THE BIOMASS AND PRODUCTIVITY OF AQUATIC MACROPHYTES IN NAVIGATION POOL 8 OF THE UPPER MISSISSIPPI RIVER

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ABSTRACT

The biomass of aquatic macrophytes in Navigation Pool 8 of the Upper Mississippi River was determined in order to provide basic data on the productivity, frequency, and distribution of these plants. Two 0.25 m^2 quadrats constituted a sample at a given site. All vegetation, including underground parts, was removed from these quadrats. The vegetation in each sample was washed, separated into component species, frozen, dried, and weighed. Oven dry weight of each species per 0.5 m^2 was recorded.

During the summer of 1975 samples were taken at sites evenly spaced along transects in each of 41 study areas in Pool 8. Most areas were sampled twice; once in early summer and once in late summer. A diverse, typical hard water flora was found. *Ceratophyllum demersum*, *Sagittaria latifolia*, and *Vallisneria americana* were the most frequently occurring species, while the greatest portion of the total biomass of Pool 8 consisted of *Sagittaria latifolia* (45.24%), *Vallisneria americana* (14.33%), and *Sagittaria rigida* (8.50%). An average late July-August biomass of 181.70 g/m^2 for the littoral zone of Pool 8 was comparable to that for hard water lakes in Wisconsin.

This study has demonstrated that environmental factors interact with each other and with the macrophyte community in determining the amount of biomass.

Two areas, typical of the mid and lower sections of Pool 8, were sampled seven times between May 28 and September 19, 1976. Community composition and productivities were determined for these areas and growth patterns, growth rates, and maximum seasonal biomass were determined for the major species growing therein. For most species, the seasonal maximum biomass occurred at the time of maximum fruit development, and could be equated with annual net production. In general, submergent communities were less productive than floating leaved communities, whereas emergent communities were the most productive of all.

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TABLE OF CONTENTS

LIST OF TABLES

APPENDIX
<u>TABLE</u>

LIST OF FIGURES

APPENIX
FIGURE

LIST OF SYMBOLS AND ABBREVIATIONS

Key to species symbols and abbreviations

1 = C. dem. = Ceratophyllum demersum L.
2 = Clad. = Cladophora spp.
3 = E. can. = Elodea canadensis Michx.
4 = H. dub. = Heteranthera dubia (Jacq.) MacM.
5 = Lemn. = Lemnaceae
6 = L. dub. = Lindernia dubia (L.) Pennell
7 = L. pal. = Ludwigia palustris (L.) Ell. var. americana (D.C.) Fern. & Grisc.
8 = M. exa. = Myriophyllum spicatum L. var. exalbescens (Fernald) Jepson
9 = N. fle. = Najas flexilis (Willd.) Rostk. & Schmidt
10 = N. pen. = Nelumbo pentapetala (Walter) Fernald
11 = N. var. = Nuphar variegatum Engelm.
12 = N. tub. = Nymphaea tuberosa Paine
13 = P. aru. = Phalaris arundinacea L.
14 = P. coc. = Polygonum coccineum Muhl.
15 = P. cri. = Potamogeton crispus L.
16 = P. fol. = Potamogeton foliosus Raf.
17 = P. nod. = Potamogeton nodosus Poir.
18 = P. pec. = Potamogeton pectinatus L.
19 = P. ric. = Potamogeton richardsonii (Benn.) Rydb.
20 = P. zos. = Potamogeton zosteriformis Fern.
21 = S. lat. = Sagittaria latifolia Willd.
22 = S. rig. = Sagittaria rigida Pursh.
23 = S. rff. = Sagittaria rigida Pursh forma fluitans (Engelm) Fern.
24 = S. val. = Scirpus validus Vahl.
25 = S. eur. = Sparganium eurycarpum Engelm.
26 = V. ame. = Vallisneria americana Michx.

Key to substrate symbols

1 = clay
2 = muck (organic)
3 = silt
4 = sand
5 = gravel
6 = clay-muck
7 = muck-silt
8 = silt-sand
9 = silt-clay

INTRODUCTION

Purpose

The objective of this investigation was to provide basic data on the biomass, productivity, frequency, and distribution of aquatic macrophytes in Navigation Pool 8 of the Upper Mississippi River.

This research was initiated as part of a simulation model study of Pool 8 conducted by the University of Wisconsin-La Crosse River Studies Center. The study attempted to correlate certain physical-chemical parameters (depth, current velocity, dissolved oxygen, turbidity, temperature, sediment particle size, and sediment nitrogen and phosphorus) with certain biological parameters (aquatic macrophytes, fish, benthos, periphyton, and bacteria). If the empirically derived data core were found to be statistically interrelated, then a model could be developed to predict the effects of physical-chemical changes on the biological community. This could result in a mangement tool for future use on the Upper Mississippi River.

Aquatic macrophyte investigations in 1975 and 1976 relative to the simulation model project were concerned with the distribution of macrophyte biomass in Pool 8 in relation to physical-chemical and other biological parameters.

In addition, in 1976, the temporal distribution of macrophyte biomass was studied. Community compositon and productivities were determined for two areas typical of the mid and lower sections of Pool 8. Growth patterns, growth rates, and maximum seasonal biomass were determined for the major species in these areas.

Description of Study Area

Navigation Pool 8 of the Upper Mississippi River is impounded by Lock and Dam No. 8 at Genoa, Wisconsin, 679.2 miles of navigable channel upstream from the mouth of the Ohio River. It extends northward to Lock and Dam No. 7 at river mile 702.5 in Dresbach, Minnesota (Figs. 1 and 2). Pool 8 is bordered by La Crosse and Vernon Counties in Wisconsin and Winona and Houston Counties in Minnesota. It lies within the Driftless Area. The pool is 23.3 river miles (47.5 km) long and 2.9 mi (4.7 km) wide at its widest point. It has a surface area of 5741 acres (14,176 ha). The descent of the Mississippi River in Wisconsin averages four inches per mile (Martin 1965). Therefore, Pool 8 descends approximately 7 3/4 feet (2.36 m) from north to south.

Major tributaries to the Mississippi River in Pool 8 are the La Crosse River, which enters from the east at mile # 698.1 and the Root River, which enters from the west at mile # 693.8.

Claflin (1973), in an environmental assessment of Pool 8, reported the following concerning its natural water quality:

> "Total hardness rarely exceeds 175 mg/1 in Navigation Pool 8 and does only when emergent ground water of local origin is concentrated in the pool. The alkalinity varies slightly around 175 mg/1 and the water has a characteristic brown color from the dissolved organic substances leached from forest floor areas."

Discharge from Pool 8 ranges from 5700 cubic feet per second (cfs) to 286,000 cfs (pers. comm. U.S. Army Corps of Engineers, St. Paul District 1976). A total of 3,655,000 tons of sediment enter this pool annually. The pool is estimated at having a trapping efficiency of 27%,

Fig. 1. Aerial photograph, 1974, of the upstream half of Navigation Pool 8 of the Upper Mississippi River, indicating (by quadrangles) the location of sampling areas described in Appendix I.

Lock &
Dam 7
La Crosse
A
B
C
F
N
miles
0 ½ 1 1½
0 1 2
kilometers

Fig. 2. Aerial photograph, 1974, of the downstream half of Navigation Pool 8 of the Upper Mississippi River, indicating (by quadrangles) the location of sampling areas described in Appendix I.

C
G
H
I
J
K
D
E
N
miles
0 ½ 1 1½
0 1 2
kilometers
Lock & Dam 8

therefore, 987,000 tons are deposited annually (U.S. Army Corps of Engineers, St. Paul District 1974b).

The floodplain material is clay, silt, loam, and decaying organic material. This topsoil is underlain by several feet of sand, which often grades into coarse gravel from three to six feet below the surface (Claflin 1973).

Pool 8 was created as part of the nine foot channel navigation project authorized by the River and Harbors Act of 3 July 1930. The objective of the project was to extend the benefits of a low cost water transportation system to the Upper Mississippi Valley, 685 miles from the mouth of the Missouri River to Minneapolis, Minnesota. The nine foot navigation project was achieved by canalization of the river through the installation of 29 Locks and Dams (U.S. Army Engineer Division, North Central 1970).

> "The purpose of the dam is to regulate water level stages of the river at low flow and to pass high river flows without raising river stages over those that would exist without the dams....For low flows, gates are operated to keep the pool at the desired elevation. Thus at high water the river surface profile will have practically the same slope as in state of nature, while at low flow, the river consists of a series of reservoirs providing a stairway for waterborne traffic" (U.S. Army Engineer Division, North Central 1970).

The locks serve to transfer aquatic vehicles from the lower elevation water level of a downstream impoundment to the higher elevation water level of an upstream pool, or vice versa.

The navigation project has been in operation since 1940. Lock and Dam No. 8 was completed in 1937 and its closure resulted in an immediate 11 foot rise in the pool elevation upstream from the dam. This rise in water level resulted in inundation of vast acres of low lying marsh, meadows, and forest and in large scale changes in the habitats within the affected area (Claflin 1973).

> "As a result of impoundment, three distinct zones can be observed in each pool. The upper ends of the pools are very much like they were prior to the project except that they have more constant water levels. In the middle areas, water now backs up over islands and meadows forming large areas of marshes and comparatively shallow water. In the lower ends of the pools and immediately above each dam, an open lake-like aspect prevails" (U.S. Army Corps of Engineers, St. Paul District 1974a).

Thus, Pool 8 is very diverse ecologically. It contains many different habitats, ranging from deep swift navigation channels supporting no vegetation, to sloughs with vegetation only on the margins, to large expanses of open water supporting deep water submergent communities, to shallow stagnant backwaters supporting luxuriant aquatic macrophyte growth.

The semistabilization of water levels so that although spring floods still occur, the backwater areas don't normally dry up in the summer and the creation of vast acres of relatively shallow water promoted the rapid establishment and growth of aquatic vegetation in the backwaters. This study provides a good view of the aquatic macrophytes at this point in time and may be used as a basis for monitoring future changes in this ecosystem and in the development of management plans for the rapidly changing Upper Mississippi River.

LITERATURE REVIEW

Most studies of aquatic macrophytes in the Upper Mississippi River to date have been of a floristic nature. A list of the marsh and aquatic plants found in Navigation Pools 4-9 was prepared by Green (1947). In 1960, Green recorded his observations concerning changes in species composition and abundance of aquatic macrophytes in the Upper Mississippi River Wildlife Refuge since inception of the nine foot channel. Hartley (1960) described the floristic composition of plant communities in the La Crosse, Wisconsin area, which borders a portion of Pool 8. The flora of the Driftless area, in which Pool 8 is included, was a classic work produced by Hartley (1962). Nontelle (1973) compiled a list of the vascular plants occurring in La Crosse County, Wisconsin. A preliminary view of the vascular flora of Myrick Marsh, which lies on the outer edge of the Pool 8 floodplain, was contributed by Sohmer (1973). Mohlenbrock (1975a, b) compiled a list of vegetation and of rare and endangered plant species occurring in the floodplain adjacent to the Mississippi River between Cairo, Illinois and St. Paul, Minnesota. Swanson (1976) studied the vascular flora and phytosociology of Navigation Pool 8 at the same time the present study was conducted. Comments on the abundance, habitat, and associations of aquatic and terrestrial species collected in Pool 8 and its floodplain were given. Submergent, floating leaved, and emergent aquatic macrophyte communities were described.

The first quantitative vegetation study on the Upper Mississippi River was conducted by Sohmer (1975b). He recorded the frequency of occurrence of vegetation on transects across the midsections of Pools 7 and 8. Where aquatic macrophytes occurred along these transects, biomass samples were taken. All vegetation, including roots and rhizomes, occurring within a cylindrical sampler (36.5 cm in diameter) was removed, separated into component species, frozen, dried, and weighed. From the total dry weight along both the transects, percent biomass of each species was determined. He found the the most frequently encountered species did not necessarily have the greatest relative biomass.

Quantitative data has accumulated for aquatic macrophytes in many Wisconsin lakes. Rickett (1921, 1924) determined the standing crop of larger aquatic plants in Lake Mendota and Green Lake. Wilson (1935, 1937, 1941) studied the macrophytes in several northeastern Wisconsin lakes. Juday (1942) reported the summer standing crop of plants in four Wisconsin lakes. The vegetation of Weber Lake was quantitatively assessed by Potzger and Van Engel (1943). Andrews (1946) determined the standing crop and discussed the phenology of plants in Lake Mendota. He concluded that there were great changes in the weight of the standing crop as well as in species composition through the course of the year. The standing crop of larger aquatic plants in several small ponds was determined by Jones (1947). Swindale and Curtis (1957) studied the occurrence of macrophytes in 555 quadrats from 54 Wisconsin lakes. They worked out the associations between many aquatic species and correlated this information with different lake types. Lind and Cottam (1969), Nichols and Mori (1971), and Baker (1975) gathered frequency and standing crop data for the submerged aquatic vegetation in University Bay of Lake Mendota, Lake Wingra, and southeastern Devil's Lake, respectively. Nichols (1971) studied the spatial and temporal distribution of macrophyte biomass in Lake Wingra by measurement of biomass and environmental factors throughout the growing season. The impact of overwinter drawdown on the aquatic vegetation of the Chippewa Flowage was determined from frequency data collected by Nichols (1975b).

The quantitative studies of aquatic macrophytes in Wisconsin lakes cited above were usually coincident with ecological studies. Correlations between the distribution and standing crop of larger hydrophytes and various environmental factors, such as depth, substrate, light penetration, and water chemistry were also attempted by: Denniston (1921), Fassett (1930), Pearsall and Hewitt (1933), Butcher (1933), Wilson (1935, 1939), Frohne (1938), Mirsa (1938), Moyle (1945), Robel (1961), Westlake (1964), Schmid (1965), Spence (1967), and Walker and Coupland (1968).

In recent years, emphasis has been placed on the determination of macrophyte productivity by measurement of biomass changes over a period of time. Edwards and Owens (1960) and Owens and Edwards (1961, 1962) performed crop studies to estimate the net productivity of macrophytes in streams in England and related it to environmental factors. This approach was also used by Nygaard (1956), Pearsall and Gorham (1956), Forsberg (1959), Wetzel (1964a, b), Westlake (1966), Mathews and Westlake (1969), Ambasht (1971), Rich et. al. (1971), Bernard (1973), Dykjova and Hradecka (1973), Fiala (1973), Szczepanska (1973), and Sankaranunni (1976). The primary productivity of Lake Wingra, Wisconsin was determined by Adams et. al (1971) and Adams and McCracken (1974) as part of an International Biology Program (IBP) study.

Since the establishment of the International Biology Program, work has proceeded on the standardization of materials and methods of collection and reporting of production data. "Primary Productivity in Aquatic Environments" (Goldman 1969) is a collection of papers presented at an IBP symposium. Westlake (1965a, b) and Wetzel (1965) provided the information concerning aquatic macrophytes at that symposium. Westlake also served as expert on aquatic vascular plants in IBP Handbook No. 12, Methods for Measuring Primary Production in Aquatic Environments (Vollenweider 1969).

The productivity and role of aquatic macrophytes were summarized by Klugh (1926), Sculthorpe (1967), Wetzel and Hough (1973), Szczepanska and Szczepanski (1973), and Wetzel (1975). Hutchinson (1975) reviewed the distribution of aquatic macrophytes. The literature on marsh production was summarized by Keefe (1972). Penfound (1956) and Westlake (1963) compared primary productivity in various environments. Westlake concluded that most submergent and floating leaved communities were poorly productive, while emergent communities were some of the most productive in the world.

MATERIALS AND METHODS

Field Methods

1975. Forty-one areas of Navigation Pool 8 were designated for sampling in the simulation model study. These areas were selected such that they: "1) possessed the greatest ranges of physical-chemical parameters occurring in the pool, and 2) the difference between the minimum and maximum values were somewhat continuous" (Claflin 1975). The areas were numbered on the basis of increasing current velocity and are described in detail in Appendix I.

With the aid of aerial photographs, transects were established in each of the 41 study areas. The transects ran across the smallest dimension of the area perpendicular to the shores and began at the upstream end of the area. Sampling points were evenly spaced along the transects. Sample sites were numbered consecutively for each study area.

Collection techniques were similar to those used by Sohmer (1975b). At each sampling point, sample number, depth, and substrate type were recorded in a bound field book. Depth measurements were taken with a sounding pole marked off in 0.1 m increments. Substrate type was subjectively determined to be clay, muck (organic), silt, sand, gravel, or a combination of them. If vegetation was present, a plant sample, consisting of two 0.25 m^2 quadrats combined, was taken. The sampler was an aluminum enclosure 0.5 m on a side and 1.0 m high. It was thrown randomly from the boat and then pushed into the sediment as far as possible to cut off material not falling within the quadrat. All vegetation (including underground parts) was removed by means of a four pronged "speedy cultivator" rake or by hand. Two blind throws of the sampler and subsequent denuding of two 0.25 m^2 areas of vegetation consituted a sample at a site. All material collected was placed in an appropriately labeled polyethylene bag.

This type of sampler was chosen for the following reasons:

1. The enclosure definitely demarked the 0.25 m^2 area through the volume of water. Therefore, only vegetation occurring within the upward projection of the quadrat was included in the sample, a convention normally used by plant ecologists (Chapman 1976).

2. The enclosure isolated the sample material, preventing it from floating downstream or other material from floating in.

3. Samples could be taken from the boat.

A total sample size of 0.50 m^2, as suggested by the species-area curve in Wood (1975), was used. It was felt that this was the minimum size necessary to give a representative sample of the biomass from an area. A single small sample is a very unreliable estimate of average biomass and tends to overestimate it. Baardseth (1955) found that the maximum biomass of the marine alga Ascophyllum nodosus was equal to 14 kg dry wt./m^2 from samples of 0.50 m^2 and 55 kg/m^2 from samples of 32 cm^2. The 0.50 m^2 sample size was also used because data could easily be extrapolated to g/m^2 of surface area. Two 0.25 m^2 quadrats were combined to give the 0.50 m^2 sample because it was felt that two smaller quadrats in an area would give a better average value for each site than one large quadrat. In addition, the 0.25 m^2 sampler was much easier to handle.

Underground, as well as above ground, plant parts were sampled because production data was desired. Westlake (1963) defined primary production as "the increase in plant biomass over a period plus any losses during that period." Therefore, estimates of production must be based on biomass. Biomass, "like the standing crop, is the weight on a unit area at a given time, but all parts of the plant are included" (Westlake 1963).

Most study areas were sampled twice, once in June or early July and once in late July or August. A total of 795 sites were visited. Two hundred four of these contained vegetation during the first sampling period and 233 during the second. Members of the Lemnaceae were not collected during the first sampling period and were for the most part insignificant at that time. They were collected during the second sampling period.

Voucher specimens of each species encountered were collected, pressed, and dried. The first set was deposited in the Herbarium at the University of Wisconsin-La Crosse. Identifications were made using Fassett (1972). Nomenclature follows Hartley (1966) except for _Nelumbo_ _pentapetala_ (Walter) Fernald (Sohmer 1975a) and _Myriophyllum_ _spicatum_ var. _exalbescens_ (Fernald) Jepson (Nichols 1975a).

_1976_. In 1976, the 41 areas designated by the simulation model study were sampled in late July and early August when most of the vegetation was in flower or fruit (Westlake, in Vollenweider 1969). Three samples were taken down the geographical center of each area on an upstream-downstream transect (parallel to the shores).

Methods of obtaining samples were the same as stated for 1975. Two more 0.25 m^2 samplers were constructed, one 2.0 m high for taking samples in deep water and one 0.25 m high for taking samples in shallow, mucky areas that could only be reached by walking.

In addition, two of the simulation model study areas (20 and 15) were sampled seven times between May 28 and September 19 in order to determine changes in community composition over the growing season, productivities, and time of seasonal maximum biomass. Westlake (1965a) emphasized that the seasonal maximum biomass should be found by frequent sampling if it is to be used for estimating the annual net production.

Study areas 20 and 15 were chosen for intensive sampling because they contained the dominant vegetation representative of the mid and lower sections of the pool, respectively.

Area 20 was a shallow backwater containing emergent, floating leaved, and shallow water submergent communities. This area was marked off in a grid with sampling stations spaced 50 m apart. Twenty four stakes marked the sampling stations (Fig. 3).

Area 15, an open deep water area, was marked off on a grid and sample sites located by means of a random numbers table. Fifteen stakes marked the sampling locations (Fig. 4).

The sampling techniques described previously were utilized with the following modification. To prevent resampling of the same area, samples were taken in a predetermined pattern around and progressively farther away from the stake. At each location, however, the throwing of the sampler was still blind so as to maintain the random nature of the sampling.

Laboratory Procedures

1975. Plant samples were washed with a jet of water in a #30 brass screened bucket or in a sink to rid them of soil, epiphytes, and animals

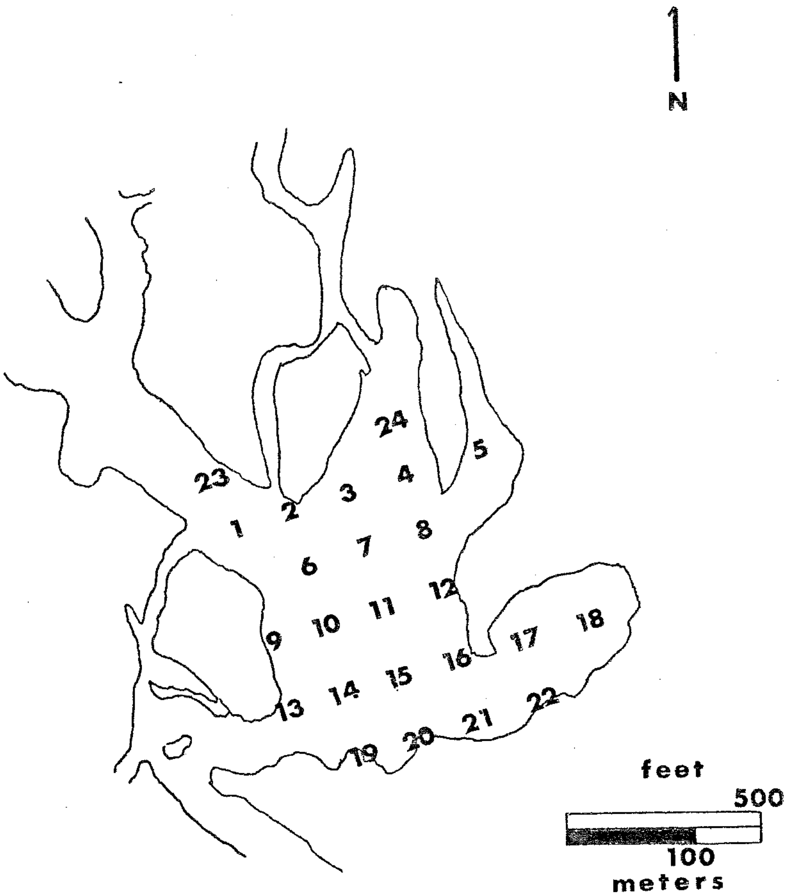

Fig. 3. Study area 20, Navigation Pool 8, Upper Mississippi River, showing location of 1976 sampling stations.

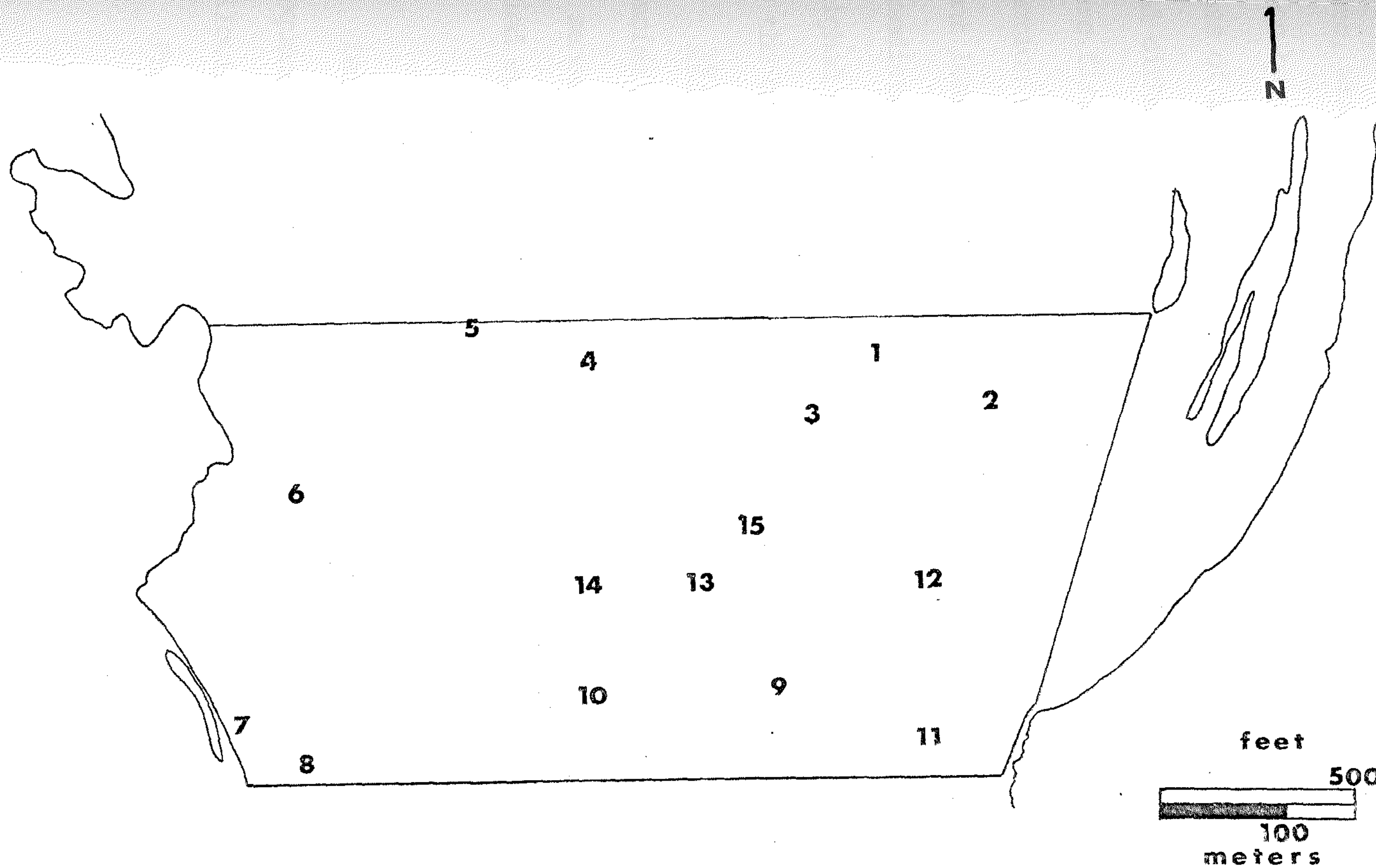

Fig. 4. Study area 15, Navigation Pool 8, Upper Mississippi River, showing location of 1976 sampling stations.

(Westlake, in Vollenweider 1969). Samples were separated into component species, with all plant parts being considered together. Dead material was discarded. Each species was labeled with name, sample number, and date, wrapped in newspaper, and placed in the cleaned polyethylene collection bag. Samples were then frozen to stop respiration and resultant loss of biomass. After having been solidly frozen, samples were thawed and either placed in a plant drier at 60° C for a minimum of 36 hours or were first partially air dried and then placed in the oven for final reduction to a constant dry weight. This low temperature was used to prevent loss of volatile constituents (Westlake 1963). The plants were immediately weighed upon removal from the oven. Small samples were weighed to the closest 0.01 g on a triple beam balance and larger ones to the closest 0.01 g on a Harvard Trip Soil Balance.

1976. Laboratory procedures were the same as in 1975, except that species were separated into above ground (green), below ground, and dead or senescent parts and each was weighed separately. Subsamples of each dried species were saved for dry ashing in the future.

Analysis

Data was placed on computer cards for analysis. Frequency, relative frequency, relative biomass, and mean biomass were determined using the following equations:

Frequency =

a) $\dfrac{\text{number of samples in which a taxon occurred}}{\text{number of samples containing vegetation}}$

b) $\dfrac{\text{number of samples in which a taxon occurred}}{\text{total number of samples}}$

$$\text{Relative Frequency (\%)} = \frac{\text{number of samples in which a taxon occurred}}{\text{total number of samples of occurrence of all taxa}} \times 100$$

$$\text{Relative Biomass (\%)} = \frac{\text{biomass of a taxon (oven dry weight)}}{\text{total biomass of all taxa}} \times 100$$

Mean biomass =

a) $\frac{\text{total biomass of a taxon}}{\text{number of samples of occurrence of that taxon}}$

b) $\frac{\text{total biomass of a taxon}}{\text{number of samples with vegetation}}$

c) $\frac{\text{total biomass of a taxon}}{\text{total number of samples}}$

Correlations and multiple correlations were made following standard procedures given in Cooley and Lohnes (1971).

The standard error of the difference in means was utilized to test for growth in stature of a plant species during the growing season.

If $(\bar{x}_1 - \bar{x}_2) > 2sd$

where $\bar{x}_1$ = sample mean at $time_1$ (minimum)

$\bar{x}_2$ = sample mean at $time_2$ (maximum)

$$Sd = \sqrt{(s\bar{x}_1)^2 - (s\bar{x}_2)^2}$$

$$s\bar{x} = \frac{s}{\sqrt{n}}$$

$$s = \sqrt{\frac{\sum f\ (x - \bar{x})^2}{n - 1}}$$

then the difference between the minimum mean biomass and the maximum mean biomass value was significant, and the plant grew in stature. The mean biomass values used in the calculation were determined by method (a) given above; only those samples in which a species occurred were used in the calculation. This eliminated the influence of vegetative growth (species spread) on the mean biomass values.

Frequency data was utilized to determine whether a species grew by spreading in area over the growing season. A mean frequency (%) for the summer was calculated for each taxon. A chi-square test was used to determine if the frequencies (%) of the sampling dates varied significantly from this mean frequency.

Net production was computed utilizing the following equations from Chapman (1976):

$$P_n = \Delta B + L + G$$

where P_n = net production (g/m^2)

ΔB = change in biomass ($B_2 - B_1$) of the taxon during the period $t_2 - t_1$

L = plant losses by death and shedding during t_1-t_2

G = plant losses by grazing during t_1-t_2

Because losses due to death must be considered in estimates of production, the total biomass of each species (including dead and senescent material) was included in the calculations.

Current net productivity was calculated from the expression:

$$\text{Net productivity } (g/m^2/day) = \frac{P_n}{\Delta t}$$

where P_n = net production (g/m^2)

Δt = number of days between t_1 and t_2.

RESULTS

1975

A list of the aquatic vascular plants collected in the 41 study areas in Navigation Pool 8 of the Upper Mississippi River was compiled (Appendix II). Twenty-seven species representing 16 families were collected. The largest family was the Potamogetonaceae and the largest genus Potamogeton, with six species. This list includes only those taxa that occurred in the study areas and thus is not a flora for the entire pool. A more complete list may be found in Swanson (1976).

The vegetational composition of each of the study areas during the June-early July and late July-August sampling periods is summarized in Tables 1 and 2, respectively. Sagittaria covered and constituted most of the biomass in areas 4, 5, and 7. In areas 1, 2, 3, 16, 17, 20, 22, 23, 25, 27, 30, 31, 32, 36, 39, and 40, it was the dominant shoreline macrophyte throughout the summer. Both in terms of relative frequency and relative biomass, Vallisneria americana dominated study areas 14, 15, 18, 21, 24, 26, and 37, which were deeper water habitats located in the southern portion of Pool 8. Vallisneria was also the predominant aquatic macrophyte on the perimeter of areas 28, 29, and 41. In area 12, Vallisneria and Ceratophyllum demersum comprised an important part of the shoreline vegetation. Ceratophyllum dominated the margins of areas 19 and 35. Nelumbo pentapetala exhibited the greatest relative biomass in area 8 during the June-early July sampling (36.80%) as well as during the late July-August sampling (38.62%) (Tables 1 and 2).

Table 1. Relative frequency and relative biomass of aquatic macrophytes in all study areas, Navigation Pool 8, Upper Mississippi River, during sampling period I (June-early July), 1975.

STUDY AREA	TAXON 1	3	4	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Mean RM[1]
1 (RF%)	23.08	23.08					7.69			7.69	7.69		7.69				23.08						187.47[2]
(RB%)	1.98	1.00					23.49			4.16	0.05		0.47				69.66						187.47[3]
2 (RF%)	40.00						10.00			10.00							40.00						127.76
(RB%)	8.45						0.97			17.87							72.72						127.76
3 (RF%)	15.38	3.85						3.85	11.54		3.85						19.23	19.23	19.23		3.85		205.03
(RB%)	0.48	0.06						6.85	1.26		0.04						15.57	42.20	11.43		22.10		205.03
4 (RF%)		25.00									25.00						50.00						128.75
(RB%)		0.03									0.40						99.57						128.75
5 (RF%)		25.00															50.00				25.00		273.35
(RB%)		0.05															99.76				0.19		273.35
6 (RF%)	23.26					9.30		2.33			16.28	9.30	2.33	9.30			20.93	6.98					149.98
(RB%)	2.59					6.40		0.22			0.89	0.31	2.07	1.64			59.83	26.04					149.98
7 (RF%)	12.00	6.00				6.00		6.00	2.00		14.00	2.00	4.00	18.00			16.00					8.00	214.87
(RB%)	0.97	0.02				6.91		3.57	0.01		0.90	0.00	6.47	1.46			79.66					0.03	214.87
8 (RF%)	18.75	6.25	3.13	1.56	1.56	15.63		6.25			18.75	9.38	1.56	10.94			1.56	1.56	1.56			1.56	76.25
(RB%)	5.70	0.62	0.03	0.01	0.01	36.80		35.47			4.17	1.37	0.64	0.32			4.48	9.89	0.13			0.27	70.80
9 (RF%)																							0.00
(RB%)																							0.00
10 (RF%)	25.00	3.13			6.25	3.13		3.13			25.00	6.25	3.13	9.38			6.25	3.13	3.13	3.13			99.08
(RB%)	4.22	0.03			0.19	2.45		4.26			11.56	4.21	5.90	0.75			27.91	1.24	0.03	36.29			99.08
11 (RF%)	15.38	7.69	3.85								7.69	11.54	11.54	7.69		11.54	7.69	7.69	3.85		3.85		20.24
(RB%)	22.16	0.15	0.05								1.42	0.56	34.55	1.32		4.43	21.19	7.56	4.78		4.78		20.24
13 (RF%)	50.00											50.00											0.70
(RB%)	57.14											42.86											0.09
14 (RF%)	16.67	16.67	11.11					5.56			16.67	5.56		11.11		5.56						11.11	95.23
(RB%)	23.52	5.96	8.54					3.20			0.64	0.35		1.13		1.12						55.44	57.14
15 (RF%)	20.00	10.00	20.00										10.00	5.00	5.00							30.00	148.08
(RB%)	2.94	0.05	4.44										5.30	1.00	0.45							85.92	98.72
16 (RF%)	15.38					7.69		23.08					15.38	15.38			7.69	15.38					174.16
(RB%)	0.06					1.01		14.52					2.60	0.16			54.64	27.01					96.76
17																							
17 (RF%)	26.32					5.26		15.79			26.32			5.26			15.79					5.26	169.98
(RB%)	3.72					1.33		22.43			2.74			0.01			69.05					0.73	113.32
18 (RF%)	22.22	5.56									16.67	5.56		5.56								44.44	50.97
(RB%)	0.69	0.05									8.59	0.02		0.03								90.60	50.97

(cont.)

Table 1 (cont.)

