The Plankton of the Bear River Migratory Waterfowl Refuge, Utah Seasonal Distribution of Organisms

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THE PLANETON OF THE BEAR RIVER MIGRATORY WATERFOWL REFUGE, UTAH

SEASONAL DISTRIBUTION OF ORGANISMS

A Thesis
Presented to
The Committee on Graduate Work
Utah State Agricultural College

In Partial Fulfillment
of the requirements for the Degree
Master of Science in the School of
Agriculture
Department of Botany

By
George Piranian
May 1937
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1. Introduction

In the summer of 1932, an investigation of some biological, physical, and chemical conditions at the Bear River Migratory Waterfowl Refuge, Utah, was begun at the Utah State Agricultural College to determine some of the factors governing the biological productivity of brackish-water marshes. Unfortunately, lack of funds made it impossible to continue work beyond the first season.

In 1936, the Wild Life Experiment Station at the Utah State Agricultural College appropriated a fund for a cooperative project between the Station and the Department of Botany at the same institution. This project, planned to be continued by various graduate fellows over a period of several years, is an investigation of conditions existing at the Bear River Refuge and at some newer refuges of similar character.

It was believed that the micro-biota of the water at the Refuge is of importance in the study of general conditions, and consequently provisions were made to determine what organisms, exclusive of bacteria, compose the microscopic population of the waters at the Refuge, and what their seasonal and geographical distribution within the area is. This paper is a report on this particular phase of the investigation.

Acknowledgments are due to Dr. E.I. Naumaseen, who made the project possible by procuring the necessary financial support, to Professor Bassett Maguire, who directed the study, and to the personnel of the United States Biological Survey at the Bear River Refuge, who generously provided laboratory space, boats, and living quarters during periods of field activity.
2. Literature

No monograph of the aquatic microflora of the Western United States is available, but analyses have been published of the biota of single bodies of water and of the organisms of one or more taxonomic order occurring within one state by Fordeyce, Pearson, Elmore, and Coon. The last three papers cited deal with the biota of alkaline waters. Two papers, one by Daniels, and one by Patrick, concerning the biota of Great Salt Lake in particular have come to the writer's attention.

In 1923, Keiser, Bovard, and Boorman gave an account of general investigations in northwestern lakes.

In 1925, Clark published a monograph on the mineral contents of various waters. His paper includes data concerning Great Salt Lake and its tributaries.

Methods of collecting and preserving plankton are discussed by Reichard in Ward and Whipple. Reichard describes the tow net, the cone dredge, the qualitative plankton net, three plankton pumps, methods of collecting nanno-plankton, and methods of making plankton counts.

3. Description of the Area Studied

(a) Location and topography. The Bear River Migratory Waterfowl Refuge was created in 1926 by Act of Congress to further the conservation of North American waterfowl. The Refuge occupies a roughly semi-circular area of 64,000 acres at the extreme end of the Bear River delta in Boxelder County, Utah. This area is so nearly level that the one-foot contour lines

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9) This report included a qualitative and quantitative analysis of over four hundred plankton samples. These analyses constituted a major portion of the present writer's undergraduate work.
are generally between one and three miles apart, and consequently dikes of relatively small height suffice to impound water over nearly the entire refuge.

(b) Water supply. The source of water is the Bear River. In spring, there are generally two periods of maximum fresh water: first, when the tributaries to Bear River below Cutler Dam are high with the water of newly melted snow, and again during May and early June, when the snow melts in the higher portions of the water shed. Between the middle of June and early October, the river is diverted for irrigation, and no water reaches the refuge, except a relatively small amount of seepage and water from small tributaries below Cutler Dam. During this time, evaporation lowers the water level approximately one foot, and in some regions the soil is exposed and dries out.

In October, fresh water becomes available again until freezing temperatures set in. No consistent policy has hitherto been followed after ice formation occurs: during some winters, the water has been kept in the units until spring; during others, the entire area has been drained to prevent damage done to the dikes and spill-boxes when the ice breaks.

