CLEAR TECHNICAL REPORT NO. 54

ENVIRONMENTAL PARAMETERS AFFECTING THE DISTRIBUTION OF THE ISOPOD *ASELLUS R. RACOVITZAI* IN WESTERN AND CENTRAL BASINS OF LAKE ERIE

Prepared by

Jeffrey R. Kerr
Center for Lake Erie Area Research
The Ohio State University

Prepared for

Large Lakes Field Station
U.S. Environmental Protection Agency
Grosse Ile, Michigan

THE OHIO STATE UNIVERSITY
CENTER FOR LAKE ERIE AREA RESEARCH
COLUMBUS, OHIO

December 1976

PREFACE

The following report was prepared by Jeffrey R. Kerr for an M.S. degree in the Environmental Biology Program. Research conducted for this thesis was part of a project coordinated by the Center for Lake Erie Area Research (CLEAR) at The Ohio State University and was in part sponsored by the U.S. Environmental Protection Agency, Grant No. R-802543. Dr. N. Wilson Britt, Department of Entomology, served as advisor. Other members of the reading committee were Drs. Charles E. Herdendorf and Emanuel D. Rudolph.

On behalf of the Center for Lake Erie Area Research, I am pleased that we are able to reproduce copies of this research effort and make it available to other scientists.

Charles E. Herdendorf
Director

ACKNOWLEDGEMENTS

My sincere appreciation is extended to Dr. N. Wilson Britt for his invaluable assistance and advice concerning this study.

I would also like to thank Al Pliodzinskas for information he provided concerning the Lake Erie Nutrient Control Study and for many other valuable suggestions. Lastly, I would like to thank Dr. C. E. Herdendorf for his advice and for information he provided concerning oxygen, currents, and sediments in Lake Erie.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

INTRODUCTION

Aquatic isopods of the genus *Asellus* have long been known as a characteristic component of the pollution fauna in lakes and streams (Moon, 1957; Ellis, 1961; Keup et al., 1966; Klein, 1957). Suprisingly, very few studies have made more than passing reference to isopods or have attempted to use them as indicators of environmental quality. Life history studies are similarly lacking and as a result, little is known about the ecology and life histories of many species.

A major factor that has impeded research for many years is the confusion that has existed concerning taxonomy. As late as 1969, there was no key in existence that could reliably separate species of the genus *Asellus*. As of 1976, there is still no known key that can separate species of the genus *Lirceus* other than by geographical location. As a result, the identity of even the common species has been confused and older literature is often difficult to interpret.

The objectives of this study were to investigate: 1) the seasonal distribution and density of *Asellus racovitzai racovitzai* Williams in western and central Lake Erie, 2) factors affecting this distribution such as oxygen, current, depth, food sources, sediment type, pH, calcium, and total dissolved solids, 3) seasonal population dynamics in Lake Erie including a size frequency distribution, 4) some aspects of life history and ecology and, 5) the potential of isopods as indicators of environmental quality.

MATERIALS AND METHODS

Field Methods

The benthos samples used in this study were collected as part of an ongoing study of the effectiveness of recent cleanup efforts in controlling eutrophication in Lake Erie. I am indebted to Dr. C.E. Herdendorf and the Center for Lake Erie Area Research for allowing my use of these samples and other data from this study as a basis for this thesis.

Samples were taken at 52 stations located in western and central Lake Erie during four cruises in 1975. (Fig. 1 and Table 1). The date of each cruise was as follows: Cruise 1- March 29-April 25, Cruise 2- June 9-June 16, Cruise 3- July 13-July 24, and Cruise 4- August 27-September 5, 1975. Two samples were taken per station using a ponar grab sampler which sampled .055 square meters. Samples were then washed through a large sieve with .425 mm mesh (U.S. soil series #40) and preserved in 5-10% formalin.

Laboratory Methods

After several months of storage, samples were stained with rose bengal in the laboratory and then rewashed through a #40 sieve. The sample was then placed in white enamel pans and organisms were hand picked under bright light by the author. The organisms were then preserved in 70% ethyl alcohol and later counted and identified. All numbers were expressed as the average number of organisms per square meter.

Identification

Isopod specimens were placed in a petri dish with alcohol and observed at 9X under the dissecting microscope. A fine pair of forceps and dissecting needles were then used to dissect off the right gnathopod, right first

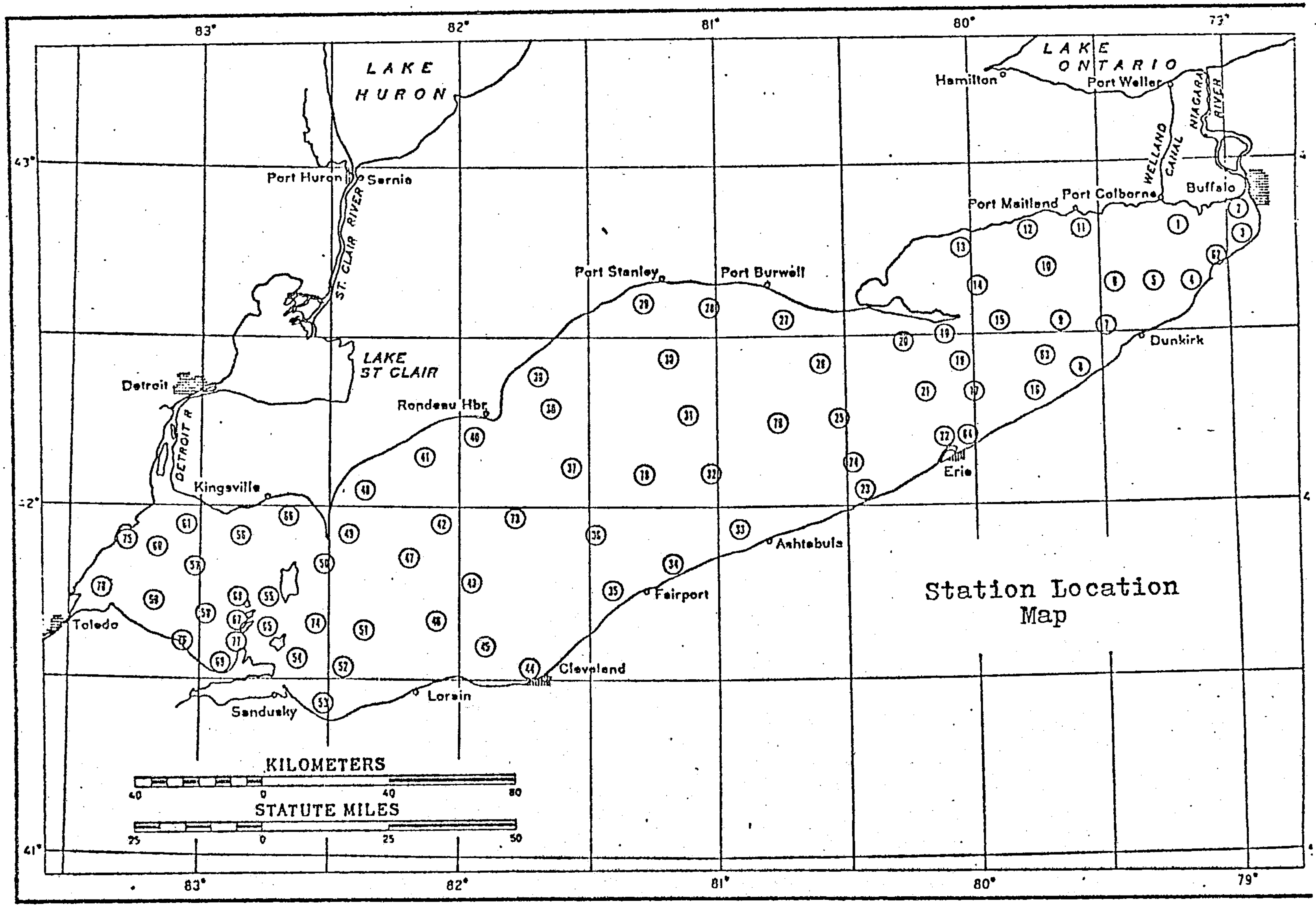

Station Location
Map
LAKE HURON
LAKE ONTARIO
LAKE ST CLAIR
ST. CLAIR RIVER
DETROIT R
WELLAND CANAL
NIAGARA RIVER
Hamilton
Port Weller
Port Colborne
Port Maitland
Buffalo
Dunkirk
Erie
Ashtabula
Fairport
Cleveland
Lorain
Sandusky
Toledo
Detroit
Kingsville
Rondeau Hbr
Port Stanley
Port Burwell
Port Huron
Sarnia
KILOMETERS
40 0 40 80
STATUTE MILES
25 0 25 50
83°
82°
81°
80°
79°
43°
42°
41°

Figure 1

Table 1

STATION LOCATIONS

STATION	LATITUDE N.	LONGITUDE W.
23	42 02' 18"	80 27' 06"
24	42 05' 54"	80 29' 00"
25	42 14' 54"	80 33' 36"
26	42 24' 00"	80 38' 12"
27	42 32' 54"	80 45' 30"
28	42 35' 30"	81 01' 00"
29	42 36' 18"	81 17' 54"
30	42 25' 48"	81 17' 54"
31	42 15' 12"	81 06' 24"
32	42 04' 54"	81 00' 42"
33	41 55' 54"	80 55' 00"
34	41 50' 00"	81 08' 54"
35	41 45' 48"	81 23' 00"
36	41 56' 06"	81 28' 42"
37	42 06' 36"	81 34' 30"
38	42 16' 54"	81 40' 18"
39	42 21' 30"	81 42' 24"
40	42 11' 30"	81 55' 18"
41	42 08' 06"	82 08' 24"
42	41 57' 54"	82 02' 30"
43	41 47' 18"	81 56' 42"
44	41 31' 48"	81 42' 30"
45	41 36' 24"	81 53' 48"
46	41 40' 54"	82 05' 12"
47	41 50' 18"	82 12' 48"
48	42 02' 48"	82 21' 54"
49	41 55' 54"	82 24' 30"
50	41 48' 48"	82 24' 30"
51	41 38' 30"	82 24' 12"
52	41 31' 54"	82 27' 12"
53	41 25' 12"	82 30' 12"
54	41 34' 00"	82 38' 02"
55	41 44' 18"	82 44' 00"
56	41 54' 42"	82 50' 24"
57	41 49' 54"	83 01' 06"
58	41 41' 06"	82 56' 00"
59	41 43' 36"	83 09' 00"
60	41 53' 30"	83 11' 48"
61	41 56' 48"	83 02' 42"
65	41 39' 00"	82 44' 00"
66	41 58' 00"	82 40' 00"
67	41 40' 00"	82 52' 00"
68	41 45' 00"	82 51' 00"
69	41 33' 00"	82 51' 00"
70	41 46' 00"	83 20' 00
71	42 18' 00"	81 22' 00"
72	41 57' 50"	81 11' 00"
73	41 58' 40"	81 45' 25"
74	41 40' 00"	82 35' 00"

Table 1 (continued)

STATION	LATITUDE N.	LONGITUDE W.
75	41 54' 00"	83 18' 00"
76	41 36' 30"	83 04' 00"
77	41 39' 30"	82 49' 36"

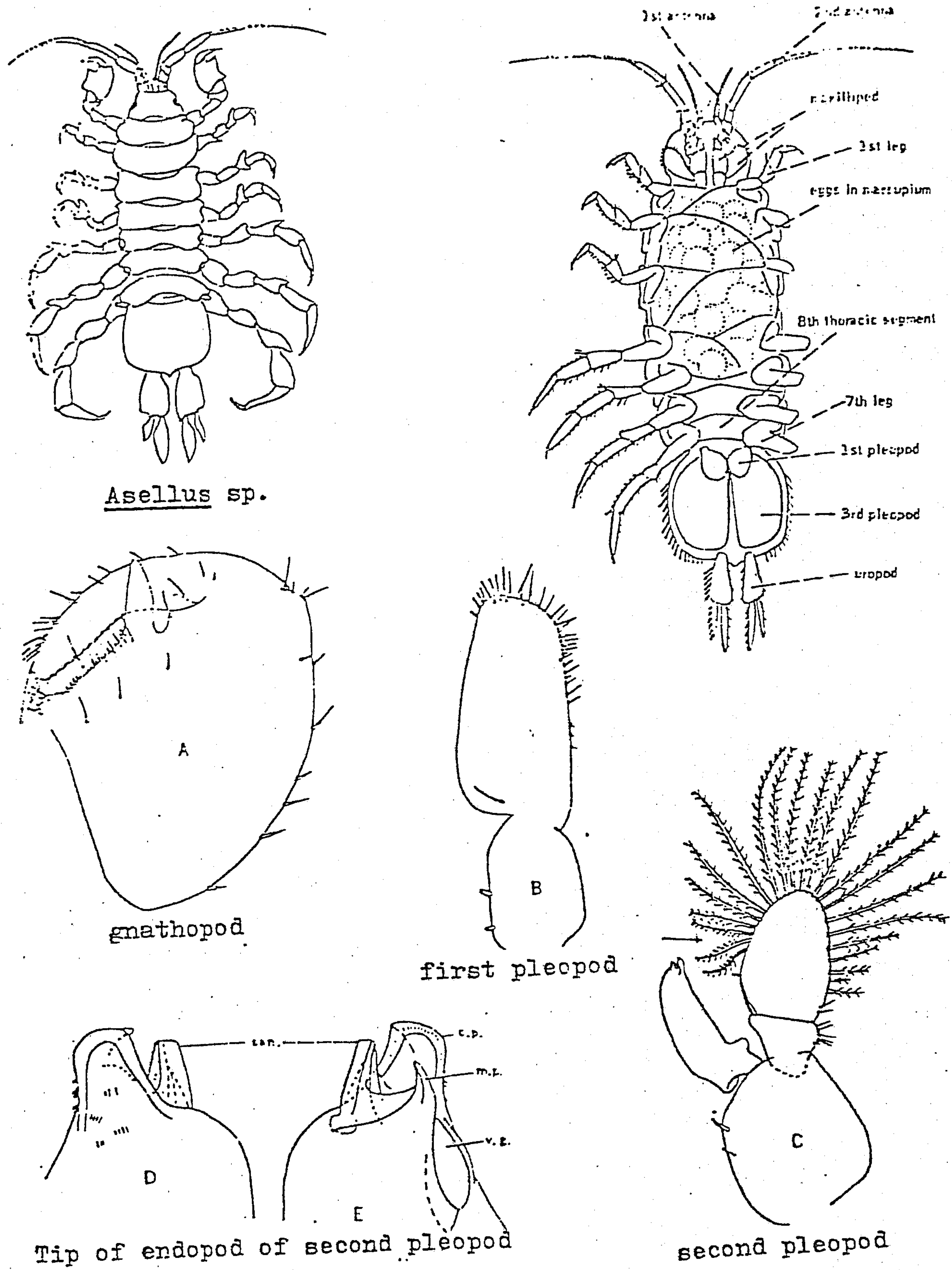
and second pleopods, and the right uropods of an adult male specimen (Fig. 2). These structures were mounted on slides in glycerin and observed at 100X and 440X under a monocular microscope.

