Gastropoda, Diptera, Trichoptera, and Ephemeroptera) may be abundant in these inadequately sampled areas with fast currents and hard substrate.

Sediment particle size and contaminant distribution basically determine the composition and density of the benthic community in SCDRS. The St. Clair River, with its wider range of sediment size and diversity of macrophytes is dominated by aquatic insects, amphipods, and snails that are intolerant of pollution. Our samples were collected mainly along the U.S. shoreline, which is less contaminated than Canadian nearshore waters (Kauss and Hamdy 1985). The diversity of macrozoobenthos in the Detroit River near Belle Isle is similar to that in the St. Clair River. The headwater areas of both rivers support large populations of the filter-feeding caddisflies Cheumatopsyche and

Hydropsyche. Densities of these two genera are higher in the Detroit River than in the St. Clair River, probably because seston levels are higher in Lake St. Clair than in Lake Huron (Kauss and Hamdy 1985). Concentrations of contaminants were moderately high in the lower Detroit River (Transect XVIII) but were low at stations along Grosse Ile (Limnotech, Inc. 1985). The bottom fauna near transect XVIII was dominated by oligochaetes, and the fine sediments were contaminated with oil. The variety of invertebrates was greater but the densities were lower in the gravel-cobble substrate of transects XIX-XXI than at transects in the upper Detroit River. The densities of most of the more primitive invertebrates, such as Oligochaeta, Nematoda, Nemertinea, and Manayunkia, were highest in the Detroit River. The transects in Lake St. Clair were devoid of macrophytes but the substrate was covered with Cladophora in October. The lake community was simple, consisting of Hexagenia, Oecetis, Sphaeriidae, Ostracoda, and Nematoda, and was typical of any healthy, lentic community living on a bottom composed of fine sediments.

Sand, a dominant substrate in many large rivers, is unsuitable habitat for many benthic invertebrates (Barton and Lock 1979; Berner 1951). In the St. Clair, Detroit, and Athabasca rivers, dominant sediments range from sand in the Athabasca River to mud in the Detroit River (Table 49). The constant flow, low turbidity, and luxuriant plant growth in SCDRS must be major factors in stabilizing and incorporating finer sediments into what would probably be a typical river and sand habitat. Although current velocities are relatively high in SCDRS, most of the littoral substrates contain relatively high percentages of silt and clay that support large populations of insects and crustaceans. This situation may be analogous to that in the Volga and Angara rivers in Russia, which also support high biomasses of amphipods and oligochaetes (Barton and Smith 1984). The Athabasca River, in contrast, is turbid; the substrate is shifting sand that contains little silt or clay; and the biomass of macroinvertebrates is relatively low (Barton 1980).

In summary, the high abundance and diversity of macrozoobenthos in SCDRS is due to the quality and diversity of the habitat: (1) high-quality water enters SCDRS from Lake Huron, (2) a wide variety of stable sediments are available, ranging from cohesive clay to cobble, (3) current velocities vary widely, ranging from 0 to 6 ft/s, and (4) submersed and emergent macrophytes are diverse and abundant.

DISTRIBUTION AND ABUNDANCE OF SUBMERSED MACROPHYTES

The submersed macrophyte community in the St. Clair and Detroit rivers changed little from 1983 to 1984. Frequency of occurrence of individual taxa between years varied by $\leq$ 7% in each river and was usually < 10% at each location. The few large discrepancies could be attributed to taxonomic or sampling problems. For example, at Point Hennepin, the occurrence of narrow-leaf Potamogeton spp. in June was 22% lower in 1984 than in 1983, but that of P. zosteriformis was 39% higher. Inasmuch as these two taxa superficially resemble each other early in the season, those collected in 1984 may have been Potamogeton spp. and those collected in 1983 may have been P. zosteriformis.

Table 49. Sediment composition (% of total) in three large rivers in North America.

Sediment	River		
	Athabasca (Alberta, Canada)	St. Clair	Detroit
Mud	8	17	56
Muddy sand	28	49	23
Sand	48	4	2
Gravel	16	30	18

The abundance of P. richardsonii in the June collections at Point Hennepin was 24% higher in 1984 than in 1983. The increase was due in part to the fact that a large bed of P. richardsonii in deep water was discovered and sampled routinely only after it broke the surface in July-August 1983.