(c) Vegetation. According to individuals who have long been acquainted with the area, Distichlis spicata, Scorpus acutus, S. paludosus, Synha latifolia, Potamogeton necinatus, Rumina maritima, and Chara sp. occurred near the river channels at the time when construction began, while large portions of the area were barren slat flats. Since completion of the dikes in 1931, some of these previous salt flats have developed a cover of Chara, Rumina, or Potamogeton.
Section

I. Methods

To prevent excessive expenditure of time and money for transportation, the investigation was limited to three of the five units composing the Bear River Refuge. From six to twelve quadrates were established in each of these three units; seven additional stations were established at spill-boxes, and one at the gates near headquarters. Since the study reported in this paper is merely one phase of a broader project, it was impossible to base the choice of sites for stations on expediency in plankton investigation.

Beginning July, 1936, the stations were visited, at intervals of a few weeks, for the work pertaining to the general program which need not be discussed in this paper. Observations were continued until winter temperatures made field activities prohibitively difficult; in April, 1937, work was resumed.

At the time of each visit to the stations within the units, plankton samples were taken, where possible, by drawing a No. 20 silk bolting Wisconsin plankton net horizontally through the water; at the spill-boxes and near headquarters, samples were taken by holding the net in the path of the water for several minutes. No attempt was made to obtain rigorously quantitative data concerning plankton, and the length of the hauls was somewhat variable; generally, it was of the magnitude of a hundred feet. Since the diameter of the net constituted an appreciable fraction of the depth of the water, a plankton pump would have been necessary to obtain data concerning the vertical distribution of the organisms. In some cases, insufficient depth of the water made it impossible to take plankton hauls; in four of the thirty-three stations, samples could never be taken. In the fall,
temperatures far below freezing prevented the taking of samples without
damaging the plankton net.

No work was done with the nanno-plankton.

The organisms were preserved in formaldehyde and kept until the
winter months when they were examined and the species listed for each
station and date of collection. Limited time, experience, equipment, and
literature made it impossible to identify all organisms specifically.
Representative samples from the collection have been sent to specialists
and verifications of identifications are now pending.

The occurrences of each species were recorded, in chronological
order of the collections, on index cards. No attempt was made to estimate
the absolute frequency of the organisms, but for each collection, each
species present was assessed as rare, frequent, common, or abundant.

For the study of geographical distribution, a table was prepared
to show the relative frequency, at each of the stations, of the seventy
most abundant organisms. The discussion (in section 6. of this paper) of
seasonal and geographical distribution is based on a study of the index
cards and this table.

List I is based on identifications by means of the following
publications:

Smith\textsuperscript{17, 18} (algae in general, incl. flagellates)
Tilden\textsuperscript{20} (blue green algae)
Taylor\textsuperscript{19} (Anabaenopsis)
Boyer\textsuperscript{1} (diatoms)
Ward and Whipple\textsuperscript{22} (Protozoa, Cladocera, Copepoda)
Leidy$^{13}$ (Rhizopoda)

Herrick and Turner$^{11}$ (Cladocera and Copepoda)

Eyferth-Schoenichen$^{9}$ (rotifers)

List II was prepared by Dr. Frank J. Myers of Ventnor, N.J., who was kind enough to examine eleven samples. In Dr. Myers' list, the discarded synonyms are given in parentheses. In the writer's own list, the organisms are designated by the names current in less up-to-date literature, since the author found himself unable, in many cases, to establish the relationship between the organisms seen by him and the names listed by Dr. Myers.

An artificial key to the common green and blue-green algae, to the Copepoda, and to the Cladocera collected will be found in the appendix.

5. Results

List I

Organisms collected at the Bear River Refuge, Utah$^{9}$

(A) Cyanophyceae

1. Anabaena variabilis Kuetz.
   Only one record: July.
2. Anabaena.
   Very rare, July.
3. Anabaenopsis Arnoldii Aptek fa. (Philippine form)
   Common in August-October; rare in Nov.; does not occur in shallow stations of Units 1 and 2.
4. Anacocapsa.
   Very rare; July, Sept. in unit 2.
5. Anaphotheca.
   Very rare in Clear Lake, May.
6. Calothrix sp.
   Rare, July.
7. Chroococcus.
   Rare, July.
8. Gloetrichia natans (Fald.) Rab.
   Common July-August; alates occur throughout the season.

