THE OXFORD UNIVERSITY EXPEDITION TO SPITSBERGEN
1921

An account, done in 1978-83

by

CHARLES SUTHERLAND ELTON

Part II : pp.64 - 119

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[11 July... Liefde Bay specimens collected by Dr Longstaff on 8 July:

The bird party was inside Liefde Bay from the 3rd to the 8th, but left (according to F.J.) at 7.20 a.m. on 8th .T.G.L.'s date may therefore be incorrect within a day or so. They did not land on the N. shore of Reindeer Peninsula.

Mallophaga: ♂ Trinotum anserinum on Grey Phalarope: Waterston noted [S.P.1, No.20] that it was obviously a straggler from its usual host, geese.

Diptera: 1 ♂ Chironomus lugubris [see Edwards, S.P.1, No. 15, where he gives "coast tundra"].

Aranea: 1 ♀ Erigone tirolensis [see Jackson, 1922 in S.P.1, No.21; he was not quite certain about the identification, without the ♂. In 1924, S.P.2, No.17, he decided that it had been Erigone psychrophila, having then further material from me.]

I took both these last two at Liefde Bay in later expeditions.

[11 July...Hermansen Island [Hermansenøya]. On the way down Foreland Sound, a party called here. Summerhayes landed and his observations and notes on birds from other members are given in our paper (pp.281-2). I was catching up on sleep! It seems to have been a rather ordinary eider duck island, with the usual other birds. Both Summerhayes and Jourdain noticed the remarkable profusion of flowering Saxifraga oppositifolia, which they likened to a Scottish heather moor in bloom. F.J.: "We left the island 6.20 p.m. for Cap Boheman and reached an anchorage, a long way out in the fjord, next morning."

12 July...Cap Boheman [Bohemanneset]. [F.J.: "It was a long row from the sloop to the shore and we had two boats out". Huxley, Summerhayes and I stayed here for several days in comfortable huts at a small Dutch coal mine, where according to F.J. there were "about 40 German workmen employed". The well-known Dutch ornithologist Dr G.J.Van Oordt (together with a friend, M.Pelletier) was working here. He and Huxley together published a paper upon the habits of the Red-throated Diver [S.P.1, No.7]. Their paper gives a succinct summary of the nature of this flattish and quite large cape: "Cape Boheman is the eastern point of the large Tundra Boheman, which is about 8 miles long. The tundra itself can be divided into a wet,swampy, low part, in which numerous lakes and pools are to be found, and a higher and drier part where, in some places, the sandstone rocks, eroded by ice action in the glacial period, reach the surface. The coast of the Tundra Boheman is not steep; it is only on the eastern side and at some places on the south coast that moderately high slopes occur. South of the tundra several islands are to be found, on which Northern Eiders and Arctic Terns breed in great numbers. However, both species were nesting also on Cape Boheman and scattered along the coast. At the east coast of the tundra, in the crevices of strongly weather-beaten

The Bird Party aboard, July. L. to r.: Binney, Huxley (standing), Powell, Brown, Paget Wickes, Jourdain, Ice Pilot, Powell.
(Photo Seton Gordon)
Probably Gordon

12 July...Cap Boheman... ["sandstone rocks, I [presumably Van Oordt] found a small colony of Mandt's Guillemots, consisting only of four pairs. Scattered all over the tundra, in the wet as well as in the higher part, the splendid King-Eiders and the Red-necked [an extraordinary mistake for Grey] Phalaropes were breeding abundantly. Characteristic birds of the dry tundra are the Snow-Bunting and the Purple Sandpiper, while at the side of the lakelets a few pairs of the beautiful Red-throated Diver (Colymbus stellatus) had their nests." I have quoted this description because, although it more or less agrees with the summary in our paper, Van Oordt had time and opportunity to cover a much wider area than we did in a few days. Most of our work was done fairly near the settlement. The peninsula lies exactly opposite Advent Bay i.e. some 45 km. inside Icefjord, on its north shore, and therefore inside the Inner Fjord Zone of better climate, as we were to define it later. We have kept no records of the weather, but certainly were able to work in the field every day; while Jourdain's weather notes do not mention rain in the areas he visited (also in the Inner Fjord), though it was not always sunny. The modern map shows the peninsula to have an extreme length and breadth of about 10 km. We were at the extreme E. end of it.]

[The mine had a wireless station manned by a friendly and serious German, who turned out to have been the operator on the German "pirate" merchant ship "Karlsruhe" during the War, when a number of our vessels were sunk by it. He seemed to be in a highly-strung state, and whenever he was using the wireless, the rather turbulent young miners always stopped making any noise that might disturb him.]

[F.J.'s Diary records a number of birds, including the nest of a King Eider with 5 eggs that Van Oordt had found. He also mentions on this date that "Elton had come across a Long-tailed Duck sitting on the open tundra with 6 eggs." I have a print of a photo of this bird taken by Seton Gordon. It was one of the two nests of this species found by the Expedition, the other being on Reindeer Peninsula [see F.J. in S.P.1, No.10]. Later, on the 16th, F.J. noted that the Cap Boheman ♀ "sat without stirring while we stood about 6 ft. off and allowed Elton to go within 2 ft. of her."]

[I kept no daily diary while here, and because nearly all the data collected are given in our paper, it is not necessary to repeat them in detail. The following are the chief observations and conclusions, together with a few comments that have occurred to me in re-reading the material. In general, my main work was on the numerous fresh-water ponds, because what I was able to find in the drier habitats was rather meagre, although the shortness of

12 - 16 July...Cap Boheman... [our stay partly accounted for this. We distinguished between the northern part which was mostly flat bogs and ponds, and the southern part with drier habitats on sandstones and slates deficient in lime. Nowhere were the hills above 50 ft. The coast has cliffs, not more than c. 30 ft., and some shingle patches.]

For the reasons given, this summary will follow the classification of habitats in our paper (p.249), not the chronological order of work, though some dates are included where they may have any value.]

[Intertidal Zone. On the rocky shore near the settlement, where seaweeds were abundant (Fucus evanescens Ag., Chaetopteris plumosus Knetz. and Phloeospora tortilis Stromf. -- the last found by me also in Richard Lagoon), I collected the following animals:

Hydroida:	Gonothyraea loveni Allman
Mollusca:	Littorina rudis var. groenlandica Uke
Crustacea:	Amphipoda (including Gammarus) v.ab.

The name L.rudis, given me in 1921 by G.C.Robson of the British Museum, should now be L.saxatilis (Olivi). According to Feyling-Hanssen (1955):"All specimens of Littorina saxatilis from Svalbard should be referred to the var. groenlandica Menke". Thus the permutations of taxonomy! But I have to mention that when, with Baden-Powell, I published an account of a raised beach section south of Bruce City, Klaas Billen Bay (described later in these notes), this distinction was not taken into account; and, as Feyling-Hanssen pointed out, we were in any case mistaken in stating that this species was extinct in Spitsbergen.]

[I saw no barnacles. In a very thorough survey of the barnacle, Balanus balanoides (L.) in Svalbard, the same author (1953) charted the occurrence and habitat of this species. He found it to be widespread, but often not noticeable because it tends to live in rock crevices where it is protected from ice. It is, however, susceptible to suspended mud. It usually lives about mid tide-level. It would not be surprising if it occurs on Cap Boheman, since it has been recorded from places on the S. coast of Icefjord, and also

12 - 16 July...Cap Boheman... [at Kapp Wijk a few miles N. of the Cap. But Feyling-Hanssen's map does not mark it for Cap Boheman. I have the impression that this area, in spite of its proximity to other places frequently visited, has not received much attention from zoologists. On 13 July I found the mite Bdella groenlandica among the cliff shales. Thor (1930) did not consider that there was any difference between this species and Bdella (now Molgus) littoralis, a large scarlet mite extremely common between tide-marks and at drift-line in many parts of Spitsbergen. This point I shall discuss in Appendix 2. On ecological grounds there is a case for treating them as separate species, as Hull, following earlier taxonomists, did. Thor cites a record of B.littoralis reported by Oudemans (1928) from material collected at Cap Boheman by Dr Van Oordt.]

[The Open Dry Tundra. This we divided into Fjaeldmark with great abundance of Dryas; and Heath, developed in sheltered places and dominated by Cassiope tetragona. My field notes record: "Land Tundra. Cassiope, Dryas, Saxifraga oppositifolia, Salix. Exceedingly dry. Nothing at all by shaking Dryas and Cassiope (not in flower or hardly)". Even allowing for the short time available for collecting, since most of my work was on ponds, this situation is correctly described. Thus in the Fjaeldmark only 12 spp. of Phanerogams, 1 Bryophyte (a moss, Hylocomium splendens) and 2 Lichens (Cetraria nivalis and Lecanora sp.) were collected. There was much dry soil with no plant cushions. Slightly damper ground had no Dryas, but 9 other Phanerogams (of species not very different from those on dry ground, but including Saxifraga hieraciifolia and S. nivalis); no moss, and only 2 Lichens (Cetraria islandica and Stereocaulon alpinum). The Heath formed a thick vegetation up to a foot high, of Cassiope with very small amounts of 3 other Phanerogams, and one moss (Dicranoweisia crispula). The plants were different from those on the Fjaeldmark, with Papaver nudicaule var. radicatum and Equisetum variegatum, but Saxifraga oppositifolia in common. The only invertebrate I collected on the Heath was the mite Sphaerozetes notatus. The record of the fly Limnophora hyperborea given for this habitat in our paper (p.251) is an error, I think caused by the fact that it is a common terrestrial fly in Spitsbergen, though our record was of it flying over bog (see Collin, S.P.1, No.16).]

[This picture of the dryness and comparative poverty of both plant and animal species in the Open Tundra is reinforced by a peculiar exception that we

12-16 July...Cap Boheman... [studied here. Although the surfaces of rocks were unusually poor in lichens (compared e.g. with Bear Island or Prince Charles Foreland) there were crevices, some up to 6 ft. deep, in the rock pavement that provided a habitat that was damper than the exposed surface, though poorer in light. V.S.S. noted two points (1) Higher plants were long and attenuated, and in the case of sorrel, Oxyria digyna, lacked anthocyanin in the usual amount (2) There was a richer flora -- 6 species of Phanerogams including Ranunculus sulphureus and Saxifraga cernua; 10 Bryophytes, including several Hepatics. It is noted in our paper (p.252) that "Saxifraga cernua is the only higher plant which is at all normal here. It has been recorded from many other countries in somewhat similar habitats" -- not of course only in these. The crevices also afforded nesting sites for Snow Buntings: "Stomachs of five birds from here had about a dozen fly pupae in them, while one had also remains of adult flies". But no doubt the hunting for food was done in the boggy areas to be mentioned.]

[Just outside such crevices I collected in the mossy zone there (12 July):

Collembola:	1 Isotoma viridis
Aranea:	2 imm. indet.
Enchytraeidae:	1 Mesenchytraeus sp.

The worm was immature and could not be named to species. So far about 3 species of this genus have been described from Spitsbergen, two of which have specific names.]

[The Purple Sandpiper has already been noted as characteristic of the dry tundra, where it nests (these Notes p.65). The food of this species is extremely varied, as has been generally recorded. 4 specimens examined at Cap Boheman contained, respectively, 4 and 6 spiders; 3 flies and plant debris; and 3 very small gasteropods and remains of seaweed! (Our paper, p. 252).]

[Wet habitats. The 1968 map (1:500,000) shows that the Cap has a shallow spine from which streams flow both northwards and southwards to the coasts. We did not notice much life in them, except locally filamentous algae on stones (which were not collected, except for Ulothrix subtilissima in a stream coming from a permanent pond; but not named in our paper).]

[But the stream margins were occupied by a characteristic flora, described by us (p.253). Of the Phanerogams, Oxyria digyna was the commonest species, and there were three species of Ranunculus -- nivalis, sulphureus and pygmaeus,

12 - 16 July...Cap Boheman... [and among other plants Saxifraga rivularis and S. hieraciifolia, also two kinds of grass, Alopecurus alpinus and Poa alpina; together with four moss species. I did not collect animals in this zone.]

[The extensive areas of Moss-bog must have had a different substratum to that of the dry tundra -- possibly clay or silt over the rocks, giving a continuing supply of snow or ground-ice melt water. V.S.S. equated them with bogs in Iceland and Greenland. He collected 23 moss species (listed by us), of which various Hypnum spp. characterized the wetter parts. There were also 5 species of hepatics. The bog had numerous Salix polaris hummocks mixed with bryophytes, in which were 10 species of Phanerogams including the following not noted in other habitats:

Cardamine bellidifolia
Eriophorum scheuchzeri
Pedicularis hirsuta
Petasites frigida

Eriophorum is, of course, a bog species and Petasites a species of damp ground; but the other two are normally plants of dry tundra and were evidently living in "islets" of soil damper than that of the arid rocky tundra already described. And V.S.S. noted the presence of 5 kinds of lichens in the top zone of these hummocks, in which he detected 5 different zones of bryophytes.]

[I Collected the following Diptera from the boggy land:

Camptocladius curvinervis var. polaris
Chironomus lugubris
Cricotopus basalis
Metriocnemus ursinus
Orthocladius consobrinus
Psectrocladius consobrinus

Most if not all of these would be breeding in the ponds. After a life-time of research on population ecology I would not now subscribe to the naive remark made on p.255 of our paper that "Phalaropes and Snow Buntings act as a big check on the aquatic flies", though they no doubt feed on them! Many Collembola occurred on the surface of water in these bogs, as also at the margins of ponds. I collected Agrenia bidenticulata.]

Grey Phalarope, King Eider and Long-tailed Duck were nesting in the boggy area.]

[I collected the large alga, Nostoc piscinale, from the moss-bog.]

12 - 16...Cap Boheman... [Pond Margins had a moss flora similar to that of the bogs. But Sphagnum fimbriatum var. concinnum occurred on the edge of a permanent pond. We stated (p.254): "The absence or relative rarity of Sphagnum in moss-bogs in Spitsbergen has been noted before...It is well-known that in bogs in the Arctic Sphagna are much less important than in temperate countries. Only in one place (Advent Bay) in Spitsbergen did we find any amount of Sphagnum and even here it is rather local." (See later, 18 July). This was certainly my own experience on expeditions of 1923 and 1924 to the western and northern regions of the archipelago. Bryce examined a sample of this Sphagnum, mixed with other mosses, and was able to identify 4 kinds of Rotifera (S.P.1, No.26):

Adineta vaga (Davis)
Mniobia russeola (Zelinka)
Habrotricha sp.
Rotifer sordidus (western)

The Mniobia had a specimen of the unknown worm parasite found also on Prince Charles Foreland and at Bruce City. There were also Tardigrada (and eggs), Nematoda, and three different kinds of mites (not named).]

[Ponds. Fresh-water ponds were very numerous in the land round the settlement, two of them (Ponds 1 and 2) being permanent ones connected in sequence by a small stream and forming the water-supply there. Our paper contains a good deal of detail about pond life -- although our time was short, the permanent daylight enabled me to study about 20 ponds, and to spend long hours at the microscope. I shall not repeat all these details here but give only the main conclusions, and add some records of algae that were not published at the time.]

[Most of these ponds were quite small and obviously temporary to varying degrees,* mainly or entirely drying up by the end of summer e.g. Pond 12 was so recorded by Dr Van Oordt. Olofssen (1918) had pointed out that in Spitsbergen small ponds must warm up more quickly than large ones, and so speed up the life-cycles of the fauna, which may explain the presence of the latter in spite of their habitat lasting such a short time. Table II (p.258) in our paper gives the Crustacea collected from 9 temporary ponds, arranged in approximate order of richness etc., assumed to be associated with the length of their existence during the season. One species, Cyclops crassicaudis was found in all of them. The largest Crustacean in these Cap Boheman ponds, the Phyllopod Lepidurus arcticus, occurred only in permanent ponds. Daphnia and Macrothrix, among the Cladocera seemed also to be restricted to them. The list of species that I collected in temporary pools is given below:

* see photo at p. 254 of our paper.

12 - 16 July...Cap Boheman... [Ponds...

Rotifera:	Euchlanis deflexa Gosse
	E.dilatata Ehrenberg
	E.orophoa Gosse
	Metopidia lepadella Ehrenberg
	Monostyla sp.
Crustacea, Cladocera:	Acroperus harpae
	Chydorus sphaericus
" , Copepoda:	Cyclops crassicaudis
	Maraenbiotus brucei
" , Ostracoda:	Candona rectangulata
	Eucypris glacialis

Acroperus harpae was a new record for Spitsbergen. The Rotifera were named by Bryce, though not included in his paper on moss species. Diptera larvae were less common than in the permanent ponds.

The fauna of the permanent ponds was as follows (Rotifers not collected):

Crustacea, Euphyllopoda:	+ Lepidurus arcticus
" , Cladocera:	Chydorus sphaericus
	* Daphnia pulex
	+ Macrothrix hirsuticornis
" , Copepoda:	* Cyclops crassicaudis
" , Ostracoda:	+ Candona rectangulata
	+ Eucypris glacialis

* In plankton
\+ On bottom

Chydorus sphaericus was noted as occurring among moss etc., and this may explain its persistence also in the temporary ponds. Chironomid fly larvae were abundant.]

[As additional background to this survey I will cite remarks by Sandon (S.P.1, No.6, p.450), based on notes I gave him about Protozoa: "In his notes made on ths spot [here referring to Klaas Billen Bay, Bruce City] Mr Elton records that Uroglena volvox was very abundant in all the ponds in this district, and that there were also found flagellates belonging to the genera Euglena and Glenodinium, and ciliates probably belonging to the genera Vorticella, Carchesium, Dileptus, Prorodon, and Colpoda. He makes the further interesting observation that whereas in the Bruce City ponds, which were fed with drainage water from limestone hills, Uroglena was very abundant, at Cape Bohemian [sic!], where the pools were in sandstone, this species was absent, and its place taken by large numbers of Synurella uvella and peridinians. From the latter region his records also include Glenodinium, Euglena sp., and three ciliates, probably Spathidium, Nassula, and Ophrydium." Our paper (p.256) notes: "Among the protozoa were large colonies of the green ciliate Ophrydium, upon which young Lepidurus were seen feeding".