20	(RF%)	17.65	11.76	1.96	3.92		1.96	5.88	7.84	3.92	1.96		7.84	13.73	11.76	9.80			54.60
	(RB%)	11.53	1.07	0.03	5.56		0.19	0.10	6.75	1.20	0.13		1.11	27.80	29.84	14.68			37.53
21	(RF%)	27.27	9.09	9.09						18.18	9.09							27.27	166.97
	(RB%)	6.30	0.08	0.06						29.11	0.02							64.43	62.62
	(RF%)	16.67	11.11	22.22		5.56					5.56	11.11						27.78	180.25
	(RB%)	2.69	0.28	7.61		7.19					1.67	0.71						79.85	100.14
25	(RF%)	9.68	3.23					3.23	3.23	12.90	3.23		6.45	35.48	12.90	6.45	3.23		166.40
	(RB%)	0.09	0.01					0.01	0.00	7.12	0.01		0.01	72.41	17.78	1.00	1.57		105.10
26	(RF%)	22.22	3.70	7.41		3.70		29.63	3.70									29.63	86.63
	(RB%)	0.47	0.04	7.47		0.87		10.14	0.03									80.98	86.63
27	(RF%)	27.27	9.09			9.09								27.27	18.18	9.09			114.96
	(RB%)	0.67	0.06			10.92								66.73	16.88	4.74			38.32
30	(RF%)	19.67	4.92		3.28			9.84	8.20	8.20	9.84		4.92	14.75	6.56	1.64		8.20	142.19
	(RB%)	1.62	0.02		5.52			1.45	2.08	12.50	1.09		0.10	55.41	19.55	0.27		0.40	66.36
31	(RF%)	19.23	19.23	3.85		3.85		7.69	7.69	7.69				19.24	7.69	3.85			103.45
	(RB%)	8.37	2.81	0.02		0.90		0.05	0.57	6.30				70.65	6.71	3.62			51.72
32	(RF%)	17.86	7.14		3.57	7.14		17.86	10.71	3.57	3.57			17.86				10.71	172.57
	(RB%)	7.16	0.02		1.39	4.52		4.53	0.87	0.39	0.03			74.13				6.75	69.03
33	(RF%)																		0.00
	(RB%)																		0.00
36	(RF%)	10.00	10.00				10.00			10.00				20.00	20.00	20.00			93.71
	(RB%)	0.51	0.11				1.14			26.04				34.08	26.89	11.24			25.56
37	(RF%)	17.86	7.14	10.71		3.57		3.57	3.57	17.86	3.57							32.14	155.94
	(RB%)	0.59	0.02	0.44		2.89		0.01	0.01	11.55	0.00							84.48	155.94
38	(RF%)	17.65	5.88			5.88		11.76	11.76	11.76				11.76	11.76	11.76			64.98
	(RF%)	0.34	0.32			24.52		0.28	0.88	25.34				24.21	13.76	10.35			16.25
39	(RF%)	19.05	7.14	4.76		2.38		16.67	2.38	11.90	16.67			9.52				9.52	124.19
	(RB%)	4.76	0.04	0.09		7.44		4.47	1.16	11.39	12.52			51.57				6.56	62.09
40	(RF%)	15.38						23.08			23.08			23.08				15.38	183.79
	(RB%)	0.05						0.21			10.83			88.87				0.05	45.95
41	(RF%)	16.67	13.33	10.00		3.33		13.33		6.67	16.67	3.33						16.67	203.33
	(RB%)	0.54	0.13	8.02		4.27		6.26		9.36	0.92	1.97						68.54	112.96

RF = relative frequency (%) RB = relative biomass (%)

[1] mean total biomass (g/m^2)

[2] based on number of samples containing vegetation

[3] based on total number of samples

Table 2. Relative frequency and relative biomass of aquatic macrophytes in all study areas, Navigation Pool 8, Upper Mississippi River, during sampling period II (late July-August), 1975.

STUDY AREA	TAXON 1	2	3	4	5	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Mean BM[1]
1 (RF)	23.81	4.76	19.05		23.80				9.52				9.52		4.76				4.76						123.70[2]
(RB)	32.78	1.76	1.12		35.70				10.24				0.16		0.51				17.73						123.70[3]
2 (RF)	38.46				7.69				15.39										38.46						209.19
(RB)	15.01				2.20				21.76										61.03						209.19
3 (RF)	12.50		4.17		20.83					4.17	8.33	4.17							20.83	20.83			4.17		175.30
(RB)	0.88		0.14		24.64					3.83	1.04	0.91							31.61	21.82			15.13		175.30
4 (RF)					50.00														50.00						214.57
(RB)					15.13														84.87						214.57
5 (RF)					50.00														50.00						328.20
(RB)					2.68														97.32						328.20
6 (RF)	23.64		1.82		21.82			9.09		1.82			5.45	1.82	1.82	7.27			16.36	5.45				3.64	248.61
(RB)	5.81		0.00		11.71			16.47		0.04			0.03	0.00	2.12	0.10			54.54	9.18				0.01	215.46
7 (RF)	12.20		2.44	4.88	9.77			9.77		4.88					7.32	9.77			21.95	2.44				14.63	350.77
(RB)	5.78		0.06	0.05	5.36			9.17		3.80					2.47	0.03			72.21	0.03				0.39	350.77
8 (RF)	27.27		4.55		15.91			22.73		9.09			2.27	2.27		2.27			4.55	2.27				6.82	105.36
(RB)	15.35		2.34		19.23			38.62		12.28			0.09	0.03		0.13			7.87	4.02				0.03	97.83
9																									0.00
																									0.00
10 (RF)	27.59		6.90		17.24			3.45		5.90			10.34	6.90	3.45				5.90	5.90		3.45			118.80
(RB)	12.01		0.01		22.60			5.72		7.47			2.59	0.06	6.46				15.02	9.09		18.96			118.80
11 (RF)	16.00		12.00		20.00							4.00	4.00	4.00	12.00	8.00			8.00	8.00	4.00				81.67
(RB)	5.41		0.21		20.59							0.40	0.22	0.04	8.00	0.18			52.94	11.88	0.13				81.67
12 (RF)	27.27			9.09	27.27											9.09								27.27	47.89
(RB)	43.57			0.06	11.43											1.52								43.43	10.26
13 (RF)	27.78		11.11	22.22	16.67								16.67					5.56							68.36
(RB)	71.56		0.47	12.11	11.14								4.52					0.19							37.98
14 (RF)	20.00	6.67	20.00	13.33	13.33					6.67					6.67		6.67							25.00	171.89
(RB)	22.30	3.82	34.36	1.12	16.50					3.41					2.06		0.01							10.41	103.13
15 (RF)	14.29	7.14	14.29	14.29									7.14		7.14	7.14								14.29	151.12
(RB)	30.67	0.52	0.09	4.00									0.02		17.83	0.01								46.85	86.35
16 (RF)	14.29		4.76		14.29	4.76				14.29			4.76		14.29	4.76			9.52	4.76				9.52	262.21
(RB)	0.27		0.07		6.34	0.03				13.87			0.01		4.43	0.02			46.31	28.34				0.31	145.67
17 (RF)	24.00			4.00	16.00			4.00		12.00			12.00			8.00		4.00	12.00	4.00				16.00	267.82
(RB)	21.20			0.01	7.84			3.05		17.84			1.83			0.07		0.02	44.43	0.02				3.68	178.55
18 (RF)	28.57			14.29																				57.14	120.54
(RB)	0.63			8.13																				91.24	120.54
19 (RF)	21.05	5.26	15.79	21.05	21.05										5.26									10.53	68.69
(RB)	67.58	2.04	0.98	8.90	16.68										3.71									0.09	22.90
20 (RF)	18.92		13.51	2.70	8.11			10.81					2.70	2.70	2.70			10.81	16.22	10.81					149.12
(RB)	8.13		1.78	1.52	2.83			10.53					0.45	0.02	0.08			1.28	45.85	27.53					109.35
21 (RF)	14.29		9.52	9.52	14.29					9.52				4.76	9.52	4.76				4.76				19.05	179.52
(RB)	8.89		3.33	6.85	6.26					0.33				0.02	11.03	0.03				0.08				63.20	79.78

(cont.)

Table 2. (cont.)

22 (RF)	16.13		9.68	12.90				9.68	9.68				9.68	6.45			12.90	3.23			9.68	230.02
(RB)	16.21		6.70	1.60				15.42	3.94				0.26	0.03			49.24	6.54			0.07	115.01
23 (RF)	10.26		12.82	12.82	5.13			7.69	5.13	5.13	2.56		12.82	2.56			10.26	2.56			10.26	241.61
(RB)	7.32		10.15	1.26	1.17			4.86	3.23	0.22	0.02		1.98	0.29			54.34	14.98			0.18	120.80
24 (RF)	14.29	7.14	14.29	14.29	7.14		14.29		7.14		7.14				7.14						14.29	151.71
(RB)	13.49	2.82	0.43	8.86	0.02		1.54		19.18		0.05				0.05						53.59	50.57
25 (RF)	13.33			10.00	3.33			3.33		3.33		3.33	17.24	3.33			33.33	6.67		3.33		277.47
(RB)	0.88			0.41	0.02			0.04		0.19		0.02	5.88	0.02			61.96	22.85		7.73		175.24
26 (RF)	15.79		10.53	21.05	5.26				5.26				5.26								36.84	129.53
(RB)	0.60		0.19	12.09	0.71				6.66				0.36								79.38	129.53
27 (RF)	26.67		6.67		13.33				6.67				6.67				20.00	13.33	6.67			141.81
	5.94		0.01		2.42				2.36				6.63				68.26	14.46	0.04			47.27
28 (RF)	22.22		22.22										11.11	22.22							22.22	71.77
(RB)	1.36		0.37										13.28	26.01							58.98	13.46
29 (RF)	12.50		12.50	12.50					12.50				12.50								37.50	111.33
(RB)	0.02		0.01	0.01					31.57				14.37								54.01	49.48
30 (RF)	16.92	1.54	7.69	4.62				3.08		1.54	6.15	1.54	12.31	15.38	1.54		12.31	6.15	1.54		7.69	192.51
(RB)	5.69	0.57	1.03	0.19				8.92		0.04	0.35	0.01	15.73	3.01	0.06		42.26	17.97	0.08		4.08	96.25
31 (RF)	12.00		12.00		20.00				8.00		8.00		8.00			8.00	16.00	8.00				260.04
(RB)	5.21		0.26		2.19				8.24		0.09		0.60			2.55	77.57	3.30				130.02
32 (RF)	17.78	2.22	8.89	11.11	2.22	2.22		2.22	2.22		13.33	4.44	2.22	8.89			11.11				11.11	199.59
(RB)	17.80	0.02	0.39	9.31	0.51	0.01		1.44	1.98		1.08	0.02	0.05	0.06			55.14				12.18	79.83
33 (RF)																						0.00
(RB)																						0.00
34 (RF)									100.00													85.80
(RB)									100.00													7.15
35 (RF)	33.33		33.33		33.33																	23.78
(RB)	70.45		6.79		22.77																	1.94
36 (RF)	9.09			9.09	9.09							9.09	18.18				18.18	18.18			9.09	92.05
(RB)	0.02			22.67	4.13							0.02	3.78				55.33	13.47			0.58	25.11
37 (RF)	15.38	7.69		7.69	15.38				3.85				19.23	3.85				3.85			23.08	175.57
(RB)	1.45	3.94		0.17	24.04				4.27				21.83	0.02				0.02			44.26	175.57
38 (RF)	21.43		7.14	7.14	14.29				7.14		7.14		14.29			14.29		7.14				112.59
(RB)	16.94		3.73	2.43	16.88				2.12		1.11		32.57			0.36		23.86				28.15
39 (RF)	21.28		6.38	10.64	8.51				2.13		6.38	2.13	8.51	14.89			8.51				10.64	181.75
(RB)	6.73		0.04	4.24	7.78				1.01		1.88	0.04	14.53	4.02			56.71				3.03	90.87
40 (RF)	18.75	6.25	6.25								12.50		6.25	18.75			25.00	6.25				145.38
(RB)	6.08	0.10	0.03								1.77		0.05	11.07			79.17	1.72				54.52
41 (RF)	16.00		8.00	12.00	20.00				4.00					4.00	16.00						20.00	194.09
(RB)	1.02		0.96	7.50	10.85				18.77					1.44	14.84						44.61	107.83

RF = relative frequency (%)   RB = relative biomass (%)

1 mean total biomass (g/m^2)

2 based on number of samples containing vegetation

3 based on total number of samples

vegetation was restricted to the perimeters of areas 12, 19, 22, 23, 27-36, and 38-41. Mean sample biomass (based on the total number of samples taken) was generally lower in those areas than in areas 1-7, which were covered with vegetation (Tables 1 and 2).

Data from all study areas was combined to given an indication of the importance of each taxon in Pool 8. Frequency and relative frequency of each taxon was determined for each sampling period. The ten species exhibiting the greatest relative frequency during sampling period I (June-early July) were Ceratophyllum demersum (18.74%), Sagittaria latifolia (12.19%), Potamogeton crispus (12.06%), Vallisneria americana (8.65%), Potamogeton pectinatus (7.73%), Elodea canadensis (7.21%), Potamogeton nodosus (5.77%), Potamogeton foliosus (5.11%), Sagittaria rigida (4.72%), and Nymphaea tuberosa (3.54%). The most commonly occurring taxa during late July and August (sampling period II) were Ceratophyllum demersum (relative frequency, 18.58%), Lemnaceae (11.28%), Sagittaria latifolia (10.95%), Vallisneria americana (9.73%), Elodea canadensis (7.52%), Potamogeton nodosus (6.64%), Heteranthera dubia (6.64%), Potamogeton pectinatus (5.42%), Potamogeton crispus (4.31%), and Sagittaria rigida (4.20%) (Table 3).

The relative frequencies of Potamogeton crispus, Potamogeton foliosus, and Sagittaria rigida forma fluitans were 12.06%, 5.11%, and 2.88% respectively in June and early July, while in late July and August these values decreased to 4.31%, 1.44%, and 0.33%, respectively (Table 3). Heteranthera dubia increased significantly in relative frequency during the summer from 3.41% during sampling period I to 6.64% during sampling period II (Table 3). Lemnaceae was not collected during the June-early July sampling, but during the late July-August sampling it ranked second in relative frequency (Table 3).

Table 3. Frequency and relative frequency of aquatic macrophytes in Navigation Pool 8, Upper Mississippi River, 1975.

TAXON	(Life Form)	SAMPLING PERIOD I No. Occur.	Frequency a[1]	Frequency b[2]	Rel. Freq.(%)	SAMPLING PERIOD II No. Occur.	Frequency a	Frequency b	Rel. Freq.(%)
C. dem.	(S)	143	0.7010	0.4074	18.74	168	0.7210	0.3784	18.58
Clad.	(S)	0	0.0000	0.0000	0.00	10	0.0429	0.0225	1.11
E. can.	(S)	55	0.2696	0.1567	7.21	68	0.2918	0.1532	7.52
H. dub.	(S)	26	0.1275	0.0741	3.41	60	0.2575	0.1351	6.64
Lemn.	(Ff)	0	0.0000	0.0000	0.00	102	0.4378	0.2297	11.28
M. exa.	(S)	1	0.0049	0.0029	0.13	2	0.0086	0.0045	0.22
N. fle.	(S)	3	0.0147	0.0086	0.39	2	0.0086	0.0045	0.22
N. pen.	(Fl)	25	0.1225	0.0712	3.28	35	0.1502	0.0788	3.87
N. var.	(Fl)	2	0.0098	0.0057	0.26	4	0.0172	0.0090	0.44
N. tub.	(Fl)	27	0.1324	0.0769	3.54	36	0.1545	0.0811	3.98
P. aru.	(E)	6	0.0294	0.0171	0.79	6	0.0258	0.0135	0.66
P. coc.	(E)	2	0.0098	0.0057	0.26	2	0.0086	0.0045	0.22
P. cri.	(S)	92	0.4510	0.2621	12.06	39	0.1674	0.0878	4.31
P. fol.	(S)	39	0.1912	0.1111	5.11	13	0.0558	0.0293	1.44
P. nod.	(S)	44	0.2157	0.1254	5.77	60	0.2575	0.1351	6.64
P. pec.	(S)	59	0.2892	0.1681	7.73	49	0.2103	0.1104	5.42
P. ric.	(S)	4	0.0196	0.0114	0.52	7	0.0300	0.0158	0.77
P. zos.	(S)	13	0.0637	0.0370	1.70	10	0.0429	0.0225	1.11
S. lat.	(E)	98	0.4559	0.2650	12.19	99	0.4249	0.2230	10.95
S. rig.	(E)	36	0.1765	0.1026	4.72	38	0.1631	0.0856	4.20
S. rff.	(S)	22	0.1078	0.0627	2.88	3	0.0129	0.0068	0.33
S. val.	(E)	2	0.0098	0.0057	0.26	2	0.0086	0.0045	0.22
S. eur.	(E)	3	0.0147	0.0086	0.39	1	0.0043	0.0023	0.11
V. ame.	(S)	66	0.3235	0.1880	8.65	88	0.3777	0.1982	9.73

S = Submergent   Ff = Free floating on the surface   Fl = Floating-leaved   E = Emergent

[1] based on samples with vegetation

[2] based on total number of samples

The aquatic macrophytes were divided into four life form categories: emergent (E), floating-leaved (Fl), free floating on the surface (Ff), and submergent (S). The life form assigned each taxon is given in parentheses after its name in Table 3. Although Nelumbo pentapetala (the American lotus) possesses emergent as well as floating leaves, it was placed in the floating-leaved category because of its resemblance to the typical floating-leaved habit. Potamogeton nodosus most closely parallels the submergent habit and was therefore placed in the submergent category even though it possesses floating as well as submergent leaves.

Submergent vegetation, with a relative frequency of 74.31% during the first sampling period, and 64.05% during the second sampling period, had the most widespread distribution throughout the summer (Table 4). Emergent vegetation ranked second with relative frequencies of 18.61% and 16.37% for the June-early July and late July-August sampling periods, respectively (Table 4).

In terms of relative biomass, however, emergent vegetation was dominant to submergent vegetation throughout the summer. Emergent comprised 57.92% and 53.60%, while submergent comprised 33.44% and 29.23% of the total biomass during sampling periods I and II, respectively (Table 4). The relative biomass of floating-leaved vegetation (10.38%) was greater than that of vegetation free floating on the surface of the water (6.78%) during the second sampling period, but the relative frequencies were reversed. Floating-leaved vegetation comprised only 8.30% of the total samples of occurrence of all vegetation, while Lemnaceae (free floating on the surface) comprised 11.28% (Table 4).

The major species in Pool 8 in terms of relative biomass in June and early July, 1975 were Sagittaria latifolia (46.27%), Vallisneria

Table 4. Relative importance of each life form of aquatic macrophytes in Navigation Pool 8, Upper Mississippi River, 1975.

LIFE FORM	SAMPLING PERIOD I		SAMPLING PERIOD II	
	Relative Freq.(%)	Relative Biomass(%)	Relative Freq.(%)	Relative Biomass(%)
Emergent	18.61	57.92	16.37	53.60
Floating-leaved	7.08	8.64	8.30	10.38
Free floating on the surface	0.00	0.00	11.28	6.78
Submergent	74.31	33.44	64.05	29.23

americana (18.35%), Sagittaria rigida (9.02%), Potamogeton nodosus (5.50%). Nymphaea tuberosa (4.91%), Nelumbo pentapetala (3.22%), Ceratophyllum demersum (2.28%), Potamogeton crispus (1.94%), Potamogeton pectinatus (1.39%), and Sagittaria rigida forma fluitans (1.25%). In late July and August the ranking of the taxa were: Sagittaria latifolia (44.21%), Vallisneria americana (10.31%), Ceratophyllum demersum (8.86%), Sagittaria rigida (7.97%), Lemnaceae (6.78%), Nelumbo pentapetala (5.41%), Potamogeton nodosus (4.69%), Nymphaea tuberosa (4.29%), Heteranthera dubia (1.93%), and Elodea canadensis (1.39%) (Table 5).

The relative biomass of Potamogeton crispus, Potamogeton foliosus, and Sagittaria rigida forma fluitans decreased greatly from 1.94%, 0.63%, and 1.25%, respectively, for sampling period I to 0.39%, 0.01%, and 0.01%, respectively, for sampling period II (Table 5).

Mean total biomass of all vegetation for the June-early July sampling was 132.81 g/m^2 based on the number of samples with vegetation and 77.19 g/m^2 based on the total number of samples taken. These values were 181.70 g/m^2 and 95.35 g/m^2, respectively, for the late July-August sampling (Table 5). Maximum biomass recorded for samples with submergent, floating leaved, and emergent life forms dominant were 365.60 g/m^2, 176.00 g/m^2, and 475.90 g/m^2, respectively, for sampling period I and 345.14 g/m^2, 459.20 g/m^2, and 606.94 g/m^2, respectively, for sampling period II.

Aquatic macrophyte biomass (Table 6) was correlated with the mean values for the physical-chemical parameters in each study area (Table 7). Because the mean physical-chemical values were determined from samples taken near the center of each area, only those quadrats taken well within each study area were utilized for the correlations. All quadrats

Table 5. Biomass and relative biomass of aquatic macrophytes in Navigation Pool 8, Upper Mississippi River, 1975.

TAXON	SAMPLING PERIOD I					SAMPLING PERIOD II				
	Range of Values	Mean a[1]	Mean b[2]	Mean c[3]	Rel. BM (%)	Range of Values	Mean a	Mean b	Mean c	Rel. BM (%)
C. dem.	0.04- 58.80	5.60	3.93	1.78	2.28	0.06-182.40	22.32	16.09	8.44	8.86
Clad.		0.00	0.00	0.00	0.00	0.30- 32.12	10.71	0.46	0.24	0.25
E. can.	0.02- 15.00	1.11	0.26	0.14	0.17	0.04-146.40	8.65	2.53	1.33	1.39
H. dub.	0.04- 64.40	10.55	1.18	0.61	0.78	0.04-126.00	13.63	3.51	1.84	1.93
Lemn.		0.00	0.00	0.00	0.00	0.36-120.00	28.15	12.32	6.47	6.78
M. exa.	0.06- 0.06	0.06	0.0003	0.0002	0.0002	0.08- 0.88	0.23	0.002	0.001	0.001
N. fle.	0.12- 0.78	0.55	0.007	0.005	0.006	0.30- 4.36	2.33	0.02	0.01	0.01
N. pen.	7.60-149.00	34.88	3.74	2.48	3.22	0.24-229.80	65.39	9.82	5.15	5.41
N. var.	6.60-132.10	69.35	0.60	0.40	0.51	16.76-133.20	72.73	1.25	0.66	0.69
N. tub.	4.43-171.40	49.29	5.71	3.79	4.91	0.50-182.20	50.45	7.80	4.09	4.29
P. aru.	0.24- 6.60	2.92	0.08	0.05	0.06	0.64- 8.48	3.29	0.08	0.04	0.05
P. coc.	23.40-122.20	72.80	0.62	0.42	0.54	1.98- 8.00	4.99	0.04	0.02	0.02
P. cri.	0.10- 62.80	5.72	2.26	1.50	1.94	0.06- 31.60	4.22	0.71	0.37	0.39
P. fol.	0.08- 40.20	4.35	0.73	0.48	0.63	0.02- 0.70	0.28	0.15	0.008	0.01
P. nod.	0.22-145.60	33.89	6.40	4.25	5.50	0.06-139.20	33.10	8.52	4.47	4.69
P. pec.	0.04- 76.40	6.39	1.62	1.07	1.39	0.06- 63.80	7.58	1.59	0.84	0.88
P. ric.	0.84- 20.00	7.60	0.13	0.09	0.11	0.04-104.00	20.85	0.63	0.33	0.34
P. zos.	0.04- 3.80	1.34	0.07	0.05	0.06	0.28- 42.40	6.96	0.30	0.16	0.16
S. lat.	1.02-475.80	134.80	61.45	35.72	46.27	0.56-606.60	189.08	80.34	42.16	44.21
S. rig.	0.18-234.40	67.91	11.98	6.97	9.02	0.20-395.40	88.80	14.48	7.60	7.97
S. rff.	0.26- 45.00	15.38	1.66	0.96	1.25	0.20- 2.36	1.06	0.01	0.007	0.01
S. val.	31.40-287.60	159.50	1.56	0.91	1.18	180.20-257.40	218.80	1.88	0.99	1.03
S. eur.	1.00-226.60	76.53	1.13	0.65	0.85	132.62-132.62	132.62	0.57	0.30	0.31
V. ame.	0.08-331.60	75.35	24.38	14.17	18.35	0.02-205.00	49.61	18.74	9.83	10.31
Total	0.70-475.90		132.81	77.19	100.00	21.54-606.94		181.70	95.35	100.00

[1] based on the number of samples of occurrence of a taxon
[2] based on the number of samples with vegetation
[3] based on the total number of samples

Table 6. Mean total biomass (g/m^2) of aquatic macrophytes in each study area, Navigation Pool 8, Upper Mississippi River, 1975.[1]

STUDY AREA	MEAN TOTAL BIOMASS (g/m^2)	
	Sampling Period I	Sampling Period II
1	143.51	99.51
2	54.20	147.47
3	154.98	214.40
4	128.75	214.57
5	273.35	328.20
6	20.04	93.06
7	214.87	350.77
8	69.88	90.77
9	0.00	0.00
10	41.92	70.97
11	19.66	70.26
12	0.00	0.00
13	0.09	37.98
14	57.14	103.13
15	98.72	86.35
16	22.93	47.50
17	32.78	56.01
18	50.97	120.24
19	0.00	0.00
20	13.74	72.70
21	62.62	79.78
22	0.00	0.00
23	0.00	0.00
24	100.14	50.57
25	11.58	10.26
26	86.63	129.53
27	0.00	0.00
28	0.00	0.00
29	0.00	0.00
30	0.00	0.00
31	0.00	0.00
32	0.00	0.00
33	0.00	0.00
34	0.00	0.00
35	0.00	0.00
36	0.00	0.00
37	155.94	176.07
38	0.00	0.00
39	0.00	0.00
40	0.00	0.00
41	0.00	0.00

1 modified to eliminate shoreline samples.

Table 7. Mean values for all physical-chemical parameters for all study areas, Navigation Pool 8, Upper Mississippi River, 1975.*

STUDY AREA	Depth (m)	CV (m/sec)	Turb. NTU	D.O. (mg/l)	Temp. °C	Org. N ug/g	NO_3 ug/g	NO_2 ug/g	PO_4 ug/g	Sediment Particle Size Fraction (%) 1	2	3	4	5	6
1	1.70	0.000	8	0.40	22.0	734.0	25.30	0.06	0.73	1.31	10.26	21.12	13.25	10.74	43.32
2	1.20	0.000	9	1.00	25.0	753.0	16.84	0.09	0.15	1.02	1.93	6.33	18.72	17.60	54.40
3	1.10	0.000	8	1.30	26.0	267.3	21.27	0.30	0.35	2.06	4.07	1.34	1.18	18.31	73.04
4	1.00	0.000	8	1.80	25.0	734.0	27.90	0.25	0.21	1.20	8.40	12.18	10.26	14.46	53.51
5	0.90	0.000	9	2.60	25.5	387.3	15.15	0.16	0.27	3.07	8.30	14.90	15.13	12.63	45.96
6	1.08	0.015	11	3.05	21.5	452.1	17.42	0.17	0.32	0.40	0.48	2.54	5.85	21.32	69.40
7	0.61	0.016	11	3.20	25.8	429.4	23.58	0.53	0.49	0.60	0.52	0.56	1.60	35.43	61.28
8	0.98	0.019	12	4.05	21.5	688.6	21.15	0.20	0.35	0.28	1.07	4.16	19.94	14.49	60.06
9	1.60	0.020	14	2.35	25.8	753.0	16.50	0.33	0.20	2.21	7.10	9.43	8.14	9.23	74.16
10	0.96	0.030	12	2.55	21.5	762.7	26.34	0.19	0.38	0.48	0.56	0.96	2.19	40.22	55.60
11	0.51	0.034	12	2.80	24.0	156.8	13.53	0.16	0.14	0.28	0.69	0.40	0.69	28.32	69.32
12	4.91	0.039	18	5.30	25.0	118.0	8.20	0.29	0.17	0.06	0.44	0.95	3.09	50.60	44.68
13	1.50	0.042	14	4.70	24.5	102.8	9.31	0.20	0.19	3.05	11.02	30.91	23.62	15.94	15.45
14	1.61	0.078	15	3.90	24.0	659.9	34.68	0.14	0.38	0.42	4.51	3.83	13.96	11.23	66.05
15	1.73	0.102	17	4.10	25.0	621.3	26.69	0.34	0.42	12.61	5.09	11.76	12.00	16.67	41.88
16	1.22	0.116	17	3.70	22.0	571.8	20.40	0.23	0.41	7.86	8.23	11.08	18.84	7.53	46.44
17	1.35	0.134	17	4.10	22.0	259.8	19.99	0.37	0.48	1.21	4.86	5.38	4.26	30.65	53.64
18	0.95	0.136	19	4.30	22.0	426.1	28.56	0.40	0.33	1.53	5.75	7.49	7.71	16.31	61.39
19	6.10	0.140	20	3.30	24.0	105.6	10.97	0.15	0.29	2.25	3.78	4.34	5.15	57.10	27.38
20	0.81	0.159	14	3.80	24.5	254.2	10.68	1.88	0.35	0.29	8.40	20.26	40.07	10.05	20.93
21	2.64	0.206	26	2.75	21.7	166.1	18.35	0.35	0.36	4.48	3.69	12.93	49.67	51.19	18.04
22	2.26	0.218	25	6.55	24.0	18.8	2.17	0.11	0.10	0.20	2.66	34.73	58.15	4.15	0.08
23	1.84	0.235	25	5.75	25.0	28.4	4.86	0.16	0.12	2.79	6.83	11.59	19.09	28.84	30.86
24	1.71	0.282	31	3.95	23.2	370.0	24.67	0.31	0.62	0.12	2.79	7.07	40.92	46.77	4.93
25	0.61	0.292	26	4.60	24.0	167.1	14.14	0.23	0.45	1.94	1.82	5.51	21.26	54.68	14.79
26	1.02	0.301	27	2.30	23.0	439.6	33.67	0.42	0.83	0.40	5.44	14.10	18.04	38.10	23.92
27	2.34	0.305	29	5.90	25.0	149.0	9.08	0.30	0.37	0.00	0.36	26.22	61.52	11.66	0.24
28	4.73	0.344	33	7.30	23.5	2.2	0.73	0.06	0.00	1.20	1.81	32.20	67.47	7.07	0.24
29	1.63	0.352	37	5.10	24.0	399.2	18.02	0.19	0.35	0.64	2.95	8.77	30.70	29.23	27.71
30	1.57	0.385	36	5.30	24.0	126.4	1.77	0.08	0.25	0.57	2.20	2.82	16.86	59.31	18.25
31	1.48	0.393	31	6.30	25.0	9.4	8.14	0.12	0.13	8.91	10.52	22.32	36.85	16.02	5.38
32	2.01	0.407	30	6.10	24.0	304.8	6.13	0.23	0.20	0.32	0.64	27.95	62.17	8.54	0.40
33	6.71	0.411	30	6.95	23.0	44.2	2.62	0.40	0.61	0.12	0.36	7.20	80.11	11.32	0.88
34	2.41	0.448	19	6.25	25.0	33.2	7.21	0.25	0.45	4.51	11.54	40.63	41.56	1.74	0.08
35	2.91	0.463	27	5.40	25.0	18.2	4.13	0.16	0.20	1.49	14.51	46.35	35.03	1.85	0.71
36	1.33	0.470	28	4.20	25.0	66.5	4.56	0.16	0.42	0.12	1.92	5.60	49.71	32.13	10.53
37	1.33	0.527	27	3.50	19.9	346.7	22.68	0.36	0.46	1.28	1.98	4.35	31.72	52.60	8.47
38	1.89	0.534	27	6.45	20.0	200.0	8.38	0.19	0.37	1.04	1.97	36.22	52.57	6.99	1.20
39	2.33	0.578	27	6.50	24.0	357.6	13.50	0.15	0.53	0.12	0.36	7.20	80.11	11.32	0.88
40	1.90	0.587	28	7.00	24.0	96.6	3.76	0.13	0.33	0.04	0.12	10.00	82.07	7.02	0.76
41	3.70	0.720	25	5.30	25.0	102.8	17.37	0.19	0.42	0.48	0.64	44.00	51.64	3.00	0.24

* from Claflin (1975 and pers. comm. 1976)

containing shoreline vegetation were eliminated because the mean physical-chemical values did not include shoreline samples. Mean values for aquatic macrophyte biomass used in the correlations were based on the total number of samples taken.

Correlation coefficients (r) between mean total macrophyte biomass and each of the individual physical-chemical parameters were low and not significant (between -.594 and .571 for sampling period I and between -.445 and .376 for sampling period II). Multiple correlation coefficients (multi-r) of .697 and .729 for sampling periods I and II, respectively, were significant at the 90% level (Table 8).

1976

From all study areas. Three samples taken down the geographical center of each study area in late July-early August 1976 were averaged to give a view of these areas in 1976 (Table 9). These values were originally meant to be correlated with the simulation model study physical-chemical parameters, but were not because of the drastically different depth and current velocity conditions on the river in 1976.

From areas 15 and 20. Study area 20, located in the midsection of Pool 8, supported four major macrophyte communities. The 24 sampling stations were grouped into emergent *Sagittaria*, floating-leaved *Nelumbo pentapetala*, and submergent *Heteranthera dubia*-*Potamogeton nodosus* and *Ceratophyllum demersum*-*Elodea canadensis* communities. Each of these communities is briefly described below.

The *Sagittaria* community occupied water depths of 0.0 m (wet muck) to 0.4 m at stations 17, 19, 20, 21, and 22 (Tables 63, 64, and 65). *Sagittaria latifolia* and *S. rigida* were the principle components.

Table 8. Correlation coefficients (r) and multiple correlation coefficients (multi-r) of mean total macrophyte biomass with mean physical-chemical parameters in all study areas, Navigation Pool 8, Upper Mississippi River, 1975.

PHYSICAL-CHEMICAL PARAMETER	MEAN TOTAL MACROPHYTE BIOMASS	
	Sampling Period I r	Sampling Period II r
Depth	-.371	-.221
Current Velocity	-.414	.000
Turbidity	-.189	-.138
Dissolved Oxygen	-.594	-.217
Temperature	.001	-.445
Organic N	.449	.185
NO_3^-	.571	.299
NO_2^-	.065	.041
PO_4^{-3}	.306	.144
Particle Size Fraction		
1	.089	.196
2	.090	-.187
3	.288	-.290
4	-.396	-.192
5	-.132	.376
6	-.402	.103
Multi-r	.697	.729

Table 9. Mean biomass (g/m^2) of aquatic macrophytes in each study area, Navigation Pool 8, Upper Mississippi River, 1976.

STUDY AREA	TAXON 1	2	3	4	5	8	10	11	12	13	15	16	17	18	19	20	21	26	MEAN TOTAL
1	32.56		0.53		18.87														51.95
2	99.03		13.31		13.24			497.54									48.19		671.29
3	23.92	0.10	2.41		55.00		18.17		86.86		0.62	5.29					25.57		217.85
4																	881.46		881.46
5																	764.82		764.82
6																			0.00
7	2.07	27.43	10.87		9.52		73.82		28.93		3.18			0.01			455.83	0.63	612.29
8	0.49	0.89	0.30			0.53	26.87		6.72		0.99			3.71				0.04	40.55
9																			0.00
10	0.29				0.11		116.29		38.34		0.43			0.04					155.50
11	7.65		3.06		0.77						5.34		8.07	2.10		0.71			27.70
12																			0.00
13	1.47		16.96	5.66	0.92									0.13		0.28			25.41
14	0.03	0.03																5.89	5.95
15	0.37	1.40	0.07	0.29											1.83			94.60	98.55
16																			0.00
17																			0.00
18		38.50		0.03							6.73							99.70	144.97
19																			0.00
20	0.09		0.05	0.09			66.81			0.07						0.03			67.15
21		58.06											51.49	0.08				107.34	216.97
22																			0.00
23																			0.00
24		0.11	0.02															117.81	117.93
25																			0.00
26		0.39											2.32					66.22	68.93
27																			0.00
28																			0.00
29																			0.00
30																			0.00
31	0.04		0.19	1.56							0.12		7.30	5.16					14.38
32																			0.00
33																			0.00
34																			0.00
35																			0.00
36																			0.00
37	0.33	24.75	0.31		5.59								5.31	4.16				117.04	157.47
38																			0.00
39																			0.00
40																			0.00
41																			0.00

No significant changes in species composition occurred in this community over the growing season.