$^{9}$ Where no specific name follows a generic name in this list, the expression "sp." indicates that the organisms probably belong to one species, and "ssp.", that they belong to two or more species, while the simultaneous absence of both expressions indicates that the author does not know whether he is dealing with one or with several species of the genus.
   Very rare.
    Frequent throughout the season, becoming increasingly abundant towards fall.
11. Merismopedia sp.
    Only one record; August.
12. Microcoleus lacustris (Nab.) Farlow.
    Only one record; July.
    Frequent, July-September.
    Only one record; July; on soil; water highly alkaline (620 p.p.m. Ca CO₃), chloride concentration 0.049 M, oxygen 3 p.p.m.
15. Mestoc. sp.
    Frequent at one station; July.
16. Spirulina major Kuetsz.
    Very rare.

(B) Bacillariaceae

17. Amphora coffeaeformis (Ag.) Kuetsz.
    Only one record.
18. Amphora ovalis Kuetsz.
    Rare, mostly in Unit 2.
19. Amphiporella sp.
    Frequent throughout season, especially July, Sept. and October.
20. Asterionella formosa Haeck.
    Rare; Sept. and Nov.
    Very rare, November, May, April; specimens observed in spring are not fossil.
22. Campylodiscus hibernicus Ehr.
    Rare, July, Aug., Nov., May. Clear Lake in May, August.
23. Chaetoceros sp.
    Frequent in August; nearly all records from Unit 2.
24. Cocconeis sp.
    Rare, mostly in Unit 1. Clear Lake in May.
25. Cyclotella.
    Frequent throughout season, mostly in Unit 2.
    Rare; throughout season.
27. Cymbopleura solae (Breb.) W. Smith.
    Rare; Nov., April, May.
28. Cymbella sp.
    Frequent throughout season, except while vegetation is scarce. Clear Lake, in May.
29. Diatoma hiemale (Lyngb.) Keilberg.
    Frequent in Clear Lake, May.
30. Diatoma vulgare Bory
    Rare, Nov., April, May; Clear Lake, in August.
31. Epithemia argus (Ehr.) Kuetsz.
    Only one record, July.
32. Epithemia sorex Kuetz.
   Only two records: July.
33. Epithemia turgescens (Ehr.) Kuetz.
   Rare, throughout season.
34. Epithemia zebra Kuetz.
   Rare, throughout season; only one record from Unit 3.
35. Fragilaria sp.
   Rare; April, May. Abundant in Clear Lake; May, Aug.
36. Comphoropsidae ssp.
   Frequent, July-August
37. Hantzschia amphioxys (Ehr.) Grun.
   Very rare.
38. Mastogloia Smithii Thw. Var. ?
   Very rare.
39. Melosira
   Rare, throughout the season, sporadically frequent in May.
40. Navicula sp. (sensus latus)
   Rare, throughout the season.
41. Nitzschia spp.
   Rare, throughout the season.
42. Pleurosigma sp.
43. Rhoicosphenia curvata (Kuetz.) Grun.
   Very rare.
44. Rhoalodias gibba (Ehr.) O. Muell.
   Very rare.
45. Rhoalodias ventricosa (Kuetz.) O. Muell.
   Frequent throughout the season.
46. Selionalourea naesoni Grun.
   Frequent in Unit 1 and in northwest portion of Unit 2.
47. Surirella Baileyana MacKay.
   Common throughout Refuge, occurs in 80% of the collections.
48. Surirella ovata Kuetz.
   Frequent throughout the Refuge.
49. Surirella spp.
   Rare.
50. Synedra spp.
   Frequent throughout the Refuge
51. Terpsinoe musica Ehr.
   One specimen seen, May.
52. Tetracyclus lacustris Hafle.
   Rare in Clear Lake, August.