12 - 16 July...Cap Boheman... [Ponds... 4 species of birds frequented the ponds: Grey Phalarope, Red-throated Diver, Long-tailed Duck and King Eider. The last needs comment. In our paper we said: "The young of the latter [i.e. King Eider (Somateria spectabilis)] feed in freshwater ponds on crustacea , plants, etc. " Løvenskiold, in his great monograph on Spitsbergen birds (1964, p.124) cites this passage as if it was based upon first-hand observation by us, though the references that follow make it obvious that we are citing other work. In fact, the remark about food refers to the observations of Manniche (1910, p.105) in E.Greenland, where he says: "In the season in which the King-Eider lives in fresh water its food consists principally of plants. In the stomachs, which I examined, I found however many remnants of insects, especially larvae of gnats. In the stomachs of downy young ones I found indeterminable remnants of crustaceans, plants and small stones." As a matter of fact, Løvenskiold gives no data for the food of this species in Spitsbergen, and presumably it has not been looked at. No doubt this is mainly because the species is not a very common one there. All observers (including Van Oordt at Cap Boheman) agree that it differs from the common eider in keeping the young on fresh-water ponds at first, only going out to sea later in the season. Two nests of this species were found at Cap Boheman, one by a pond, the other in Cassiope heath. Løvenskiold says that the male, an extremely conspicuous black and white bird, stays by the nest at first. Does this mean that it can stand up to an arctic fox, as can the pink-footed goose?]

[Algae. The ponds contained an extremely rich algal flora, especially Desmids. Evidently this is not an uncommon feature of Desmids in non-calcareous waters. Lind and Brook (1980) remark: "Especially abundant in the base-poor, granitic regions typical of parts of the English Lake District. A good collection can contain an almost bewildering array of desmids, and it is not too uncommon to find over 50 species in one sample". This was more or less my experience here. And cf. remarks above about Sphagnum.

Desmids, which are remarkable for their binary symmetry and beautiful structural details, and some other algal groups I collected, are not listed completely in our paper, but are all included below. I do not feel at all sure now that the sampling justified the distinctions we made between the algae of temporary and permanent ponds, since material from only half-a-dozen were completely examined by B.M.Griffiths. I have kept the complete lists, but did not insert the species authorities, though we give them for those species selected for our paper. I do not think it practicable now to assign them to the others.

12 - 16 July...Cap Boheman...

Algae from ponds

Desmidioideae (Placoderm or "true" Desmids):

Closterium leibleinii
* Cosmarium arctoum Nordst.
* C.bioculatum Breb.
* C.bisetum Breb. & C.b.var. simplex
C.botrytis Menegh.
C.capitulum var. groenlandica
* C.conspersum Ralfs. var. latum West
* C.crenatum var. bicrenatum Nordst.
" var.subcrenatum
C.cucumis var. magnum
* C.cyclicum Lund. var. arcticum Nordst.
C.cymatopleuron
C.globosum Bulnh.
C.granatum
C.granatulum var.subgranulatum
* C.holmiense var. integrum Lund
C.holmii
* C.impressulum Elfv.
C.obliquum C.o. var.minor
* C.ochthodes Nordst. *C.o. var. amoebum
C.phaseolus var. elevatum
C.protumidum Nordst.
C.punctulatum *C.p.subpunctulatum Nordst.
* C.protumidum Nordst.
C.pycnochondrium
* C.quadratum Ralfs.
C.quasillus
C.speciosum C.s. var. biforme
C.subspeciosum
C.subtumidum
C.turpinii
Euastrum binale E.b. var. dissimile
E.crassicolle
E.elegans
E. polare
E.tetrabolum
Hyalotheca dissiliens
Penium curtum
Pleurotaenium ehrenbergii
Spondylosium papillatum

12 - 16 July...Cap Boheman...

Algae from ponds (cont.)

Desmids...

Staurastrum arcuatum
* S.beineanum Rabenh.
S.brevispinum var. obtusum
S.capitulum var. amoenum
S.cuspidatum
S. dejectum
S.furigerum
S.megalonotum
S.muticum
S.oligacanthum
S.pachyrhynchum Nordst.
S.paradoxum var. parva
* S.polymorphum Breb.
S.punctulatum S.p. var. subproductum
* S.subbrebissonii Schmidle var. hexagonum Sutwinski
S.tricorne
Xanthidium antilopeum

Other non-blue-green groups:

Botryococcus braunii
Coelastrum sp.
Euastropsis sp.
* Eudorina elegans Ehr.
* Gloeocystis infusionem West
* Oocystis solitaria Wittr. & O.gigas
* Nephrocytium obesum West
* Pandorina morum Bory.
Pediastrum boryanum Reisch. var. longicorne
Phormidium sp.
Sphaerella sp.
Tetraedron platyisthmum
Tetraspora lubrica
Uronema confervicola
Zygnema sp.

Cyanophyceae:

* Aphanocapsa grevillei Rabenh.
* Aphanotheca microscopica Naeg.
A.prasina
* Chroococcus turgidus Naeg.
Gomphosphaeria nageliana
* Lyngbya perelegans Lemm.
Merismopedia glauca Naeg.
* Synechococcus aeruginosus Naeg. ← Microcystis holsatica & S.a. var. maximus
Tolypothrix distorta Kuetz penicillata Lemm.
T.tenuis

Besides the flagellates etc. mentioned on p.71 above, I collected Dinobryon cylindricum from a pond here.

The species marked * above are those printed in our paper. Several others have been allotted their species authorities derived from other parts of our paper.

From a small Stream I collected Ulothrix subtilissima Rabenh.]

17 July. Sassendale [Sassendal].

[F.J.'s Diary records that early today a party from the ship visited here "where we left Segnit & Summerhayes, who worked the slopes of Colorado Mt., and found a big colony of fulmars nesting there." I did not go ashore. F.J. also noted: "Rain in a.m. Half a gale of wind from W. in afternoon + cold driving rain. A bad day." The main bird party found that the river was very wide and they could not ford it. There were "vast stretches of shingle with sparse vegetation -- Arctic poppy, Draba, etc. By a big tarn were many geese -- pink-foot, brent and a few barnacle, all unable to fly & a small flock of flying brent." They shot 18 geese. Binney collected a bird-louse, Trinotum anserinum, from a pink-foot (S.P.1, No.20).. Of small waders F.J. mentions purple sandpiper and possible sanderling; and about 5 pairs of dunlin (Calidris alpina) apparently breeding. The last is mentioned by F.J. in S.P.1, No.10:"No occupied nest was found in the limited time available, though the birds were evidently breeding." Løvenskiold states that this species is rare in Svalbard, and he himself visited Sassendale in 1950 and saw quite a lot of young dunlins. He is definite that the evidence that they breed there is good, but it still has not been proved absolutely.]

[In our paper, pp. 276-9, Summerhayes gives a good account of some of the vegetation types in this place i.e. south-east of Temple Bay [Tempelfjorden] covering the S. slopes and lower plateaux of the Colorado Range [Coloradofjellen]. Here he was able to see the vegetation associated with the bird-cliffs that rise several hundred feet and have rich flower-moss slopes on the screes below. F.J. has left no record (except for the Fulmar) of the species of sea-birds nesting on these cliffs and slopes, and V.S.S. mentions only "large numbers of the usual sea-birds". But these no doubt included Kittiwake and Brünnich's Guillemot, which Løvenskiold records as breeding in this district.]

[I shall repeat here only the main points from the vegetation survey.]

[Bird-cliffs and slopes. These were of special interest to us, as being the only ones studied by either of us, apart from my limited notes on nest Diptera on Bear Island, and Huxley's brief visit to Vogel Hook (see pp.54-5 of these Notes). Lying on the south-facing slops of Sassendale, with an interior fjord climate and bird manuring, the slopes were rich in

17 July...Sassendale... [plant species growing in "a continuous carpet of dicotyledons, grasses and mosses". One of the abundant species was Polemonium humile. The flora also included Chrysosplenium alternifolium var. tetrandrum, 4 species of Draba, 3 of Ranunculus, 4 of Saxifraga, 2 of Melandrium [the Wahlbergella of our paper], and 3 kinds of grass. Some of these species e.g. Polemonium and Melandrium affine are definite inner fjord ones. There were large sheets of Cerastium alpinum. His account does not make it clear whether the moss species he mentions were actually seen by him here or the names derived from the literature for other places he cites. I feel pretty certain that he did not collect mosses much on this day, since none are mentioned for the other habitats except stream sides. (I do not have any of his original notes from this Expedition).]

[I am inserting here an observation made by Gordon on 13 July, when some of the Expedition visited Dickson Land; because it concerns a rather similar habitat to that just described and also gives an important record for a moth, of which there are few in this country. This area lies between Dickson Fjord and Klaas Billen Bay. Longstaff and Huxley climbed Mt.Congress [Kongressfjellet] to 2000 ft. and noted [T.G.L. p.243] "the soft green headland of Dickson Land just opposite us". F.J. wrote:"Reached our anchorage near Mt.Congress". It is evidently this southern bit of Dickson Land that Gordon refers to in his book, and in any case T.G.L. noted that the fjord itself was frozen further up. S.G. says he climbed about 100 ft. Below some cliffs with many guillemots on, "the hill slope beneath the rocks was tinged with blue" i.e. with Polemonium and "in the air was a subtle scent given off by these deep blue flowers. For the first time, too (and incidentally, the last also), the rare Spitsbergen moth crossed the hill slope just below us. A sturdy and good-sized moth he was, of a dark brown colour which easily eluded an attempt made to capture him." In my own notebook the incident was written down on 16 July, with some slight differences in the details: "Seton Gordon reports a moth seen, on the side of a warm hill in Dixon [sic] Land, about 300 feet up. A lot of flowers (Polemonium, Draba, etc.). Flying from flower to flower, and a rather heavy flight. Size about or rather below that of common blue [butterfly]. Colour dark. (He was rather vague about the size)." I have discussed this and other records of Lepidoptera in Spitsbergen, in a paper (S.P.2, No. 16) published in 1925. The matter will be referred to in my notes on the 1924 Expedition.]

17 July...Sassendale... [Raised Beaches. On a series of these, Dryas octopetala was locally abundant, and in one place a heath of Dryas and Cassiope tetragona had developed, together with 7 other phanerogams, including Polygonum viviparum, Pedicularis lanata and Silene acaulis.]

[In one spot among the beaches was a talus of blocks, and here the flora included a fern, Cystopteris fragilis -- not a common species in Spitsbergen; also Melandrium affine.]

[Invertebrates and Fjaeldmark. This formation-type occupied most of the slopes and plateux, though the vegetation was sparse, partly forming a cushion-heath of Dryas and Cassiope and 18 other phanerogams, including grasses and an Equisetum, some details of which are given in our paper. There was also one moss and three kinds of lichen.]

[The only animal collected here was the spider Leptyphantes sobrius(1 ♀), a species characteristic of unstable slopes or at any rate places with loose stones. Jackson, in his taxonomic paper (S.P.1, No.21) accidentally omitted this locality, though it is in the MS list from him that I kept. Of course, Holm, in his considerable survey of this part of Icefjord (see these Notes, p. 36) records it from this area, and various other spiders as well.]

[Stream sides. The streams on the plateau run in wide valleys with much damp vegetation, and a grass, Alopecurus alpinus, dominant. "Papaver nudicaule var. radicatum also occurs in quantity, which is surprising since it is usually a plant of very dry habitats. Mosses occur here submerged, Philonotis fontana* and var. alpicola Jur. and Hypnum giganteum being the commonest." There was a thin marginal strip of mosses on the slopes: 6 species are listed in our paper, with the remark that "These mosses are similar to those by streams in Iceland." Also were 6 species of phanerogams, including Cochlearia officialis, Cardamine bellidifolia and Saxifraga flagellaris and rivularis.]

18 July. Advent Bay. [On the previous evening the ship had left at 5 p.m. and F.J.'S Diary noted : "Soon after a strong head wind got up, and rough sea and made little headway; about 9.30 p.m. got partly under the lee of islands and were able to take J.S.H., Brown and Van Oordt on board". They had been left with a boat that morning to look at Orton's marine raft. "Quite impossible to land at Cap Boheman so ran for Longyear City, reached early next morning." The 18th at Advent Bay was "a dull and chilly day". They visited the barnacle goose rocks but there were no geese. His Diary notes that young snow buntings were everywhere, on the houses as well as in the

* Dixon (S.P.1, No.29), referring to this states: "Philonotis tomentella Mol. ... Not hitherto recorded from Spitzbergen, but doubtless included in the forms recorded by Berggren as P. fontana Brid."

18 July...Advent Bay... [valley."]

[No vegetation survey was done here, but I did a limited amount of collecting on the lower slopes of a lateral valley behind Longyear City (cf. also p. 37 of these Notes)*. In our paper we listed the Diptera obtained from flowers of Dryas octopetala and Cerastium alpinum, but not other groups. The latter are added below (they were published, without any but locality detail, by Hull for mites (S.P.1, No.23) and Jackson for spiders (S.P.1, No.21) but not in our general paper):

Hemiptera:		Aphid (under a stone)
Diptera:	1	Sciara sp.
	1♀	Camptocladius pumilio
	1♀	Limnophora megastoma
	1♂	Rhamphomyia caudata ("black shining fly")
	1♀	Syrphus tarsatus ("hover-fly")
Acarina:		Bdella decipiens
		Rhagidia gelida
		Sphaerozetes notatus
Aranea:	1♂	Hilaira glacialis
	1♂,2♀♀, 11 imm.	Leptyphantes sobrius
	2 imm.	indet.

The inclusion of the Chironomid fly Psectrocladius borealis in the Diptera, in our paper, was evidently an error in transcription, since Edwards' lists do not give it for this place; I did collect it at Cap Boheman and Bruce City area.]

[The flies were taken from flowers of Dryas octopetala and Cerastium alpinum, and so recorded in the papers by Edwards and Collin. Obviously, since only one specimen of each was collected, there is no certainty as to which species of flower each came from! Of the Rhamphomyia, Holmgren wrote "In floribus Dryadis ad Advent Bay a me frequenter observata"; and of the Syrphus, "In floribus Dryadis ad Advent Bay...haud infrequens". Hackman (1968) gives a list of localities for Rhamphomyia in Spitsbergen, and states: "Mainly taken on flowers of Dryas and Cerastium". Holmgren's phrase may be translated as "not at all uncommon", a true remark, since he collected more specimens than all the various people have done since. Kanervo gives a list (1968) of the localities for Syrphus tarsatus known to him up to that date: Advent Bay, Gipsdal, Sassendal, King's Bay [Kongsfjorden]. I have collected it in three of these (not Sassendal). The enormous survey, mainly of upland habitats behind Advent Bay area, done by Hinz in 1968 (publ.1976), turned up a few S.tarsatus, and suggested a preference for warm slopes; but the numbers found were extremely small.]

* A soil sample from dry tundra here was found by Sandor (S.P.1, No.6) to contain 9 flagellate Protozoa, 1 or more Ciliates and 8 Rhizopoda. pH was acid, 5.3.

18 July...Advent Bay... [Here I have to elucidate an ambiguous sentence printed in our paper (p.282): "The larvae of Syrphus feed on aphids, of which one species -- Scaeva dryadis -- is recorded from Advent Bay". The fact is that Scaeva dryadis was the name used by Holmgren for this hover-fly, of which he collected here 12 ♂♂ and 35 ♀♀ within 3 - 10 August 1868. He pointed out that their presence implied that there must be aphids present as food for their larvae. I believe the aphid I collected was the first of this group to be taken in Spitsbergen. Unfortunately, I can find no trace of the specimen. (In case it is ever found at Oxford or London, the code for it is F 1, and the label should also have place and date). More recent evidence about the aphid species resident in Spitsbergen is summarized by Heikinheimo (1968), though in a slightly confusing paper. It deals partly with the great migrant horde of aphids onto North-East Land in 1924, which I shall be discussing in the Expedition work of that year. The rest concerns resident species, or supposed species. One has to recognise the taxonomic difficulties encountered in this group. Thor (1930) collected aphids partly from Advent Bay, but there are difficulties about his identifications, and his collection seems to have been lost. Perhaps 3 or 4 species have been discovered and named since. Two of these were taken in Sassendal, during expeditions under Holm in 1954 and Kaisila in 1965: they are very small species, around 2 mm. in length, described so far only from Spitsbergen -- Acyrthosiphon calvulus and A. svalbardicus. The former had been described by Ossiannilsson (1958) as living on Poa arctica in Sassendal. The latter is based on one specimen from the Advent Bay area, where Kaisila also found A.calvulus. Hinz found a few aphids during his wide survey, but the species are not recorded.]

[A great deal of collecting has been done in recent times, some casual and some more systematically, in the region of Advent Bay to Sassendal, as well as other localities on the West coast, and I shall not attempt to review these data here, except to say that they fully confirm the reality of the Inner Fjord Zone, as defined in our 1928 paper. Furthermore, a good many of the invertebrate species are markedly scarce and local in distribution.]

[Ringed plover (Charadrius hiaticula)at Advent Bay. F.J. (in S.P.1, No.10, states: "In Spitsbergen it has been recorded on many occasions since 1827 on the west and north coasts, as well as in King Karl Land, but though evidently breeding, no nests have hitherto been found. At Advent Bay three or four

(21 July)...Advent Bay... [pairs were found breeding about 300 ft. up the side of the valley on 21 July, 1921. In one case the bird was watched on to young which had only been hatched six hours or so (S.Gordon)". F.J.'s Diary also mentions this and adds that "almost the only vegetation was a few clumps of Dryas." Løvenskiold summarizes later evidence about this species. It has bred here and in some other localities, but is not common. I have inserted the note above, out of date-order, though I was not myself at Advent Bay then. It was visited by the main contingent of the First Party on their way home. (Our wrong attribution of this record to Green Valley is corrected on p. 35 of these Notes)].

18 July...Advent Bay... [Sphagnum Bog. Although no special study of bogs was made by us here, 3 species of Sphagnum were collected. Our paper states for Advent Bay: "In the valley between the two Longyear City mines moss-bogs occur in various places. In addition to the usual bog mosses given above [i.e. for Cap Boheman], the following species of Sphagnum occur:

Sphagnum acutifolium var. subnitens Russ. and Warnst.
S. subsecundum var. contortum Schimp.
S. squarrosum var. semisquarrosum Warnst "

The taxonomy of the first two of these species is discussed by Dixon (S.P.1, No.29). There he makes subnitens a separate species from acutifolium, and denotes the second species as one of five new moss species-records from Spitsbergen made by the Expedition.]

[Sandon (S.P.1,No.6, dealing with my 1921 samples), included there also three soil samples brought back by B.W.Tucker from his visit to this area with F.J. in 1922. For the one below bird-cliffs see these Notes, p. 55. The other two were from Advent Bay and are of some interest:

His Sample 2, Advent Valley, boggy patch on hill-side, vegetation Sphagnum etc. pH 6.0 -- much less acid than the one from below bird-cliffs on Green Mountain. He identified 4 spp. of Flagellata, 2 of Ciliata, 6 of Rhizopoda, Total 12.

