

**U. S. NAVAL OCEANOGRAPHIC OFFICE
CHARTING OF THE ANTARCTIC (*)**

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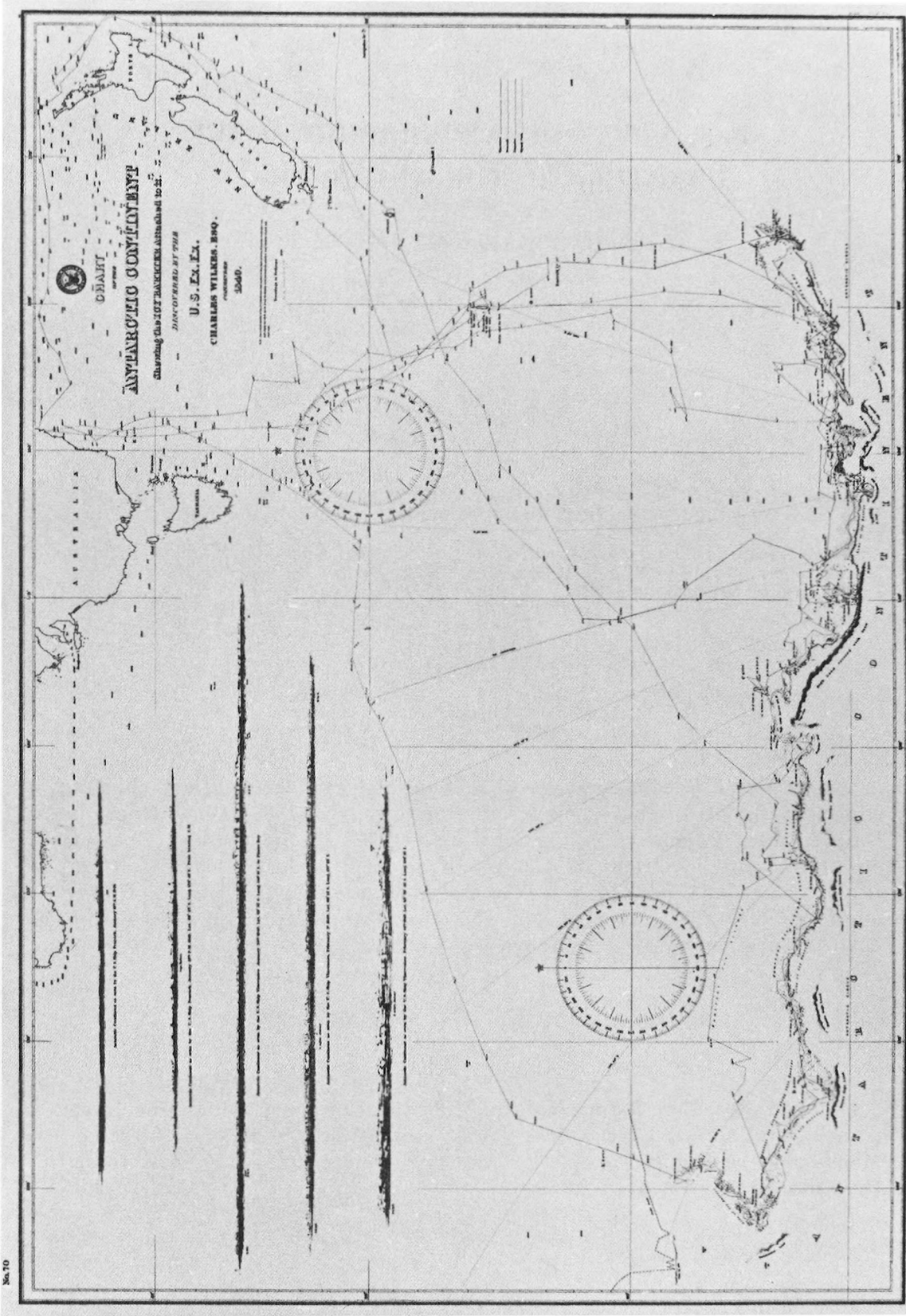
Abstract

U.S. Naval Oceanographic Office nautical and aeronautical charting efforts in the Antarctic and surrounding waters are described from the *United States Exploring Expeditions* (1838-1842) to the present. Charting programs, and requirements for the BYRD expeditions, *Operation High-jump*, *Operation Windmill*, and *Deep Freeze Operations* that have continued annually since 1955, are also reviewed. Illustrations are included showing past and present nautical chart coverage of the Antarctic.