The macrophyte community in SCDRS has remained stable since at least 1978. Schloesser and Manny (1982) collected one more taxon (19) in 1978 than we did and recorded the same dominant taxa by area (Chara spp. in the St. Clair River and Vallisneria americana in the Detroit River). In our study, maximum coverage averaged 53% over the six locations and varied less than 12% between years. Schloesser and Manny (1982) found submersed macrophytes at 68% of their stations, none of which were located in the shipping channel. Because a portion of our sampling grid extended into the shipping channel, where few plants lived, our estimates of percent cover on the shoals would have to be adjusted upward to be comparable with theirs. If that adjustment was made, our results would be similar to theirs.

The percent occurrence of taxa at our island locations also varied from that given by Schloesser and Manny (1982), who sampled most extensively in littoral waters adjacent to the Canadian and U.S. mainland (Table 50). The occurrences of V. americana, P. richardsonii, Myriophyllum spicatum, and Elodea canadensis were lower at our St. Clair River island locations than reported by Schloesser and Manny (1982) at their mainland stations. Potamogeton gramineus and particularly Potamogeton spp. were more abundant at our locations than at their adjacent mainland locations. In the Detroit River, Potamogeton spp., V. americana, P. richardsonii, and Characeae were more common at our sampling locations, whereas Heteranthera dubia was more common at their mainland locations. Some of these differences may reflect design and sampling differences, but it appears that at least Potamogeton spp. are more common in shoal areas at the head and side of islands in SCDRS than along the U.S. and Canadian mainland shorelines. The factor most affecting the distribution of aquatic macrophytes is bottom type, which is largely determined by current velocity (Westlake 1975). Current velocities at the heads of islands in SCDRS are higher than those along the mainland shore; this difference may affect soil textures and the ability of various species to anchor in a given sediment (Ozimek et al. 1976).

Extensive monospecific stands of submersed macrophytes were largely lacking at the six sampling locations in SCDRS. Large stands of Chara spp. at Fawn Island and Vallisneria americana at Point Hennepin were the exceptions. The average number of taxa per grab was 2.5 over all locations and was highest (3.3) at Belle Isle. Crowder et al. (1977) found a mean value of 5.5 taxa in Lake Opinicon, Ontario, but their sampling area (25-cm-square quadrant) was somewhat larger than ours; Liston and McNabb (1986) collected about 2 taxa per Ponar grab in the St. Marys River.

Schloesser and Manny (1982) found that the areal distribution of macrophytes was more limited in the Detroit River than in the St. Clair River, but wrote that the proportion of plant beds with high, medium, and low densities was

Table 50. Percent frequency of occurrence of dominant submersed macrophytes collected in littoral mainland areas (Schloesser and Manny 1982) and on island shoals (present study) in the St. Clair and Detroit rivers.

Taxon	St. Clair River		Detroit River	
	Mainland	Island shoals	Mainland	Island shoals
Vallisneria americana	28	4	49	70
Characeae	68	74	9	23
Potamogeton richardsonii	49	32	4	21
Myriophyllum spicatum	28	8	13	20
Elodea candensis	36	25	7	7
Heteranthera dubia	1	1	31	7
Potamogeton spp.	24	54	3	30
Najas flexilis	1	5	5	5
Potamogeton gramineus	11	24	3	5

similar in the two rivers. We found similar bed coverage between rivers and a 12% lower biomass in the Detroit River. Schloesser and Manny (1982) reported that maximum seasonal biomass over the entire system ranged from 118 to 427 g/m². Our September biomass estimates ranged from 93 to 265 g/m² over the six locations, and the highest seasonal biomass was 382 g/m², in block 6 at Stony Island.

Maximum biomass estimates for SCDRS made by Schloesser and Manny (1982) and by us were at the lower end of a range of 110-520 g/m² reported by Westlake (1963) for aquatic macrophyte stands in rivers at temperate latitudes. The mean biomass of 176 g/m² in SCDRS in September is similar to maximum values of 150 g/m² measured in the shallow littoral area of the St. Lawrence River (Cooley 1978) and 170 g/m² in the Red Cedar River, Michigan (Ball and Bahr 1975). In the Red Cedar River, several years of low discharge were followed by several years of record high flows that scoured and eliminated most of the macrophytes. Scouring due to extended high flows does not occur in SCDRS, and once macrophyte beds become established, it seems likely that only dredging or filling activities would physically remove them. The spring ice jam of 1984 did not scour beds, however the soft frazzle ice which typified this jam may not be an effective scouring agent.