His Sample 3, Advent Valley, from dry tundra at the foot of hills. pH 5.2 i.e. quite acid: 9 spp. of Flagellata, 3 of Ciliata, 6 of Rhizopoda, Total 18.

Scourfield (1897) reported on the microfauna of 14 moss samples brought back from the neighbourhood of Advent Bay by J.W.Gregory (in Martin Conway's Expedition of 1896). He gives the names of the commoner mosses but remarks: "Strangely enough there was no Sphagnum, and in fact Dr Gregory tells me that this moss is comparatively scarce and local in Spitsbergen." His report includes notes on Algae, Protozoa, etc. and names 21 species of Rhizopoda,

"Bruce City", with the Nordenskiöld glacier and Mount Terrier behind. Shingle-covered raised beach with spaced clumps of Dryas octopetala.

18 July...Advent Bay... [4 of Tardigrada, and of 2 kinds of Copepod seen, one being Cyclops bisetosus.* Bryce (1897) found 26 species of Rotifera in this material.]

19 July. Bruce City, Klaas Billen Bay [Brucebyen, Billefjorden].

[The ship left Advent Bay for Cap Boheman on the evening of the 18th. F.J.: "Weather still dull and gloomy...Van Ooordt went ashore with Huxley and Paget Wilkes and returned about 10.30 a.m. with Gordon...Started for Bruce City in wet and cheerless weather and reached it about 4.30 a.m....Here Longstaff, who had stayed with Stobart, reports a pair of Buffon Skuas about, possibly going to nest...Arctic Terns breeding near the Glacier in some numbers on a strip of ground betweeen the river and the Glacier."]

[The "City" consisted of four well-constructed long wooden huts belonging to the Scottish Spitsbergen Syndicate, two of which were used by us. The others were occupied by Scottish miners, who were often working by day across the fjord. They were very helpful to us. In the hut we used for messing there was a small cubicle that I used for sorting material and for microscope work. (see photo, p. 111A) These huts are still used by visiting explorers, including some later Oxford (and Cambridge) Expeditions. They are flanked by two shallow fresh-water lagoons, the site being 28 ft. above sea-level. The plane-table survey made by Harland's Cambridge Expedition of 1949 (publ. 1952, and reproduced in these Notes later, p. 139B) marks it between the 20 and 30 ft. contours. Walton (S.P.1, No. 5) incorrectly gave the height as 15 ft..]

[The surface of the large area of raised beaches around is shingle on the sea-ward side, and silty or boggy inland. There is a steep fall to a narrow lower beach which lies a few feet above sea-level. Feyling-Hanssen (1955) states that the tidal range here is only about 1 m. Behind rise the impressive mountains of the Campbell Range, and to the N.E. the enormous Nordenskiöld Glacier [Nordenskiöldbreen] descends steeply to the sea. When we were there it constantly calved off bergs, some of great size, and the brash of small ice littered the shingle beach drift-line below camp. (see photo) The Glacier was then about 1 mile away at its nearest point, but has since retreated perhaps a mile or so, the lines of retreat being marked on a map in Harland's paper. The head of the Fjord here was called Adolf Bay [Adolfbukta] and, according to Walton, soundings had reached a depth of about 650 ft. Certainly, opposite our

*Judging from Olofsson (1918) this should be C. crassicaudis Sars.]

Dr Longstaff. going to feed the sledge-dogs "Bruce City", Klaas Billen Bay. Campbell Range behind.
(Photo C.E. 1921 : No. 926)

19 July...Bruce City... [camp an enormous berg was grounded, and the part above water was at least 100 ft.]

[The Expedition, after the departure of the main part of the First Party, was now reduced to two small groups: (1) The Sledge Party -- Odell, Frazer and Longstaff (Stobart being still unfit to travel) (2) The Base Scientists -- Carr-Saunders (in charge), Segnit, Walton, Slater and myself. Life was harmonious and everyone extremely busy. My recollection, supported by many photographs that I have, suggests that the weather during the month that followed was truly "Inner Fjord" i.e. mostly sunny and by Arctic standards warm. It was attributed to adiabatic winds that flow down a glacier becoming warmed up by increasing pressure and tending to dissipate fog. We kept no regular weather log, except that Slater (S.P.1, No.32) states that temperatures were taken in a screen from July 22 - August 25 "with a break of eight days of bright sunshine during the first week of August". The average was 43-44°F. (say c.6.5° C). He gives no other details and I think the records are now lost. (See also Addendum, p.82A). I made some readings of maximum and minimum temperatures (mostly at 11 a.m. daily) in the shallow large Pond VII, from 24 July - 4 August (see our paper p.272). On 24 July the average was 6.5°C.; it then rose to a fluctuating level of c. 10 - 12° during 28 July - 4 August; after this it fell to 5.5° by 7 August and then rose to 9° by 12 August. The highest max. temperatures were 14° on 30 July and 1 August. These temperatures may have been lower than those in the air, as the supply of water in the pond presumably came from gradually melting frozen subsoil -- there was little rain. According to Walton the rainfall at the head of the Bay was only about 8 in. p.a., but I dont know where he got this figure. There must now be fuller records.]

[I kept no systematic Diary during the month here, though much information is available, published though scattered, and unpublished in my field-notes and specimen catalogue. As there were only a few camp duties, I was forunately left to work on my own projects, which especially concerned aquatic life, though also covering in outline the fauna of other habitats from sea-level upwards. I also examined a Holocene raised beach section. Walton did an excell- independent vegetation survey (S.P.1,No.5), centred mainly on ecological success-

Bruce City...

ADDENDUM

[I recently found some weather figures recorded by the Cambridge Expedition of 1949 (Harland, 1952), for Bruce City:

	July 23-31	August	Sept. 1-13
Average Temperature	41.5°F.	39°F.	35°F.
Maximum	50°	50°	44.5°
Minimum	38.5°	30°	29°
Precipitation (mm.)	0	19.7	11.7
Clear Weather	42%	16%	13%
Overcast Weather	47%	47%	52%

These records were not regularly kept at fixed times of day and were published with this reservation. The temperature figures are not widely different from those we have for 1921. The precipitation confirms the dryness of this head-of-fjord station. My impression is, however, that we had sunnier days in August.]

19 July...Bruce City... [ion from salt-marsh to drier zones. I have some very good photo prints by him (and others by Carr-Saunders) of vegetation types and also close-up ones of some flowering species. This survey was supplemented by a few days of observations by Summerhayes, and those of myself.]

[Various dates. Before describing the ecological work I will give brief notes on other activities of the Expedition at or from this base.]

[Frazer, a highly qualified mathematical physicist from the National Physical Laboratory, set up a curious experiment that greatly fascinated the rest of us. A glass flask of oil was placed on a c. 4 ft. pillar. Floating submerged in it was an ovoid or spherical glass on each end of which was stuck a thin piece of Aluminium. Two observers watched it for hours, one using a telescope and the other taking notes. The glass sphere was never quite at rest, but it tended to set with the metal ends true not magnetic N and S. Passing clouds upset it, also the near presence of people -- hence the telescope. I simply do not know what the outcome of this work, if any, was, but I think Frazer's notion was that the direction was kept by electrical states in the Equatorial/Polar circulation. (See Photo).]

[Sledging. The start of the Sledge Party was dogged by delays (a) by some shipping hold-up in Norway (b) by one set of metal runners sent out being the wrong size, and so necessitating modification of one sledge (c) by Odell, the Leader, being rather a deliberate starter, though famous for his ability to keep going once started (cf. his feats on Everest and Nanda Devi). The loss of Stobart, who had a relapse of health not long before the start, meant that two sledges could not be taken the whole way, though he helped greatly with preparations. (It does not seem certain that the sledge-dogs would have been much help, considering the frequently bad conditions on the inland plateau).

[The sledging plans fell into three phases. As the inland route was not known, being in unmapped land, a preliminary reconnaissance was made by Odell, Longstaff and Segnit, to climb the larger of the two mountains that stand as nunataks in the Nordenskiöld Glacier, Mount Terrier. (The other is Mount Ferrier). The Norwegian map of 1968 gives the height of the higher peak as 1200 m. The reconnaissance party made that of the lower peak 3544 ft. and the main peak 3963. A full account is given by Frazer of this and the main journey, in S.P.1, No.1; and an excellent summary also by T.G.L.]

Segnit (l.) & Stobart (r.) watching the experiment in physics. Bruce City, August. (Photo A.M. Carr-Saunders)

Frazer (l.) and Stobart (r.) testing some instruments for the sledge journey. Bruce City. August. (Photo A.M. Carr-Saunders).

Dryas clumps on the shingle.

Inland journeys from Bruce City...Various dates... [A forced march by Odell enabled him to see a suitable sledge route just before mist closed in on it. From the top of Mount Terrier the party had a view also over to Wijde Bay, and Storfjord, with its large islands. They returned after a 24½ hr. journey. Longstaff collected some Collembola from about 2800 ft.:

12 Achorutes viaticus
2 Agrenia bidenticulata

These have some interest as illustrating how some invertebrates might survive increased glaciation on high nunataks. The same comment applies to the plants mentioned below.]

[Fulmar petrels were nesting up here. T.G.L.: "This south-west side of Mount Terrier is surrounded by a clearly marked band of vertical cliffs, above steep scree slopes. High on these cliffs hundreds of fulmar petrels were nesting, safe from their enemy the arctic fox." He adds: "On the limestone screes were many lumps of coral and other fossils, with which Segnit loaded himself -- and us".]

[Between 31 July and 4 August some preliminary carrying of sledges (which could not be safely dragged over the sharp surface of the moraine) and of stores was done with the help of other members of the Expedition. (I can remember humping 60 lb. of chocolate on my back -- the first time I had been on a glacier).]

[The Sledge Party left on 9 August, consisting of Odell as Leader, Frazer as surveyor, and Longstaff. All were experienced mountain travellers, both on rock and ice, especially Longstaff. Their journey, often in bad conditions of surface and weather, took them as far to the N.E., mainly over a snow plateau, as the "Lion Nunatak" and Svarttoppen, some 25 miles from Bruce City. They had left one of the two sledges just beyond Mount Terrier, but had sufficient toilsome work with the other. The 1923 Oxford sledge party (again including Odell and Frazer) was to travel in the opposite direction from Hinlopen Strait and link up with the 1921 map. In 1921, on the way across Frazer noted a cliff "which we referred to as Fulmar Cliff... much esteemed by the fulmar petrel (Fulmar[us] glacialis) as a breeding station, and numerous fox tracks in the vicinity showed that this fact was already known to others than ourselves. In the Oxford Glacier area fulmars

The Sledge Party ready to start inland, from the Nordenskiöld Glacier, early August 1921. (Photo R.W. Segnit)
l. to r. Frazer, Odell, Longstaff

Inland journeys from Bruce City...Various dates...

[flew over eastwards and westwards; but Longstaff noted that those nesting on Fulmar Cliff came from the direction of Klaas Billen Bay. Several Ivory Gulls (Pagophila eburnea) [T.G.L. says 2] also paid a passing visit here, probably coming from their known breeding stations about Olga Strait en route for Ice Fjord." The Fulmar Cliff and Svarttoppen are shown on the comprehensive Cambridge Expeditions' map compiled by W.B.Harland and D. Masson-Smith (Royal Geographical Society, 1962). Jourdain, referring to West Spitsbergen (S.P.1, No.10, p.168) also mentions the inland breeding of fulmars: "On Spitsbergen it was ubiquitous, patrolling the coast line with tireless flight and breeding in most of the mountain cliffs. Here, too, we found nesting colonies several miles up the valleys, and subsequently the exploring party noticed breeding stations on Mt.Terrier up to 3000 feet, and found a small colony at the head of the Oxford Glacier, 20 miles from the sea in either direction."]

[In spite of harassing delays by bad weather, the Sledge Party managed to get back to Bruce City in the early hours of August 25th, in time to catch the S.S.S. ship "Autumn" to go home. They sailed through a severe twelve-hour storm on the way.]

[From the area of Svarttoppen, the summit of which Frazer estimated at 2578 ft., Longstaff brought back a small collection of plants which went to the British Museum (Natural History) where they were named by A.J.Wilmott. These are listed both by Frazer and by T.G.L.: *

Papaver nudicaule var. radicatum (Rottb.)
Cochlearia officinalis var.
Draba (probably arctica, but there were no flowers or fruit)
Cerastium alpinum (L.)
Alsine(rubella, probably)
Saxifraga caespitosa (L.)
S. oppositifolia (L)
S. rivularis (L.)
S. cernua (L.)
Poa cenisia (A..l)

[Frazer published some fine panorama photos of the region].

*In our paper, p. 264, Summerhayes included an incomplete and rather puzzling list for this place e.g. Draba given definitely as alpina, Cerastium "caespitosum" as well as alpinum, also the addition of a moss Grimmia apocarpa. I suspect some mistake in transcription, as the list above is doubly authenticated.

Bruce City...August...

[Marine dredging. In the early part of the month Carr-Saunders and I did some bottom dredging from our small dinghy, in the shallower zone opposite Bruce City. From what was noted in the paper by myself and Baden-Powell (1931) about the Mollusca, which he identified from this collection, the depth we dredged at was 5 - 6 fathoms (10 - 12 m.). The fauna was remarkably rich, considering the proximity of the big Glacier and the grinding action of bergs calved from it. In 1933 Stott, whose work will be referred to again below, carried out a much more extensive marine faunal survey around here, dredging in depths up to c. 25 m. He states: "In nearly all the area examined the shore line descends very rapidly owing to the fjord formation of the bays, so that this shallow inshore zone is a very narrow one. Furthermore, the ice action prevents the permanent occupation of the intertidal and shallow water zones by any but a few small forms such as the worm Lumbricillus aegialites. The greater part of the region examined had a bottom that was shingle inshore, but a mixture of varying proportions of sand and grey mud in deeper water. This region is marked C in Map 1." Though his remarks about "shallow" are here unintentionally ambiguous, he found a rich benthic fauna, which (if we combine his and our observations) we may assume to have lived between 10 m. and 25 m. at least. Stott dredged from around Cape Napier near Bruce City down the coast as far as Cape Ekholm; and on the opposite shore of the fjord round into Petunia Bay.]

[Our collections went to the British Museum (Natural History) but only a few groups were named and reported upon at the time; though no doubt material may by now have got into other publications. Apart from the intertidal boulder/mud zone to be mentioned later, there are known published lists of the following 3 groups:

Polyzoa: Named by R.Kirkpatrick and printed in the Appendix to S.P.1. They are repeated below, because of the limited circulation of that volume:

Membranipora sophiae (Busk)
Schizoporella hyalina (L.)
Alcyonidium disciforme (Smitt)
A.hirsutumn (Fleming)
A.gelatinosum (L.)
Lichenopora verrucaria (Fab.) ?
Anarthropora monodon (Busk)

Mollusca: Named by Baden-Powell (op.cit.) and discussed later.

Annelida, Polychaeta: Published (23 species) by Fauvel in S.P.1, No.25]

Bruce City...August...

[Sea-birds feeding by the Nordenskiøld Glacier. During A.R.Glen's Oxford University Arctic Expedition of 1933 a very remarkable phenomenon was studied by Hartley and Fisher (1936), in close cooperation with the plankton studies of Stott (1936). I mention this matter here because in 1921 it was either not noticed or was not happening then, probably the latter. Hartley and Fisher found a huge concourse of sea-birds assembled at a c.50 m. wide bay of brown-coloured water about the centre of the glacier front. Stott notes that "The bird-feeding occupied the inner part of the brown zone and the maximum density of the bird population occurred close up to the glacier face where, curiously enough, the chances of death through falling ice were greatest. We frequently saw birds killed through ice falls and 'calving'. " Either this brown water was caused by convection currents from the deep-water face of the glacier bringing up plankton forms, or else the glacier drainage stream(s) full of detritus were creating at the surface an imitation of the darker zones and this caused a vertical movement of the deeper plankton. Stott concluded that the second explanation was the correct one. The effect was to bring into the feeding-reach of surface birds a huge supply of food normally less available. The birds were chiefly kittiwakes (estimated at c. 2000 at any one time) and fulmar petrels (c.5 - 700). By counting the birds, their rates of feeding, and their food contents, the total removal of marine animals could be approximately calculated. To give the best example, kittiwakes were estimated to take c. 5,778,000 of the Euphausid Crustacean Thysanoessa inermis per day! Fisher found a similar phenomenon at the S. end of Wijde Bay by the Mittag-Leffler Glacier; and Lovenskiøld at the great Monaco Glacier in Liefde Bay. The phenomenon has also been studied in Greenland.]

[None of us in 1921 noticed anything unusual of this kind, and my own belief is that if anything on this scale had then been going on we would have done so (see photos p.87A). The following points have occurred to me on this question:

(1) The kittiwakes mostly flew in some 30 miles from the south coast of Ice Fjord, and "The counts were made from the end of the south-west lateral moraine of the glacier, the principal flight lines lying over or near this point...The flight lines lying over or near this point...The flight-lines and numbers of birds flying remained more or less constant throughout the latter part of July and up to the last week of August". And of course it went on day and "night".]

The Nordenskiöld Glacier

Glacier face with recently calved iceberg. Mt. DeGeer behind. Photo by T. G. Longstaff between 1 and 9 August. (This photo is in S.P.I. No. 32, where Slater defines the lit in the foreground as "dead ice". He also has a photo of it after complete fall!).

Ditto. Photo by Segrit, August. R.W.