(c) Chlorophyceae

53. Bulbochaetes sp.
   Very rare, July.
54. Cladophora.
   Frequent as pioneer on barren areas.
55. Closterium sp.
   Very rare.
56. Cosmarium spp.
   Frequent in July; rare in August.
57. Nudorina elegans Ehr.
   Occasionally present throughout season; sporadically frequent in spring.
58. Mougeotia sp.
   Rare, Clear Lake in May.
59. Cardionium spp.
   Frequent July, Sept. present throughout season.
60. Pandorina morum Ehr
   Frequent; July, August.
61. Pedinastrum Boryanum (Tyrp.) Menegh.
   Frequent throughout the season.
   Frequent in November, rare in May.
63. Pedinastrum duplex Mayen var. clathratum (A. Brown) Lagerh.
   Frequent throughout season, except very rare July and August.
64. Pedinastrum duplex Mayen var. gracillimum V. & O.S. West.
   Rare, July-August.
65. Pedinastrum duplex Mayen var. reticulatum Lagerheim.
   Common throughout season, except in west-end of Unit I, and during September and early October, when this variety was not found at all.
66. Pedinastrum integrum Naegeli.
   Rare. October, November, all collections from Unit I.
67. Pedinastrum tetras (Ehr.) Ralfs.
   Only one record, July.
68. Scenedesmus bijuga (Turp.) Lagerh.
   Very rare.
69. Scenedesmus dimoropus (Turp.) Kuetz.
   Only one record.
70. Scenedesmus quadricauda (Turp.) DeBriep.
   Rare, occurring through the season.
71. Scenedesmus sp.
   Very rare.
72. Schroederia sp. ?
   Rare, mostly in Sept.-Oct.
73. Spyropogon.
   Rare; common in Clear Lake; May, August.
74. Steurastrum sp.
   Very rare, Aug.-Nov.
75. Stigeoclonium sp.
   Abundant on wooden stake, July.
76. Ulithrix sp.
   Rare, Nov., May.
77. Volvox sp.
   One specimen seen, May.

(D) Protozoa.

78. Ceratium hirundinella (O.F.M.) Schrank.
79. Beroepyxia ?
   Attached to Harshia only, rare.
80. Diffugia?
Very rare, throughout Refuge in November, April, May.

81. Dinobryon setariae Ehr.

82. Euglena sp.
Rare in spring and fall, sporadically abundant in summer, forming green or red blooms.

83. Glenodinium?
Very rare; October.

84. Feridinium.
Very rare; October, April; Clear Lake in August.

85. Centropyxis aculeata Stein.
Rare; July, Nov.

86. Vorticella.
Only two records.

(E) Rotatoria.

87. Anuraea aculeata Ehr.
Present throughout season; very abundant Sept., Nov., especially in regions distant from headquarters.

88. Anuraea cochlearis Gosse.
Frequent throughout season.

89. Arthroplana Vlastkeni? Bergd.l.
Only one record.

90. Asplanchna spp.
Rare.

91. Brachionus Bakeri var. ?
Very rare.

92. Brachionus pala amphigeros Ehr.
Frequent, except in Unit. 1.

93. Brachionus pala var. ?
Frequent; spring, until July.

94. Brachionus urceolaris O. F. Mull.
Common July-Oct.; occurs in Clear Lake.

95. Brachionus spp.
Frequent, July-Oct.

96. Cathypna luna Ehr.
Frequent, May-Aug.

97. Cathypna unguiculate Gosse.
Only one record.

98. Colurus leptus Gosse.
Rare; July, Sept.

99. Distyla sp.
Only one record.

100. Macrurris spp.
Very rare; spring and summer.

101. Furcularia forficula ? Ehr.
Only one record.

102. Lepidella acuminata (Ehr.)
Only one record.

103. Lepidella patella (O.F.M.)
Frequent; July-August.
104. Lepadella sp.
   Rare.
105. Monostyla lunaris Ehr.
   Only one record.
106. Monostyla quadridentata Ehr.
   Common; July – Aug.
107. Monostyla spp.
   Common; July – Sept.
108. Notonis militaris Ehr.
   Common; July, August; frequent in May; perhaps sensitive to
   salt.
109. Notalca striata Ehr.
   Common; April
110. Notalca striata acuminata Ehr.
   Abundant, Oct. – Nov.; common, April – May.
111. Notomasta spp.
   Rare.
112. Pedalia sp.
   Clear Lake in August.
113. Polyarthra plagiopera Ehr.
   Clear Lake, in August.
114. Battulus.
   Frequent in August.
115. Salpina brevispina Ehr.
   Very rare.
116. Salpina ventralis Ehr.
   Very rare.
117. Synchaeta spp.
   Common; Oct., Nov.
118. Triarthra longiseta Ehr.

(F) Cladocera.

