ENVIRONMENTAL STUDIES OF MACROZOOBENTHOS, AQUATIC MACROPHYTES, AND JUVENILE FISHES IN THE ST. CLAIR-DETROIT RIVER SYSTEM, 1983-1984

INTRODUCTION

The U.S. Army Corps of Engineers (Corps) is considering the extension of operation of the Locks at Sault Ste. Marie, Michigan, from 8 January ± 1 week to 31 January ± 2 weeks. To provide information needed in the preparation of a Supplemental Environmental Impact Statement addressing this extension in the winter operation of the lock facilities at Sault Ste. Marie, Michigan, and the subsequent increase in vessel traffic in the St. Clair-Detroit River system (SCDRS), the Corps funded a comprehensive environmental study of SCDRS in 1983-1985. The SCDRS includes the St. Clair River, Lake St. Clair, and the Detroit River. The present study of macrozoobenthos, aquatic macrophytes, and juvenile fish in SCDRS is an integral part of that comprehensive study. Other components of the Corps-funded research on this system include those undertaken by the U.S. Army Cold Regions Research and Engineering Laboratory on sediments and water chemistry, by the Michigan Department of Natural Resources on adult fish populations and anglers' catches, and by the U.S. Fish and Wildlife Service (Sandusky Biological Station) on fish spawning and nursery areas (Muth, K. M. et al. 1986).

The objectives of the present study were (1) to describe the present distribution and abundance of macrozoobenthos, aquatic macrophytes, and juvenile fish within SCDRS, and (2) to predict the potential environmental impact of an extended navigation season on these organisms in SCDRS.

Currently (1986) there is some navigation on SCDRS during the proposed extension period. This is the contemporary baseline condition, and extension of lock operation would result in increased vessel traffic in the system over and above the 1986 situation. Ice cover is limited or lacking in both St. Clair and Detroit rivers during normal winters, but usually is well developed on Lake St. Clair. Potential impacts of extended lock operation would typically be evaluated on the basis of anticipated or modeled considerations involving the biology, distribution and abundance of organisms in relation to ship movement and ice breaking during winter ice conditions. However, an extensive ice jam (described later), that occurred in spring 1984 on the St. Clair River, provided an opportunity to evaluate differences in abundance and distribution of biota that might be attributable to relatively large between-year differences in ice cover, shipping activities, and ice scour.

Concern over possible adverse impacts of winter shipping on the Great Lakes has provided impetus for a number of environmental studies on connecting channels over the past several years (Gleason et al. 1979; Hiltunen 1979, 1980; Jones 1982; Liston et al. 1980, 1981; and Poe et al. 1980). These studies were supplemented by pollution related studies on SCDRS (USACE 1980; Harlow 1965; Michigan Water Resources Commission 1967; Ontario Ministry of the Environment 1979; Texas Instruments 1975; and Thornley and Hamdy 1984). Studies on fish in SCDRS (Goodyear et al. 1982; Hatcher and Nester 1983; and

Poe 1983) documented the distribution of important taxa and their habitats. An annotated bibliography of macrozoobenthos and aquatic macrophytes in SCDRS was prepared with Corps funding (McCauley 1985). Limno Tech, Inc. (1985) developed a bibliography and summary of the water quality problems in the system. Thornley and Hamdy (1984) and the Ontario Ministry of the Environment (1979) described the impact of man's discharge of contaminants, particularly of organics and heavy metals, on the biota and habitat. Many of these studies have pointed out the importance to the fishery of the extensive, submersed macrophyte beds and their stable, macrozoobenthos-rich substrates.

One of the major environmental concerns associated with the impact of winter navigation was the possibility of increased scouring of benthic habitat by flow modifications and ice, and the displacement downstream of plants, benthos, and substrate (Poe and Edsall 1982). In the present study we focused on upstream areas of five islands and one shoal area that the USACE identified as potentially vulnerable to impact by ice scour during an extended navigation season. All six areas were extensively covered with submersed macrophytes. Aerial photographs and plant and fish samples were taken from spring to fall in 1983 and 1984 in each area. The benthos samples were collected along the main navigation channel throughout the SCDRS, in spring and fall in 1983 and 1984.

Given the possible impact of ice scour on the benthic habitat in the St. Clair River in 1984, we concentrated on statistically analyzing variation in the abundance of major taxa of macrozoobenthos between years and between rivers, in relation to physical variables and changes in fish and plant populations. We then focused our attention on variation in community structure of macrozoobenthos, plants, and fish in relation to the effects of the ice jam.

