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An Aerial Census of Spotted Seal, *Phoca vitulina largha*, and Walruses, *Odobenus rosmarus*, in the Ice Front of Bering Sea

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I. Summary

Twenty-five individual survey flights for marine mammals were made in the ice front of Bering Sea during the March-April period of 1976 and 1977. These included 8 extensive flights in a Lockheed P-2V aircraft and 17 flights in a Bell 206 helicopter launched from the NOAA vessel OSS SURVEYOR. Results obtained from these flights showed that both spotted seals, Phoca vitulina largha and walruses, Odobenus rosmarus occur throughout the front. Large concentrations of both species were present in central and western Bristol Bay, a region which must be considered as critical habitat. The number of walruses in the ice front during April 1976 was estimated at 10,000. No estimate of the number of spotted seals could be made.

Observed densities of spotted seals in large sectors of the front, as surveyed with the P-2V, ranged from 0.02 to $2.75/NM^2$. Density of seals as determined by localized flights in the helicopter ranged from 0 to $6.75/NM^2$ in 1976 and 0.5 to $6.72/NM^2$ in 1977. Spatial distribution of seals throughout the front in both years was similar. Subadults composed the highest proportion of seals in areas of high seal density. In the vast region of the front west of Bristol Bay most of the seals observed were adults with pups.

The helicopter was slightly better for surveying than was the P-2V. More seals were observed from the helicopter although counts obtained from each were close.

Weather conditions and time of day when surveys were conducted did not significantly affect the results of surveys which were conducted in April of both years.

It was estimated that less than 14 percent of the seals in areas of high seal density were on the ice when surveys were conducted. Twenty-five to 50 percent were hauled out in those areas occupied mainly by adults and pups. The density of pups throughout the ice front was directly related to the density of older seals. However, the proportion of pups in high density areas was low.

Annual differences in the location of the ice front did not result in significantly different patterns of spotted seal distribution within the front during 1976 and 1977. Ice conditions during 1976 resulted in a broader distribution of spotted seals north of the front. This did not appear to occur in April 1977.

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II. Introduction

In the eastern Bering Sea during late winter and spring the southern terminus of sea ice normally reaches a position extending from Bristol Bay to the vicinity of the Pribilof Islands. Two proposed OCS lease areas, Bristol Bay and St. George Basin, occur in this region. During formulation of the Outer Continental Shelf Environmental Assessment Program it was determined that baseline information about the distribution and abundance of ice associated marine mammals occurring in the proposed lease areas should be obtained.

This report is primarily about such an assessment of spotted seals, Phoca vitulina largha, based mainly on aerial surveys in the ice front of eastern Bering Sea during the late-winter, early-spring of 1976. A secondary objective was to obtain similar information about winter distribution of walrus, Odobenus rosmarus, in the ice front.

Several delays in preparation of this annual report have provided opportunity to incorporate data obtained during the March-April 1977 cruises of the OSS SURVEYOR.

Spotted or largha seals are one of the five ice associated species of pinnipeds which occur in the seasonally ice covered regions of Bering Sea. The others are: ribbon seals, Phoca fasciata; ringed seals, Phoca hispida; bearded seals, Erignathus barbatus; and walrus.

During summer months, when the Bering and Chukchi Seas are ice free, spotted seals are widely distributed mainly along the coasts of Siberia, Alaska and the northern Bering Sea islands. They occupy estuaries, bays and the mouths of rivers, and frequently haul out on land. Along the Alaskan coast, summer distribution extends from the Aleutian Islands and Alaska Peninsula, to Demarcation Point. Greatest numbers occur between Kuskokwim Bay and Wainwright.

In the western Bering Sea these seals occupy a range extending from the Kuril Islands in the south to at least Cape Schmidt in the Chukchi Sea. On the Siberian coast the greatest numbers occur between Karaginski Bay and East Cape (Golt'sev, pers. comm.).

During summer and early fall spotted seals mainly occupy a near shore habitat and haul out on land. From November through June they are associated with ice and appear to prefer particular sea ice conditions. These include relatively thin ice through which the seals can poke holes with their heads, or relatively small floes comprising what can be termed unconsolidated pack ice.

As sea ice forms in late autumn, spotted seals occupying the more northerly parts of their range move south, into Bering Sea. They are most numerous in the "front" zone of the advancing (and forming) ice cover. This process continues throughout the early winter - more spotted seals moving away from the coast and associating with the front of a southward advancing ice cover.

Usually, by late winter the ice cover obtains its maximum extent. Annual differences in climatic conditions and extent of ice in Bering Sea are significant. In some years ice covers all of Bristol Bay, extending down to the western tip of the Alaska Peninsula. In other years it barely reaches St. Matthew and Nunivak Islands. However, on the average, the southern limit of ice in central Bering Sea coincides with the edge of the continental shelf (200m isobath). In eastern Bering Sea it "normally" occurs down to 57° or 58° N latitude.