The endopodite of the second pleopod was often difficult to get into viewing position and often had to be flipped over and manipulated. Care was taken to avoid distortion that can occur during mounting and/or clearing. If a commercial mounting media is used, it should be chosen carefully to minimize contraction and shrinking during clearing. Williams (1970) recommends that 70% ethyl alcohol or water be used in temporary mounts. The author, however, found this to be unsatisfactory due to rapid evaporation under microscope heat.

Sex Determination

The sexes of a number of isopods from each cruise was determined at 9X and 27X under the dissecting microscope (Table 2). Organisms were first measured and if found to be less than 4 mm or in poor condition, characterized as unidentifiable. Organisms smaller than 4 mm were extremely difficult to categorize due to incomplete development of key structures.

Females differed from males primarily in the structure of the first paraeopod and the second pleopod. In males, the first paraeopod is enlarged and clawlike whereas the female structure is small and indistinct. However, this character was not used due to the prevalence of missing limbs and the incomplete development of this structure in smaller organisms. A much more reliable characteristic is the structure of the second pleopods. In males, the endopodites of the second pleopods are greatly modified to form a copulatory structure not present in females. In addition to this, the first pleopod is absent in females and present in males. To alleviate confusion, the "first" pleopod in females is usually referred to as the second



A. racovitzai racovitzai.
(modified from Pennak, 1953; Williams, 1970)

Figure 2: Structures of Asellus

pleopod (Williams, 1970). The presence of oostegites in females is also an unmistakable characteristic.

Length Measurements

Isopod lengths were measured under a dissecting microscope to the nearest tenth of a millimeter. The organisms were straightened and measured ventral side down from the anterior margin of the cephalothorax to the posterior margin of the telson exclusive of the uropods. All measurements were performed at 9X using an ocular micrometer calibrated by the author with a stage micrometer. Measurements of greater accuracy than 0.1 mm were deemed impractical due to intrinsic error in calibrating the ocular micrometer and the fact that isopod intersegmental muscles were in various states of relaxation and contraction thus effectively lengthening or shortening the organism. Obviously lengthened individuals were not included in the size frequency distribution.

Egg and Immature Counts

Egg and immature counts were generally begun by closely inspecting the marsupium for damage. Organisms with damaged marsupia were not incorporated into the data due to the possible loss of eggs and young. The marsupia in undamaged specimens was carefully teased open using dissecting needles and eggs, embryos, and young were counted under 9X or 27X. Eggs and young were then carefully washed back into the original vial so as not to invalidate biomass data yet to be taken.

Biomass

The dry weight biomass of isopods at several stations was also determined. Three groups of four clean, six dram vials were each placed in a separate petri dish cover. The petri dish cover facilitated removal of groups of vials from the oven without excessive handling with forceps. The vials and dishes were then placed in the oven for three hours at 40 C to evaporate any excessive moisture in or on the vials. The oven was then turned off and left to equilibrate with room temperature. Vials were removed in groups of four and individually weighed to 0.0001g on a Mettler Macro Balance Model #15 which was accurate to 0.00005g. Forceps were used in the handling of all glassware that was to be weighed. Organisms, which were preserved in 70% ethyl alcohol, were then placed in the appropriately labelled vial either by manual picking or rinsing with alcohol. Vials were then heated at 40 C for 24 hours. After this time period, the oven was turned off and the vials removed and weighed in the manner described above. It was evident that some vials with a large amount of organisms were not yet dry. As a result, the vials were again placed in the oven and dried and reweighed until no significant weight loss was noted.

Food Studies

The guts of several isopods were removed under the dissecting microscope, cut open, and mounted on slides in alcohol. The contents were then examined under a monocular microscope at 100X and 440X.

LITERATURE REVIEW

The history of aquatic isopods in Lake Erie is a subject upon which very little has been published. Consequently, it is almost impossible to evaluate changes that may or may not have taken place in distribution, number, and possibly species in Lake Erie.

The first deepwater isopods referred to in Lake Erie were collected by W.P. Hay during the late 1890's (Wood, 1953). No reference can be found to the exact date. These specimens were identified by Hay as Asellus communis and deposited in the United States National Museum. Studies by Wright et al., in 1929 and 1930 (1955) and Shelford and Boesel (1942) made no reference to isopods as being part of the fauna. However, during 1952 Clemens collected a large number of isopods in 90 feet of water near Rondeau Harbor, Ontario. It was stated by Clemens that the isopod was an important part of the fauna there (Wood, 1953).

As part of his Lake Erie benthos study of 1953, Kenneth Wood noted that isopods were present at ten of his stations in western Lake Erie which were all east of a line south of Point Pelee. Specimens were sent to J.G. Mackin who distinctly separated this species from Asellus communis thus casting doubt on Hay's original identification. The isopod in question was found by Wood to be most prevalent (86/10 liters of sediment) in poorly sorted silt. An average depth of 15.6 meters was noted for the isopod with a range of 13.5-17.5 meters (Wood, 1953).

During the 1963-64 U.S. Department of the Interior investigations of Lake Erie, isopods were commonly noted in the central basin and to some extent in the western basin. A distribution map compiled from approximately ten cruises shows a distribution pattern quite different from ones obtained in this study. This will be discussed further in another section. The isopod collected during the 1963-64 study was identified as *Asellus militaris*. This was probably a misidentification since *A. militaris*, now known as *A. intermedius*, has never been found in the lake by other investigators and no reliable key existed at that time which could differentiate species. Nevertheless, the study did indicate that isopods were a characteristic fauna of the "moderately polluted zone" where only a few types of organisms could survive in the "soft, shifting, bottom organic sludge blanket" (U.S. Dept. of the Interior, 1964). The study also concluded that isopods may have been effectively isolated from predators and could thus reproduce in large numbers.

A near shore fauna study by Veal and Osmond (1968) noted isopods in western and central Lake Erie near the Canadian shore. *Asellus* sp. was found at 29% and 5% of the stations in the central and western basins respectively and ranged in depth from 5-18 meters.

During a study by Britt et al., (1973) *Asellus* sp. was noted in very small numbers ($1/m^2$) at a station northwest of South Bass Island and at another east of Middle Bass Island.

In 1970, the identity of the Lake Erie isopod was finally elucidated in Williams' revision of the North American epigean species of *Asellus*. Specimens of the isopod collected by J. Hiltunen in 1963 were identified as *Asellus racovitzai racovitzai* Williams (1970) as were specimens from Lakes Ontario, Huron, and Superior.

History of the Subspecies

The holotype of *Asellus racovitzai racovitzai* was collected by W.P. Hay at the edge of the Potomac River near Washington, D.C. on March 15, 1896. Specimens were placed in the United States National Museum and identified by Racovitza in 1920 as Aselllus communis Say. Racovitza provided an excellent description of these organisms but it seems that his decision to regard them as Asellus communis was quite arbitrary (Williams, 1970). According to Williams, it appears that Racovitza did not even site Say's original description of the species in 1818 and named the organism on the basis of geographical similarities. Unfortunately, Say's original material could not be located to compare with Racovitza's description. It was thus necessary to create a neotype of Asellus communis. Collections were made by Williams in the area described by Say in 1818 and a species quite different from Racovitza's 1920 description was noted. It was, therefore, decided that Racovitza's description was indeed a new species and was named Asellus racovitzai racovitzai by Williams in 1970. The other isopod collected at this location is now the neotype of Asellus communis.

Geographical Distribution

Asellus r. racovitzai is the dominant species of isopod in the Laurentian Great Lakes and is most common in Lake Erie and Lake Ontario. In fact, this may be the only species of Asellus found in the Great Lakes with the exception of one specimen of Asellus forbesi found in Lake Huron (Williams, 1970). Asellus has been collected from 20-42 meters in the Great Lakes but may also be found in creeks, rivers, ponds, small lakes, and swamps. This particular subspecies is most common in the northeastern United States and southeastern Canada but has also been found in Washington and Indiana (Williams, 1970). As of 1970, the subspecies had been found in the following states and areas: Indiana, Maryland, Massachusetts, Michigan, Vermont, Washington, D.C., Washington, and Ontario. During 1972, several new localities were reported by Fleming. Suprisingly, these included Quarry cave and

Lawson's cave in Tazewell county, Virginia. The subspecies was also reported from Pulaski county and Roanoke county, Virginia. This was the furthest south that the subspecies has ever been reported and the first time that it has ever been found in caves. Williams (1970) should be consulted for a more complete listing of localities where collected.

RESULTS

Sex Determination

The data of Table 2 indicate a numerical superiority of females over males during March 29-April 25, 1975. When tested with Chi square, the null hypothesis that the number of males equal the number of females was rejected at the 0.05 probability level. During this period, females comprised approximately 68% of the population as compared to only 32% males. The remaining months of the study had much more even numbers of males and females and when tested with Chi square, the null hypothesis could not be rejected. However, due to the small size of the sample these data should be viewed with caution.

Table 2

Number of Males and Females Collected
During Random Sampling of Cruises 1-4 1975

Date	Males	Females	Unknown
March 29-April 25	11	24	7
June 9-June 16	11	12	9
July 13-July 24	8	11	9
Aug. 27-Sept. 5	9	8	39

Depth

A mean depth of 18.3 meters was noted for all stations posessing *Asellus*. Stations 31,32,33,34, and 36, which consistently had the highest numbers of the organism, had a mean depth of 21.1 meters. Both of these values are much higher than Wood's 1953 data which proposed an average depth of 15.56 meters for stations posessing *Asellus*. Wood's stations were, however, largely confined to the shallower western basin and there have been significant depth increases in both basins since 1953.

Size Frequency Distribution

Cruise 1: Females with marsupia were found to have an average length of 6.1 mm (Table 8). The highest number of organisms was found in the 6-7 mm size range. There were no organisms noted in the 1-2 mm size interval thus indicating low reproduction in the preceding winter months.(Fig. 13). Eggs were irregularly rounded and approximately .3 mm in diameter.

Cruise 2: The majority of organisms (26.2%) again fall within the 6-7 mm size interval. An average length of 5.8 mm was noted for females with marsupia. Eggs, embryos, and young were noted in the marsupia. Well developed young approximately 1.1-1.2 mm in length were found to still be in the marsupium.

Cruise 3: There has been a radical change in size frequency from June to July (Fig. 13). The majority of organisms (41.3%) now fall within the 2-3 mm size range. The number of isopods in the 1-4 mm size range has increased from 9.6% and 9.0% in cruises 1 and 2 respectively to 55.9% and 67.7% in cruises 3 and 4 (Table 7). This is obviously due to the emergence of a large number of young which must take place in mid June to July and last until late August or early September. The number of females with marsupia declined to only 7.3% of the total population.

Cruise 4: The number of females with marsupia has now dropped to only 3.3% of the total population. Reproduction has slowed appreciably but young are still emerging. The number of larger organisms (7-12mm) has significantly decreased from 18.4% in cruise 3 to only 4.4% in cruise 4 (Table 7).

The largest male isopod collected was 11.9 mm and the largest female was 9.9 mm.

Biomass

Biomass data obtained during this study indicated a variance in weight during different times of the year. During March-April and June an average dry weight per organism of 1.7 and 1.6 mg were noted respectively (Table 5). During this time period, the biomass of isopods at some stations was estimated by the author to comprise approximately 30-50% of the total benthic biomass. At the majority of stations, however, the biomass of isopods is relatively insignificant. During July and September, populations were largely composed of young organisms and weights of .8 and .9 mg per organism respectively were noted. (Table 5). It should be pointed out that all of these weights may be artificially low due to loss of weight in preservation and loss of limbs during sorting, measuring, and sex determination.

The highest biomass values obtained were at station 33 during cruise 2 and were calculated to be 10.6 kg/hectare.

Other Members of the Faunal Assemblage

A number of other organisms were noted in association with *Asellus*. These were identifed by Dr. N. Wilson Britt as part of the Lake Erie Nutrient Control Study of 1975. The author is indebted to Dr. Britt for allowing the use of this data. The list of organisms was as follows:

Phylum Arthropoda
- Class Insecta
  - *Chironomus* (Chironomus) *plumosus*
  - *Chironomus* (Chironomus) *riparius*
  - *Chironomus* (Cryptochironomus) sp.
  - *Tanytarsus* sp.
  - *Microspectra* sp.
  - *Procladius* sp.
  - *Coelotanypus* sp.
  - *Heterotrissocladius* sp.
- Class Crustacea
  - *Gammarus fasciatus*

Phylum Mollusca
Class Gastropoda
Valvata sincera
Valvata tricarinata
Amnicola sp.

Class Pelycypoda
Sphaerium sp.
Psidium sp.

Phylum Annelida
Class Oligochaeta (report pending by A. Pliodzinskas)

Class Hirudinea
Helobdella stagnalis
Helobdella elongata

Phylum Platyhelminthes
Class Turbellaria
Order Rhabdocoelida?

The relative frequency of occurrence of these organisms at stations with and without *Asellus* is given in Table 9.

Food Studies

Guts from Lake Erie's isopods were found to contain a large number of the desmid *Tetraedron* and the chlorophycean *Pediastrum*. Pieces of cladocerans were also fairly common as were the palmelloid stages of algae and unidentifiable debris. Filamentous algae fragments, *Anabaena*, fish scales, silt and sand, and diatom frustules were also occasionally found. The majority of material was organic debris of no recognizable form.

Table 3

Mean Number of *Asellus r. racovitzai* Per Square Meter

Station	Cruise 1	Cruise 2	Cruise 3	Cruise 4
24	28.5	--	19.0	57.0
27	19.0	--	--	95.0
29	28.5	--	--	114.0
30	19.0	19.0	--	--
31	28.5	--	114.0	399.0
32	28.5	313.5	9.5	19.0
33	9.5	1187.5	123.5	--
34	351.5	28.5	446.5	--
35	133.0	--	--	--
36	57.0	66.5	180.5	38.0
37	--	--	19.0	--
38	9.5	38.0	47.5	38.0
40	38.0	--	9.5	19.0
41	66.5	19.0	28.5	--
47	--	9.5	--	--
48	38.0	--	--	142.5
49	19.0	19.0	--	--
50	--	--	38.0	38.0
51	--	--	9.5	--
53	--	--	9.5	--
68	--	19.0	--	--
73	--	--	9.5	--
74	--	9.5	--	--
78	19.0	--	57.0	161.5
79	--	171.0	47.5	--

Table 4

Calcium and Total Dissolved Solids at One Meter Depth for Selected Stations in Lake Erie*

	Mouth of Grand River, Ohio	Off Grand River, Ont.	Mid Lake Cen. Basin
Ca (mg/l)	76.5	40.9	38.4
TDS (mg/l)	373	198	490

Off Detroit River	Cleveland Harbor	Mid Lake off Cleve.	N.E. Western Basin
32.9	56.5	40.1	32.4
168	490	202	162

S. Central W. Basin	Toledo Harbor
34.5	50.3
166	323

* Samples taken from June 1-Oct. 30, 1967. Data from International Lake Erie Water Pollution Board (1969).

