RECENT BIOLOGICAL RESEARCH IN GREENLAND

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BOTANY. BY T. W. BÖCHER AND K. HOLMEN[1]

Taxonomy

Vascular plants: The large amount of vascular plant material collected in southwest Greenland by the botanical expedition of 1946 has been published by Böcher (1952a), who has discussed several species in earlier studies (1950, 1951) and has written a monograph on *Carex Heleonastes-amblyorhyncha* in its entire circumpolar range (1952b). Material from other expeditions has been included in Sørensen's (1953) study of the difficult genus *Puccinellia*, and in his present research on the genera *Hierochloe*, *Calamagrostis*, and *Braya*, and in K. Holmen's systematic studies of the genus *Festuca*.

Our knowledge of the chromosome numbers in Greenland vascular plants has recently been advanced by a list of chromosome numbers of the Peary Land plants published by Holmen (1952), one conclusion being that the extent of polyploidy in that flora is not significantly higher than in other arctic areas, contrary to the theory that polyploidy should increase with worsening climatic conditions. A comprehensive review of the chromosome numbers in the Greenland flora, the work of a team consisting of C. A. Jørgensen, Th. Sørensen, and M. Westergaard, is approaching completion. T. W. Böcher is continuing his study of the *Arabis Holboellii* complex (1951), and has now included several North American races for comparison. In addition to cytological investigation, breeding experiments have established significant genetical differences between the Greenlandic and North American populations of the species. Cytological factors in the *Stellaria longipes* complex are also under study. Intensive research on the *Papaver radicatum* complex and other closely related species of *Papaver* is being carried out by C. A. Jørgensen.

There has long been a need for a concise handbook of the vascular plant flora of Greenland, and one is now being prepared by T. W. Böcher, K. Holmen, and K. Jakobsen. This handbook, which is designed for both teachers in the Greenland schools and for plant collectors, will list all the Greenland vascular plants and give their distribution within the country. The text will be in Danish, but there will be a foreword in English with

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translations of the more important technical terms and a map of the floristic regions. An elementary botany in Greenlandic for school use, which will contain examples taken from the commonest Greenland species, is also planned by the same authors.

Bryophytes: Of all the plant groups, the bryophytes are the richest in species in Greenland. The principal source material, however, is still the collections made by S. Berggren and N. Hartz during the nineteenth century, and our knowledge of the group is fairly poor. The situation should soon be remedied, for since the Second World War comprehensive collections of bryophytes have been obtained from several areas. Thus K. Holmen made a study of the bryophytes round Søndre Strømfjord and Arsuk Fjord in west Greenland in 1946, and of Peary Land in the north and of Ella Ø and Clavering Ø in east Greenland in 1947–50. The Sphagnum species of this material are included in a work on all the Greenland Sphagna by Bodil Lange (1952), the Hepaticae by Eva Clausen and the Musci by K. Holmen will soon be ready for publication. Studies are also being made of the extensive material collected by K. Jakobsen from 1947–50 in the region between the Nugssuaq Halvø and Thule in west Greenland, and of smaller collections from other areas.

Lichens: The macrolichen flora of Greenland is fairly well known through the work of the Norwegian botanists B. Lynge, P. Scholander, and Eilif Dahl, but there is still much to be done. The large collections brought back by the Danish botanists M. Skytte Christiansen (mostly from Søndre Strømfjord and Arsuk Fjord in 1946), K. Holmen (from Peary Land in 1947–9), and K. Jakobsen (from the Nugssuaq Halvø in 1947, 1948, and 1950), is at present being studied by Christiansen, who has discovered several species of macrolichens not formerly recorded from Greenland in this material.

The microlichen flora is much less known. In the Scandinavian herbaria there are large collections of crustaceous lichens, but the determination of them requires an immense amount of microscope study, and the working up is a long process. Only a few genera, such as *Rhizocarpon*, are well enough known to permit phytogeographical discussion. At present the number of species with restricted distribution seems too large in proportion to the number of known circumpolar species. There is still a great amount of collecting to be done, but by trained lichenologists only, since a large number of crustaceous lichens are so inconspicuous that they may easily escape the notice of even experienced botanists.