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In accomplishing its mission, the U.S. Naval oceanographic Office must provide charts for all the waters within which the U.S. Navy or Merchant Marine may be required to operate. Among these are the waters surrounding the Antarctic Continent.

(*) Reprinted, with modifications, from the March 1966 issue of the *Antarctic Journal of the United States*, by permission of the National Science Foundation, Washington, D.C.



United States Exploring Expedition

United States Navy interest in antarctic cartography began when, in 1838, a squadron of six Navy ships under the command of Lieutenant (later Rear Admiral) Charles WILKES sailed from Hampton Roads as the *United States Exploring Expedition*. Although the expedition was to explore and carry out scientific research in many parts of the world, its primary mission was exploration and charting in the Pacific and the South Seas. The expedition had been specifically authorized only after Congress had been subjected for many years to urgent pleas by whalers, sealers, and ship owners of the United States for better charts of the waters into which their ships sailed.

The expedition visited many parts of the world and added a great deal to the store of scientific and navigational knowledge, but its most noted accomplishment was the cruise into antarctic waters during the 1839-1840 season. On December 26, 1839, the squadron left Sydney, Australia, and sailed south toward Antarctica, sighting the continent for the first time on January 16, 1840, in the vicinity of longitude 157°56'E. During the next month WILKES skirted the ice barrier for approximately 1500 miles to longitude 97°30'E, charting the waters and land features as he proceeded along the land mass which now bears his name.

Although WILKES was unable to find a suitable landing site along the shore, he knew, by the number of landfalls, that his sightings were of continental proportions. Samples of rocks (granite and sandstone), collected from floating ice near the land, strengthened his conviction. Relying on this evidence, he was able to conclude, and was the first to announce, that the land, a part of which he had discovered, constituted a continent and not just a group of islands protruding from the sea.

Lt. WILKES was an experienced nautical surveyor, having previously surveyed and charted Georges Shoal and Bank off Cape Cod, and having commanded the Depot of Charts and Instruments, the original fore-runner of what became the Navy Hydrographic Office and is today the U.S. Naval Oceanographic Office. One of the most important charts resulting from his antarctic voyage was the "Antarctic Continent", which was republished by the Hydrographic Office in 1875 as H.O. Chart 70 (figure 1). This chart was updated and reprinted numerous times but was cancelled in May 1953 because of the availability of more recently published charts of larger scale coverage. The engraved copper plate for H.O. 70 is still retained by the Naval Oceanographic Office for historical purposes. It is surprising to observe in how many cases this chart agrees favorably with current information.

United States Antarctic Service

With the decrease in United States sealing and whaling activities in the Antarctic, U.S. Navy interest in the area also decreased until Rear Admiral BYRD's antarctic expeditions in 1928-1930, 1933-1935, and 1939-

1941. The first two expeditions were privately financed, but the third was partially financed by the U.S. Government and was organized as the *United States Antarctic Service*. The primary objective of this expedition was to delineate the unknown coastline of Marie Byrd Land and to explore the hinterland. To support this expedition the Hydrographic Office, in 1939, compiled and published, on the Mercator projection, two small scale nautical charts, H.O. 5411 and H.O. 5412. H.O. 5411 covered the antarctic coastline between 60° W and 150° W and included the Antarctic Peninsula. H.O. 5412 covered the coastline between 130° W and 165° W and included portions of Marie Byrd Land. These charts, the first of Antarctica to be compiled by the Hydrographic Office, were used by the *United States Antarctic Service* and subsequent Navy expeditions to the Antarctic, but have been superseded by more recent charts and are no longer published. Figure 2 shows the extent of Hydrographic Office nautical chart coverage of the Antarctic at the time of *United States Antarctic Service*, 1939-1941.

