of the Arctic, on the scale 1:10,000,000, for Vol. 1 of the *Bolshoy Sovetski Atlas Mira* [*Great Soviet Atlas of the World*] (Moscow, 1937): in particular there was a rearrangement of January isotherms showing among other things that there was a new "Pole of Cold" at Oymekon.† In 1936 a series of publications entitled *Materialy po klimatologii polyarnykh oblastey SSSR* [*Material on the climatology of the polar regions of the U.S.S.R.*] was inaugurated. Up to 1945 sixteen numbers had been published (as volumes of the *Trudy Arkticheskogo Instituta* [*Transactions of the Arctic Institute*]), giving fairly detailed climatic descriptions, by regions, of the whole of the Soviet arctic coastline and of the off-lying islands. This series, which was completed by Ye. A. Leont'yeva's monograph *Klimat sovetskoy arktiki* [*Climate of the Soviet Arctic*], throws light on the theory that the Arctic is warming up, and on the phenomenon, observed at some points in the Arctic, of a rise in temperature in the middle of the winter.

Results of work during this period tend to confirm previously known or surmised facts. Of particular interest perhaps is the fact that the film of cold air over the Arctic, whose existence has long been known, reaches maximum thickness in the eastern sector of the Soviet Arctic in summer, while in the western sector it may reach maximum thickness in winter. Synoptic work on the basis of the data provided by polar stations has led to the formulation of new theories on the circulation of the atmosphere in polar regions. It is study of this point which is most important in working out long-term weather, and ice, forecasts.

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HYDROLOGICAL WORK IN THE SOVIET ARCTIC, 1920–45

[Summarised from Gidrologicheskie issledovaniya v sovetskoy arktike za 25 let (1920–45) [Hydrological research in the Soviet Arctic during 25 years (1920–45)] by K. A. Gomoyunov. *Izvestiya Vsesoyuznogo Geograficheskogo Obshchestva* [*News of the All-Union Geographical Society*] (Leningrad), Tom 77, No. 6, 1945, p. 328–40.]

Marine Hydrology

In 1920 hydrological work in the Soviet Arctic was resumed for the first time since the revolution. The Northern Scientific Industrial Expedition [Severnaya Nauchno-Promyslovaya Ekspeditsiya] and its successor the Institute for the Study of the North [Institut po Izucheniya Severa] organised work in the Barents Sea, along the coast of Novaya Zemlya and as far north as Zemlya Frantsa-Iosifa [Franz Josef Land] between 1920 and 1927.[1]†† In 1928 the voyages of the icebreakers *Krasin* and *Malygin* in search of Nobile's expedition provided an opportunity for V. A. Berezkin on the one and V. Yu. Vize on the other to study the hydrology of the north part of the Barents Sea.[2] Thenceforward, so-called "complex" expeditions (those on which scientific work in a number of different fields was undertaken) were sent out with increasing frequency, and hydrological work was done on almost all of these. In 1930 work was done in the region of Zemlya Frantsa-Iosifa and in the northern part of the Kara Sea.[3] Both areas were covered again in 1931.[4]

† Lat. 63° 30′ N., long. 143° E. It was previously at Verkhoyansk.—T.E.A.

†† For notes see p. 359–60.

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From 1929 the number of coastal polar stations rapidly increased. A plan for hydrological work was elaborated for them. One of the main features of this plan was the study of tides, and a series of publications contained the detailed results obtained.[5] Tidal year-books, tables and charts drew upon the information compiled in this series. Non-tidal fluctuations of sea-level were also studied.[6]

Before 1932 most of the hydrological work done was in the seas in the western part of the Soviet Arctic. Attention was also paid to the hydrology of the seas farther east. After 1932, the year in which the Northern Sea Route was traversed for the first time in one season, and in which the Second International Polar Year started, work was done in the north-east part of the Barents Sea,[7] Proliv Vil'kitskogo[8] (the strait between Severnaya Zemlya and Mys Chelyuskina), Proliv Shokal'skogo[8] (between two islands of Severnaya Zemlya), and parts of the Chukchi and Laptev Seas.[9] In 1934 work was done from six ships cruising in the Laptev and Kara Seas.[10]