119. Alona costata Sars.
   Sporadically frequent throughout the season.
120. Bosmina.
   Rare throughout season. Unit 2 and west end of Unit 3.
121. Ceriodaphnia sp.
   Very rare.
122. Chydomus sphaericus (O.F.M.)
   Rare; July, Aug., May. Clear Lake in May.
123. Daphnia longispina (O.F.M.)
   Rare; July, Nov., May.
124. Diaphanosoma brachyurus (Lieven)
   Frequent; second half of July.
125. Diaphanosoma Lechottenbergianum Fischer.
   Only one record; July.
126. Dunhevedia setigera (Birge).
   Very rare; July.
127. Kursia latissima (Kurz).
   Only one record; April.
128. Latonopsis sp.
   Rare.
129. Leydigia quadrangularis (Leydig).
   One record; Nov., 1932.
130. Macrotethrix laticornis (Jurine).
   Rare; Nov., May.
131. Macrotethrix rosea (Jurine).
   Very rare; July.
132. Melae affinis Birge.
   Common; May; abundant in shallow water, east end of
   Unit 3.
133. Pleuroxus.
   Very rare.
134. Simocephalus.
   Very rare.

(c) Copépoda.

135. Canthocamptus sp.
   One specimen seen; May.
136. Cyclops chalcreatus Koch.
   Frequent at one station; July.
137. Cyclops serrulatus Fischer.
   Sporadically frequent July, Aug., April, May. Clear Lake
   in May.
   Only one record; Nov., 1932
139. Cyclops viridis Jurine.
   Abundant in spring; this species is probably responsible
   for most of the records of unidentified Cyclops.
140. Cyclops spp.
   Frequent throughout the season.
141. Diaptomus Juday March.
   Common throughout the season; very abundant west end of
   Unit 1 in Nov.; probably the organism of most or all the
   unidentified Diaptomus.
142. Diaptomus novemexicanus Herrick.
   Frequent at one station; July.
143. Diaptomus musculus Marsh.
   Frequent at one station, August.
144. Diaptomus sicilis Forbes.
   Only one specimen, May.
   Only one record, November.
146. Diaptomus spp.
147. Marasia albuquerqueensis Herrick
   Rare throughout season, but frequent in most collections
   from Unit 1, Quad. 1, and from spill-box 3-3/3. Females
   bearing ovisacs in May.
148. Marasia brevicaudata Herrick.
   Rare in August, frequent in May. Not recorded from Unit 1,
   Casar Lake in May.

*) Identification confirmed by Dr. Charles B. Wilson of Westfield, Mass.
(II) Miscellaneous.

149. Chaetonotus enormis ? Stokes.
   One record only.

150. Ostracoda.
   Frequent in shallow water throughout the season.

151. Phyllodota (Anostraca).
   Two females collected in Unit 1, Station 1, April.

152. Nematodes.
   Present throughout season; frequent in spring.

153. Tribonema sp. ?
   Present October-November; rare in May.

LIST II

Rotifers identified by Dr. F.J. Myers

1. Asplanchna seiboldi Leydig.

2. Asplanchna silvestrii Dadey.

3. Asplanchnopus hyalinus Haring.

4. Asplanchnopus multiceps (Schrank).
   (Asplanchnopus myrmeces)

5. Brachionus angularis Gosse.

   (Brachionus amphicerus)

7. Brachionus angularis caudatus (Barrias and Dadey).


9. Brachionus capsuliflorus entzii (France).
   (B. bakerii entzii)

    (Brachionus militaris)

    (B. muelleri)

    (B. urceolaris)

13. Cephalodella gibba (Ehrenberg).
    (Diaphnia gibba)

    (Diglena forcipata)
15. Diurella brachyura Gosse.
17. Diurella Tigris (Mueller).
20. Filinia longiseta (Ehrenberg).
   (Triarthra longiseta)
   (Amuraea cochlearis)
23. Keratella cochlearis v. tecta (Lauterborn).
   (Amuraea tecta)
24. Keratella quadrata f. divergens (Voight).
   (Amuraea aculeata divergens)
   (Amuraea valga)
26. Keratella valga f. brehmi Klausner
27. Keratella valga f. monstrosa (Apestein-Barrics and Daday).
28. Lecane luna (Mueller).
   (Cathypna luna).
29. Lepadella patella (Mueller).
   (Metopidia patella).
30. Monostyla bulla Gosse.
31. Monostyla closterocerca Schwarda.
32. Monostyla cornuta (Mueller).
33. Monostyla quadridentata Ehrenberg.
34. Monostyla thalera Harring and Myers.
35. Mytilina ventralis (Ehrenberg).
   (Salpina ventralis)
36. Notholca striata (Mueller)
37. Notholca striata acuminata (Ehrenberg).
   (Notholca acuminata)
38. Polyarthra trigla Ehrenberg.
   (Polyarthra platyptera)