Table 5

Biomass of Isopods at Selected Stations
During Cruises 1-4, 1975

Station	No. of Org.*	Dry Weight (g)	Dry Weight/Org.(g)
Cruise 1			
31	3	.0034	.0011
32	3	.0068	.0023
33	1	.0019	.0019
34	37	.0719	.0019
36	6	.0147	.0024
38	1	.0006	.0006
			Mean=.0017
Cruise 2			
31	0	--	--
32	33	.0513	.0016
33	125	.1162	.0013
34	3	.0083	.0028
36	7	.0090	.0013
38	4	.0036	.0009
			Mean=.0016
Cruise 3			
31	12	.0074	.0006
32	1	.0005	.0005
33	13	.0157	.0012
34	47	.0024	.0001
36	19	.0225	.0012
38	5	.0059	.0012
			Mean=.0008
Cruise 4			
31	21 (1 drop)	.0372	.0017
32	2 (inc.)	.0014	.0007
33	0	--	--
34	0	--	--
36	4	.0022	.0006
38	4	.0026	.0007
			Mean=.0009

* No. of organisms equals the composite of two ponar grabs.

Table 6

Brood Size of Females Collected During Cruises 1-2, 1975

Female length (mm)	No. eggs	No. embryos	No. immat.
Cruise 1			
5.3	40	--	--
5.4	38	--	--
5.7	52	--	--
5.8	53	--	--
5.9	66	--	--
6.0	87	--	--
6.5	82	--	--
6.7	79	--	--
7.3	96	--	--
Cruise 2			
5.0	43	--	--
5.3	45	--	--
5.3	31	--	--
5.6	26	--	--
5.7	14	--	--
5.8	--	--	30
5.8	--	--	34
6.0	--	24	--
6.0	--	--	25
6.0	--	20	--
6.1	--	44	--
6.1	--	--	20
6.3	81	--	--
6.3	--	--	37
6.3	--	79	--
6.5	81	--	--
6.5	65	--	--
6.7	--	--	22
6.7	75	--	--
6.8	--	41	--
6.8	--	--	11

Table 7

Length Frequency Distribution, Cruises 1-4, 1975

Interval Length (mm)	Frequency	% of Total
Cruise 1		
.99-1.99	0	0
1.99-2.99	2	2.1
2.99-3.99	7	7.5
3.99-4.99	7	7.5
4.99-5.99	16	17.2
5.99-6.99	28	30.1
6.99-7.99	18	19.4
7.99-8.99	12	12.9
8.99-9.99	2	2.1
9.99-10.99	2	2.1
10.99-11.99	0	0
Cruise 2		
.99-1.99	1	.5
1.99-2.99	4	2.1
2.99-3.99	12	6.4
3.99-4.99	25	13.4
4.99-5.99	42	22.4
5.99-6.99	49	26.2
6.99-7.99	14	7.5
7.99-8.99	21	11.2
8.99-9.99	11	5.9
9.99-10.99	3	1.6
10.99-11.99	0	0
Cruise 3		
.99-1.99	7	6.4
1.99-2.99	45	41.3
2.99-3.99	9	8.2
3.99-4.99	5	4.6
4.99-5.99	11	10.1
5.99-6.99	12	11.0

Table 7 (continued)

Interval Length (mm)	Frequency	% of Total
Cruise 3		
6.99-7.99	4	3.7
7.99-8.99	3	2.7
8.99-9.99	4	3.7
9.99-10.99	5	4.6
10.99-11.99	4	3.7
Cruise 4		
.99-1.99	10	11.1
1.99-2.99	31	34.4
2.99-3.99	20	22.2
3.99-4.99	15	16.7
4.99-5.99	4	4.4
5.99-6.99	6	6.7
6.99-7.99	1	1.1
7.99-8.99	2	2.2
8.99-9.99	0	0
9.99-10.99	0	0
10.99-11.99	1	1.1

Total Number of Organisms

Cruise 1- 93
Cruise 2- 187
Cruise 3- 109
Cruise 4- 90

Table 8

Population Data

Date of Collection	No. of Organisms	No. Gravid Females	% Gravid Females*	Ave. Length Gravid Female	% of Organisms 1-4 mm long
3/29-4/25	93	27	29.0	6.1 mm	9.6
6/9-6/16	187	37	19.8	6.1 mm	9.6
7/13-7/24	109	8	7.3	--	56.0
8/27-9/5	90	3	3.3	--	67.7

* % of total population

Table 9

Other Organisms in Association with Asellus

Organism	No. of Stations in Association with Asellus	No. of Stations not in Association with Asellus
C. plumosus	24	36
C. riparius	23	39
C. (Cryptochironomus)sp.	4	14
Tanytarsus sp. ?	7	5
Procladius sp.	17	32
Coelotanypus sp.	2	20
Heterotrissocladius sp.	2	4
Gammarus fasciatus	2	6
Valvata sincera	2	5
Valvata tricarinata	1	1
Amnicola sp.	1	2
Helobdella stagnalis	5	11
Helobdella elongata	1	6
Turbellaria	21	27

Asellus was found at 28 stations out of a total of 83 stations sampled.

Data on *Sphaerium* sp. and *Psidium* sp. were incomplete.

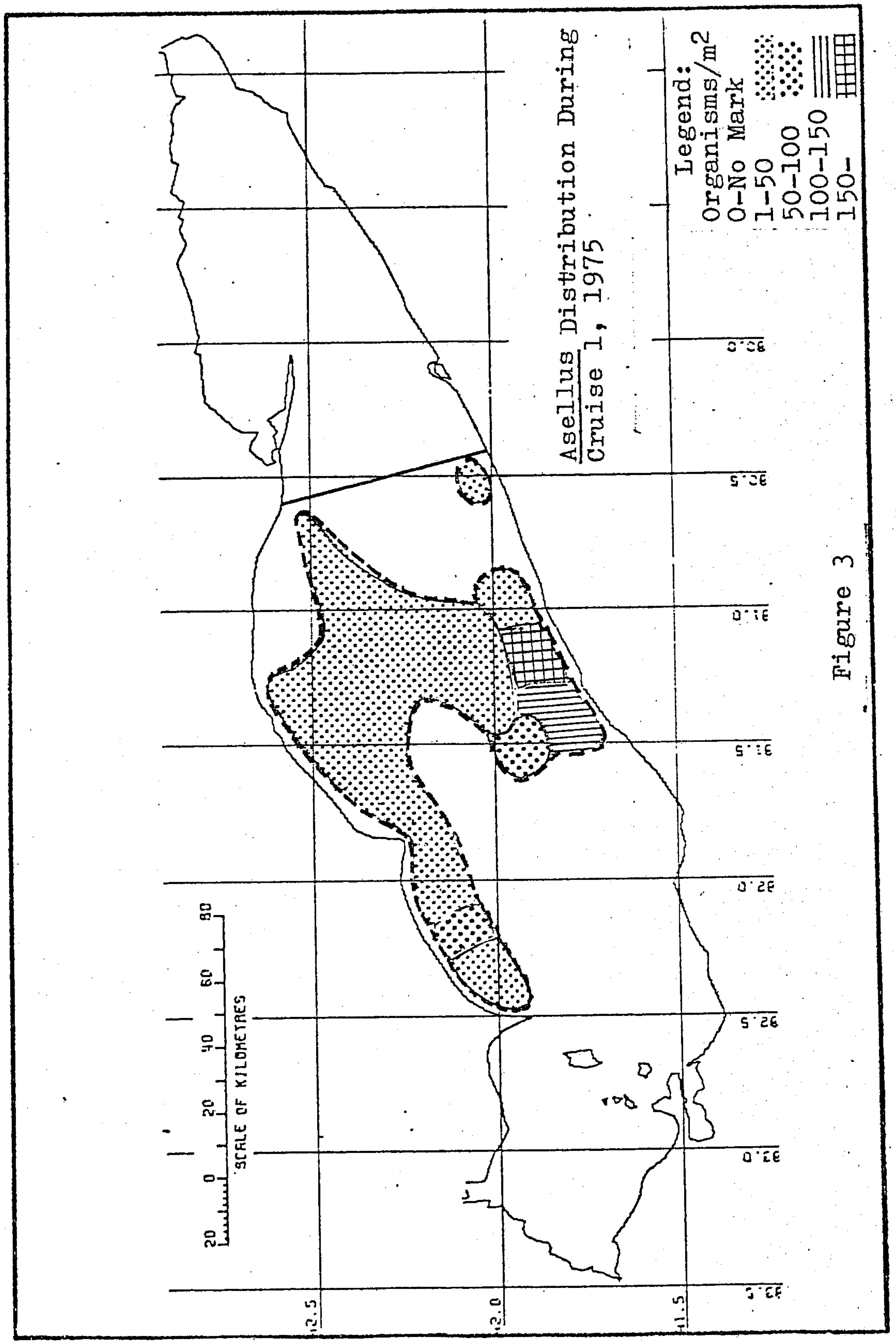
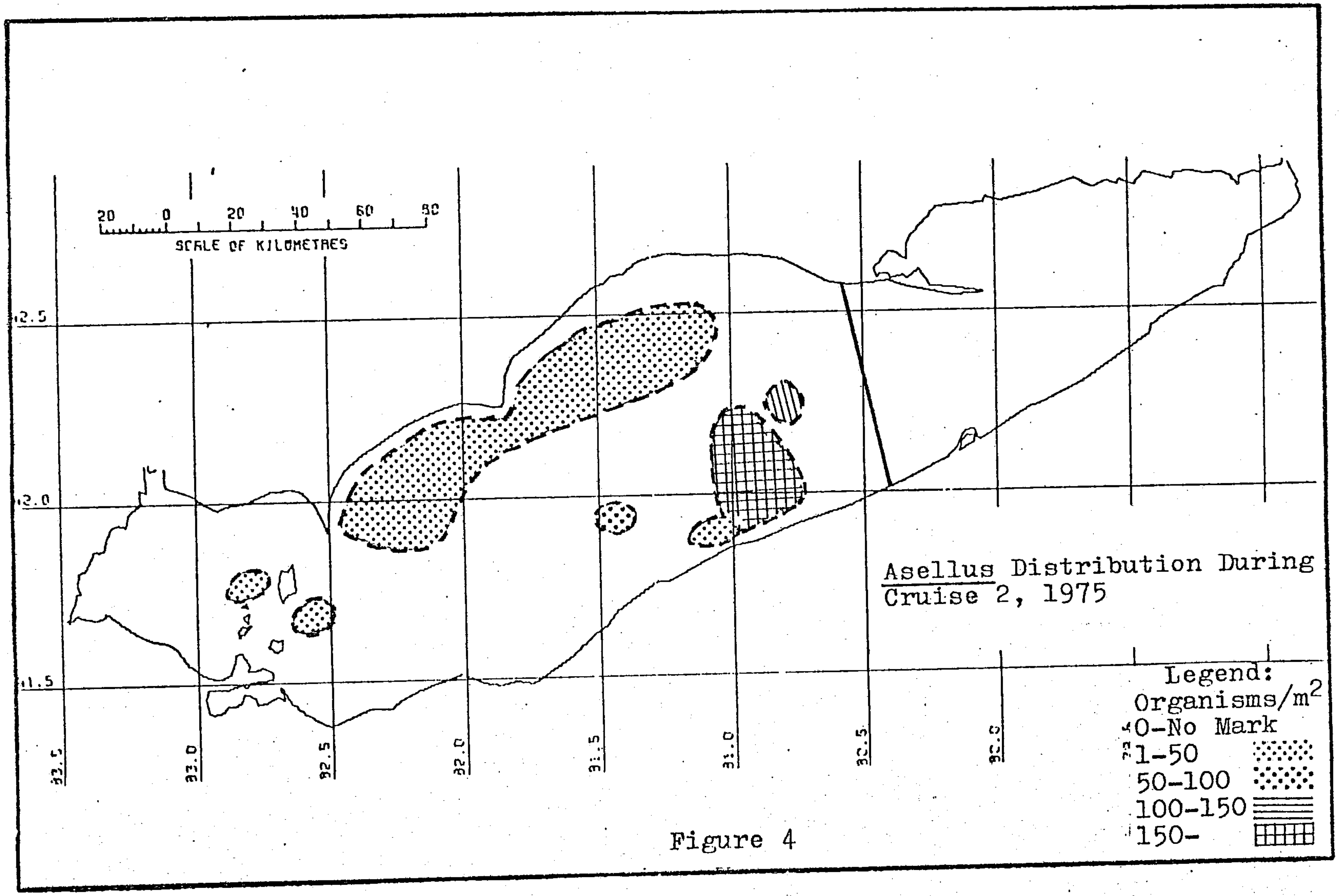

Asellus Distribution During
Cruise 1, 1975
Legend:
Organisms/m2
0-No Mark
1-50
50-100
100-150
150-
SCALE OF KILOMETRES
20
0
20
40
60
80
80.0
80.5
81.0
81.5
82.0
82.5
83.0
83.5