The preference of spotted seals for ice consisting of relatively small, unconsolidated floes appears to be maintained throughout the late winter and spring and the greatest relative density of these seals occurs in the front zone, extending from Alaska to Siberia. However, density of seals in different regions of the front varies greatly. They also occur in favorable localized areas north of the front.

The diet of spotted seals can be indicated, in general terms, as including a variety of schooling and demersal fishes and, of secondary importance, shrimps. During the late winter-spring period of 1976, studies conducted aboard the OSS SURVEYOR (RU#230) showed that capelin, Mallotus villosus, were of primary importance (Lowry, Frost, Burns 1977). Observations during previous years have indicated that walleye pollock, Theragra chalcogramma, herring, Clupea harengus pallasi, smelt, Osmarus mordax dentex, eulachon, Thaleichthys pacificus, sandlance, Ammodytes hexapterus, saffron cod, Eleginus gracilis, Arctic cod, Boreogadus saida, greenling (Hexagrammidae), sculpins (Cottidae), and flatfishes (Pleuronectidae) among others are also of importance.

Late winter-spring distribution of spotted seals, mainly in the ice front, is no doubt the result of an abundance of appropriate prey species at and just north of the continental shelf break, combined with the presence of favorable sea ice conditions.

The annual sequence of biological events in the life of spotted seals (and all other pinnipeds as well) directly affects opportunities for observation and enumeration of seals hauled out on ice or land. Events of direct significance to aerial surveys are the periods of reduced feeding activity, birth, lactation and molt.

Spotted seals are mainly in the water during the cold months of January and February. They start to haul out on the ice, en masse, during March, depending on air temperature and wind conditions. The period of annual molt begins about mid-March and extends through June (some molting occurs as late as September). Subadult animals molt mainly during the first half of this three and one-half month period and adults during the last half. During the molt seals spend a great amount of time basking on the ice. The number of seals hauled out at any given time is related to weather conditions. Unfortunately, the significance of important correlates influencing hauling out are not adequately known.

Spotted seals breed annually. Birth occurs between the last days of March and the end of April. Most pups are born by mid-April; the peak period being between the 7th to 15th (Tikhomirov 1964, 1966; Burns 1970; Burns et al. 1972). There appears to be minor annual variation in peak pupping dates, associated with prevailing weather conditions. However, additional study is required to confirm this point. Pups are born on the ice. At birth they are covered by a dense coat of lanugo which is off-white or greyish-white in color. The function of lanugo is that of thermal insulation (Davydov and Makarova 1965). Lanugo begins to shed when pups are about two weeks of age. It is entirely lost by four or five weeks of age. The shedding of lanugo occurs simultaneously with an increase in thickness of the blubber layer. Pups do not normally enter the water for long periods of time until they have acquired a thick blubber layer and shed most of their lanugo.

Our experience, based upon capturing pups for marking, indicates that about 50 percent of the pups will enter the water, if harassed, after about 24 April. Under normal conditions they spend almost all of their time on the ice until they are abruptly weaned at three to four weeks of age (early to mid-May).

Adult spotted seals are monogamous. Mothers are relatively attentive toward their pups and males maintain a close association with the females (Burns et al. 1972). On days when temperatures are relatively warm and winds are not strong, triads of a pup, mother and an adult male are commonly seen. Several such pairs with pups may occur in a small area but rarely closer than .25 kilometer apart (Burns et al. 1972). This suggests some degree of territoriality and is a subject deserving of further investigation.

During cold, windy weather pups seek shelter if available, in the rough parts of their "home" floe, resting in crevices or becoming completely covered by a blanket of snow. During such periods the adults may leave the floe to feed or to swim in close proximity to it.

All of the above information relates directly to programs which are dependent upon the detection of seals hauled out of the water during the late winter-spring period.

April is normally optimum for such work because it is the time of maximum concentration of spotted seals; they occur mainly in areas of specific and recognizable ice conditions; it is the time of peak molt in subadult spotted seals; the adults are usually highly visible; and pups are still restricted to the ice floes.

Unfortunately, the proportion of seals, especially subadults, which haul out at any specific time, remains unknown. Also, variation in weather conditions directly influences the proportion of all spotted seals older than young pups which are out of the water.

Walrus are distributed over a broad area in Bering Sea during winter. However, they are mainly north of the ice front and there are regions where they are known to concentrate in large numbers. These areas include northwestern Bristol Bay, outer Kuskokwim Bay and the northcentral Bering Sea south of St. Lawrence Island (Kenyon 1960, 1972; Burns 1965; Fay, in prep.).

Walrus are highly migratory and most move north, leaving Bering Sea when it is ice free. However, several thousand animals, mostly males, remain in Bristol Bay during summer.

A large variety of benthic animals, mainly infauna, are utilized as food by walrus although only a few species comprise the bulk of their diet. Major food items include mollusks of the genera *Mya*, *Spisula*, *Serripes*, *Clinocardium* and *Hiatella*, with lesser amounts of gastropods including *Neptunia*, *Buccinum* and *Polinices*, crabs, shrimps, and tunicates (Fay, Feder and Stoker 1977).