Fungi: In the past, collections of Greenland fungi have been brought home by many expeditions. Most of the known species, however, were collected unintentionally on specimens of higher plants. E. Rostrup and J. V. Lind, who made a special study of herbarium specimens, have published a number of papers on Micromycetes found in this way, and our knowledge of the Greenland Micromycetes is probably fairly complete. Rostrup has also published scattered records of fleshy fungi, especially in his survey of 1888, in which most of the older records are summarized.

Comprehensive collections of Macromycetes and a study of their ecology were made in the Ivigtut, Godthaab, and Søndre Strømfjord areas in 1946 by M. Lange. Lange (1948) has also published a list of the Greenland Macromycetes which includes typical arctic species as well as elements of a steppe flora. In investigating the relationship of the Macromycetes flora, he found that the Greenland species tested were infertile with similar species from Europe and North America.

Algae: Recent publications include K. Holmen's collections of marine algae from Peary Land which have been worked up by Lund (1951), and the freshwater algae (Grönblad, 1952) and diatoms (Foged, 1953) collected by T. W. Böcher in southwest Greenland in 1946. Altogether 271 species were found in 42 samples from southwest Greenland, including several diatom species new to science. N. Foged is at present studying a series of diatom samples collected by Holmen in Peary Land, and his own large collections from the 1952 expedition to northwest Greenland sent out by the Commission for Scientific Investigations in Greenland. Also approaching publication are S. Lund's important collections of marine algae from Scoresby Sund and Ella Ø.

Plant geography

In southwest Greenland Böcher (1952a) found a significant floristic contrast between the coastal area and the inland region at the head of Søndre Strømfjord. In a local flora of 200 species of vascular plants there are 47 species which are absent or are very scarce in the coastal parts and 73 coastal species which become scarcer or are absent in the inland region. There is also a considerable difference between the vascular plant flora of the inland areas of Søndre Strømfjord and that of the more southerly Godthaab Fjord. It has been shown that a number of species which favour an Atlantic (maritime) climate have a limit of northern distribution running diagonally from the interior of Godthaab Fjord to the coast at Holsteinsborg, a line which coincides with the isohyets and with the lines of equal mean annual temperature range. On the basis of the observed floristic differences and the distribution maps for a large series of plants, it has been possible to divide southwest Greenland into floristic districts. Johannes Grøntved has also been working on the flora of southwest Greenland for many years, and during the 1953 season was collecting there with C. A. Jørgensen.

The comprehensive plant collections brought back by the Geological Survey of Greenland expedition to northwest Greenland will shortly be published by K. Jakobsen, who was responsible for most of the botanical collecting, and is preparing a local flora of the region between the Nugssuaq Halvø and the Thule district.

A local flora of the vascular plants of Peary Land is about to be published by K. Holmen, who has also found significant differences between the coastal and inland floras. Of some 90 species collected in that northernmost region by the Pearyland expedition of 1947–50, only 27 were previously known from the area.

In a recent report (Holmen and Mathiesen, 1953) describing the finding of *Luzula Wahlenbergii* in northeast Greenland, a species not known from Greenland hitherto, an analysis of the vegetation in which the species is found is included.

The distribution of mosses and lichens also has interesting features. K. Holmen's investigations in Søndre Strømfjord and Arsuk Fjord have shown that the composition of the moss flora varies greatly both from the coast inland and also from north to south. The lichen flora of southwest Greenland has recently been studied by Dahl (1950) who finds that the macrolichen flora there is almost identical with that of Scandinavia, a fact that can be explained by the survival of the flora on ice-free refugia during the last ice age. The North American element in the macrolichen flora of southwest Greenland is very small. A closer study of the lichens of the Rocky Mountains, and of the Ural' and Altai ranges, is still badly needed for an understanding of the relationships within the arctic lichen flora. K. Holmen's collections from Peary Land, according to Skytte Christiansen, indicate the presence of a high-arctic, arid element in the flora which Greenland has in common with Ellesmere Island. Christiansen's own collections from the continental areas in Søndre Strømfjord point to the appearance of a steppe or desert element in the lichen flora on loess soils on southern slopes.