Figure 3



Asellus Distribution During Cruise 2, 1975

Figure 4

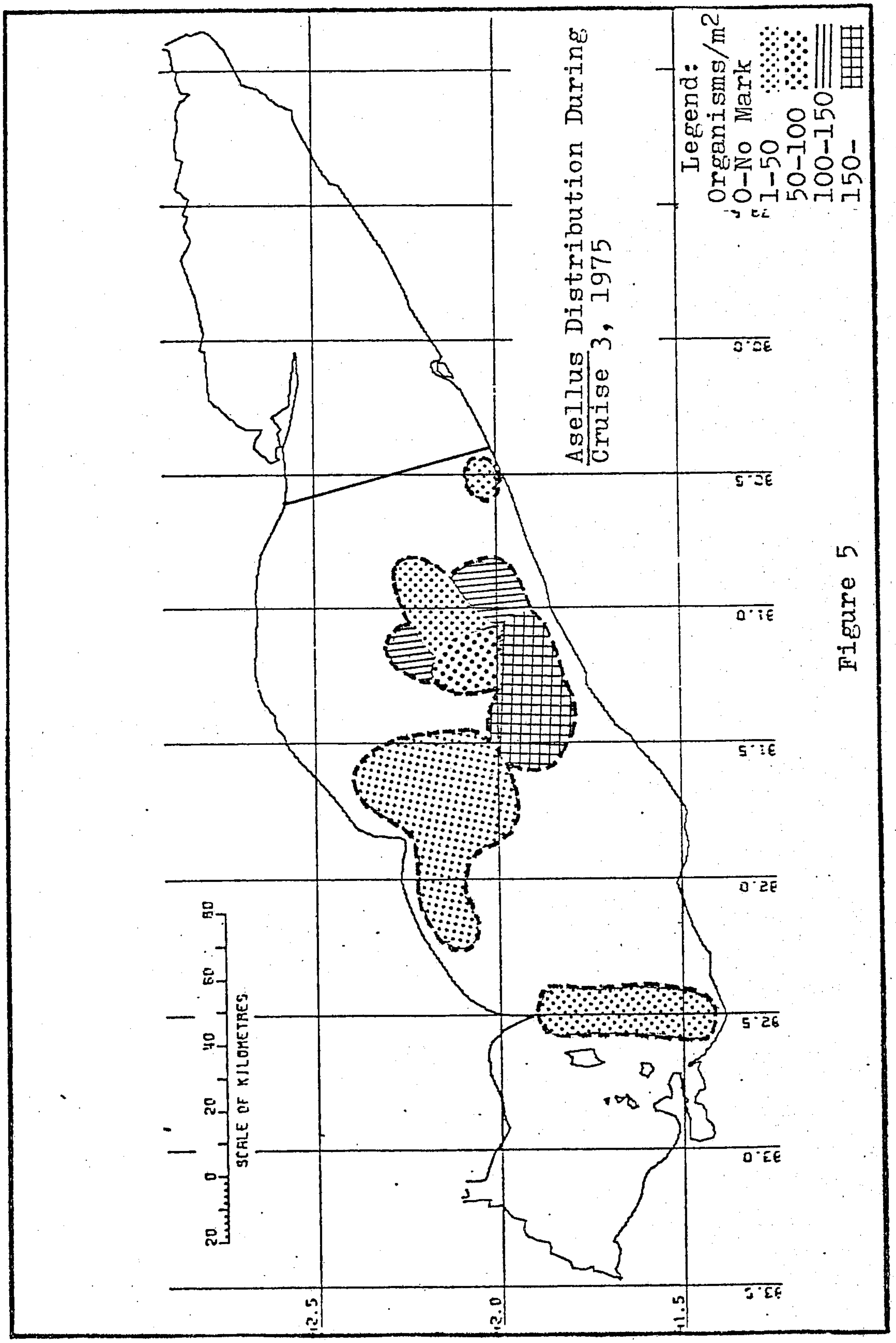

Asellus Distribution During
Cruise 3, 1975
Legend:
Organisms/m²
0-No Mark
1-50
50-100
100-150
150-
SCALE OF KILOMETRES
20
0
20
40
60
80
12.5
12.0
11.5
30.0
30.5
31.0
31.5
32.0
32.5
33.0
33.5

Figure 5

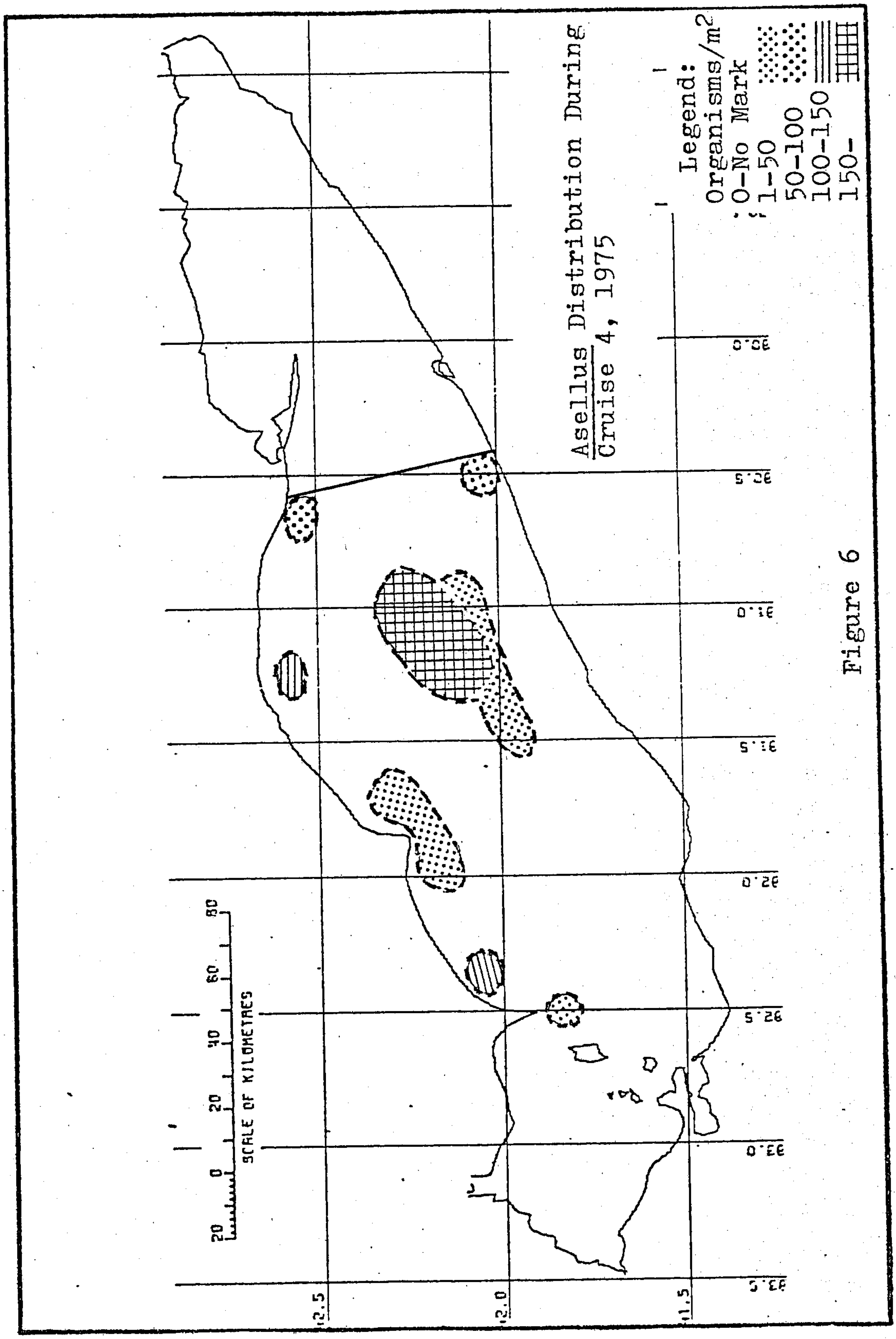
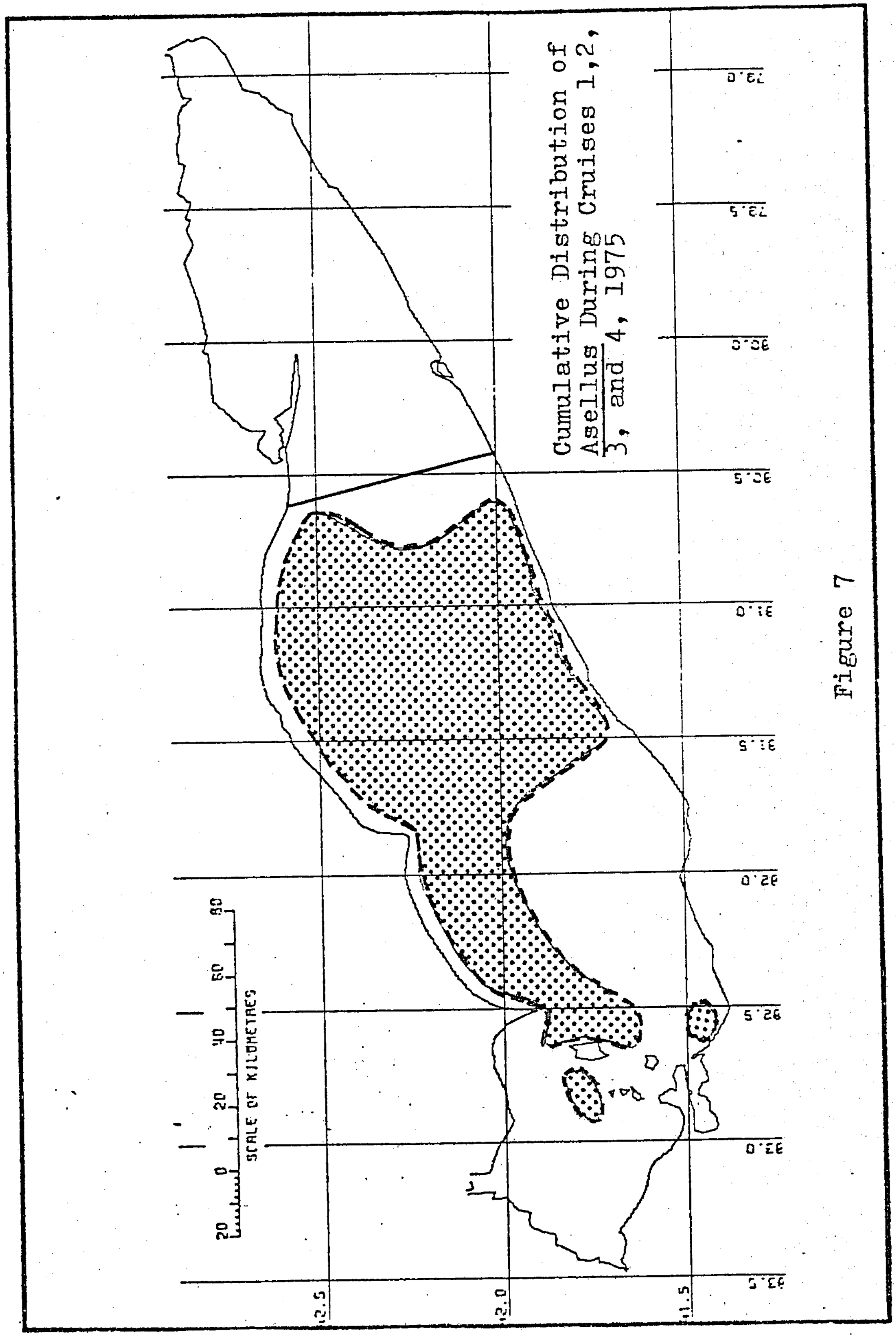

Asellus Distribution During
Cruise 4, 1975
Legend:
Organisms/m²
0-No Mark
1-50
50-100
100-150
150-
SCALE OF KILOMETRES
20
0
20
40
60
80
90.0
90.5
91.0
91.5
92.0
92.5
93.0
93.5
12.5
12.0
11.5

Figure 6



Cumulative Distribution of *Asellus* During Cruises 1,2, 3, and 4, 1975

Figure 7

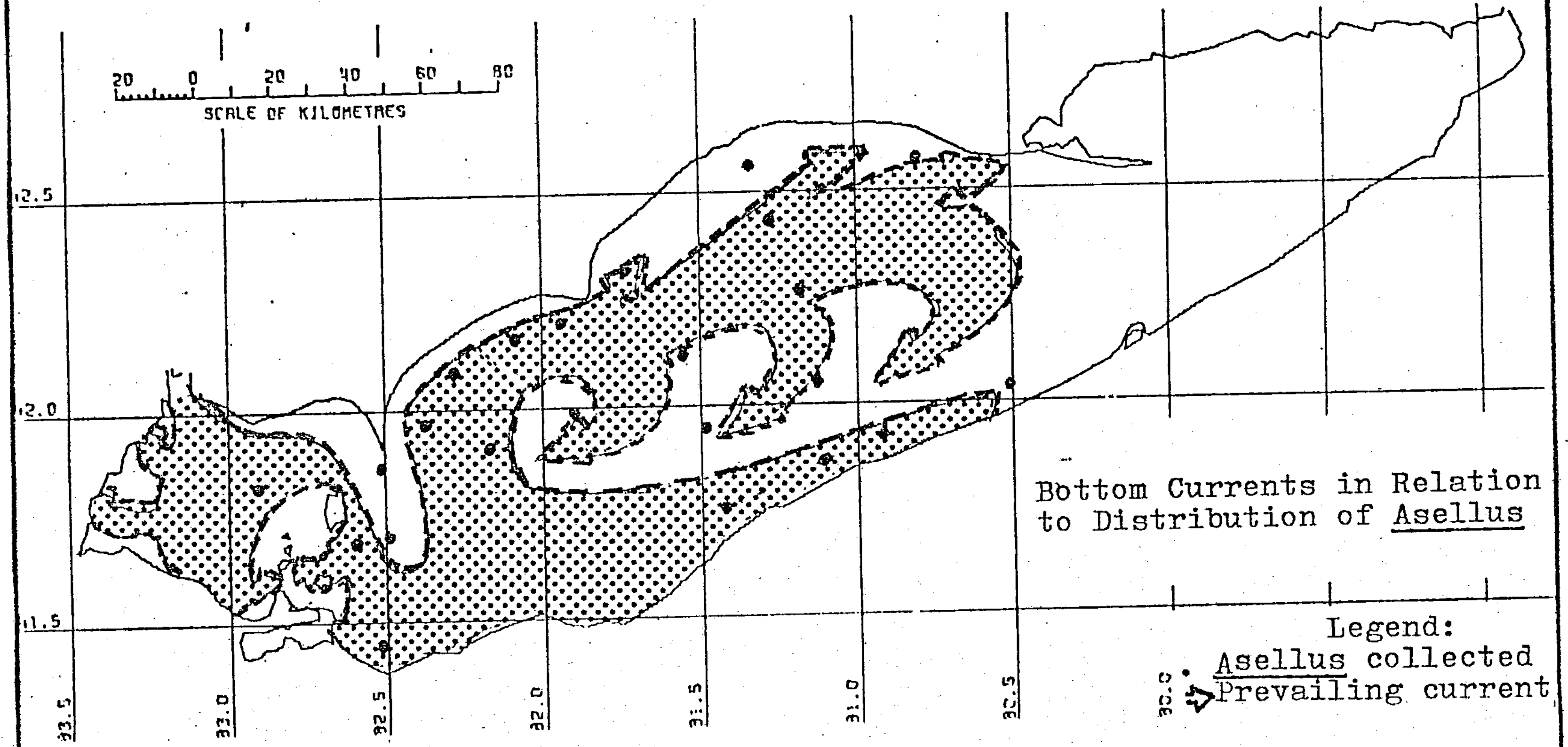


Figure 8

(modified from Int. Lake Erie Water Poll. Bd., 1969)