Problems associated with aerial censusing of walrus are generally similar to those mentioned with respect to spotted seals. However, sightability within one half mile of the aircraft was definitely not a problem. Additionally, it appeared that during the period of our surveys most of the walrus were on the ice. Therefore, the numbers of walrus observed approximated more closely the total number in areas surveyed.

During the time of our surveys, two other intensive survey programs were also being conducted. These were by H. W. Braham (RU#67) in eastern Bering Sea mainly north of the ice front and by G. A. Fedoseev (Magadan Branch, TINRO, USSR) in central and western Bering Sea.

It is the mutual intention of investigators that undertook each of these three independent survey efforts to combine their data and prepare a comprehensive report. Formal arrangements to accomplish this objective have been completed and will result in the most intensive and comprehensive assessment of marine mammals ever achieved in the ice covered regions of Bering Sea.

III. Current state of knowledge

No intensive surveys specifically designed to assess the population status and distribution of spotted seals over the broad ice front of central and eastern Bering Sea have been undertaken prior to our effort in April 1976. However, numerous shipboard expeditions (including commercial sealing by the Soviets, since about 1962), general aerial surveys of marine mammals and marine mammal studies from coastal villages, have provided information required for the design of such a survey.

A general picture of the late winter-spring distribution of spotted seals and ribbon seals in Bering Sea can be constructed from the works of Kenyon 1960, 1972; Krylov et al. 1964; Shustov 1965a, b, 1967, 1969, 1972; Kosygin 1966; Kosygin et al. 1975; Tikhomirov 1961, 1964, 1966; Tikhomirov and Kosygin 1966; Fedoseev 1966, 1976; Burns 1969, 1970; Burns et al. 1972; Bychkov 1971; Fay 1974; Golt'sev et al. 1975; and Braham et al., 1977.

Pertinent references dealing with the methodology of aerial surveys as utilized in this study include Kenyon 1960, 1972; Pastukhov 1965; McLaren 1966; Shustov 1969; Fedoseev 1970; Burns and Harbo 1972; Smith 1973; Gilbert et al. 1976; Mate 1976; Schneider 1976; Stirling et al. 1977. A general review of marine mammal census methods is presented by Chapman et al. 1977.

As previously stated, information about the natural history and distribution of spotted seals provided the basis for determining that they are concentrated mainly in the ice front during late winter and spring and that biological activities during April (birth, lactation and molt) result in significant numbers of seals hauling out on the ice.

Previous shipboard studies, particularly aboard the R/V ALPHA HELIX in 1968 and 1972 and on the U. S. Coast Guard Cutter, GLACIER in 1971, indicated that in March and April spotted seals occurred throughout all areas of the ice front traversed by these vessels. Most importantly, although position of the front varied significantly in these years, the seals were associated with it.

The cruise of the GLACIER in 1971 provided a unique opportunity to traverse an extensive region of eastern Bering Sea from Norton Sound to Unimak Pass. During the traverse from Norton Sound to the south, no spotted seals were observed until we reached the ice front on 11 April. Our first sighting of this species was at approximately 58°20'N, 171°57'W. Between 11 and 20 April the ship remained in the front, moving generally eastward. Spotted seals, especially triads of an adult male, an adult female and her pup were common throughout the area between 171°57'W and 166°W and were observed to the edge of the pack ice as we departed it on 20 April. Use of helicopters aboard GLACIER, for survey and capture of seals, provided frequent opportunity to observe seals, to ascertain their response to aircraft and to refine procedures for a large scale survey effort.

During the ALPHA HELIX and GLACIER expeditions very few subadult spotted seals (ages 1-4 or 5) were observed or collected. The wintering area(s) for this cohort of the population were not found.

In March and April 1976 the research vessel OSS SURVEYOR also operated along the extreme southern edge of the ice front in central and eastern Bering Sea. During March, concentrations of spotted seals were located and preliminary surveys, using the ship's helicopter, were undertaken. A large concentration of mainly subadult seals was found in the Bristol Bay area. Information obtained during March was incorporated into the design of our April surveys. Aerial surveys utilizing the SURVEYOR's helicopter were also undertaken during April, and provide data for a comparison with results obtained from the fixed-wing aircraft.

The methodology of aerial surveys for ice associated marine mammals is more or less standard and will be discussed in a subsequent section of this report.

Accurate estimation of the total number of spotted seals, based on aerial survey techniques, is not yet feasible. The proportion of seals which are hauled out on the ice and visible to observers remains unknown. Adequate study of the significance and effects of parameters relating to haul out behavior of spotted seals has not been accomplished.

Haul out behavior of walruses is better known (Fay and Ray 1968, Ray and Fay 1968). Thermal tolerances of walruses are greater than those of spotted seals. Based on field observations, a larger proportion of walruses in a localized area (as compared to spotted seals) haul out when weather conditions are favorable. This is probably related to the highly gregarious nature of walruses.