DESCRIPTION OF THE STUDY AREA

The study area extended from Port Huron on the north to the lower end of Grosse Ile on the south, including the St. Clair and Detroit rivers (Fig. 1). The surface bedrock geology in the study area dates back to the Devonian period, is of marine origin, and consists mainly of shales in the St. Clair River and Lake St. Clair, and dolomites in the Detroit River. Glaciation has modified the topography by scouring and filling. The SCDRS lies in a morainal trough and is characterized by sediments consisting of glacial till and lake and stream deposits. The rivers are incised into a bed of glacial, lake-deposited clays with thicknesses of 80-200 ft (24-61 m) in the St. Clair River (Cole 1903) and 20-140 ft (6-43 m) in the Detroit River (Mozola 1969).

The SCDRS which is 89 mi (143.2 km) long, and drops 8 ft (2.4 m) between Lake Huron and Lake Erie, can be divided into five major segments: the upper St. Clair River, the lower St. Clair River, Lake St. Clair, and the upper and lower segments of the Detroit River (Fig. 1). Most of the following hydrographic information on the system comes from Derecki (1984 a, b, c). The upper St. Clair River is 27.9 mi (45 km) long and receives water from Lake

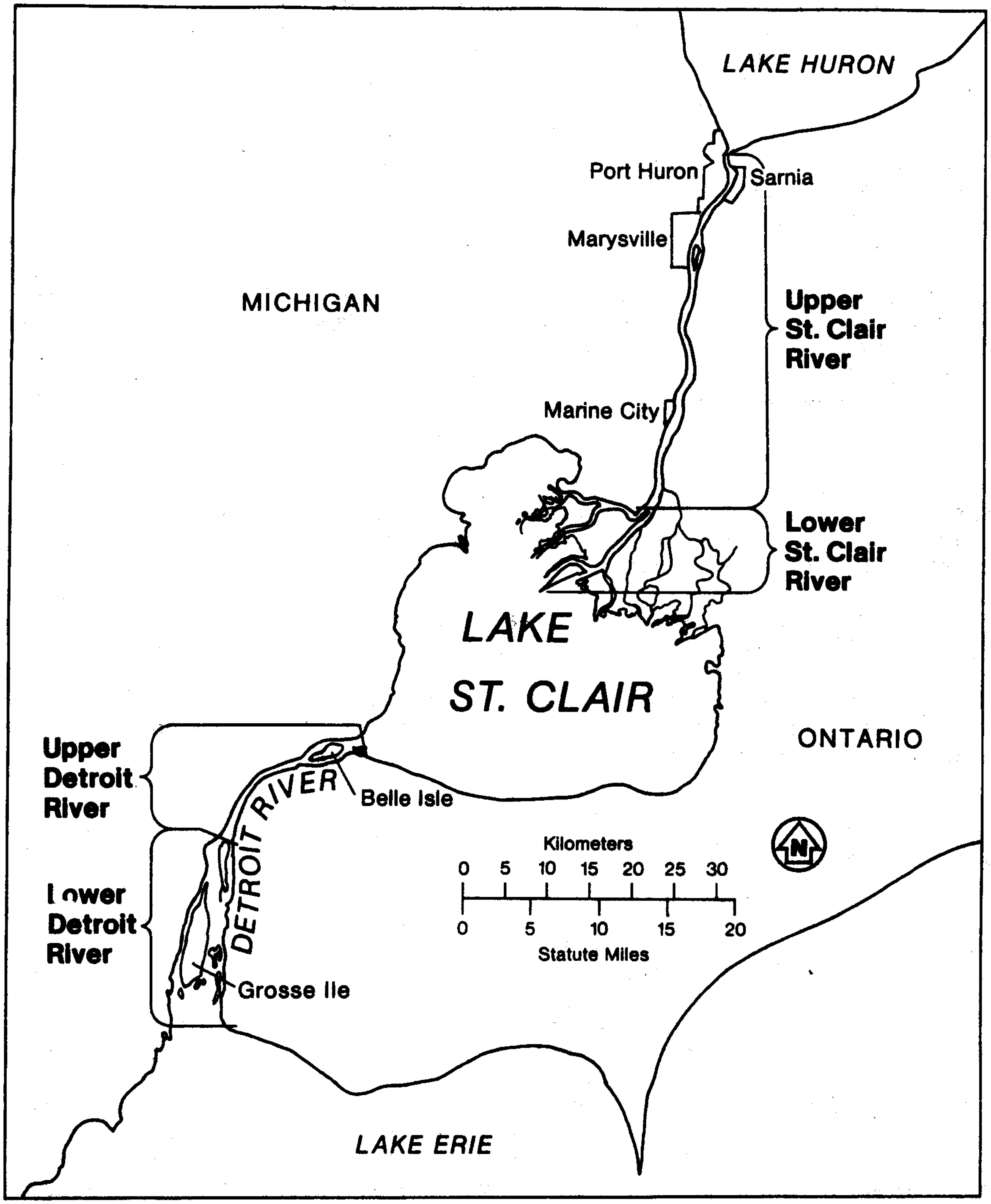

Figure 1. The St. Clair-Detroit River System.

Huron and three major tributaries (the Black, Pine, and Belle rivers). The lower St. Clair River, begins at the branching of the north and south channels near Algonac, Michigan, is 11.2 mi (18 km) long and divides to form a large delta area consisting of three main channels (north, middle, and south) and a number of secondary channels that empty into Lake St. Clair.

Width of the St. Clair River ranges from 820 to 3,940 ft (250-1200 m) and averages 2,625 ft (800 m) in the upper section. The widths of the three main channels in the delta area range from 700 to 3,000 ft (214-915 m). Mid-channel depths are 27 to 70 ft (8.2 - 21.5 m); a minimum statutory depth of 27 ft is maintained by dredging. Littoral depths are typically 6-13 ft (1.8-4.0 m). Mean annual discharge rate of the St. Clair River into Lake St. Clair was 214,000 ft^3/s (6,060 m^3/s) in 1983 and 209,000 ft^3/s (5,920 m^3/s) in 1984. These flows are about 17% higher than the historical average discharge of 180,000 ft^3/s (5,100 m^3/s). Velocities in the St. Clair approach 6 ft/s (1.8 m/s) in the navigational channel