40. *Pedaalia fennica v. oxyrus* (Sernov).  
    (Pedalion oxyure)

41. *Rotaria rotatoria* Pallas.  
    (Rotifer vulgaris)

42. *Synchaeta littoralis* Rousselet

43. *Synchaeta pectinata* Ehrenberg.

44. *Synchaeta tremula* (Mueller).

    (Pterodina patina)

    (Pterodina intermedia)

47. *Trichocerca cristata* Harring.  
    (Rattulus carinatus)

    (Rattulus pusillus)
Chemistry

The following data concerning the chemistry of the water are included for the sake of interest; the methods by which they were obtained will be reported in a later account. Correlation between data on chemistry and data on plankton must necessarily await the collection of further information.

The water at the Bear River Refuge generally has a pH of 8.0 or higher, except in a few places where aquatic vegetation is scarce and the alkalinity high. The highest pH recorded with assurance of accuracy is 10.1; other data lead the author to believe, however, that the pH often approaches and sometimes reaches 11. The pH is highest during periods of photosynthetic activity.

At headquarters, the total alkalinity varies between 268 and 317 parts per million, expressed as calcium carbonate. Within the units it varies between 100 and 400 parts per million, except in very shallow water of high salt content. Low alkalinity is generally associated with dense vegetation, high pH, and high oxygen concentration.

The alkalinity to phenolphthalein varies between zero and 79 parts per million. In general, the higher the total alkalinity, the lower is the alkalinity to phenolphthalein.

The chloride concentration varies between 0.005 N and 0.2 N, although, in exceptional cases, a concentration of 1 N may be approached.

The alkalinity, pH, and salinity relationships are in accordance with the findings of Bushrer and Williams and of Breaseale, whose experiments indicate that the presence of chlorides increases the solubility of calcium carbonate, but decreases the extent of its hydrolysis.
The oxygen concentration in the surface water is usually near saturation or higher. The temperature of the water seldom exceeds 27° C. The maximum recorded is 35° C.

6. Discussion

It is of interest to note that the following organisms, which the writer has found to be common in this geographical region, were seldom, or not at all, found at the Bear River Refuge: Conochilus unicornis, Nototheca longispina, Datheina longispina, D. rufex, Cosiosphaerium spp., Antho-edenon flos-aquae, Dinobryon spp., Tabellaria spp., Fragilaria spp., Asterionella formosa, Echonalia gibba (replaced at the Bear River Refuge by E. ventricosa), Cosmarium spp., Staurosstrum spp., and Ceratium hirundinella.

The following organisms are more or less peculiar to the refuge: Anabaenopsis Arnoldii, Biddulphia levii, Chaetoceros spp., Cyclotella, Scolionura naisonis, Surirella Baileyana, S. ovata. Biddulphia levii is typical of inland salt waters. Chaetoceros is a marine genus; one fresh water species is reported from Devil's Lake, North Dakota (Elmore).

Scolionura naisonis, according to Boyer, is peculiar to salt lakes.

A few species occur commonly throughout most or all of the season, as, for example, Surirella Baileyana, S. ovata, and Amuraee cochlearia.

Most species, however, exhibit more or less marked periodicity, as Anabaenopsis Arnoldii (common in August and October; rare in November; not observed at other times), Modularia Harveana (frequent in July and September), and Cathypna Luna (frequent in May and August). Amuraee aculeata and Marahia albuquerqueana occur throughout the season, but show a marked increase in number, the first as the temperature drops below 20° C. in fall, the latter in spring. The abundance of Gloeostrichia natana...
C. Key to the Copepoda common at the Bear River Refuge