IV. Study Area

Our studies were conducted in a specific ice habitat (the front) rather than in a fixed geographical area. Previous studies have shown that spotted seals occur in greatest numbers in this ice habitat during late winter and spring (Tikhomirov 1964; Kosygin 1966; Shustov 1967a, b; Burns 1969, 1970; Burns et al. 1972; Fay 1974). The ice front is that zone of seasonal ice extending north from a jagged and indefinite "edge" for between 15 and about 80 miles depending on winds and currents.

The southern limit of seasonal sea ice in eastcentral Bering Sea (from 168°W to 178°W) usually approximates the edge of the continental shelf as indicated by the 200 m contour. In the area east of 168°W longitude, the late winter-spring ice edge is always considerably north of the shelf break. There is considerable annual variation in extent of ice cover in Bering Sea. Accordingly, there are major annual differences in location of the ice edge and front zone. The winter and spring of 1976 was a period of prolonged north winds, lower than normal temperatures (especially in April) and extensive ice coverage. During March and April, the southern limit of ice may be as far south as 55°10'N or as far north as 61° or 62° (as it was in 1967).

The front is characterized by small floes usually less than 20 meters wide, separated by water or slush ice and subject to rapid dispersal or compaction by winds and ocean currents (Burns 1970). In his description of the front, Fay (1974) states:

> "At its southern edge, the pack is intermittently affected throughout the winter also by southerly winds associated with the continuous progression of North Pacific storms. These winds seem to have two major effects: temporary compaction of ice north of the edge, due to opposition to the southwesterly drift, and destruction of the edge itself, due to the heavy swells produced in the open sea. Strictly speaking, there is no actual "edge" for a 15- to 65-km wide zone at the southern periphery of the pack is alternately dispersed and compressed. American biologists working in this zone in recent years (e.g. Burns et al. 1972) have referred to it as the "front,"....

Figures 1 and 2 are Multispectral Scanner (MSS) images of the Landsat 2 satellite system, taken on 13 and 19 April 1976. They show ice conditions in the survey area north of Cold Bay and in central Bering Sea near the Pribilof Islands.