and range from 0.3 to 2.8 ft/s (0.09-0.86 m/s) near the channel. Total flushing time from Lake Huron to Lake St. Clair is normally about 21 hours; about one-third of this time is required to flush the delta area. Stag and Fawn Islands, 8.7 mi (14 km) and 21.7 mi (35 km) respectively, downstream from Lake Huron, are the only islands in the upper section of the St. Clair River. The delta area includes Russell, Harsens, Dickinson, and Seaway islands.

Lake St. Clair has a surface area of about 430 mi^2 (1,114 km^2), a mean depth of 11 ft (3.4 m), and a maximum natural depth of 21 ft (6.4 m). A navigation channel 18 mi (29 km) long, which has a statutory depth of 27 ft (8.2 m) bisects the lake from the mouth of the South Channel of the St. Clair River to the head of the Detroit River. These data are based on a Great Lakes low water datum of 573.3 ft (174.7 m) above mean sea level; in 1983-1984 the water levels were 3.25 ft (1.0 m) above this low-water datum. Major tributaries are the Clinton River on the United States side and the Sydenham, Thames, Belle, and Ruscom rivers on the Canadian side. Flushing time of the lake is 5 - 7 days.

The upper Detroit River, which is 13 mi (21 km) long, receives water from Lake St. Clair. The lower Detroit River, which is 18.9 mi (30.5 km) long, begins at the head of Fighting Island, where the river separates into three channels (Trenton, Livingstone, and Amherstburg). Major tributaries are the Rouge and the Ecorse rivers, both on the U. S. side. Width of the river ranges from 1,970 to 8,450 ft (600 - 2,600 m) in the upper section, and from 4,920 to 10,400 ft (1,500 - 3,000 m) in the lower section. Mid-channel depths are 20 - 49 ft (6.2 - 15.1 m) and littoral depths are 7-20 ft (2.2-6.2 m). Mean annual discharge rate of the Detroit River into Lake Erie was 217,000 ft^3/s (6,140 m^3/s) in 1983 and 215,000 ft^3/s (6,090 m^3/s) in 1984. These flows are about 17% higher than the historical average discharge of 185,000 ft^3/s (5,200 m^3/s). Average flow velocities were 2 - 6 ft/s (0.6 - 1.8 m/s) in the mid-channel region and 0.1 - 1.9 ft/s (0.03-0.58 m/s) in the nearshore and near channel areas. Total flushing time from Lake St. Clair to Lake Erie is about 19 hours in the main channel. The upper river has two large islands, Peach Island and Belle Isle, and the lower river has Fighting Island, Grosse Ile, Bois Blanc, and several small islands.