1. Separation into cephalothorax and abdomen distinct —— 4
2. Antennae of 8 segments —— Saxthecamatus
3. Caudal setae fused at base —— N. albuquerqueensis
4. Antennae of 24 or 25 segments —— Phoebus
5. Antennae of 17 segments; furcae without row of spines —— C. viridis
6. Antennae of 12 segments; furcae externally with a fine row of spines —— C. serratus
coincides with the presence of aquatic vegetation, which serves as mechanical support, and with high temperatures. The skinettes of this species are well distributed throughout the refuge at all times. Pedalion sp., very common in late July, was not collected within the refuge earlier than May 16, (temperature 23°C.), nor later than October 4 (temperature 17°C.). One later occurrence at the head gates is recorded for this species (November 1, temperature 8°C.). Notasna striata acuminata made its appearance on September 22 (temperature 22°C. at time of collection, 3 p.m.; average temperatures on that day well below 20°C.), one week before the autumnal fresh water supply was available. It is of interest to note that, as the season progressed, this rotifer approached more and more a form intermediate between the variety and N. striata proper.

The seasonal and geographical distribution of Notasna militaris is worthy of particular attention. Only once was this species collected in Unit 3 (chloride concentration 0.031 N), and once in Unit 1 (chlorides 0.014 N). From Unit 2, the organism was recorded nine times. All but one of these collections had been from water with a chloride concentration of 0.031 N or less. At the exceptional station, the chloride concentration had risen from 0.008 N on July 24 to 0.073 N on August 22. On July 24, Notasna militaris had been very numerous; a few individuals were still present on August 22. It should be worth while to study the behavior of this organism, since it is easily recognized and may, therefore, be a useful indicator in the study of brackish inland waters.

Diptonon Judayi is rare in the spring and summer. During October, its number experiences a very remarkable increase. On October 25, the
author, visiting an area in the northeast portion of unit 1 (depth 9 inches, temperature 13.5°C, chloride concentration 0.083 N), estimated the frequency of this organism to be of the order of magnitude of fifty individuals per liter of water.

The fact that the micro-biota of the Bear River Refuge is an aggregate developing within the area and is not merely "washed down" by the river is evident from the differences between collections from the river at headquarters and collections from the other stations. *Asterionella formosa* occurs more commonly near headquarters than at any other station. *Surirella halveyana*, *E. owatia*, and *Brachionus plicatilis* are absent from headquarters at times when they occur within the refuge. The following organisms were never observed at headquarters, although collections were made at such times that, should the organisms originate before the waters enter the refuge, they could not have escaped attention: *Anabaenansea arnoldii*, *Nodularia harveyana*, *Campylocystis hibernicus*, *Gomphonema*, *Rhaphidella ventricosa*, *Acolporate naegina*, *Calyptroplana luna*, *Aloha costata*, and *Harbia albinaquacea*.

Most species that occur with any degree of frequency were found throughout the area studied. A remarkable exception is *Anabaenansea arnoldii*, which, being very common over a period of several weeks, was never collected at certain stations.

Excepting the gates at headquarters, no single station or group of stations can be set apart as different from the others in the qualitative composition of its plankton with respect to more than one species. Species that are recorded as rare, however, are more likely to occur in the central and eastern portion of Unit 2 and in the west end of Unit 3 than elsewhere.
This indicates that most of the common organisms at the Bear River Refuge are able to succeed under a wide range of conditions, but that the environment presents threshold values of salinity or alkalinity to the rarer organisms. Evidence for this is also offered by the facts that many of the organisms rare at the Refuge are common in other waters of the geographical region, and that the areas noted for absence of the rarer species also show a poor cover of aquatic vegetation.

7. Summary and Conclusions.

The answer to the question "What are the microscopic organisms occurring at the Bear River Refuge?" cannot well be given in a form more condensed than that of Lists I and II on pages 6 and 15, resp. The following statements merely present a summary of additional facts determined more or less incidentally, during the course of the investigation.

1. Collections of plankton taken at different times of the year at the Bear River Migratory Waterfowl Refuge were analyzed.

2. The distribution of the common plankton organisms at the Bear River Refuge is nearly homogeneous.

3. Some of the organisms collected are brackish-water species.

4. Some species occur throughout the season, others during a more or less limited period of time.

5. The presence of the rotifer *Mastus militaris* in waters of the Bear River Refuge indicates that the chloride concentration of the water is probably below 0.05 N.