There are no obvious signs of the sea-bird flocks seen in 1933 by the Oxford Expedition.

position of each sounding. This large-scale map, related to the survey pegs inland, will provide a basis for comparing the shoreline changes which are proceeding by erosion, or deposition of shingle. The chart, with its 350 soundings along a mile and a half of coast, has been forwarded to various Norwegian and British authorities. It has been generalized in the contours of Figure 2. In September a similar survey of Gipsvika was out of the question, because of the distance and the extensive shallow reefs at a time of

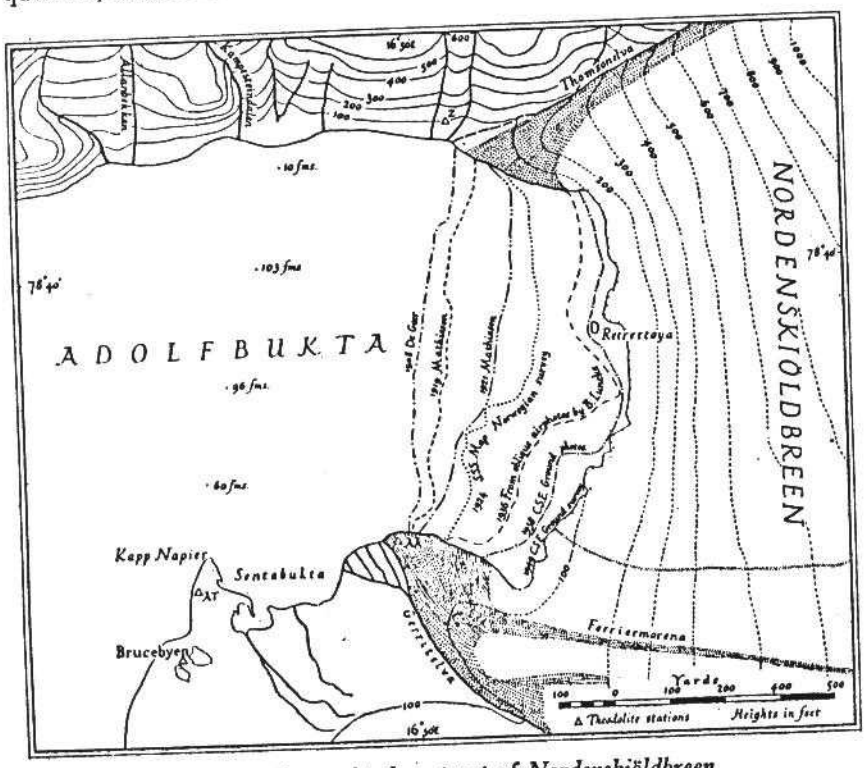

Fig. 3. Stages in the retreat of Nordenskiöldbreen

From W. B. Harland (1952) — Cambridge Spitsbergen Expedition, 1949.
[This map is also copied by Feyling-Hanssen (1955); but his comment that "the scale is incorrect only refers to the fact that his copy is slightly enlarged].

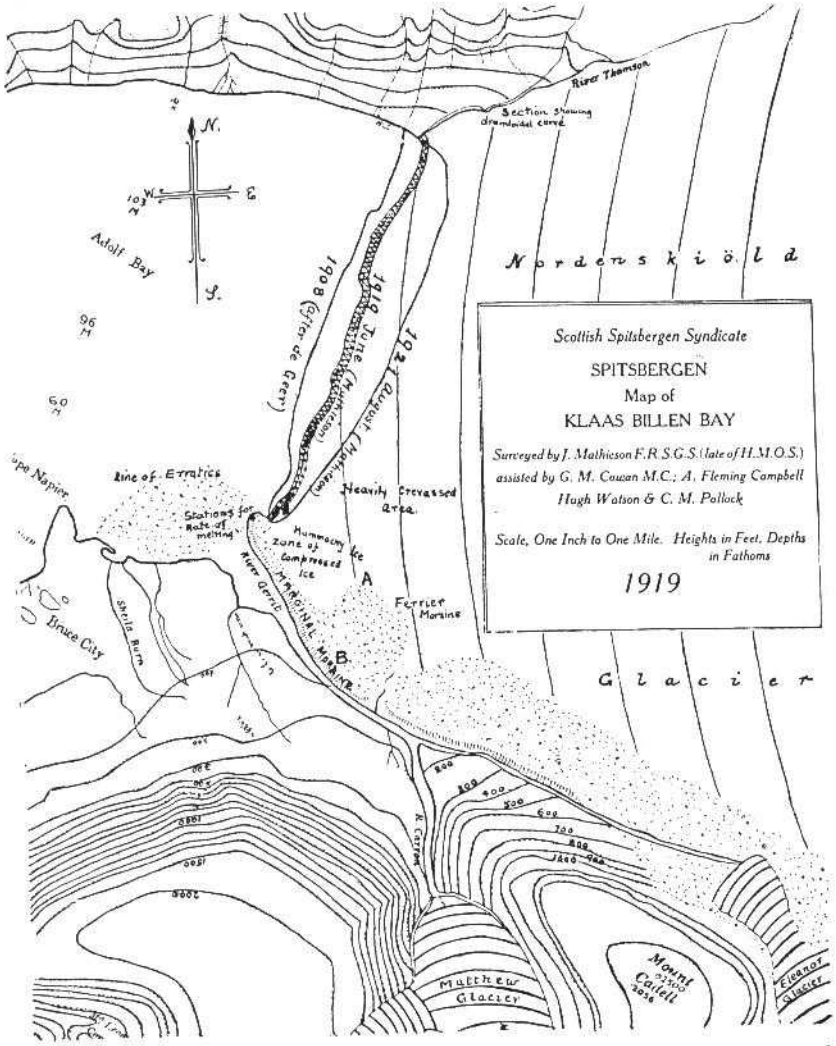

FIG. 10.—Map of the termination of the Nordenskiöld Glacier, 1919. Reproduced by kind permission of the Scottish Spitsbergen Syndicate, through the courtesy of J. Mathieson, Esq.

From G. Slater (1925) — S.P.I, No. 32.
N.B. Surveyor Mathieson has added 1921 Glacier face to his 1919 map.

Bruce City...August... [(1) cont. But these flights would seem likely to have passed over or within sight of Bruce City itself, and I find it hard to believe that we would not have noticed the calculated 15,600 individual kittiwake flights per 24 hours. The First Party had visited the tern colony at the moraine area but Jourdain makes no mention of flocking by the glacier's centre i.e. in his Diary (his published paper is very condensed). Both Longstaff and I were keen bird observers, though we certainly avoided the face of the Glacier in our boat, as the waves created by falling ice, not to speak of the ice itself, made this very dangerous. It is indeed remarkable that Stott, studying the plankton situation, tow-netted across the "bird-bay" -- as fast as he could, an action requiring some nerve owing to the "frequent falling of ice from the 80-ft. ice cliffs of the glacier".]

(2) Harland (1952) has a map showing the ice-front of the Nordenskiöld Glacier at various dates during its retreat: 1908, 1919, 1921, 1924, 1936, 1938 & 1939. Originally the front was more or less straight, or at any rate unindentated. The sharp feeding bay first appears in this series in 1936 i.e. almost at the same time as the 1933 work. Later it changes to a wide incurving stretch in the centre. It seems that the structure described by Stott et al. was not there in 1921 but had formed by 1933-36. N.B. I do not wish to place too much weight on our own negative observation, as anyone who has missed the obvious in research will realise.]

(3) It is, however, at least plausible to suppose that the situation of the ice in relation to the changing terrain during retreat might create a temporary condition of upwelling or of heavy suspended detritus , whichever is the factor of importance. In support of this notion is the fact that a good many large glaciers in Spitsbergen apparently do not have the bird-flocking of this kind. Slater, in the paper cited, noted that "The position of concentration of sub-glacial drainage appears to vary. In 1921 it was nearer the southwest side, and torrential falls of ice at this place were of daily occurrence."]

[Intertidal grounds. (The brackish water series of communities as described later, as leading up to the relict lagoon system and other freshwater habitats)

(1) Shingle shore. The parts below the drift-line were extremely poor in life. We stated in our paper (p.259) that there was no seaweed growing there.

Caulking the dinghy, "Bruce City". L. to r.: Longstaff, Walton, C.S.E. Petunia Bay beyond.

Line of boulders where mud-living ascidians were found; by Nordenskiold Glacier. (Boulders mostly < 1 m. high).

(Photos A. M. Carr-Saunders 1921).

Bruce City...July-August... [Shingle shore, cont. Carr-Saunders (who was a trained zoologist with a personal interest in various worm groups) found a small species of Nemertine worm abundant. On 10 August I collected 12 Collembola -- Archisotoma beselsi -- at low-tide mark at Cape Scott, to the S. of Bruce City. The large red mite Bdella (or Molgus) littoralis was found once under stones. Both the last two are pretty well confined to the sea-shore zone in Spitsbergen. Stott noted that Lumbricillus aegialites, (the Enchytraeid worm discussed below) was very numerous under stones in parts of the intertidal zone. I don't believe that Carr-Saunders could have mistaken this form for a nemertine. Stott's collections all went to the British Museum, where presumably his identifications were made.]

(2) The Boulder Zone. A long line of large boulders left in former times by the Glacier (see sketch in our paper, Fig.5) — these Notes p.108 ran across the muddy estuary of the streams coming down from the mountains on the hither side of the Glacier moraine (see photo). They protected the area inside from erosion by floating ice, and the mud was completely exposed at low tide. Walton gives a list of 7 species of alga, including Fucus of the vesiculosus group, and the green Ulva. I collected some of the fauna associated with the boulders and the mud. Those marked * were also collected here by Stott in 1933:

Hydroida:	Gonothyraea loveni (Allman)
	Opercularia lacerta (Johnston)
Polyzoa:	On algae. Indet.
Crustacea:	Gammaracanthus loricatus Sab.
	* Gammarus locusta var. zaddachi Sexton
	* Pseudalibrotus litoralis Kröyer
	Several kinds of Copepods (Dactylopusia, Harpacticus, etc.)
Halacaridae:	On the hydroids (a mainly marine group of water-mites)
Birds:	Arctic Tern

The Hydroida were named by R.Kirkpatrick and also included in the Appendix to S.P.I. G.loricatus is an amphipod which has become relict in a number of fresh-water lakes across the northern hemisphere, including one discovered by Olofsson in Bell Sound. In fresh-water it develops as a var. lacustris. I verified that none of the Bruce City boulder zone ones I took showed any such tendency. But the habitat must definitely be classified as fluctuating brackish. Stott found barnacles on these boulders, named as Balanus porcatus (Da Costa). This = Balanus balanus (L.), for which there are other Ice Fjord

Bruce City...July-August... [(2) The Boulder Zone, cont. records (see Feyling-Hanssen, 1955, p. 172)]

[I had already made some study of Gammarus. Danish work has shown that the structural details of Gammarus locusta depend on the degree of salinity, though this species does not tolerate permanent fresh water. We note in our paper that there was a certain amount of local variation in the amount of "zaddachi" structure in this species: "Those in Pond 1 [the outermost estuarine pond to be described] are more like the extreme variety zaddachi, while those from the boulders and from Cape Scott are intermediate". The terns would be fishing for Gammarids. Stott also lists Gammarellus homari (Fab.) from here.]

[In the sandy mud around the boulders was a population of a small Tunicate, identified (and re-described) by Kirkpatrick in S.P.1, No.14, as Rhizomolgula globularis Pallas. At first he had believed this to be a new species, and its proposed name (R.conynephora) therefore appears in the Appendix to S.P.1. This should be ignored. The visible part of the animal is about 1 cm. wide and 1 cm. high (not counting the buried stem-like process). The species has been recorded, sometimes under different names, from around the Arctic seas,* and in waters from shallow to 40 m. It was at the top of its vertical range here, though (because of the stream water) it would not ever be dry at low tide. Kirkpatrick noted an interesting parasite: "There are present in all the [26] examples examined numerous specimens of a species of parasitic Protozoa of the group Suctoria with a globular sessile body 0.5 to o.1 mm. in diameter". When an Ascidian was cut in half these appeared "like snow-balls scattered over the tentacles". These particular parasites do not seem to have been recorded before, though members of the group occur on other Ascidians. I found a few Polychaete worms in the mud, but do not have their names.]

[Bdella littoralis was common running on the wet mud inside the boulders.]

[The Drift-line. A good deal of sea-weed was deposited at the high-tide level and was an important habitat for animals, and a foraging place for Purple Sandpipers. We have Walton's statements about sea-weeds offshore, but I am not certain whether he collected them, or they were in the dredgings by Carr-Saunders and myself. I think the former. He states: "In the Bay, at a depth of 8 - 10 fathoms there is a rich vegetation of Lithothamnion spp. [calcareous algae] with occasionally Polysiphonia sp. The Laminaria Zone,

* this record thus filling a gap in its known distribution.

Bruce City...July-August... [The Drift-line, cont. "which occurs at depths of 3 - 4 fathoms, consists of a rather sparse flora" of which he lists 6 species. Presumably it is from this zone along the sea-bottom that most of the drift-line sea-weed was derived. There was also a good deal of drift-wood, but no animal life was found under it. The following species were collected from above the drift-line sea-weed zone:

Collembola: Onychiurus armatus var. arcticus

Aranea: 1♂ Erigone arctica
1♀ "E.tirolensis" = psychrophila (see p. 64 of these Notes)

Acarina: Bdella littoralis

Oligochaeta, Enchytraeidae: Lumbricillus aegialites v.ab.]

[Stott noted that L.aegialites was v.ab. under stones in parts of the intertidal zone. In a dead ring-seal (Phoca hispida) that we found on the drift-line, were great numbers of an Enchytraeid that Stephenson (S.P.1, No.24) at the time named as Lumbricillus necrophagus. Both were described as new species, in great structural detail. (The latter was collected on 25 July, the former given by him as "last week in August", which is impossible and may be a mistake for "first week"). He attributed shore material collected by me in north Spitsbergen in 1923 as L.aegialites (Stephenson, 1924). But after examining still further material I brought him from various places in Spitsbergen in 1924, he decided (1925) that aegialites was consistent, but that necrophagus was identical with it and the name should lapse. As far as I can make out, no more Enchytraeidae were collected in Svalbard until Nurminen (1965) did so in 1964! He equated Stephenson's species with L.pagenstachii Ratzel, which he found in similar habitats in the Advent Bay area, Magdalena Bay and King's Bay [Ny-Ålesund]. I am unable to judge this question, but do know that Stephenson was an extraordinarily thorough taxonomist and that the material I brought him was preserved by standard methods.]

[This dead seal was thoroughly searched for parasites. I got several people to hold up the very long small intestine, while I snipped along it with scissors. I obtained a tapeworm that Baylis (S.P.1, No.27) described as a new genus and species: Anophryocephalus anophrys. The material arrived home in fragments, but was estimated at an individual length of about 65 mm. This was the first record of a member of the Tetrabothriidae (of the Cestoda) being

Bruce City...July-August... [Drift-line, cont. found in a seal -- he stated that they occur mostly in birds and possibly in whales also. Attached to the wall of the large intestine were several Acanthocephala, Corynosoma strumosum; and there was a small immature nematode of the family Ascaridae in the stomach, probably Contracaecum strumosum.]

[I cannot remember anything about live seals in the Fjord that year, except that they certainly were not conspicuous near our bit of shore. In 1933 Hartley and Fisher found Phoca hispida abundant in Adolf Bay, throughout July and August, but far fewer in early September. "It was usually possible to count 40 or 50 in a day within 400 yards of the glacier, and there were often as many as six swimming in the bird zone at the same time." 8 were shot and all contained Thysanoessa, and 3 had Euthenisto as well. The largest number of the former in one stomach was 5000.]

[I mention here that one morning between 19 July and 9 August there was a shout from below the huts, that a Polar Bear had turned up. It was heading fast towards the smell of bacon frying for our breakfast! It had to be shot. Although we skinned it and also examined it very carefully outside and in for parasites, none were found. Where it came from is a mystery, but it is just possible that it had made its way overland to Ice Fjord from the E.coast.]

[The lagoon system. My central interest here was in the striking series of raised beaches, rising in broad steps from sea-level up to about 40 feet, and the series of shallow ponds from intertidal ones to fresh-water ones, the latter containing as a relict species one copepod that is normally in brackish water. (see photo p. 92A) This area was first visited by the Swedish limnologist, O.Olofsson in 1909-10, and his work is mentioned more fully below. It is important to note that I did not become aware of this previous work (which was published in 1918) until after the Expedition's return. Indeed, it was rather a shock to find that part of what I had discovered around Bruce City had been anticipated. At the same time, as we stated in our paper, his work was of the greatest value and apart from its ecological content, the taxonomic descriptions in this and his 1917 paper were essential to me for naming my own material.]

[Olofsson's Surveys. He seems to have made a reconnaissance in 1909 and done his main surveys in 1910. He was the first person to make extensive community collections in Spitsbergen brackish and fresh waters, although

View of raised beach & lagoon system at "Bruce City", from 800 ft. on Mt. Campbell. Huts are between the two large ponds. Petunia Bay beyond. (Photo by J. Walton, publ. in S.P.I, No. 5). [The Cape, centre r., is C. Napier, not C. Scott as stated in the legend in J.W.'s paper].

Bruce City...July-August... [Olofsson's Surveys, cont. there had been some earlier collecting of a less complete nature in other parts of Spitsbergen. The thoroughness and exhaustive detail of his work are remarkable, and at times intensely tedious to read. He described 24 water bodies in Ice Fjord: 6 from the Bruce City area; 4 from across the Fjord here; 2 at Cap Diabas, Sassen Bay; 7 at Advent Bay; 2 at Coles Bay; and 3 ponds near Esmarks Glacier and on Erdmann's Tundra (S. of Cap Boheman). Most of these were fairly small ponds or lagoons, but several were larger. He also made important discoveries in Bell Sound, in a deep lake and a smaller nearby water on Credners Moraine in Braganza Bay, at the head of Van Mijen Fjord (which is the N. arm of the Sound).]

[Although we made clear in our paper the value and priority of Olofsson's work, there was not space available to deal with it in any detail. Furthermore, my knowledge of German was still elementary, and it was quite impossible to absorb the enormous and rather repetitive (and unindexed) information contained in 636 pages of text, plus a formidable bibliography -- perhaps over a quarter of a million words! So, in 1981, I pay tribute to his enterprise, learning and tenacity.]

[The Intertidal Lagoons. The long boulder zone had a protective effect on the mud-flats formed by the streams from inland, and allowed the quiet development of a fascinating series of ponds. The Gerrit River [Gerritelva] comes out closer to the main glacier moraine and does not come into this survey. The nearer stream, shown on later maps as "Sheilabekken", flows out onto these mud-flats; though actually the series of tidal ponds we studied starts with a fresh-water spring at their source. They were carefully studied by Walton for plant life and by me for animals. He made a plane-table survey, with my assistance, published in his account of ecological succession (S.P.1, No.5, p.122) and reproduced here (p.93B). I have also copied a sketch-map I made independently, as it covers a somewhat wider area of this estuary (p.93C). (On it I have made a few changes, for clarity, explained in the legend below it.). Both these maps agree in essentials. The system was re-surveyed by Dobbs in 1936, and his work is referred to later.]

[In the photo, p.93A, the general appearance of the lagoons can be seen, with the line of boulders and the glacier behind. Our maps show how they are additionally protected from wave-action by a series of shingle bars.]

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Brackish lagoon I, flooded at high tide, containing Mysis oculata. Nordenskiöld Glacier & Mt. Terrier behind; line of boulders between.

(Photo A. M. Carr-Saunders.)
August.