The Nelumbo community was composed of three subcommunities. Stations 1, 2, 6, 8, 9, and 15, with water depths ranging from 0.3 m to 1.1 m and a muck substrate, supported Nelumbo pentapetala (American lotus) growth early in the summer. These stations were located on the periphery of study area 20 (Fig. 3). Few submergent species were present in this subcommunity. The only significant change in species composition in this subcommunity over the summer was the buildup of Lemnaceae at stations 9 and 15 (Tables 59 and 62, respectively).

Stations 7, 10, 11, and 14 had water depths of 1.2 m or more (Tables 58, 59, 60, and 61) and were located near the center of area 20 (Fig. 3). These sites were presumably too deep to support rooted submergent vegetation, as only trace amounts were found. Nelumbo appeared and increased in biomass at these stations as it spread from the shallow periphery into the deeper water in the middle of area 20 during the summer.

Nelumbo also encroached into shallow mucky areas which were originally dominated by submergent vegetation. Submergents (primarily Ceratophyllum, Elodea, and Potamogeton crispus) comprised 99.86% of the total biomass on 28 May at station 12 (Table 60). With the encroachment of Nelumbo and the buildup of Lemnaceae (duckweed), the relative biomass of submergent vegetation at station 12 dropped to .25% on 25 August. Absolute values for submergent vegetation also decreased from 110.46 g/m^2 on 28 May to 0.60 g/m^2 on 25 August. This decrease was presumably due to the shading effect of the lotus and the duckweed. At station 4, Heteranthera dubia was initially the major species, but it became senescent as Nelumbo and

Lemnaceae increased in biomass (Table 56).

The submergent Heteranthera dubia-Potamogeton nodosus community was found at stations 13 and 24 (Tables 61 and 66). Both stations were shallow (less than 0.6 m), had a sand substrate, and were influenced by current. No significant changes in species composition occurred in this community over the growing season.

Stations 5, 18, and 23 possessed a Ceratophyllum demersum-Elodea canadensis community. The total biomass at these stations was initially high (205.70 g/m^2 at station 5, 70.62 g/m^2 at station 23, and 25.58 g/m^2 at station 18) and remained high throughout the summer (Tables 57, 66, and 63). At station 5 the minimum biomass of submergents (92.00 g/m^2) was recorded on 29 July, two weeks after the maximum biomass of Lemnaceae (125.24 g/m^2) was recorded. The biomass of submergent vegetation increased again as the duckweed decreased later in the summer.

Table 10 summarizes the contribution of each taxon in study area 20 (in terms of relative frequency and relative biomass) throughout the growing season. Ceratophyllum demersum and Elodea canadensis originally had the most widespread distribution in area 20. Relative frequencies calculated for Ceratophyllum on 28 May, 15 June, and 29 June were 23.21%, 18.75%, and 19.05%, respectively (Table 10). Elodea had a relative frequency of 14.29% on May 28, 20.00% on June 15, and 17.86% on June 29. During subsequent sampling, however, the relative frequency of Nelumbo pentapetala (16.48% on 15 July, 18.52% on 29 July, and 22.22% on 25 August) equaled or exceeded that of Ceratophyllum and Elodea (Table 10).

Sagittaria latifolia constituted the greatest percentage of the total biomass in area 20 on the first five sampling dates (relative biomasses of 30.38%, 36.96%, 44.59%, 46.63%, and 47.18% on 28 May, 15 June, 29 June,

Table 10. Frequency, relative frequency, mean biomass, and relative biomass of aquatic macrophytes in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

	SAMPLE DATE											
	28 May		15 Jun		29 Jun		15 Jul		29 Jul		25 Aug	
TAXON	F RF(%)	BM(g/m²)[1] RBM(%)	F RF(%)	BM(g/m²) RBM(%)	F RF(%)	BM(g/m²) RBM(%)	F RF(%)	BM(g/m²) RBM(%)	F RF(%)	BM(g/m²) RBM(%)	F RF(%)	BM(g/m²) RBM(%)
C. dem.	0.54 23.21	7.15 19.55	0.63 18.75	6.52 8.42	0.67 19.05	7.69 5.69	0.63 16.48	15.44 6.98	0.54 16.05	6.18 2.08	0.54 18.06	11.95 3.60
Clad.	0.00 0.00	0.00 0.00	0.04 1.25	0.00 0.00	0.00 0.00	0.00 0.00	0.08 2.20	0.19 0.09	0.04 1.23	0.22 0.08	0.04 1.39	0.34 0.10
E. can.	0.33 14.29	13.18 36.07	0.67 20.00	15.78 20.40	0.63 17.86	17.54 12.97	0.71 18.68	12.14 5.49	0.50 14.81	10.50 3.54	0.50 16.67	14.05 4.24
H. dub.	0.13 5.36	0.02 0.07	0.17 5.00	1.78 2.30	0.17 4.76	2.82 2.09	0.21 5.49	2.57 1.16	0.17 4.94	3.43 1.15	0.21 6.94	1.74 0.52
Lemn.	0.00 0.00	0.00 0.00	0.13 3.75	0.35 0.45	0.17 4.76	2.30 1.70	0.38 10.71	9.84 4.45	0.38 11.11	11.24 3.78	0.33 11.11	9.06 2.73
L. dub.	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.04 1.10	0.29 0.13	0.04 1.23	0.08 0.03	0.00 0.00	0.00 0.00
L. pal.	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.04 1.10	0.29 0.13	0.04 1.23	0.08 0.03	0.00 0.00	0.00 0.00
N. fle.	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.04 1.10	0.02 0.01	0.04 1.23	0.01 0.00	0.00 0.00	0.00 0.00
N. pen.	0.21 8.93	0.44 1.19	0.46 13.75	12.23 15.80	0.54 15.48	30.41 22.49	0.63 16.48	62.27 28.15	0.63 18.52	104.47 35.10	0.67 22.22	155.54 46.86
P. aru.	0.04 1.79	0.01 0.02	0.08 2.50	0.13 0.16	0.08 2.38	0.07 0.05	0.08 2.20	0.32 0.14	0.08 2.47	0.31 0.10	0.00 0.00	0.00 0.00
P. cri.	0.17 7.14	1.67 4.56	0.38 11.25	3.46 4.46	0.33 9.52	2.79 2.06	0.21 5.49	0.73 0.33	0.17 4.94	0.10 0.03	0.17 5.56	0.05 0.01
P. fol.	0.08 3.57	0.00 0.01	0.13 3.75	0.10 0.12	0.04 1.19	0.02 0.02	0.04 1.10	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
P. nod.	0.13 5.36	0.39 1.06	0.08 2.50	1.01 1.30	0.08 2.38	1.63 1.20	0.08 2.20	1.82 0.82	0.08 2.47	1.52 0.51	0.08 2.78	1.66 0.50
P. pec.	0.04 1.79	0.00 0.01	0.04 1.25	0.01 0.02	0.17 4.76	1.95 1.44	0.08 2.20	0.06 0.03	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
P. zos.	0.29 12.50	0.21 0.58	0.25 7.50	0.27 0.35	0.25 7.14	0.54 0.40	0.21 5.49	0.46 0.21	0.33 9.88	0.11 0.04	0.13 4.17	0.02 0.01
S. lat.	0.21 8.93	11.10 30.38	0.21 6.25	28.59 36.96	0.21 5.95	60.31 44.59	0.21 5.49	103.16 46.63	0.21 6.17	140.42 47.18	0.21 6.94	124.06 37.40
S. rig.	0.13 5.36	2.38 6.50	0.04 1.25	7.09 9.16	0.13 3.57	7.80 5.77	0.13 3.30	11.89 5.37	0.13 3.70	19.02 6.39	0.08 2.78	13.27 4.00
S. rff.	0.00 0.00	0.00 0.00	0.04 1.25	0.06 0.08	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
V. ame.	0.04 1.79	0.00 0.00	0.00 0.00	0.00 0.00	0.04 1.19	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.04 1.34	0.00 0.00

F = frequency BM = mean biomass RF = relative frequency RBM = relative biomass
[1] based on the total number of samples

15 July, and 29 July, respectively) (Table 10). The relative biomass of Nelumbo pentapetala in area 20 increased throughout the growing season 1.19%, 15.80%, 22.49%, 28.15%, and 35.10% on 28 May, 15 June, 29 June, 15 July, and 29 July, respectively), until on 25 August its relative biomass (46.86%) exceeded that of S. latifolia (37.40%) (Table 10).

Nelumbo pentapetala constituted the greatest relative frequency (22.22%) as well as the greatest relative biomass (46.86%) in the study area on August 25, 1976 (Table 10). It was thus the most important species in area 20 at that time both in terms of its contribution to the net production of the area and its widespread distribution.

Current net production and productivity were calculated for area 20 based on changes in biomass over time (Table 11). Greatest productivity rates (4.13 g/m^2/day, 5.38 g/m^2/day, and 5.46 g/m^2/day) were recorded between 15 June and 29 July. These rates were associated with the growth of Sagittaria and Nelumbo, which constituted the majority of the biomass in area 20. A mean productivity of 3.70 g/m^2/day was calculated for the growing season (Table 11).

Productivities were also computed for study area 15, an open, deeper water habitat located in the southern portion of Pool 8 (Fig. 4). The mean seasonal productivity of area 15 was 2.97 g/m^2/day (Table 12). A maximum productivity of 5.85 g/m^2/day was recorded during the period from 20 July to 2 August, coincident with fruit development in Vallisneria americana and a buildup of the green alga, Cladophora.

Four major communities were recognizable in area 15. Station 1 supported a floating leaved Nymphaea tuberosa community (Table 67). Potamogeton nodosus dominated stations 2 and 12 (Tables 67 and 72). Station 11, primarily a Heteranthera dubia community, contained variable

Table 11. Mean biomass, current net production, and current net productivities in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

	SAMPLING DATE										
	28 May		15 Jun		29 Jun		15 Jul		29 Jul		25 Aug
Mean biomass (g/m^2)	36.55		77.36		135.24		221.24		297.63		331.73
Current net production (g/m^2) (change in biomass)		40.81		57.88		86.00		76.39		34.10	
Days between sampling		18		14		16		14		27	
Current net productivity ($g/m^2/day$)		2.27		4.13		5.38		5.46		1.26	

Mean productivity for growing season = 3.70 $g/m^2/day$

Table 12. Mean biomass, current net production, and current net productivities in study area 15, Navigation Pool 8, Upper Mississippi River, 1976.

	SAMPLING DATE					
	1 Jun	16 Jun	30 Jun	20 Jul	2 Aug	24 Aug
Mean biomass (g/m^2)	2.47	13.55	43.51	109.15	179.38	174.35
Current net production (g/m^2) (change in biomass)		11.08	29.96	65.64	70.23	0
Days between sampling		15	14	21	12	22
Current net productivity ($g/m^2/day$)		0.74	2.14	3.13	5.85	0

Mean productivity for growing season = 2.97 $g/m^2/day$

amounts of many other species (Table 72). The submergent community in which Vallisneria americana was predominant could be divided into three portions. Stations 3, 7, 13, and 15, with water depths between 0.9 m and 1.3 m, supported the growth of Vallisneria early in the summer (Tables 68, 70, 73, and 74). Stations 10 and 14 contained little or no Vallisneria early in the growing season, but this species became very important in late summer. (Tables 71 and 73). Very little Vallisneria (or other species for that matter) was found at stations 4 and 5 throughout the growing season. The water depths of these stations were 1.8 - 1.9 m (Tables 68 and 69).

Stations 6, 8, and 9, with water depths of 1.9 m or greater throughout the growing season, contained no vegetation (Tables 69, 70, and 71). Thus, 1.9 m appeared to be the limiting depth for growth of rooted aquatic vegetation in area 15 in 1976.

The importance of each taxon in area 15 in terms of its relative frequency and relative biomass on each sampling date is summarized in Table 13. The production of area 15 was clearly dominated by Vallisneria americana throughout the growing season. Vallisneria exhibited the greatest relative frequency (near 20%) and relative biomass (near 50%) throughout the summer (Table 13).

The green alga Cladophora increased greatly in relative frequency during the summer until on 24 August its relative frequency (16.90%) equaled that of Vallisneria (Table 13). At that time, Cladophora constituted 24.43% of the total biomass in area 15.

Although the mean biomass of Potamogeton nodosus increased from 0.39 g/m^2 on 1 June to 17.06 g/m^2 on 2 August, its relative biomass decreased from 15.89% to 9.51% during that period (Table 13).

Table 13. Frequency, relative frequency, mean biomass, and relative biomass of aquatic macrophytes in study area 15, Navigation Pool 8, Upper Mississippi River, 1976.

TAXON	SAMPLE DATE											
	1 Jun		16 Jun		30 Jun		20 Jul		2 Aug		24 Aug	
	F RF(%)	BM(g/m²)[1] RBM(%)	F RF(%)	BM(g/m²) RBM(%)	F RF(%)	BM(g/m²) RBM(%)	F RF(%)	BM(g/m²) RBM(%)	F RF(%)	BM(g/m²) RBM(%)	F RF(%)	BM(g/m²) RBM(%)
C. dem.	0.42 17.86	0.24 9.78	0.50 18.18	0.27 1.98	0.75 17.31	6.49 14.91	0.75 19.56	6.63 6.07	0.58 11.29	5.84 3.26	0.75 12.68	7.29 4.18
Clad.	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.25 5.77	0.40 0.92	0.08 2.17	19.63 17.98	0.92 17.74	40.17 22.39	1.00 16.90	42.57 24.43
E. can.	0.08 3.57	0.00 0.10	0.25 9.09	0.05 0.39	0.33 7.69	0.25 0.57	0.25 6.52	0.54 0.50	0.25 4.84	0.18 0.10	0.50 8.45	0.12 0.07
H. dub.	0.08 3.57	0.00 0.24	0.33 12.12	0.22 1.65	0.17 3.85	0.07 0.16	0.33 8.70	2.65 2.43	0.42 8.06	13.95 7.77	0.75 12.68	16.09 9.23
Lemn.	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.08 2.17	0.06 0.05	0.08 1.61	6.57 3.66	0.33 5.63	2.13 1.22
N. fle.	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.17 3.85	0.03 0.08	0.08 2.17	0.08 0.07	0.08 1.61	0.03 0.01	0.17 2.82	0.08 0.04
N. tub.	0.08 3.57	0.33 13.22	0.08 3.03	0.27 1.96	0.08 1.92	1.58 3.62	0.08 2.17	2.28 2.09	0.08 1.61	4.84 2.70	0.08 1.41	0.93 0.53
P. cri.	0.42 17.86	0.07 2.83	0.33 12.12	0.97 7.16	0.58 13.46	4.51 10.37	0.42 10.87	1.11 1.02	0.67 12.90	0.83 0.46	0.50 8.45	0.59 0.34
P. fol.	0.08 3.57	0.02 0.71	0.08 3.03	0.50 3.69	0.08 1.92	0.05 0.11	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
P. nod.	0.25 10.71	0.39 15.89	0.25 9.09	3.27 24.17	0.25 5.77	11.41 26.21	0.33 8.70	15.48 14.18	0.33 6.45	17.06 9.51	0.33 5.63	8.84 5.07
P. pec.	0.25 10.71	0.14 5.50	0.25 6.06	0.95 7.04	0.50 11.54	2.82 6.48	0.25 6.52	1.83 1.68	0.58 11.29	2.54 1.42	0.50 8.45	6.55 3.76
P. ric.	0.00 0.00	0.00 0.00	0.08 3.03	0.06 0.44	0.25 5.77	0.13 0.29	0.25 6.52	0.52 0.48	0.25 4.84	1.55 0.87	0.00 0.00	0.00 0.00
V. ame.	0.67 28.57	1.28 51.74	0.67 24.24	6.98 51.53	0.92 21.15	15.79 36.29	0.92 23.91	58.35 53.46	0.92 17.74	85.83 47.85	1.00 16.90	89.08 51.12

F = frequency BM = mean biomass RF = relative frequency RBM = relative biomass
[1] based on the total number of samples

Growth patterns, growth rates (productivities), seasonal maximum biomass, and percentages of the biomass below ground and dead or senescent were determined for the major taxa in study areas 15 and 20.

Nelumbo pentapetala. The American lotus increased in frequency from 0.21 to 0.67 during the summer of 1976, a significant variation from the mean frequency of 0.52 calculated for the season (Table 10). The difference between the mean biomass values of 2.09 g/m^2 recorded on 28 May and 233.30 g/m^2 recorded on 25 August (Fig. 5) was also significant. The above data confirmed previous observations that Nelumbo increased both by vegetative growth and by an increase in the stature of the plant in the same area.

A maximum seasonal biomass of 803.36 g/m^2 was recorded for Nelumbo at station 2 on 19 September (Table 55). However, 51.49% of the 19 September biomass was dead or senescent. A maximum of 771.64 g/m^2 was recorded at station 2 on 25 August when only 12.02% was senescent. The time of maximum seasonal biomass corresponded with maximum fruit development in Nelumbo.

Growth rates (current net productivities) were calculated from the mean biomass at each sampling time. The greatest growth rate (4.82 g/m^2/day) occurred from 15 July to 29 July, coincident with flowering and fruiting of Nelumbo. Productivity for the season averaged 2.69 g/m^2/day (Table 14).

The senescent proportion of the Nelumbo biomass became important near the end of the summer. On 25 August, an average of 16.92% of the biomass of Nelumbo was dead or senescent; this value was 50.63% on 19 September (Table 15).

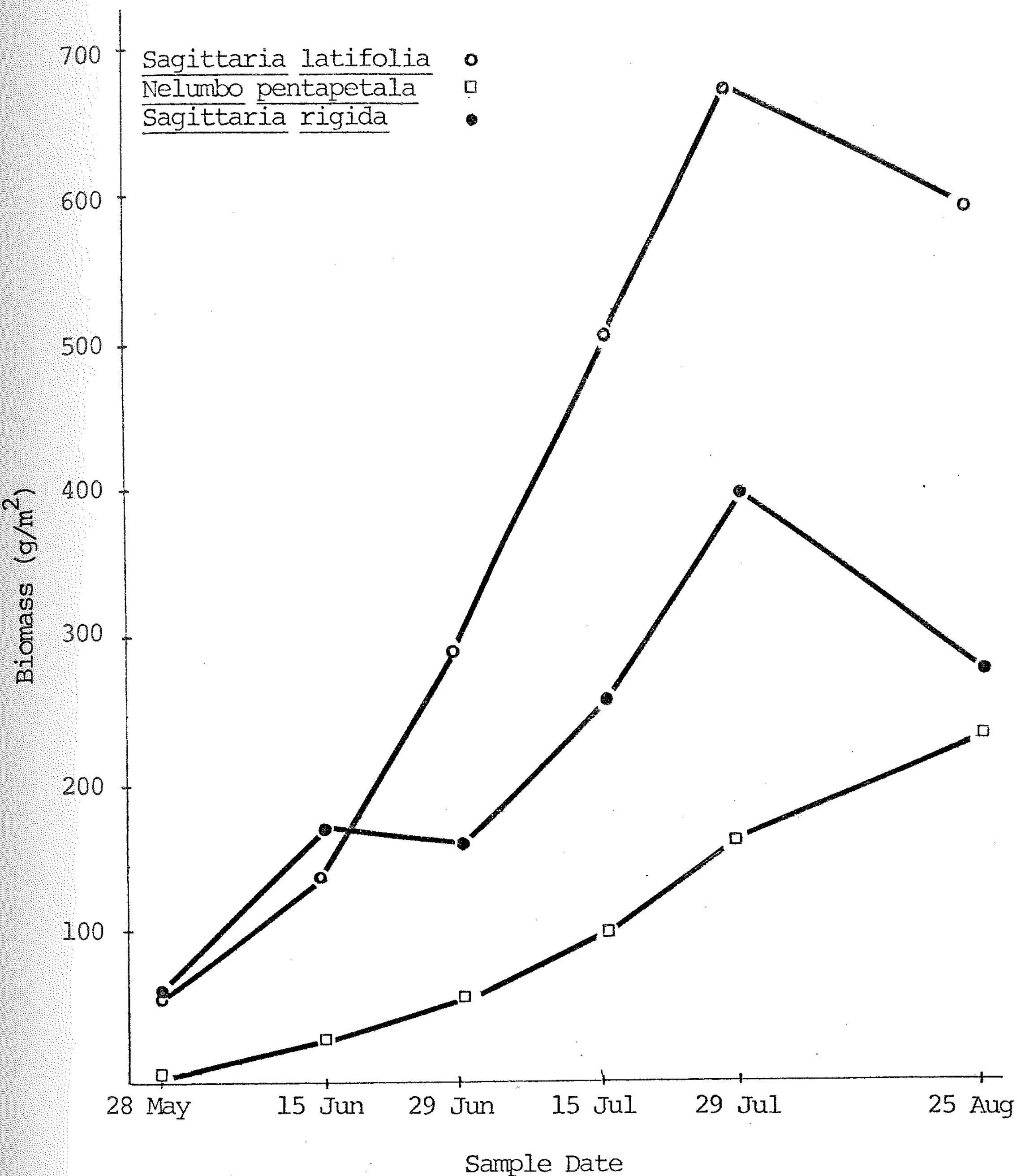

Fig. 5. Growth curves for Sagittaria latifolia, Nelumbo pentapetala, and Sagittaria rigida in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

Table 14. Growth rates (g/m^2/day) of the major aquatic macrophytes in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

TAXON	28 May-15 Jun	15 Jun-29 Jun	29 Jun-15 Jul	15 Jul-29 Jul	29 Jul-25 Aug	Mean for growing season
Heteranthera dubia	0.58[1]	0.45	0	0.59	0	0.41
	0.10[2]	0.07	0	0.06	0	0.06
Lemnaceae	0.23	0.69	0.78	0.26	0	0.49
	0.02	0.14	0.47	0.10	0	0.18
Nelumbo pentapetala	1.37	2.11	2.72	4.82	2.45	2.69
	0.66	1.30	1.99	3.01	1.89	1.77
Potamogeton nodosus	0.50	0.53	0.14	0	0	0.39
	0.03	0.04	0.01	0	0	0.03
Sagittaria latifolia	4.66	10.87	12.86	12.77	0	10.29
	0.97	2.27	2.68	2.66	0	2.15
Sagittaria rigida	6.30	2.94	2.94	10.24	0	5.61
	0.26	0.05	0.26	0.51	0	0.27

[1] calculated from means based on the number of samples of occurrence of a taxon.
[2] calculated from means based on the total number of samples.

Table 15. Percentage of the total biomass of the major aquatic macrophytes in study area 20, Navigation Pool 8, Upper Mississippi River, which was dead or senescent on each sampling date in 1976.

TAXON	SAMPLING DATE						
	28 May	15 Jun	29 Jun	15 Jul	29 Jul	25 Aug	19 Sep
Ceratophyllum demersum	3.02	3.36	1.40	0.92	0.90	0.27	0.00
Elodea canadensis	0.00	5.03	6.86	2.46	5.63	5.79	1.97
Heteranthera dubia	0.00	0.00	0.00	0.00	4.85	56.33	32.15
Nelumbo pentapetala	0.00	0.00	0.29	3.42	7.45	16.92	50.63
Potamogeton crispus	0.00	0.00	0.00	1.14	91.38	89.09	55.56
Potamogeton nodosus	0.00	0.00	0.00	0.00	0.00	1.76	3.46
Potamogeton zosteriformis	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sagittaria latifolia	0.00	0.82	2.43	7.20	11.92	30.95	77.70
Sagittaria rigida	0.00	1.27	0.32	2.96	6.68	35.48	37.86

The below ground portions of the petioles of Nelumbo averaged 2.12% of the total biomass for the growing season. Roots, rhizomes, and tubers were excluded because of the difficulty of removing them in a quantitative manner from deeper water.

Sagittaria latifolia. S. latifolia exhibited the first growth pattern type; it increased in stature without spreading. The frequency of occurrence of this species remained constant at .21 for each sampling date (Table 10). The mean biomass of S. latifolia increased significantly over the summer, reaching a maximum of 674.02 g/m^2 on July 29, 1976 (Fig. 5). Since the overwintering turions of S. latifolia are used up early in the summer, its maximum seasonal biomass may be equated with annual net production. On 29 July, station 22 exhibited the maximum recorded biomass for S. latifolia (1075.26 g/m^2) (Table 65). Following its biomass peak at the end of July, S. latifolia died rapidly. On 25 August, 30.95% of the biomass was senescent. This proportion had increased to 77.70% by 19 September (Table 15).

Current net productivity of S. latifolia averaged 10.29 g/m^2/day for the growing season. The highest values were recorded between 29 June - 15 July (12.86 g/m^2/day) and 15 July - 29 July (12.77 g/m^2/day), corresponding to flowering and fruiting of S. latifolia (Table 14).

The below ground proportion of S. latifolia ranged from 45.78% on 28 May to 15.29% on 19 September and averaged 24.55% for the growing season.

Sagittaria rigida. S. rigida increased significantly in biomass (Fig. 5) but not in frequency (Table 10) over the growing season. This species thus exhibited the same growth pattern as S. latifolia; it increased in stature in the same area without spreading. As with S. latifolia, seasonal maximum biomass (annual net production) of S. rigida was reached on 29 July when a value of 401.92 g/m^2 was recorded at station 20 (Table 64).

A seasonal growth rate of 5.61 g/m^2/day was calculated for Sagittaria rigida (Table 14). The highest value (10.24 g/m^2/day) was recorded between 15 July and 29 July when fruit development occurred.

The dead or senescent portion of S. rigida was 6.68% on 29 July, but increased to 35.48% on 25 August and 37.86% on 19 September (Table 15).

The below ground biomass of S. rigida averaged 25.47% for the growing season.

Lemnaceae. Members of this family increased significantly in frequency from 0.0 to 0.38 (Table 10) and in biomass in area 20 (Fig. 6). This seemed to indicate that the plants increased in stature as well as spread. However, because of the minute size of the individual plants, a greater biomass was recorded at a given site because of the larger numbers of this taxon in the m^2 area.

The maximum mean biomass calculated for Lemnaceae was 29.93 g/m^2 on July 29, 1976 (Fig. 6). The maximum value recorded at any one site was 125.24 g/m^2 at station 5 on 15 July (Table 57). Current net productivities of Lemnaceae averaged 0.49 g/m^2/day for the growing season (Table 14).

Vallisneria americana. The mean biomass of Vallisneria in area 15 increased significantly from 1.93 g/m^2 to 93.36 g/m^2 (Fig. 7). Vallisneria spread to new sites during the summer (Tables 69, 71, and 73) and the change in frequency from 0.67 to 1.00 (Table 13) was significant. Thus, Vallisneria increased both by vegetative growth and by an increase in the stature

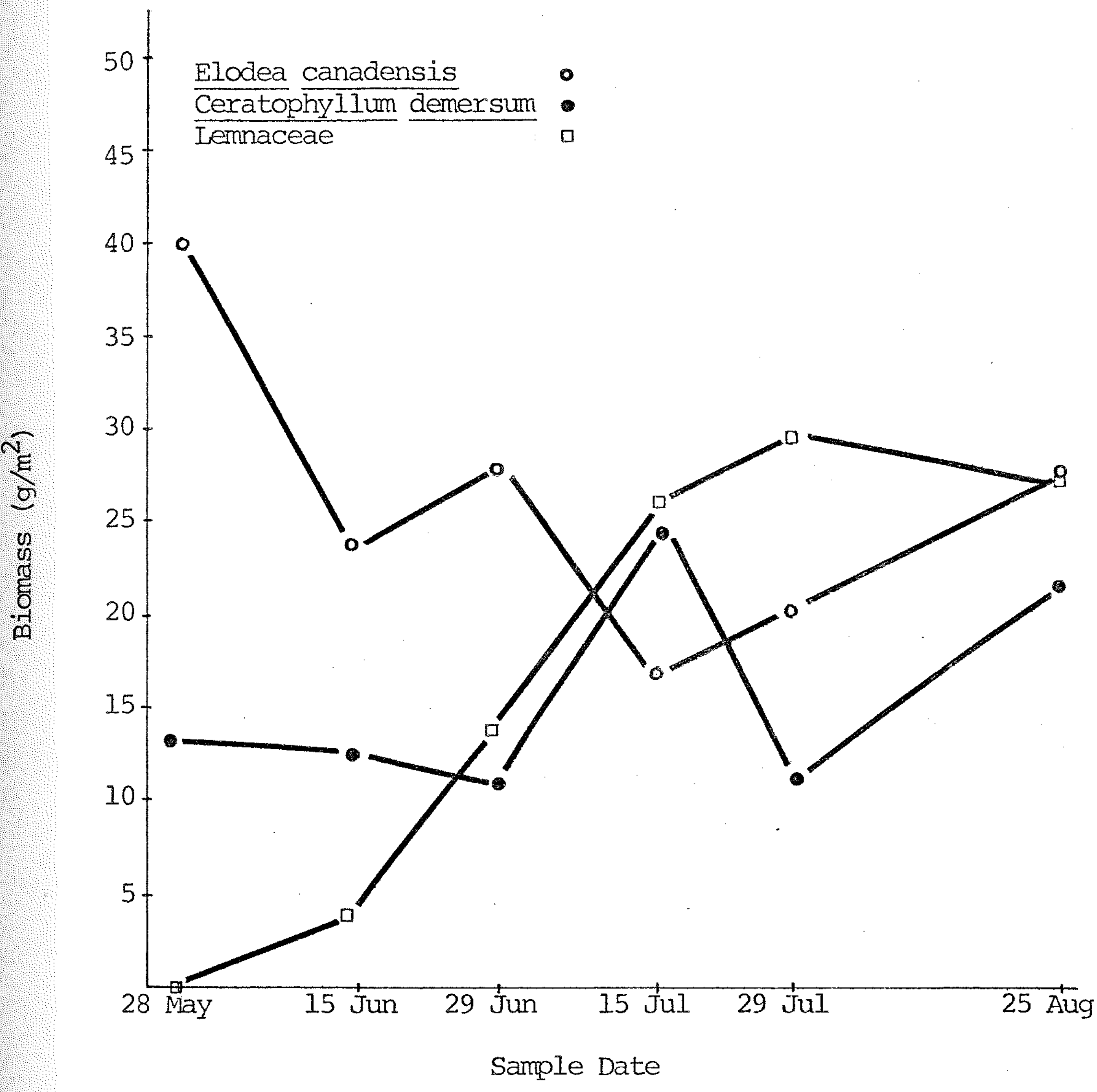

Fig. 6. Growth curves for Elodea canadensis, Ceratophyllum demersum, and Lemnaceae in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

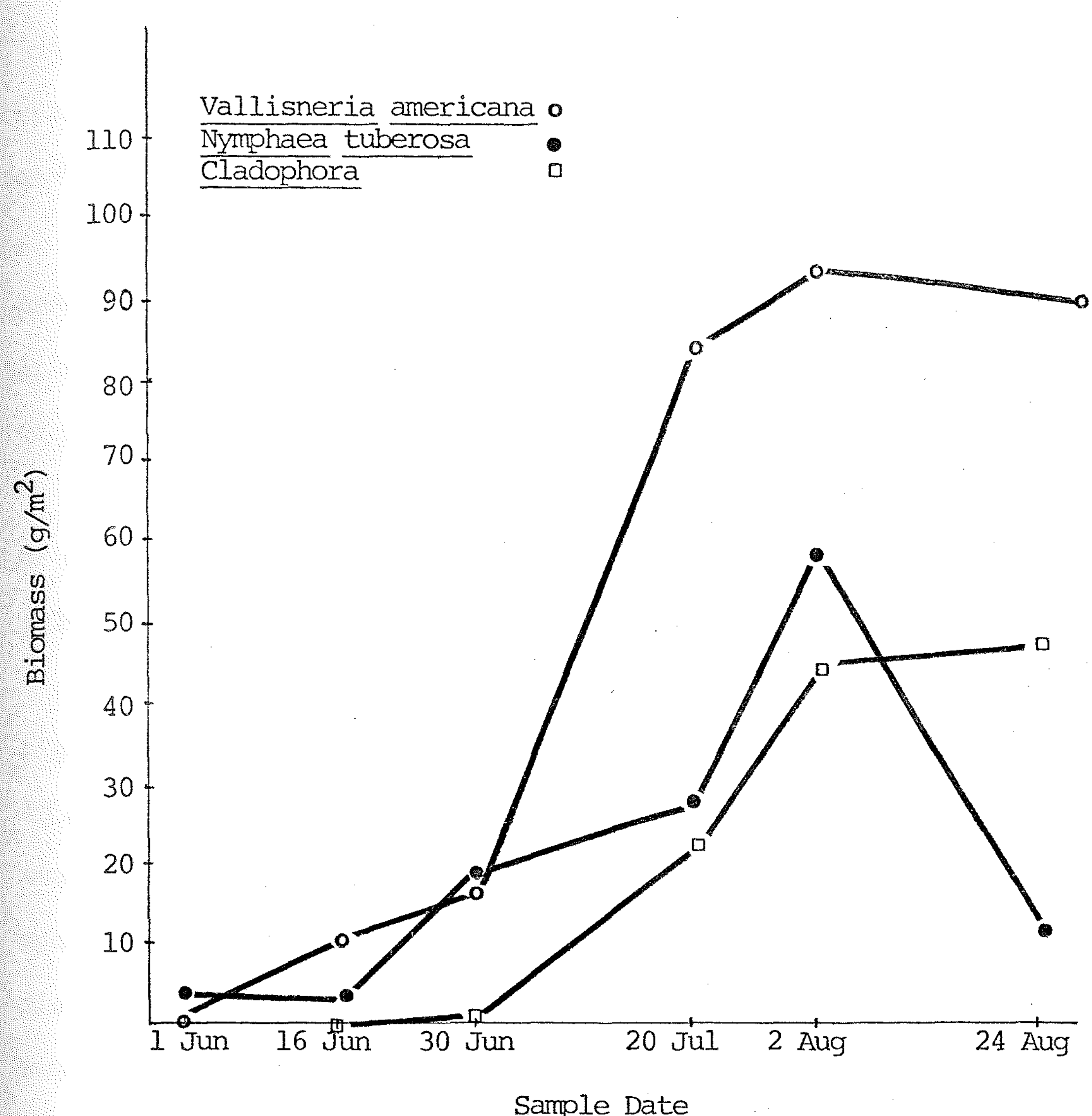

Fig. 7. Growth curves for Vallisneria americana, Nymphaea tuberosa, and Cladophora in study area 15, Navigation Pool 8, Upper Mississippi River, 1976.

of the plant in the same area.

Vallisneria is an annual whose initial spring biomass is neglible; therefore its seasonal maximum biomass gives an estimate of the annual net production. On 24 August, a maximum biomass of 267.36 g/m^2 was recorded at station 10 (Table 71). The maximum average biomass (93.63 g/m^2) occurred on 2 August (Fig. 7).

Growth rates for Vallisneria are given in Table 16. The greatest productivity (2.50 g/m^2/day) was recorded between 20 July and 2 August, at the time of flowering and fruit development. A seasonal productivity of 1.44 g/m^2/day was calculated (Table 16).

The below ground biomass of Vallisneria americana ranged from 2.88% of the total on 1 June to 10.23% on 19 September, giving an average of 6.94% for the growing season.

Cladophora. Because of its great biomass in area 15, this green alga was considered with the macrophytes. It was first recorded in area 15 on 30 June (frequency of 0.25). By 24 August, it was found at all stations which had vegetation (Table 13). Thus, Cladophora grew by spreading. The biomass of Cladophora also increased significantly over the growing season (Fig. 7). Because of the minute size of each filament, this biomass increase was not due to growth in stature of the individual filaments, but to an increase in the number of filaments within a given area.

A maximum average biomass of 43.82 g/m^2 was calculated for Cladophora on 2 August (Fig. 7). Station 11 recorded a maximum of 168.20 g/m^2 on 20 July (Table 72). The relationship of these values to the annual net production of Cladophora is unknown.