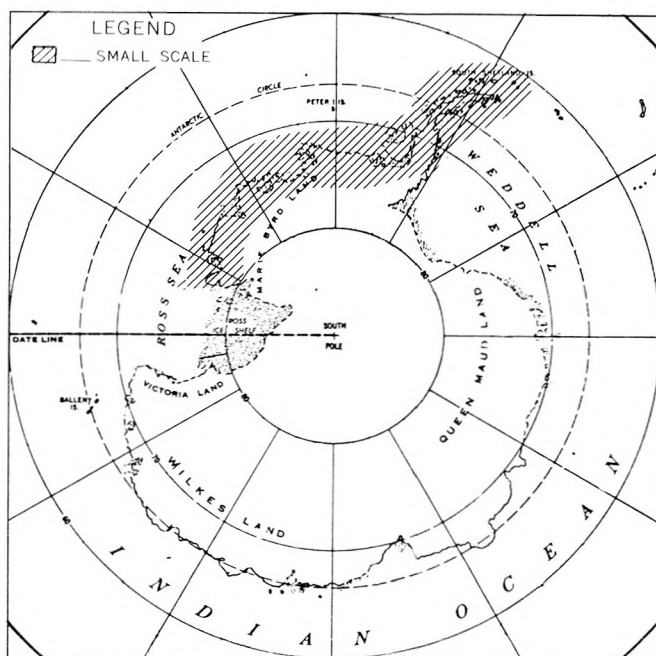


FIG. 2

In May 1939, at the suggestion of the Secretary of State, the Hydrographic Office was requested to design, compile, and publish a small scale chart of Antarctica, which the State Department desired to use to assist in resolving questions of sovereignty, expected to arise at the time. This chart, H.O. 2562, was compiled by Commander R. A. J. ENGLISH with the assistance of Mr Carl HERLACHER, the Hydrographic Office's principal antarctic cartographer at that time.

In compiling H.O. 2562, extensive use was made of data accumulated by the Hydrographic Office from previous antarctic expeditions, supplemented by some 46 foreign charts and data contained in more than 50 other publications, such as technical reports and explorer's reports and books,

both foreign and domestic. In addition to charts and publications, the personal knowledge of several prominent individuals was drawn upon, among them Rear Admiral Richard E. BYRD, who made many visits to the Hydrographic Office to assist in the compilation.

Many conflicts between different source materials had to be evaluated and resolved, one of the most difficult ones being a controversy over proper place names for geographic features. Before the chart was released to the public, it was submitted to President Franklin D. ROOSEVELT and the situation regarding the questions of names explained to him. Upon approval by the President, the chart was issued in 1943, in six colors, on an azimuthal equidistant projection, scale 1/11 250 000.

Operation Highjump

The participation of the United States in World War II eliminated Antarctica from the U.S. Navy's sphere of interest for the next few years, but immediately following the war, the interest was revived. In the autumn of 1946, the Navy sent a large expedition officially named *Antarctic Development Project, 1947*, and code named *Highjump*, to the Antarctic. The expedition consisted of 12 navals ships, one Coast Guard icebreaker, and more than 4 700 men.

Upon arrival in the operating area, the expedition was divided into three main task groups. One, known as the Central Group, set up a base and airfield on the Ross Ice Shelf near Little America, and conducted aerial exploration and photography by systematic outward expansion from that base. The second, or Eastern Group, was built around a seaplane tender, and conducted its operations from the vicinity of Peter I Island eastward. The mission of the Eastern Group was the systematic aerial exploration and photography of the coastline, stressing delineation of its unknown or improperly charted portions. The third task group, known as the Western Group, initiated its operations in the vicinity of the Balleny Islands and continued its operations westward along the continental perimeter. Its primary mission was similar to that of the Eastern Group.

Approximately 350 000 square miles of antarctic "land" was discovered by these three groups. Nearly 5 500 airline miles, or 60 % of the antarctic coastline, was photographed. A total of 70 000 trimetrogon aerial reconnaissance photographs were obtained for mapping purposes, with the largest number (40 000) being taken by the Western Group, primarily along the coast of WILKES Land.