From 1934 detailed study was undertaken of currents in various straits through which shipping frequently passed. Between 1934 and 1936 parties in three small boats worked at Karskie Vorota (between Novaya Zemlya and Ostrov Vaygach)[11] and Matochkin Shar. In the years that followed other parties studied Proliv Vil'kitskogo, Proliv Lapteva (between Ostrova Lyakhovskie and the mainland), Proliv Sannikova (between Ostrova Lyakhovskie and Ostrova Novosibirskie) and Bering Strait. I. V. Maksimov of the Arctic Institute [Vsesoyuzny Arkticheski Institut] (as the Institute for the Study of the North had been renamed in 1930) duly worked up the results of all these expeditions and produced a navigational atlas of currents for each area.[12]

Work in the open sea had, up to 1936, only been possible by putting hydrologists on board icebreakers or cargo ships, or with "complex" expeditions whose main object was generally geographical. In 1936, however, the *Nerpa* carried the first wholly hydrological expedition to the south-west and north-west parts of the Kara Sea, and a survey was made. The study of open-sea currents was one of the features of this expedition. Work was continued in the following year.[13]

After 1938, when the Arctic Institute became responsible for all ice reporting and forecasting work, it was possible to have hydrologists on board ice-patrol vessels; detailed work was done for instance by G. P. Smirnov on board the *Smol'ny* in the Chukchi Sea, 1940–44.

In 1939 aspects of the hydrology of the Greenland and Norwegian Seas were investigated by I. V. Maksimov,[14] and the next year Ya. Ya. Gakkel' worked in the Laptev Sea. In 1941 an aircraft landed a party of scientists on the ice in the region of the "Pole of Inaccessibility" and Ya. S. Libin, the party's hydrologist, did valuable work which included observation of the force and direction of the Atlantic current.

During the war, work in the western sector of the Soviet Arctic became impossible; the plan for continuing the survey of the Kara Sea in 1941 had to be abandoned, and the research ship *Akademik Shokal'ski* was sunk by a U-boat in 1942. Hydrological work was in fact limited to observations from ice patrol boats in the Chukchi Sea.

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The work so far mentioned was done by the Arctic Institute and its predecessors. From 1933 the Arctic Institute had been under the control of the Chief Administration of the Northern Sea Route [Glavsevmorput']. Study of marine hydrology was also undertaken by the last-named organisation, and by one of its departments, the Hydrographic Administration [Gidrograficheskoye Upravlenie].

The Chief Administration of the Northern Sea Route organised in 1933, the first year of its existence, the famous *Chelyuskin* expedition. The plan included hydrological work which was duly done by Ya. Ya. Gakkel' and P. G. Lobza in the Kara, Laptev and Chukchi Seas.[15] In 1934 the icebreaker *Krasin*, sent to rescue the *Chelyuskin* survivors, visited Ostrov Vrangelya and hydrologists on board were able to do some detailed work in the north-east part of the East Siberian Sea and the north-west part of the Chukchi Sea, and also in Bering Strait and Proliv Longa (between Ostrov Vrangelya and the mainland). In the same year the Chief Administration organised the voyage of the *Litke* along the whole Sea Route; among the hydrological observations of this voyage was the first, and up to 1945 the only, study of the elements of waves in the open sea of the Soviet Arctic.[16] In 1935 work was done in the extreme north of the Chukchi Sea (lat. 73° 30′ N. was reached in long. 175° 30′ E.) on board the *Krasin* by G. Ye. Ratmanov, P. P. Shirshov and N. P. Noskov. In that year also the *Sadko* on a "high latitude expedition" cruised in Svalbard, Zemlya Frantsa-Iosifa and Severnaya Zemlya waters and hydrological work was done.[17] In 1937–38 the North Polar Drift Expedition collected valuable hydrological information[18] during its drift on an icefloe from the Pole to East Greenland; two of the party of four—P. P. Shirshov and Ye. K. Fedorov—were Arctic Institute scientists. All these expeditions were organised by the Chief Administration; from 1938, however, "high latitude expeditions" became the responsibility of the Arctic Institute.