Table 16. Growth rates ($g/m^2/day$) of the major aquatic macrophytes in study area 15, Navigation Pool 8, Upper Mississippi River, 1976.

TAXON	1 Jun- 16 Jun	16 Jun- 30 Jun	30 Jun- 20 Jul	20 Jul- 2 Aug	2 Aug- 24 Aug	Mean for growing season
Cladophora	0[1]	0.11	0.94	1.87	0	0.97
	0[2]	0.03	0.92	1.71	0.11	0.69
Heteranthera dubia	0.04	0	0.36	2.13	0	0.63
	0.01	0	0.12	0.94	0.10	0.23
Nymphaea tuberosa	0	1.12	0.40	2.56	0	1.36
	0	0.09	0.03	0.21	0	0.11
Potamogeton nodosus	0.77	2.32	0.04	0.39	0	0.88
	0.19	0.58	0.19	0.13	0	0.27
Vallisneria americana	0.57	0.48	2.21	2.50	0	1.44
	0.38	0.63	2.03	2.29	0.15	1.10

[1] calculated from means based on the number of samples of occurrence of a taxon.
[2] calculated from means based on the total number of samples.

Daily biomass increments for Cladophora are given in Table 16. An average increment of .97 g/m^2/day was computed.

Nymphaea tuberosa. The above ground biomass of Nymphaea tuberosa, plotted in Fig. 7, increased from 3.92 g/m^2 on 1 June to a maximum of 58.10 g/m^2 on 2 August. It could not be determined whether this increase was significant, however. Nymphaea was only collected at station 1 in area 15, and therefore the standard error of the difference in the means could not be computed. The biomass of N. tuberosa remained in good condition until 19 September, when 25.05% was degenerate (Table 17). An average seasonal growth rate of 1.36 g/m^2/day was calculated for the above ground portion of Nymphaea (Table 16).

Ceratophyllum demersum, Elodea canadensis, Potamogeton nodosus, Heteranthera dubia, and Potamogeton crispus were found in significant quantities in both of the study areas.

Ceratophyllum demersum. The mean biomass of Ceratophyllum in areas 15 and 20 did not show significant variation over the summer (Figs. 6 and 8). The time of the maximum summer biomass varied at the different stations in area 20. A maximum of 61.66 g/m^2 was recorded on 28 May at station 5, of 160.94 g/m^2 on 15 July at station 23, and 129.88 g/m^2 on 27 August at station 18 (Tables 57, 66, and 63, respectively). In area 15, a maximum of 70.62 g/m^2 was recorded at station 10 on 30 June (Table 71).

Ceratophyllum was found at a rather constant frequency in area 20 (Table 10). In area 15, however, Ceratophyllum increased significantly in frequency from .42 to .75 (Table 13).

Since Ceratophyllum was observed to overwinter in the green condition and to continue growth throughout the year, a definite statement

Table 17. Percentage of the total biomass of the major aquatic macrophytes in study area 15, Navigation Pool 8, Upper Mississippi River, which was dead or senescent on each sampling date in 1976.

TAXON	SAMPLING DATE						
	1 Jun	16 Jun	30 Jun	20 Jul	2 Aug	24 Aug	19 Sep
Ceratophyllum demersum	73.10	39.13	90.65	0.35	1.54	4.18	2.29
Cladophora	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elodea canadensis	0.00	15.63	25.68	0.00	0.00	0.00	30.43
Heteranthera dubia	0.00	0.00	0.00	0.00	0.00	0.00	12.96
Nymphaea tuberosa	0.00	0.00	0.00	0.00	0.00	0.00	25.05
Potamogeton crispus	0.00	0.00	0.00	53.44	52.73	91.50	90.14
Potamogeton nodosus	0.00	0.00	0.00	0.00	0.00	11.79	45.77
Vallisneria americana	0.00	0.00	0.00	0.00	0.00	0.00	1.14

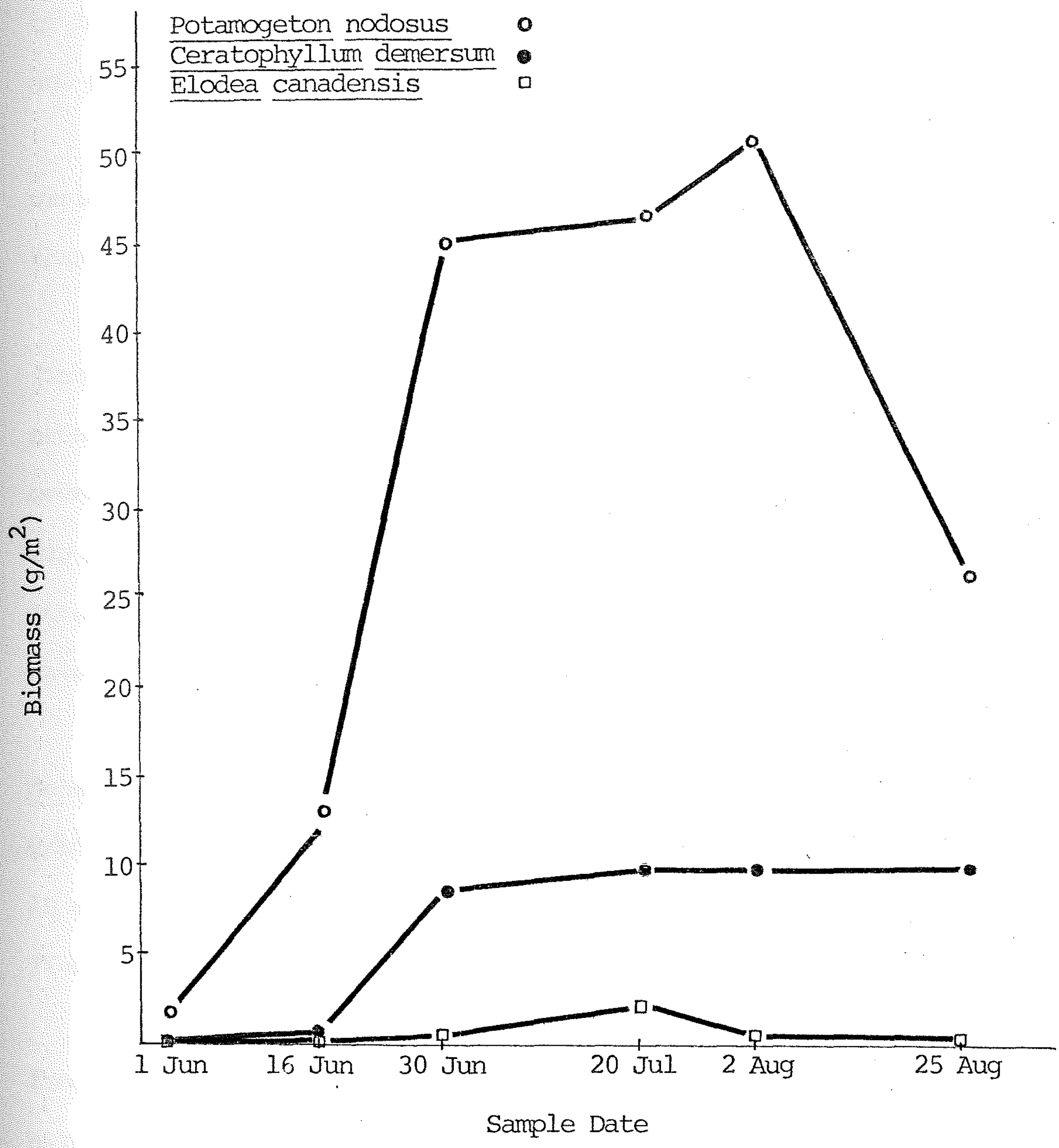

Fig. 8. Growth curves for Potamogeton nodosus, Ceratophyllum demersum, and Elodea canadensis in study area 15, Navigation Pool 8, Upper Mississippi River, 1976.

concerning its growth pattern could not be made without measurement of its biomass throughout the year. Likewise, annual net production and productivities could not be determined for the species.

The proportion of the biomass of Ceratophyllum that was senescent varied throughout the summer, but was generally higher at the start than at the end of the summer (Tables 15 and 17).

Elodea canadensis. Elodea increased significantly in frequency (Tables 10 and 13) but not in biomass (Fig. 6 and 8) in both study areas 15 and 20 during the summer of 1976. Like Ceratophyllum, it overwintered in the green condition and a substantial initial biomass was present in the spring. Thus, statements concerning the productivity, annual net production, and the growth pattern of Elodea could not be made without biomass samples throughout the year.

A maximum summer biomass of 303.60 g/m^2 was recorded for E. canadensis at station 5 in area 20 on 19 August, while the maximum (102.12 g/m^2) at station 23 occurred on 28 May (Tables 57 and 66, respectively). In area 15, a maximum of 6.00 g/m^2 was recorded at station 2 on 21 July (Table 67).

Potamogeton nodosus. P. nodosus neither increased significantly in frequency in area 15 or in area 20 (Tables 10 and 13, respectively). Although its mean biomass increased from 3.10 g/m^2 to 21.79 g/m^2 in area 20 (Fig. 9) and from 1.57 g/m^2 to 51.17 g/m^2 in area 15 (Fig. 8), these differences were not significant because of the variability of the samples. This increase in biomass was primarily associated with fruit development.

Since P. nodosus is an annual whose initial (spring) biomass is negligible, its seasonal maximum biomass may be equated with its annual net production. In area 20, a maximum seasonal biomass of 42.08 g/m^2

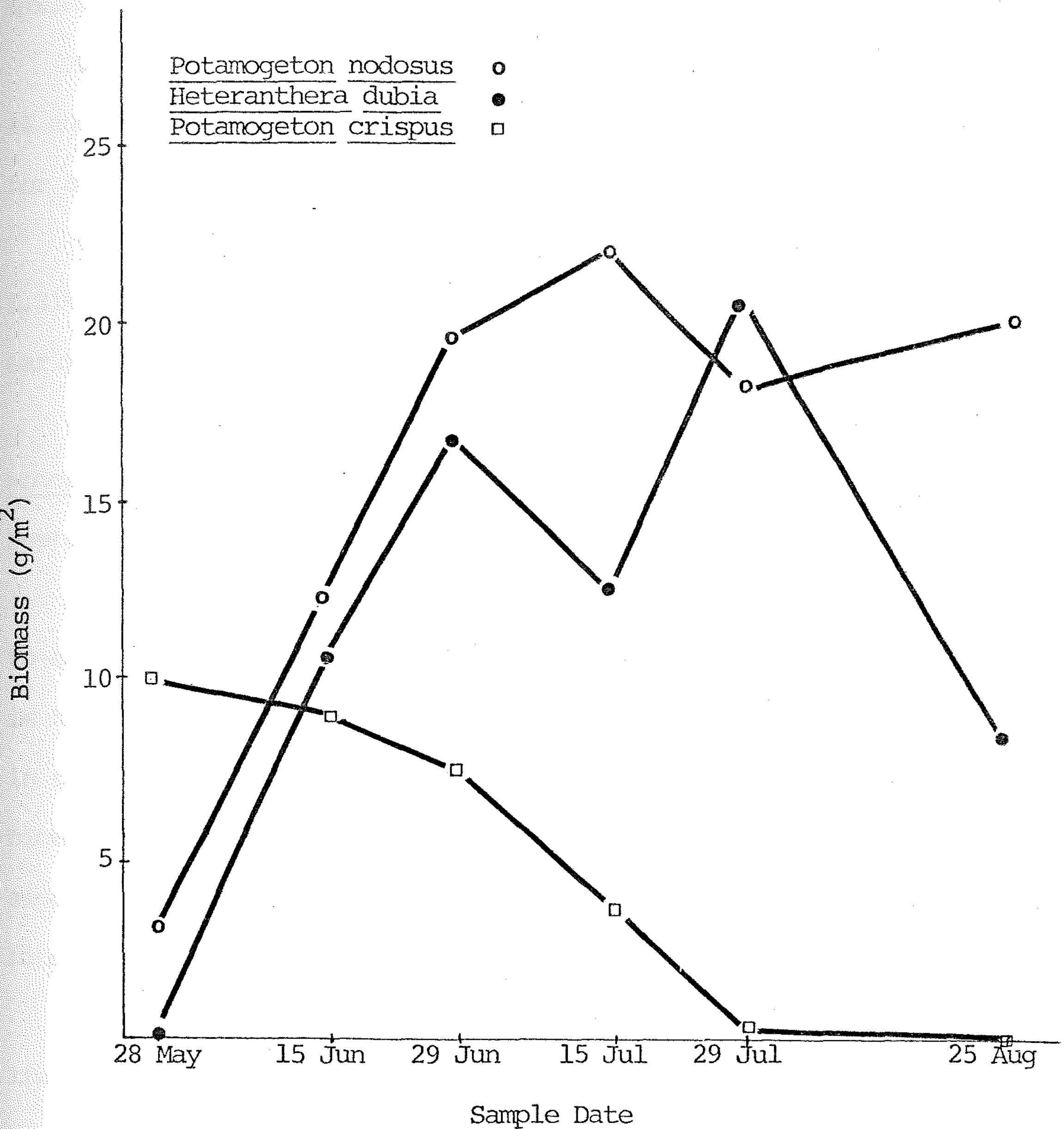

Fig. 9. Growth curves for Potamogeton nodosus, Heteranthera dubia, and Potamogeton crispus in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

was recorded at station 24 on 15 July (Table 66), while in area 15, the maximum of 116.70 g/m^2 occurred at station 12 on 3 August (Table 72).

Growth rates for P. nodosus in areas 15 and 20 are given in Tables 14 and 16, respectively. The average seasonal productivity was higher for study area 15 (0.88 g/m^2/day) than for area 20 (0.39 g/m^2/day).

The portion of the biomass of P. nodosus that was below ground averaged 6.31% in area 15 and 7.93% in area 20. This proportion was greater in early summer and decreased toward the end of the growing season.

In September, the dead or senescent portion of the biomass of P. nodosus increased. It was 3.46% in area 20 and 45.77% in area 15 on 19 September (Tables 15 and 17, respectively).

Heteranthera dubia. In study area 20, Heteranthera was restricted to sandy or silt and sand substrates where there was some current. It is thus not surprising that it did not change significantly in frequency in that area (Table 10). Heteranthera did increase significantly in biomass in area 20, however (Fig. 9). In area 15, H. dubia increased significantly in frequency from .08 to .75 (Table 13) as well as in biomass (Fig. 10).

Since the initial (spring) biomass of Heteranthera was negligible, its seasonal maximum biomass may be used as an estimate of the maximum cumulative net production. In area 20, the seasonal maximum biomass of Heteranthera was 20.06 g/m^2 on 29 July (mean value, from Fig. 9), and 41.76 g/m^2 (maximum site value) at station 24 on 19 September (Table 66). In area 15, these values were 33.47 g/m^2 on 2 August (Fig. 10) and 153.04 g/m^2 on 24 August (Table 72). In August and September, a substantial portion of the biomass of Heteranthera was senescent. In area 20, 56.33% of Heteranthera's biomass was senescent on 25 August (Table 15),

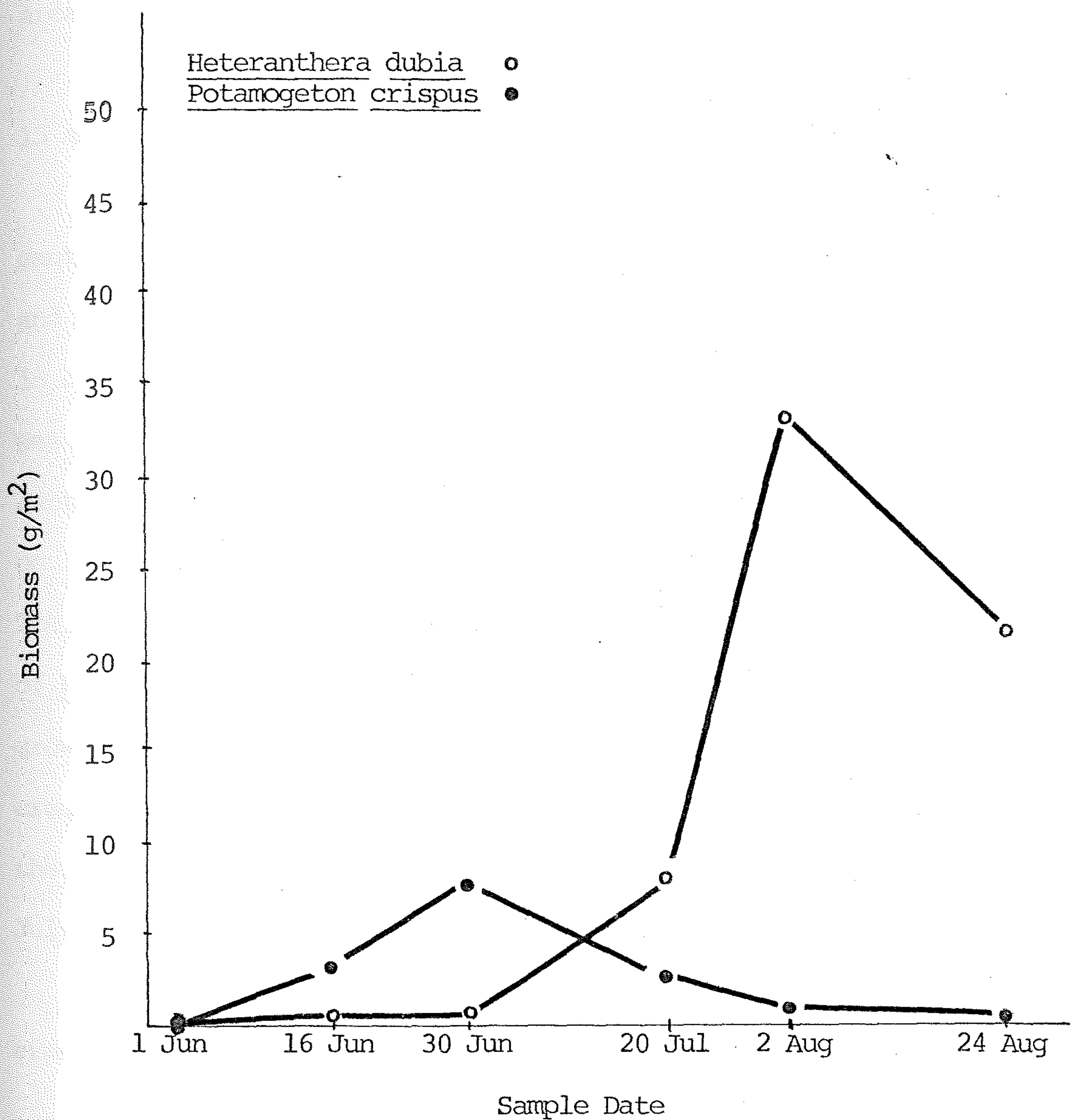

Fig. 10. Growth curves for Heteranthera dubia and Potamogeton crispus in study area 15, Navigation Pool 8, Upper Mississippi River, 1976.

while this value was 12.96% on September 19, 1976 in area 15 (Table 17).

Mean seasonal productivities for Heteranthera were 0.41 g/m^2/day in area 20 and 0.63 g/m^2/day in area 15 (Tables 14 and 16, respectively).

The below ground biomass of Heteranthera averaged 3.09% for area 15 and 3.88% for area 20.

Potamogeton crispus. The frequency of P. crispus changed significantly in both area 20 and area 15 over the growing season. (Tables 10 and 13, respectively). In area 20, the frequency decreased from .38 on 15 June to .17 on 29 July (Table 10). The mean biomass of P. crispus was greatest initially in area 20 (10.01 g/m^2), then decreased significantly thereafter. In area 15, the mean biomass increased from .17 g/m^2 on 1 June to 7.74 g/m^2 on 29 June, but decreased thereafter (Fig. 10). The above information may be explained by observation of the phenology of P. crispus. P. crispus appeared and was observed to have its maximum growth early in the spring, then formed overwintering "burs" and decreased in biomass and abundance during the summer. More than 50% of the biomass of P. crispus consisted of senescent "burs" on or after 29 July in area 20 (Table 15) and on and after 20 July in area 15 (Table 17).

Potamogeton crispus had an average below ground biomass of 3.08% in area 20 and 1.28% in area 15.

DISCUSSION

1975

Results are representative of the mid and southern sections of Navigation Pool 8 of the Upper Mississippi River, as all the areas designated for sampling in the simulation model study were located in these portions of the pool. The northern end of the pool is "in essentially normal river condition...marsh development is limited and the old condition of deep sloughs and wooded islands is found" (Green 1960). The mid and lower sections of Pool 8 were initially most greatly altered by the nine foot navigation channel, and continue to change rapidly. Since quantitative data provided in this study may be used as a basis for assessing future changes in Pool 8, it is appropriate that data was collected from the areas of the pool that are changing most rapidly. In addition, since macrophyte development is limited in the northern section of the pool, omission of study areas from this portion of the pool may not have made the data unrepresentative of the pool as a whole.

Of the 27 species of aquatic vascular plants found in Pool 8, 15 had a mean relative frequency of greater than 2.0% during the summer of 1975 (Table 18). This compares to 7 of a total of 18 species collected by Nichols and Mori (1971) in Lake Wingra and 4 of a total of 18 species collected by Lind and Cottam (1969) in University Bay of Lake Mendota which had relative frequencies greater than 2.0%. Thus, Pool 8 appeared to support a greater diversity of aquatic macrophytes than these two hard

Table 18. Ranking of aquatic macrophytes according to frequency of occurrence in 1975 (present study 1976) as compared to 1973 (Sohmer 1975b).[1]

TAXON	Present Study (1976) Mean Rel. Freq. (%)[2]	Sohmer (1975b) Frequency
Submergent and Floating-leaved Taxa		
Ceratophyllum demersum	18.66	1.00
Vallisneria americana	9.19	0.14
Potamogeton crispus	8.19	0.93
Elodea canadensis	7.37	0.93
Potamogeton pectinatus	6.58	0.57
Potamogeton nodosus	6.21	0.50
Lemnaceae	5.64	0.00
Heteranthera dubia	5.03	0.21
Nymphaea tuberosa	3.76	0.36
Nelumbo pentapetala	3.58	0.14
Potamogeton foliosus	3.28	0.64
Potamogeton zosteriformis	1.41	0.57
Potamogeton richardsonii	0.65	0.00
Cladophora	0.55	0.00
Nuphar variegatum	0.35	0.00
Najas flexilis	0.31	0.00
Myriophyllum spicatum var. exalbescens	0.17	0.07
Ranunculus circinatus	0.00	0.07
Emergent (Marsh) Taxa		
Sagittaria latifolia	11.57	0.64
Sagittaria rigida	4.46	0.54
Sagittaria rigida forma fluitans	1.61	0.36
Phalaris arundinacea	0.73	0.36
Sparganium eurycarpum	0.25	0.27
Scirpus validus	0.24	0.18
Polygonum coccineum	0.24	0.18
Sagittaria engelmanniana	0.00	0.18
Scirpus fluviatilis	0.00	0.09

1 Absolute values for the studies are not comparable.
2 Average value for summer 1975.

water lakes in southern Wisconsin. In addition, in terms of relative frequency, no macrophytes clearly dominated Pool 8, as all species exhibited relative frequencies of less than 20% (Table 18). Lake Wingra was dominated by Myriophyllum spicatum (relative frequency, 68.40%), while Myriophyllum exalbescens dominated University Bay of Lake Mendota (relative frequency, 55.61%) (Nichols and Mori 1971, Lind and Cottam 1969).

It was expected that Pool 8 would support a large variety of aquatic macrophytes because it is very diverse ecologically. Habitats range from shallow pondlike areas in the midsection of the pool, to deeper, open, lake-like areas in the southern portion of the pool, to sloughs with vegetation only on the margins, to deep swift navigation channels containing no vegetation.

A comparison of the list of marsh and aquatic vascular plants along a transect across the midsection of Pools 7 and 8 (Sohmer 1975b) with the species found in the present study (Appendix II) revealed 19 taxa in common. Three species (Sagittaria engelmanniana, Scirpus fluviatilis, and Ranunculus circinatus) recorded by Sohmer was not found in the present study, while seven species (Lindernia dubia, Ludwigia palustris, Najas flexilis, Nuphar variegatum, Polygonum coccineum, Potamogeton richardsonii, and Pontederia cordata) recorded by the present author were not found by Sohmer. This discrepancy is probably due to the rareness of these species in Pool 8 and to the fact that different areas were sampled by the two authors rather than to a change in species composition since 1973.

Moyle (1945) classified the waters of Minnesota as soft, hard, and alkali based on the observed preferences and tolerances of aquatic plants.

"The natural separation between hard and soft water seems to be at a total alkalinity of about 40 parts per million (ppm), 30 (ppm) being the lower limits of the toleration of the more typical hard water species and 50 (ppm) the upper limit of toleration of the more characteristic soft water species....The hard water flora is typical of waters with a total alkalinity of 90-250 (ppm) and a sulphate ion concentration of less than 50 (ppm) (Moyle 1945). The total alkalinity of Mississippi River Navigation Pool 8 varies slightly around 175 mg/l (Claflin 1973). Thus, it is not surprising that most of the aquatic vascular plants occurring in Pool 8 (Appendix II) were listed by Moyle as typical members of the hard water flora. Pontederia cordata, found in waters ranging in alkalinity from 18.7-92.5 ppm and from 0-10 ppm in sulphate concentration (Moyle 1945) was not categorized by Moyle because it could be found in both soft and hard water. Lindernia dubia, Ludwigia palustris, and Phalaris arundinacea, more terrestrial herbs growing on wet mud, were not listed by Moyle.

Moyle (1945) found the commonest submergent plants in the larger rivers of Minnesota to be Vallisneria americana, Elodea canadensis, Potamogeton nodosus, Heteranthera dubia, and Potamogeton pectinatus. These species ranked among the top eight submergent taxa in mean seasonal relative abundance in Pool 8 of the Upper Mississippi River (Table 18).

The time at which frequency and biomass data are collected is important in determining the results. Potamogeton crispus, P. foliosus, and Sagittaria rigida forma fluitans decreased significantly, while others increased significantly, in relative frequency and relative biomass in Pool 8 during the growing season. Some of the differences between the ranking of the species on the basis of frequency as compared to that of biomass found by Sohmer (1975b) may be accounted for by the fact that his frequency data was collected in June and July while the biomass data was collected in August. However, like Sohmer's, the present study shows that the most frequently encountered species do not necessarily constitute the greatest relative biomass.

Average seasonal relative frequency calculated for the taxa in the present study of Pool 8 was compared with the results obtained by Sohmer (1975b) (Table 18). Both studies found Ceratophyllum demersum to be the most frequently occurring species in the submergent and floating-leaved habitat. However, the rankings of the various taxa differed thereafter. This may be explained by the fact that Sohmer's values were based on transects across the midsections of Pools 7 and 8 of the Upper Mississippi River, while the values in the present study were based on samples taken from both the mid and southern sections of Pool 8. The mid and lower sections of Pool 8 differ greatly in species composition and biomass. Vallisneria, for example, is rare in the midsection of Pool 8, but abundant in the lower section. Thus, it ranked eighth in Sohmer's study, but was the second most frequent submergent in the present study. Potamogeton zosteriformis, which is frequent in the midsection of Pool 8, ranked fourth in abundance in Sohmer's study. It ranked twelfth in the present study, due to the fact that it is rare in the southern portion of Pool 8.

The three most frequent species recorded by Sohmer (1975b) in marsh habitats were Sagittaria rigida, S. latifolia, and S. rigida forma fluitans. In the present study, the ranking of Sagittaria rigida and

S. latifolia was reversed; Sagittaria latifolia was by far the most frequently occurring emergent species (Table 18).

Sohmer (1975b) also determined the relative biomass for taxa occurring in the submergent and floating leaved habitat. He found Potamogeton nodosus to constitute the greatest relative biomass (32.51%) along the transects across the midsections of Pools 7 and 8. In the present study, P. nodosus (relative biomass, 5.50%) ranked fifth; Vallisneria americana, with a relative biomass of 18.55%, was the most important species in that habitat. Sohmer ranked Vallisneria fifth, with a relative biomass of 3.04% (Table 19). The differences may be explained by the same reasoning as the differences in the ranking of the frequency data; i.e. Sohmer's results were based on only 24 samples collected from both Pools 7 and 8 and did not include data from the southern portion of the pools.

Sohmer did not determine the relative biomass of the marsh herbs in Pools 7 and 8. In the present study, an emergent, Sagittaria latifolia, constituted 45.24% of the total biomass in Pool 8 (mean relative biomass for the summer, Table 19). This species was also the second most frequently occurring in the pool (mean seasonal relative frequency 11.57%, Table 18). It constituted such a great proportion of the total biomass because of its frequent occurrence and the large size and weight of an individual plant. The frequent occurrence of this species may be explained by the fact that it grows well in water depths ranging from wet muck to 1.0 m. Such environments are abundant in the backwaters of the pool. S. latifolia may also be able to withstand current, and thus have a competitive advantage over other emergent species on shallow slough margins.

Table 19. Ranking of aquatic macrophytes according to relative biomass in 1975 (present study 1976) as compared to 1973 (Sohmer 1975b).[1]

TAXON	Present Study (1976) Mean Rel. Biomass (%)[2]	Sohmer (1975b) Relative Biomass (%)
Submergent and Floating-leaved Taxa		
Vallisneria americana	14.33	3.04
Ceratophyllum demersum	5.57	17.42
Potamogeton nodosus	5.10	32.51
Nymphaea tuberosa	4.60	0.00
Nelumbo pentapetala	4.32	20.81
Lemnaceae	3.39	2.55
Heteranthera dubia	1.36	4.40
Potamogeton crispus	1.17	1.55
Potamogeton pectinatus	1.14	0.00
Elodea canadensis	0.78	15.12
Sagittaria rigida forma fluitans	0.63	0.02
Nuphar variegatum	0.60	0.00
Potamogeton foliosus	0.32	0.28
Potamogeton richardsonii	0.23	0.00
Cladophora	0.13	0.00
Potamogeton zosteriformis	0.11	2.07
Najas flexilis	0.008	0.00
Myriophyllum exalbescens	0.0006	0.23
Emergent (Marsh) Taxa		
Sagittaria latifolia	45.24	----[3]
Sagittaria rigida	8.50	----
Scirpus validus	1.11	----
Sparganium eurycarpum	0.58	----
Polygonum coccineum	0.28	----
Phalaris arundinacea	0.06	----

1 Absolute values for the studies are not comparable.
2 Average value for summer 1975.
3 No values determined.

Ceratophyllum was the most widespread species in Pool 8 and ranked fourth in relative biomass in 1975 (Tables 18 and 19). The ranking in relative biomass was probably due to the frequent occurrence of Ceratophyllum, because its biomass at any one site was small (Table 5). C. demersum is commonly free-floating, or when rooted, only weakly so. Thus, its distribution is not as dependent on the substrate type as is that of many rooted species. In addition, Ceratophyllum overwinters and continues growth throughtout the year (Nichols 1971) and thus has a advantage over seasonal plants. It can reach peak biomass when competitors are gone (Smart 1976, unpublished data).

Vallisneria ranked second in relative biomass and third in relative frequency in Pool 8. This species, with long flexous leaves from a basal rosette, is well adapted for withstanding current. Vallisneria reaches greatest development in areas possessing current. Meyers et. al (1943) reported that V. americana could survive at lower light intensities than Potamogeton richardsonii, Najas flexilis, Elodea canadensis, and Heteranthera dubia. Vallisneria thus has a competitive advantage over those species in the deep water areas in the southern portion of Pool 8.

Sagittaria latifolia, Ceratophyllum, and Vallisneria all reproduce vegetatively. Therefore, they can quickly spread to favorable habitats, another characteristic explaining their abundance in the backwaters of Pool 8. More study of the physiological adaptations allowing these species to successfully compete is recommended.

An average biomass of 181.70 g/m^2 was calculated for Pool 8 based on the number of samples containing vegetation during late July and August (Table 5). Quadrats without vegetation were generally from deep sloughs and channels not capable of supporting vegetation, and thus were not used in the calculation. This figure (181.70 g/m^2) is an estimate of the biomass of the littoral zone of Pool 8. It is much higher than the mean values of 0.7 - 16.8 g/m^2 recorded for the littoral zone of the soft water lakes in northern Wisconsin (Table 20). It lies between the values for Green Lake (178 g/m^2) and Lake Mendota (202 g/m^2), hard water lakes in southern Wisconsin. It is comparable to the 179.08 g/m^2 calculated for Lake Onalaska in Navigation Pool 7 of the Upper Mississippi River (Table 20). Forty-five percent of this average crop in Pool 8 was composed of emergent S. latifolia, however, while in the above lakes, submergent species were dominant.

The "Stoddard stump field" areas (14, 15, 21, 24, 37) were open lake-like habitats located in the southern portion of Pool 8. These areas were dominated by submergent Vallisneria and Potamogeton spp. The mean total biomass of 165.96 g/m^2 calculated for these areas for sampling period II (from Table 2) was slightly lower than the average biomass of 179.08 g/m^2 determined for Lake Onalaska, a similiar environment located in the southern section of Pool 7.

Distribution, abundance, and biomass of aquatic macrophytes in Pool 8 were influenced by many environmental factors. The relationship of macrophyte biomass to depth, sediment particle size, sediment nutrients, turbidity, current velocity, dissolved oxygen, and temperature were examined in the simulation model study.

Depth, as it controls light penetration, has long been recognized as controlling the distribution of submergent aquatic plants (Pearsall and Hewitt 1937, Meyers et. al. 1943, Westlake 1964, Schmid 1965, Spence 1967). The limiting depth for plant growth in Pool 8 appeared to be

Table 20. Average summer crop of aquatic macrophytes from various locations.

Site	Average Crop dry weight (g/m^2)	Source
Trout L., N.E. Wis.	0.07	Wilson 1941
Silver L., N.E. Wis.	0.08	Wilson 1935
Muskellunge L., N.E. Wis.	0.45	Wilson 1935
Little John L., N.E. Wis.	0.52	Wilson 1935
Sweeny L., N.E. Wis.	1.73	Wilson 1937
Weber L., N.E. Wis.	16.80	Potzger and Van Engel 1942
Green L., S.E. Wis.	178	Rickett 1924
L. Mendota, S.E. Wis.	202	Rickett 1921
L. Onalaska, Navigation Pool 7, Upper Mississippi River	179.08	Claflin 1976, unpublished data
Navigation Pool 8, Upper Mississippi River	181.70	present study 1976

approximately 1.9 m (based on 1975 and 1976 data and observations). The biomass of plants at depths below 1.9 m was probably dependent on other environmental factors, such as sediment particle size, sediment nutrients, turbidity, or current velocity.

Sediment particle size plays an important role in determining the quantity and quality of rooted aquatic vegetation (Claflin 1975). Sand substrates support very little aquatic macrophyte growth, even in very shallow areas. Rooting is difficult in coarse substrates (Wilson 1939, Nichols 1971). Emergent and floating leaved plants with strong anchoring systems and plants such as Ceratophyllum and Elodea, which are commonly free floating, predominate on soft substrates with a fine particle size. Aquatic vegetation also influences sediment particle size by trapping silt particles and by contributing organic matter to the sediment.

Sediment nitrogen and phosphorus certainly influence the growth of aquatic macrophytes. Rooted aquatic vegetation, in turn, is of paramount importance in autochthanous cycling of nutrients in the littoral zone of Pool 8 (Claflin 1975).

Turbidity, which is influenced by current velocity, affects light penetration, and thus the amount of macrophyte growth. Robel (1961) found a strong negative correlation between the biomass of Potamogeton pectinatus and turbidity, with less turbid areas producing a greater biomass.

Current velocity influences many of the other environmental parameters. Sediment particle size and turbidity are directly dependent, while sediment nutrients, dissolved oxygen, and temperature are indirectly dependent on current velocity (Claflin 1975). The ability of plants to withstand current influences their distribution and biomass. Some plants, such as Ceratophyllum and Elodea, reach greatest development in stagnant areas, while others, such as Vallisneria, P. nodosus, Heteranthera, and Nelumbo reach greatest development in areas with some current velocity.