Ecology

The work of the French botanist H. de Lesse in the Eqe region at the head of Disko Bugt (de Lesse, 1952) is an important contribution to our understanding of the vegetation of central west Greenland. He has discussed the eleven main types of plant community in detail and has given tabular analyses, soil profiles, pH determinations, and measurements of organic content of selected patches.

In Böcher's (1954) study of the plant communities in southwest Greenland, the vegetation is divided phytogeographically on the basis of the distribution of the species, especially their climatic and soil preferences. Two main vegetational areas: oceanic and continental are described. Each area is subdivided into vegetation complexes which have a homogeneous ecology, and again into vegetation types which are of homogeneous appearance.

Further vegetational descriptions and ecological data are in preparation by K. Holmen from Peary Land, by H. Mathiesen from northeast Greenland, and by K. Jakobsen from northwest Greenland. Investigations of plant communities dominated by lichen or by moss are being made by Skytte Christiansen and K. Holmen respectively.

In 1948 S. Nielsen began a quantitative study of the phytoplankton of Disko Bugt. His results will be published with other recent analyses using radioactive carbon (C-14) to study the organic production. N. Foged's paper on the west Greenland diatoms (1953) contains abundant ecological data including halobion and pH spectra for the waters investigated.

Tree planting

In 1948 C. A. Jørgensen and the late C. H. Bornebusch studied the present tree growth and the possibilities for future planting in southwestern Greenland. Since then, in collaboration with Syrach Larsen, Jørgensen has grown a large stock of young trees in Denmark of various forest species which should be suitable for Greenlandic conditions. Under Jørgensen's supervision these trees have been planted out in the most sheltered valleys of south Grenland, and a tree nursery has been established at Uperniviarssuq near Julianehaab.

Future work

The most immediate need is for investigations of the botanically least known regions of Greenland by qualified botanists. Districts which should be visited as soon as possible include the areas between Peary Land and the Thule district, between Danmarks Fjord and Skærfjorden, and parts of southeast Greenland. Reinvestigation of the inner Scoresby Sund area is also needed as the ecological conditions seem to be especially interesting, and there are possibilities of finding isolated occurrences of continental Siberian or North American species. Finally, the great amount of botanical work which has been done in Greenland should be crowned with the publication of a complete and scientific Greenland flora, including vascular plants, mosses, and thallophytes. Such a work would be an important milestone in Greenland research, and would be invaluable for future investigations of the country.

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II. Zoology and Marine Biology. By M. J. Dunbar[1]

Terrestrial and freshwater faunistic studies

The "Zoogeographical investigation of Greenland", organized under the Greenland Department of the Danish Ministry of State, and with the cooperation of the Zoological Museum of Copenhagen University, began field work in 1948, and has as its final objective the complete exploration and classification of the land and freshwater fauna of Greenland from the zoogeographical point of view. The investigation is carried out by Christian Vibe with the assistance, in the field, of young Greenlanders who show special interest in natural history.

During the six years 1947 to 1952, Vibe covered most of west Greenland in this way, from Thule to the Julianehaab district. In the 1953 season he worked from Mesters Vig on the east coast along the shores of Kong Oscars Fjord. All land animals and all freshwater animals are collected, and the insects, which are being worked up for publication, have so far yielded over 100 species new for Greenland and over 30 new to science.

This study of the Greenland fauna, and especially of the insects and mammals, has given support to the view that there must have been an ice-free area in the north of Greenland during the Pleistocene glaciation, which served as a refuge for much of today's "high-arctic" fauna in north Greenland as a whole. It also supports the theory, first put forward by Murray (1912) and by O. Pettersson (1913), that the glaciation caused the Polar Basin and surrounding land areas to be isolated more or less completely from what we know today as subarctic and boreal regions, even to the extent of containing, to a large degree, the polar water, and preventing the Atlantic Drift from affecting the climate of the polar regions. Thus the southern part of Greenland, on this view, might have been milder than it is at present, owing to the blocking of the Atlantic water south of the barrier. The barrier is taken to have been along the Wyville Thompson ridge and its extension westward to Greenland.