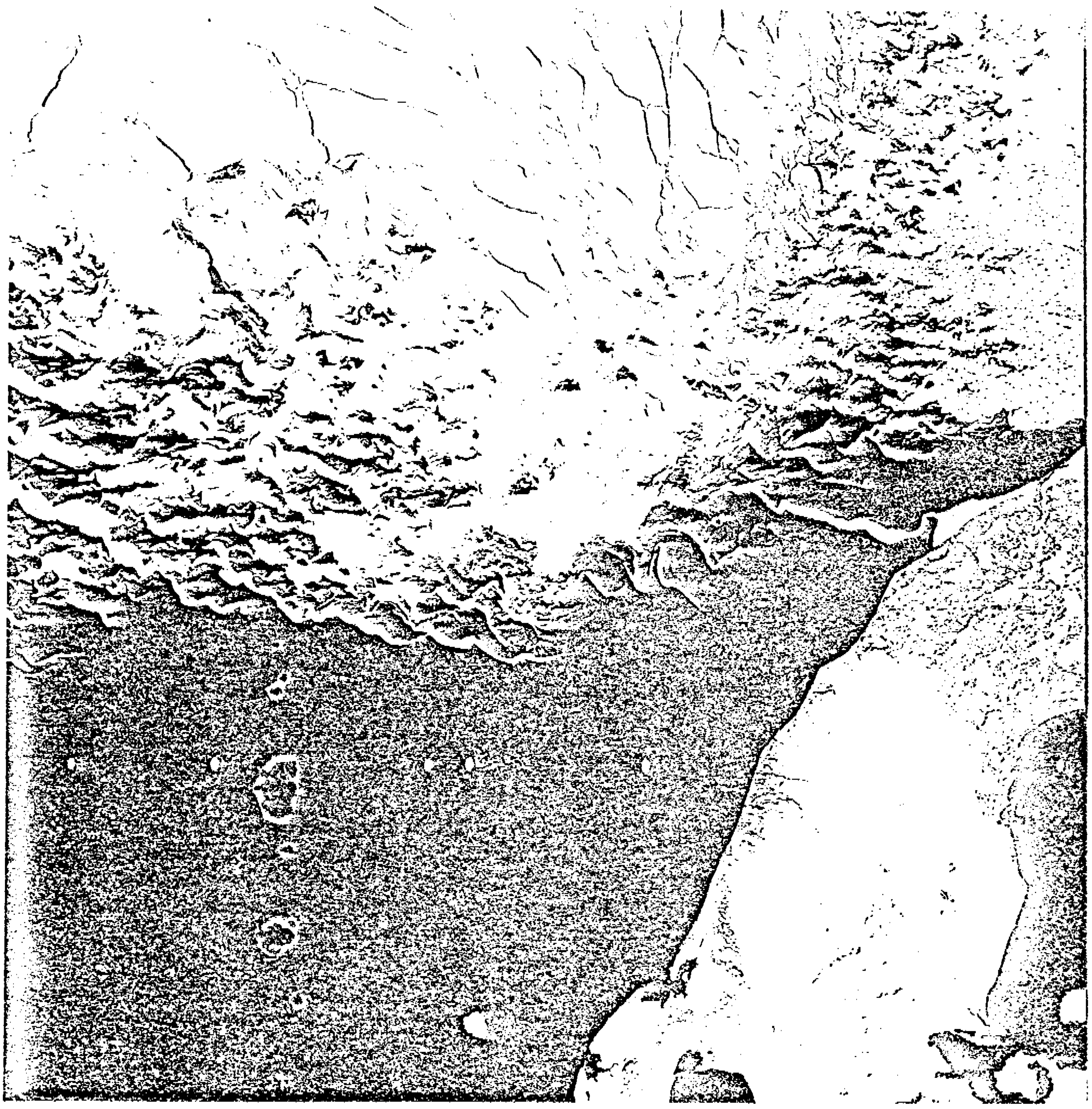

Fig. 1 LANDSAT image 2447-21110; ice edge and front zone in the area north of Cold Bay and Amak Island, 13 April 1976.

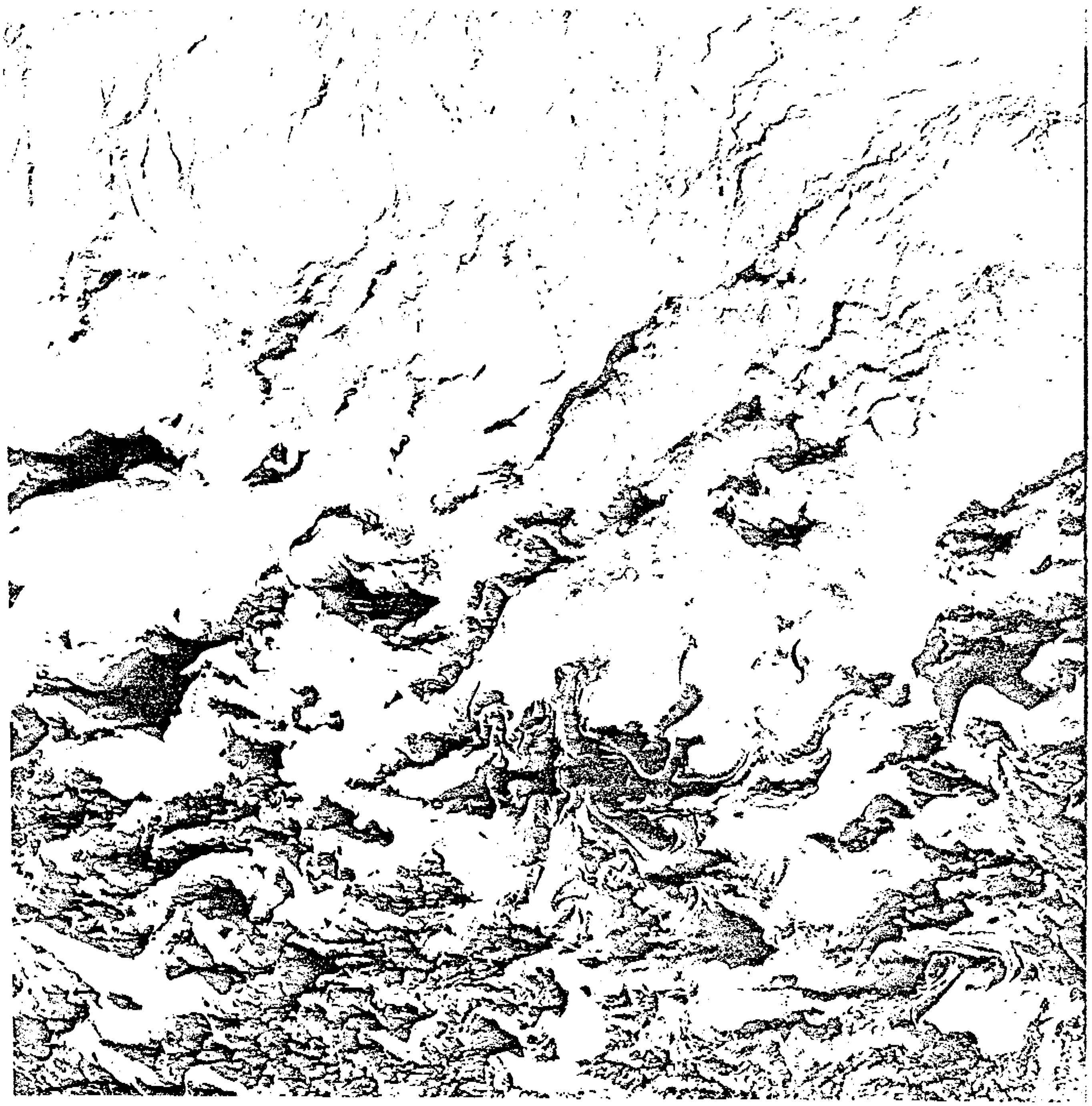

Fig. 2 LANDSAT image 2453-21445; ice edge and front zone in area between 169°30'W and 172°30'W, 19 April 1976.