6. The plankton at the Bear River Refuge is qualitatively different from that of Bear River.
Bibliography


7. Elmore, C.J. 1922. The Diatoms of Nebraska. Univ. of Nebraska Studies 21: 22-274.


Appendix

A. Key to the green and blue-green algae common
at the Bear River Refuge.

1. Cells with nuclei and plastids ----------------- Chlorophyceae 3
2. Cells without nuclei and plastids; color often
   bluish-green ------------------------------- Oenopylennceae 2
2. Filaments without heterocysts, cells cylind-
   rical or disc-shaped ------------------------ Oscillatoria
2. Filaments tapering, with heterocysts at one
   end ------------------------------------------ Olistirichia
2. Filaments more or less straight, with inter-
   calary heterocysts ---------------------------- Nodularia
2. Filaments in circles or spirals, with one
   heterocyst at each end ----------------------- Anabaenopsis
3. Single-celled ----------------------------------------------- 9
3. Colonial -------------------------------------------- 6
3. Filamentous ------------------------------------------ 4
4. Filaments branched -------------------------------- Cladophora
4. Filaments simple ------------------------------------- 5
5. Chloroplastids one to several spiral bands ------- Emicosra
5. Chloroplastid reticular ----------------------------- Scenedesmum
6. Cells 16 or more, in motile spherical colonies 8
6. Cells four or eight, not forming a circular
   plate ------------------------------------------- Scenedesmum
6. Cells usually 16 or more, forming a circular
   plate ------------------------------------------- Pediasantrum 7
7. Plate entire ------------------------------------------ P. Borz anus
7. Plate perforate --------------------------------------- P. Duclex

The segregation of this species into varieties depends
on the size of the perforations: see Smith{25}. 
8. Cells angular by mutual compression

9. Cells spherical

9. Cells arcuate, without constriction

9. Cells with constriction separating two symmetrical semi-cells

10. Semi-cells with processes

10. Semi-cells without processes
B. Key to the Cladocera
collected at the Bear River Refuge

1. Both rami of the antenna 3-jointed .......................... 5

2. Dorsal ramus of the antenna 4-jointed, ventral ramus
   3-jointed .................................................. 3

2. Abdominal claw with 3 spines -------------- Latononasia

2. Abdominal claw without spines ------------------- Bisphanasoma

3. Shell with long terminal spine ----------------------------- Daphnia

4. Shell without long terminal spine ----------------------------- 5

4. Antennules large, fixed. Valves with short
   spine at lower posterior corner. ------------------- Bosmina

4. Antennules small; if large, attached at ventral
   side of head, freely movable ----------------------------- 5

5. Antennules small, covered by rostrum ------------------- Simocanhalus

5. Antennules small, not covered by rostrum; head
   small, conspicuously depressed ----------------- Caridocanhalus

5. Antennules large, freely movable .............................. Moina

6. Post-abdomen straight and narrow; claws
   with secondary tooth in middle ------------------------ Kurzia

6. Post-abdomen broad, with clusters of large
   spines ........................................................ Lacinia

6. Post-abdomen otherwise ------------------------------------ 7

7. Animal circular in outline ------------------------------- Chydorus

7. Animal more or less elongate in outline ---------------- 8

8. Rostrum exceeding the antennules markedly, claw
   with two basal spines ----------------------------- Fleuroxas

8. Rostrum not exceeding the antennules markedly-- 9

9. Valves with spine anterior to lower posterior corner  Dunhevedia

9. Valves without such spine ----------------------------- Alona
C. Key to the Copepoda common at the Bear River Refuge

1. Separation into cephalothorax and abdomen distinct ---- 4
    1. Separation into cephalothorax and abdomen indistinct -- 2
        2. Antennae of 8 segments ------------------------ *Canthocamatus*
        2. Antennae of 6 segments ------------------------ *Harshia* 3

3. Caudal setae fused at base --------------------- *H. albuquerqueensis*
3. Caudal setae not fused at base ----------------- *H. brevicaudata*

4. Antennae of 24 or 25 segments ------------------ *Diaphanosoma*
4. Antennae of 17 or fewer segments --------------- *Cyclone* 5

5. Antennae of 17 segments; furcae without row of spines-- *C. viridis*
5. Antennae of 12 segments; furcae externally with a fine row of spines ------------------- *C. serrulatus*