The present-day fauna is divided into a northern "high-arctic" and a southern "low-arctic" element, the former restricted to the extreme northwest, the north, and the northeast, and the one sharply separated from the other by the conditions of winter climate. In the high-arctic climate the mean summer temperature is below 6°C, and the winter temperature is always

[1]Text completed in 1953.

below freezing, never showing the sharp oscillations of freeze and thaw which are so common in the low-arctic winter. The high-arctic fauna, including (among the mammals) muskox, caribou, Greenland lemming, weasel, arctic hare, and fox, is circumpolar in distribution. In low-arctic areas the caribou and hare tend to be restricted to high altitudes, and the fox to the tidal zone, in feeding habits, and they differ racially from their counterparts farther north.

The low-arctic insect fauna of Greenland contains a large number of boreal species, partly nearctic, partly palearctic, partly holarctic, and partly confined to Greenland. They are taken to be the remainder of an originally much richer boreal fauna which in Europe and North America was in part extinguished during the glaciation or has since succumbed in competition with immigrants. Scattered occurrences of this fauna are to be found on both coasts of Greenland up to the 72nd parallel.

Vibe has also undertaken a biometric study of the Greenland fox material collected in recent years and to be found in the collection of the Zoological Museum in Copenhagen, which has resulted in the conclusion that not less than three distinguishable races exist in Greenland: one in the extreme northeast, in common with the Canadian Arctic Archipelago, one with a discontinuous distribution in northwest and east Greenland, and one in the southwest.

Marine and terrestrial zoology in Peary Land and the northeast

The zoologist on the Danish Pearyland expedition, Palle Johnsen, made collections of both land and marine animals, to be worked up and published in due course; and our knowledge of the biology of the plankton and other marine fauna in pure polar water should be further advanced by the sending of a young biologist to Danmarks Fjord in 1953, on the northeastern corner of Greenland, to make a year's study of the biological cycle in the sea. The results of this study should be extremely interesting, for it will shed light on the still obscure problem of the production level of life in the polar sea itself, and allow direct year-round observation of the growth rates of planktonic forms in that very cold water.

Fisheries and marine biological investigations in west Greenland

These are the largest-scale biological researches in Greenland, and have been so for a long time, for the good reason that the marine resources of Greenland are by far the most important to the country's economy. They began, in the present organization, in 1908, under A. S. Jensen, and have now for many years been led by Poul M. Hansen. The investigations expanded greatly when it became clear that the increased Atlantic influence in the west Greenland waters, first observed about 1917–20, was to endure for some time, and that therefore the cod and halibut fisheries, especially the former, would reach first-rank importance if properly developed. A new research vessel, the 38-ton *Adolf Jensen*, was brought into use after the last war, and several motor boats are also engaged in the field work.

Much of this work is continued routine, involving the recording of the size and age of the fish taken each year, and of their migration. Current developments, and future plans, may be summarized under the following headings:

Cod: Particular attention is being paid at present to the stocks of Atlantic cod (*Gadus callarias*) in Godthaab and Ameralik fjords. These fjords lie side by side but are of quite different kind: Godthaab Fjord is a so-called "Atlantic" fjord, with a deep or much indented threshold allowing the passage of Atlantic water at all depths, and Ameralik Fjord is an "arctic" fjord with a high submarine threshold which keeps out the deeper water and therefore builds up in the deeper parts of the fjord a local water-mass of low temperature, below zero Centigrade. The cod in the two fjords are of similar year-class composition and otolith type, different in both characteristics from the rest of the west Greenland stock, but the Ameralik population does not stay in the fjord all the year round. It moves out with the caplin (*Mallotus villosus*)—an important food organism of the cod—in the summer. The Godthaab Fjord stock remains in the fjord the whole year and has a slower growth rate than the Ameralik cod. The Godthaab cod are extremely numerous, and their smaller size is no doubt mainly due to overcrowding. It is thought that the Ameralik cod are the surplus of the Godthaab stock.