Spotted seals are mainly pisciverous. Eleven spotted seals were collected from the OSS SURVEYOR, during March and April 1976, within the areas we surveyed (annual report, RU 232, April 1977). Four of the 11 seals had empty stomachs and the remaining 8 had fed entirely on capelin (*Mallotus villosus*). It is generally assumed that a large standing stock of suitable food fishes occurs at or near the shelf break and that the usual combination of suitable ice conditions and availability of food favors concentration of spotted seals in the ice front. However, the distribution of forage fishes may be correlated more with location of the ice edge than with bathymetry. This question deserves further investigation.

Location of the study areas within which marine mammal surveys were conducted during March and April 1976 are indicated in Figs. 3 and 4. It extended from the eastern limits of Bristol Bay to 178°58'E longitude and from the southern limit of seasonal sea ice to as much as 70 nautical miles north of the ice edge. The most intensive surveys were in eastern Bering Sea within an area bounded by 160°W and 169°W longitudes and 56°N and 57°N latitudes. West of 169°W, the ice edge gradually tended farther north. Accordingly, survey tracks were also farther north.

Survey areas during March and April 1977 are shown in Fig. 5.

A comparison of the general southern limit of drifting ice during March-April 1976 and March 1977 is shown in Fig. 6.

Areas included in the proposed Bristol Bay and St. George Basin leases are shown in Fig. 7.

V. Methods

A. Survey procedures

Aircraft used for surveys were a Bell 206 helicopter (based on board the OSS SURVEYOR) and a Lockheed P-2V. Strip transects were flown.

During March-April 1976 and April 1977 the OSS SURVEYOR operated in the ice front, providing opportunity to obtain information about distribution of species, general age composition and density in different areas, and activity patterns. Sampling schemes for use during the period of intensive survey (8 to 23 April) were developed and tested during 1976, using the helicopter.

Helicopter flights were made along predetermined tracks. A Global Navigation System (GNS) was used for precise navigation during surveys. Width of the strip transect within which all animals were counted was either one-half or one-fourth nautical mile on either side of the helicopter. Transect width depended upon sightability of animals as affected by light conditions, size and surface topography of ice floes and brightness of the background upon which animals were resting.