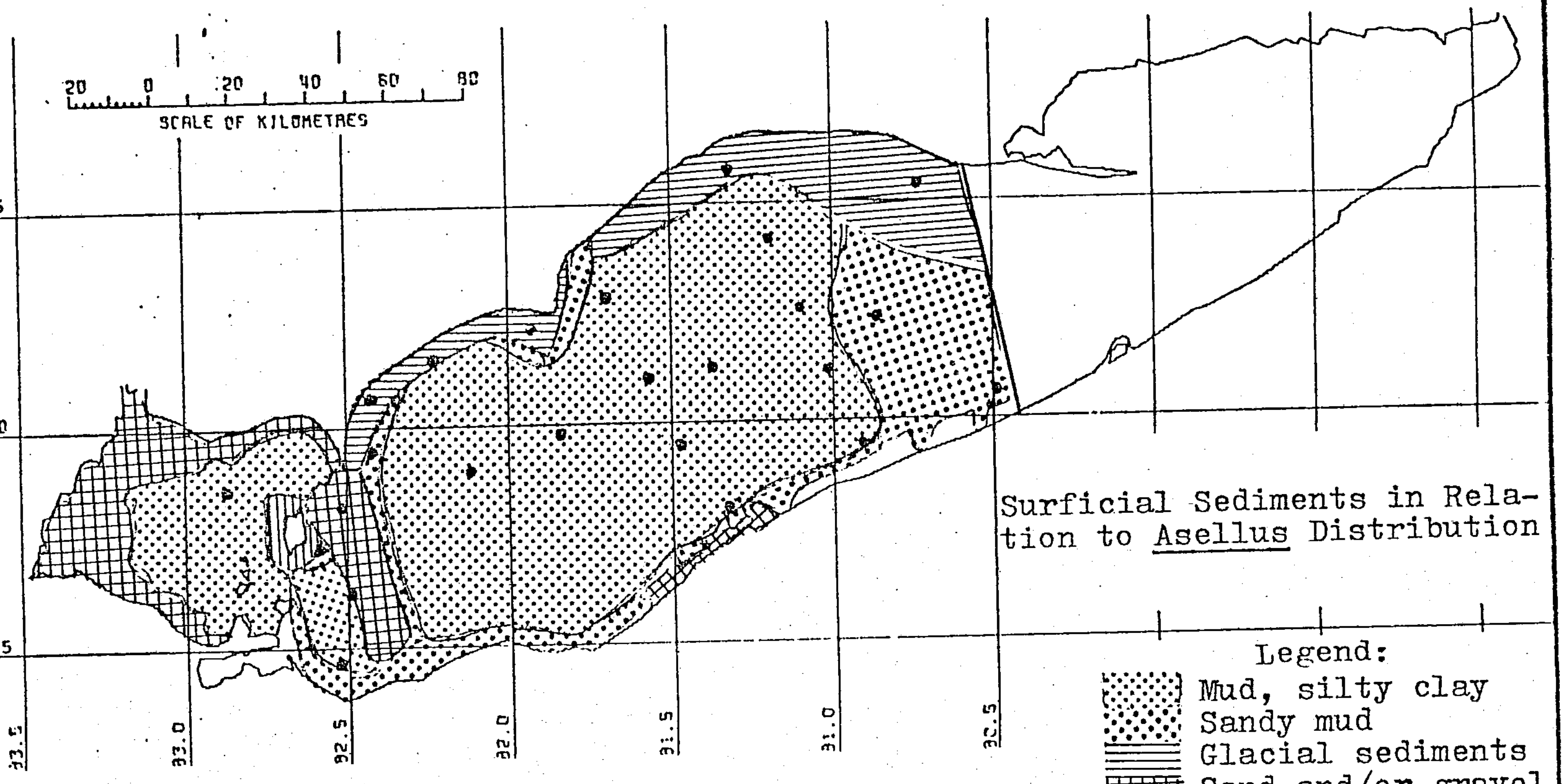
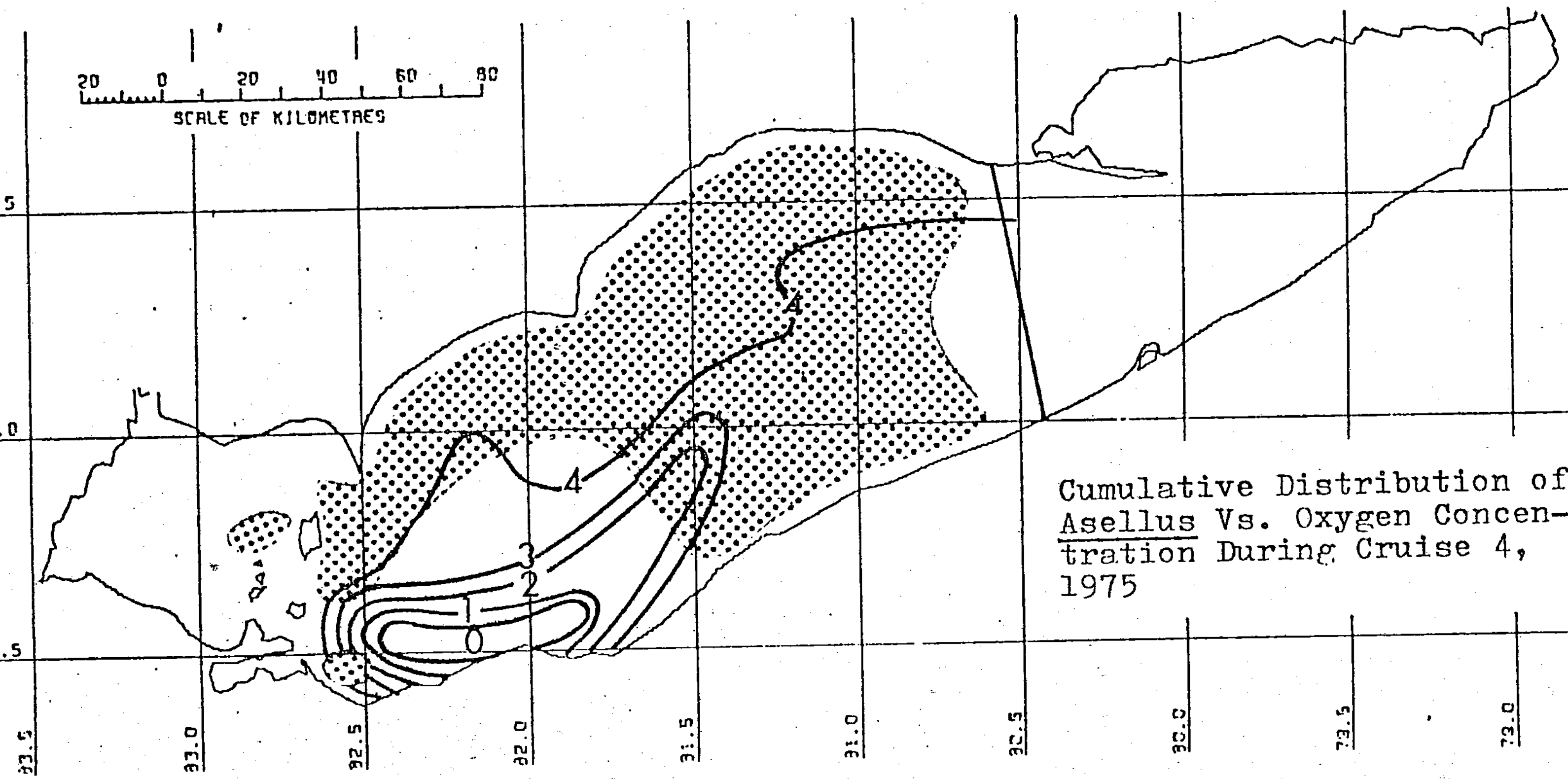


Figure 9

(modified from Thomas et.al., 1976)



Cumulative Distribution of <u>Asellus</u> Vs. Oxygen Concentration During Cruise 4, 1975

Figure 10

(oxygen data from Herdendorf, 1976)

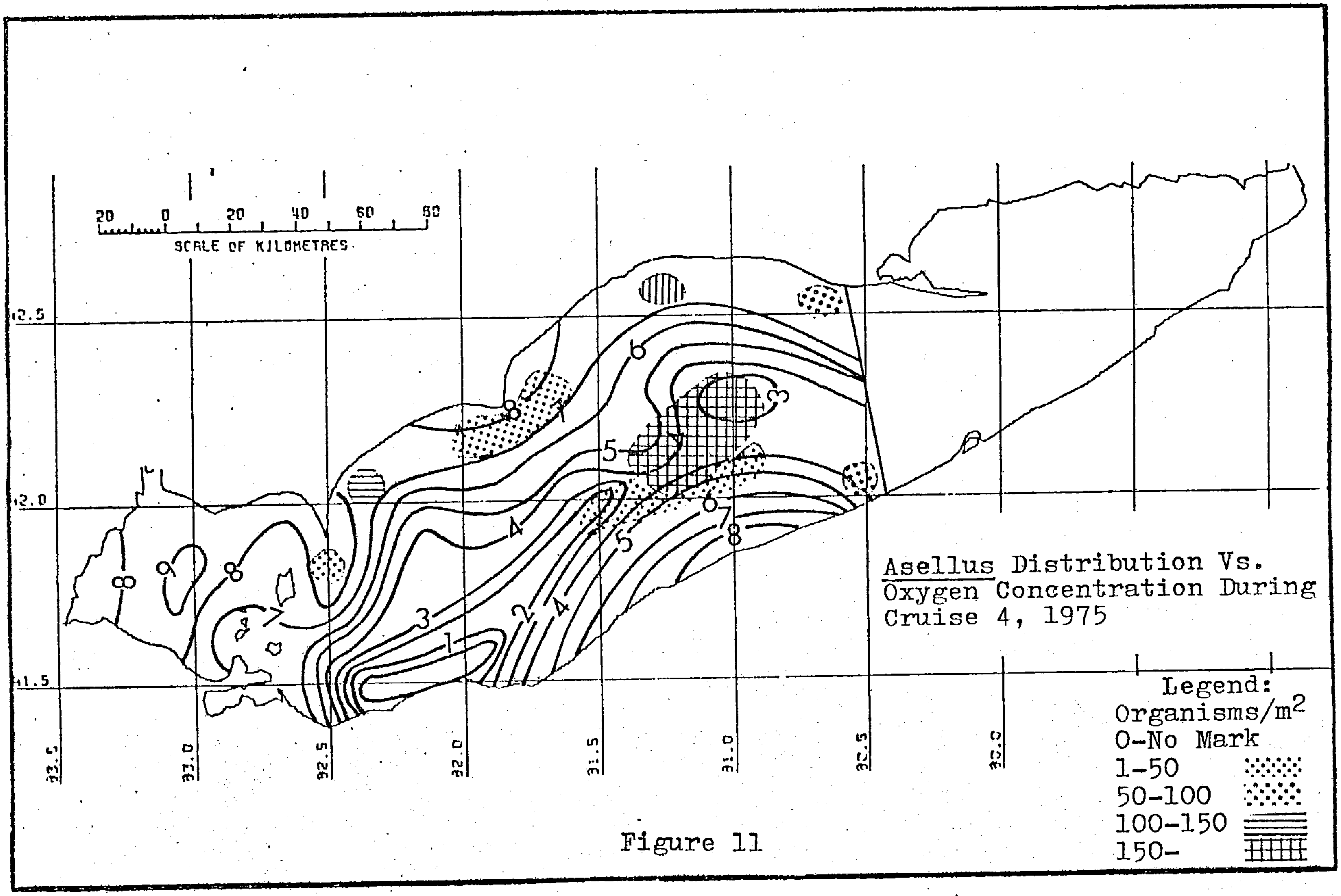


Figure 11

(oxygen data from Herdendorf, 1976)