Maximum summer biomass of submersed macrophytes in SCDRS is probably not related to nutrient availability. Nitrogen (200-400 μg/ℓ) and phosphorus (2-30 μg/ℓ) in the system were near the concentrations (100-200 μg/ℓ and 20-30 μg/ℓ, respectively) that Westlake (1975) believed to be sufficient to support optimum growth; the exception may be in the St. Clair River, where mean phosphorus levels were reported to be only 12 μg/ℓ (Ontario Ministry of the Environment 1979).

The seasonal growth patterns we found agreed largely with those reported by Schloesser et al. (1985). We found a higher biomass in September at every location, although biomass values for September were not significantly different from those for July-August at Belle Isle and Point Hennepin. Of the four locations we sampled in common, we were in agreement at Russell Island (October maximum), Belle Isle (August-September maximum), and Grosse Ile (August maximum). At Stag Island Schloesser et al. (1985) found Potamogeton spp. peaked in July and P. richardsonii in August; we found proportional increases in both taxa from June to September. Brown (1983) also recorded maximum biomass in Anchor Bay between August and November. The growing season for aquatic angiosperms is restricted to periods when water temperatures exceed 50°F (Haag 1979, Kunii 1981). The ice jam in the St. Clair River, in spring 1984 delayed the rise of water temperatures to 50°F by about 10 days but this delay did not affect the date on which maximum seasonal biomass was reached.

In the Detroit River, turbidity may reduce light penetration and prevent the development of certain species of submersed macrophytes in the deeper portions of the littoral area. It is a general view that aquatic macrophytes extend to depths receiving only 1-4% of surface light (Sculthorpe 1967), although a limit of 15% was observed by Bodkin et al. (1980). Chambers and Kalff (1985) found that angiosperms were limited to depths where an average of

at least 21% of the photosynthetically active radiation incident on the water surface was received over the growing season. The average light transmission to the bottom of the littoral area in the Detroit River (16%) is near the lower limit for plant growth; consequently any increase in turbidity in the Detroit River during the early growing season may eliminate some of the more light-sensitive species such as P. crispus and P. pectinatus (Sheldon and Boylen 1977).

The reduction of current velocity by vegetation in a lotic system is well documented (Gregg and Rose 1982; Nowell and Jumars 1984), and such a reduction clearly may allow small fish to live in areas where current velocity would otherwise exclude them. In addition, vegetation harbors benthic invertebrate food organisms and provides cover for juvenile fishes (Werner et al. 1983).

Macrophytes affect invertebrate community structure and abundance both directly and indirectly. Submersed macrophytes, by modifying the current, influence sediment deposition and thus influence the composition of invertebrate species on the bottom. Macrophytes create heterogeneity and can increase habitable surface area over a square meter of bottom by a factor of 2 (Brown et al. In Press). The most important function served by submersed macrophytes may be provided in fall, when the plants die and the plant material is released in a "pulse" in a form that can be rapidly used by aquatic detritivores (Hill and Webster 1983). In the New River, Virginia, this pulse accounted for 13.1% of the total annual organic input (including periphyton and allochthonous inputs) to the river and for 28% of the input generated within the middle reach of the stream (Hill and Webster 1983). The organic input provided by submersed plants is probably much greater in the SCDRS than in rivers such as the New River because little other organic matter that enters the SCDRS is derived from the watershed with the exception of storm sewers in the city of Detroit.

The taxonomic composition and abundance of aquatic macrophytes in SCDRS probably reflect the stability of flow more than any other environmental variable. The lack of spates provides long-term stability to the system. The pattern of distribution in the system reflects physiological and morphological adaptations of the macrophytes to light and current and results in communities that are fairly predictable. These developing beds then modify the current and light, thus allowing additional species to exploit this new microhabitat. Because competition and space are limited, this development is less predictable and prevents recognition of consistent associations between species. Differences in seasonal growth of different taxa further complicate the system, but they are predictable and further increase stability.

DISTRIBUTION AND ABUNDANCE OF FISH

Most species of fish in the vicinity of island shoals in the St. Clair and Detroit rivers where our collections were made are either rare, transient species, or prefer other areas of the river. Our small hoop nets collected mostly yellow perch and rock bass, along with 34 other species. Larger trap nets (77 m long lead, 1.8 m deep heart) set by the Michigan Department of

Natural Resources (Haas et al. 1986) at the outer fringes of the shoal areas also collected mainly adult yellow perch and rock bass, along with 46 other species. Cosentino (1983) found 14 species commonly in a marsh-bay complex in the St. Clair River near Russell Island; however, only 6 of these were collected in our study. Island shoals, because of their openness and vulnerability to environmental extremes, may typically have fish communities dominated by only a few species.