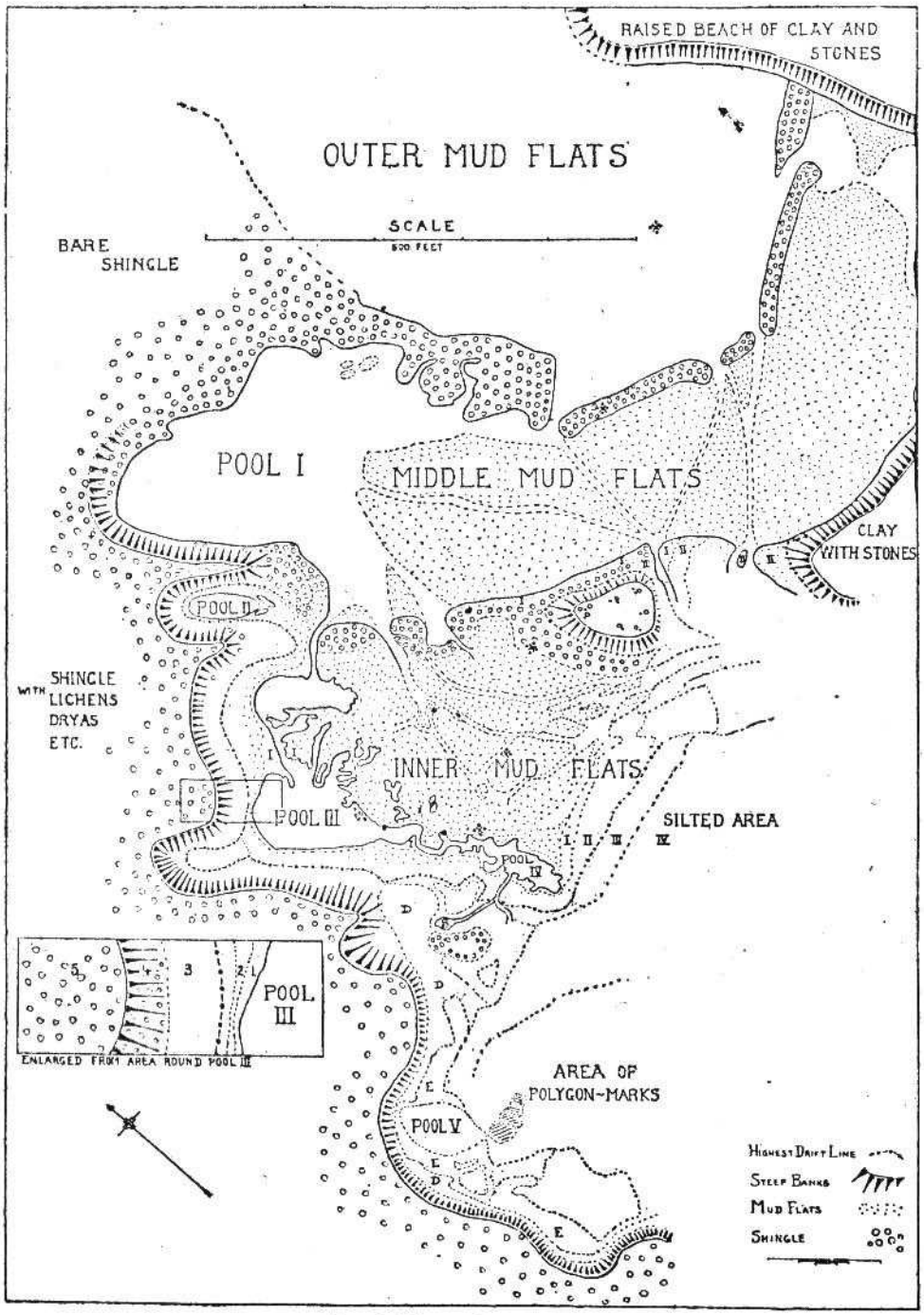
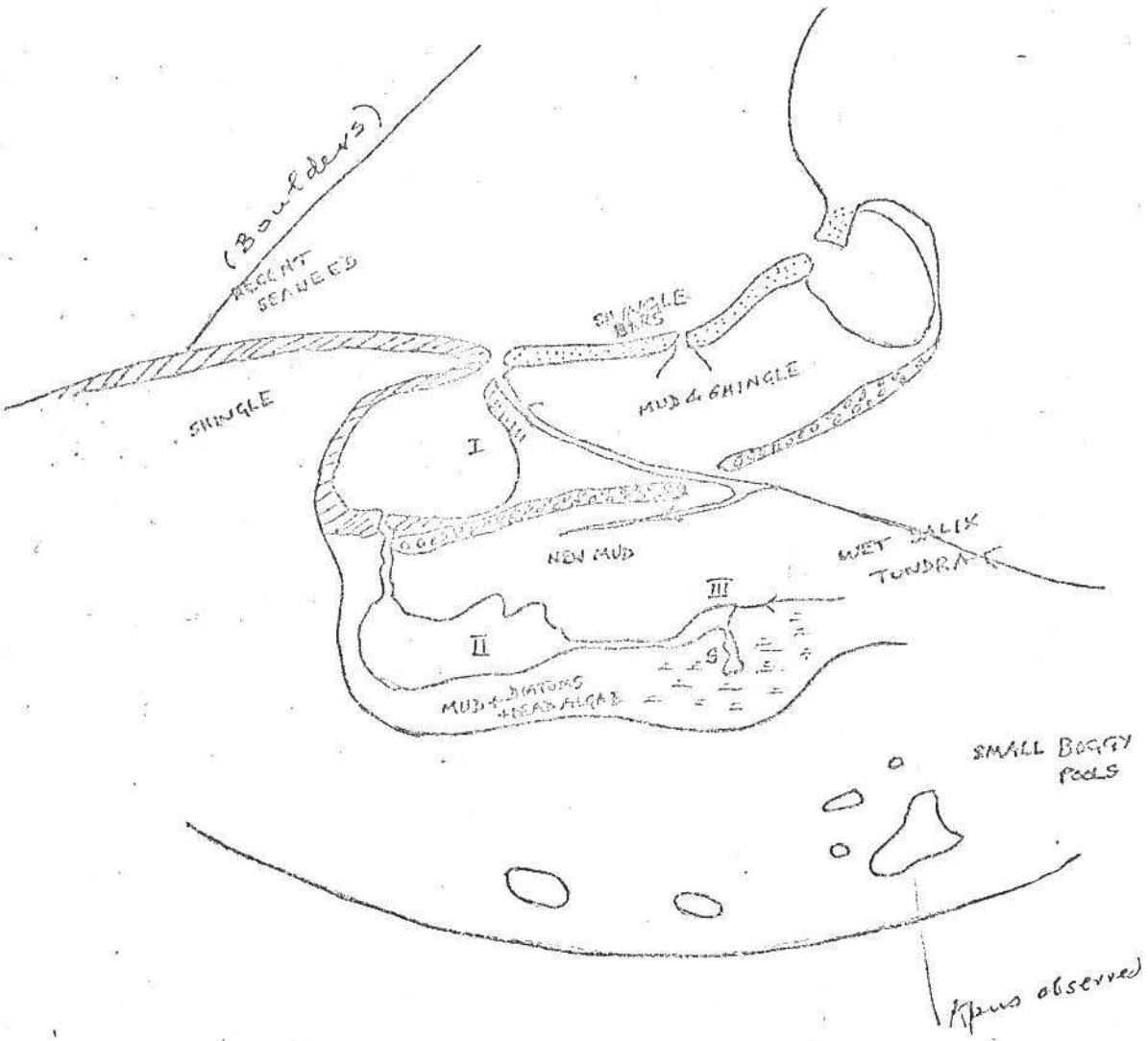


Fig. 4. Plane-table Survey.

J. Walton, 1922, J. Ecology, Vol. 10, p. 112.



Sketch-map of intertidal pools by C.S.E.
(Numbers altered to conform with our paper;
'Boulders' added, to explain angled line;
"Apus" = Lepidurus arcticus).

(Xerox of inked-in pencil drawing in my field note-book).

Bruce City...July-August... [The Intertidal Lagoons, cont. We have, therefore, 4 sets of data: (1) Olofsson's for animals, 1909-10 (2) Mine for 1921 (3) Walton's for vegetation in 1921 (4) Dobbs' ditto in 1936. I shall deal with my survey first, as it leads on directly from the Boulder Zone etc. In our paper the ponds in this intertidal and raised beach system were numbered I - XI , the first three being intertidal, the rest fresh-water. But I did not include the very small pool that J.W. numbered as Pool II, with the result that his III = our II, and his IV = our III. In his paper he states that"Pool II has no supply of fresh water and in character is analogous to a pan...It is only flooded at the highest tides of the year. There is no apparent vegetation close to it." I made no notes on its fauna and it does not form part of the main sequence studied by me.]

[The following account is substantially based upon our paper, though some of it is arranged differently. Pond I was shallow, less than 1-2 ft. at high tide, with no plants except algae. The sand-mud bottom had a thin brown felt of diatoms and blue-green algae. I did not collect any diatoms. Pond II was similar but smaller. Pond I was also small.* The Spring source (S on Walton's map, and our diagrams of the beach series, p.108 of these Notes) was fresh and flowed quite fast into Pond I. It was presumably derived from the boggy area above.]

[A list of the animals I found is given in Table II of our paper (p.266) and copied here on p.94A. The zonation of Crustacea was especially interesting, in that there were four species that were potential relicts in fresh water, though only one (Eurytemora raboti) of them was found in the fresh-water ponds, -- a point also confirmed by Olofssen's surveys. The total absence of the only relatively large Crustacean commonly found in fresh-water, the Phyllopod Lepidurus arcticus, agrees with all other records from Spitsbergen. With one exception the two larger Crustacea in the list, Mysis oculata and Gammarus locusta var. zaddachi were characteristic of the more saline Pond III, while Eurytemora raboti had its headquarters in the weak brackish water of Pond I. A few young Mysis were noted in Pond I -- presumably washed in by the tide, but only late in the season (August 14). I observed that adult Mysis were very few in Pond I, but the young extremely abundant all the time. One Mysis had the leech Pontobdella attached to it, indicating that it had come in from the sea. I noted that young Mysis, though behaving

* My field notes for 29 July record that Ponds I - III, & also the sea at about high tide, had pH = 8·5 i.e. alkalinity like that of many British lowland ponds.

TABLE III. *Fauna and Flora of the Tidal Ponds.*

		Pond No.	I	II	III
Birds:	Arctic Tern*		×	(×)	–
Fish:	... ...		(×)	–	–
Crustacea:					
Schizopoda:	Mysis oculata Fab. var. relicta Lov.				
	young		×	–	(×)
	adult		(×)	–	–
Amphipoda:	Gammarus locusta var. zaddachi ...		×	(×)	–
	Pseudalibrotus litoralis		×	–	–
Copepoda:	Eurytemora raboti Richard ...		–	(×)	×
	Tachidius spitzbergensis Olofsson ...		×	×	×
	T. longicornis Olofsson		×	×	?
Collembola:	Archisotoma beselsi		×	×	?
	Achorutes viaticus		×	×	×
Hirudinea:	Pontobdella muricata		(×)	–	–
Rotifera:	Colurella colurus Ehrb.		×	×	×
	Encentrum? raptor Gosse ...		×	×	×
Tardigrada:	... ...		–	×	×
Nematoda:	... ...		×	×	×
Protozoa:	... ...		×	×	×
Algae:					
Chlorophyceae:	Enteromorpha sp.		×	×	–
	Ulothrix sp.		.	.	×
	Zygnema sp.		×	?	×
Cyanophyceae:	Chroococcus turgidus		×	.	.
	Gomphosphaeria aponina Kuetz. ...		×	.	.
	Merismopedia glauca		×	.	.
	Oscillatoria sp.		.	×	×
	Rivularia sp.		×	?	×
	Spirulina subsalsa Oersted ...		×	×	×

× normally present; – definitely absent; (×) accidental or sporadic;
? probably present though not found.

(V.S.S. & C.S.E. 1923, p. 266. Brackets have been added to × of young Mysis in Pond III).

* Jourdain's Diary (15 July) mentions that about 100 pairs were nesting by the moraine.

Bruce City...July-August... [The Intertidal Zone, cont. in a positively rheotactic way, but being small and weak swimmers, only occurred part of the way up the connecting stream between Ponds I and II. And as they were bottom-livers here, their chance of being washed further in by tides seemed small. Though Mysis oculata adults were scarce in the brackish waters, in 1933 Stott found it to be a common species in the surface plankton of Adolf Bay and upper Klaas Billen Bay generally, whereas Thysanoessa, so enormously abundant in the glacier bird-feeding zone, was rather scarce elsewhere at the surface. He stated: "Mysis oculata occurred in the shore zone particularly where small streams passed out into the sea and low salinity values such as 27‰ were recorded. A few specimens were occasionally found in the stomachs of fulmars, kittiwakes, and eider ducks, but Arctic terns, Mandt's guillemots, and puffins contained greater quantities and evidently selected Mysis as a food." We know that Mysis oculata, in its form relicta, is able to live quite well in fresh water. The scarcity of adults in these ponds I therefore attributed to the Arctic terns, which were often watched diving for food in Pond I and sometimes Pond II. They would hover over Pond III but not dive. This behaviour agrees with the distribution of adult Mysis and of Gammarus. The stomachs of terns from Pond III contained remains of amphipod shrimps, but not of Mysis -- these might presumably have included Pseudalibrotus as well as Gammarus. A tern fishing near the Boulders contained Mysis. (I often watched terns diving for Gammarus locusta along the south shore of Reindeer Peninsula, Liefde Bay, in 1924). Another fact about young Mysis, is that they were "small, transparent and very agile, but...Gammarus, which hides in the mud and occasionally makes short journeys,...is quite conspicuous".]

[There is a very large literature about the fresh-water relict form of Mysis, M. relicta (or strictly M.oculata var. relicta). It has been found in a great many lakes most of which can be proved to have been formerly connected to Holocene Arctic seas e.g. around the Baltic, in some Irish Lakes, and in Ennerdale Water in the English Lake District, 368 ft. above sea-level -- to mention only very few. The relict form, essentially a retarded form that can breed, differs slightly from the ordinary juvenile of the species. (Olofsson has an extensive discussion of this matter). My specimens were submitted to W.M.Tattersall, an authority on Crustacea. We did not give all the details of his report, which is as follows:

Bruce City...July-August... [The Intertidal Zone, cont.

"Townet E.N.E. of Anser Is.,17 July 1921. About 30 specimens of Mysis oculata, Fabr. ♀ grown. c.13 mm. Typical form.

K 3 [i.e. Pond I], 27 July 1921. About 400 specimens of Mysis oculata, Fabr. var. relicta Lovén. None larger than 9 mm. All quite juvenile. Telson as in Olofsson Fig. 16c, p.377.

K 55 [i.e. Pond I] Klaas Billen, 10 August 1921. 1 adult ♂ Mysis oculata Fabr., var relicta Lovén. 18 mm. in length. Telson as Olofsson Fig. 16a, p.377."

In his covering letter he said: [of K 55] "It is a typical relicta. The small forms from K 3...are intermediate between oculata and relicta & have the telson shaped and cleft as in Olofsson's Fig.16c. The specimens from the townet off Anser Is. are typical oculata as figured by Sars. I presume this locality is more open water. " The Anser Is. lie at the mouth of Klaas Billen Bay, but still some 75 km. from the open sea.(The plankton was collected by some other expedition member here, during operations connected with Orton's raft experiment).]

[The failure of Mysis to become a fresh-water relict at Bruce City is quite simply explained. These shallow lagoons would freeze quite solid in winter. The only place where the species is known to have succeeded in becoming relict in Spitsbergen is in the lake on Credner's Moraine, in Bell Sound, discovered by Olofsson, where the water is deep.]

[At the time I did not realize that Olofsson's paper contained the information that the two small Copepods, Tachidius spitzbergensis and T.longicornis, described by him in his 1917 paper as new species, were also potential relicts. He did in fact find them in several brackish lagoons and also relict in some fresh-water ones in Spitsbergen. Their distribution in the Klaas Billen ponds confirms this range of tolerance. But neither he nor I found them in any of the fresh-water lagoons on the raised beach system.]

[It will be seen that Eurytemora raboti was a strictly weak-brackish water inhabitant here. Before pursuing this point, I will give the background for salinity conditions in the area. According to the general map of marine salinity zonation in western Spitsbergen included in Løvenskiold's monograph on the birds of Spitsbergen (1964), the oceanic values in the Gulf Stream are about 35 ‰. but fall to just over 34 ‰ near the mouth of Icefjord and along

Bruce City...July-August... [The Intertidal Zone, cont. the W.coast. Stott in 1933 took samples in a vertical series off Cape Napier. The bottom water at 50 m. was c.34 °/₀₀, but the surface only c. 30 °/₀₀, owing to the fresh water from the glacier and other streams. The two tables from our paper, copied below, give information (from samples brought home) for the sea and the intertidal ponds. They show the great differences between high and low tides, in the ponds.

TABLE IV. *Chloride content in gms. per litre.*

Locality		Low tide Aug. 10th	High tide Aug. 7th
Sea by Bruce City, Aug. 1st ...	18·26	—	—
„ „ Aug. 3rd ...	17·57	—	—
Boulders	—	17·11	—
Pond I	—	1·01	16·12
„ II	—	0·57	15·23
„ III. Main pond	—	0·22	9·10
„ III. Where stream enters	—	—	0·55

TABLE V. *Pond I. High tide, inner side, August 7th. Amounts given in gms. per litre.*

CaO	0·754 =	1·346 $CaCO_3$ or 2·179 $CaH_2(CO_3)_2$
MgO	1·664 =	3·764 $MgSO_4.2H_2O$
Cl_2	16·120 =	1·513 $MgCl_2$
		24·750 NaCl
SO_3	1·930	

Total solids = 31·373

(Direct determinations of Total Solids gave 31·00 and 31·05.)
Ammonium and Potassium salts absent.

Pond III. Low Tide. August 10th. Amounts given in gms. per litre.

CaO	0·092 =	0·164 $CaCO_3$ or 0·266 $CaH_2(CO_3)_2$
MgO	0·049 =	0·191 $MgSO_4.2H_2O$
Cl_2	0·225 =	0·371 NaCl
SO_3	0·079 =	0·078 Na_2SO_4

Total Solids = 0·804

(Direct determination of Total Solids gave 0·797.)
Ammonium and Potassium salts absent.