The climate in the study area is semi-maritime due to its proximity to lakes Huron and Erie. The mean annual surface air temperature is 9 - 10°C (48-50°F); however, intense cells of cold arctic air can lower temperatures as much as 28°C (81°F) over a 24-hour period. Air temperatures from December to March averaged 4.6°C lower in 1983-1984 than in 1982-1983. Air temperatures were 1.0°C higher in April-June and 1.7°C lower in July-September in 1984 than in 1983 (Fig. 2).

High winds and storms are common and significantly affect the thermal budgets of Lake Huron and SCDRS. Prevailing winds are from the west. High winds generate seiches and surges that strongly affect the lower Detroit River, causing water levels to rise or fall 2-3 ft. Wind speed and direction also sometimes affect ice buildup and cause ice jams in the St. Clair River. Typically the river remains clear of ice and only a narrow band of shore ice forms along the banks, except in the delta area. However, ice may enter the St. Clair River from Lake Huron under the influence of northerly winds. The current carries this ice downstream until it meets resistance from solid ice cover in the delta or in Lake St. Clair. When large amounts of ice enter the system, the ice accumulation may extend upstream from Lake St. Clair nearly to Port Huron (Fig. 1). During most of the winter a large natural ice arch forms at the outlet of Lake Huron and prevents ice from entering the river. This condition usually lasts through the winter, but strong southerly winds, particularly in March and April, may disrupt the ice arch and push the ice field away from the river mouth. If the ice arch does not re-form, a north wind can then push the ice field back into the river in large quantities, as it did in 1901 (Cole 1903), 1920, 1942, and 1984 (USACE 1984).

In 1984 the ice jam in the St. Clair River lasted from April 5 to April 30 (USACE 1984). On April 1 no ice existed in the St. Clair River, but a large pack of ice covered the southern portion of Lake Huron. On April 5 a large amount of ice was reported floating downstream in the vicinity of Marine City. By April 7 pack ice extended from Marysville to the mouth of the St. Clair River. The large ice pack in Lake Huron and persistent winds from the north in April choked the St. Clair River with ice until April 30. Ice as thick as 8 ft was reported. Water temperature during April in the St. Clair River was about 6°F lower than normal and a reduction in flow of almost 95,000 ft^3/s (2690 m^3/s) resulted in a 2-ft drop in the Lake St. Clair water level for about 3 days. During April at least 140 vessels were led through the St. Clair River by four Coast Guard ice breakers. Movement through the river at this time was slow and difficult, and several vessels ran aground.

The upper Detroit River normally does not freeze over, except in the broad, shallow area between Belle Isle and the United States mainland. Minor ice jams occur when large quantities of floe ice from Lake St. Clair encounter the narrow channel and shallow ice-covered areas in the lower river, which block downstream passage of the floe ice. Easterly winds can also cause