It is also possible that the community of fish inhabiting the island shoals was not adequately sampled by our gear. This inadequacy would account for both variation in species caught and the large variation in our spatial and temporal catch rates. Hoop nets were chosen as our gear because of the difficulty of sampling in areas of high current. Although hoop nets tend to yield a lower catch per unit of effort and a more variable catch than other gears (Pennington et al. 1980), and are not equally efficient for all species (Kallemeyn and Novotny 1977), they may be one of the few gears that can be fished quantitatively in flowing water. And though electroshocking is not recommended for sampling in deep, turbid, high-gradient streams (Larimore and Garrels 1985), two-boat electroshocking might prove to be effective in the riverine portions of SCDRS. More effort and the use of other sampling gear, would have increased the size and diversity of our catch, but probably would not have contradicted our finding that yellow perch and rock bass are the permanent, dominant residents of the littoral fish community of these island shoals. Larger species that may belong to this community, but that may not have been adequately captured by our gear are smallmouth bass in the St. Clair River and channel catfish and stonecat in the Detroit River. We cannot speculate on the composition of fish shorter than 100 mm in littoral communities because of the relatively large mesh size (1-inch stretched measure) of the netting from which the body of our hoop nets were constructed.

A major objective of this study was to determine if fish used plant beds. We believe that the higher catches observed in plant beds than in non-vegetated areas may reflect species-specific (yellow perch, hornyhead chub, spottail shiner) tendencies, which may also depend on location (e.g. at Fawn Island fish abundance and the presence of plants were significantly related). These tendencies were more strongly expressed in 1983 than 1984, and were correlated with season. The occurrence of significant trends could have been masked by various factors. Early in the season it was difficult to find well-defined, high-profile plant beds extending substantial distances into the water column; consequently we usually selected low profile Chara spp. beds as the vegetated areas in which we set our nets. Later in the season, high high-profile vegetation was so lush in some areas that it was difficult to find non-vegetated areas. Both situations could result in catches that might not support the well-documented preference of fish for structured environments of the sort provided by high profile vegetation (Brouha and von Geldern 1979; Prince and Maughan 1979; Helfman 1979; Paxton and Stevenson 1979). The poorly defined relationship between fish catch and vegetation in 1984 could be due to the rate of development of vegetation in spring 1984, which was generally lower and also varied more widely from location to location in 1984 than in 1983.

Overall, after considering the above variability, we believe that vegetation was related to abundance of three of the four common species inhabiting the island shoals. Submersed vegetation was also the only underwater structure in SCDRS, because the low gradient and navigation-related maintenance eliminate structure such as boulders and snags common to other riverine systems. Thus the submersed macrophyte beds are of considerable importance to fish production in SCDRS.

CHARACTERIZATION OF SCDRS HABITATS

Because of the number and variety of the data, a site-by-site treatment of major taxa might facilitate impact analysis on a habitat basis. Table 51 shows a geographic breakdown of the dominant taxa of macrozoobenthos, submersed macrophytes, and fish found in SCDRS. The benthic transect numbers I-XXI are used as locators. With the following exceptions, sampling locations for fish and macrophytes were also sampling locations (transects) for macrozoobenthos: Transect XVIII at Point Hennepin, at the tip of Grosse Ile, was the macrozoobenthos sampling location closest to the Mamajuda Island Shoals plant and fish sampling locations: and transect XXI was several thousand feet upstream from the fish and macrophyte location at Stony Island. Vegetation at each of the transects was usually at the shallower, off-channel station, except at Stag Island, where the benthic samples were taken at the head of the island in an area devoid of plants.

Physical differences in the rivers can serve as a basis for this characterization. The St. Clair River can be divided into four types of shallow-water habitat (≤ 12 ft deep), each with a slightly different faunal composition: the entrance into the St. Clair River, the mainland shore in the upper river, the shoreline along the delta islands, and the island shoals. Transect I typifies the headwaters of the St. Clair River. In this area current velocities are fairly high, the substrate is composed of sand, and macrophytes are lacking. The fauna was composed of chironomids having special adaptations (thin, streamlined bodies) for living in sand; planktonic copepods and cladocerans; and the ubiquitous oligochaetes (Table 51). Biomass and density are low.