The Hydrographic Administration of the Northern Sea Route was founded in June 1933 to take over from the hydrographic department of the Arctic Institute; the latter was finding the amount of hydrographic work too great to be properly covered. The first task of the Hydrographic Administration was to secure the safety of shipping; but its ships did a certain amount of hydrological work as well until 1938, when this side-line was handed back to the Arctic Institute. Because it was a side-line, the hydrological work of the Hydrographic Administration was inevitably not very systematic, but some useful work was done; notably in the eastern part of the Kara Sea in 1935,[19] and in the region of Arkhipelag Nordenshel'da in the Kara Sea during the winters of 1936–37 and 1938–39.

River hydrology

Work on the effect of the heat and freshness of river water on sea ice and hydrology, and study of the hydrological regime of the lesser explored rivers with a view to their development for shipping are the main tasks of the Arctic Institute in this field.

The first expeditions with these objects wintered on the Pyasina and the

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Khatanga, in 1934–35 and in 1935–36.[20] In 1935 parties went to the Anabar, Lena, Indigirka and Kolyma.[21] In 1937 V. S. Antonov led an expedition to the south part of Poluostrov Taymyr. The object of this expedition was to look for a navigable waterway from the Yenisey to the Khatanga, across the base of the peninsula. Three possible routes were found, each of which could be developed without too great difficulty.[22]

Some general works on rivers in the Soviet Arctic were published,[23] and also some information on the chemical composition of certain rivers.[24] In 1939 all river work was handed over by the Arctic Institute to the Hydrographic Administration of the Northern Sea Route.

Compilation and publication of results

Apart from expedition work, the Arctic Institute undertook the compilation and production of a number of hydrological reference works. Among these were exhaustive general surveys of a given sea, based on all available observations of that sea and dealing with its temperature, salinity, chemical composition, density, currents, colour, transparency, turbulence, fluctuations of level, sea bottom, ice and meteorological conditions. K. A. Gomoyunov has completed two volumes of such a work on the Kara Sea based on all observations up to 1935. In course of compilation are surveys of the Laptev Sea by T. P. Al'fer'yeva, the East Siberian Sea by V. N. Stepanov and the Chukchi Sea by G. Ye. Ratmanov, N. Ya. Uralov and A. V. Kavardina. Ye. I. Chaplygin and V. A. Trapnovskaya have worked up the hydrological observations of polar stations from their establishment until 1943. A series of geographical monographs on the arctic seas of the U.S.S.R. was due for publication in 1947. These were expected to contain much hydrological information. Laktionov is compiling that on the Kara Sea, V. S. Bol'shakov the Laptev Sea, V. N. Stepanov the East Siberian Sea and P. A. Gevorkyants the Chukchi Sea. Atlases of currents in the straits along the course of the Northern Sea Route were produced between 1936 and 1939; that for Bering Strait was completed in 1942 but had not been published by 1945. Further, the Arctic Institute compiled, and the Hydrographic Administration of the Soviet Navy [Gidrograficheskoye Upravlenie Voyenno-Morskogo Flota] published, two atlases of physical geography as navigational hand-books—one of the Kara Sea in 1943 and one of the East Siberian Sea in 1945.