[A comparison of the two tables, whose figures partly overlap, makes it clear that Table IV should really have been labelled chlorine, not chloride, (the former is on the MS report by Manley that I still have). The former represents the element or ion content, the latter the compounds -- here sodium chloride and magnesium chloride. Hardy (1956) summarizes the general composition of sea-water both as ions and as compounds, giving a total salinity (i.e. all compounds) of 34 °/₀₀ for Polar regions. Chlorine accounts for about 55%, sodium chloride being c. 77.8% and magnesium chloride c. 11%. These figures are obviously very general ones that would not apply in detail to a Spitsbergen inner fjord. Taking just the figures in the tables above

Bruce City...July-August... [The Intertidal Zone, cont. sodium chloride in Pond I at high tide was about 80% of the total solids (which I take as = "salinity" as usually stated). The total solids there were c. 31‰, a value almost the same as Stott's 30 ‰, for the open fjord surface, but higher than the 27 ‰ he gave for some shallow coast waters. A fuller (upublished) analysis of water taken at the Boulders gave the ratio of sodium chloride (25.54 ‰) to total solids (32.69 ‰) as c. 78%. Considering the highly variable and heterogeneous conditions around here, and sampling differences, the agreement of all these figures is as good as can be expected. They indicate that Ponds I and II temporarily reached sea-water values at high tide, but that Pond III was much lower -- with total solids at low tide falling to 0.8 ‰, and reaching chlorine value of only 9.10 ‰ at high tide.] .

[I worked out a further point, which might have biological implications for brackish-tidal animals. This is that the ratios between different salts varies according to the tidal mixture. I quote here a short discussion in our paper: "It will be seen that the total amount of salts in Pond III is about 1/4oth of that in Pond I at high tide, and the osmotic pressures etc., would differ accordingly. Also calcium carbonate is present in relatively greater proportion than the other salts in the fresher water of Pond III. Thus comparing the two samples, there is about 1/9th of the amount of calcium in one that there is in the other. But the amounts of other elements compared in the same way are far smaller, e.g. magnesium 1/50th, sodium 1/50th, chlorine 1/70th. This shows that the effect of tidal influence is not merely that of diluting or concentrating a given solution, but is more complicated. "]

[Eurytemora raboti is a Calanoid Copepod, just over 2 mm. in length, and distinctly pink in colour. It occurs very widely in brackish lagoons in Spitsbergen, also relict in fresh-water ponds. First described by Richard (1897) from material from Recherche Bay, Bell Sound ; also recorded by him (1898) from Amsterdam I. and Advent Bay area. It was collected by Olofsson in a number of tidal and fresh-water lagoons in Icefjord. It lived in most of the freshwater ponds on the Klaas Billen raised beach, described later. In 1924 I found it commonly in Liefde Bay, and in 1923 saw it in a lagoon on the coast of Lomme Bay, off Hinlopen Strait. Just from the tables (which give only sample days) its chloride range was from 0.22 ‰ to 9.10 ‰ in Pond III, to 0.57 ‰ to 15.23 ‰ in Pond II, though only adults were found in the latter, suggesting that they were perhaps washed down from by the stream and tidal movement from their headquarters in Pond III, in which case the apparent salinity tolerance might be misleading.]

Bruce City...July-August... [Intertidal Zone, cont.

[Tolerance experiments for salinity, on Crustacea. Four species were tested viz. Mysis oculata relicta, Gammarus locusta zaddachi, Eurytemora raboti and Daphnia pulex (Eurytemora from Pond III, Daphnia from Pond VII). The last was common in the fresh-water ponds above, but absent from tidal water. The tests were done on 1 and 3 August, because sea-water samples (analyzed later, as explained) were available. It was used pure and in various mixtures with boiled pond water from VII, also pure fresh water alone. The results for Eurytemora were mentioned briefly in our paper (p.268) but the full data have not been published and are given below. The times of survival must be treated as approximations, since I was not able to watch them continuously because of other jobs. The salinity figures (i.e. chloride values) have been rounded off to the nearest whole number.]

[Expt. A. E.raboti in the following:

Sea-water 18 ‰ (1♂. 1♀, 1 imm.). All dead in 16½ min.

Sea x fresh-water 13 ‰ (no details of animals). All but 1 sluggish or dead after 1 hr. 40 min.

Ditto 12 ‰ (no details). All alive and active after 55 min.

Ditto 9 ‰ (♂♂,♀ ads., ♂,♀ imm.). Ditto after 3 hr. 28 min.

Expt. B. E.raboti in following:

Sea-water 18 ‰ (5♂♂, 2♀♀, 2 ♀♀ + eggs, 1 imm.). "Rushed about when first put in". When looked at after 20 min. all were dead.

Sea x fresh-water 9 ‰ (8♂♂, 2♀♀, 2♀♀ + eggs, 1 imm.) All alive and active after 3½ hours.

Expt. 2. All four species tested.

(1) Sea-water 18 ‰.

Mysis and Gammarus, alive after 2½ hours. Eurytemora, some dead after 18 min., all at 37 min. Daphnia, ——→ dying after 18 min., all dead (no heart-beat -- the heart is easily visible) at 37 min.

(2) Sea-water 2 : 1 fresh water, 12 ‰.

After 20 min. Daphnia dying and dead; other species alive and still so after 1 hour. But one Eurytemora was slowed down, and eaten by Gammarus.*

(3) Sea-water 1 : 1 , 9 ‰.

Examined after 1 hr. 20 min.: all Daphnia dead, others alive and active.

(4) Sea-water 1 : 2 fresh, 6 ‰.

After 1 hr. 36 min. all alive and active, including Daphnia.

Bruce City...July-August...

[Expt.D. Gammarus alive and active after 12¾ hours in pure sea-water. Expt.E. Mysis and Gammarus alive and active after c.12¾ hours in fresh water.

Our paper (p.268) notes: "Gammarus zaddachi from Pond I would eat large numbers of Eurytemora in captivity. Table III shows that these two species hardly ever meet. This may be another limiting factor for Eurytemora."]

[General summary for these four species. Daphnia is killed by full fjord salinity and down to chloride 9 ‰, but did survive for 1½ hours at 6 ‰. However it is not a species of moving water. Eurytemora can survive up to 12 ‰ for at least an hour, and in 9 ‰ for at least 3½ hours. It was killed by sea-water. The Mysis and Gammarus can survive in pure sea-water and in pure fresh water for at least 13 hours or so. The field distribution is in accordance with these tolerances, except for the scarcity or absence of Mysis and Gammarus in the upper ponds, which I have attributed to the attentions of Arctic terns. The fact that Gammarus eats Eurytemora may also matter. We drew attention to the time/salinity factor, and because of this the exact survival conditions for Eurytemora are only approximately known. But the following notes in our paper are relevant: "These ponds lie very near high water mark, and are only flooded by the sea for an hour or two" (p.268). "If Pond III were raised only a foot or two it would then be a relict freshwater pond like those higher up the beaches" (p.267).]

[Freezing experiments. Some invertebrates were frozen or super-cooled to test survival. These tests are described later in relation to the upper ponds. Briefly, Mysis, Gammarus and Eurytemora could not withstand freezing. As the two former carry their eggs and very young in a brood-pouch, these could not survive a winter's freezing. Eurytemora apparently survives the winter as eggs, according to Olofsson, whose conclusion seems to be based reasonably upon the seasonal population cycle of the species, though not on experiment. In any case it is the only possible explanation!]

[The large population of small Mysis in Pond I must either have come in from the fjord as very young animals, or else been brought in by parents that perhaps subsequently were eliminated by terns. I noticed that they were living mostly near the bottom, not in a planktonic manner like the adults.]

Bruce City...July-August... [The Intertidal Zone, cont.

[Some other species. The Amphipod Pseudalibrotus litoralis, here found only in the outer pond, also occurred in tidal brackish water in Richard Lagoon (these notes, p.54).

The rotifer Colurella colurus is known to have a remarkably wide habitat distributinn from salt to fresh water. Olofsson (pp.603-4) noted that this applies to various parts of Europe and in the Arctic. I found it in Ponds I, II and III. In view of the capacity of rotifers to get dispersed by air in a dried-up state, this species does not add any evidence about relict fresh-water animals. (N.B. Olofsson used the name C.amblytelus (Gosse), but Bryce, in S.P.1, No.26, p.316, treats this as a synonym for C.colurus (Ehrenberg). I do not know what modern opinion is).

(Here I should point out that my pond rotifers collected on this Expedition were named by Bryce, but for some reason he does not include them in his table of species taken by the expedition, which were mainly from my moss collections. It is, however quite certain that he named them).

The Collembola are species commonly found on the sea-shore, A.beselsi being confined to that zone, while Achorutes viaticus has a much wider range. My catalogue records and Carpenter's paper give this information:

Archisotoma beselsi "many on surface of brackish tidal pool, 8 August; 2 on edge of salt marsh, 13 August"
Achorutes viaticus "16 on surface of tidal pools, end of July".

We drew attention to the absence in my collecting of fly larvae (Chironomidae), that form such a large constituent in fresh-water ponds and lakes in Spitsbergen.]

[Fresh-water spring source, "S" on maps. Though very small as a water body, this was the main cause of the graded salinity in the three pools. Our paper (p.267):" There are no Crustacea. A collembolan Sminthurides malmgreni was seen on the surface. An oligochaete Henlea heleotrophus was abundant in submerged Hypnum cordifolium. Also (3 spp. indet.) * rotifers, tardigrades, nematodes and protozoa." Of each it seems I brought home only one specimen, but evidence below suggests that this was a characteristic habitat for both species. The minute springtail was found by me on the edge of a stream by Ella Lake, Bear I. (these Notes p. 26). Wahlgren (1900) had previously taken it from the surface of a small pool in the north of the Island. Bertram and Lack (1938) in their Bear I. survey gave "partially submerged moss bog" and "on water". Valpas (1967) has summarized the published references about this species in Svalbard, not all of which I have seen.

* "Apparently of the genus Macrobiotus" (Bryce, loc. cit. (14))

Bruce City...July-August... [The Intertidal Zone, cont.

[Stephenson (S.P.1, No.24) described the 1 cm.-long Enchytraeid worm as a new species, Henlea (Henleanella)heleotrophus, from this one specimen and another from wet moss on the bank of Pond VII (see table later). I collected it again in 1924 from moss of a temporary stream, then dry, and in mud of a temporary pond, on Reindeer Peninsula, Liefde Bay. Nurminen (1965) in a wide survey of Enchytraeids, found it in a sedgy beach in Advent Bay, and in "poor grassland" in King's Bay [Ny-Ålesund]. He mentions that the Spitsbergen specimens agree well with ones found by Overgaard Nielsen and Christian (1959)* in Denmark.]

[Olofsson's intertidal lagoon. He examined a small series of water bodies in the area of Bruce City (built later, of course), of which one, his "Strandlagune XI" is of importance here.His usual practice was to give a rather detailed description of the places he collected in, sometimes with a photo, but unfortunately he seems to have paid a very brief visit to this tidal estuary, on 5 August (1910 almost certainly). This is a free translation from his German: "This lagoon lies on the above-mentioned tongue of land, c. 1.5 km. from the Nordenskiøld Glacier. It is connected to the Fjord by a 5 - 10 m. deep and c. 1 m. wide channel. The inner, shallower part has slowly-flowing water from the flat land. It was here that the collection was made. The water tasted completely fresh. In the outer parts of the lagoon there was however mixing with the salty water of the Fjord and the fresh water, The water was here "stark gestreift" (I take to mean variable in salinity) especially in the outlet. The proportion of salt and fresh water varies with ebb and flow of the tide."

He took only one collection (it was his practice to list each one separately), the animals in which very closely resemble in composition the fauna of Pond III:

Crustacea:

Mysis oculata var.relicta	c
Eurytemora raboti	rr
Tachidius longicornis	rr
T.spitzbergensis	c
Ectinosoma arcticum	rr
E.major	rr
Microstella norvegica	r
Rotifera:	
Colurella amblytelus	r [=colurus, see p. 101]
2 spp. indet.	r

Also Protoza, Nematoda, and Tardigrada in small numbers. Filamentous algae.]

* who only say it "fits" their material, but in the absence of chromosome material they "hesitate to claim identity." Habitats: along brooks and ditches, and in a garden.

Bruce City...July-August... [The Intertidal Zone, cont. Olofsson...

[Microstella (like the leech in Pond I) was a stray from the fjord fauna. Of the other 5 Copepoda I collected 3, but not either species of Ectinosoma -- new species described by Olofsson (1917) and regarded by him as brackish forms. In his discussion of the Mysis records he obtained, he gives the lengths as 8.6 - 9.3 mm and the structure of the telson as resembling that of relicta. They were smaller than the population of true relicta that he found on the lake in Bell Sound (on 12-13 August). He stated that the Fjord forms of M.oculata resemble those of the typical species (and see Tattersall), but were not completely normal. And he mentions that the salinity at the surface of the Fjord outside this lagoon was only c. 27 ‰, -- which agrees with Stott's experience. Olofsson found a third locality where this species was entering a brackish lagoon. This was on the S. side of Sassen Bay, north from Mt.Marmier. If I follow his account correctly, the Mysis were entering the lagoon at flood-tide and being swept out completely when it ebbed, but not establishing any population of young ones permanently during the summer.]

[The close correspondence of his Lagoon XI with our Pond I system is striking. Yet there are some inconsistencies I find hard to explain. The distance from the Glacier places his lagoon clearly in the estuary area of Sheilabekken , yet the great depth of the outflow channel does not, as I remember the area as an expanse of flat mud with no deep channels. It is possible that the physiography had changed between 1910 and 1921. Yet it is an area highly protected from wave and wind-driven tides, also his meagre description gives no clue to its shape or the origin of the fresh flow in detail. In my sketch-map (these Notes, p. 930) there is shown a second lagoon about the same size in the same estuary area, but nearer the Glacier. But I made no investigation of it, or of the nature of its inflowing fresh water, if any. In our paper we equated the two, and this is probably correct -- his Lagoon XI and our Ponds I -III .]

[The presence of Eurytemora in this assemblage can only be explained by assuming the existence of a brackish pond above, and the washing down of a few specimens. He states that only adults were found, and these very rarely, and that one was a ♀ with eggs.]

Bruce City...July-August... [The Intertidal Zone, cont.

[Walton's survey of vegetation. The tidal pool system and its margins formed the central focus of his work (see map. p.93B, these Notes). The following summary picks out only some of his main observations, and it is not necessary to go into great detail, since his paper (also that of Dobbs) is in the same easily accessible J.Ecology as our own. He was especially concerned to identify the zonation of plant associations, as representing probably the future course of ecological succession, from the pool margins up to dry land. He examined the algae of Ponds III (our II) and IV (our III). In his III there were large masses of Enteromorpha, plus Oscillatoria and Spirulina; also diatoms, with Synedra pulchella dominant. These three algae were also characteristic of the Middle Mud Flats. But the Inner ones, seldom reached by tides, were almost sterile and partly dried-up with a salt encrustation, also some signs of mud-polygon formation (see photo in his paper). Pool IV had an algal flora of mixed brackish and fresh-water type: Zygnema, Ulothrix, Rivularia, plus Oscillatoria and Spirulina.]

[He states that the Spring was supplied from a source that sank underground near his Pool V (our Pool IV). In it he found abundant algae: "The actual mouth of the stream is black with a growth of Oscillatoria sp. and round about there occurs a mass of green algae consisting of Ulothrix sp. and others. Among these algae there is a rich flora of diatoms which are almost exclusively fresh water. The dominating species is Diatoma elongatum Ag." He names 5 other species as frequent."]

[My original list of algae named by B.M.Griffiths adds some species determinations for the Spring:

Oscillatoria curvipes
O. tenuis
Ulothrix subtilissima
U. zonata]

[Walton submitted a series of diatom samples to an expert, N.Yermoloff, in order to find out if they showed any modifications in structure, on the lines of Mysis relicta. He gives a list of 10 dominant species. Yermoloff ascertained that there were many "transitional forms of the group Navicula radiosa, N.Cincta and N.gracilis, forms closely connected with Navicula gracilis var. rhizonemoides V.H. and that he thought that these transitionals were adaptations from a brackish to a freshwer environment."]

Bruce City...July-August... [The Intertidal Zone, cont.

[Dobbs' survey of vegetation, 21 July - 19 August 1936. Dobbs, a plant ecologist from King's College, London University, re-surveyed this intertidal pond area as well as other habitats surrounding it and in the neighbourhood of Bruce City. His two maps (these Notes pp. 106-07) give a good idea of the local distribution and complexity of these associations, which I will not attempt to discuss in any detail. For the ponds he used Walton's numbering system. He found that there had been little topographical change there in the 15 years since Walton's survey, though there was some shift in the emphasis of vegetation types. The tidal flats were almost bare, but in some places there was grass (Puccinellia phryganodes -- Walton had used the synonym Glyceria vilfordia, but the former is now in general use). Also the alga Enteromorpha and the bryophyte Swartzia inclinata. But the main cover was a wrinkled skin of blue-green algae. He thought that Puccinellia had spread considerably since 1921. Walton did not note the moss in the tidal flats, though he gave it as a constituent of the higher zone by Pond III, a habitat flooded only at highest tides and having a debris of driftwood and seaweeds. (He used the name Distichium capillaceum for this moss, which Dobbs treats as a synonym for S.inclinata). Dobbs stated that the amount of water in these ponds varied from year to year e.g. the small pan, Pool II, was dry in 1936 (according to an informant), but had water in 1937. He mentions this for other pools, but does not specify which, or whether any referred to the Ponds I - III series -- which would be unlikely unless the Spring itself had dried up. I suppose this is not impossible, in so far as Spitsbergen was in this period undergoing a temporary amelioration of climate, so that the area, -- dry in any case -- might have been drier. But his map shows the pools much as they were in 1921.

[Fresh-water lagoon series on the raised beach system. The beaches rise in a series of steps, sloping slightly upwards, to about 40 ft. They are described physiographically by Feyling-Hanssen (1955). And they are shown in my sketch-map made from the foothills of the Campbell Range, and in the vertical cross-section (p.103; also Walton's "aerial" photo, p. 92A, and the maps on pp. 139A,B). On these beach levels was a very interesting series of shallow ponds, numbered by me IV - XI.* Much the largest were the lagoons flanking the huts of Bruce City. There have been some changes in the pond system since 1921, which I will mention individually.]

* In the sketch-map in our paper, p. 265, Pond XI was written by me accidentally as XII, though correct in the cross-section.