Transect II represents the only mainland littoral area sampled in the upper St. Clair River. This narrow band between the shoreline and the 12-ft depth contour has a mean width of about 170 ft, runs along both mainland shorelines, and covers 1157 acres or 14% of the total area of the upper St. Clair River. Sediments along this narrow band range from sand-silt in protected areas and sand, gravel, or cohesive clays in plant beds along the shipping channel. The texture of superficial sediments at any given site depends on bed material and current velocity, which in turn is determined by river width and channel configuration. The fauna at transect II is characterized by the high standing stocks of net-spinning caddisflies (Table 51), which presumably eat the seston coming from Lake Huron. Farther downstream the seston begins to settle out and the net-spinners are replaced by collector-gatherers such as amphipods and mayflies. Macrozoobenthos biomass along this band is high, probably due to extensive beds of macrophytes dominated by *Chara* spp., *Potamogeton* spp., *Vallisneria americana*, and *P. richardsonii*. Schloesser and Manny (1982, 1984)

Table 51. Dominant macrozoobenthos, submersed macrophytes, and fishes in the SCDRS in 1983-1984. Order of presentation of taxa in table indicates numerical or biomass rank. Transect number, substrate and current velocity values are associated with the macrozoobenthos data. Density (no./m²) and biomass values (g ash-free dry weight/m² for macrozoobenthos; g dry weight/m² for macrophytes) are for all taxa combined[a/].

Transect	Dominant substrate		Surface current velocity (ft/s)		Macrozoobenthos			Macrophytes		
	Off-channel	Channel	Off-channel	Channel	Taxa	Density	Biomass	Macrophytes*/	Biomass	Fishes
I	Sa	Sa	1.7	1.8	Chironomids, cladocerans, copepods, oligochaetes	1,700	0.14	none		
II	Sa Si	Gr	0.7	2.3	Hydra, oligochaetes, chironomids, snails, caddisflies	56,000	1.72	Potamogeton spp. P. richardsonii Vallisneria		
III (Stag Island)	Gr	Gr	1.8	2.1	Hydra, chironomids, oligochaetes, caddisflies, snails	5,200	0.17	Chara Potamogeton spp. P. richardsonii	92	Yellow perch Hornyhead chub Rock bass
IV (Fawn Island)	Sa Si	Sa	1.1	2.5	Hydra, oligochaetes, snails, chironomids, amphipods, clams	24,900	1.28	Chara P. gramineus P. richardsonii	130	Yellow perch Rock bass Hornyhead chub
V (Russell Island)	Sa Si	Gr	1.4	2.8	Hydra, oligochaetes, chironomids, snails, amphipods, mayflies	50,900	1.90	Chara P. gramineus Potamogeton spp.	164	Yellow perch Rock bass Hornyhead chub
VI	Sa Si	Sa Si	0.5	1.2	Hydra, chironomids, oligochaetes, amphipods, mayflies, snails	40,900	2.30	Chara* P. richardsonii		
VII	Sa Si	Cl	0.6	1.9	Hydra, oligochaetes, chironomids, snails, amphipods, mayflies	60,800	3.06	Chara* P. richardsonii		
VIII	Si Cl	Sa Si	0.2	0.7	Oligochaetes, Hydra, chironomids, Manayunkia, mayflies, amphipods	66,500	1.24	Chara* Potamogeton spp.		
IX	Sa Si	Sa Si	0.3	0.4	Oligochaetes, chironomids, Manayunkia, amphipods, Hydra, snails	15,900	0.62	Chara*		
X	Sa	Sa Si	0.4	0.4	Oligochaetes, chironomids, Hydra, snails, amphipods, mayflies	11,600	0.48	Chara*		
XI	Si Cl	Si Cl	0.5	0.2	Oligochaetes, nematodes, Manayunkia, mayflies, clams, chironomids	14,700	1.38	none		
XII	Si Cl	Si Cl	0.2	0.2	Oligochaetes, mayflies, chironomids, Manayunkia, nematodes, amphipods	7,800	1.46	none		
XIII	Si Cl	Si Cl	0.6	0.5	Oligochaetes, mayflies, chironomids, nematodes, clams, Manayunkia	6,300	1.38	none		
XIV	Sa Gr	Sa Si	0.8	1.2	Oligochaetes, Manayunkia, clams, chironomids, snails, caddisflies	4,600	1.15	Vallisneria*		
XV	Sa Cl	Sa Cl	0.7	1.6	Caddisflies, Hydra, oligochaetes, snails, clams, chironomids	9,500	1.18	Chara*		
XVI (Belle Isle)	Si	Sa Si	0.1	0.9	Oligochaetes, chironomids, nematodes, Hydra, amphipods, ostracods	19,100	4.52	P. richardsonii Vallisneria Nitellopsis	106	Rock bass Yellow perch
XVII	Si	Sa Si	0.3	1.4	Manayunkia, oligochaetes, nematodes, copepods, Hydra, chironomids	19,400	1.00	Vallisneria* Chara		
XVIII (Point Hennepin)	Si	Si	0.4	0.9	Oligochaetes, snails, nematodes, nemertines, rhabdocoels, triclads	80,900	1.36	Vallisneria P. richardsonii Potamogeton spp.	73	Yellow perch Rock bass Spottail shiner
XIX	Si Cl	Gr Sa	0.4	1.3	Oligochaetes, Manayunkia, nemertines, nematodes, snails, rhabdocoels	14,800	0.66	Vallisneria*		
XX	Co Gr	Sa Cl	0.7	1.9	Oligochaetes, nematodes, nemertines, snails, Hydra, chironomids	10,100	0.34	Heteranthera* Vallisneria Potamogeton spp.		
XXI (Stony Island)	Sa Si	Gr Cl	0.8	1.1	Oligochaetes, Manayunkia, nematodes, Hydra, nemertines, clams	12,900	0.62	Vallisneria Myriophyllum Heteranthera	163	Rock bass Channel catfish Stonecat