Three recent observations on the west Greenland cod, published in Hansen's report on fishery research for 1952, are interesting and so far largely unexplained: (1) The largest cod and the older year-classes are found in the northern part of the west Greenland waters (Disko Bugt and northward). (2) The average length of the cod taken in the commercial catch in 1952, year-class for year-class, was significantly lower than during the years 1931–9. The cause of the decrease in growth-rate is probably a food shortage brought about either by overcrowding or by a change in the hydrographic conditions. (3) Marking experiments have shown an emphatic movement southward along the coast of fish which grew up in the north. This is apparently a new development and somewhat mystifying, particularly since the northern waters have hitherto, at least in recent years, shown as good or better conditions for the growth of the cod, when compared with the southern part of the coast. There is naturally an anxiety, fostered also by short cold reversions in the climate during the past few years, that this phenomenon may have some connection with a weakening of the influence of the Atlantic water.

Other fishes: The Atlantic halibut, the arctic halibut, Greenland shark. arctic char, herring, redfish, catfish, and lampsucker are all used to a greater or lesser extent commercially or for local consumption. Recently Jørgen Nielsen joined the staff of the Greenland Fishery Investigations to work on the arctic char and the herring.

The Greenland shark, *Somniosus microcephalus*, has been fished in Greenland since the beginning of the nineteenth century, the oldest fishery in the country. Dr. Hansen has recently reviewed the fishery and what little is known of the biology of this remarkable fish in an article (1953) in the new

journal *Grønland*, published in Copenhagen. It is essentially an arctic rather than a subarctic fish, although found also in the Subarctic, and it is becoming less abundant in west Greenland, especially in the southwest, as a result of the warming of the marine climate in recent decades. It is still important north of Disko Bugt, and it is probable that the population has increased on the Canadian side of Baffin Bay owing to this northward movement into water of more arctic origin; but since the Canadian Eskimo have never used the shark, this must remain conjecture for the time being. It is an interesting and unexplained fact that the vitamin A content of the liver oil of the Greenland shark is always higher in arctic water; higher in east Greenland than in west Greenland, and higher in the northern part of west Greenland than in the southwest.

The value of the shark is not inconsiderable. In 1948 it was worth a little over one million kroner (Danish) to the Greenland economy, and the value of the Norwegian shark fishery in east Greenland was five times as great. The Norwegian shark fishery is pursued mainly in the Denmark Strait area, where it is now more important to the Norwegians than the hooded seal hunt.

Shrimp: The deep-water shrimp, *Pandalus borealis*, is growing in economic importance in Greenland; new trawling grounds have been found, and a new cannery has been built at Narssaq in the Julianehaab district. Erik Smidt is engaged in a study of the biology of the shrimp in Greenland, and has taken a leading part in the exploration for new grounds. In 1951 trawling experiments in Godthaab Fjord gave poor results in the Kugssuk channel and at Korkut; trawling in the Kapisigdlit area was more successful, but the production was nevertheless not large. Farther south, Kvanefjord gave poor results, but the experiments at Ivigtut were very successful, and the middle and outer parts of Igaliko Fjord also gave good results. These will give useful support to the new cannery at Narssaq, which is already being supplied from the trawling grounds in Skovfjord, Tunugdliarfik Fjord, and Lichtenaufjord, discovered some years earlier.

The shrimp stocks in the Holsteinsborg district were badly damaged by the low temperatures of the 1948–9 winter. Temperatures at the bottom of Amerdlok and Ikertok fjords dropped from about 1.5°C in the summer of 1948 to -1.5°C or lower in the summer of 1949. The temperatures are now back to the 1948 level, but the shrimp stocks are still small. The shrimp supplied to the Holsteinsborg cannery in 1949–50, a record year, came from new trawling grounds in Disko Bugt.

Zooplankton work at Narssaq: A student, Svend Haasted, went to Narssaq on a year's study of the biology of the Greenland shrimp in 1953, particularly to examine the planktonic stages, and the zooplankton in general. He planned to take regular quantitative samples of the plankton with Hensen nets in different depth ranges during a full twelve-month cycle; this will provide material for the study of the whole annual production cycle of the zooplankton in a subarctic area with ice-free water during the winter.