To support this operation, the Hydrographic Office was required to furnish nautical charts of all antarctic waters in which the ships were expected to operate. Only four nautical charts of the area had been published by the Hydrographic Office prior to this time (H.O. 70, 5411, 5412, and 2562). It was necessary to revise these charts and to furnish new charts as well. Using data collected by the USS *Bear* on the *United States Antarctic Service* expedition of 1939-1941 and data from selected British surveys of the area, the Hydrographic Office in November, 1946, compiled and

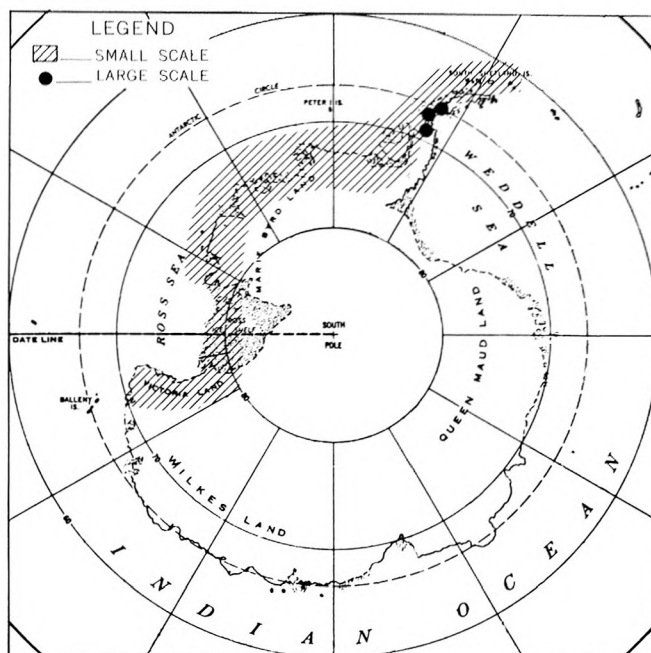


FIG. 3

published H.O. charts 6650 through 6654. These charts of the Antarctic Peninsula, on the Mercator projection, ranged in scale from 1/4050 to 1/201 350. Figure 3 shows total nautical chart coverage of Antarctica following *Operation Highjump*. The Hydrographic Office also was designated as the clearinghouse and coordinating agency for hydrographic, scientific, and other mapping data obtained by *Highjump*. Despite the paucity of ground control, topographic manuscripts and photo mosaics were produced from the aerial photographs received. These proved extremely valuable in revising nautical charts and for planning subsequent U.S. Navy operations in Antarctica.

Operation Windmill

Although the photography obtained in *Highjump* was useful, it would have been of much more value if accompanied by an adequate series of ground control points. For fuller utilization of this photography, the U.S. Navy undertook in 1947-1948 the *Second Antarctic Development Project*, unofficially named *Operation Windmill*. The project was executed by the use of two icebreakers, USS *Edisto* and USS *Burton Island*, with their regularly embarked aircraft (one ship equipped with two helicopters and the other with one helicopter and one fixed wing aircraft). This force was officially designated U.S. Navy Task Force 39. While the force was charged with a number of minor missions, such as cold weather training of personnel and testing of equipment, etc., its primary objective was to establish ground control to permit fuller utilization of the *Highjump* photography. The ships explored the ice barrier of the Ross Sea and Wilkes Land, and

established a number of ground control points which were easily recognizable on the aerial photography. When the icebreakers were as close as they could get to a desired control point, surveyors were dispatched, usually by helicopter, to establish the exact geographical location of the control point. Upon completion of the operation, the coastline, as delineated from prior photography, was revised for use on new charts and in new editions of old charts.

In support of *Windmill*, the Hydrographic Office was required to furnish such nautical chart coverage and related data as would be useful in assuring the success of the operation. In addition, a three month course in photogrammetry was given by the Hydrographic Office to the personnel assigned to the operation. To assist in ship navigation in the Antarctic, three special plotting sheets (H.O. 16892-1, 2, and 3) were produced. These proved superior to sheets previously used and, since *Windmill*, have been issued to all U.S. Navy antarctic expeditions.