Besides these large-scale works, members of the Arctic Institute staff have written a large number of papers on a wide variety of hydrological subjects. It is clear from the number of papers devoted to each sea that the Barents and Kara Seas have been very much more thoroughly studied than the three eastern seas. The tendency has been for the Arctic Institute to become responsible for more and more of the hydrological work done in arctic seas. Before the creation of the Chief Administration of the Northern Sea Route in 1932 the Arctic Institute (and its predecessors) only published 20% of the total volume of work, whereas from 1933 to 1944 it published over 60%.

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Conclusions

Besides the work already mentioned, the general achievements of the Arctic Institute and the Chief Administration of the Northern Sea Route and its departments in the field of hydrology from 1920 to 1945 can be summed up as follows. A number of islands have been discovered and reconnaissance voyages have been made in high latitudes and in the central polar basin. The general scheme of the circulation of surface water in the arctic seas has been worked out and published.[25] Charts have been compiled (to be found in Soviet pilot books) showing temperature, salinity, density and other information for each of the Soviet arctic seas for July, August, September and October—the months during which navigation is possible. Bathymetric charts have been published for the whole area, and charts showing constant and variable currents for certain regions. Plans for hydrological work to be done at polar stations have been issued. Work on river hydrology has produced sufficiently reliable results to show that previously held views on the extent to which river water melted sea ice were exaggerated.

In face of this, however, inadequate knowledge is admitted on a number of subjects. In particular, very little is known of the winter hydrological regime in the open sea. Winter conditions have been studied only from shore polar stations and by a very small number of winter hydrological expeditions. To establish hydrological behaviour over the period of a year is therefore almost impossible. Quite apart from winter observations, some areas have had very much more attention than others, with the result that it is extremely hard to distinguish effectively the general characteristics of any wide expanse of water. The seas themselves are most unevenly studied, as already mentioned. The Chukchi Sea, though much less thoroughly investigated than the Kara Sea, is in turn better known than the Laptev or East Siberian Seas. The central regions of all the seas are most inadequately studied, especially the northern parts of each through which runs the so-called northern variant of the Northern Sea Route (north of Novaya Zemlya, Severnaya Zemlya and Ostrova Novosibirskie). One of the tasks of the Arctic Institute in the years to come will be to make good these gaps in existing knowledge, and to do so in a well-planned and systematic way.

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Notes

Most of the references given in these notes were provided by the author of the article on which this summary is based. Entries marked with an * have been verified and additional bibliographical data have been added where this seemed useful. The following abbreviations are used:

Trud. Inst. po Iz. Sev. = *Trudy Instituta po Izucheniyu Severa* [*Transactions of the Institute for the Study of the North*] (Leningrad). *Trud. Ark. Inst.* = *Trudy Arkticheskogo Instituta* [*Transactions of the Arctic Institute*] (Leningrad). *Prob. Ark.* = *Problemy Arktiki* [*Problems of the Arctic*] (Leningrad). *Byull. Ark. Inst.* = *Byulleten Arkticheskogo Instituta* [*Bulletin of the Arctic Institute*] (Leningrad).

[1] *Trud. Inst. po Iz. Sev.*, Tom 49, 1931, p. 4–98 [1929 expedition to Zemlya Frantsa-Iosifa].*

[2] *Trud. Inst. po Iz. Sev.*, Tom 50, 1931, by V. A. Berezkin; Tom 45, 1929, p. 15–55, by V. Yu. Vize.*

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[3] *Trud. Ark. Inst.*, Tom 1, 1933, p. 1–138, 151–73.*

[4] *Trud. Ark. Inst.*, Tom 6, 1933, p. 13–33.*

[5] Called Materialy po prilivam arkticheskikh morey [Material on the tides of the arctic seas], and published as volumes of *Trud. Ark. Inst.* Seven volumes were published up to 1945; these include Tom 36, 52, 81, 119.*

[6] *Trud. Ark. Inst.*, Tom 175, 1941, by V. G. Kort.