a/ Cl = clay, Si = silt, Sa = sand, Gr = gravel, Co = cobble; * Based on visual estimates of plants present in samples of macrozoobenthos.

estimated that the standing crop of submersed macrophytes along the mainland shorelines is 60-160 g/m².

Transects III, IV, and V are associated with island shoals. Between the shoreline and the 12-ft depth contour, these three island shoals, plus the St. Clair Middle Ground and a small shoal just above Fawn Island, cover 429 acres and represent 5% of the total surface area of the upper St. Clair River. Our sampling over most of this area indicated that the percent coverage by submersed macrophytes in this shallow water was about 60-70%. However, the shoals at the head of Stag Island are devoid of plants, current velocities are high, the substrate is gravel, and benthos standing crop is low. Plant coverage over the rest of Stag Island is also low (20%), and where plants are present standing crop is also low (< 100 g/m²). Although current velocities are high at the head of Fawn and Russell islands, plants such as P. gramineus, P. richardsonii, and Potamogeton spp. ring the outer edge of the shoals, and these species along with Chara spp. cover almost 70% of the rest of the shoals. Macrozoobenthos and plant biomass are high at both Fawn and Russell islands (Table 51). Dominant taxa of macrozoobenthos, aquatic plants, and fish are similar between sites. Seston concentrations are capable of sustaining relatively high levels of caddisflies in gravel substrates at Stag Island, but not at Russell Island.

Transects VI - X are along the shoreline of the South Channel and St. Clair Cutoff Channel in the St. Clair River delta area. A band of shallow water extends an average of 374 ft from the shoreline to the 12-ft depth contour along both the U.S. and Canadian sides of the river. This area covers 905 acres and represents 50% of the total surface area of this portion of the river. Currents were low (< 1.0 ft/s) and sediments were dominated by mixtures of silt and sand. Some of the highest biomass values for macrozoobenthos were found at transects VI and VII (Table 51), but biomass and densities declined dramatically along transects nearer to Lake St. Clair. Dominant invertebrate groups were similar between transects, with only minor shifts in order of abundance. High densities of Manayunkia appeared at transect VIII, and oligochaetes replaced Hydra as the dominant taxon on this transect. Chara spp. was the dominant plant on all transects (> 80% of samples) but P. richardsonii was also common at transects VI and VII.