Marine biological station at Godthaab: The scientific station at Godhavn, established early in the present century by Morten P. Porsild, is well known. It has recently been taken over by Copenhagen University. The marine biological station at Godthaab, on the other hand, is quite new (1953), and is run by the Greenland Fishery Investigations under Dr. Hansen. In charge of it is Jens Kreutzmann, a young Greenlander who became interested in marine biology while still at school at Godthaab during the war (with the practical encouragement of the Canadian Consulate), and became assistant on board the research ship *Adolf Jensen* and at the Copenhagen headquarters, in the following years. The station will be occupied in the collection of information on fish and seal from the Greenland fishermen and hunters, and in the biological investigation of Godthaab and Ameralik fjords. From the marine biological point of view, it is ideally situated. Kreutzmann will also make quantitative routine plankton collections all year round at four stations in Godthaab Fjord and the surrounding waters, including phytoplankton samples taken with the Nansen bottle.

Seal: Marine research in Greenland has not hitherto paid much attention to the sea mammals. But the possibility of a return to colder marine conditions, which would increase the economic importance of the mammals at the expense of the fishes, and the general interest expressed internationally in such organizations as the International Committee for the Northwest Atlantic Fisheries (ICNAF), have directed the attention of the Danes to research on these animals in Greenland. Field research on marine mammals is not easy except at the breeding grounds, but it is planned to carry out investigations of census, migrations, and age composition on the seals of west Greenland, in cooperation with the Norwegian work in east Greenland and the Canadian investigations on the harp seals (*Phoca groenlandica*) in the waters of Newfoundland and the Gulf of St. Lawrence, and the ringed (*Phoca hispida*) and bearded seals (*Erignathus barbatus*), and walrus (*Odobenus*) in the Canadian Eastern Arctic.

Offshore research west of Greenland

All the marine work summarized above, except in Peary Land and Danmarks Fjord, comes within the operations of the Greenland Fisheries Investigations headed by Poul M. Hansen, and under the aegis of the Greenland Department. In the offshore waters of west Greenland, and also east of Greenland, hydrographic and biological work, with emphasis on the former, has been done and is being done by the staff of the Danish Fisheries and Marine Research Laboratory on board the Research Vessel *Dana*, and also by the Norwegians. The stations occupied by the *Dana* in 1950 and 1952, and by the Norwegian ship *Uran* in 1948, are shown in Fig. 1. The *Dana* sections are now routine, and most or all of them will be maintained every year in future. In 1953 the southernmost section southwest from Kap Farvel was extended as far as the Labrador coast. The usual physical and chemical parameters are measured at these stations, samples for the determination of the phytoplankton crop are taken, and mid-water trawls with such nets as