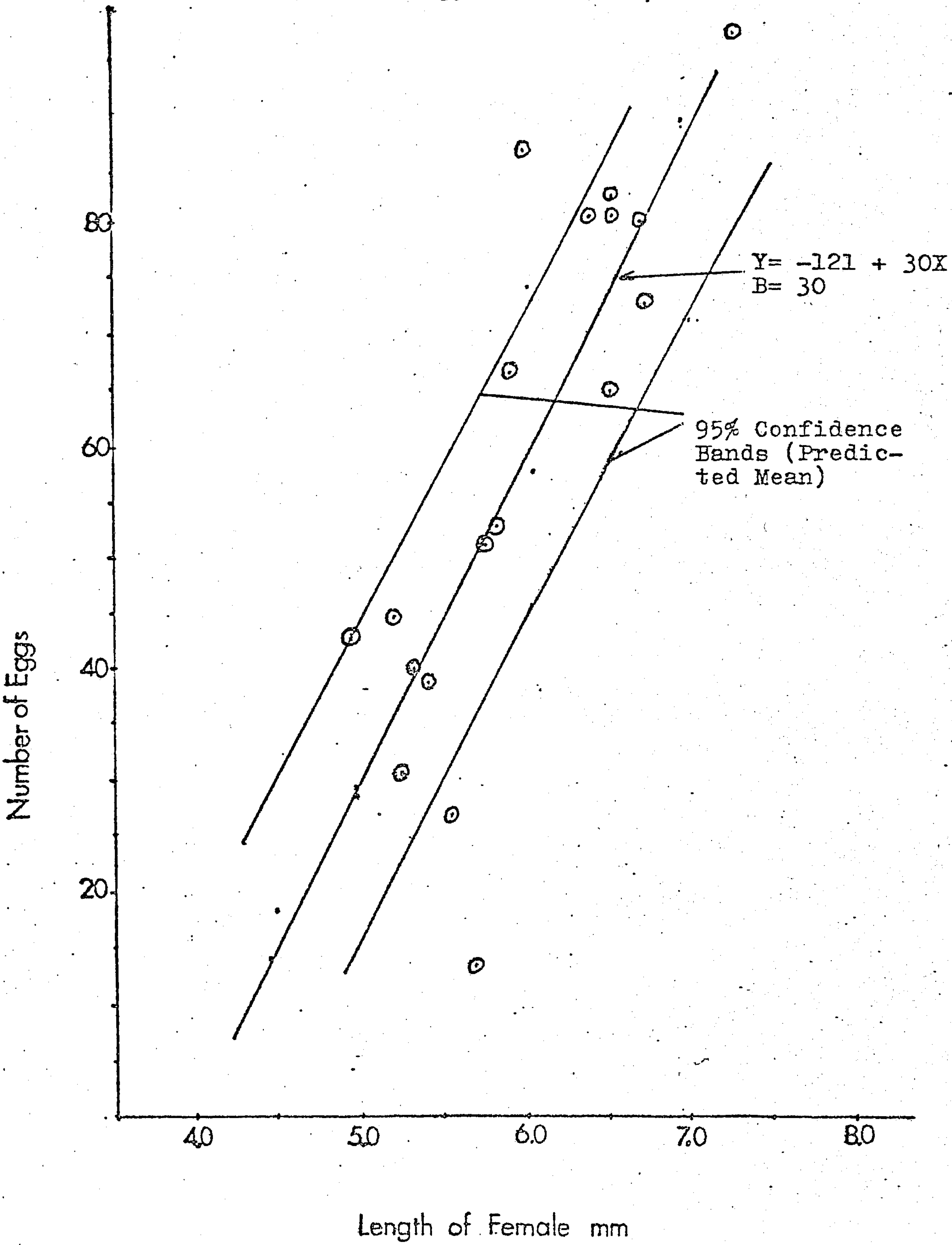


Fig. 12: Length of Female vs.
Number of Eggs

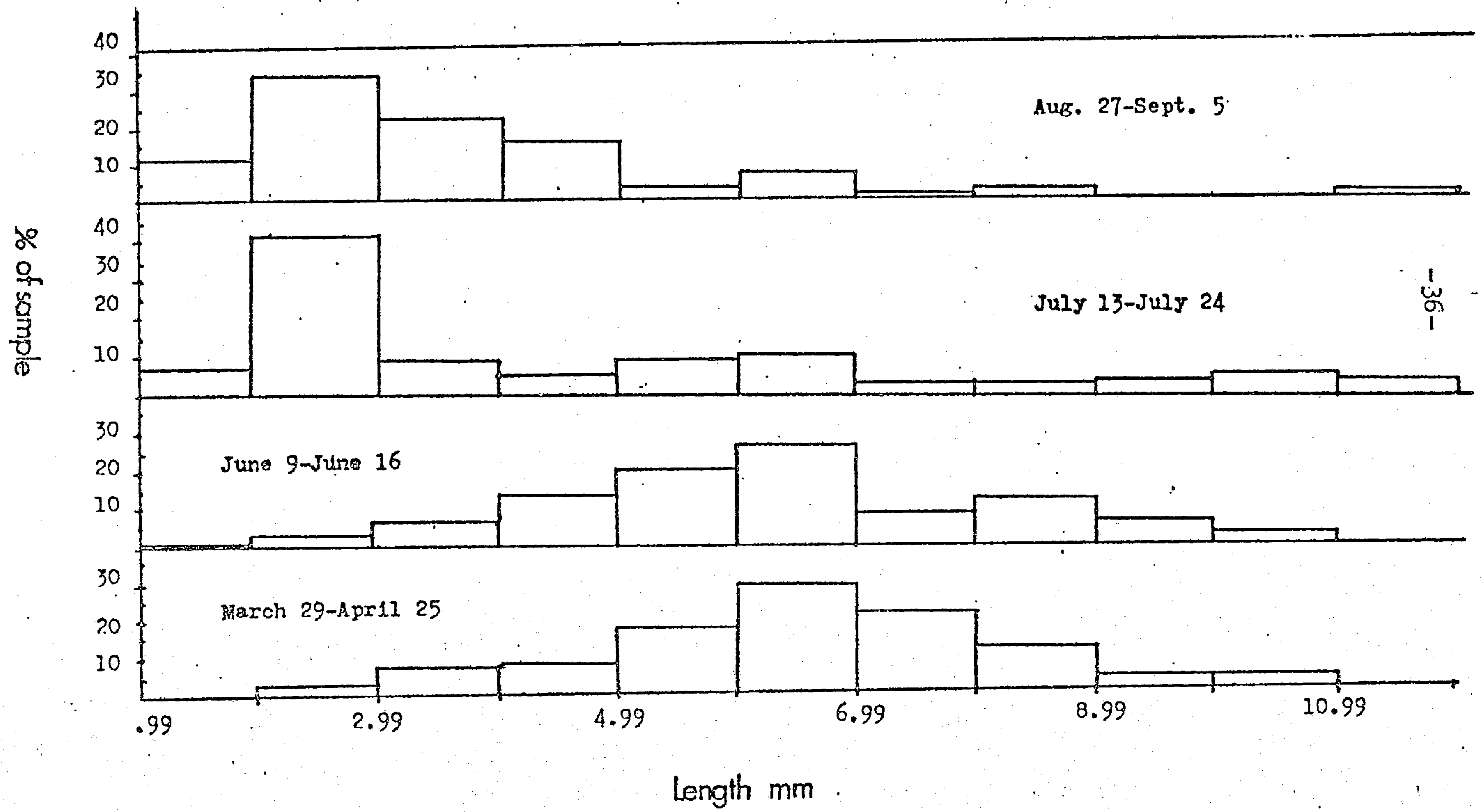


Fig. 13 Size Frequency Distribution

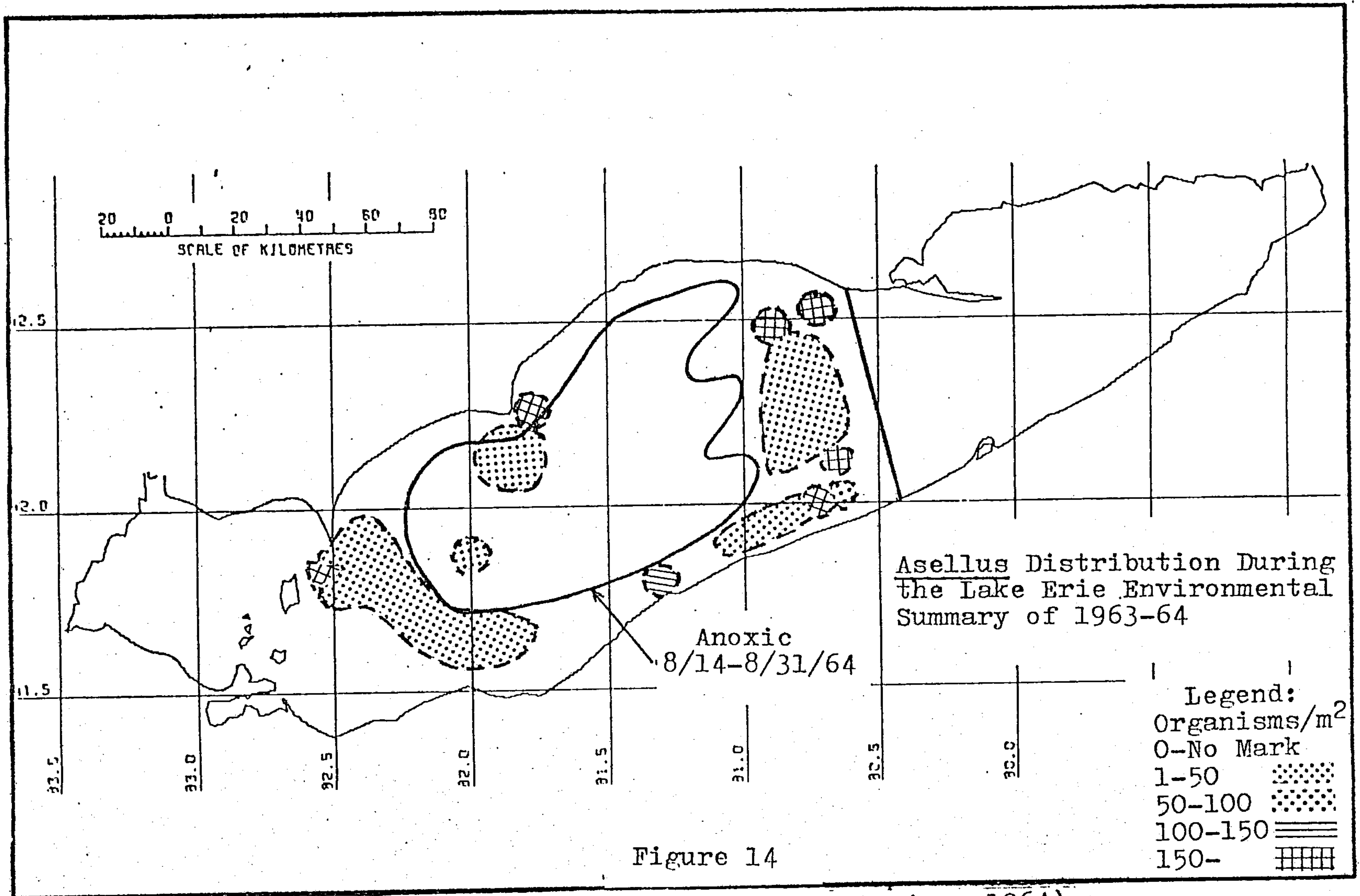


Figure 14

(data from U.S. Dept. of the Interior, 1964)

DISCUSSION

Distribution and Density

Analysis of samples taken during cruises 1,2,3, and 4, showed that *Asellus* was predominantly found in the central basin (Figs. 3,4,5,6,7, and Table 3). Only small numbers of the organism were noted in the western basin and these were generally restricted to the Bass Island area and areas south of Point Pelee. This tends to be supported by previous studies (Wood, 1953; Britt et al., 1973; Herdendorf, 1973b;1974) which found only very low numbers of *Asellus* west of a line south of Point Pelee.

The reason for the lack of *Asellus* in the western basin is unclear but may be related to an excess of wave orbital energy acting upon the sediment of that basin. High inputs of fine grained sediments into the basin greatly overbalance the output into the central basin. There is also a general deficit in coarser materials. There is, therefore, a resultant lack of equilibrium between the texture of the sediment and the environmental energy working on it.(Thomas et al., 1976). As a result, mixing and resuspension of sediment occurs which is followed by redeposition. This mechanism appears to be supported by trace metal and nutrient studies in which mixing of the sediment appears to occur at sediment depths of 14-20 cm in the western basin (Thomas et al., 1976). This mixing may be due in part to bioturbation, however there is little doubt that physical mixing is a very important process. What this all leads up to is the hypothesis that the substrate in the western basin is too unstable for isopod colonization. The food source of this deposit feeder, namely the surficial sediments, are in a constant state of turnover and flux which may render them unavailable to the organism.

Near shore areas in both basins were not sampled during this study and consequently leave a gap in the data. The organism has, however, been collected from beneath large rubble along the shore of Gibraltar Island by the author and is probably present at many other near shore locations.

The highest densities of Asellus were consistently found in the area northeast of Fairport harbor and west of Ashtabula in the central basin (Figs. 3,4,5, and 6). The most probable reason for this is food supply. Food supply for invertebrates is generally the dominant controlling factor that influences productivity and population dynamics in a freshwater benthic community (Hall, 1970). Ellis (1961) noted that *A. intermedius* was found in highest numbers approximately one hundred yards downstream from a sewage outfall. Moon (1957) stated that *A. aquaticus* has been noted in Europe as a characteristic animal in areas of fairly severe organic pollution. This suggests that sewage is a likely food source for isopods. Stations 33 and 34 consistently have the highest numbers of Asellus in Lake Erie and are close enough to shore to experience the littoral drift of sewage along the southern shore. This area also posesses large populations of Oligochaeta which rangedin number from approximately $5000/m^2$ near shore to $2000/m^2$ during a 1973 study (Herdendorf, 1973b). These values indicate higher organic content closer to shore. Densities of Asellus just north of the area are also high during different times of the year and may be due to the transport of material originating on the southern shore to the northern shore by open lake currents.

Currents

Subsurface currents in Lake Erie are generally the least understood. They appear to be indirectly related to wind driven currents and are also believed to be the result of seiche activity (Ohio Div. Geol. Survey, 1966). More recent information suggests that they may be due to thermocline elevation and depression as a result of wind set up and the resultant internal seiche, and the sinking and upwelling of water masses (Herdendorf, 1973a). Bottom current information has largely been ascertained by the use of a bottom drifting device known as a sea bed drifter. Upon review of data from drifter studies, it can be shown that bottom circulation is of two general types: open lake flow and near shore flow. Several investigators have concluded that open lake currents are responsible for the transport of materials from the southern shore to the northern shore in a layer adjacent to the bottom (Ohio Div. Geol. Survey, 1966).

Both open lake and near shore currents have an effect on the distribution of Asellus. It should be realized, however, that some of these currents may only occur during the summer when the lake is stratified (Herdendorf, 1973a). The most important of these effects is probably the distribution of a food resource. According to Stokes law, particles of a given density sediment through water at a rate which is proportional to the size of the particle. Small particles such as particulate organic carbon are therefore, held in suspension in moving water and are deposited at the bottom in static water (Wetzel, 1975). As already noted, the Asellidae prefer high organic content in sediments and as a result should be more common in static water. When Asellus distribution is superimposed upon a bottom current map (Fig. 8) it is difficult to note this relationship. However, some stations such as 40, 41, 48, and 49 obviously recieve deposition due to littoral drift and changes in current direction and Asellus is commonly found there. Stations 33 and 34, as already mentioned, recieve a littoral drift of sewage along the southern shore.

Aggregation of organisms due to rheotropic response to current as discussed by Alee (1929) was probably insignificant due to the slow velocities of bottom currents and the fact that a current swept bottom is not conducive to deposit feeding organisms.

Surficial Sediments

There is insufficient data available to the author to attempt to correlate the distribution of *Asellus* with surficial sediment type or organic carbon content in sediments. However, some general trends can be noted.

Asellus seems to be most common in post glacial muds composed of soft, silty clay (Fig. 9). This area comprises approximately 58% of the lake bottom and can be closely correlated with areas of higher organic carbon content reported by Thomas et al., (1976). This appears to be consistent with the findings of Sanders (1958) who correlated the distribution of several deposit feeders in Buzzards Bay, Massachusetts with the percentage clay. Sanders concluded that this clay preference was due to the larger relative surface area of clay and the resultant binding of more organic matter which is the food source of deposit feeders.

Asellus is also found in glacial deposits along the northern shore of Lake Erie which are characteristicly low in organic matter (Fig. 9). The reason for this is unclear but the local effects of sewage and industrial effluents may be important. *Asellus* was also occasionally collected in the sandy areas south of Point Pelee but was usually found there only in small numbers.

Wood (1953) noted that *Asellus* was most common in western Lake Erie on poorly sorted silt of phi median 5.53.

Oxygen

Oxygen is probably the single most important factor affecting the distribution of *Asellus* in central Lake Erie.

Each year during the summer, the central basin stratifies and the hypolimnion is gradually depleted of oxygen. This depletion generally starts in the southwestern part of the basin and then spreads eastward (Herdendorf, 1973b). This same area in the central basin is conspicuously lacking in Asellus (Fig. 10).