The benthic fauna at all areas sampled in the St. Clair River, except transect I in Lake Huron, was usually dominated by Hydra, oligochaetes, chironomids, gastropods, amphipods, and mayflies. Densities of Hydra were usually highest in October at most transects; however, densities were high in May at transects VI - VIII and X in 1983 but not in 1984. The depth distribution of Hydra is also variable, densities usually being highest in deeper, near-channel areas; in other areas (e.g., transect V) its density peaked in shallow water. The presence of solid substrates such as vegetation or coarse gravel may modify the distribution, regardless of depth. Sand, gravel, and cohesive clay are usually present where current velocities exceed 2 ft/s, and sand and silt where velocities are less than 1 ft/s. Oligochaetes were most common in shallow water in May, and chironomids were common in shallow water in May and

October. Gastropods were most common in October; Amnicola dominated in shallow water and Elimia in deeper water. Densities of amphipods were high in shallow water and Gammarus was the dominant genus. Mayflies do not become abundant until transect IV, perhaps reflecting pollution effects from Sarnia at the head of the river. Hexagenia and Caenis were the most common genera and were densest in the fall; Hexagenia was the more abundant in deepwater and Caenis in shallow water. Ephemerella was also common, but distributed evenly over all depths. The Trichoptera were dominated by Cheumatopsyche and Hydropsyche; densities were high only in the upper St. Clair River. Neither genus showed trends in abundance related to water depth. Yellow perch, rock bass, and hornyhead chubs were the dominant fishes except seasonally when rainbow smelt occasionally were the most abundant.

Transects XI - XIII were located in Lake St. Clair in the deepest part of the lake (> 12 ft). Sediments were uniformly fine in the silt-clay class. Aquatic macrophytes were lacking, although sparse stands of Cladophora were evident in October. Benthic invertebrates were not abundant, but biomass was about equal to the system-wide average because the number of large Hexagenia nymphs was high (Table 51). The dominant genus of clams was Pisidium, and the dominant amphipod was Gammarus. Although substrate and current velocities appeared to be uniform among the transects, there were considerable differences in relative abundance of taxa other than oligochaetes.

Transects XIV - XV were in the headwaters of the Detroit River. These two transects differed in substrate, aquatic macrophyte composition, and macrozoobenthos composition (Table 51). Manayunkia was abundant at transect XIV but not abundant at transect XV, and Hydra and caddisflies were more abundant at transect XV. Current velocities were similar, but bed material was different at the two locations. Subtle differences in substrate and the presence or absence of Chara spp. and Vallisneria americana apparently influence the composition of benthic invertebrates more strongly than do current velocities. Macrozoobenthos densities were low but biomass values were near average for the system. Plant biomass values were low, in the 20-90 g/m^2 range (Schloesser and Manny 1982).

About 18% of the 5,160 total surface acres of the upper Detroit River overlie water less than 12 ft deep. These littoral areas include 272 acres around Belle Isle; 159 acres in the Scott Middle Ground; 472 acres along both shores, where the average width of the littoral band is 150 ft; and about 40 acres at the head of Fighting Island. Composition and density of fauna at transects XVI and XVII are probably only representative of shoals in the vicinity of Belle Isle. Our estimate of the biomass of aquatic macrophytes at Belle Isle (106 g/m^2) fell within the range measured by Schloesser and Manny (1982) in this area in 1978; however, they found almost no plants along the narrow band of shallow water along the U. S. mainland shore and only a few plants in areas (Ambassador Bridge and above Fighting Island) along the Canadian shoreline below Belle Isle. At transect XVI, the densities of macrozoobenthos were lower than the average of 25,500/m^2 for the system, but the biomass was the highest recorded in SCDRS in 1983-84. This high biomass was due in part to the large mussel population in the Belle Isle area. Transect XVII was the only transect

where Manayunkia was numerically dominant. Benthic copepods and ostracods also were among the six most abundant taxa at the two Belle Isle transects. The rock bass was the dominant fish species.

Transects XVIII - XXI in the lower Detroit River cover a variety of habitats ranging from protected areas with fine, oil-contaminanted sediments (XVIII) to areas with high current velocities and bedrock substrate (XX). Of the 28,800-acre area of the lower Detroit River, about 82% is less than 12 ft deep. Because of the complexity of the system this area was not divided into mainland, island, or shoal areas. Plant biomass ranged from sparse at Point Hennepin (73 g/m^2) to dense at Stony Island (163 g/m^2). Schloesser and Manny (1982) reported a similar range of values, including high biomass (150-220 g/m^2) on the west side of Grosse Isle, around Celeron Island and the east side of Fighting Island, and generally lower values (60-160 g/m^2) in most other areas of the river except along the U. S. mainland shoreline (where plants were lacking). Vallisneria americana and Heteranthera dubia were the dominant taxa in their collections and in ours. Biomass of macrozoobenthos was low, and dominated by oligochaetes--especially at transect XVIII. Snails, clams, and chironomids were the only other taxa to develop relatively high populations in the area. A variety of substrates were present but no pollution-sensitive insect group developed sizable populations. However, there were small populations of mayflies and caddisflies in areas with high current velocity and rock substrate. Rock bass dominated the fish community at Belle Isle and Point Hennepin, but the spottail shiner and two species of ictalurids were dominant in the lower Detroit River.