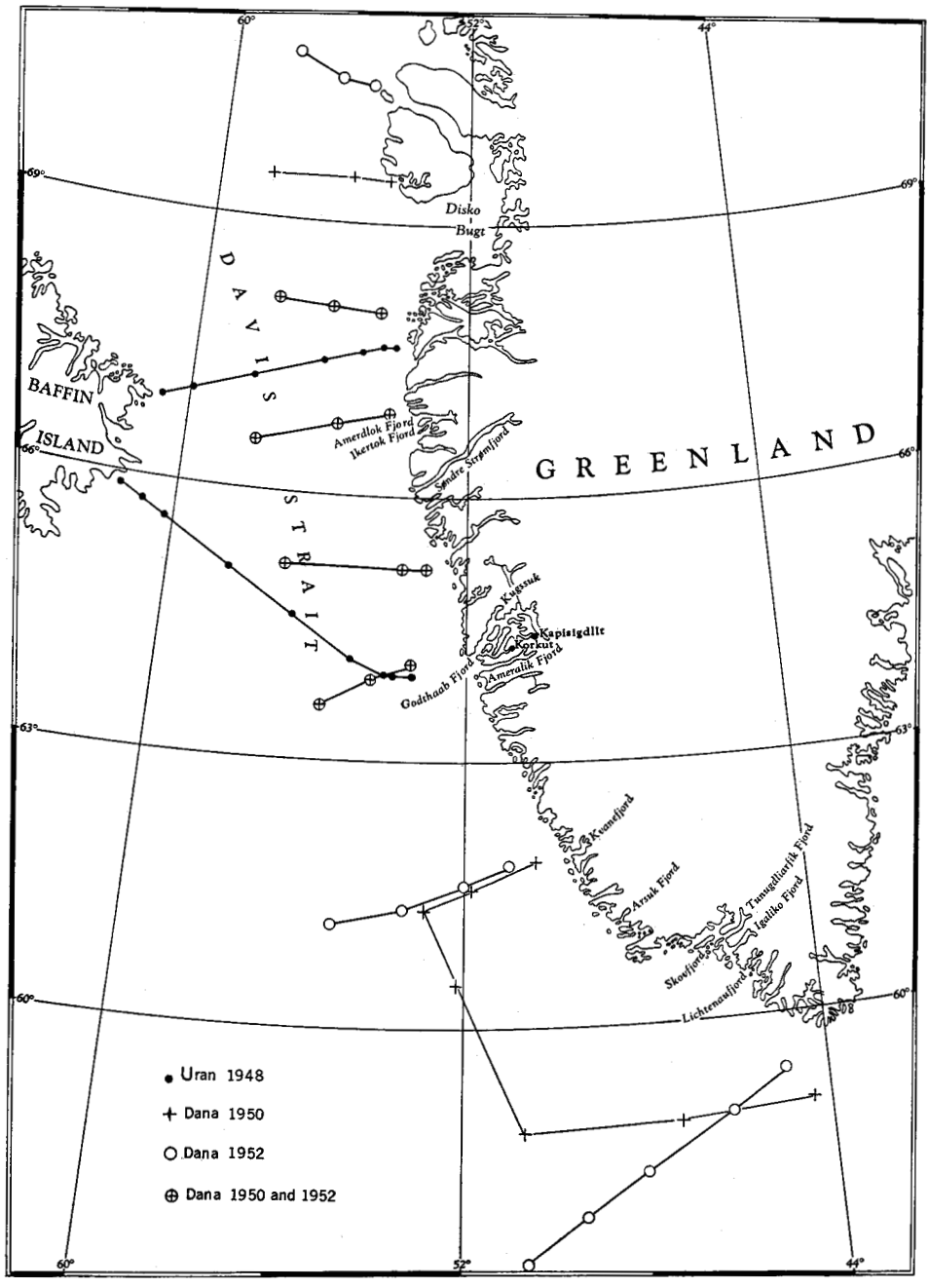

Fig. 1. Hydrographic and plankton stations in waters west of Greenland in 1948, 1950, and 1952. (From a drawing prepared by J. Grøntved).

the 2-metre stramin trawl are made. The value of this work can hardly be over-estimated, because it provides an annual record of hydrographic and biological conditions in an oceanographic region which is, at the present

stage in the postglacial cycle, peculiarly subject to oscillations, and which at the same time is of very great economic importance to man; and the economic importance depends on the climatic cycle to a great extent.

Fundamental to the economic value of the Canadian Eastern Arctic and west Greenland are the factors underlying the differences in, and variations in, organic production in the sea. Studies of the rate of production of organic material in the west Greenland waters have begun, and in the meantime the estimation of the standing crop of phytoplankton during the summer months is receiving special attention on the basis of samples collected by the *Dana*, the *Uran*, and the *Adolf Jensen*, which are being worked out by Julius Grøntved in the Plankton Laboratory at Charlottenlund Slot in Denmark. Quantitative phytoplankton investigations on the west Greenland banks were first made by the Norwegian biologist Gran (1929), and a recent manuscript report by R. W. Holmes deals with the annual cycle of the phytoplankton in the Labrador Sea (1950–1) based on weekly collections made on board the weather ship at Station Baker (56°30N., 51°00W.) Grøntved's work, however, which will be published in the *Meddelelser fra Danmarks Fiskeri- og Havundersøgelser*, will be of much greater scope than either of these studies, based as it is on quantitative collections during three seasons at the stations shown in Fig. 1, plus stations occupied by the *Adolf Jensen* in April and May 1950 and 1952 on the Fylla and Store Hellefiske banks.

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