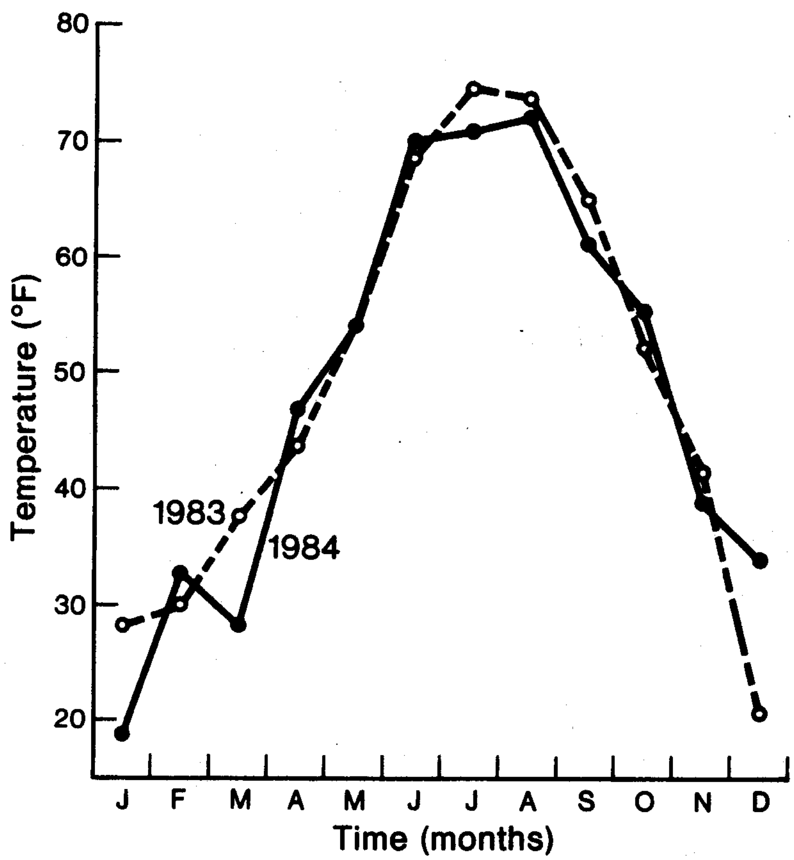

Figure 2. Mean monthly air temperatures in 1983 and 1984 at Windsor, Ontario, airport.

jams by moving Lake Erie ice into the lower river. Ice cover develops in the lower river in the broad, shallow expanses adjacent to the many islands; however, the main navigation channels are generally open. Occasionally the river fills completely with ice, when there is heavy ice movement from Lake St. Clair and the river mouth is blocked by ice from Lake Erie (Derecki 1984 c).

Concentrations of toxic materials in sediments are elevated in several areas within SCDRS. Although we collected no data on contaminants, past work has demonstrated that contaminants adversely effect the health and abundance of fish, macrophytes, and particularly macrozoobenthos (Limno-Tech, Inc. 1985). Concentrations of pollutants in the sediments of SCDRS are relatively high and some exceed EPA criteria; potential contaminants treated by Ontario's guidelines and IJC objectives are polychlorinated biphenyls (PCB), hexachlorobenzene (HCB), octachlorostyrene (OCS), phenol, polyaromatic hydrocarbons (PAH), cyanide, oil and grease, cadmium, chromium, and mercury. The contaminated areas tend to be near shore, and near point sources, but also include depositional zones far removed from known point sources. The distribution of contaminants in sediments is difficult to assess--as it is in most riverine environments. The major point source in the St. Clair River is the Sarnia industrial complex. The reported ranges of concentrations of contaminants in the upper St. Clair River follow: PCBs, 0-10,000 ppb; OCS, 0-193 ppb; oil and grease, 250-600 ppm; and mercury, 0.1-58 ppm. PCB levels exceed the Ontario guidelines (50 ppb) and IJC objectives (100 ppb), and mercury in certain areas (>1 ppm) exceeds the EPA guidline (no standards exist for OCS in sediments). Oil and grease levels are acceptable in most areas. Concentrations of contaminants are lower in the St. Clair delta, but sampling there has been limited. Deposition of sediments in Lake St. Clair in the mid-lake area near the navigational channel has resulted in the following ranges of concentrations: PCB 0-50 ppb, HCB 36-99 ppb, OCS 0-30 ppb, cadmium 1-2 ppm, and mercury 1-3 ppm. Cadmium concentrations (>1 ppm) exceed Ontario's guidelines and mercury levels indicate heavy pollution; no guidelines exist for HCB in sediments. The entire Detroit River--particularly the lower section associated with the industrial complex on the U.S. shore--is the most severely polluted area in SCDRS. Pollutants include PCB 0-3800 ppb, HCB 0-36 ppb, OCS 0-10 ppb, oil and grease 100-29,000 ppm, cyanide 0.25-2.94 ppm, phenols 0-1 ppm, chromium 4-330 ppm, mercury 0-8 ppm, and cadmium 0-17 ppm. PCB, oil and grease, cyanide, chromium, cadmium, and mercury levels exceed EPA's guidelines for heavily polluted sediments. No standards exist for phenol or PAH. A total of 15 PAH compounds have been found at detectable levels, and mean concentrations of individual compounds measured have been as high as 39 ppm. Some of these data were collected in the 1970's, and some pollutants have declined since then. Hamdy and Post (1985) concluded that mercury in superficial sediments of the Detroit River declined substantially between 1970 and 1980. Pugsley et al. (1985) could not determine whether PCB levels in sediments had decreased or remained reasonably static in SCDRS over the last 10 years, and Mudroch (1985) found metal concentrations in the Detroit River to be significantly higher in 1983 than in 1969-73. More data are needed to provide a comprehensive and current assessment of contaminants in sediments, and to establish standards.