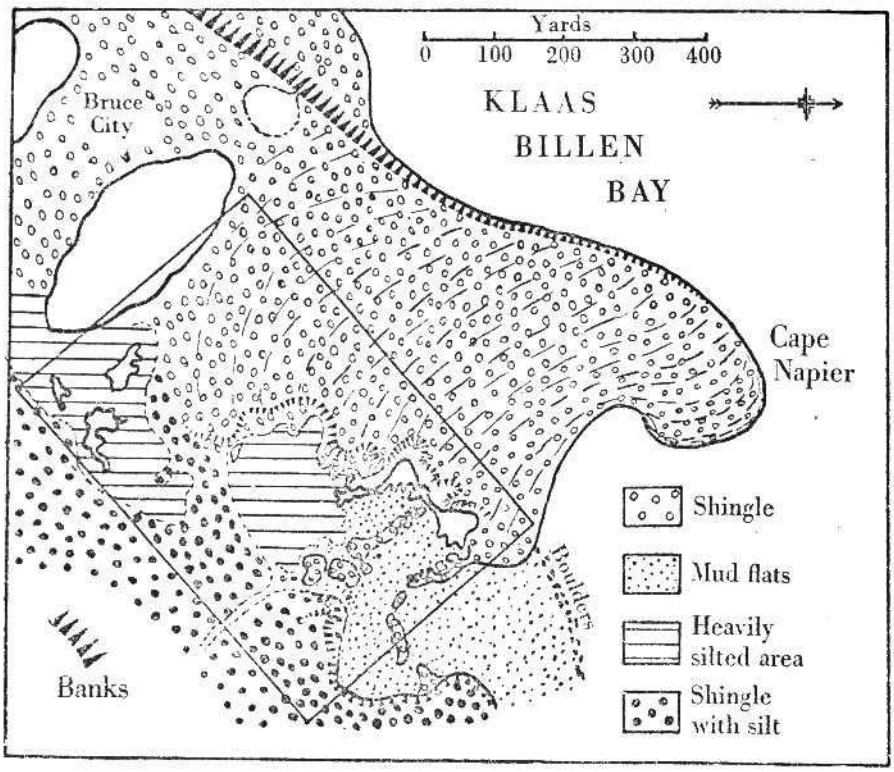
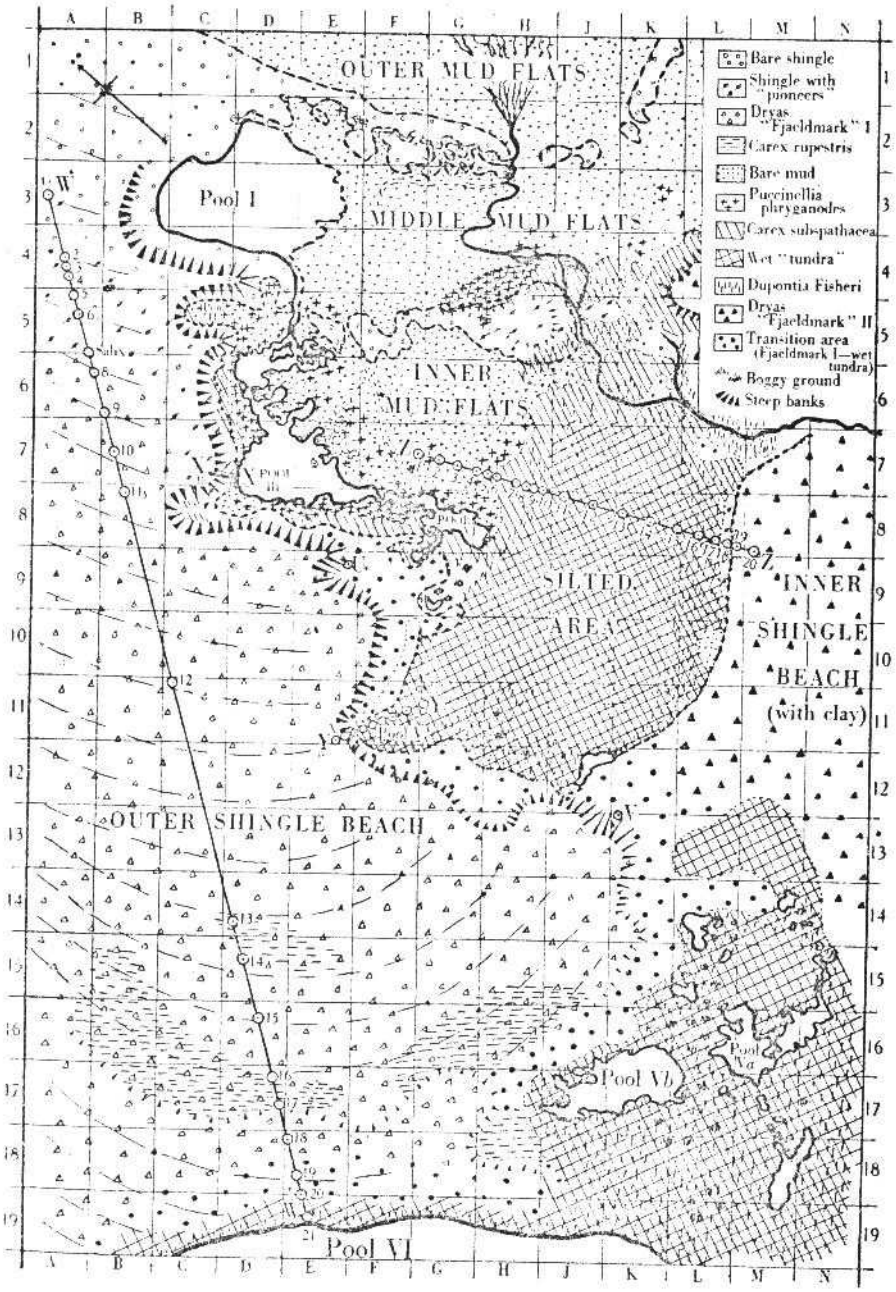


Fig. 1. Cape Napier—topographical sketch-map based upon a rough survey. The rectangle encloses the area shown in Fig. 2.

From Dobbs (1939). J. Ecol. 27 : 128-48.



"Pool VI" = IV

FIG. 2. Vegetation map based upon a plane-table survey covering the same ground as Walton's Fig. 4 (1922). The map is divided into 100 ft. squares which are referred to in the text with the numeral first (thus—4 G). References to the points on the frequency transects have the letter first (W 3).

From Dobbs (1939). J. Ecol. 27: 12-48. N.B. Pool numbers = Walton's, but there is one misprint.

For XII
read XI

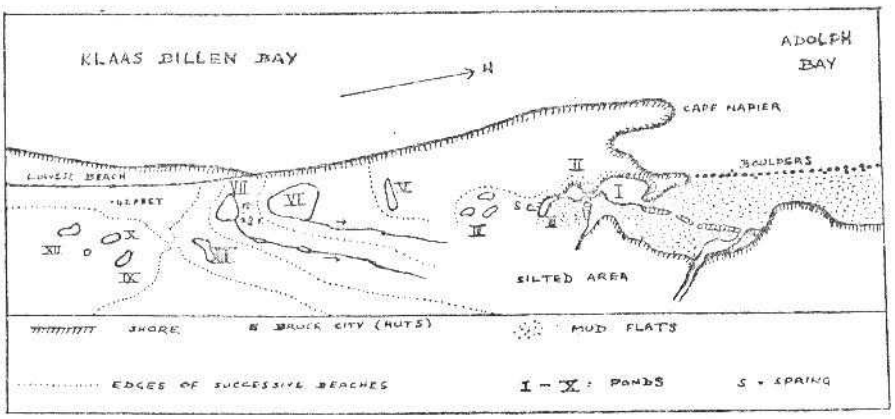


FIG. 5. Diagrammatic sketch of Klaas Billen Ponds and Beach lines. Heights are accurate.

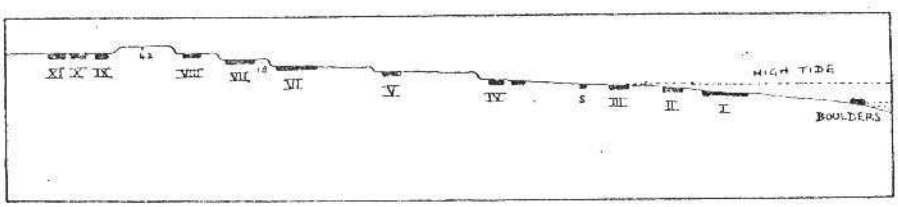


FIG. 6. This shows the relative positions of the ponds and the relation between successive elevations.

(V.S.S. & C.S.E. 1923, p. 265)

Bruce City...July-August.... [Fresh-water lagoons, cont.

[Most of the ponds, except smaller ones with a considerable encroachment by vegetation, were clearly identifiable structurally as former brackish lagoons since raised up from sea-level. This is very clearly seen in the two largest ones, VI and VII. Indeed, in the unpublished sketch from my field-notes the position of the former lagoon entrance is shown for VI (these Notes, p.109A). The map by Dobbs (these Notes, p.106) shows the outer part of this former entrance as a small pool.]

[In 1921 Pond V was visible structurally on the lowest beach level, but was then dried up, and does not further concern this account].

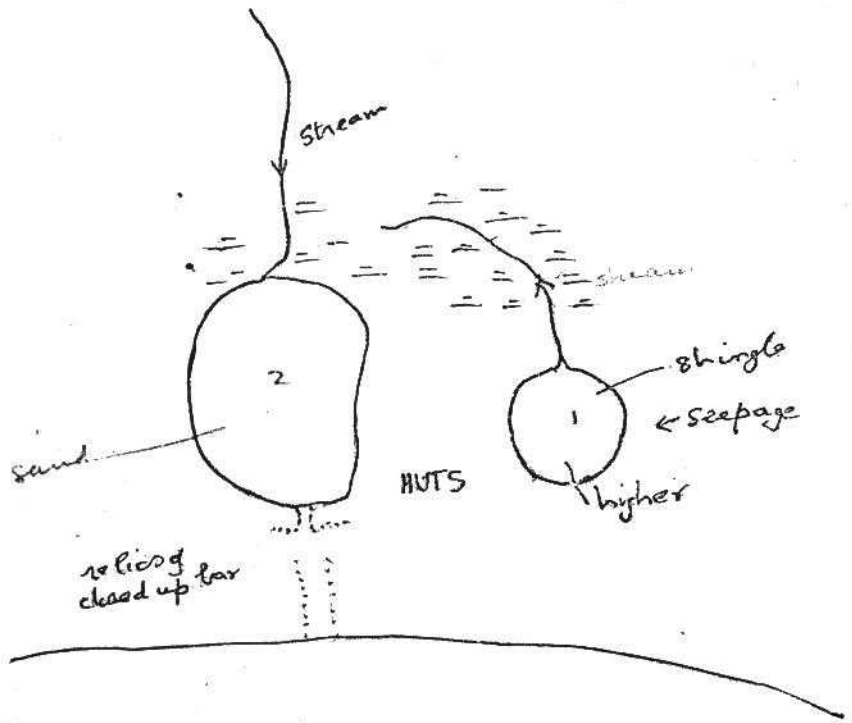
[We are left with the 7 fresh-water ponds studied by me, and the 6 described by Olofsson for 1909-10. Most of the latter can safely be identified with my series; or at least in the same ecological group on one level. The correlation of numbering systems, runs as follows:

C.S.E. (& V.S.S.)	Walton	Olofsson
IV	V [+ Dobbs Va and Vb]	-
VI	VI	X
VII	VII	IX (almost certainly)
VIII		VIII
IX, X, & XI		VI & VII

This is the relationship given in our paper. Feyling-Hanssen (1955) in his 1950 survey marked on his sketch-map only our VI and VII, and states in a footnote (p.87): "Several smaller ponds are marked on the sketch maps of Summerhayes and Elton (1923) and Walton (1922). I did not observe them in 1950, and they are not marked on the Cambridge Expedition map (Harland) 1952)." Harland's map is shown in these Notes p. 1398/1, but its negative evidence is not necessarily relevant, since little detail is shown. It was made in 1949. But Feyling-Hanssen's observations sound conclusive.* It would therefore seem that our own survey was fortunately made at a date when all but one "relict lagoon" were still present, and had in them Eurytemora, a point discussed later.]

[Pond IV (Walton V). We stated: "One of several pools in boggy land, and the newest of the series." Walton recorded that it was almost filled with sedge (Carex salina var. subspathacea) -- for which Dobbs and also Rønning

* our Ponds VI, VII, VIII & IX are shown on Acocks's mapped transect surveyed in 1936 (see these Notes, p. 127).



Inked-in pencil sketch-map of the shallow relict lagoons by "Bruco City" huts. Numbers in our paper (1923) are different:

1 = VI

2 = VII

(Xerox from my Diary notes)

Bruce City...July-August... [Fresh-water lagoons, cont. use the name subspathacea as a species; the rush Juncus biglumis; and the large alga Nostoc. There were some tussocks of Salix polaris. But, according to Dobbs "this pond has now [1936] disappeared altogether and is wet polygon tundra." But he named two other ponds Va and Vb, noting that "they have evidently grown in size and are now definite sheets of standing water, without much vegetation in them." But these two ponds, judging from his maps(see these Notes pp.106-07),lay much nearer the Huts than Pond IV and probably on the same beach terrace as VI. Our published snhematic sketch (these Notes p.108) shows a stream flowing down in that direction. For this pond I have only the list of Crustacea; but it included Lepidurus (usually an indication of permanence!), though it was the only one in my series without the planktonic water-flea Daphnia pulex. Olofsson did not collect here.]

[Pond VI. This former lagoon, the largest in the series, was about twice as big as its neighbour on the other side of the Huts area: c. 300 yd.(paces) in length, but on a slightly lower beach level than VII. 1-2½ ft. deep, it had a sandy-mud bottom and occasional shore strips of beach shingle. The edge fell abruptly to the water and had a mossy bank. But it was partly being encroached upon by bog. (These and other data about the ponds are partly from our paper and partly from my field notes, in this instance the latter being of 19 July). We noted that "its fauna is the same as that of Pond VII." Walton (p.120) has some remarks about this pond: "It is too deep for colonisation by Phanerogams. Euroglena [sic -- a misprint for Uroglena] is an abundant plankton constituent. Occasionally near the margins there are submerged plants of Ranunculus hyperboreus L. which develop flowers of quite normal form under the water." He points out that there is a dense mossy turf forming a barrier over the mouth of the pool. (The marginal communities of these ponds are dealt with later on in these Notes).]

[Olofsson's Pond X is clearly this one, judging from his description-- several 100m. from the shore, lying in flat land, size 100 x 200 m., depth 20-30 cm., no inlet or outlet streams. Mossy shore, part with small stones; bottom mud, part stony. When he visited on 5 August the open water temperatures varied locally from 10.75°- 11.5°C.]

[Pond VII . The second-largest lagoon, lying S. of the Huts at about 26 ft.

Bruce City...July-August... [Fresh-water lagoons, cont. is on about the middle of the raised beach levels studied for ponds. Photo p. 111B shows the very marked moss margin. "The bottom is mostly shingle, with a few patches of mud, as a result of which Lepidurus is rather scarcer than in Pond VI" (our paper, p.271). "The water is very clear, quite fresh and alkaline. The continuous daylight of the arctic summer enables photosynthesis by algae to continue all the time. This must cause the oxygen content of the water to be high and the CO_2 content low, which is probably one reason for the constant alkalinity of the water. All waters examined (on Bear Island and Klaas Billen) had a pH of 8.2-8.5" (p.273). This was the pond I studied most intensively (cf. photo p. 111A !). The temperature regime has already been referred to (These Notes, p.82). The complete curves are shown in the diagram below, from our paper (p.273):

Fig. 7 gives the temperatures of the water during the end of July and beginning of August. These were usually taken at 11 a.m., but on several days they were taken at other times (July 25th at 1.30 p.m., July 28th at

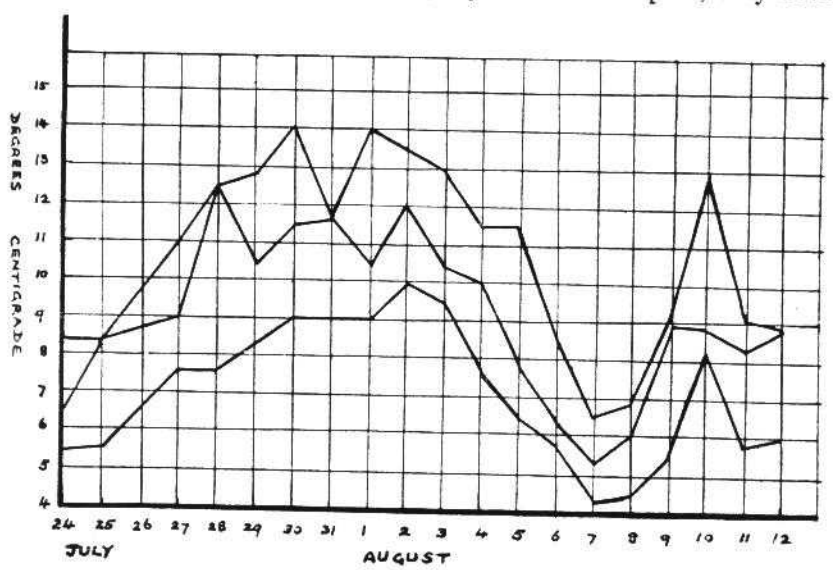


Fig. 7. Temperature of Pond VII (no record for July 26th). Readings were taken daily at 11 a.m. in the shade, at a depth of 9 inches. Curves show maximum, actual, minimum.

5 p.m., Aug. 12th at 2.30 p.m.). These latter records show that the maximum temperature is reached in the middle of the day. In this region it is usually colder at night. It will be seen that the average daily range is about 3·5° C., the maximum temperature 14° C. and the minimum 4·3° C.

V.S.S. & C.S.E. (1923), p.272.

C. S. E. studying pond life at "Bruce City". (Photo A. M. Carr-Saunders 1921).

Pond VII, Bruce City, mossy margin. Campbell Range behind, and in the distance the lateral moraine of the Nordenskiöld Glacier. Dryas on shingle, r. (Photo J. Walton).
(Publ. V.S.S. & C.S.E., J. Ecol. 16, (1923), Pl. II, p. 254.

Bruce City...July-August.... [Fresh-water lagoons, cont. We noted that the temperatures correspond with waters in the willow zone of the Scandinavian mountains, and c. 2000 m. in the Rhaetic Alps. Stobart told me that Ponds VI and VII were just unfrozen in the middle on 14th June. We know that such waters begin to freeze in September, so that life in them has only about 3 months of activity, at most. The circumstantial evidence fully discussed by Olofsson, seems to prove that all the Crustacea in these shallow ponds, e.g. Daphnia and Eurytemora and Lepidurus, must pass the winter as eggs. I noted that the two former were about a week ahead in development in the smaller (and warmer) ponds. Olofsson also remarks on this. During our stay the big pond levels fell by several inches.].