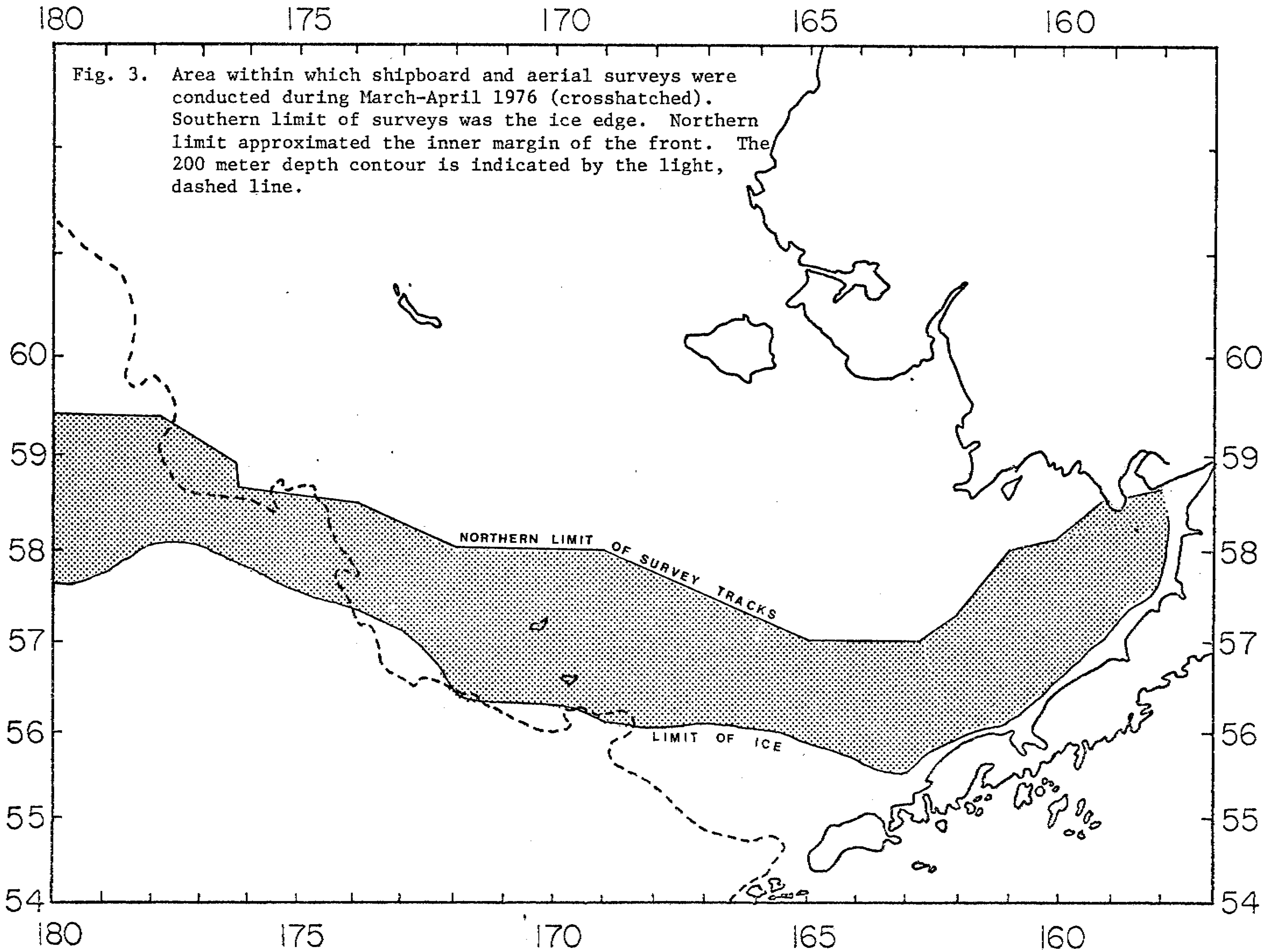

Fig. 3. Area within which shipboard and aerial surveys were conducted during March-April 1976 (crosshatched). Southern limit of surveys was the ice edge. Northern limit approximated the inner margin of the front. The 200 meter depth contour is indicated by the light, dashed line.