There is no data available to indicate the tolerance of A.r.racovitzai to low level oxygen conditions. However, experiments conducted with A. aquaticus by Russian investigators have shown that that organism could survive from 22-48 hours in the absence of oxygen and could probably exist normally at levels as low as 0.4-0.5 mg/l (Birstein, 1951). According to Waterman (1961) resistance to low partial pressures of oxygen in Asellus varies with the likelihood of there being inadequate amounts of oxygen in the normal environment. As a result, one would expect A.r.racovitzai to be tolerant of quite low oxygen situations. There are, however, no indications that the organism could tolerate a month or more of anoxia such as that which occurs in Lake Erie. It seems reasonable to conclude that Asellus is effectively eradicated from anoxic areas each year. Since this section of the central basin is most likely to go anoxic, it is no suprise that Asellus is rarely found in this area (Fig. 10).

When oxygen data from cruise 4 is mapped over isopod distribution data from the same cruise, anoxic exclusion is again evident (Fig. 11). Isopods can, however, be found in large numbers at dissolved oxygen concentrations of 3-4 mg/l.

During the 1963-64 U.S. Dept. of the Interior investigations of Lake Erie, isopods were rare in the area north of Fairport Harbor but much more common in the far eastern portion of the central basin (Fig. 14). It is significant to note that the area north of Fairport Harbor was anoxic that year and isopods may have been eradicated from this area or possibly forced eastward over a long period of time.

It should be kept in mind that the area north of Cleveland which is frequently lacking in Asellus is subject to many other environmental influences. For example, a great deal of industrial and municipal waste has been dumped into this area in the past. Heavy metals in such effluents can be very toxic to bottom living organisms. Some metals, such as the iron oxides, may precipitate out covering the bottom and may smother bottom living organisms. Other metals such as copper and zinc may have a synergistic toxic effect (Fed. Water Qual. Adm., 1970).

Hydrogen Ion Concentration

In regeneration experiments by Needham (1947) Asellus aquaticus was found to regenerate most rapidly at a pH of 7.4 with normal regeneration occurring in the 6-8.0 pH range. Needham suggests that this is the actual pH range for the organism. In other experiments, A. aquaticus was found to survive from 12-24 hours at a pH of 4.5 and two weeks at a pH of 5.6 (Birstein, 1951). No similar information exists for A.r.racovitzai.

In Lake Erie, pH is relatively uniform and ranged from only 7.2-8.6 at one meter above the bottom during a previous study (Herdendorf, 1973). As a result, it is doubtful whether pH has any significant impact on the distribution or density of Asellus in Lake Erie.

Alkalinity and Total Dissolved Solids

Moon (1957) concluded that there were no physical chemical properties of the water in English lakes that could be correlated with the distribution of Asellus meridianus and Asellus aquaticus. However, Reynoldson (1961) suggests that there is a strong correlation between the distribution of Asellus sp. in English lakes and the presence of calcium and total dissolved matter. In his data, Asellus was most common at calcium levels greater than 10 mg/l and at total dissolved matter levels greater than 90 mg/l.

It is the opinion of this author and that of Wetzel (1975) that to attempt to explain distribution or abundance by using a single chemical difference is often an oversimplification. There is hardly a group of freshwater organisms in existence that has not had its distribution related to calcium (Wetzel, 1975).

In Lake Erie, the central basin is uniform chemically with respect to the major ions (Int. Lake Erie Water Poll. Bd., 1969). There may be localized areas of high concentrations of major ions from tributaries or other point sources but these are soon dissipated in homogenous lake waters. As a result, calcium levels are quite uniform and average about 40 mg/l at open lake stations (Beeton and Edmonson, 1972). Similarly, total dissolved solids average about 180 mg/l at mid-lake stations (Int. Lake Erie Water Poll. Bd., 1969) with much higher values occurring in harbors and at river mouths (Table 4). Therefore, the average values in Lake Erie are much higher than the preferred levels cited by Reynoldson (1961). Exclusion by low levels of calcium and total dissolved solids is, therefore, highly unlikely.

Food Studies

The Asellidae seem to prefer a diet of vegetable matter with large diatoms and periphytic algae as their favorite foods. When these foods are unavailable, they feed upon dead macrophytes and leaves with elm and alder as their apparent favorites (Birstein, 1951). According to Pennak (1953), isopods have been observed eating dead and injured aquatic animals of many kinds. This fact leads Pennak to conclude that the isopods are true scavengers. Ellis (1961) has noted large numbers of *Asellus* associated with areas of moderate to heavy organic pollution. Organic matter in sewage is probably an ideal food source for the organism.

In the laboratory, isopods subsist quite well on a diet of the green alga Pithophora and dried elm or poplar leaves (Ellis, 1961).

During this study, the desmid Tetraedron, the chlorophycean Pediastrum, and pieces of cladocerans were the most commonly noted food items in isopod gut contents. However, it should be kept in mind that gut contents have already been ground by mandibles and have undergone digestion so that only the most resistant structures will be found in the gut. It is suprising that diatom frustules were rarely found in the gut contents during this study since other investigators (Birstein, 1951) have noted that diatoms are a favorite food item of isopods.

Other Members of the Faunal Assemblage

The association of Asellus with other organisms was tested by setting up a 2 X 2 contingency table for each organism and testing the association with chi square. The formula $X^2 = \frac{(ad-bc)^2 N}{(a+b)(c+d)(a+c)(b+d)}$ was used with N as the total number of stations sampled and a,b,c, and d as the values of the contingency table.

From these calculations, the Turbellaria were found to be positively associated with Asellus at the 0.05 probability level. The reason for this may be a predator-prey relationship. Young (1968) noted that Asellus meridianus was the main prey organism of the turbellarian Dendrocoelum lacteum. The identity of the turbellarian in Lake Erie and its ecology remain unclear.

A negative association, significant to the 0.05 probability level, was noted between the midge Coelotanypus sp. and Asellus. This may be due to the fact that the distribution of Coelotanypus is related to temperature. In Lake Erie, Coelotanypus is found in the western and southern parts of the lake where the water is a few degrees warmer (Brinkhurst, 1969). Asellus is rarely found in the western portion of the lake and is common in cold, deep, northern waters where Coelotanypus is absent.

Chironomus plumosus and Tanytarsus sp. were also positively correlated with Asellus but only at the 0.1 probability level. Tanytarsus is considered to prefer oligotrophic conditions and is most common in the northern and eastern portions of the lake at colder temperatures (Int. Lake Erie Water Poll. Bd., 1969). Asellus is common in the northern part of the lake but is also common in the south where Tanytarsus is lacking. The value of this correlation may be limited due to the low number of times that Tanytarsus was actually collected. Chironomus plumosus is very common throughout the western and central basins and is considered as a tolerant form. As a result, it is often found in association with Asellus when little else is present. However, it is commonly found in the western basin where Asellus is lacking. This correlation could also break down if more samples were considered.

In all other associations tested, the null hypothesis that the two organisms occurred independently could not be rejected.

Population Dynamics

The organisms collected during this study were regarded as random samples of the population with respect to sex ratio, size frequency, and gravidity. Upon analysis of brood size data, it was noted that there was a linear relationship between the size of the female and the number of eggs (Fig. 12). This agrees with the findings of Berg (1948), A. aquaticus, Hatchett (1947), A. communis, and Ellis (1961), A. intermedius, who noted that the number of young in the marsupium increases with the size of the female. Regression analysis of the number of eggs versus female size showed a predicted value of 59 eggs for a 6 mm organism and 89 eggs for a 7 mm organism (Fig. 12). The null hypothesis that slope B was equal to zero was rejected using the T-test. Slope B was found to be acceptable to the 95% probability level. Confidence limits were calculated for a mean $\hat{Y}$ which was predicted to be observed on the average when X was value X_p.

These brood size values are difficult to compare to literature on other species because in other studies the average number of eggs, embryos, and young were considered as one entity. In the present study, there was such a large discrepency between the the number of eggs and the number of young that an average would misrepresent the data.

In Ellis' (1961) study, relatively few undeveloped eggs were noted and the number of eggs and embryos were only about 17% greater than the number of young ready to leave the pouch. In *A. aquaticus*, the excess eggs and embryos are reported to be shed to allow enough room for adequate water circulation and growth (Birstein, 1951). Variation in the number of young ready to leave the pouch could be due to the emergence of some young while others remain (Markus, 1930).

During the present study, eggs, embryos, and young had mean numbers of 59, 42, and 26 respectively. This indicated a loss of approximately 56% between egg number and young number. The reason for this high mortality is unclear but may be due to the severe environmental conditions encountered by the organism. A nematode of the genus *Dorylaimus* was noted in the marsupium of one isopod (identification by John Crites). This is a stylet feeding nematode and may have been feeding on eggs within the marsupium (John Crites, personal communication). It is unknown whether this nematode has a significant effect on isopod populations.

Breeding Season

Observations of incomplete data on *A.r.racovitzai* indicate a breeding season from mid March to late June. During this time period, approximately 40% or more of the females were gravid.

Alee (1912) found that the breeding season of A. communis was from spring to mid summer. Berg (1948) similarly concluded that A. aquaticus bred mostly during spring and summer and Markus (1930) noted that Mancasellus macrourus reached a reproductive peak between March and April. Ellis (1961) found that A. intermedius had its main breeding season between May and September. He used the criterion that 40% or more of the females were gravid during this time period.

Gravid females collected during the March 29-April 25 collections were found to only posess eggs. Since eggs usually develop into young and emerge in 20-30 days (Pennak, 1953) this must be interpreted as the beginning of the reproductive season. Temperatures, during this time period of a previous year, were found to range from 2-6 C in the hypolimnion (Herdendorf, 1974). This suggests that copulation takes place at temperatures as low as 1 C. A temperature of 20 C at the bottom may be the warmest temperature encountered by the organism year round. A. intermedius was found by Ellis (1961) to reproduce at temperatures of at least 1-23.9 C.

Growth Rate

The growth rate of the organism in the field can be estimated from the size frequency data of Table 7 and histogram Fig. 13. The newly emerged organisms in the 2-3 mm size interval of cruise 3 appear to be the same organisms found in the 4-5 mm size interval of cruise 4. This would indicate a growth rate of approximately 10-12% per month during mid July to early September. It appears that the same group of organisms can be traced through to next year assuming cruise 1 to be the same as next year's data. During this seven month period, the 1-2 mm organism of cruise 4 has increased to 5-6 mm. This would indicate a growth rate of about 5% per month during October to March. Ellis (1961) noted a 10% linear increase per month during April to September, but only a 4% increase per month during the remaining months for *A. intermedius*.

In general overview of the data, it appears that there is only one brood per organism per year and that the life span is about one year. Several investigators have noted that, in general, the large overwintering adults reproduced in the spring and then disappeared. Their progeny then developed during the spring and summer with some reproduction occurring in the summer (Markus, 1930; Berg, 1948; Ellis, 1961). The data of the present study, however, do not indicate a large population of overwintering adults (Table 7 and Fig. 13). Instead, a population of 84% small organisms (1-5mm) was seen approaching the winter months. These organisms grew to reproductive size during the winter months and reproduced in early spring.

Biomass and Biotic Potential

The biomass of *Asellus* may make a substantial contribution to the total benthic biomass in a river or lake (Mozley, 1975). In a study of *Asellus aquaticus* in a dystrophic Russian lake, a biomass of 23 kg/hectare (wet weight) was noted to comprise 15.2% of the total benthic biomass (Birstein, 1951). The potential productivity of *A. aquaticus*, however, is much higher and can be calculated using growth rates, fertility data, and biomass data. Assuming a density of 2,200 organisms per square meter in a Russian lake, and that one pair can produce 3,000 young, a total of 3,300,000 young could be produced in one year. According to Birstein, if these organisms were to attain a length of 7-9 mm and weigh 7.1 mg (wet weight) then there would be a potential yield of 23.4 kg/m^2 of bottom in this lake.

In Lake Erie, the biomass of *Asellus* was previously mentioned by Wood (1953) who found an average weight of 10 mg per organism. This was obviously a wet weight, which was not used by this author due to variance that may occur in the amount of water in tissues and internal cavities. Dry weight has the disadvantage of losing volatile substances during drying and variance may occur in the inorganic salt content in tissues, but is generally much more preferable (Russell-Hunter, 1970).

Economic Importance

Even though aquatic isopods are intrinsically very important in their role as scavengers and detritus consumers in an aquatic ecosystem, it is often necessary to justify their value in economic terms. The primary economic value of aquatic isopods probably lies in their ability to convert leaves and other detritus into a food readily available to fish. Fish have often been found to feed on isopods but relatively few studies attempt to carry identification further than order. In western Lake Erie, Price (1963) noted a small number of isopods in the stomachs of the trout perch (*Percopsis omiscomaycus*) and the yellow perch (*Perca flavescens*). There have been very few stomach analysis studies in Lake Erie's central basin where isopod densities are much greater. As a result, insufficient data is available to indicate the value of isopods as a food for Lake Erie fish.

Asellus has, however, been found to be very important in the diet of a number of fish. In a study of Echo Lake in Maine, it was found that salmon (*Salmo char*) and brook trout (*Salvelinus fontinalis*) fed heavily on *Asellus* sp. during winter and early spring (Lackey, 1969). In a 1957 study by Ellis and Gowing, the brown trout (*Salmo trutta*) was found to feed heavily on *Asellus intermedius* during the summer months and regularly fed upon them year round.

In a recent study of the food habits of the yellow perch (*Perca flavescens*) in Onieda Lake, Clady and Hutchinson (1976) found that *Asellus* sp. occurred in stomachs with a frequency of 1-10% since 1966. Previously (1958-65), isopods were almost never found in perch stomachs and the burrowing mayfly (Hexagenia limbata) was very important as a food source. Severe oxygen depletions in 1959 and 1963 severely damaged mayfly populations in Onieda Lake thus forcing perch to feed on substitues such as chironomids, isopods, and amphipods. A similar situation may be occurring in Lake Erie since the mayfly decline reported by Britt (1955), however there is little available evidence to substantiate this.

Asellids are also consumed by a large number of commercial fish in Russian lakes and streams. Asellus aquaticus has been found in the stomachs of the crucian carp, carp, ruff, burbot, and some whitefishes (Birstein, 1951). Due to their high productivity and adaptability to artificial breeding conditions, isopods may have some value as a live fish food (Birstein, 1951). They do, however, have the disadvanges of being intermediate hosts for parasitic nematodes and acanthocephala of birds, fish, and amphibians and are occasional pests in beds of water cress (Pennak, 1953).

Potential as an Indicator Organism

According to Mason (1974), good indicator organisms should have the following qualities: 1) they should have a wide range of habitat preferences and requirements. 2) there should be a high diversity of species 3) there should be abundant numbers of the organism present 4) they should have a cosmopolitan distribution and be easily identified.