[Olofsson's Pond IX, which I have equated with our VII, was certainly in a very different state in 1910, in being much dried up, though the fauna was similar. A rough rendering of Olofsson's description is: lies near Pond VIII [see later] and is like it, a remaining relic of a larger water, which is now in great part dried-up. On July 22 its size was c. 10 x 15 m., depth 10-20 cm, bottom mud. Margin partly moss, partly dried-up mud. Temperature in open water 6.5°C., on 22 July. On 5 August the drying-up had progressed still further. It was now reduced to a basin 10 - 15 cm.deep. Temperature in open water 9.25°C. If, as I believe, this was the same as our Pond VII, the conditions of climate or ground drainage or both must have been very different. In 1921 Pond VII was c. 140 yd. (paces) long, and 6 in. - 1 ft. deep. This was three times bigger in 1921 than in 1910, and there was no sign of drying-up. There are three ways in which the pond level could be affected (1) more evaporation, implying climatic change (2) changes in subsoil water supply from frozen ground below, or from surface flow (3) changes in vegetation at the outlet. Considering the general lack of change indicated in the other ponds, I believe that possibility (3) may be the real cause. After all, some vagary in the destruction by spring melting, or even a herd of reindeer, could have opened up the boggy outlet. The great similarity in fauna, geographical position and absence of possible alternative ponds, plus the indications of drying up of a formerly larger basin, seem fairly conclusive.]

[Pond VIII. Described by us as "two small ponds lying in boggy land connected by a narrow channel", and on a higher beach shelf, also more inland than VII. Olofsson's Pond VIII corresponds with it in position, structure and

Bruce City...July-August... [Fresh-water lagoons, cont. fauna. He went there on 22 July and 5 August. He describes it at follows: 200 m. further from the shore than his VI and VII. On 22 July it was mostly dried-up, though it appeared to have been larger earlier. Only two small ponds, with a c. 2 cm. deep connection, were left; depth 10 - 20 cm; bottom mud; margin partly mossy, partly dried mud, temperature in open water 8°C., in marginal vegetation 7.5°C.]

[Ponds IX, X and XI. There is a large area on top of these beaches that is evidently the remains of a former large lagoon. (Its history is discussed later in these Notes, but see maps pp. 108; 139A and 139B). On the inner side were the ancient whale bones described at the end of these Notes. The highest point of the beaches here was 42 ft. above the sea, and the floor of the old lagoon about 40 ft. Possibly the ponds remaining in it were slightly higher than VIII. These were three in number, all similar in character --mostly mud sandy bottoms and plant covered margins. I have measurements of X: 20 x 15 yd., depth 4 - 6 in., with mud and shingle bottom, and partly muddy edge with Dryas clumps complicated by large polygons.]

[Olofsson studied two ponds up here (his VI and VII). Though it is not possible to identify them individually with ours, they may indeed have been the same as two of them. This is a summary of his description:

VI. Lay in the S. and W. part of the beaches, several tens of metres from the shore and 2 km. from the Glacier, c. 10 m. above the sea. These figures must have been guesses and agree with ours as well as can be expected. Size 10 x 20 m., depth 10 - 25 cm., no entrance or exit streams, shore of bog, bottom mud partly with moss and Eriophorum growing, temperature in open water 11°C. Collections in night of 21/22 July, in calm clear weather.

VII. A few metres from Pond VI and connected partly by swampy bog. It was covered by thick vegetation of Eriophorum, grasses etc. amd very small -- only c.5 X 10 m. It would obviously be joined to V in spring. Same temperature. It was very poor in Crustacea and rich in algae.

Between these ponds was a bog pool with very shallow water, that had three species of Crustacea.]

Bruce City...July-August... [Fresh-water lagoons, cont.

[Fauna. The table below, from our paper (p.271) summarises the species of Crustacea found in a sequence of 5 ponds, from lower to higher beach levels. There were 1 Phyllopod, 3 Cladocera, 3 Copepoda and 2 Ostracoda. This community (± Eurytemora) is very generally spread through many similar ponds in Icefjord. I have made a correction of one error in the published table.

TABLE VI. *List of Crustacea occurring in the Freshwater Ponds.*

Pond No.	IV	VI	VII	VIII	X
Lepidurus arcticus	×	×	×	×	×
Daphnia pulex	–	×	×	×	×
Macrothrix hirsuticornis	×	×	×	×	O
Chydorus sphaericus	×	×	×	×	×
Eurytemora raboti	×	×	×	×	×
Cyclops crassicaudis	×	×	×	×	O
Maraenbiotus brucei	–	–	×	×	O
Candona rectangulata	×	×	×	×	O
Eucypris glacialis	×	×	×	×	O

O = recorded by Olofsson (our collection lost).

[It is possible to distinguish the more planktonic species such as Daphnia from the bottom-living forms such as Macrothrix and Ostracods, and the plankton ones from those more found in the mossy marginal zone. This was done commonly by Olofsson, and we did so in the list for Pond VII. I now feel the distinctions are hard to maintain in any safe way, especially in the smaller ponds. Olofsson's Ponds VIII and IX (our VIII and VII) contained exactly the same list, with one exception to be mentioned; and his VI (cf. our IX - XI) also, except for the absence of Daphnia. His X (our VI) lacked Maraenbiotus and the 2 Ostracods; and his small high-level VII had only Chydorus. But the general impression is of great uniformity, with a few species missing or not captured.]

[One remarkable feature of his pond lists is the almost complete absence of Lepidurus glacialis. He recorded it only in one of the topmost ponds (his VI), and this is mentioned separately in his discussion of the species on pp.282-92, not in his pond list. He explains, no doubt correctly, why he had so few records of this species, by saying that it did not occur in his net-sweeps, and altogether in the 24 water bodies he surveyed it is only recorded in 6! It seems to me that in concentrating on one rigid method of collecting, he failed to observe one of the most obvious, certainly the biggest, species moving about on the bottom.]

[Rotifera. I made little study of this group, but Olofsson recorded lists of species from his pond series. As with the Crustacea, his monograph contains extensive descriptions (illustrated) of all the species concerned.

Bruce City...July-August... [Fresh-water lagoons, cont...

Rotifera...But I don't think his net-sampling could be complete enough to prove the absence from any particular pond, for this group of very small animals. Therefore I give below a total list of what he found in the fresh-water ponds here:

Colurella obtusa (Gosse)
Diurella obtusifrons Olofssen
D.uncinata Voigt
D. bidens Lucks.
Diaschiza gibba (Ehrbg.)
Euchlanis dilatata Ehrbg.
E.oropha Gosse
Metopidia lepadella Ehrbg.
Monostyla lunaris (Ehrbg.)
M.cornuta (O.F.Müller)
Mytilina brevispina (Ehrbg.)
M.mucronata (O.F.Müller)
Notholca foliacea (Ehrbg.)
Polyarthra trigla Ehrbg. (=platyptera Ehrbg.)

He caught Notholca foliacea in 4 out of 5 ponds. One curious absentee from his fresh-water lists for this area is Colurella colurus (=amblytelus), in spite of its known tolerance for fresh water and its local occurrence in Ponds I - III. And Olofsson himself recorded it only from one fresh-water pond on the south shore of Sassen Bay, and another at Advent Bay.]

[There are evidently three main habitat zones or types in which Spitsbergen rotifers live:

(1) Plankton* in open water. Exemplified by Polyarthra; also Anuraea aculeata found in a few other localities. He considered (p.631) that these were the only true planktonic species in his list. He mentions 3 others as mainly planktonic, but these were not found at Bruce City.

(2a) Predominantly vegetation species occurring sporadically in open water-- at least 14 species.

(2b) Purely ditto., occurring neither in plankton nor in bog.

(2c) Ditto, but occasionally also in bog.

(3) Purely or predominantly in bog (which means mainly in mosses). "None of my species belong here", he notes.

He collected altogether 34 species from fresh-water ponds in Icefjord, 14 of which were found at Bruce City. Bryce (see S.P.I, No.26), working with dried moss samples I brought back from various habitats, noted 5 species of Ploïma and 21 Bdelloida from there. There were none of the latter in Olofsson's collections. This sharp distinction between the communities

* Amrén (1964a & b) has done extensive work on plankton rotifers, in water bodies at the mouth of Icefjord though this is not directly relevant to the Bruce City studies.

Bruce City...July-August... [Fresh-water lagoons, cont.

Rotifera... in (1) and (3) is discussed by both authors. Bryce's report notes one interesting exception. He described a new species, Encentrum murrayi, from my Bruce City material. It was named after James Murray who had collected the same form in the Antarctic during Shackleton's Expedition of 1909-10, but did not give it a name, though he described its structure. At Bruce City it was living in dry tundra moss (Grimmia commutata) and Bryce remarks: "This new form is therefore to be added to the very short list of Ploïmid species, which can protect themselves from desiccation."]

[Our paper (p.271) gives a list of the animals found in Pond VII, to which I gave particular attention. In addition to the 9 species of Crustacea already cited in the Table, there were 5 kinds of rotifers -- Polyarthra platyptera in open water, and in the littoral zone of moss etc. Lepadella patella (Müller) Monostyla cornuta, M.lunaris and Mytilina ventralis var. brevispina -- all Ploïmid forms. Olofsson recorded 2 species in open water of his Pond IX and 3 from its moss margin. Only one species is common to these two lists, either because of chance or the known earlier conditions of that pond. The four rotifers mentioned were among submerged Hypnum vernicosum and stellatum. They were described by Bryce as "dead specimens of several species of ordinary pond-dwelling rotifers which were recognized from the more or less empty but distinctive loricae."]

[It may be assumed that most of the species of Chironomid flies caught on land here had bred in pond waters. On 1 August I saw a ♀ Cricotopus glacialis laying eggs in Pond VII,* while C. basalis was also associated with the water. Presumably the mosquito Aedes alpinus, mentioned later, also bred there. For Enchytraeid worms, see the description of marginal zones of this pond, later. We mentioned also Nematoda and Tardigrada. And my original field notes record two species of very small planarian Rhabdocoel worms, one white the other chocolate-coloured.]

[Protozoa and Algae. For my notes on flagellates and ciliates here, see p.71, under Cap Boheman, cited by Sandon. My identifications were made by using Ward and Whipple's large book "Fresh-water Biology"; and from my experience of Oxford ponds of which I will say more. In addition more needs to be said about the colonial flagellate Uroglena volvox, which was extremely abundant in Ponds VI and VII, and (according to the information I gave Sandon) "in all the ponds" here. In our paper we noted that in Pond VII it carried a very large epizoic Vorticella, and my original field notes report this for Pond VI, 9 August. But we find Olofsson recording Volvox,

* In the paper by Edwards (S.P.I., No.15) "Pond I" should read "Pond VII".

Bruce City...July-August... [Fresh-water lagoons, cont. as being very abundant ("ccc") in his Pond X (equated with our VI) on 5 August. Similarly in his Ponds III and IV in Mimersdal (across the Fjord from here) on 15-16 July and 8 August. I feel certain that he mistook Uroglena for Volvox. Both are remarkable colonial flagellate algae forming hollow colonies. Volvox is perfectly sphaerical, green and just large enough to be detectable by eye. Uroglena is not mainly sphaerical but usually ovoid and a bit variable, and looks brown. There is a superficial resemblance between them unless one examines them by microscope, and Volvox is the one that a zoologist would usually recall from a text-book of types. My own identifications are quite authentic: (1)my original field notes for Pond VI, 22 July, say "Uroglena looks yellowish brown en masse" (2) I had examined it at Bruce City under the microscope (3) its colonies were not regular sphaerical (4) in the spring of 1921 it happened that I had been collecting it during a regular survey of a pond in the Oxford Botanic Garden, the naming of various forms being confirmed by Dr A.H.Church, whose hand-written notes and sketches (as well as my own) I still have. It occurred very abundantly between 14 March and 2 May, and Church and I noted a rotifer, Synchaeta, feeding on it. He gave the size of a colony as 56μ. It was curious to find the same species in an Arctic pond 3 months later! * In this pond the rotifers Polyarthra and Anuraea also lived, but the Copepods were quite different from those in the Bruce City ponds.]

[My original list contains the following alga records for Pond VII, not published in our paper:

Rhizoclonium sp.
Botryococcus braunii
Cosmarium ochthodes Nordst.]

[In spite of the comments that Sandon quoted from me, the differences in groups other than flagellate algae etc. , between Cap Boheman and Bruce City, are not very marked, and the Crustacea follow a pattern that was also found widely in Icefjord by Olofsson.]

[Some observations were made upon the habits and the food of some of these species, partly by direct observation and partly by looking at gut contents. It was noticed that Daphnia pulex was very strongly positively phototropic, so that they gathered in a swarm on the side of, e.g. Pond VI, towards the low sun. And since the sun was above the horizon all the time we were there,

* and see B.117A.

ADDENDUM to p. 117.

[I have since consulted the paper by Thomasson (1958), who carried out a survey of plankton, by quantitative methods, in 16 water bodies, from ponds to small lakes, in the area between the coast and the ice-sheet in Murchison Bay, S.W.North-East Land [Nordauslandet]. These have colder waters than those at Bruce City. (They are in a region of Hecla Hook lower Palaeozoic rocks, including limestones). The main lists of species in these waters are of algae, many identical with ones that occur in Icefjord. The dominant species varied from water to water, and included Uroglena americana [? = volvox] and Dinobryon socialis and D.cylindricum; also very commonly the rotifer Polyarthra dolichoptera (= platyptera, or trigla), and occasionally other rotifers, etc. Uroglena occurred in 4 water bodies, and in 2 instances Dinobryon was also present, though not noted as dominant. In the 4 waters in which the latter was dominant, Uroglena was absent. I saw Dinobryon at Cap Boheman, but it was not noted for Bruce City -- if present it was not in large numbers. It should perhaps be mentioned that these waters were each visited by Thomasson on a single date, not observed throughout the season.]

Bruce City...July-August... [Fresh-water lagoons, cont. "during the 24 hours this crowd made a complete circuit of the pond, following the sun." This was especially noticeable on sunny days, which we mostly had. The visibility of Daphnia in the water was conspicuous in August because of the dark ephippia or winter-egg cases that began to form early in that month. My field notes for the 9th record that "ephippia formed mostly, but not many with eggs out of the ovary yet." Olofsson gives convincing evidence that D.pulex in these Spitsbergen ponds are able to form eggs without fertilization by males, as occurs in temperate ponds. This is an adaptation to the extreme shortness of the Arctic summer. My own notes, though not at all complete, confirm this fact, as far as I can make out.]

[My field notes record some tests done in my hut "laboratory": Cyclops and Chydorus were also phototropic, but Macrothrix (a bottom-living species) was negative. In these experiments "the Daphnia and Cyclops left the Uroglena [behind] and dashed for the light, while Uroglena followed in about quarter of an hour". Thus these two big ponds could have been calibrated to make sun-clocks, with Uroglena quarter of an hour slow! The Daphnia swarms were not affected in their direction by changes in the wind.]

[No very thorough observations were made upon the food of all these species, and casual ones in a community that is very polyphagous may be misleading. Some remarks on this point are given in our paper, p.273, where we stated that "almost all the fresh-water animals are vegetarian or scavengers. Lepidurus has been seen to eat Daphnia in captivity, and [according to Johansen's Greenland work] Eucypris to attack old individuals of Lepidurus. The Eucypris and Candona here were found to feed mostly on diatoms, together with other algae." For Lepidurus eating Ophrydium, see these Notes p.71.].

[Because of the presence of people and sledge-dogs at Bruce City this year bird-life was not very abundant at the ponds, except for Purple Sandpipers and Arctic Terns. I found remains of Lepidurus in the former. Arctic Terns frequently hovered, sometimes arriving in small groups, and dived for food in Ponds VI and VII in August -- the only possible prey being Lepidurus which by this time were growing to adult size. (Olofsson's table of dates and sizes on p.387, shows an increase after the hatching of over-wintering eggs from up to 2 mm. to eventually 12-14 mm on 3 - 12 August). The terns flew back to their colony by the Glacier. We noted that there was a distinct chance that a tern carrying Lepidurus to its young might very occasionally drop one and thus help in dispersal.]

Bruce City...July-August... [Fresh-water lagoons, cont.

Our 1923 Expedition briefly visited Bruce City on 28 August, to pick up our sledge party. My diary noted that the Scottish Spitsbergen Syndicate men had made only a short visit that year, so that more birds had returned. There were a pair of Red-throated Divers and 2 nearly full-grown young on Ponds VI and VII. But they would of course have been feeding at sea. Purple Sandpipers were seen wading up to their middles on Pond VII. "Many little flocks of P.S. about e.g. on salt-marsh, where they did not stay to feed. One there feeding at water's edge. Our survey footprints and Walton's holes still fresh."]

[I made some observations on Lepidurus (not published) that have some bearing upon their capture by terns. These were made on Pond VI, on 25 July. "A few cruising about on the bottom. These are only about half the size of maximum adult as measured by a carapace of dead former year's one. Calm evening. Bottom temperature nearly 9°C. They either cruise about fairly fast on the bottom or half burrow and proceed "snow-ploughing" slowly along and leaving a tortuous track. What makes them come out? ...In Pond XI in middle of day in bright sunlight L. were rushing about, occasionally going up to the surface and looping the loop several times. Why?"]

[Eurytemora raboti. This brackish-water species, relict in a number of shallow fresh-water ponds in Spitsbergen, has a distribution consistent with the idea that it is mainly a true relict enclosed in former brackish lagoons and raised up. My notes suggest that in Pond III i.e. flowing water, these animals stayed mostly near the bottom. In the fresh-water ponds they were certainly planktonic. It is therefore theoretically possible that Arctic Terns (the most likely birds, but other species might also be concerned) could disperse Eurytemora accidentally from one pond to another. Common sense suggests that even if this did happen they would here be dispersing them to ponds already occupied by the same species. And, on the whole, the known occurrence of the species in Spitsbergen is consistent with the idea of their being actual relicts, and it is certain that this process must have happened often. I mention these points because when we worked in Spitsbergen it seemed natural to suppose that the age of the raised beach system was to be measured in hundreds of years. Feyling-Hanssen's analysis, to be discussed later, makes it likely that the period is much more likely to be thousands of years, which would enormously increase the chances of dispersal by accident (for e.g. reindeer might also by agents, since they feed on summer grass in fresh-water ponds).