The plotting charts are essentially outline-type charts, on a polar stereographic projection, and may be used for a variety of planning and plotting purposes. They are especially helpful for plotting oceanographic stations, bathythermograph lowerings, ships' tracks, and ice limits. H.O. 16892-1, at a scale of 1/12 000 000, includes the entire Antarctic Continent and ocean areas to 45°S latitude. H.O. 16892-2, at a scale of 1/5 000 000, covers the area between 45° and 80°S and 130° and 160°W. H.O. 16892-3, also at 1/5 000 000, covers the area from 45° to 78°S and 60° to 130°W. All three charts are printed in green to enhance legibility of plotted information.

Although no nautical charts were published immediately following *Operation Windmill*, the data gathered during this expedition proved invaluable in charting and planning for subsequent operations in the Antarctic.

International Geophysical Year

Following *Operation Windmill* in 1948, the Hydrographic Office was relatively inactive in antarctic cartography until 1954, when the Department of Defense was directed to provide logistic support for United States participation in the antarctic phase of the International Geophysical Year (1957-1958). The Secretary of the Navy was given the responsibility for implementing the Department of Defense assignment. The Navy organized Task Force 43, under the Commander in Chief, U.S. Atlantic Fleet, to carry out the operations necessary to meet these responsibilities.

Because there was not sufficient time available to plan and send a major expedition to Antarctica in 1954, USS *Atka*, a Navy icebreaker, was dispatched to search for base sites and to gather as much hydrographic and oceanographic data as possible for use in compiling the nautical and aeronautical charts which would be required. *Atka* traversed antarctic waters from the Ross Sea eastward around the Antarctic Peninsula and across the Weddell Sea to Queen Maud Land. In addition to finding suitable base sites and making valuable contributions to the knowledge of antarctic oceanography, the ship obtained a total of 30 000 miles of soundings, of which over 9 000 miles were taken in antarctic waters.

Deep Freeze I

As of 1954, the Hydrographic Office had on issue only nine nautical charts, and no aeronautical charts of the whole antarctic area. To support *Operation Deep Freeze I*, 1955-1956, the Hydrographic Office used the data collected in 1954 and on previous Navy expeditions, along with data from foreign sources, to produce six additional nautical charts and seven new aeronautical charts.

The nautical charts (H.O. 6636 through 6641), at a scale of 1/1 500 000, covered the periphery of the Antarctic Continent from the Ross Sea eastward to and including Queen Maud Land. The original charts were published on the Lambert conformal projection but have since been revised and placed on the Mercator projection, at the specific request of navigators. These charts were intended primarily for navigation along the coast of the continent outside the continental ice barriers.

Six aeronautical charts were produced, V30-SP-5 through V30-SP-10, on a polar stereographic projection, scale 1/2 188 800, and included all the land area of Antarctica. One trail charts in two parts, H.O. 16384-1 & 2, at a scale of 1/1 000 000, was published for the area between McMurdo and Byrd Station.

In addition to supplying the necessary charts, the Hydrographic Office prepared detailed specifications for the conduct of all surveys scheduled for *Deep Freeze I*. Records of previously established geodetic control stations were scrutinized, and sites for new observations proposed where necessary to control unexplored sectors and to reestablish control where previous observations were inadequate. Hydrographic Office personnel were specially trained and equipped for this purpose. The results of photographic missions flown during previous operations were analyzed and new flight lines specified for accomplishment by *Deep Freeze I* aircraft operating from the base on Ross Island. The Hydrographic Office specialists were assigned to carry out field evaluation of the aerial photography to insure that specifications were met.

Other surveys planned on an opportunity basis included geodetic control (triangulation) and geophysical (gravity and magnetic) observations. Standard observing procedures for these were specified, although it was not expected that much effort could be devoted to them. As it developed, however, most of the survey effort was confined to control and geophysical operations. None of the planned photo-mapping flights materialized, so Hydrographic Office photogrammetrists assigned for this work assisted the survey team in making geodetic and astronomic observations.

A total of six positions, all in the Ross Sea area, were determined by solar observations. In addition, 42 positions were determined by triangulation methods. These control points were to prove invaluable in later charting of the Ross Sea area. In all, 12 civilian technicians of the Hydrographic Office were assigned to the sea and shore units charged with the execution of this work.