Unfortunately, the Asellidae lack many of these qualities. Many species have extremely limited distributions and their habitat preferences are generally unknown. Diversity of species is extremely low since only one species is usually found in a given lake or steam. Lastly, in many areas isopod numbers are very low and identification is often difficult.

Isopods are, however, tolerant of organic pollution and may be found in large numbers in streams and lakes subject to organic pollution (Moon, 1957; Ellis, 1961). In a study reported by Parker (1975), most of the tolerant species to a diesel oil spill were detritus or deposit feeders. The oil caused a significant increase in organic matter in the sediments and, as a result, the biomass of deposit feeders greatly increased. Ellis (1961) noted that the distribution and abundance of _A. intermedius_ was related to the concentration of domestic sewage. Isopods were most abundant where concentrations of sewage were highest in a one mile stretch below a sewage outfall. Above the outfall, numbers of the organism were significantly lower. Using these data, abundance could be closely correlated with the concentration of sewage.

A similar correlation could feasibly be worked out for organic polluted areas in Lake Erie. However, the effects of other environmental parameters would also have to be taken into account.

Isopods, therefore, may have some utility in indicating the presence of organic pollution, but would probably be more useful as part of an indicator community.

SUMMARY

1. A study was made to determine the environmental parameters affecting the distribution of Asellus r. racovitzai in western and central Lake Erie. Some aspects of life history and other aspects of ecology were discussed.

2. As a result of four cruises, Asellus was found to be most common in Lake Erie's central basin at certain localities. The lack of Asellus in the western basin was postulated to be due to excessive resuspension of sediments and wave orbital energy.

3. Asellus r. racovitzai was the only species of isopod collected during this study.

4. Females were found to comprise approximately 68% of the population during March to April. More even numbers of males and females were noted during the rest of the year.

5. Observation of gut contents showed that the green algae Pediastrum and the desmid Tetraedron were commonly fed upon by isopods. Sewage was also noted to be a likely food source.

6. Highest densities of Asellus seemed to be correlated with areas experiencing a littoral drift of domestic sewage.

7. Bottom currents were proposed to affect Asellus distribution by their distribution of organic carbon food sources such as sewage and particulate organic carbon.

8. Isopods were found at an average depth of 18.3 meters. Stations with the highest densities of Asellus had an average depth of 21.1 meters. Near shore areas were not sampled.

9. Asellus seemed to prefer post glacial muds composed of soft, silty clay as a substrate. The organism was rare over sandy areas.

10) Calcium and total dissolved solids were not found to significantly affect the distribution of Asellus in Lake Erie.

11) Oxygen was found to be the major limiting factor to Asellus distribution in central Lake Erie. The organism was found to be of intermediate tolerance to low oxygen conditions. It was found in areas with 2-4 mg/l of oxygen but was rare or absent in anoxic areas.

12) pH was relatively uniform at the sampling stations and had no impact on distribution.

13) The Turbellaria were positively correlated with Asellus distribution. Coelotanypus sp. was negatively correlated.

14) The biomass of isopods was found to comprise approximately 30-50% of the total benthic biomass at some stations but was insignificant at the majority of stations.

15) Egg number was found to increase with the size of the female. A significant loss of organisms was noted between the egg and young stages.

16) Breeding season was found to occur from mid March to late June. During this time, 40% of the females were gravid.

17) Field growth rate was found to be 5% during October to March and 10% during April to September.

18) A large population of small organisms (68% from 1-4 mm) were found at the approach of the winter months. It was proposed that these smaller organisms developed during the winter months and reproduced during the spring.

19) Asellus was found to have only marginal use as an indicator organism. However, it may be of some value in indicating organic pollution.

Appendix Table 1

No. of Isopods Collected Per Station,

Cruises 1-4, 1975

Station	Sample 1 No. Collected	Sample 1 No./m^2	Sample 2 No. Collected	Sample 2 No./m^2	Mean No./m^2
Cruise 1					
24	2	38	1	19	28.5
27	1	19	1	19	19.0
29	3	57	0	-	28.5
30	2	38	0	-	19.0
31	1	19	2	38	28.5
32	0	-	3	57	28.5
33	0	-	1	19	9.5
34	18	342	19	361	351.5
35	5	95	9	171	133.0
36	6	114	0	-	57.0
38	0	-	1	19	9.5
40	3	57	1	19	38.0
41	4	76	3	57	66.5
48	4	76	0	-	38.0
49	1	19	1	19	19.0
78	2	38	0	-	19.0
Cruise 2					
30	1	19	1	19	19.0
32	11	209	22	418	313.5
33	58	1102	67	1273	1187.5
34	1	19	2	38	28.5
36	1	19	6	114	66.5
38	2	38	2	38	38.0
41	1	19	1	19	19.0
47	1	19	0	-	9.5
49	2	38	0	-	19.0
68	1	19	1	19	19.0
74	1	19	0	-	9.5
79	15	285	3	57	171.0

Appendix Table 1 (cont.)

Cruise 3 Station	Sample 1 No. Collected	Sample 1 No./m²	Sample 2 No. Collected	Sample 2 No./m²	Mean No./m²
24	0	-	1	19	9.5
31	6	114	6	114	114.0
32	1	19	0	-	9.5
33	2	38	11	209	123.5
34	5	95	42	798	446.5
36	8	152	11	209	180.5
37	2	38	0	-	19.0
38	2	38	3	57	47.5
40	1	19	0	-	9.5
41	1	19	2	38	28.5
50	1	19	3	57	38.0
51	1	19	0	-	9.5
53	0	-	1	19	9.5
73	0	-	1	19	9.5
78	3	57	0	-	28.5
79	1	19	4	76	47.5
Cruise 4					
24	6	114	0	-	57.0
27	9	171	1	19	95.0
29	2	38	10	190	114.0
31	21	399	ns*	-	399.0
32 (inc.)	2	38	0	-	19.0
36	0	-	4	76	38.0
38	3	57	1	19	38.0
40	0	-	2	38	19.0
48	12	228	3	57	142.5
50	4	76	0	-	38.0
78	15	285	2	38	161.5

* ns=no sample
inc.=lab accident, incomplete

Appendix Table 2

Biomass Data Cruises 1-4, 1975

Station	Vial wt (g)	Vial+Org wt (g)	Org wt (g)*
Cruise 1			
31	16.5319	16.5353	.0034
32	16.2561	16.2629	.0068
33	17.2189	17.2208	.0019
34	16.4534	16.5253	.0719
36	16.3337	16.3484	.0147
38	16.0817	16.0823	.0006
Cruise 2			
31	17.0625	17.0626	--
32	16.3785	16.4298	.0513
33	16.7485	16.9147	.1662
34	16.9338	16.9421	.0083
36	16.7298	16.7388	.0090
38	16.5541	16.5577	.0006
Cruise 3			
31	16.4201	16.4275	.0074
32	15.9700	15.9705	.0005
33	16.8829	16.8986	.0157
34	17.1296	17.1320	.0024
36	15.8158	15.8383	.0225
38	16.2676	16.2735	.0059
Cruise 4			
31	16.2078	16.2450	.0372
32	16.6180	16.6194	.0014
33	16.7620	16.7616	--
34	16.6215	16.6213	--
36	16.3649	16.3671	.0022
38	16.0749	16.0775	.0026

* org. wt.=organism dry weight

LITERATURE CITED

Alee, W.C. 1912. An experimental analysis of the relation between physiological states and rheotaxis in isopods. J. Exper. Zool. 13:270-344.

Alee, W.C. 1929. Studies in animal aggregation: Natural aggregations of the isopod *Asellus communis*. Ecology 10:14-36.

Beeton, A.M., and W.T. Edmonson. 1972. The eutrophication problem. J. Fish. Res. Bd. Canada 29:673-682.

Berg, Kaj. 1948. Biological studies on the River Sussa. Folia Limnol. Scandinavica 4:1-318.

Birstein, Y.A. 1951. Fauna of U.S.S.R. Crustacea. Fresh-water isopods (Asellota). 7(5):1-148. Translated by Israel program for scientific translations, 1964. Office of technical services, U.S. Dept. of Commerce. Washington, D.C.

Brinkhurst, R.O. 1969. Changes in the benthos of Lakes Erie and Ontario. Proceedings of the Conference on Changes in the Biota of Lakes Erie and Ontario. Bulletin of the Buffalo Society of Natural Sciences 25(1):45-71.

Britt, N.W. 1955. Stratification in western Lake Erie in summer of 1953: effects on the *Hexagenia* (Ephemeroptera) population. Ecology 36(2):239-244.

Britt, N.W., James T. Addis, and Ronald Engel. 1973. Limnological studies of the island area of western Lake Erie. Ohio Biol. Surv. Bull. N.S. 4(3):1-85.

Clady, M., and B. Hutchinson. 1976. Food of the yellow perch, *Perca flavescens*, following a decline of the burrowing mayfly, *Hexagenia limbata*. Ohio J. Sci. 76(3):133-138.

Crites, John L. 1976. Personal communication.

Ellis, Robert J., and Howard Gowing. 1957. The relationship between food supply and condition of wild brown trout, *Salmo trutta* (L.), in a Michigan stream. Limnol. and Oceanog. 2:299-308.

Ellis, Robert J. 1961. A life history study of *Asellus intermedius* Forbes. Trans. Amer. Micros. Soc. 80(1):80-102.

Federal Water Quality Administration. 1970. Investigation of mercury in the St. Clair River-Lake Erie systems. Great Lakes regional office, National field investigations center, Chicago. 108pp.

Fleming, Laurence E. 1972. The evolution of the eastern North American isopods of the genus Asellus. Int. J. Speliol. 4:221-256.

Hall, P.J. 1970. An experimental approach to the production dynamics and structure of freshwater animal communities. Limnol. and Oceanog. 15:839-928.

Hatchett, Stephen P. 1947. Biology of the Isopoda of Michigan. Ecol. Mongr. 17:47-79.

Herdendorf, C.E. 1973a. Shoreline changes of Lake Erie and Ontario with special reference to currents, sediment transport, and shore erosion. Center for Lake Erie Area Research, Ohio State University (Pub.). Tech. Rep. No. 11. 44pp.

__________ editor. 1973b; 1974. Lake Erie Nutrient Control Program: An asessment of its effectiveness in controlling lake eutrophication. (Unpublished data) Prepared for U.S. EPA large lakes research station, Grosse Ile, Michigan. Center for Lake Erie Area Research, Ohio State University, Columbus.

__________ 1976. Preliminary report of water quality in western and central basins of Lake Erie in 1975. (Unpublished data) Prepared for U.S. EPA large lakes research station, Grosse Ile, Michigan. Center for Lake Erie Area Research, Ohio State University, Columbus.

International Lake Erie Water Pollution Board. 1969. Pollution of Lake Erie: A report to the International Joint Commission. Chicago. 315pp.

Keup, E. Lowell., W.M. Ingram, and K.M. Mackenthun. 1966. The role of bottom dwelling macrofauna in water pollution investigations. Public Health Service Pub. No. 999-WP-38.

Klein, Louis. 1957. Aspects of River Pollution. Academic Press Inc., New York. 621pp.

Lackey, Robert T. 1969. Food interrelationships of salmon, trout, alewives, and smelt in a Maine lake. Trans. Amer. Fish. Soc. 98:641-651.

Markus, Henry C. 1930. Studies on the morphology and life history of the isopod, Mancasellus. Trans. Amer. Micros. Soc. 49:220-237.

Mason, William T. 1974. Chironomididae (Diptera) as biological indicators of water quality. Organisms and Biological Communities as Indicators of Environmental Quality-A Symposium. Ohio Biol. Surv. Inf. Circ. No. 8.

Moon, H.P. 1957. The distribution of Asellus in Windermere. J. Anim. Ecol. 26:113-123.

Mozley, Samuel C. 1975. Benthic community responses to energy related effluents in the Great Lakes. Proc. of the Second Federal Conference on the Great Lakes. Public information office of the great lakes basin commission. Chicago.

Needham, A.E. 1947. Growth and regeneration in Asellus aquaticus (L.) in relation to age, sex, and season. J. Exper. Zool. 112(1):49-78.

Ohio Division of Geological Survey. 1966. A preliminary report on currents and water masses in Lake Erie. 56pp.

Parker, Robert H. 1975. The Study of Benthic Communities. Elsevier Scientific Publishing Co., New York. pp. 242-245.

Pennak, Robert W. 1953. Freshwater Invertebrates of the United States. Ronald Press Company, New York. 769pp.

Price, John W. 1963. A study of the food habits of some Lake Erie fish. Bull. of the Ohio Biol. Surv. 2(1):1-88.

Reynoldson, T.B. 1961. Observations on the occurrence of Asellus (Isopoda, Crustacea) in some lakes of northern Britain. Verh. Int. Ver. Limnol. 14:988-994.

Russell-Hunter, W.D. 1970. Aquatic Productivity. The Macmillan Company, London. 306pp.

Sanders, H.L. 1958. Benthic Studies in Buzzards Bay I. Limnol. and Oceanog. 3(3):245-258.

Shelford, V.E., and M.W. Boesel. 1942. Bottom animal communities of the island area of western Lake Erie in the summer of 1937. Ohio J. Sci. 42:179-190.

Thomas, R.L., J.M. Jaquet, and A.W. Kemp. 1976. Surficial sediments of Lake Erie. Jour. Fish. Res. Bd. Can. 33(3):385-403.

U.S. Dept. of the Interior. 1964. Lake Erie Environmental Summary 1963-64. Federal Water Pollution Control Administration, Chicago.

Veal, D.M. and D.S. Osmond. 1968. Bottom fauna of the western basin and nearshore Canadian waters of Lake Erie. Proc. 11th Conf. Great Lakes Res. pp. 151-160.

Waterman, T.H. 1961. Physiology of Crustacea. Academic Press Inc., New York. 605pp.

Wetzel, Robert G. 1975. Limnology. W.B. Saunders Co., Philadelphia. 743pp.

Williams, W.D. 1970. A revision of North American epigean species of *Asellus*. Smithsonian Contributions to Zoology. 49:1-80.

Wood, Kenneth G. 1953. Distribution and ecology of certain bottom living invertebrates of the western basin of Lake Erie. Unpublished Ph.D. thesis. Ohio State University Library. 145pp.

Wright, Stillman., L.H. Tiffany, and Wilbur M. Tidd. 1955. Limnological survey of western Lake Erie. U.S. Fish and Wildlife Service Special Scientific Report No. 139. 341pp.

Young, J.O. 1968. A quantitative study of the population biology of *Dendrocoelum lacteum* (Turbellaria, Tricladia) Oikos 15:237-263.