Dissolved oxygen and temperature influence aquatic vegetation, as well as are influenced by it.

From the above discussion, it can be hypothesized that environmental factors interact and no single one may be deduced as the sole factor controlling plant growth and distribution. That this is the case was shown by correlations of the environmental parameters discussed above with mean total macrophyte biomass in each study area. The correlation between any individual physical-chemical parameter and macrophyte biomass was low (Table 8). However, multiple correlation coefficients of .697 and .729 were calculated for sampling periods I and II, respectively. These multi-r values were significant at the 90% level.

It is probable that other environmental factors, which were not measured in the simulation model study, are involved in determining macrophyte biomass, accounting for the fact that the multi-r values were not highly significant (at the 95% level). Sampling error may have been involved. Current velocities and temperatures, for example, were taken at different times in different areas. A month elapsed between sampling of macrophytes in the first and in the last study areas. Thus some of the biomass difference between areas may have been obscured or amplified due to macrophyte growth during that time. This effect was partially eliminated by sampling shallow water areas first and deeper water areas later. Plants in shallow water usually reach maturity (peak biomass) before those in deeper water (Rickett 1921). Enough samples may not have been taken to give a good representation of the macrophyte biomass in an area. Variability characterizes aquatic macrophyte biomass in nature (Nichols 1971, Szczepanska 1973). Szczepanska (1973), however, reported that increasing the number of samples did not decrease the coefficient of variability for the biomass of rushes. The coefficient of variability was 46% at four replications, 42% at 10, and 52% at 27.

Macrophytes greatly affect the environment as well as being influenced by it. The environment of the backwater is probably as much a product of the macrophyte community as the macrophyte community is of the environment (Nichols 1971).

1976

From all study areas. Due to drought conditions, the current velocities and depths recorded for the study areas of Pool 8 were much less in 1976 than those recorded for 1975. Thus, a larger crop of aquatic macrophytes would be expected in 1976. Unfortunately, the data collected in 1976 could not be compared to 1975 data. Since the vegetation in the centers of most of the study areas differed greatly from that on the perimeters, three samples taken from the geographical center of each area could not be compared with samples taken from all parts of the areas. The 1976 data, however, can be used as a basis for assessing future changes in vegetation abundance and biomass in the centers of these areas. A future study for comparison purposes would be relatively easy; it would not involve a lot of samples and could be done over a short period of time.

From areas 15 and 20. This study is significant in determining growth rates (net productivities) and maximum seasonal biomass for species for which these values have not been reported in the literature. The seasonal maximum biomass can be equated with annual net production if the initial (spring) biomass is neglible or if it disappears before the seasonal maximum is reached and if losses other than respiration are negligible (Westlake 1965). This is true for Sagittaria spp., Potamogeton spp., Heteranthera dubia, Vallisneria americana, Najas flexilis, and Lemnaceae in Pool 8. Boyle and Sheldon (1976) also reported that Najas and Vallisneria did not overwinter; they began growth in early and mid June, respectively, in Lake George, New York. In the present study, the annual net production (mean seasonal maximum biomass) of submergent Vallisneria was 93.63 g/m^2, compared to 233.30 g/m^2 for floating-leaved Nelumbo, and 674.02 g/m^2 for emergent S. latifolia (Fig. 5 and 7). Maximum site values for Vallisneria, Nelumbo, and S. latifolia were 267.36g/m^2, 803.36 g/m^2, and 1075.26 g/m^2, respectively (Tables 71, 55, and 65). Wetzel (1975) noted that submersed macrophytes generally exhibited conspicuously lower production than plants of floating leaved or emergent communities. This pattern was observed in Pool 8.

Many authors have assumed that the maximum biomass of aquatic macrophytes occurs about the time of flowering or ripening of seed, usually July or August in the northern hemisphere (Westlake 1963). In the present study, maximum seasonal biomass for Sagittaria latifolia and S. rigida occurred in late July, and for Nelumbo, Vallisneria, and P. nodosus in August, at the time of maximum fruit development in these species. Maximum productivity rates were coincident with flowering and fruiting in the above mentioned species.

Productivities in area 20, representative of emergent, floating-leaved, and submergent communities occurring in the midsection of Pool 8 ranged from 1.26 - 5.46 g/m^2/day, with an average productivity of 3.70 g/m^2/day for the growing season (June to August) (Table 11). In area 15, representative of submergent communities in the southern portion of Pool 8, productivities ranged from 0.74 - 5.85 g/m^2/day, with a mean seasonal productivity of 2.97 g/m^2/day. Mean daily productivities, based on dry weight biomass changes, have not been reported for Wisconsin lakes or other comparable habitats. Edwards and Owens (1960) and Owens and Edwards (1961, 1962) reported average daily productivities ranging from 1.12 g dry wt/m^2/day to 4.13 g/m^2/day for the River Ivel, an English chalk stream, dependent on the year, season, and reach analysed. Productivities of 4.93 g/m^2/day were reported for the River Test between April and May and 8.86 g/m^2/day for the River Yare between May and June 1960 (Owens and Edwards 1962). Westlake (1963) felt that Owens and Edwards (1962) results probably represent the greatest productivity found in temperate rivers. These English rivers had a completely submergent flora quite different than that in Pool 8.

Growth patterns were determined for the major taxa in areas 15 and 20. Growth, generally defined as an increase in biomass, can occur by an increase in stature of a plant or by its spreading to a new area. With these possibilities, four growth patterns can be described. A plant can grow by: 1) increasing in stature in the same area, 2) by spreading in area, 3) by both increasing in stature and spreading, or 4) by neither increasing in stature nor spreading (Nichols 1971). Two species, *Sagittaria latifolia* and *S. rigida*, exhibited growth pattern no. 1; they increased significantly in stature in the same area. Lemnaceae and *Cladophora* grew by spreading in area. Growth pattern no. 3 was exhibited by *Nelumbo* and

Vallisneria, which increased both by vegetative growth (spreading) and by an increase in the stature of the plant in the same area. The growth patterns of Nymphaea tuberosa, Ceratophyllum demersum, Elodea canadensis, Potamogeton nodosus, Heteranthera dubia, and P. crispus could not be determined accurately from the data. Nichols (1971) described the growth patterns of three of these species (Nymphaea, P. nodosus, and Ceratophyllum) in Lake Wingra. Nichols found that Nymphaea and P. nodosus exhibited rapid initial growth until they reached the surface, but after that they did not change significantly in stature nor spread in area by vegetative growth. Nichols reported an above ground biomass of 80.9 ± 25.0 g/m^2 for Nymphaea. The above ground biomass of N. tuberosa in area 15 during 1976 was 20.43 ± 20.62 g/m^2. The lower biomass of Nymphaea in Pool 8 than in Lake Wingra was probably due to the fact that in area 15, it exhibited a growth form characterized by long and thin petioles, small lamina, and few flowers, suggesting that optimum conditions did not occur for Nymphaea in this deeper water habitat.

Nichols (1971) found Ceratophyllum demersum in apparent good health and in rather constant proportions throughout the year. He felt Ceratophyllum represented the fourth growth pattern, those which neither grow in stature nor spread in area. Loss of plant material is balanced by growth.

Underground, as well as above ground, portions of plants were collected and weighed separately in 1976. The biomass of underground organs can vary from about 0-10% in submergent to over 50% among other aquatic plants (summarized in Westlake 1963). All submergent species in the present study were found to have a seasonal underground biomass of less than 10% of the total. Roots were not separated from Ceratophyllum and Elodea, which are usually free-floating or very loosely rooted. Emergent Sagittaria latifolia and S. rigida were found to have approximately one-fourth of their biomass underground in the present study. Strodthoff (1976, unpublished data), working on Lake Onalaska in Pool 7 of the Upper Mississippi River, recorded an average underground biomass of 26% for S. latifolia and 30% for S. rigida during the period from 27 May to 15 September 1976. Floating leaved Nuphar variegatum, which possesses very large rhizomes, had an average of 59% of its biomass underground. This is comparable to values of 50-80% reported by Wetzel (1975) for N. lutea and N. pumilum. Thus, root systems and organs of storage comprise a significant portion of the biomass of aquatic macrophytes and cannot be neglected in determinations of production (Westlake, in Vollenweider 1969).

Role of Aquatic Macrophytes in Pool 8

Aquatic macrophytes have an important functional impact on Pool 8 as a whole. They are primary producers, forming the basis of the trophic scheme and regulating the total energy traffic of the pool. Rooted aquatic vegetation is of paramount importance in autochthanous nutrient cycling in the backwater areas, and thus influences the rate of eutrophication. It has already been noted that aquatic macrophytes affect, as well as are affected by, the biotic and abiotic environment. Sculthorpe (1967) provides an excellent summary of the interactions between vascular hydrophytes, their environment, and other aquatic organisms. Aquatic macrophytes directly affect the oxygen balance through their "photosynthetic and respiratory activities, productivity, and decay" and indirectly affect it through modification of the physical nature of the environment. They affect flow, siltation, light penetration, and temperature. The metabolic processes of aquatic macrophytes also affect the chemistry of their environment. In addition, "many vascular hydrophytes occupy key positions in biotic relationships. Their soil-binding roots, rhizomes, and stolons help to reduce erosion and facilitate colonization by benthic algae and invertebrates. Their foliage offers shelter, support, and at least during daylight, a locally enriched oxygen supply and consequently often bears a rich and varied epiphytic microflora and fauna. Hydrophytes of all life forms provide a direct or indirect source of food for an immense variety of aquatic invertebrates and fishes and for those birds and mammals that frequent aquatic habitats" (Sculthorpe 1967).

Aquatic macrophytes constitute the greatest single biomass of any group of organisms in the backwater areas of Navigation Pool 8. The backwaters are thus the major sources of synthesis of organic matter, contributing singificantly to the production and regulation of the metabolism of the whole ecosystem.

SUMMARY AND CONCLUSIONS

This study provides a good view of the frequency, biomass, productivity, and distribution of aquatic macrophytes in Navigation Pool 8 of the Upper Mississippi River during 1975 and 1976.

A diverse, typical hard water flora was found in the backwater areas of the pool. Ceratophyllum demersum, Sagittaria latifolia, and Vallisneria americana were the most frequently occurring species, while the greatest portion of the total biomass of Pool 8 was comprised of Sagittaria latifolia (45.24%), Vallisneria americana (14.33%), and Sagittaria rigida (8.50%). An average late July-August biomass of 181.70 g/m^2 for the littoral zone of Pool 8 was comparable to that for hard water lakes in Wisconsin.

For most species in Pool 8, the seasonal maximum biomass occurred at the time of maximum fruit development, and could be equated with annual net production. Submergent communities were less productive than floating leaved, while emergent communities were the most productive of all.

Correlations of macrophyte biomass with environmental factors determined that the factors interacted with each other and with the macrophyte community in determining biomass.

The backwater areas of the Upper Mississippi River are vital to the productivity of the river ecosystem. The quantity of aquatic macrophytes can be expected to increase greatly in the backwaters in the future if the current trends (sedimentation, decreasing depth, eutrophication) continue. The rate of succession of the backwaters to a terrestrial environment (and their loss as valuable aquatic habitat) depends on management. Data from this study will be useful in the development of future management plans for the Upper Mississippi River.

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Appendix I. Descriptions of the 41 areas established for sampling in the simulation model study of Navigation Pool 8 of the Upper Mississippi River during the summer of 1975.

Forty-one areas of Navigation Pool 8 were designated for sampling in the simulation model study. The areas were numbered on the basis of increasing current velocity. Mean depth and mean current velocity of each area was obtained from Claflin (1975). The major aquatic macrophytes occurring in each area were determined and their relative biomass calculated (total dry weight of a species in an area/total dry weight of all species in an area). The % biomass figure given in parentheses after each species name is an average of two samplings. The first sampling occurred in June and early July and the latter in late July and August. Original data on the biomass of aquatic macrophytes in each area is given in Appendix III. Figures 11-21 are enlargments of the delineated sections of Navigation Pool 8 shown in Figs. 1 and 2.

Areas 1-5. These areas were small, eutrophic marsh openings located above the Goose Island area in the midsection of the pool (Fig. 11). All had no measureable current velocity. They varied slightly in size and were differentitated on the basis of the size of the opening of water in the center. All contained large amounts of emergent vegetation. Area 1, with a mean depth of 1.7 m, contained the largest opening. Ceratophyllum demersum (17.4%) was the predominant species in the opening. Patches of Nuphar variegatum (16.9%) occurred along the edges of the emergent Sagittaria latifolia (43.7%) surrounding the area. Area 2 had a mean depth of 1.2 m. Ceratophyllum demersum (11.7%) and Nuphar variegatum (11.4%) were found in the opening, which was bordered by dense stands of Sagittaria latifolia (66.9%). Area 3 had a mean depth of 1.1 m and contained emergent and floating leaved communities. Sagittaria rigida (32.0%), Sagittaria latifolia (23.6%), and Sparganium eurycarpum (18.6%) were the major emergent macrophytes. Nymphaea tuberosa

Fig. 11. Aerial photograph, 1974, of middle Running Slough and adjoining backwaters of the upper Goose Island area in the midsection of Navigation Pool 8 of the Upper Mississippi River.

B

(5.3%) dominated the floating leaved community. The buildup of Lemnaceae (12.3%) was marked during the summer. Both areas 4 and 5 had dense Sagittaria stands consisting of 92.2% and 98.5% Sagittaria latifolia. Area 4 had a mean depth of 1.0 m and area 5 a mean depth of 0.9 m.

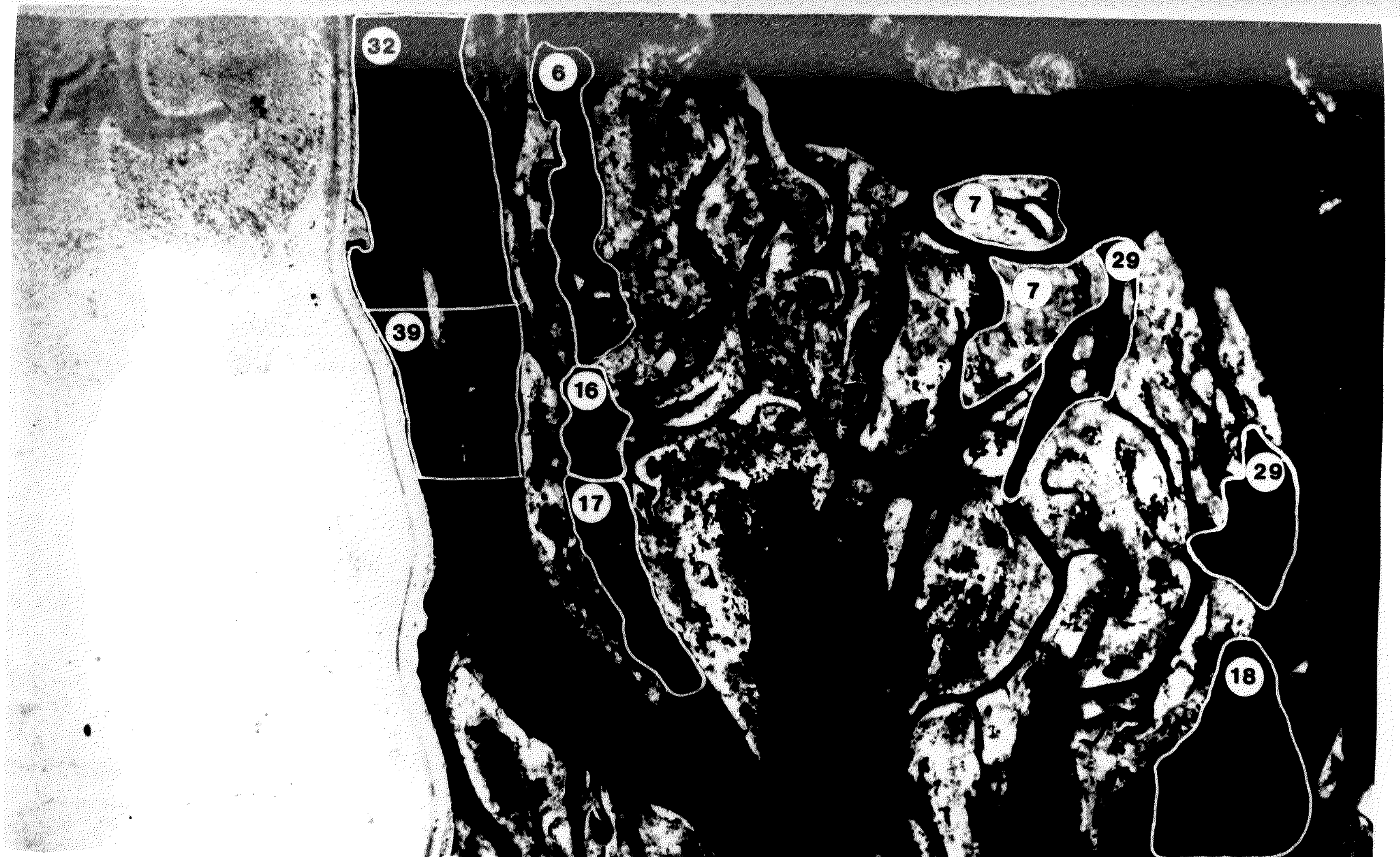
Area 6. Located in a side channel along the east side of upper Raft Channel (Fig. 12), area 6 had a mean depth of 1.08 m and a current velocity of 0.015 m/sec. The center of the area was open, but the margins possessed stands of Sagittaria latifolia (57.2%), Sagittaria rigida (17.6%), and Nelumbo pentapetala (11.4%).

Area 7. This area was south of the main channel above the "S" curve below Brownsville, Minnesota (Fig. 12). The mean depth was 0.61 m. The area contained a stand of Sagittaria latifolia (75.9%) with a slight current (0.016 m/sec) passing through it due to its location next to the channel. Nelumbo pentapetala (8.0%), Potamogeton nodosus (4.5%), and Nymphaea tuberosa (3.7%) occurred on the edges of the Sagittaria beds.

Area 8. Located east of upper Raft Channel and separated from it by a thin land mass (Fig. 13), area 8 had a mean depth of 0.98 m and an average current velocity of 0.019 m/sec. This was predominantly a floating leaved community containing Nelumbo pentapetala (37.7%), Nymphaea tuberosa (23.9%), and associated submergent species. Sagittaria rigida (6.95%) and Sagittaria latifolia (6.2%) were found near the shoreline.

Area 9. Located approximately 1.7 km downstream from the head of Running Slough (Fig. 11), area 9 had a mean depth of 1.6 m and a current velocity of 0.020 m/sec. The water flow in this area was a result of currents from Running Slough. The water was too deep to support an

Fig. 12. Aerial photograph, 1974, of middle Raft Channel and associated backwater areas downstream from Brownsville, Minnesota in Navigation Pool 8 of the Upper Mississippi River.



J

Fig. 13. Aerial photograph, 1974, of the confluence of Raft Channel and the main channel, immediately below Brownsville, Minnesota in Navigation Pool 8 of the Upper Mississippi River.


8
10
30
40

appreciable amount of vegetation. Aquatic macrophytes were not collected from this area.

Area 10. This area adjoined study area 8 on its downstream border (Fig. 13). There were no obvious physical or chemical barriers between these areas. The mean depth was 0.96 m and the current velocity was 0.300 m/sec. Like area 8, it supported a floating-leaved community containing Nymphaea tuberosa (5.9%) and Nelumbo pentapetala (4.1%). Emergent Scirpus validus (27.6%) and Sagittaria latifolia (21.5%) were found on the perimeter of the area.

Area 11. Study area 11 was located just off Running Slough at the downstream end of area 35 (Fig. 14). The mean depth was 0.51 m with a current velocity of 0.034 m/sec. Potamogeton nodosus (21.3%), Ceratophyllum demersum (13.8%), and Lemnaceae (10.3%) were predominant in the open water. Emergent macrophytes were Sagittaria latifolia (37.1%) and Sagittaria rigida (9.7%).

Area 12. This area, referred to as Ebner's Gravel Pit, was located east of area 11 (Fig. 14). The mean depth was 4.91 m with a current velocity of 0.039 m/sec. Being so deep, vegetation was restricted to the shallow perimeter, where Ceratophyllum demersum (43.6%) and Vallisneria (43.4%) were the predominant species.

Area 13. A long, slender area that opened at its lower end into area 11 (Fig. 14), area 13 had a mean depth of 1.50 m and a current velocity of 0.042 m/sec. The water was too deep and turbid to support an appreciable amount of aquatic vegetation. Emergent vegetation was not present. Submergent Ceratophyllum demersum (64.35%) and Potamogeton foliosus (21.4%) were the predominant macrophyte species encountered.

Fig. 14. Aerial photograph, 1974, of upper Running Slough and adjoining backwater areas in the midsection of Navigation Pool 8 of the Upper Mississippi River.

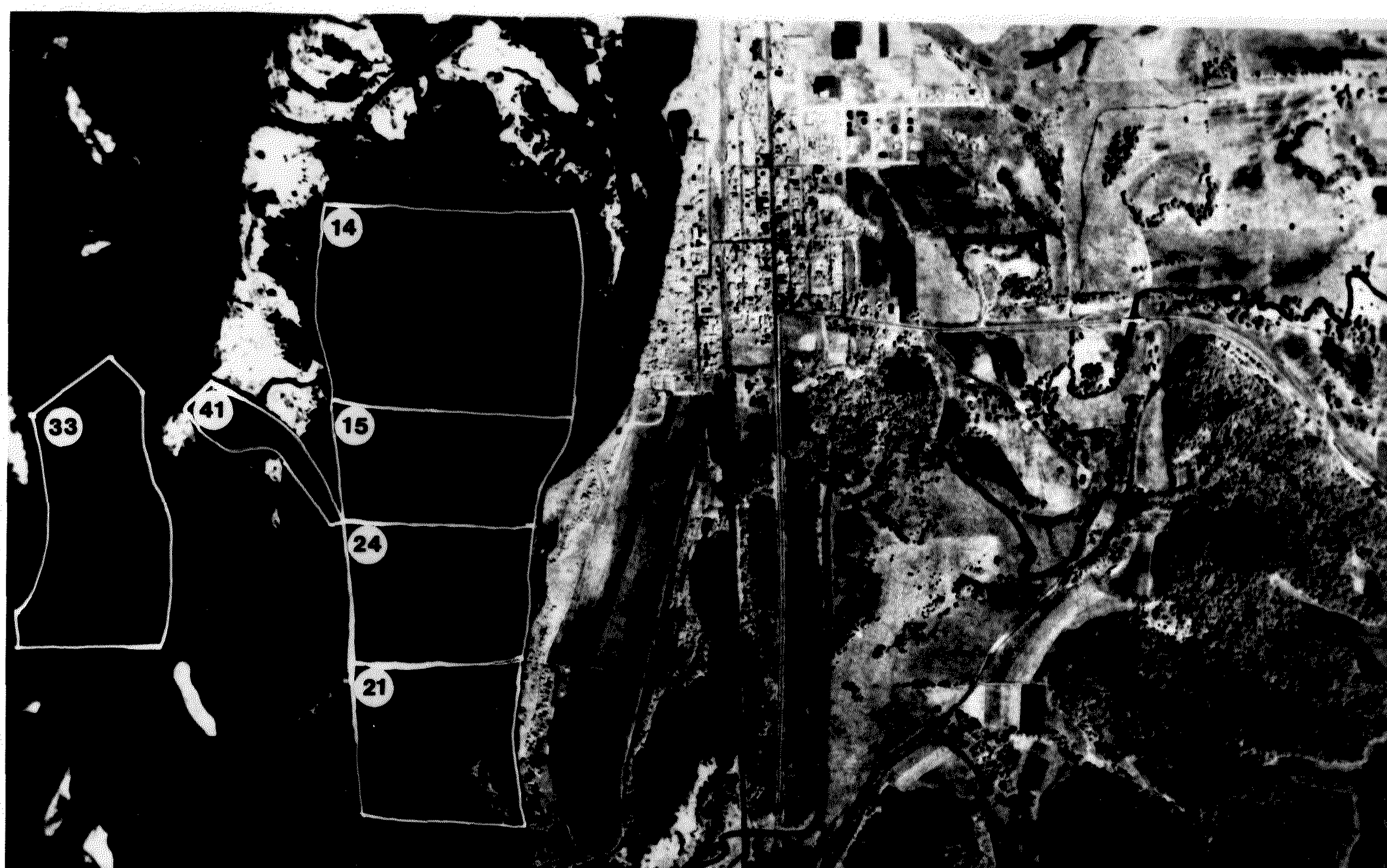
A

Areas 14 and 15. These areas were contiguous and situtated in the upper end of the Stoddard stump field (Fig. 15). They possessed silt and clay sediments. The water currents were best characterized as being slow sheeting movements that were uniform throughout the entire area. Area 14 had a mean depth of 1.61 m with a current velocity of 0.078 m/sec while area 15 had a mean depth of 1.73 m and a current velocity of 0.101 m/sec. Both areas contained deep water submergent communities typical of the southern portion of the pool. The primary macrophytes in area 14 were Vallisneria americana (35.9%), Ceratophyllum demersum (22.9%), and Elodea canadensis (20.5%). Vallisneria americana (66.3%), Ceratophyllum demersum (16.8%), and Potomogeton nodosus (11.6%) were the major species in area 15.

Areas 16 and 17. These areas were located below area 6 (Fig. 12) just east of Raft Channel. The increased current velocity in areas 16 and 17 was due to a chute off Raft Channel located near the downstream end of area 6. The mean depth of area 16 was 1.22 m with a current velocity of 0.116 m/sec. Area 17 had a mean depth of 1.35 m and a current velocity of 0.134 m/sec. The centers of these areas were deep and open, but floating leaved and emergent vegetation was present along the edges. Sagittaria latifolia (50.5%), Sagittaria rigida (27.7%), and Nymphaea tuberosa (14.2%) were the major macrophytes bordering area 16, while S. latifolia (56.7%), N. tuberosa (20.1%), and Ceratophyllum (12.5%) were for area 17.

Area 18. Study area 18 was situated west of the main channel, downstream from the "S" curve below Brownsville, Minnesota (Fig. 12). Its currents were created by an inflow of water from the main channel. The mean depth was 0.95 m with a current velocity of 0.136 m/sec. A deep

Fig. 15. Aerial photograph, 1974, of the Stoddard stump fields east of the main channel, adjacent to Stoddard, Wisconsin in the southern section of Navigation Pool 8 of the Upper Mississippi River.



D

water submergent community dominated by Vallisneria americana (90.9%) was found here.

Area 19. This study area was located downstream from area 12 (Fig. 14) and like area 12, contained dredged portions which were quite deep. The mean depth of study area 19 was 6.1 m with a current velocity of 0.140 m/sec. Although the center was too deep to support aquatic vegetation, the shallower borders supported Ceratophyllum demersum (67.6%) Lemnaceae (16.7%), and Heteranthera dubia (8.9%).

Area 20. Located in the upper Goose Island backwaters (Fig. 11), study area 20 was a pond-like area which received its inflow of water from small feeder channels connected to Running Slough. The mean depth was 0.81 m with a current velocity of 0.159 m/sec. It supported emergent, floating leaved, and shallow water submergent communities typical of the midsection of Pool 8. The major emergent macrophytes were Sagittaria latifolia (36.8%) and S. rigida (28.7%), floating leaved Nelumbo pentapetala (8.0%), and submergent Ceratophyllum demersum (9.8%).

Area 21. This area was located at the lower end of the Stoddard stump field (Fig. 15). It was similar to study areas 14 and 15, except that it had fewer landforms to protect it from the currents of the main channel. The mean depth was 2.64 m with an average current velocity of 0.206 m/sec. The dominant macrophytes in this deep water submergent community were Vallisneria americana (63.8%), Potamogeton nodosus (20.1%), and Ceratophyllum (7.6%).

Area 22. Located at the upper end of Crosby Slough (Fig. 16), area 22 possessed a fairly swift current (0.218 m/sec). The mean depth of area 22 was 2.26 m. The depth, current, and sediments of the channel were unsuitable for macrophyte growth. There were, however, plant

Fig. 16. Aerial photograph, 1974, of the main channel and upper Crosby Slough in the midsection of Navigation Pool 8 of the Upper Mississippi River.

G

communities along the shore, the dominant species being Sagittaria latifolia (49.2%), Ceratophyllum demersum (16.2%), Nelumbo (15.4%), and Sagittaria rigida (6.5%).

Area 23. Study area 23 was located immediately downstream from study area 22 (Fig. 17). There was a slightly higher current velocity (0.235 m/sec) than area 22, due to the smaller mean depth (1.84 m). A high influx of sediments caused the downstream end to be fairly shallow. Area 23 also supported a denser macrophyte population than area 22; the major shoreline species being Sagittaria latifolia (54.3%), S. rigida (15.0%), and Elodea canadensis (10.1%).

Area 24. Located immediately above area 21 in the Stoddard stump field (Fig. 15), this area resembled study area 21 in its general ecology and vegetation. The dominant species were Vallisneria americana (66.9%), Nymphaea tuberosa (13.2%), and Heteranthera dubia (8.2%). Area 24 had a mean depth of 1.71 m and a current velocity of 0.282 m/sec.

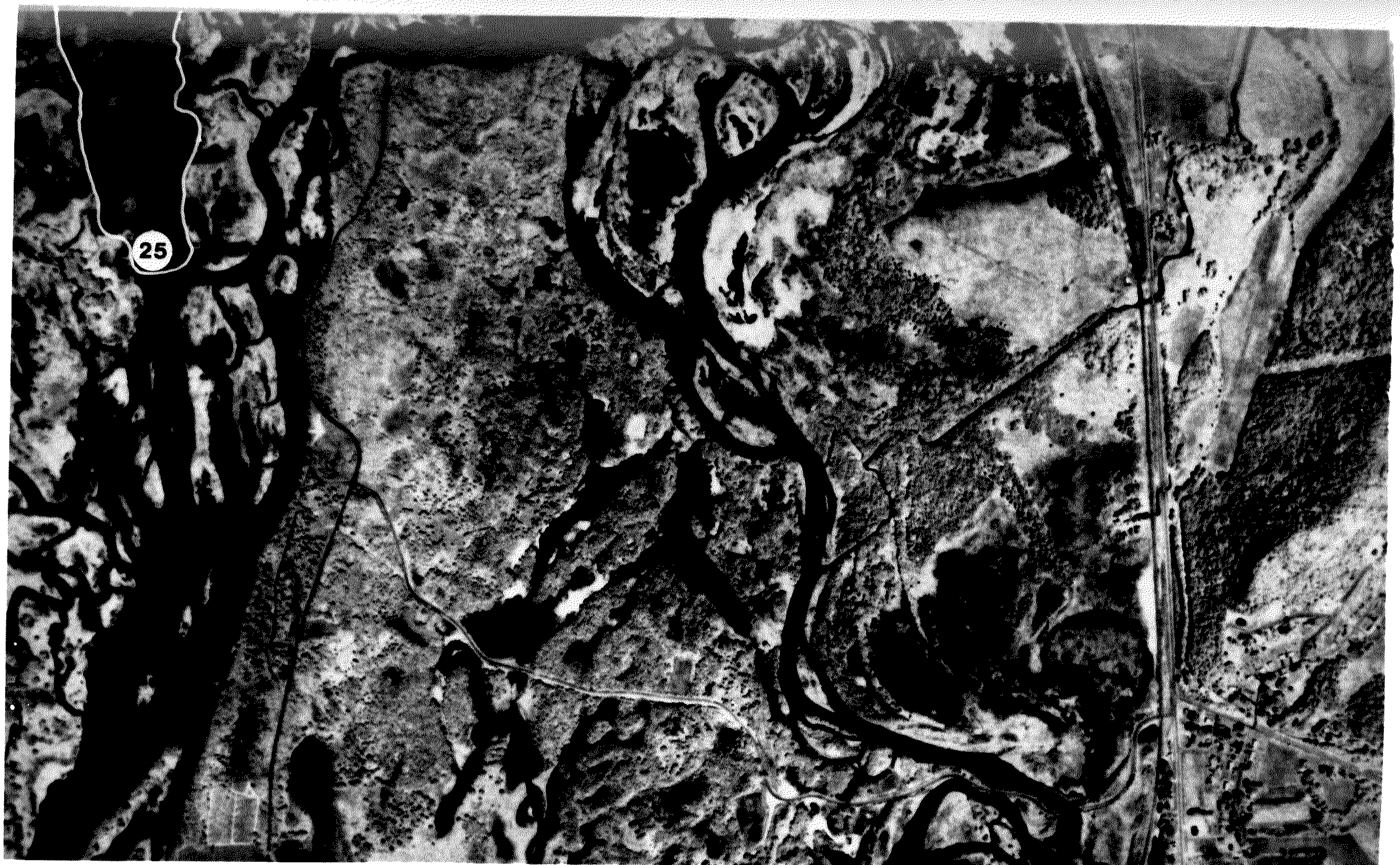
Area 25. A large lake-type area with its downstream end at the lower end of Running Slough (Fig. 18), area 25 was fed by numerous small, meandering channels. Although the area was shallow (mean depth, 0.61 m), the area precluded the growth of most aquatic macrophytes except for a few patches of Potamogeton nodosus (6.5%). Stands of emergent species bordered the area, with Sagittaria latifolia (67.2%) and S. rigida (20.3%) dominant.

Area 26. Study area 26 was also a large lake-type area (Fig. 19) located immediately below area 18. Its relatively high current velocity (0.301 m/sec) can be attributed to the main channel bordering on its eastern boundary, and numerous feeder channels off Raft Channel to

Fig. 17. Aerial photograph, 1974, of the main channel and lower Crosby Slough in the midsection of Navigation Pool 8 of the Upper Mississippi River.


23
28
H

Fig. 18. Aerial photograph, 1974, of lower Running Slough and adjoining backwaters in the Goose Island area in the midsection of Navigation Pool 8 of the Upper Mississippi River.



C

Fig. 19. Aerial photograph, 1974, of the lower reaches of Raft Channel and associated backwater areas, downstream from Brownsville, Minnesota in Navigation Pool 8 of the Upper Mississippi River.

K

the west. The area supported a deep water submergent community in which Vallisneria americana (80.2%) and Heteranthera dubia (9.8%) were the dominant species.

Area 27. A small side channel off of lower Running Slough, area 27 was fairly deep (2.34 m) and had a relatively high current velocity (0.344 m/sec). The area only possessed vegetation on the shallow borders, with Sagittaria latifolia (67.5%), S. rigida (15.7%), and Nymphaea tuberosa (6.6%) being predominant.

Area 28. This area was located in the main channel with its upstream end bordering the mouth of Crosby Slough (Figs. 16 and 17). The mean depth was 4.73 m with a current velocity of 0.344 m/sec. The area was virtually devoid of macrophyte populations except along the shoreline where the dominant species were Vallisneria americana (59.0%), Potamogeton pectinatus (26.0%), and P. nodosus (13.3%).

Area 29. Located along the west of the main channel at the lower end of the "S" Curve (Fig. 12), area 29 was bordered by large stands of Sagittaria latifolia. The mean depth was 1.63 m with a current velocity of 0.352 m/sec. The predominant macrophytes were Vallisneria americana (54.0%), Nymphaea tuberosa (31.6%), and Potamogeton nodosus (14.4%).

Area 30. Located a short distance downstream from the entrance to Raft Channel (Fig. 12), this area was fairly deep and open with a gradual slope on the eastern shore. The mean depth was 1.57 m with a current velocity of 0.385 m/sec. The dominant macrophytes along the shoreline were Sagittaria latifolia (48.8%), S. rigida (18.8%), and Nelumbo pentapetala (7.2%). Potamogeton nodosus (14.1%) also occurred on a sandbar near the eastern shore of the area.

Area 31. Study area 31 was a small channel system located at the downstream end of area 27 along with some flow from lower Running Slough (Fig. 12). The channels were fairly deep (1.57 m), swift (0.393 m/sec), and open. The borders supported stands of Sagittaria latifolia (74.1%), Ceratophyllum demersum (6.8%), Sagittaria rigida (5.0%), Nymphaea tuberosa (4.6%), and Potamogeton nodosus (3.4%).