[7] *Trud. Ark. Inst.*, Tom 34, 1935, p. 7–30.*

[8] *Trud. Ark. Inst.*, Tom 42, 1936, p. 7–65.*

[9] *Trud. Ark. Inst.*, Tom 10, 1933, p. 39–87, 103–30.*

[10] *Trud. Ark. Inst.*, Tom 18, 1935, p. 5–84 [north-west part of Kara Sea];* Tom 64, 1936, p. 43–170 [north part of Kara Sea];* Tom 83, 1937, p. 7–134 [Kara Sea].*

[11] *Arctica* (Leningrad), Tom 5, 1937, p. 133–52.*

[12] For instance, Maksimov, I. V. *Atlas prilivo-otlivnykh i postoyannykh techeniy v prolive Karskie Vorota* [*Atlas of tidal and constant currents in Proliv Karskie Vorota*], Leningrad, 1937.*

[13] Short accounts of these expeditions are given in *Byull. Ark. Inst.*, No. 10–11, 1936, p. 474–77 [1936 expedition];* *Prob. Ark.*, No. 1, 1938, p. 77–78 [1937 expedition].*

[14] *Trud. Ark. Inst.*, Tom 183, 1944, by V. T. Timofeyev.

[15] *Nauchnye rezul' taty rabot ekspeditsii na "Chelyuskine", Tom* 1, *Gidrografo-gidrologicheskie issledovaniya* [*Scientific results of the "Chelyuskin" expedition, Vol.* 1, *Hydrographic and hydrological investigations*], 1938.

[16] *Trud. Ark. Inst.*, Tom 29, 1935, p. 47–52.* For other hydrological work done on this voyage, see p. 7–39, 53–55.*

[17] Papers by N. M. Chirigin and V. A. Berezkin in *Trudy pervoy vysokoshirotnoy ekspeditsii na "Sadko" v* 1935 *g.* [*Transactions of the first high latitude expedition in the "Sadko" in* 1935], Tom 1, No. 1, 1939.

[18] *Comptes Rendus* (*Doklady*) *de l'Académie des Sciences de l'URSS* (Moscow), Tom 19, No. 8, 1938, p. 569–80.*

[19] *Raboty ekspeditsii* 1935 *g. v severo-vostochnoy chasti Karskogo morya na l/p "Malygin" Gidrograficheskogo upravleniya Glavsevmorputi* [*Work of the* 1935 *expedition in the north-east part of the Kara Sea on the icebreaker "Malygin", organised by the Hydrographic Administration of the Chief Administration of the Northern Sea Route*], No. 2, 1938.

[20] *Trud. Ark. Inst.*, Tom 75, 1936, p. 1–46 [Pyasina, 1934–35];* Tom 128, 1939, p. 5–26 [Pyasina, 1935–36];* Tom 105, 1938, p. 125–41 [Khatanga].*

[21] *Trud. Ark. Inst.*, Tom 106, 1938, p. 1–53 [Anabar];* Tom 105, 1938, p. 99–124 [Indigirka];* Tom 105, 1938, p. 183–241 [Kolyma].*

[22] *Prob. Ark.*, No. 1, 1938, p. 99–102 [Preliminary results].*

[23] Skachkov, B. I. Obshcheye sostoyanie izuchennosti rek arkticheskoy zony [General state of knowledge of rivers of the arctic zone]; Antonov, N. D., and Zaykov, B. D. O rechnom i teplovom stoke v arkticheskie morya [On warm river water running into arctic seas].

[24] *Prob. Ark.* No. 1, 1943, p. 159–65 [Pyasina and lower Taymyr];* *Trud. Ark. Inst.*, Tom 105, 1938, p. 73–97 [Lena and Ebetem];* Tom 106, 1938, p. 45–53 [Anabar].*

[25] Berezkin, V. A. *General'naya skhema techeniy v Severnom ledovitom okeane i sopredelnykh moryakh* [*General scheme of currents in the Arctic Ocean and adjacent seas*], 1945. This information is also published in the new editions of the Soviet pilot books.

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