Commanders of ships of Task Force 43 were requested to evaluate,

for accuracy, all charts used during the operation and to collect all possible data for revision of these charts or the compilation of new ones. A total of 162 842 miles of oceanic soundings was recorded, including soundings en route to and from the Antarctic. In antarctic waters, the tracks of the ships were usually based on factors other than the gathering of soundings of uncharted or poorly charted waters; nevertheless, a considerable amount of information on previously unsounded waters was collected. In addition, USS *Edisto* in February 1956 checked the charts of Robertson Bay, and obtained much new sounding information there.

The following comments concerning chart deficiencies, made by the Commanding Officer of USS *Glacier* following *Deep Freeze I*, are typical of those reported to the Hydrographic Office. They revealed the paucity of reliable data available when the charts were compiled and confirmed an urgent need for additional surveys :

“ Specific errors noted :

“ (1) H.O. 2562. Scott Island is shown on this chart to be approximately 15 miles south of its true position.

“ (2) H.O. 6636.

(a) Coulman Island is actually about 12 miles south of the position shown.

(b) Franklin Island was found to be only 5 miles long and not 12 miles as shown on the chart.

“ (3) Ship grounded on an uncharted shoal in McMurdo Sound at latitude 77°48'55"S, longitude 166°35'E. ”

Deep Freeze II

Using data gathered during *Deep Freeze I*, the Hydrographic Office in 1956 published 15 new nautical charts and five new aeronautical charts for use by the Task Force during *Deep Freeze II* in 1956-1957.

H.O. 6642-6644, at a scale of 1/1 500 000, completed the series of small scale coastal charts of the periphery of the continent, covering the area from Queen Maud Land to the Ross Sea. The remaining 12 charts, H.O. 6662-6673, were produced to supplement the small scale coverage with more detailed large and medium scale charts for inshore operations, particularly in the vicinity of United States stations. For example, H.O. 6662 shows Kainan Bay in the Ross Sea at a scale of 1/50 000 on the Mercator projection. Other charts in this group, all on the Mercator projection, range in scale from 1/15 000 to 1/100 000.

The five new aeronautical charts were compiled to fulfill a requirement for strip charts for flights to and from the Antarctic Continent, and between United States stations in the Antarctic. These strip charts vary in scale from 1/15 840 to 1/1 000 000 and are on the Mercator projection for the larger scale and transverse Mercator projection for the smaller scale charts. Strip chart H.O. 16384-3 & 4 (one chart with two parts printed back-to-back) covers the area from McMurdo to Christchurch, New Zealand, H.O. 16384-5, the area from Eights Coast to South America; H.O. 16384-6 & 7, from Mc-

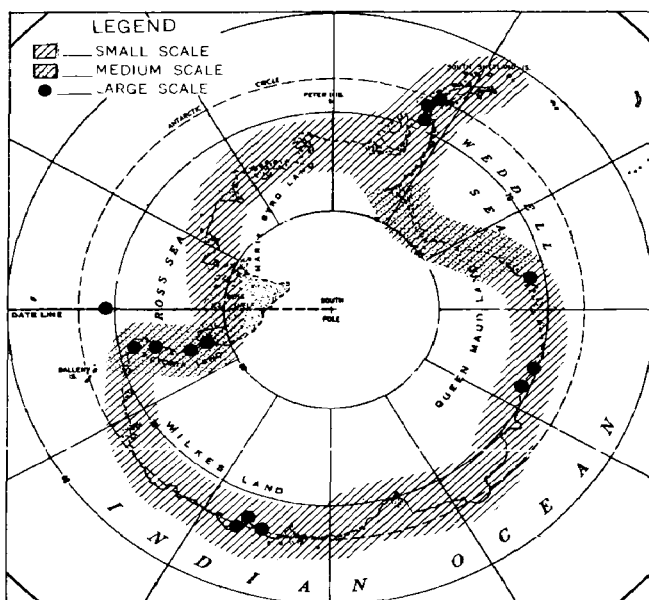


FIG. 4

Murdo to the South Pole; H.O. 16384-8 & 9, "Fashion Lane", a heavily crevassed area on the trail between Little America and Byrd Station; and H.O. 16384-10 & 11, the area between McMurdo and Byrd Station. This last chart replaced H.O. 16384-1 & 2 which was originally published in 1955.