Area 32. This area (Fig. 12) bordered the downstream edge of area 30. It included the widest part of Raft Channel and had a mean depth of 2.01 m. The mean current velocity was 0.407 m/sec. The western portion was fairly deep and open, supporting only a small amount of Vallisneria americana (9.6%). Sagittaria latifolia (64.6%), Ceratophyllum demersum (12.5%), and Nymphaea tuberosa (3.3%) were the major macrophytes on the shallower eastern shore.

Area 33. Located in the main channel at the downstream end of the "S" curve (Fig. 15), area 37 lacked aquatic macrophytes. The mean depth was 6.71 m with a current velocity of 0.411 m/sec.

Area 34. The middle reach of Running Slough (Figs. 11 and 14) was relatively deep (2.41 m) and had a current velocity of 0.448 m/sec. It was similar in its general ecology to upper Running Slough (area 35) but was slightly slower-flowing due to side channels branching off at the downstream end of area 35. The only macrophyte sampled along the shoreline was Nymphaea tuberosa (100%).

Area 35. The upper part of Running Slough (Fig. 14) had a mean depth of 2.91 m. The current velocity was 0.463 m/sec. This area received its water flow directly from the main channel and was, itself, quite channelled. Aquatic macrophytes were found along the shore only, with Ceratophyllum demersum (70.4%) the dominant species.

Area 36. Study area 36 was located off the east side of the main channel, a short distance downstream from the entrance to Running Slough (Fig. 20). The primary inflow of water was from the main channel. Area 36 flowed back into the main channel approximately 350 meters downstream from where it began. Although the area was fairly shallow (mean depth, 1.33m), the sand sediment and high current velocity (0.470 m/sec) precluded the growth of aquatic macrophytes in the center of the area. The dominant macrophytes along the shore were Sagittaria latifolia (44.7%), S. rigida (20.2%), Potamogeton nodosus (14.9%), and Heteranthera dubia (11.3%).

Area 37. Located downstream from the Stoddard stump field (Fig. 21), area 37 was bordered on the western side by the main channel. It, therefore, received heavy flow from the main channel. The current velocity was 0.527 m/sec and the mean depth was 1.33 m. The area supported large beds of submergent vegetation, with Vallisneria americana (64.4%), Potamogeton nodosus (16.7%), and Lemnaceae (12.0%) being the dominant species.

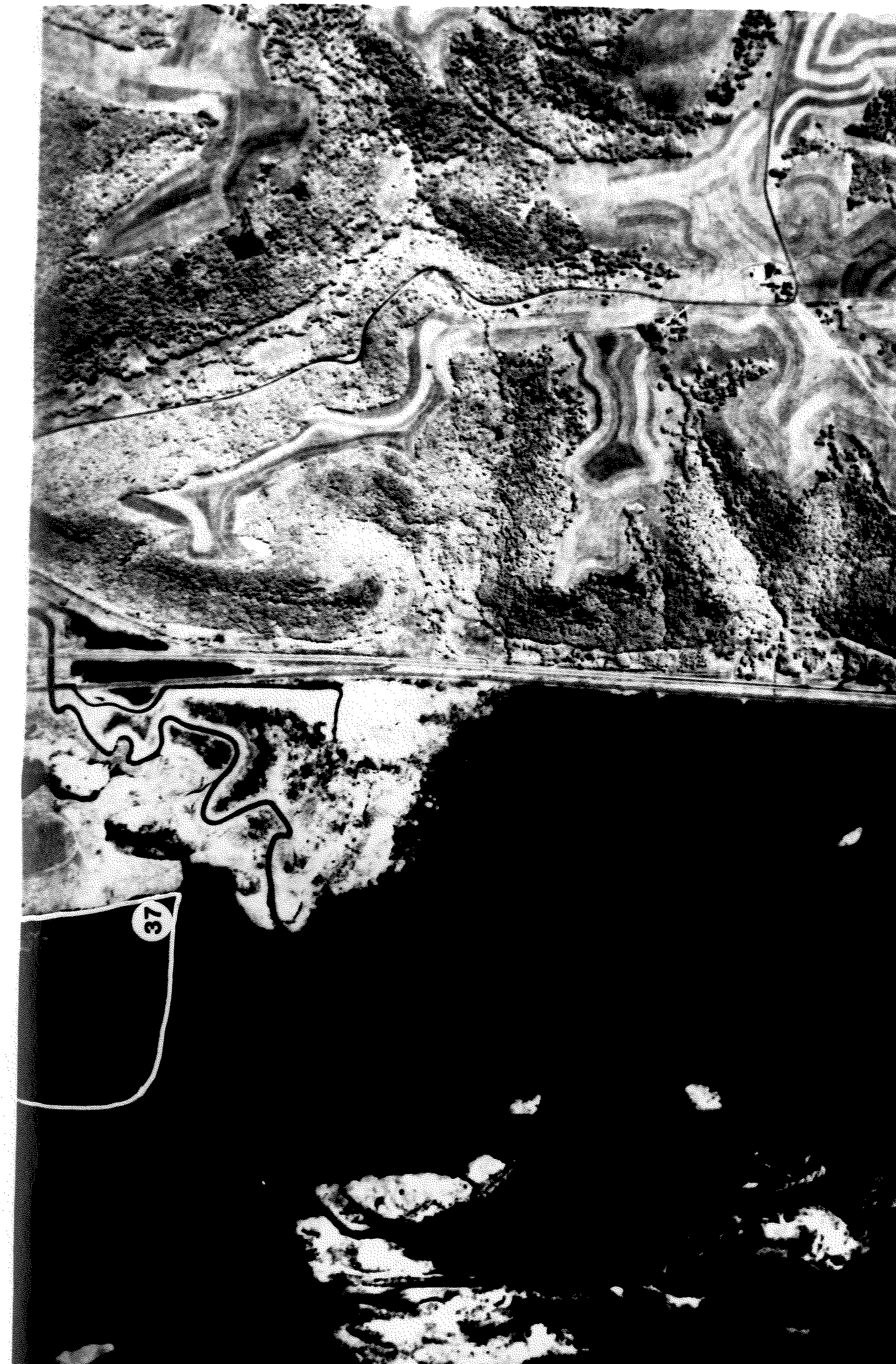
Area 38. This study area was the downstream-most portion of Running Slough that was sampled (Fig. 11). It was a channelled area with a mean depth of 1.89 m and a current velocity of 0.534 m/sec. Vegetation was lacking in most of the area with the dominant shoreline forms being Potamogeton nodosus (28.95%), Sagittaria rigida (18.8%), Nymphaea tuberosa (13.3%), and Sagittaria latifolia (12.1%).

Area 39. Located below area 32 (Fig. 12), area 39 was the farthest downstream portion of Raft Channel sampled. Very little vegetation was supported in most of the area due to the depth (2.33 m) and current velocity (0.578 m/sec). Sagittaria latifolia (54.1%) and Potamogeton nodosus (13.0%) were the predominant species along the shallow eastern

Fig. 20. Aerial photograph, 1974, of the main channel and backwaters immediately downstream from the mouth of Running Slough in the midsection of Navigation Pool 8 of the Upper Mississippi River.

F

Fig. 21. Aerial photograph, 1974, east of the main channel in the southern section of Navigation Pool 8 of the Upper Mississippi River immediately downstream from Stoddard, Wisconsin.



E

boundary and along the island in the center of the area.

Area 40. The uppermost portion of Raft Channel (Fig. 13) possessed a high current velocity (0.587 m/sec) due to the direct flow from the main channel. The area had a mean depth of 1.9 m. The majority of the area was open, with vegetation restricted primarily to the shorelines. The major species were Sagittaria latifolia (84.0%), Potamogeton pectinatus (10.9%), and Ceratophyllum demersum (3.1%).

Area 41. A narrow chute located along an outside curve of the main channel (Fig. 15), area 41 had the highest current velocity of any area sampled (0.72 m/sec) and was fairly deep (3.7 m). The constricted channel lacked aquatic vegetation; however, Vallisneria americana (56.6%), Nymphaea tuberosa (11.5%), and Potamogeton richardsonii (8.4%) bordered the chute.

Appendix II. List of the species of aquatic vascular plants collected in the 41 study areas in Navigation Pool 8 of the Upper Mississippi River.

The families to which the taxa collected belong are presented in the order of the classification system of Cronquist (1969). Genera are arranged alphabetically within each family and the species are arranged alphabetically within each genus.

Nomenclature follows Hartley (1966), except for Nelumbo pentapetala (Walter) Fernald (Sohmer 1975) and Myriophyllum spicatum L. var. exalbescens (Fernald) Jepson (Nichols 1975).

Statements concerning the life form, habitat, and associations of each taxon are given, followed by the number of the study areas wherein the taxon listed was collected. Locations and descriptions of these study areas are provided in Appendix I.

NYMPHAEACEAE (Water lily Family)

Nuphar variegatum Engelm. - spatterdock

Leaves floating in 0.2 - 1.1 m water; in shallow stagnant backwater areas possessing a muck substrate. 1, 2.

Nymphaea tuberosa Paine - white water lily

Leaves floating in 0.2 - 1.1 m water; muck substrate; widespread in shallow stagnant areas, in quiet bays along swift side channels, and in deep water habitat in the southern portion of the pool. 3, 6, 7, 8, 10, 14, 16, 17, 21, 22, 23, 24, 26, 27, 29, 31, 32, 34, 37, 38, 39, 41.

NELUMBONACEAE (Lotus Family)

Nelumbo pentapetala (Walter) Fernald - American lotus

Floating and emergent leaves in water depths of 0.3 - 1.7 m; usually forming homogeneous stands along sloughs which possess a slight to moderate current. 3, 6, 7, 8, 10, 16, 17, 20, 22, 23, 25, 30, 32.

CERATOPHYLLACEAE (Hornwort Family)

Ceratophyllum demersum L. - coontail

Cosmopolitan in submergent, floating leaved, and emergent communities at all water depths, but not reaching great biomass except in some shallow stagnant areas which possess a muck substrate. 1, 2, 3, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 35, 36, 37, 38, 39, 40, 41.

POLYGONACEAE (Buckwheat Family)

Polygonum coccineum Muhl.

Emergent in wet muck to 0.7 m water; associated with Sagittaria latifolia in shallow stagnant backwaters. 1, 2, 3, 11.

HALORAGACEAE (Watermilfoil Family)

Myriophyllum spicatum L. var. exalbescens (Fernald) Jepson - water milfoil

Submergent in 0.5 - 0.8 m water; in a slow moving slough and with emergent vegetation on the margin of a side channel. 8, 16, 32.

ONAGRACEAE (Evening primrose Family)

Ludwigia palustris (L.) Ell. var. americana (D.C.) Fern. & Grisc. - false loosestrife

Nearly prostrate in wet mud under a Sagittaria latifolia stand which was succeeding towards a terrestrial environment; associated with Lindernia dubia and Phalaris arundinacea. 20.

SCROPHULARIACEAE (Figwort Family)

Lindernia dubia (l.) Pennell - false pimpernel

In wet mud under a Sagittaria latifolia stand which was succeeding towards a terrestrial environment; associated with Ludwigia palustris and Phalaris arundinacea. 20.

ALISMATACEAE (Water-plantain Family)

Sagittaria latifolia Willd. - wapato, duck potato

Emergent; forming large homogeneous stands in shallow stagnant backwaters and along the shallow margins of sloughs; normally in less than 1.0 m water; muck substrate. 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 16, 17, 20, 21, 22, 23, 25, 27, 30, 31, 32, 36, 38, 39, 40.

Sagittaria rigida Pursh. - stiff wapato

Emergent, usually forming homogeneous stands on the deeper water edge of Sagittaria latifolia beds; in stagnant backwaters and along slough margins; muck substrate. 3, 6, 7, 8, 10, 11, 16, 17, 20, 22, 23, 25, 27, 30, 31, 36, 37, 38, 40.

Sagittaria rigida Pursh forma fluitans (Engelm.) Fern.

Submergent, sterile, spring and early summer form of Sagittaria rigida. 3, 8, 10, 11, 20, 25, 27, 30, 31, 36, 38.

HYDROCHARITACEAE (Frog's-bit Family)

Elodea canadensis Michx. - waterweed

Widespread in submergent, floating leaved, and emergent communities, but reaching large biomass only in shallow stagnant backwater areas possessing a muck substrate. 1, 2, 3, 4, 5, 7, 8, 10, 11, 13, 14, 15 16, 18, 19, 20, 21, 22, 23, 24, 25, 28, 30, 31, 32, 35, 36, 37, 38, 39, 40. 41.

Vallisneria americana Michx. - wild celery

Submergent, with greatest development in water depths of 0.9 - 1.5 m in the deep water habitat in the southern portion of the pool; also found along borders of swift sloughs; often associated with Heteranthera dubia, Potamogeton nodosus, and Potamogeton richardsonii. 7, 8, 12, 14, 15, 16, 17, 18, 19, 21, 22, 23, 24, 28, 29, 30, 32, 36, 37, 39, 40, 41.

NAJADACEAE (Naiad Family)

Najas flexilis (Willd.) Rostk. and Schmidt - naiad

Submergent; in the deep water habitat of the lower section of the pool; rarely in shallow water. 8, 10, 20, 24.

POTAMOGETONACEAE (Pondweed Family)

Potamogeton crispus L. - curly-leaved pondweed

Widespread submergent species reaching greatest development in shallow stagnant backwaters with muck substrate; reaches peak biomass early in summer, then develops overwintering "burs" and decreases in biomass and frequency during the course of the summer. 1, 3, 4, 6, 7, 8, 10, 11, 13, 14, 15, 16, 17, 18, 20, 24, 30, 31, 32, 37, 38, 39, 40, 41.

Potamogeton foliosus Raf. - leafy pondweed

Submergent in 0.2 - 1.1 m water in shallow stagnant backwaters, quiet bays along sloughs, and deep water submergent communities; reaching peak development in early summer in shallow water on muck substrate. 6, 8, 10, 11, 13, 14, 18, 20, 24, 25, 30, 31, 32, 36, 38, 39.

Potamogeton nodosus Poir. - long-leaved pondweed

Floating-leaved submergent found on sand substrates in shallow areas with high current velocity, along slough margins, and in deep water habitat; often associated with Heteranthera dubia, Potamogeton pectinatus, and Vallisneria americana. 1, 6, 7, 8, 10, 11, 14, 15, 16, 19, 20, 21, 22, 23, 24, 25, 27, 28, 29, 30, 31, 32, 36, 37, 38, 39, 40, 41.

Potamogeton pectinatus L. - sago pondweed

Submergent, found along slough margins, in quiet bays along swift side channels, and deeper water habitat; sometimes associated with *Potamogeton nodosus* in shallow areas possessing a sandy substrate and a high current velocity. 6, 7, 8, 10, 11, 12, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 27, 28, 29, 30, 31, 32, 36, 37, 38, 39, 40, 41.

Potamogeton richardsonii (Benn.) Rydb. - clasping leaf pondweed

Submergent of 0.6 - 1.8 m water in the deep water habitat in the southern portion of the pool; associated with *Vallisneria americana*. 15, 24, 30, 41.

Potamogeton zosteriformis Fern. - flat-stemmed pondweed

Submergent in 0.01 - 1.0 m water in stagnant backwaters and quiet bays along sloughs in the midsection of the pool; muck substrate. 11, 13, 14, 17, 20, 25, 30, 31, 38.

CYPERACEAE (Sedge Family)

Scirpus validus Vahl. - great of soft stemmed bulrush

Emergent in small round homogeneous colonies on shallow sandy margins of sloughs, often stranded on sand as river level drops. 10, 25.

GRAMINEAE (Grass Family)

Phalaris arundinacea L. - reed canary grass

In drier portions of emergent communities which were succeeding towards a terrestrial environment; rarely in shallow submergent communities near the water's edge. 3, 20, 23, 25, 30, 36.

SPARGANIACEAE (Burreed Family)

Sparganium eurycarpum Engelm. - common burreed

Emergent in 0.1 - 1.0 m water, associated with Sagittaria latifolia and S. rigida in shallow stagnant backwaters which possess a muck substrate. 3, 11.

LEMNACEAE (Duckweed Family)

Lemna minor L. - lesser duckweed

Free-floating on the surface of the water; reaches greatest development in late summer in shallow stagnant backwaters; also found over deep water submergent communities and with floating leaved and emergent communities in quiet bays and along slough margins; associated with Spirodela polyrhiza and Wolffia columbiana. 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 19, 20, 21, 23, 24, 25, 27, 31, 32, 35, 36, 37, 38, 39. 41.

Spirodela polyrhiza (L.) Schleid - water flaxseed

Free floating on the surface of the water; associated with, and having the same habitat as, Lemna minor and Wolffia columbiana. 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 19, 20, 21, 23, 24, 25, 27, 31, 32, 35, 36, 37, 38, 39, 41.

Wolffia columbiana Karst - watermeal

Free floating on the surface of the water; associated with, and having the same habitat as, Lemna minor and Spirodela polyrhiza. 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 19, 20, 21, 23, 24, 25, 27, 31, 32, 35, 36, 37, 38, 39, 41.

PONTEDERIACEAE (Pickerelweed Family)

Heteranthera dubia (Jacq.) MacM. - water stargrass

Submergent; in shallow sandy areas influenced by current and in deep water habitat; often associated with Vallisneria americana and Potamogeton nodosus. 7, 8, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 29, 30, 31, 32, 36, 37, 38, 39, 41.

Pontederia cordata L. - pickerelweed

Emergent in 0.2 m water on the outer edge of the Sagittaria latifolia stand; muck substrate. 10.

Appendix III. Biomass of aquatic macrophytes in all study areas of Navigation Pool 8 of the Upper Mississippi River in 1975.

Table 21. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 1, 2, 3, 4, and 5, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Sub-strate	TAXON 1	2	3	5	11	12	13	14	15	17	21	22	23	25
1	1-1	6/25	1.0	2	2.61		0.11						0.15		90.70			
1	1-2*	6/25	1.8	2														
1	2-3	6/25	1.1	2	1.80		0.29		66.05					1.33	2.30			
1	2-4*	6/25	1.5	2														
1	2-5	6/25	0.7	2	1.17		0.10					11.70			102.90			
1	1-6	7/29	0.4	2	37.16	5.43	0.24	8.50										
1	1-7	7/29	0.4	2	10.71		0.04	34.40					0.46					
1	2-8	7/29	0.2	2	9.97		2.65	24.80	8.38				0.05	1.58				
1	2-9	7/29	0.8	2	34.41		0.54	19.70										
1	2-10	7/29	0.2	2	9.11			23.00	23.28						54.83			
2	1-1	6/25	0.9	2	1.74										87.40			
2	1-2	6/25	1.0	2	2.80										26.20			
2	1-3	6/25	1.1	2	0.54										71.81			
2	2-4	6/25	0.7	2								61.10			63.20			
2	2-5	6/25	1.1	2	23.80				3.30									
2	1-6	7/28	0.3	2	0.30										220.40			
2	1-7	7/28	0.3	2	36.20										44.87			
2	1-8	7/28	0.3	2	2.70				63.60						20.90			
2	2-9	7/28	0.3	2	28.70										28.30			
2	2-10	7/28	0.3	2	10.60			11.50	47.20						4.70			
3	1-1	6/26	1.0	2	0.47					35.10	1.90				1.72	30.60	7.70	
3	1-2	6/26	1.0	2	1.25										3.01	47.30	10.60	113.31
3	1-3	6/26	0.9	2	0.58										1.70	74.36	19.50	
3	1-4	6/26	1.0	2			0.33				3.30				59.50	29.00	5.50	
3	1-5	6/26	1.0	2	0.15						1.25		0.20		13.90	35.05	15.30	
3	1-6	7/28	0.1	2	2.10		0.06	8.10		16.80					15.10	64.50		
3	1-7	7/28	0.1	2				35.00							17.00	18.60		66.30
3	1-8	7/28	0.1	2				14.90			0.32	4.00			36.20	6.10		
3	1-9	7/28	0.1	2	0.77			17.20			4.24				39.20	2.70		
3	1-10	7/28	0.1	2	0.98			32.80							31.01	3.71		
4	1-1	6/25	1.0	2			0.04						0.51		51.70			
4	1-2	6/25	1.0	2											76.50			
4	1-3	7/28	0.3	2				9.27							91.10			
4	1-4	7/28	0.3	2				23.20							91.00			
5	1-1	6/25	0.7	2			0.15								106.50			0.50
5	1-2	6/25	0.7	2											166.20			
5	1-3	7/29	0.2	2				4.30							133.00			
5	1-4	7/29	0.2	2				4.50							186.40			

* vegetation present, but no sample taken

Table 22. Biomass of aquatic macrophytes (g/0.5 m^2) in study area 6, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Sub-strate	TAXON 1	3	5	10	12	15	16	17	18	21	22	26
6	1-1	7/3	0.7	2	16.30					0.07				101.30	36.30	
6	1-2	7/3	1.3	4												
6	1-3	7/3	0.8	2	0.12					1.03					110.20	
6	2-4	7/3	0.8	2	2.78						1.39			83.20		
6	2-5	7/3	1.3	4												
6	2-6	7/7	0.8	2	0.33					0.23				43.30		
6	3-7	7/7	0.6	2	0.52						0.06			82.90		
6	3-8	7/7	0.7	2										60.70	87.35	
6	3-9	7/7	0.5	2				14.50			1.49		3.50			
6	4-10	7/7	0.7	2	3.75				2.17	1.70	0.10			76.70		
6	4-11	7/7	1.3	2	0.22			10.00		0.18						
6	4-12	7/7	0.7	2	0.17								11.95	68.60		
6	5-13	7/7	0.8	2								20.20	0.02			
6	5-14	7/7	1.1	2	0.15			25.80		0.28			0.55	32.23		
6	5-15	7/7	0.8	2	0.91			12.10		5.20				34.30		
6	1-16	8/7	0.8	2	44.50		3.50	0.12			0.02			36.70	28.00	0.02
6	1-17	8/7	1.1	4												
6	1-18	8/7	0.4	2	1.12		23.20		0.63	0.40					84.50	
6	2-19	8/7	0.6	2	15.10		7.10			0.03				92.80		
6	2-20	8/7	1.1	4												
6	2-21	8/7	0.4	2	2.20		14.20						1.01	188.00		
6	3-22	8/7	0.6	2	6.00	0.03	27.00						0.32	117.40		
6	3-23	8/7	0.7	2	0.03									120.50	35.80	
6	3-24	8/7	0.5	2	0.06		36.30	38.10					0.16			
6	4-25	8/7	0.5	2	9.90		40.00			0.13				112.00		
6	4-26	8/7	1.0	2	0.17		1.50	114.90								
6	4-27	8/7	0.6	2	11.80		16.70						0.12	81.30		
6	5-28	8/7	0.8	2	0.10		7.10					34.20				0.07
6	5-29	8/7	0.6	2	0.32		1.10	84.00						44.90		
6	5-30	8/7	0.6	2	2.60		11.50	29.00						87.70		

Table 23. Biomass of aquatic macrophytes (g/0.5 m^2) in study area 7, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Substrate	TAXON 1	3	4	5	10	12	13	15	16	17	18	21	22	26
7	1-1	7/8	0.7	2					3.80						3.90	122.00		
7	1-2	7/8	0.6	2					74.50						13.50			
7	1-3	7/8	0.8	2								3.28			0.05	169.30		
7	1-4	7/8	1.1	2	9.64					16.90		2.62			0.02			
7	1-5	7/8	0.7	2	0.10	0.08						1.31			0.30	73.40		0.18
7	1-6	7/8	1.0	2						19.60				30.30				
7	1-7	7/8	0.8	2											0.08	208.80		0.08
7	1-8	7/8	0.8	2	0.02	0.02				9.50		1.82		53.10	0.35			0.04
7	1-9	7/8	1.0	3	2.32	0.13			10.80							30.10		
7	1-10	7/8	0.9	7								1.28				92.80		
7	1-11	7/8	0.8	3	0.11						0.12	0.28	0.06		0.04	173.50		0.08
7	1-12	7/8	0.6	3	0.26							1.06			0.60	157.10		
7	1-13	8/12	0.7	2					13.40							104.20		
7	1-14	8/12	0.4	2					59.10						10.00			
7	1-15	8/12	1.0	2										1.01		172.80		0.06
7	1-16	8/12	0.8	2	59.80			9.90								169.00		
7	1-17	8/12	0.9	2	38.60	1.30	0.97								0.22	118.50		0.13
7	1-18	8/12	0.9	2						16.40				44.70				
7	1-19	8/12	0.9	2												213.90		0.04
7	1-20	8/12	0.8	2	0.48			8.50		63.50				6.30				0.17
7	1-21	8/12	1.1	2	21.70			52.00	114.40							41.50		
7	1-22	8/12	0.9	2	1.09			42.50	6.10						0.15	151.10		7.40
7	1-23	8/12	0.7	2											3.90	252.30		
7	1-24	8/12	0.5	2			0.06									296.40	0.65	0.36

Table 24. Biomass of aquatic macrophytes (g/0.5 m^2) in study area 8, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Substrate	TAXON 1	3	4	5	8	9	10	12	15	16	17	18	21	22	23	26
8	1-1	7/3	0.6	2	0.86						20.18		9.54	0.20						
8	1-2	7/3	0.9	2	0.15	0.20					17.12		0.73			0.10				
8	1-3	7/3	0.9	2	4.70	2.70					6.47		0.65	0.25		1.22	22.20			
8	2-4	7/3	0.6	2	0.10		0.15				49.40	6.80	3.00							
8	2-5	7/3	1.0	2							14.30		1.20							
8	2-6	7/3	1.0	2																
8	2-7	7/3	0.7	2	0.08	0.03					4.90	48.60				0.02				
8	3-8	7/3	0.8	2	0.36						16.10		1.01	0.13		0.10				
8	3-9	7/3	1.0	2	0.51		0.02				30.70		1.05							
8	3-10	7/3	1.0	2	0.30						9.00		0.40			0.03				
8	3-11	7/3	0.8	2	3.00	0.15						34.70	0.56	0.15	3.15	0.06				
8	4-12	7/3	0.7	2	0.24								0.22			0.05		49.02	0.62	
8	4-13	7/3	1.0	2	0.14						14.20	85.70	1.43	0.04						
8	4-14	7/3	0.6	3	17.80				0.03	0.06			0.88	6.00						1.36
8	1-15	8/4	0.7	2	33.30						4.20									
8	1-16	8/4	0.7	2	21.10						41.00									
8	1-17	8/4	0.4	2	11.50	1.92		18.70			14.60						47.70			
8	2-18	8/4	0.7	2	0.52			17.10			38.20	0.62								
8	2-19	8/4	0.8	2	0.03						11.80	19.10								0.13
8	2-20	8/4	0.6	2																
8	2-21	8/4	0.6	2	4.40			14.30			57.30									
8	3-22	8/4	0.7	2	24.90	14.10		7.50			30.00									
8	3-23	8/4	0.9	2							37.10									
8	3-24	8/4	0.8	2	1.46						25.20		0.65	0.20		0.90				
8	3-25	8/4	0.6	2	4.60			3.40				51.30								
8	4-26	8/4	0.4	2	1.21			10.90									6.20	27.50		
8	4-27	8/4	0.7	2	0.37						5.10	13.10								0.01
8	4-28	8/4	0.4	2	1.73			59.80												0.07

Table 25. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 9, 10, and 11, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Sub-strate	TAXON 1	3	4	5	9	10	12	14	15	16	17	18	20	21	22	23	24	25
9	1-1	6/26	2.0	2																		
9	1-2	6/26	2.1	2																		
9	1-3	6/26	1.4	2																		
9	2-4	6/26	2.0	2																		
9	2-5	6/26	2.3	2																		
9	2-6	6/26	2.9	2																		
9	1-7	7/28	1.6	2																		
9	1-8	7/28	1.7	2																		
9	1-9	7/28	1.1	2																		
9	2-10	7/28	1.7	2																		
9	2-11	7/28	1.9	2																		
9	2-12	7/28	2.6	2																		
10	1-1	7/2	0.5	2	1.80				0.37				0.70			0.23		68.30	4.90	0.13		
10	1-2	7/2	1.1	2	0.27								2.90									
10	1-3	7/2	1.1	2	0.70						16.90		3.80									
10	1-4	7/2	0.4	3	3.37				0.39				1.27	7.08		0.29					143.80	
10	2-5	7/2	0.6	2	1.89								2.35	9.60		2.44		42.30				
10	2-6	7/2	1.3	2	3.10								30.50									
10	2-7	7/2	0.9	2	0.88					9.70			2.52									
10	2-8	7/2	0.9	2	4.70	0.11							1.77		32.40							
10	1-9	8/4	0.2	2	5.30	0.02		16.20					0.11	0.15				13.80	28.20			
10	1-10	8/4	0.7	2	0.54						32.00											
10	1-11	8/4	0.7	2	19.60	0.02		2.80			3.50		7.10									
10	1-12	8/4	0.2	2	2.00			32.00													90.10	
10	2-13	8/4	0.4	2	1.10			36.20										57.60	15.00			
10	2-14	8/4	0.8	2	28.10								5.10	0.15								
10	2-15	8/4	0.7	2	0.31					27.20												
10	2-16	8/4	0.4	2	0.11			20.20							30.70							
11	1-1	6/18	0.8	2	1.20	0.05								0.06						2.90		
11	1-2	6/18	0.7	2										0.13	0.38			12.20	4.50			
11	1-3	6/18	0.9	2	5.38											0.30	0.90					
11	1-4	6/18	0.8	2	6.43								0.12		12.60		1.76		0.09			
11	1-5	6/18	1.0	2									0.86			0.50						
11	1-6	6/18	0.7	2	0.45	0.04	0.03							0.15	8.00		0.03	0.67				1.00
11	1-7	8/1	0.0	2	4.20	0.32		8.24											17.80			
11	1-8	8/1	0.0	2	0.17	0.17						0.99						66.70	5.90			
11	1-9	8/1	0.0	2				1.70								0.05		63.00				
11	1-10	8/1	0.1	2	1.27	0.03		11.00							12.20				5.40			
11	1-11	8/1	0.3	2	7.61			1.41					0.54	0.11	0.41	0.38				0.31		
11	1-12	8/1	0.0	2				28.10							7.00							

Table 26. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 12 and 13, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Sub-strate	TAXON 1	3	4	5	15	16	18	20	26
12	1-1	8/22	0.6	3	6.70			2.80			1.09		6.60
12	1-2	8/22	2.7	3									
12	2-3	8/22	0.4	3	2.80			4.80					7.40
12	2-4	8/22	9.6	3									
12	2-5	8/22	8.5	3									
12	2-6	8/22	1.0	4									
12	3-7	8/22	2.6	3									
12	3-8	8/22	8.0	3									
12	3-9	8/22	7.3	3									
12	3-10	8/22	0.7	3	21.80		0.04	0.61					17.20
12	4-11	8/22	2.2	3									
12	4-12	8/22	11.5	3									
12	4-13	8/22	7.0	3									
12	4-14	8/22	1.8	3									
13	1-1	6/17	0.7	2	0.20					0.15			
13	1-2	6/17	1.5	2									
13	1-3	6/17	1.3	2									
13	2-4	6/17	0.8	2									
13	2-5	6/17	1.4	2									
13	2-6	6/17	1.0	2									
13	3-7*	6/17	0.6	2									
13	3-8	6/17	1.6	2									
13	3-9	6/17	1.3	2									
13	1-10	7/31	0.4	2	36.90	0.05	0.22		6.20				
13	1-11	7/31	1.2	2									
13	1-12	7/31	0.9	2									
13	2-13	7/31	0.4	2	13.10	0.75	6.88	0.44	0.13			0.33	
13	2-14	7/31	0.4	2	5.20		10.60						
13	2-15	7/31	0.6	2	31.80			15.30					
13	3-16	7/31	0.4	2	35.29		3.00	3.30	1.40				
13	3-17	7/31	1.2	2									
13	3-18	7/31	1.0	2									

* sample lost

Table 27. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 14 and 15, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Sub-strate	TAXON 1	2	3	4	5	12	15	16	17	18	19	20	21	26
14	1-1	7/18	1.0	2	5.90		7.50	0.60			0.70	0.50						
14	1-2*	7/18	1.4	2														
14	1-3	7/18	1.8	2														
14	1-4*	7/18	1.3	2														
14	1-5	7/18	1.0	2	20.00		0.71	11.60			0.12			1.33		1.60		79.00
14	2-6	7/18	0.9	2	7.70		0.31				0.10			0.28				0.19
14	2-7*	7/18	1.3	2														
14	2-8	7/18	2.0	2														
14	2-9*	7/18	1.3	2														
14	2-10*	7/18	1.3	2														
14	1-11	8/14	1.0	2	10.50		50.30	0.73										
14	1-12*	8/14	1.6	2														
14	1-13	8/14	2.0	2														
14	1-14*	8/14	1.4	2														
14	1-15	8/14	1.1	2	23.00	9.84	0.88	2.17	9.35				5.32					42.30
14	2-16	8/14	1.0	2	24.00		37.40		33.20	8.80					0.02			0.02
14	2-17*	8/14	1.4	2														
14	2-18	8/14	1.9	2														
14	2-19*	8/14	1.5	2														
14	2-20*	8/14	1.3	2														
15	1-1	7/23	1.0	1														82.00
15	1-2	7/23	2.3	1														
15	1-3	7/23	1.0	1	4.06		0.05	0.56					22.81					39.33
15	1-4	7/23	1.9	6														
15	1-5	7/23	1.1	1	8.87		0.18	18.57						4.45				17.30
15	1-6	7/23	1.0	1	0.03			0.40										97.11
15	2-7*	7/23	1.4	6														
15	2-8*	7/23	1.3	6														
15	2-9*	7/23	1.4	6														
15	2-10	7/23	1.2	3	0.08								0.73		2.00			74.02
15	2-11	7/23	2.2	6														
15	2-12	7/23	0.8	3				0.19										71.49
15	1-13	8/14	1.0	6														116.80
15	1-14	8/14	2.4	6														
15	1-15*	8/14	1.3	6														
15	1-16	8/14	2.0	6														
15	1-17	8/14	1.1	1	1.00	1.57	0.11	2.38			0.07			0.04				43.50
15	1-18	8/14	1.1	3	91.70		0.16						53.90					14.60
15	2-19*	8/14	1.5	6														
15	2-20*	8/14	1.3	6														
15	2-21*	8/14	1.4	6														
15	2-22*	8/14	1.2	6														
15	2-23	8/14	2.3	6														
15	2-24	8/14	0.8	3				9.70										25.10

* vegetation present, but no sample taken

Table 28. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 16 and 17, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Sub-strate	TAXON 1	3	4	5	8	10	12	15	17	18	20	21	22	26
16	1-1	7/7	0.7	2										0.05		237.90		
16	1-2	7/7	0.8	8	0.06					4.40	7.70		5.70				0.39	
16	1-3	7/7	0.9	2													117.20	
16	2-4	7/7	1.0	8														
16	2-5	7/7	1.6	8														
16	2-6	7/7	0.9	8														
16	3-7	7/7	0.7	2							1.54		5.60	0.64				
16	3-8	7/7	1.8	8														
16	3-9	7/7	0.8	2	0.22						54.00							
16	1-10	8/7	0.7	2	0.17											303.30		
16	1-11	8/7	0.7	8	1.50			16.80			22.50		21.50			0.25		1.90
16	1-12	8/7	0.8	2												185.80		
16	2-13	8/7	0.9	8														
16	2-14	8/7	1.4	8														
16	2-15	8/7	0.8	8														
16	3-16	8/7	0.5	2	0.09	0.46		0.75	0.19		21.90	0.07	7.00	0.13				0.15
16	3-17	8/7	1.6	8														
16	3-18	8/7	0.5	2				24.00			46.50		0.56					
17	1-1	7/7	0.9	2	6.30					6.80	40.80	3.60						
17	1-2	7/7	1.9	8														
17	1-3	7/7	0.8	2	0.23							4.00				139.60		
17	2-4	7/7	0.8	2												35.90		3.70
17	2-5	7/7	2.4	8														
17	2-6	7/7	0.9	2	6.25						44.15	0.35						
17	3-7	7/7	0.8	2	4.90							5.50		0.06		176.60		
17	3-8	7/7	2.2	8														
17	3-9	7/7	0.8	2	1.27						29.43	0.51						
17	1-10	8/7	0.7	2	71.80			54.60		24.50	13.10						0.14	
17	1-11	8/7	1.7	8														
17	1-12	8/7	0.6	2	36.00		0.12					13.40		0.03		110.70		0.10
17	2-13	8/7	0.7	2	12.70			3.80								121.60		29.30
17	2-14	8/7	2.2	8														
17	2-15	8/7	0.6	2	0.04			1.18			55.50	1.23						0.08
17	3-16	8/7	0.7	2	3.90			3.40			74.70							
17	3-17	8/7	2.0	8														
17	3-18	8/7	0.8	2	45.90							0.10		0.56	0.18	124.70		0.11