Oligochaetes, chironomids and Hydra dominated the upper Detroit River and oligochaetes, nematodes and nemertines dominated the lower Detroit River. Oligochaetes and nematodes were more common in shallow water in May, in contrast to nemertines and Manayunkia, which were more abundant in October in deeper water. Hydra was common only in May in 1983. Elimia, Amnicola, and Ferrisia were the most common gastropod taxa. Pisidium was the dominant pelecypod and Hydropsyche and Cheumatopsyche were the dominant caddisfly taxa. Both Gammarus and Hyalella were common amphipod taxa. Copepods were represented by benthic harpacticoids rather than planktonic taxa.

Spring 1984 Ice Jam

The ice jam that stalled vessels and required ice breaking activity for 3 weeks in late April and early May 1984 provided us with a chance to evaluate a potentially worst-case condition similar to one that might develop under extended season navigation. Macrozoobenthos populations appeared to be the most adversely affected of the three groups studied. Densities of 10 taxa and total biomass were lower in 1984 than in 1983 and most declines occurred in the St. Clair River. However, most of the affected taxa had recovered by fall 1984 to levels equally or exceeding those in fall 1983, and taxa that did not recover completely reached densities that were within 30% of the fall 1983 values. It is not known whether these declines were due to ice scour, lower temperature, or some other factor or combination of factors. Maximum densities of the affected taxa were at the inshore station, and most of the taxa could be categorized as living near

the mud-water interface. Thus the decline could logically be attributed to ice scour in the shallow areas. It would be difficult to ascertain whether lower temperatures were involved, because organisms of each of the taxa have different physiological responses and age structures. Whatever the cause, most taxa that exhibited a seeming decline recovered to 1983 densities within 6 months.

The distribution and occurrence of aquatic macrophyte taxa changed little between years. Maximum percent coverage of macrophyte beds varied little between years and rivers. Development of beds in June was delayed in 1984 in the St. Clair River and at Belle Isle, but by September the beds were little different in 1984 than in 1983, at least through the upper two-thirds of SCDRS. There were significant differences in biomass between years, but there were no consistent differences between locations or months. Impacts on submersed macrophytes, other than possibly delayed development due to lower temperature, could not be ascribed to the ice jam.

Fish catches were usually lower in 1984, but this trend occurred in both rivers and in most comparisons was not statistically significant. Lower catches in 1984 may have been due to the effect of lower temperatures on development of plant beds, general activity level, and seasonal migrations.

CONCLUSIONS AND RECOMMENDATIONS

This study was conducted to describe the present distribution and abundance of macrozoobenthos, aquatic macrophytes, and juvenile fishes in SCDRS. We believe that we have addressed this objective for the open water season on SCDRS within the constraints imposed by our data, and that our study provides a baseline data set that can be used to evaluate any future extension of the navigation season. We do not believe that the results of our study can be used alone to answer the question of whether increased winter vessel traffic will have a measurable effect on SCDRS. The ice jam of April 1984 may have had an undefined effect, but we cannot show that the ice jam was caused or exacerbated by navigation, or that the jam simulated conditions that might occur from vessel operation in January or February.

The benthic, aquatic plant, and fish communities described here appear to exist at the observed level of traffic without obvious ill effects from winter ship traffic. However, winter vessel traffic has occurred in SCDRS for many years and thus there is no truly unaffected baseline from which the effects of winter navigation that may have already occurred can be empirically judged. It has been postulated that increased shipping might amplify ice scour, turbulence, flooding, and dewatering, which in turn could affect the density, location, and behavior of biota in the system. It has also been postulated that the environmental impacts of increasing winter shipping may be cumulative and take several years to become readily observable. We believe that an adequate evaluation of the potential impacts of winter navigation on SCDRS will require the development of an energy flow model plus an age-structured fishery model.