While *Operation Deep Freeze I* was still in progress, the original mission of *Operation Deep Freeze II* was modified to include the construction of two additional bases, requiring an increase in the number of ships, airplanes, equipment, and personnel participating. As in *Operation Deep Freeze I*, the Hydrographic Office prepared detailed specifications for surveys to be conducted by its personnel accompanying the Task Force. The commanding officers of the ships in the Task Force were again requested to evaluate the charts which were furnished and to report deficiencies to the Hydrographic Office. In addition, ship commanders were under orders to gather new data for charting use.

Approximately 300 000 miles of soundings were obtained during *Deep Freeze II*. Other hydrographic and oceanographic data were also collected. On the basis of these data, the Hydrographic Office published, in 1957, 16 new nautical charts and 15 new editions of nautical charts for the Navy's areas of operations.

These charts represented a continuation of effort by the Hydrographic Office to issue larger scale and more detailed charts of antarctic waters. Charts H.O. 6626-6631 inclusive and H.O. 6659-6660 constitute a series of medium scale (1/100 000) charts of the coastline of Victoria Land on the Ross Sea and are used for navigation in the vicinity of McMurdo Sound and Hallett Station. H.O. 6646-6649 inclusive are medium scale charts (1/200 000) of the Weddell Sea area. H.O. 6656, 6657, and 6658 are large scale charts (1/12 000) of the Windmill Islands area in Wilkes Land, and were compiled from Hydrographic Office photogrammetric manuscripts.

These charts were published for use by ships supporting Wilkes Station. H.O. 6635, also published in 1957, is a 1/35 000 scale chart of McMurdo Sound. All of these charts are on the Mercator projection. Figure 4 shows total nautical chart coverage at the conclusion of *Operation Deep Freeze II* in 1957.

Other Deep Freeze Operations

Deep Freeze operations have continued annually from *Operation Deep Freeze I* to the present. The primary mission of the Hydrographic Office during each of these operations continued to be the support of the United States Naval Support Force, Antarctica, with charts and other hydrographic and oceanographic data as well as technical advice and assistance through the Hydrographic Office personnel assigned to the operations. During the years, U.S. Navy ships have continued to collect soundings and other observations for Hydrographic Office use.

In the last eight years the Hydrographic Office (since 1962 now known as the Oceanographic Office) has produced a total of 17 new nautical charts, 44 new editions of nautical charts, and one new and 73 new editions of aeronautical charts in support of the antarctic program. The nautical charts range in scale from H.O. 6710, of the waters from New Zealand to Scott Island in Antarctica, at a scale of 1/2 519 700, to H.O. 6712, a 1/6 250 scale chart of the McMurdo Station and vicinity. Between these two extremes are charts of medium to large scale. H.O. 6633, 6687-6689, and 6713 are medium scale (1/500 000) charts of the coastline of Marie Byrd Land between the Ross Sea and the Antarctic Peninsula. Also in the medium scale category are H.O. 6943-6948 (1/200 000) of the west coast of the Antarctic Peninsula.

For navigation in the vicinity of the United States stations, or proposed stations, the Oceanographic Office has published large scale charts such as H.O. 6661 and H.O. 6796. The former contains seven different plans of harbors in the South Shetland Islands at scales of 1/15 000 to 1/50 000, while the latter shows Deception Island at a scale of 1/50 000, with plans of harbors at scales of 1/7 500 to 1/12 000. Other charts in the large scale category are H.O. 6690, at a scale of 1/50 000, covering the approaches to Arthur Harbor in the Antarctic Peninsula, and H.O. 6691, showing the immediate vicinity of Arthur Harbor at a scale of 1/25 000, with an inset plan of Arthur Harbor at a scale of 1/12 500. The latter was compiled from data obtained by a Navy survey team in 1965. All of the above charts are published on the Mercator projection. In addition, during this period, an average of seven nautical charts were revised and reissued annually for use on *Deep Freeze* operations.

The one new aeronautical chart was V30-SP-11 at a scale of 1/2 188 800 on a polar stereographic projection. It was compiled to cover, in one sheet, the entire area of primary operational interest to the United States.