Table 29. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 18 and 19, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Sub-strate	TAXON 1	2	3	4	5	15	16	17	18	26
18	1-1	7/15	0.9	3										15.20
18	1-2	7/15	0.6	3	0.42					1.25				21.20
18	2-3	7/15	0.9	3										18.00
18	2-4	7/15	1.0	3										32.20
18	2-5	7/15	1.1	3										21.00
18	3-6	7/15	1.0	3	0.44								0.07	38.10
18	3-7	7/15	0.9	3	0.45					8.49	0.05			20.50
18	3-8	7/15	1.0	3	0.10		0.11			7.78				18.50
18	1-9	8/12	0.8	3	2.08									67.50
18	1-10	8/12	0.7	3	0.08									71.40
18	2-11	8/12	0.8	3				38.50						69.00
18	2-12	8/12	1.0	3				0.70						38.60
18	2-13	8/12	1.0	3										45.30
18	3-14	8/12	1.2	3	0.16									53.70
18	3-15	8/12	1.3	3	0.74									31.40
18	3-16	8/12	1.2	3										63.00
19	1-1	8/22	0.3	3	45.89		0.94	0.80	16.52			5.10		
19	1-2	8/22	7.0	8										
19	1-3	8/22	0.5	2	11.90		0.39	0.17	3.49					0.08
19	2-4	8/22	0.3	2	34.70	2.80	0.02	0.06	1.18					0.05
19	2-5	8/22	9.5	8										
19	2-6	8/22	0.2	5	0.35			11.20	1.73					
19	3-19	8/22	2.6	3										
19	3-20	8/22	13.5	8										
19	3-21	8/22	2.0	3										
19	4-22	8/22	2.2	3										
19	4-23	8/22	4.6	8										
19	4-24	8/22	2.2	3										

Table 30. Biomass of aquatic macrophytes (g/0.5 m^2) in study area 20, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Sub-strate	TAXON 1	3	4	5	10	13	15	16	17	18	20	21	22	23
20	1-1	6/18	0.7	2	0.12	1.20				0.58	0.11	0.16			0.59	0.51		
20	1-2	6/18	1.2	3														
20	1-3	6/18	1.0	3														
20	2-4	6/18	0.7	2									3.20			54.90	15.90	14.40
20	2-5	6/18	1.6	4														
20	2-6	6/18	0.8	2												5.40	15.70	4.10
20	3-7	6/18	0.9	2	0.61	1.33	0.10		7.60			0.12			0.22			
20	3-8	6/18	0.9	2	0.18	0.03							0.40			10.95	4.60	
20	3-9	6/18	1.2	2														
20	3-10	6/18	0.9	2	29.40	0.38					0.07				1.90			
20	3-11	6/18	0.9	2	0.45							10.30						
20	4-12	6/18	1.1	2	0.26				9.10									
20	4-13	6/18	1.0	2														
20	4-14	6/18	0.8	2	0.75						0.11					1.80	38.70	22.50
20	4-15	6/18	0.7	2	0.63	0.19								0.39		0.71	5.90	2.40
20	4-16	6/18	0.6	2	2.22	0.09						9.70			0.61	9.21	8.80	0.68
20	1-17	7/31	0.0	2	17.20	1.15			3.50			0.14			2.38	85.10		
20	1-18	7/31	0.9	2														
20	1-19	7/31	0.8	2														
20	2-20	7/31	0.0	2									0.68			53.50	33.00	
20	2-21	7/31	1.1	4														
20	2-22	7/31	0.0	2												23.12	130.50	
20	3-23	7/31	0.2	2	0.55	0.08	12.50		13.10						2.10			
20	3-24	7/31	0.1	2					10.90							114.40		
20	3-25	7/31	0.9	2														
20	3-26	7/31	0.2	2	18.50	0.70		5.80							5.70			
20	3-27	7/31	0.3	2	15.64	3.73		10.10										
20	4-28	7/31	0.2	2	1.32			7.30	58.90						0.32			
20	4-29	7/31	0.5	2	12.80	8.90					3.70							
20	4-30*	7/31	0.2	2														
20	4-31	7/31	0.0	2												51.50	47.50	
20	4-32	7/31	0.0	2	0.65											48.40	14.80	

* sample lost

Table 31. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 21 and 22, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Substrate	TAXON 1	3	4	5	10	12	16	17	18	21	22	26
21	1-1	7/24	0.7	3	0.02							72.80				35.40
21	1-2	7/24	2.2	3												
21	1-3	7/24	2.0	3												
21	1-4	7/24	3.3	3												
21	1-5*	7/24	1.1	3												
21	2-6	7/24	1.8	3												
21	2-7	7/24	3.2	3												
21	2-8*	7/24	1.6	3												
21	2-9	7/24	1.0	3	0.07							0.11				73.87
21	2-10	7/24	0.8	3	15.70	0.20	0.15						0.04			52.10
21	1-11	8/13	1.1	3								31.90	0.10			22.10
21	1-12	8/13	2.5	3												
21	1-13	8/13	2.2	3												
21	1-14	8/13	3.6	3												
21	1-15	8/13	1.0	3	29.20	0.95	6.30	5.40		0.25						85.90
21	2-16	8/13	1.9	3												
21	2-17	8/13	3.4	3												
21	2-18	8/13	2.0	3												
21	2-19	8/13	1.0	2	0.29			0.18				7.70				68.20
21	2-20	8/13	0.7	3	2.43	11.00	18.30	16.90		0.94	0.01			0.28		50.70
22	1-1	8/26	0.5	2	33.80	2.00			4.80	10.00		0.16	0.17			
22	1-2	8/26	3.3	4												
22	1-3	8/26	0.3	7	3.90	16.80	7.53			3.06				84.20		0.26
22	2-4	8/26	0.5	2	2.10							1.57	0.06	156.50	45.10	
22	2-5	8/26	3.6	4												
22	2-6	8/26	1.5	4												
22	3-7	8/26	0.4	2			0.11		39.10	14.10		0.07		12.00		0.08
22	3-8	8/26	1.4	4												
22	3-9	8/26	0.5	2	72.00	27.40	3.35							87.10		0.12
22	4-10	8/26	0.8	2	0.08		0.03		62.50							
22	4-11	8/26	1.5	4												
22	4-12	8/26	1.0	2												

* vegetation present, but no sample taken

Table 32. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 23 and 24, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Sub-strate	TAXON 1	2	3	4	5	9	10	12	13	15	17	18	19	21	22	26
23	1-1	8/26	1.4	4																
23	1-2	8/26	3.2	4																
23	1-3	8/26	1.1	4																
23	2-4	8/26	0.6	2	14.40		73.20		5.48		24.90	1.64								0.09
23	2-5	8/26	2.8	4																
23	2-6	8/26	0.4	3	2.27		0.25	3.03			10.10	21.80	0.77	0.12	0.03	2.07		13.00		1.05
23	3-7	8/26	0.3	8				0.16							0.28			88.60		
23	3-8	8/26	2.4	4																
23	3-9	8/26	0.9	2	35.80		0.04	5.78	2.99						0.72			204.30		0.17
23	4-10	8/26	0.5	2	0.59		0.04	0.04							8.70				108.60	
23	4-11	8/26	1.8	4																
23	4-12	8/26	0.2	4			0.02	0.10			0.26		0.81		4.61			88.00		0.03
24	1-1*	7/23	1.4	8																
24	1-2	7/23	2.8	8																
24	1-3*	7/23	1.4	8																
24	1-4	7/23	1.1	9				3.40												72.10
24	1-5	7/23	2.2	8																
24	1-6	7/23	0.9	3	10.62		0.98	28.42				32.40					2.78			11.45
24	2-7	7/23	1.1	3																122.69
24	2-8*	7/23	1.6	8																
24	2-9	7/23	1.1	3	0.52			0.66												87.40
24	2-10	7/23	2.0	8																
24	2-11	7/23	1.9	8																
24	2-12	7/23	0.9	3	0.97		0.28	1.83								7.54	0.42			66.16
24	1-13*	8/20	1.5	8																
24	1-14	8/20	2.7	8																
24	1-15*	8/20	1.3	8																
24	1-16*	8/20	1.3	9																
24	1-17	8/20	2.3	8																
24	1-18	8/20	1.0	8	15.30		0.29	3.64		0.15		29.10		0.07			0.07			28.10
24	2-19*	8/20	1.1	3																
24	2-20*	8/20	1.6	8																
24	2-21*	8/20	1.4	3																
24	2-22	8/20	1.9	8																
24	2-23	8/20	2.1	8																
24	2-24	8/20	0.9	3	5.17	4.28	0.36	9.80		2.18										53.20

* vegetation present, but no samples taken

Table 33. Biomass of aquatic macrophytes (g/0.5 m^2) in study area 25, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Substrate	TAXON 1	3	4	5	10	13	15	16	17	18	20	21	22	23	24
25	1-1	6/23	0.9	4	0.40	0.12					0.05		4.80			12.70	20.00		
25	1-2	6/23	1.9	8															
25	1-3	6/23	1.0	4									52.10						
25	1-4	6/23	0.5	3												97.10			15.70
25	2-5	6/23	1.0	3	0.30								9.80		0.08	15.70			
25	2-6	6/23	1.0	2								0.04	4.37		0.02	57.30			
25	2-7	6/23	1.9	4															
25	2-8	6/23	1.8	4															
25	2-9	6/23	0.8	3												138.60			
25	3-10	6/23	0.9	2										0.08		86.20			
25	3-11	6/20	1.0	2												83.10			
25	3-12	6/20	1.6	4															
25	3-13	6/20	1.8	4															
25	3-14	6/20	0.9	2												9.70	107.40	5.20	
25	3-15	6/20	1.0	7												73.30	36.80	4.80	
25	4-16	6/20	1.0	2	0.15											109.30			
25	4-17	6/20	1.3	4															
25	4-18	6/20	1.3	4															
25	4-19	6/20	1.0	2												39.90	13.30		
25	1-20	7/30	0.1	4	10.10								16.70	0.28		16.50			
25	1-21	7/30	1.1	4															
25	1-22	7/30	0.1	4									46.17						
25	1-23	7/30	0.0	2						3.20						173.30			128.70
25	2-24	7/30	0.1	7									17.70			174.20			
25	2-25	7/30	0.1	7			0.17					0.30	15.90			2.67			
25	2-26	7/30	1.0	4															
25	2-27	7/30	0.9	4															
25	2-28	7/30	0.0	2	3.90											51.20			
25	3-29	7/30	0.2	2												264.10			
25	3-30	7/30	0.2	2			5.90									57.70			
25	3-31	7/30	1.0	4															
25	3-32	7/30	1.2	4															
25	3-33	7/30	0.1	2									1.49			9.00	197.70		
25	3-34	7/30	0.3	7					0.60								182.70		
25	4-35	7/30	0.3	2	0.38			0.41								120.60			
25	4-36	7/30	0.9	4															
25	4-37	7/30	1.5	4															
25	4-38	7/30	0.4	2	0.25		0.68									162.30			

Table 34. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 26 and 27, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Sub-strate	TAXON 1	3	4	5	12	15	16	17	21	22	23	26
26	1-1	7/18	1.0	2	0.09				3.00	0.05						18.20
26	1-2	7/18	0.7	2	0.08	0.13				31.40	0.09					3.40
26	1-3	7/18	0.6	7	0.05					2.50						54.30
26	1-4	7/18	0.5	3						0.25						33.70
26	2-5	7/18	1.0	2	1.09					0.22						59.00
26	2-6	7/18	0.8	2	0.29		10.80			0.10						27.40
26	2-7	7/18	0.7	2	0.03		15.10			0.06						59.30
26	2-8	7/18	0.8	7						0.57						25.30
26	1-9	8/13	1.1	2	0.60	0.83	0.02	3.20	30.20							3.50
26	1-10	8/13	0.9	3	1.27	0.04						1.64				47.90
26	1-11	8/13	0.6	2												79.10
26	1-12*	8/13	0.9	3												
26	2-13	8/13	0.9	2	0.87											97.90
26	2-14	8/13	1.0	3			15.40									50.40
26	2-15	8/13	1.1	3			24.10									31.60
26	2-16	8/13	0.9	3			15.30									49.50
27	1-1	6/25	0.8	3	0.76								3.70	30.80	10.90	
27	1-2	6/25	3.8	4												
27	1-3	6/25	3.2	4												
27	2-4	6/25	0.9	3									76.20			
27	2-5	6/25	3.8	4												
27	2-6	6/25	2.5	4												
27	3-7	6/25	1.1	4												
27	3-8	6/25	3.8	4												
27	3-9	6/19	0.7	2	0.23	0.14							73.50	8.00		
27	4-10	6/19	2.0	4												
27	4-11	6/19	2.5	4												
27	4-12	6/19	0.9	2	0.56				25.10							
27	1-13	8/22	0.3	2	8.28								50.20	12.10		
27	1-14	8/22	3.2	4												
27	1-15	8/22	2.7	4												
27	2-16	8/22	0.4	2	1.04								95.30			
27	2-17	8/22	3.1	4												
27	2-18	8/22	1.9	4												
27	3-19	8/22	0.6	4												
27	3-20	8/22	3.3	4												
27	3-21	8/22	0.3	3	0.73	0.02		4.00				18.80				
27	4-22	8/22	1.3	4												
27	4-23	8/22	1.7	4												
27	4-24	8/22	0.1	3	6.50			2.85					48.10	28.90	0.10	

* sample lost

Table 35. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 28 and 29, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Sub-strate	TAXON 1	3	4	12	17	18	26
28	1-1	8/28	0.3	2	1.39	0.11				27.40	
28	1-2	8/28	4.7	4							
28	1-3	8/28	4.4	4							
28	1-4	8/28	1.2	4							
28	2-5	8/28	1.4	4							
28	2-6	8/28	5.3	4							
28	2-7	8/28	5.0	4							
28	2-8	8/28	1.6	4							
28	3-9	8/28	0.6	2	0.07	0.29			14.30	0.60	0.10
28	3-10	8/28	6.5	4							
28	3-11	8/28	5.6	4							
28	3-12	8/28	3.2	4							
28	4-13	8/28	3.3	4							
28	4-14	8/28	6.8	4							
28	4-15	8/28	5.0	4							
28	4-16	8/28	0.3	8							63.40
29	1-1	8/29	0.6	2					32.00		
29	1-2	8/29	1.7	4							
29	1-3	8/29	0.7	2		0.02					50.60
29	2-4	8/29	0.6	2							69.60
29	2-5	8/29	1.9	4							
29	2-6	8/29	0.8	2	0.04		0.03	70.30			0.06
29	3-7	8/29	1.5	4							
29	3-8	8/29	2.5	4							
29	3-9	8/29	1.1	4							

Table 36. Biomass of aquatic macrophytes (g/0.5 m^2) in study area 30, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Substrate	TAXON 1	3	10	15	16	17	18	20	21	22	23	26
30	1-1	7/1	0.5	6	7.10	0.04		0.56	0.15			0.80	87.40			1.10
30	1-2	7/1	2.1	4												
30	1-3	7/1	0.7	3	1.02		38.21	0.07			0.32	0.07				
30	2-4	7/1	0.8	2	0.49					44.00			39.00			
30	2-5	7/1	2.0	4												
30	2-6	7/1	0.7	3	0.07								72.30	34.90		
30	3-7	7/1	1.2	4												
30	3-8	7/1	2.4	4												
30	3-9	7/1	0.8	4												
30	3-10	7/1	0.5	3	0.26	0.10		0.22		14.90	0.12		6.30	51.70		0.25
30	4-11	7/1	0.7	3							0.22		12.80	106.70	2.70	
30	4-12	7/1	1.7	4												
30	4-13	7/1	0.8	8	0.09					25.20						
30	4-14	7/1	0.5	3						37.70	5.50					1.23
30	5-15	7/1	0.6	1	0.22				0.08		0.08		134.50			0.04
30	5-16	7/1	1.5	4												
30	5-17	7/1	0.8	8												
30	5-18	7/1	0.5	2	0.07			4.60	0.18			0.14	39.50			
30	6-19	7/1	0.9	1	0.15		16.70									1.37
30	6-20	7/1	1.1	4												
30	6-21	7/1	0.8	8												
30	6-22	7/1	0.5	3	2.52	0.03		0.56	0.18	2.60						
30	7-23	7/1	3.4	4												
30	7-24	7/1	3.9	4												
30	7-25	7/1	1.2	4												
30	7-26	7/1	0.5	3	2.10			8.40			4.60		29.00	1.32		
30	8-27	7/1	4.1	4												
30	8-28	7/1	1.9	4												
30	8-29	7/1	1.3	4												
30	8-30	7/1	0.5	3	2.00				20.10				130.70			

Table 37. Biomass of aquatic macrophytes (g/0.5 m^2) in study area 30, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Sub-strate	TAXON 1	2	3	4	10	13	15	16	17	18	19	21	22	23	26
30	1-31	8/5	0.5	6	54.50	8.30		0.04						0.78		125.90			
30	1-32	8/5	1.8	4															
30	1-33	8/5	0.4	3					84.10					0.03					
30	2-34	8/5	0.6	6	14.80								17.10	0.22	0.86	73.50	3.10		
30	2-35	8/5	1.8	4															
30	2-36	8/5	0.5	7	0.28											53.00	107.50	1.18	5.30
30	3-37	8/5	1.0	8															
30	3-38	8/5	2.2	4															
30	3-39	8/5	0.5	4															
30	3-40	8/5	0.2	3	2.39		0.09						31.50	0.48			17.20		
30	4-41	8/5	0.6	6	0.85											25.70	131.70		
30	4-42	8/5	1.4	4															
30	4-43	8/5	0.5	8									66.10						
30	4-44	8/5	0.5	3	0.20		0.02						58.90	4.70					0.04
30	5-45	8/5	0.5	1	0.23									0.67		47.70			9.30
30	5-46	8/5	1.4	4															
30	5-47	8/5	0.8	4															
30	5-48	8/5	0.3	2	0.17			0.23			0.70		0.05	7.70		97.50			0.03
30	6-49	8/5	0.5	4					44.70										
30	6-50	8/5	0.8	4															
30	6-51	8/5	0.5	3									48.60						
30	6-52	8/5	0.3	3	0.13		14.60	2.50		0.52	3.80		0.84	0.12					44.30
30	7-53	8/5	3.1	4															
30	7-54	8/5	3.7	4															
30	7-55	8/5	1.0	4															
30	7-56	8/5	0.4	3	3.86		0.02				0.13	0.17	4.00	27.90		53.80			
30	8-57	8/5	3.9	4															
30	8-58	8/5	1.6	4															
30	8-59	8/5	1.0	4															
30	8-60	8/5	0.4	3	4.70		0.07				0.42			0.90		133.10			

Table 38. Biomass of aquatic macrophytes (g/0.5 m^2) in study area 31, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Substrate	TAXON 1	3	4	5	12	15	16	17	20	21	22	23
31	1-1	7/20	2.1	4												
31	1-2	7/20	0.7	2						0.08				73.90		
31	1-3	7/20	0.7	2	0.18	0.10								89.40		
31	1-4	7/20	1.7	4												
31	1-5	7/20	2.1	4												
31	1-6	7/20	1.8	4												
31	1-7	7/20	2.0	4												
31	1-8	7/20	0.8	2	6.12	6.15				0.15	1.83	13.20				
31	1-9	7/20	0.7	2	0.15	0.70	0.06							17.70	17.70	
31	1-10	7/20	0.9	2	23.80	3.20									6.60	13.10
31	1-11	7/20	2.2	4												
31	1-12	7/20	3.0	4												
31	1-13	7/20	0.7	2	0.05	0.04			3.25		0.25	9.60		0.79		
31	1-14	7/20	0.6	2										74.00		
31	1-15	8/1	1.7	4												
31	1-16	8/1	0.1	2										253.10		
31	1-17	8/1	0.1	2										274.80		
31	1-18	8/1	1.3	4												
31	1-19	8/1	1.8	4												
31	1-20	8/1	1.4	4												
31	1-21	8/1	1.5	4												
31	1-22	8/1	0.3	2	1.32	2.10		9.50	6.90	0.75		0.72	21.20			
31	1-23	8/1	0.2	2		0.05		2.86		0.10				51.20	17.14	
31	1-24	8/1	0.1	2	45.80	0.18		3.30					2.00		12.90	
31	1-25	8/1	1.8	4												
31	1-26	8/1	2.5	4												
31	1-27	8/1	0.3	2	0.28			2.83	68.10			4.70				
31	1-28	8/1	0.1	2				1.40						126.90		

Table 39. Biomass of aquatic macrophytes (g/0.5 m^2) in study area 32, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Sub-strate	TAXON 1	2	3	4	5	8	10	12	15	16	17	18	21	26
32	1-1	6/30	0.8	5														18.60
32	1-2	6/30	4.1	4														
32	1-3	6/30	2.5	4														
32	1-4	6/30	0.7	1	1.07								0.26	2.00			143.20	
32	2-5	6/30	0.7	5														12.10
32	2-6	6/30	3.4	4														
32	2-7	6/30	1.5	4														
32	2-8	6/30	0.7	1	0.07						9.60	2.23			2.70		10.30	
32	3-9	6/30	1.3	3														
32	3-10	6/30	3.7	4														
32	3-11	6/30	1.3	4			0.08											
32	3-12	6/30	0.9	1	30.40								0.36	2.03			118.80	
32	4-13	6/30	2.0	4														
32	4-14	6/30	3.7	4														
32	4-15	6/30	2.2	4														
32	4-16	6/30	0.9	1	17.80							29.00	0.40				66.50	
32	5-17	6/30	0.6	3			0.07						29.90	1.97				17.30
32	5-18	6/30	3.5	4														
32	5-19	6/30	1.7	4														
32	5-20	6/30	0.5	1	0.10								0.37			0.18	172.90	
32	1-21	8/6	0.6	5	0.05			0.06					2.60			0.05		36.70
32	1-22	8/6	3.9	4														
32	1-23	8/6	2.3	4														
32	1-24	8/6	0.4	1	0.03		0.40						1.50			0.10	134.00	
32	2-25	8/6	0.6	5	3.70			0.63								0.10		40.00
32	2-26	8/6	3.2	4														
32	2-27	8/6	1.3	4														
32	2-28	8/6	0.6	1	10.40			6.20			11.50		0.51	0.02	0.42		7.50	
32	3-29	8/6	1.0	3														
32	3-30	8/6	3.5	4														
32	3-31	8/6	1.0	4														
32	3-32	8/6	0.7	1	92.90								0.80				78.50	
32	4-33	8/6	1.7	3														
32	4-34	8/6	3.5	4														
32	4-35	8/6	1.9	4														
32	4-36	8/6	0.5	1	26.80	0.15	2.10		4.10	0.04		15.80	0.04				57.00	0.10
32	5-37	8/6	0.3	3	0.65		0.41	63.00						0.15				19.60
32	5-38	8/6	3.2	4														
32	5-39	8/6	1.3	4														
32	5-40	8/6	0.6	1	7.60		0.22	4.40					3.20			0.24	163.20	0.87

Table 40. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 33, 34, and 35, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Sub-strate	TAXON 1	3	5	12
33	1-1	7/17	3.2	4				
33	1-2	7/17	4.5	4				
33	1-3	7/16	3.7	4				
33	2-4	7/17	4.7	4				
33	2-5	7/17	5.5	4				
33	2-6	7/17	5.1	4				
33	3-7	7/17	6.6	4				
33	3-8	7/17	8.7	4				
33	3-9	7/17	7.1	4				
33	1-10	8/13	3.5	4				
33	1-11	8/13	4.4	4				
33	1-12	8/13	3.8	4				
33	2-13	8/13	4.4	4				
33	2-14	8/13	5.6	4				
33	2-15	8/13	5.0	4				
33	3-16	8/13	6.8	4				
33	3-17	8/13	9.0	4				
33	3-18	8/13	7.4	4				
34	1-1	8/22	1.0	4				
34	1-2	8/22	4.4	4				
34	1-3	8/22	2.3	4				
34	2-4	8/22	0.8	4				
34	2-5	8/22	2.7	4				
34	2-6	8/22	3.3	4				
34	3-7	8/22	0.8	4				
34	3-8	8/22	2.4	4				
34	3-9	8/22	2.3	4				
34	4-10	8/22	2.8	4				
34	4-11	8/22	2.1	4				
34	4-12	8/22	0.5	2				42.90
35	1-1	8/22	2.2	4				
35	1-2	8/22	4.0	4				
35	1-3	8/22	1.2	4				
35	2-4	8/22	1.6	4				
35	2-5	8/22	5.0	4				
35	2-6	8/22	1.5	4				
35	3-7	8/22	1.4	4				
35	3-8	8/22	3.9	4				
35	3-9	8/22	0.5	4				
35	4-10	8/22	1.1	4				
35	4-11	8/22	2.0	4				
35	4-12	8/22	0.4	8	8.20	0.79	2.65	

Table 41. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 36 and 37, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Sub-strate	TAXON 1	2	3	4	5	12	13	15	16	17	18	21	22	23	26
36	1-1	6/23	0.8	8							1.60					20.30	28.00	14.80	
36	1-2	6/23	1.3	4															
36	1-3	6/23	1.0	4															
36	2-4	6/23	1.0	4															
36	2-5	6/23	1.6	4															
36	2-6	6/23	1.4	4															
36	2-7	6/23	0.9	4															
36	3-8	6/23	0.8	8												27.60	9.80	1.00	
36	3-9	6/23	1.6	4															
36	3-10	6/23	1.8	4															
36	3-11	6/23	1.0	8	0.71		0.15							36.60					
36	1-12	8/1	0.1	8										0.35		15.40	5.50		
36	1-13	8/1	1.2	4															
36	1-14	8/1	0.6	4															
36	2-15	8/1	0.5	4															
36	2-16	8/1	0.9	4															
36	2-17	8/1	0.8	4															
36	2-18	8/1	0.4	4															
36	3-19	8/1	0.0	8												61.00	13.10		
36	3-20	8/1	1.0	4															
36	3-21	8/1	1.1	4															
36	3-22	8/1	0.3	8	0.03			31.30	5.70				0.03	4.87					0.80
37	1-1	7/24	1.0	3										8.60					64.10
37	1-2	7/24	0.9	3	0.83			0.30		20.29			0.05	7.49					31.00
37	1-3*	7/24	1.5	3															
37	1-4	7/24	1.0	3	2.55		0.08							57.35					35.52
37	1-5	7/24	0.7	3	0.04		0.03	0.55				0.10		1.92					18.77
37	2-6	7/24	1.2	3															57.50
37	2-7	7/24	1.2	3															115.86
37	2-8	7/24	1.0	3				2.27							0.03				102.70
37	2-9	7/24	1.0	3	0.04														95.91
37	2-10	7/24	0.9	3	0.68									5.68					71.50
37	1-11	8/20	1.1	3				0.11						11.27					50.90
37	1-12	8/20	1.0	3	0.54	4.71			24.84	22.50				34.20					18.00
37	1-13*	8/20	1.6	3															
37	1-14	8/20	1.0	3	0.20	16.06			10.26					43.50					39.30
37	1-15	8/20	1.0	3	2.71			0.77	60.00					10.80					13.60
37	2-16*	8/20	1.5	3															
37	2-17*	8/20	1.4	3															
37	2-18*	8/20	1.3	3															
37	2-19	8/20	1.1	3											0.13		0.10		102.50
37	2-20	8/20	0.9	3	4.20				31.50					15.20					8.80

* vegetation present, but no samples taken

Table 42. Biomass of aquatic macrophytes (g/0.5 m^2) in study area 38, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Substrate	TAXON 1	3	4	5	12	15	16	17	20	21	22	23
38	1-1	6/19	2.0	4												
38	1-2	6/19	2.6	4												
38	1-3	6/19	0.7	3	0.15				23.90	0.09	0.14	9.30		2.70	10.10	8.60
38	2-4	6/19	2.4	4												
38	2-5	6/19	1.8	4												
38	2-6	6/19	2.7	4												
38	3-7	6/19	2.4	4												
38	3-8	6/19	2.2	4												
38	3-9	6/19	0.7	3	0.11	0.31					0.72			20.90	3.31	1.49
38	4-10	6/19	1.4	4												
38	4-11	6/19	2.4	4												
38	4-12	6/19	1.0	3	0.07					0.18		15.40				
38	1-13	7/29	2.0	4												
38	1-14	7/29	2.6	4												
38	1-15	7/29	0.7	3	2.70			7.00	3.58			21.40	0.14		40.30	
38	2-16	7/29	2.4	4												
38	2-17	7/29	1.8	4												
38	2-18	7/29	2.7	4												
38	3-19	7/29	2.4	4												
38	3-20	7/29	2.2	4												
38	3-21	7/29	0.7	3	23.04	6.30		21.50		1.88			0.47			
38	4-22	7/29	1.4	4												
38	4-23	7/29	2.4	4												
38	4-24	7/29	1.0	3	2.87		4.10					33.60				

Table 43. Biomass of aquatic macrophytes (g/0.5 m^2) in study area 39, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Sub-strate	TAXON 1	3	4	5	12	15	16	17	18	21	26
39	1-1	7/2	0.8	2	9.80				46.20	4.06			1.34		
39	1-2	7/2	3.4	4											
39	1-3	7/2	0.6	6	3.14	0.16				0.24			4.60	54.70	
39	1-4	7/2	2.1	4											
39	1-5	7/2	0.9	6	1.15	0.02				1.42		0.15		151.20	
39	2-6	7/2	2.0	8											
39	2-7	7/2	3.7	4											
39	2-8	7/2	0.6	6	12.20		0.27					4.10	1.32	91.90	
39	2-9	7/2	1.5	4											
39	2-10	7/2	0.8	6	0.46					17.30		12.40	0.37	22.40	0.11
39	3-11	7/2	2.3	8											
39	3-12	7/2	3.3	4											
39	3-13	7/2	0.6	1	2.60								38.20		
39	3-14	7/2	0.9	8	0.12					2.54		40.50	5.80		0.56
39	3-15	7/2	0.6	6	0.11	0.08	0.30			0.95	7.20		26.10		11.90
39	4-16	7/2	1.8	8											
39	4-17	7/2	3.1	4											
39	4-18	7/2	0.9	8								13.60			
39	4-19	7/2	1.3	4											
39	4-20	7/2	0.5	6						1.22					28.15
39	1-21	8/6	0.5	2	0.11			23.30	9.20						
39	1-22	8/6	3.1	4											
39	1-23	8/6	0.5	6	8.30								0.64	175.10	
39	1-24	8/5	1.9	4											
39	1-25	8/6	0.5	6	38.70	0.09	1.10			1.15		1.04	2.51	189.60	0.18
39	2-26	8/6	1.7	4											
39	2-27	8/6	3.4	4											
39	2-28	8/6	0.4	6	10.90	0.04		6.70				24.70	0.40	47.06	
39	2-29	8/6	1.2	4											
39	2-30	8/6	0.5	9	0.25		0.07						0.80	103.60	0.06
39	3-31	8/6	2.0	4											
39	3-32	8/6	3.0	4											
39	3-33	8/6	0.2	6	0.21		0.02						30.10		0.04
39	3-34	8/6	0.5	3	0.40							36.70	0.04		
39	3-35	8/6	0.3	9	0.85		37.30	32.40		0.10					0.13
39	4-36	8/6	1.5	4											
39	4-37	8/6	2.9	4											
39	4-38	8/6	0.6	8	0.20			8.30				69.60			
39	4-39	8/6	1.0	4											
39	4-40	8/6	0.4	9	1.28	0.23	0.02			15.80	0.35		2.02		27.10

Table 44. Biomass of aquatic macrophytes (g/0.5 m^2) in study area 40, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Substrate	TAXON								
					1	2	3	15	17	18	21	22	26
40	1-1	7/2	0.7	8							66.70		
40	1-2	7/2	3.5	4									
40	1-3	7/2	3.3	4									
40	1-4	7/2	0.3	8				0.27		0.40	89.80		0.10
40	2-5	7/2	0.8	4									
40	2-6	7/2	3.3	4									
40	2-7	7/2	3.0	4									
40	2-8	7/2	0.3	4									
40	3-9	7/2	0.5	9	0.08			0.05		6.20	170.16		
40	3-10	7/2	2.3	4									
40	3-11	7/2	2.8	4									
40	3-12	7/2	0.3	3									
40	4-13	7/2	0.7	4									
40	4-14	7/2	3.6	4									
40	4-15	7/2	1.7	4									
40	4-16	7/2	0.5	8	0.12			0.42		33.20			0.08
40	1-17	8/5	0.5	8	26.00	0.43	0.15	0.11	0.23		92.50		
40	1-18	8/5	3.2	4									
40	1-19	8/5	3.1	4									
40	1-20	8/5	0.4	8						11.30			
40	2-21	8/5	0.6	4									
40	2-22	8/5	3.0	4									
40	2-23	8/5	2.8	4									
40	2-24	8/5	0.0	4							70.20		
40	3-25	8/5	0.4	9	0.36			7.60		14.20	157.09		
40	3-26	8/5	2.2	4									
40	3-27	8/5	2.6	4									
40	3-28	8/5	0.0	4							25.50	7.50	
40	4-29	8/5	0.5	4									
40	4-30	8/5	3.4	4									
40	4-31	8/5	1.5	4									
40	4-32	8/5	0.5	8	0.17					22.80			

Table 45. Biomass of aquatic macrophytes (g/0.5 m^2) in study area 41, Navigation Pool 8, Upper Mississippi River, 1975.

Study Area	Transect-Sample #	Date	Depth (m)	Sub-strate	TAXON 1	3	4	5	12	15	17	18	19	26
41	1-1	7/17	0.8	3	0.15	0.22	32.20			29.60		0.39		49.40
41	1-2	7/17	5.0	4										
41	1-3	7/17	0.6	3	2.08	0.31			21.70	0.91		0.11		29.20
41	2-4	7/17	0.9	3	0.10					1.16	5.70	0.04	10.00	165.80
41	2-5	7/17	4.8	4										
41	2-6	7/17	1.5	3										
41	3-7	7/17	0.8	3	0.21	0.09	8.20			0.14		3.90		86.90
41	3-8	7/17	2.5	4										
41	3-9	7/17	0.7	3	0.18	0.05	0.35				41.90	0.23		17.10
41	1-10	8/13	0.9	3				4.80					52.00	0.95
41	1-11	8/13	5.1	4										
41	1-12	8/13	0.6	3	2.70	4.60	1.40	0.37	91.10				2.60	69.80
41	2-13	8/13	0.7	3	1.70		25.50	31.70					17.30	64.60
41	2-14	8/13	5.0	4										
41	2-15	8/13	1.7	3										
41	3-16	8/13	0.7	2	0.40	0.06		5.00				7.00		43.50
41	3-17	8/13	2.8	4										
41	3-18	8/13	0.7	2	0.13		9.50	10.80					0.11	37.60

Appendix IV. Biomass of aquatic macrophytes in all study areas of Navigation Pool 8 of the Upper Mississippi River in 1976.

Table 46. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 1, 2, 3, 4, and 5, Navigation Pool 8, Upper Mississippi River, 1976.

		STUDY AREA														
		1			2			3			4			5		
Sample #		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Depth (m)		0.4	1.2	1.2	0.6	0.3	0.3	0.5	0.3	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Substrate		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
TAXON																
	a	2.04	6.75	40.05	116.71	19.70	12.13	20.71	9.37	5.80						
1	b															
	s															
	a	0.76		0.03	9.32	2.11	8.53	0.14	3.48							
3	b															
	s															
	a			28.30	10.04	7.06	2.76	81.17	1.33							
5	b															
	s															
	a							23.50								
10	b							3.76								
	s															
	a					161.28	142.45									
11	b					181.28	261.30									
	s															
	a								39.39	57.81						
12	b								30.48	0.06						
	s								1.23	1.32						
	a								0.79							
15	b								0.14							
	s															
	a								7.94							
16	b															
	s															
	a					43.35			25.39		308.54	253.66	396.06	217.24	245.77	309.01
21	b					28.92			12.97		49.67	62.09	81.09	31.72	30.84	56.41
	s										45.77	26.11	99.20	51.63	89.01	115.60

a = above ground biomass b = below ground biomass s = senescent biomass
Sample dates: areas 1, 2, 3, and 4 = 7/27; area 5 = 7/28

Table 47. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 6, 7, 8, 9, and 10, Navigation Pool 8, Upper Mississippi River, 1976.

		STUDY AREA														
		6			7			8			9			10		
Sample #		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Depth (m)		1.4	1.2	1.2	1.1	0.8	0.8	0.3	1.0	1.0	2.6	1.9	1.6	1.0	1.0	1.0
Substrate		4	4	4	2	2	2	2	2	2	2	2	2	2	2	2
TAXON																
	a				0.01	3.09		0.52	0.04	0.18				0.06	0.02	0.36
1	b															
	s															
	a				12.10	21.31	7.74	1.34								
2	b															
	s															
	a				1.29	15.01		0.45								
3	b															
	s															
	a				9.13	5.15										0.16
5	b															
	s															
	a							0.80								
8	b															
	s															
	a					99.02		11.32		28.51				40.93	108.54	
10	b					11.00				0.47				5.29	16.94	
	s					0.71									2.74	
	a						26.22	10.08								43.67
12	b						17.18									13.84
	s															
	a				2.01	0.80	1.75		0.11	0.07						0.27
15	b				0.21					0.01						0.13
	s							1.47	0.45	0.11				0.08		0.16
	a					0.02		4.92	0.07	0.02						0.06
18	b							0.56								
	s															
	a				228.62	75.73	292.81									
21	b				23.18	10.18	36.03									
	s				13.26	1.72	2.21									
	a				0.94				0.06							
26	b															
	s															

a = above ground biomass b = below ground biomass s = senescent biomass
Sample dates: areas 6 and 7 = 7/23; areas 8 and 10 = 7/20; area 9 = 7/28

Table 48. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 11, 12, 13, 14, and 15, Navigation Pool 8, Upper Mississippi River, 1976.

		STUDY AREA														
		11			12			13			14			15		
Sample #		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Depth (m)		0.3	0.6	0.5	9.8	7.7	12.2	0.2	0.9	0.6	1.6	1.7	1.8	1.8	1.4	1.4
Substrate		2	2	2	8	8	8	2	2	2	6	6	6	6	6	6
TAXON																
1	a	7.49	0.92	2.92				1.51	0.02	0.67			0.05	0.07	0.04	0.30
	b															
	s			0.15										0.14		
2	a												0.04	0.06	0.13	1.91
	b															
	s															
3	a	2.31	0.12	2.16				25.44						0.11		
	b															
	s															
4	a							8.49							0.04	0.32
	b															0.07
	s															
5	a	0.91	0.24						1.38							
	b															
	s															
15	a	3.01	4.50	0.50												
	b															
	s															
17	a	10.09														
	b	2.02														
	s															
18	a	3.15								0.19						
	b															
	s															
19	a													2.70		
	b													0.05		
	s															
20	a															
	b	1.06						0.42								
	s															
26	a										7.43		0.11	8.25	96.67	27.68
	b										1.27		0.03	0.69	6.39	2.22
	s															

a = above ground biomass b = below ground biomass s = senescent biomass

Sample dates: areas 11 and 13 = 7/28; areas 14 and 15 = 7/21; area 12 = 8/6

Table 49. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 16, 17, 18, 19, and 20, Navigation Pool 8, Upper Mississippi River, 1976.

		STUDY AREA														
		16			17			18			19			20		
Sample #		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Depth (m)		1.2	1.0	1.2	1.8	2.4	3.2	1.1	1.1	0.9	7.3	13.0	5.6	0.9	1.2	1.5
Substrate		8	8	8	8	8	8	3	3	3	8	8	8	8	3	7
TAXON																
1	a														0.13	
	b															
	s															
2	a							9.36	3.83	49.56						
	b															
	s															
3	a													0.08		
	b															
	s															
4	a									0.05				0.14		
	b															
	s															
10	a														35.42	63.63
	b															
	s														1.17	
13	a													0.11		
	b															
	s															
15	a							0.72	1.28							
	b															
	s									8.10						
20	a														0.05	
	b															
	s															
26	a							83.89	20.32	34.75						
	b							4.51	2.70	3.38						
	s															

a = above ground biomass b = below ground biomass s = senescent biomass

Sample dates: areas 16 and 17 = 7/23; area 18 = 7/22; area 19 = 8/6; area 20 = 8/29

Table 50. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 21, 22, 23, 24, and 25, Navigation Pool 8, Upper Mississippi River, 1976.

		STUDY AREA														
		21			22			23			24			25		
Sample #		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Depth (m)		1.5	1.3	1.0	2.8	2.0	1.7	4.1	2.0	1.7	1.4	1.4	1.4	1.7	1.2	1.4
Substrate		8	8	8	4	4	4	4	4	4	8	8	8	4	4	4
TAXON																
	a	0.43	67.22	19.44									0.16			
2	b															
	s															
	a											0.03				
3	b															
	s															
	a		23.61	52.58												
17	b		0.29	0.75												
	s															
	a			0.12												
18	b															
	s															
	a	98.41	31.66	23.63							41.91	89.11	38.28			
26	b	4.46	1.57	1.28							2.08	3.12	2.21			
	s															

a = above ground biomass b = below ground biomass s = senescent biomass

Sample dates: areas 22, 23, and 25 = 8/7; area 21 = 7/22; area 24 = 7/21

Table 51. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 26, 27, 28, 29, and 30, Navigation Pool 8, Upper Mississippi River, 1976.

		STUDY AREA														
		26			27			28			29			30		
Sample #		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Depth (m)		1.7	1.1	1.4	3.8	2.6	1.9	4.3	5.2	5.4	1.8	1.6	1.9	1.7	1.8	2.2
Substrate		3	3	3	4	4	4	4	4	4	8	8	8	4	4	4
TAXON																
	a		0.59													
2	b															
	s															
	a		3.33													
17	b		0.15													
	s															
	a	0.11	92.43													
26	b		6.79													
	s															

a = above ground biomass b = below ground biomass s = senescent biomass

Sample dates: area 26 = 7/22; area 27 = 8/6; area 28 = 8/7; area 29 = 7/23; area 30 = 8/4

Table 52. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 31, 32, 33, and 34, Navigation Pool 8, Upper Mississippi River, 1976.

		STUDY AREA													
		31					32			33			34		
Sample #		1	2	3	4	5	1	2	3	1	2	3	1	2	3
Depth (m)		0.6	1.4	2.6	3.2	0.6	2.6	2.9	2.9	4.3	5.0	8.5	2.5	2.2	3.0
Substrate		4	4	4	4	4	4	4	4	4	4	4	4	4	4
TAXON															
	a	0.09													
1	b														
	s														
	a	0.48													
3	b														
	s														
	a	3.82													
4	b	0.09													
	s														
	a														
15	b	0.29													
	s	0.02													
	a	13.57				1.84									
17	b	2.51				0.34									
	s														
	a					11.96									
18	b					0.94									
	s														

a = above ground biomass   b = below ground biomass   s = senescent biomass
Sample dates: area 31 = 8/7; area 32 = 8/4; area 33 = 7/23; area 34 = 8/6

Table 53. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 35, 36, 37, 38, and 39, Navigation Pool 8, Upper Mississippi River, 1976.

		STUDY AREA														
		35			36			37			38			39		
Sample #		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Depth (m)		4.7	4.4	2.6	2.1	1.8	1.7	1.2	1.2	1.1	2.5	3.2	2.4	3.5	2.8	2.3
Substrate		4	4	4	4	4	4	3	3	3	4	4	4	4	4	4
TAXON																
1	a							0.49								
	b															
	s															
2	a							6.61	23.99	6.52						
	b															
	s															
3	a								0.47							
	b															
	s															
5	a							7.16	1.22							
	b															
	s															
17	a							5.84		1.96						
	b									0.16						
	s															
18	a							0.18	2.63	3.41						
	b															
	s															
26	a							81.00	42.68	38.71						
	b							3.50	3.60	6.07						
	s															

a = above ground biomass   b = below ground biomass   s = senescent biomass

Sample dates: areas 35, 36, and 38 = 8/6; area 37 = 7/22; area 39 = 8/4

Table 54. Biomass of aquatic macrophytes (g/0.5 m^2) in study areas 40 and 41, Navigation Pool 8, Upper Mississippi River, 1976.

	STUDY AREA					
	40			41		
Sample #	1	2	3	1	2	3
Depth (m)	3.3	3.5	2.2	5.4	5.5	2.7
Substrate	4	4	4	4	4	4
TAXON						

Sample dates: area 40 = 8/4; area 41 = 7/22

Appendix V. Biomass of aquatic macrophytes in study area 20 of Navigation Pool 8 of the Upper Mississippi River in 1976.

Table 55. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 1 and 2 in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION												
		1						2						
Date		5/28	6/15	6/29	7/15	7/29	8/15	5/28	6/15	6/29	7/15	7/28	8/25	9/19
Depth (m)		0.7	0.8	0.7	0.9	0.9	0.9	0.6	0.8	0.6	0.8	0.8	0.9	0.8
TAXON														
	a	0.07	2.37	0.58	1.31	1.40	1.33	0.19	0.03	0.19	0.20	0.09		
1	b													
	s	0.02			0.19			0.46		0.03	0.01			
	a	0.02	1.85		0.19				0.10	0.57	0.01			
3	b													
	s		0.20		0.14					0.02				
	a				0.28									
4	b													
	s													
	a				0.50						0.01			
5	b													
	s													
	a	0.34	9.50	21.20	60.40	108.68	96.10		10.62	36.10	65.96	130.78	338.35	180.16
10	b				5.20	6.53	3.76				2.05	3.15	1.09	14.70
	s				1.70	5.79	39.98					7.22	46.38	206.82
	a		0.14		0.84				0.05	0.51				
13	b		1.30		0.11				0.03	0.19				
	s													
	a		0.24		0.34							0.03		
15	b													
	s													
	a		0.29											
16	b													
	s													
	a				0.15									
18	b													
	s													
	a	0.01	0.73	0.28		0.27	0.08							
20	b	0.04		0.34										
	s													
	a							0.03						
22	b													
	s													

a = above ground biomass   b = below ground biomass   s = senescent biomass
Substrate: station 1 = 2; station 2 = 2

Table 56. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 3 and 4 in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION											
		3						4					
Date		5/28	6/15	6/29	7/15	7/29	8/25	5/28	6/15	6/29	7/15	7/29	8/25
Depth (m)		0.8	1.0	0.9	1.0	0.9	0.8	0.6	0.8	0.3	0.6	0.5	0.6
TAXON													
	a	0.02					0.56				1.04		
1	b												
	s												
	a		0.01		0.01	0.08				4.00	3.84		
3	b												
	s										0.03		
	a					0.14		0.18	5.35	5.16	5.68	5.56	0.29
4	b							0.02		0.30	0.35	0.25	0.09
	s												5.60
	a										4.50		10.84
5	b												
	s												
	a									51.40	76.10	92.74	104.71
10	b										2.45	1.95	
	s											4.70	8.92
	a					0.11							
13	b												
	s												
	a			0.05					1.33	0.56			
15	b												
	s												
	a								0.85				
16	b												
	s												
	a	0.08							0.09	0.40	0.75	0.45	0.12
17	b								0.04				
	s												0.23
	a									0.20			
18	b												
	s												

a = above ground biomass b = below ground biomass s = senescent biomass
Substrate: station 3 = 8; station 4 = 4

Table 57. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 5 and 6 in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION													
		5							6						
Date		5/28	6/15	6/29	7/15	7/29	8/27	9/19	5/28	6/16	6/29	7/15	7/29	8/25	9/19
Depth (m)		0.5	0.8	0.6	0.7	0.5	0.5	0.4	1.0	1.1	1.0	1.1	1.1	1.0	1.1
TAXON															
1	a	30.83	10.68	1.60	3.20	5.05	14.25	5.46		0.24	0.95				
	b														
	s				0.08	0.15				0.01					
3	a	71.71	71.47	83.38	46.87	40.48	110.39	148.80		0.01					
	b														
	s		1.20	1.97	0.29	0.20	0.31	3.00							
5	a		4.08	7.33	62.62	47.93	3.28	11.74							1.24
	b														
	s														
10	a								0.65	16.64	26.51	88.20	114.91	114.47	97.30
	b											1.53	7.70	2.23	
	s											1.30	16.70	66.19	91.12
13	a								0.07						
	b														
	s														
15	a	0.01	0.21	0.13											
	b														
	s				0.10	0.12									
20	a	0.30	0.10				0.02								
	b														
	s														

a = above ground biomass b = below ground biomass s = senescent biomass

Substrate: station 5 = 2; station 6 = 2

Table 58. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 7 and 8 in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION											
		7						8					
Date		5/28	6/15	6/29	7/15	7/30	8/25	5/28	6/15	6/29	7/14	7/29	8/27
Depth		1.3	1.4	1.2	1.3	1.2	1.2	0.5	0.9	0.7	0.8	0.6	0.7
TAXON													
1	a			0.03		0.13	0.69	1.53	1.76	9.50	5.59	1.43	2.60
	b												
	s	0.07		0.02				0.89	0.20			0.07	0.17
3	a			0.02				0.03	0.58	0.33	0.00	4.18	0.08
	b												
	s								0.19			0.20	
4	a												0.07
	b												
	s												
5	a											2.44	6.78
	b												
	s												
10	a					35.42	71.46		10.57	8.43	24.20	62.26	84.40
	b						1.22						
	s					1.17	25.10				2.41	4.98	9.28
13	a			0.09									
	b												
	s												
15	a								0.17	0.52	0.04		
	b												
	s												
16	a				0.01								
	b												
	s												
18	a			0.03									
	b			0.01									
	s												
20	a					0.05		0.13		2.76		0.35	
	b							0.01		0.14			
	s												

a = above ground biomass   b = below ground biomass   s = senescent biomass

Substrate: station 7 = 3; station 8 = 2

Table 59. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 9 and 10 in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION											
		9						10					
Date		5/28	6/15	6/29	7/15	7/28	8/24	5/28	6/15	6/29	7/15	7/30	8/25
Depth (m)		0.3	0.3	0.4	0.4	0.3	0.6	1.7	1.5	1.4	1.4	1.7	1.5
TAXON													
1	a	0.82	1.93	2.58	1.37	1.22							
	b												
	s	0.19											
3	a		5.17	2.99	9.29	3.19							
	b												
	s												0.30
5	a			2.31	2.89	1.36	17.60						
	b												
	s												
10	a	2.00	27.58	94.93	136.01	160.53	145.10		6.62	13.50	24.30	35.79	49.20
	b			0.37	1.77	4.49	4.92				0.67	3.18	
	s					3.41	19.70					9.80	19.65
15	a		1.42	4.39									
	b		0.20										
	s						0.26						
17	a	0.01											
	b												
	s												
20	a	0.05	0.84		2.10	0.14							
	b	0.49	0.12										
	s												

a = above ground biomass b = below ground biomass s = senescent biomass

Substrate: station 9 = 2; station 10 = 3

Table 60. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 11 and 12 in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION											
		11						12					
Date		5/28	6/15	6/29	7/15	7/30	8/25	5/28	6/15	6/29	7/15	7/29	8/25
Depth (m)		1.4	1.4	1.2	1.5	1.5	1.6	0.4	0.6	0.3	0.6	0.6	0.6
TAXON													
1	a	0.03						21.62	2.48	16.18	33.45	1.30	
	b												
	s								0.07	0.85	0.15	0.08	
3	a							24.60	0.27	11.86	26.19	1.02	0.10
	b												
	s								4.54	8.00	0.96		0.06
5	a										11.93	26.85	34.35
	b												
	s												
10	a		5.65	7.70	32.90	63.63	74.98		1.82	1.90	3.57	9.99	60.15
	b			0.27								0.73	1.28
	s						12.68					6.87	22.27
15	a							7.46	31.39	0.71	2.80		
	b							1.30	2.10				
	s											0.37	0.14
20	a							0.61	0.52	2.59	1.87	0.13	
	b							0.14	0.04				
	s												
22	a							0.08					
	b												
	s												

a = above ground biomass b = below ground biomass s = senescent biomass
Substrate: station 11 = 7; station 12 = 2

Table 61. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 13 and 14 in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION											
		13						14					
Date		5/28	6/15	6/29	7/15	7/28	8/25	5/28	6/15	6/29	7/15	7/29	8/25
Depth (m)		0.5	0.6	0.5	0.5	0.5	0.4	1.7	1.5	1.4	1.2	1.6	1.4
TAXON													
1	a				0.17		11.05						
	b												
	s												
2	a				1.51								
	b												
	s												
3	a				0.14		0.10						
	b												
	s												
4	a	0.08	4.17	11.93	16.67	18.32	5.33						
	b		0.25	0.54	1.00	0.33	0.58						
	s						3.93						
5	a				0.33								
	b												
	s												
10	a								1.70	6.72	15.45	45.01	60.60
	b										0.02	0.22	
	s											0.77	13.00

a = above ground biomass b = below ground biomass s = senescent biomass

Substrate: station 13 = 4; station 14 = 3

Table 62. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 15 and 16 in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION												
		15							16					
Date		5/28	6/15	6/29	7/15	7/29	8/25	9/19	5/28	6/15	6/29	7/15	7/29	8/27
Depth (m)		1.0	1.0	0.9	1.0	1.1	1.0	0.8	0.4	0.7	0.5	0.7	0.6	0.7
TAXON														
	a		0.01	0.09	0.04			0.24	5.46	5.02	7.40	11.90	2.45	14.70
1	b													
	s								0.96	1.13		0.12	0.05	
	a									0.01				
2	b													
	s													
	a			0.01					36.01	49.95	43.35	15.78	17.50	5.32
3	b													
	s										3.20	1.48	0.80	0.74
	a							17.50		1.15	6.98	27.26	43.82	23.76
5	b													
	s													
	a	1.70	22.90	37.51	95.36	133.97	180.62	112.56				0.33	8.75	22.55
10	b						15.74	9.44						
	s				15.63	25.58	17.83	126.74					6.42	4.92
	a	7.39	4.23	23.55	5.47	0.07			7.39	4.23	23.55	5.47	0.07	
15	b								1.63		0.25			
	d												0.57	
	a		0.58						0.62	0.25	0.01	0.10		
20	b		0.13						0.03					
	d													

a = above ground biomass b = below ground biomass s = senescent biomass
Substrate: station 15 = 2; station 16 = 2

Table 63. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 17 and 18 in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION											
		17						18					
Date		5/28	6/15	6/29	7/15	7/29	8/27	5/28	6/15	6/29	7/15	7/29	8/27
Depth (m)		0.2	0.3	0.1	0.1	0.3	0.2	0.2	0.5	0.3	0.2	0.5	0.5
TAXON													
	a	0.26	0.13	0.74	0.03	0.58	0.19	12.64	37.50	27.59	44.41	27.56	64.80
1	b												
	s			0.10					0.95	0.10	0.09	0.04	0.14
	a		0.09	0.54	0.83	1.19	2.73	0.03	0.05	0.10	0.30	2.09	5.55
3	b												
	s						0.70						
	a								0.92	11.00	7.98	8.21	
5	b												
	s												
	a					0.09							
9	b												
	s												
	a												
15	b												
	s												0.09
	a	0.01						0.02					
16	b	0.01											
	s												
	a									0.09			
18	b												
	s												
	a							0.08		0.33		0.13	
20	b							0.02		0.04			
	s												
	a	12.53	78.34	146.38	227.46	243.74	162.24						
21	b	8.75	31.25	43.05	74.45	97.09	129.40						
	s			7.79	26.32	32.40	86.80						
	a			5.34	6.45	10.11	11.34						
22	b			1.43	3.72	2.09	4.03						
	s				0.25	0.39	1.00						

a = above ground biomass b = below ground biomass s = senescent biomass

Substrate: station 17 = 2; station 18 = 2

Table 64. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 19 and 20 in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION												
		19						20						
Date		5/28	6/15	6/29	7/15	7/28	8/27	5/28	6/15	6/29	7/15	7/28	8/27	9/19
Depth (m)		0.1	0.3	0.3	0.2	0.4	0.3	0.2	0.3	0.2	0.2	0.3	0.2	0.2
TAXON														
1	a		0.37	1.47	0.43	0.31			0.02	0.18			0.10	1.40
	b													
	s					0.20								
3	a		2.68	4.30	1.08	1.73			0.11		0.40	0.50	0.04	0.02
	b													
	s			0.08										
5	a					1.41	10.30					0.86		21.92
	b													
	s													
10	a	0.54	31.99	37.04	73.44	111.30	101.06			7.08	8.48	7.51	3.82	
	b		1.12	10.20	3.04	10.07	12.25			2.17		0.90		
	s			1.03	4.52		9.98							
15	a			0.03					0.02					
	b													
	s													
20	a													0.26
	b													
	s													
21	a	4.34	15.77	39.50	157.18	160.00	135.48	12.98	20.47	18.48	38.45	76.75	79.88	15.25
	b	1.55	3.14	10.42	20.51	82.70	52.05	12.39	5.18	4.00	5.49	14.30	50.38	8.74
	s					14.55	44.35		0.35		0.68	2.94	37.33	23.08
22	a							17.92	63.74	67.12	109.00	139.10	63.68	25.30
	b							10.47	20.26	14.80	16.49	47.51	23.70	58.44
	s								1.08	0.30	3.75	14.35	55.50	51.64
23	a								0.48					
	b								0.25					
	s													

a = above ground biomass b = below ground biomass s = senescent biomass

Substrate: station 19 = 2; station 20 = 2

Table 65. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 21 and 22 in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION													
		21						22							
Date		5/28	6/15	6/29	7/15	7/29	8/27	5/28	6/15	6/29	7/15	7/29	8/27	9/19
Depth (m)		0.0	0.3	0.1	0.01	0.3	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0
TAXON														
1	a		0.04	0.93	1.02	0.25	0.09							
	b													
	s													
3	a	0.18	0.88	0.83	6.44	5.46	0.09							
	b													
	s													
5	a					2.00	2.27							
	b													
	s													
6	a										3.51	0.99		
	b													
	s													
7	a										0.47	0.28		0.18
	b													0.08
	s													
9	a				0.24									
	b													
	s													
13	a										2.80	3.60		1.60
	b										0.09			5.96
	s													1.52
16	a		0.01	0.27										
	b													
	s													
18	a							0.04						
	b													
	s													
20	a			0.04	0.71	0.14	0.10							
	b													
	s													
21	a	22.97	77.71	175.89	273.15	259.10	96.15	19.41	80.68	180.04	210.53	334.07	150.98	3.72
	b	20.76	14.83	61.65	108.05	129.36	76.23	17.54	12.96	26.70	33.61	87.14	95.20	32.26
	s		0.75	4.68	6.08	34.48	143.18		1.70	5.10	56.01	116.42	149.06	186.22
22	a			3.50	0.99	10.08								
	b			1.09	1.78	4.09								
	s				0.22	0.51								

a = above ground biomass b = below ground biomass s = senescent biomass

Substrate: station 21 = 2; station 22 = 2

Table 66. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 23 and 24 in study area 20, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION												
		23						24						
Date		5/28	6/15	6/29	7/15	7/30	8/27	5/28	6/15	6/29	7/15	7/29	8/27	9/19
Depth (m)		0.5	0.4	0.3	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.5	0.4	0.3
TAXON														
1	a	9.68	13.00	21.00	79.41	31.70	32.63						0.01	
	b													
	s		0.27	0.19	1.06	0.08	0.08							
2	a					2.69	4.05							
	b													
	s													
3	a	25.60	46.66	39.77	29.84	41.51	31.38		0.01	4.00	0.18		3.08	0.16
	b													
	s		3.40	1.17	0.69	5.98	7.42						0.23	
4	a		0.03	0.03	0.33		0.03	0.02	11.52	15.07	6.53	16.60	2.50	13.90
	b			0.02						0.82	0.06		0.22	0.24
	s												2.22	6.74
10	a				0.25		0.55							
	b													
	s													
15	a						0.06	2.12	0.05	3.22				0.08
	b							0.11		0.03				
	s													0.10
17	a							4.25	10.68	17.32	18.85	16.82	16.00	17.94
	b							0.31	1.30	1.78	2.19	1.01	3.43	0.48
	s												0.12	0.66
18	a								0.15	14.90	0.61			
	b									0.18				
	s													
20	a				0.71	0.08								
	b													
	s													
26	a	0.03		0.33										
	b			0.10									0.02	
	s													

a = above ground biomass b = below ground biomass s = senescent biomass

Substrate: station 23 = 2; station 24 = 4

Appendix VI. Biomass of aquatic macrophytes in study area 15 of Navigation Pool 8 of the Upper Mississippi River in 1976.

Table 67. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 1 and 2 in study area 15, Navigation Pool 8, Upper Mississippi River, 1976.

	STATION													
	1							2						
Date	6/1	6/16	6/30	7/21	8/2	8/24	9/19	6/1	6/16	7/1	7/21	8/2	8/24	
Depth (m)	1.3	1.2	1.1	1.0	1.2	1.2	1.1	1.2	0.9	1.2	1.0	1.0	1.0	
TAXON														
1 a	0.055	0.62	1.33	31.86	32.00	15.82	5.18	0.215	0.23	0.22	1.88	0.50	3.13	
1 b														
1 s	0.09	0.17					0.04	0.60	0.10					
2 a			2.08	7.68	35.30	10.60	4.25			0.24	17.78	28.09	29.46	
2 b														
2 s														
3 a		0.02	0.06		0.04	0.02			0.15		3.00	0.95	0.11	
3 b														
3 s									0.01					
4 a						10.29			0.15		3.19	0.15		
4 b											0.17			
4 s														
5 a												39.44	4.77	
5 b														
5 s														
12 a	1.96	1.59	9.45	13.68	29.05	5.57	4.10							
12 b		79.47	0.02	19.61	4.51									
12 s							1.37							
15 a	0.125		0.92	0.08	0.23		0.03		1.91	7.00	1.67			
15 b									0.18	0.03				
15 s					0.09	0.02						0.80	2.60	
17 a							0.02	0.92	17.58	23.81	29.73	36.05	5.50	
17 b								0.075	1.88	2.40	0.29	1.83	0.47	
17 s													6.25	
18 a			6.58		2.24	0.04		0.355	5.62	9.53	3.36	1.46		
18 b								0.175						
18 s														
19 a			0.34						0.36		0.29			
19 b														
19 s														
26 a			5.42	1.58	10.98	3.74	18.27	0.175	0.36	1.47	4.68	3.89	0.60	
26 b			0.48	0.41	3.54	0.51	2.96	0.035	0.02	0.16	0.18	0.55		
26 s							0.50							

a = above ground biomass b = below ground biomass s = senescent biomass
Substrate: station 1 = 6; station 2 = 6

Table 68. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 3 and 4 in study area 15, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION											
		3						4					
Date		6/1	6/16	6/30	7/21	8/2	8/24	6/1	6/16	6/30	7/20	8/2	8/24
Depth (m)		1.3	1.3	1.4	1.4	1.3	1.3	1.6	1.6	1.6	1.8	1.7	1.7
TAXON													
	a	0.015	0.03	0.01			1.17				0.07		0.17
1	b												
	s	0.125	0.22	0.15							0.14		
	a				0.51	4.29	30.00				0.06	3.89	0.41
2	b												
	s												
	a	0.015					0.20				0.11		
3	b												
	s												
	a		0.06				0.61						
4	b												
	s												
	a	0.07				0.63							
15	b												
	s												
	a						16.30						0.18
18	b						0.04						
	s												
	a										2.70		
19	b										0.045		
	s												
	a	0.83	4.25	4.89	29.50	49.19	51.59	0.015	0.20	0.53	8.25	15.60	27.13
26	b		0.61	0.69	4.59	9.90	6.60		0.01	0.04	0.685	1.81	9.16
	s												

a = above ground biomass   b = below ground biomass   s = senescent biomass

Substrate: station 3 = 6; station 4 = 9

Table 69. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 5 and 6 in study area 15, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION											
		5						6					
Date		6/1	6/16	6/30	7/21	8/2	8/24	6/1	6/16	6/30	7/21	8/2	8/24
Depth (m)		1.8	1.8	1.9	1.8	1.9	1.8	3.0	3.0	3.1	3.1	3.2	3.0
TAXON													
2	a						0.06						
	b												
	s												
3	a						0.05						
	b												
	s												
4	a						0.05						
	b												
	s												
26	a						1.09						
	b						0.25						
	s												

a = above ground biomass b = below ground biomass s = senescent biomass

Substrate: station 5 = 9; station 6 = 8

Table 70. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 7 and 8 in study area 15, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION												
		7							8					
Date		6/1	6/16	6/30	7/20	8/2	8/24	9/19	6/1	6/16	6/30	7/21	8/2	8/24
Depth (m)		0.9	1.0	1.0	1.0	1.0	1.0	0.9	1.9	1.9	2.0	2.0	2.0	1.9
TAXON														
	a				0.17	26.15	24.40	16.92						
2	b													
	s													
	a						1.80	0.24						
4	b						0.20							
	s													
	a	0.175	0.65	0.32	0.93			0.04						
15	b													
	s				0.76	0.52	0.11	0.24						
	a	1.025	16.38	38.79	66.71	97.27	88.18	56.52						
26	b	0.09	0.68	0.70	4.07	4.94	6.63	6.30						
								0.34						

a = above ground biomass b = below ground biomass s = senescent biomass

Substrate: station 7 = 8; station 8 = 8

Table 71. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 9 and 10 in study area 15, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION												
		9						10						
Date		6/1	6/16	6/30	7/21	8/2	8/24	6/1	6/16	6/30	7/21	8/2	8/24	9/19
Depth (m)		2.0	2.0	2.1	2.0	2.1	1.9	2.0	2.0	1.8	1.4	1.4	1.3	1.3
TAXON														
1	a									0.36	0.04	0.13	0.30	1.40
	b													
	s									34.95				
2	a										0.13	26.20	75.10	14.86
	b													
	s													
3	a									0.16				0.16
	b													
	s									0.38				
4	a									0.12	0.04	0.76	0.97	0.32
	b													0.10
	s													0.18
5	a												2.62	
	b													
	s													
9	a									0.03				
	b													
	s													
15	a									0.04			0.15	
	b													
	s													
18	a									0.42		1.67	10.03	0.26
	b													
	s													
19	a									0.20				0.44
	b													
	s													
26	a									4.80	96.67	99.00	127.28	100.24
	b									0.03	6.39	6.24	6.40	9.20
	s													0.88

a = above ground biomass b = below ground biomass s = senescent biomass

Substrate: station 9 = 8; station 10 = 9

Table 72. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 11 and 12 in study area 15, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION													
		11							12						
Date		6/1	6/16	6/30	7/20	8/3	8/24	9/19	6/1	6/16	6/30	7/20	8/3	8/24	9/19
Depth (m)		0.9	1.0	1.0	0.9	1.1	1.0	0.9	1.2	1.2	1.2	1.1	0.9	1.2	1.1
TAXON															
1	a	0.015		0.26	1.75	0.94	0.29	6.00		0.06	0.67	0.09		1.04	3.56
	b														
	s		0.05								0.08				0.16
2	a				84.10	1.37	12.60	5.58				0.06	2.39	8.46	7.20
	b														
	s														
3	a							0.16			0.02				
	b														
	s							0.14							
4	a	0.035		0.26	11.81	68.60	74.58	19.68		1.00					
	b			0.03	0.29	2.19	1.94	1.14							
	s							3.04							
5	a						3.15	6.74				0.34		2.23	
	b														
	s														
9	a			0.17	0.45	0.08	0.05								
	b					0.07									
	s														
15	a	0.015	2.48	16.30		1.40			0.035		0.68				
	b		0.24	0.12		0.06									
	s				2.81	0.77		0.40							
16	a	0.105	3.00	0.29											
	b														
	s														
17	a	0.565	0.005	4.30	5.23	5.14	7.25		0.635	0.18	35.63	47.51	57.28	17.65	4.84
	b	0.16			0.59	0.05	0.15				2.30	7.92	1.07	0.46	0.14
	s							0.60							3.62
18	a			0.01	0.14	0.15			0.005		0.04		1.19		
	b														
	s														
19	a			0.21								0.09			
	b														
	s														
26	a	0.015	0.005	4.28	0.37	0.11	3.89	0.12	0.055	8.52	6.50	17.41	26.39	30.57	24.32
	b			0.05			0.11		0.015	0.62	0.18	1.00	3.51	5.28	4.86
	s														0.14

a = above ground biomass b = below ground biomass s = senescent biomass
Substrate: station 11 = 8; station 12 = 8

Table 73. Biomass of aquatic macrophytes (g/0.5 m^2) at stations 13 and 14 in study area 15, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION												
		13							14					
Date		6/1	6/16	6/30	7/20	8/3	8/24	9/19	6/1	6/16	6/30	7/21	8/2	8/24
Depth (m)		1.3	1.2	1.1	1.2	1.1	1.2	1.3	1.9	1.9	1.8	1.4	1.4	1.3
TAXON														
	a		0.04	0.78		0.37	0.30	0.10			0.01	0.30	0.14	19.68
1	b													
	s		0.09					0.18			0.04			1.83
	a			0.07	2.63	80.30	43.60	2.38				1.91	2.07	19.77
2	b													
	s													
	a		0.10	0.86	0.15	0.09	0.26							
3	b													
	s		0.03											
	a		0.13			11.58	3.79					0.32	0.04	1.25
4	b					0.16	0.79					0.07		0.08
	s													
	a													0.42
9	b													
	s													
	a			1.66									0.02	
15	b													
	s					0.25	0.50						0.08	
	a				1.60	0.92	14.32							
17	b						0.96							
	s													
	a	0.265	0.10	0.34	7.49	7.73	8.50							4.22
18	b	0.015												
	s													
	a					0.05							1.48	
19	b												0.12	
	s													
	a	3.365	6.49	20.18	31.13	35.24	46.20	35.60			1.39	27.68	68.24	34.70
26	b		0.43	0.48	2.02	2.80	3.06	3.80			0.18	2.22	6.71	4.20
	s							1.16						

a = above ground biomass b = below ground biomass s = senescent biomass
Substrate: station 13 = 6; station 14 = 9

Table 74. Biomass of aquatic macrophytes (g/0.5 m^2) at station 15 in study area 15, Navigation Pool 8, Upper Mississippi River, 1976.

		STATION					
		15					
Date		6/1	6/16	6/30	7/20	8/2	8/24
Depth (m)		1.2	1.3	1.4	1.2	1.2	1.3
TAXON							
	a	0.09			3.64	0.42	
1	b						
	s	0.245		0.08			
	a				2.54	30.98	0.95
2	b						
	s						
	a						0.05
3	b						
	s						
	a						0.17
4	b						
	s						
	a		0.36		0.43		0.15
15	b						
	s					0.10	
	a					0.79	
18	b						
	s						
	a					7.60	
19	b					0.06	
	s						
	a	2.015	3.00	3.20	38.55	63.70	68.49
26	b	0.035	0.31	0.30	6.01	6.37	8.84
	s						

a = above ground biomass b = below ground biomass s = senescent biomass
Substrate: station 15 = 6