During this period, two series of large scale topographic maps were compiled by the Oceanographic Office using stereophotogrammetric methods, to meet the U.S. Navy Bureau of Yards and Docks engineering requirements. The first series, of the Marble Point area of McMurdo Sound,

was compiled in 1958 and consisted of 11 sheets at a scale of 1/2 400 with a contour interval of five feet. The second series, of McMurdo Station and vicinity, was compiled in 1960 and consisted of nine sheets at a scale of 1/1 200 with a contour interval of two feet. These maps served a dual purpose in that they were also used in the compilation and revision of nautical charts of the area. Figure 5 shows total nautical chart coverage of the Antarctic at the present time.

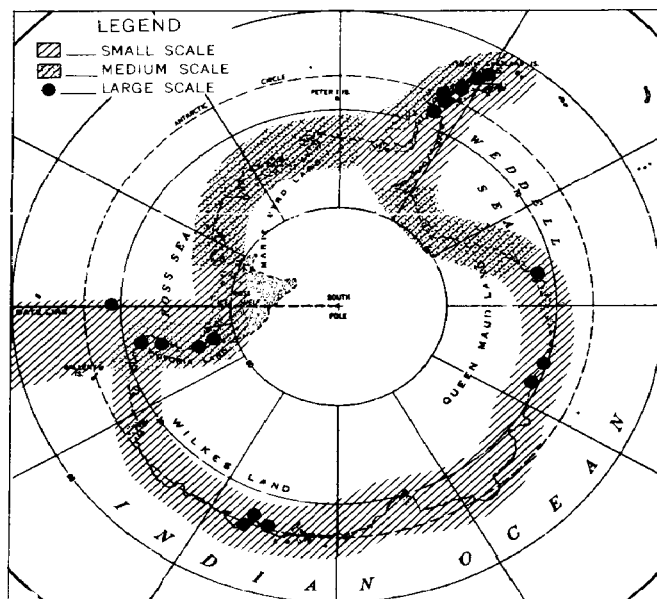


FIG. 5

Assistance by Other Agencies

The U.S. Naval Oceanographic Office has been greatly assisted in the production of its nautical charts of the Antarctic through the cooperation of other agencies of the U.S. Government. The United States Coast Guard has participated in most of the Navy's antarctic operations since *Operation Highjump*. Coast Guard icebreakers have collected much of the data used in nautical charts of the area. U.S. Air Force aeronautical charts of Antarctica have provided some of the data used in the compilation of nautical and aeronautical charts published by the Oceanographic Office. Other geodetic control and topographic source materials used in Oceanographic Office nautical charts are based on the original mapping accomplished by the U.S. Geological Survey.

The Oceanographic Office charting effort has also benefited from the results of other nations' work in the Antarctic which, since the IGY, have been exchanged freely. Much of this information covers areas outside the United States' sphere of operations. Among the foreign charts utilized are those of Great Britain, Argentina, Chile, Australia, New Zealand, the U.S.S.R., France, Germany, and Norway.

Present Chart Coverage

The present Oceanographic Office chart coverage of Antarctica consists of 56 nautical charts, five special plotting charts, six miscellaneous charts, and 12 aeronautical charts (cf. figure 6). An index of all Oceanographic Office charts of the antarctic area may be found in H.O. Publication No 1-N, *Catalog of Nautical Charts and Publications, Region 2*, and H.O. Publications No. 1-V, *Aeronautical Charts - Publications*.

At the present time, the Oceanographic Office has only one chart of the Antarctic in preparation, H.O. 15254-14. Now in the compilation stage, it is intended to supplement the 12-sheet, Mercator projection chart of the world published in 1961. The new chart will cover the entire antarctic area on a polar stereographic projection, scale 1/8 500 000.

Future Cartographic Participation

The future participation of the U.S. Naval Oceanographic Office in antarctic cartography depends to a large degree upon the extent of United States activities in the Antarctic. So long as United States ships and naval aircraft are involved, the Oceanographic Office is responsible for providing accurate navigational charts and publications and related hydrographic and oceanographic data and services within its capability. Effort will be made to improve the products of the Oceanographic Office as newer and better data are obtained, and to produce newer and larger scale nautical and special purpose charts as required.