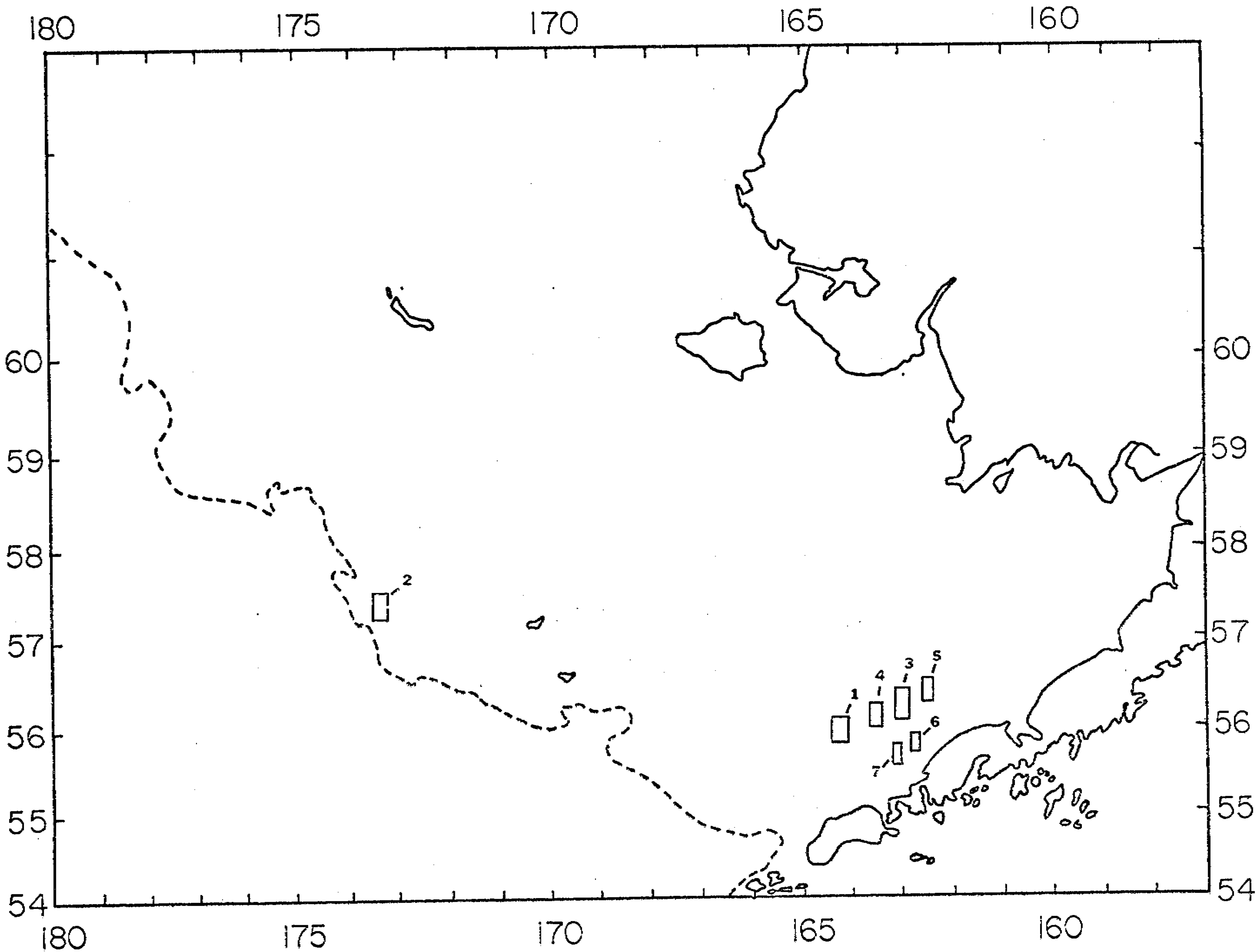

Fig. 4. Areas within which helicopter surveys of spotted seals were conducted during March-April 1976.

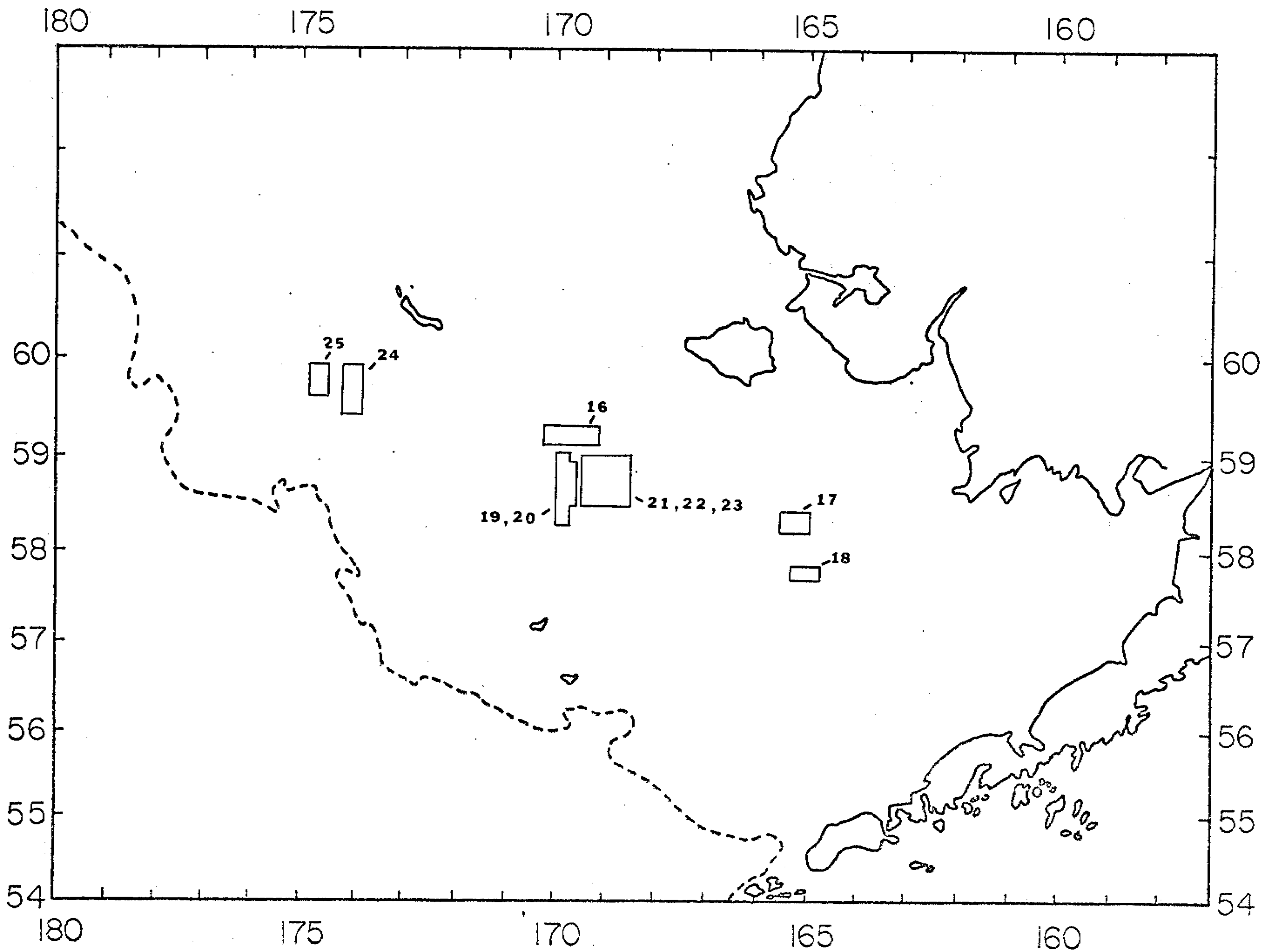

Fig. 5. Areas within which helicopter surveys of spotted seals were conducted during March-April 1977.

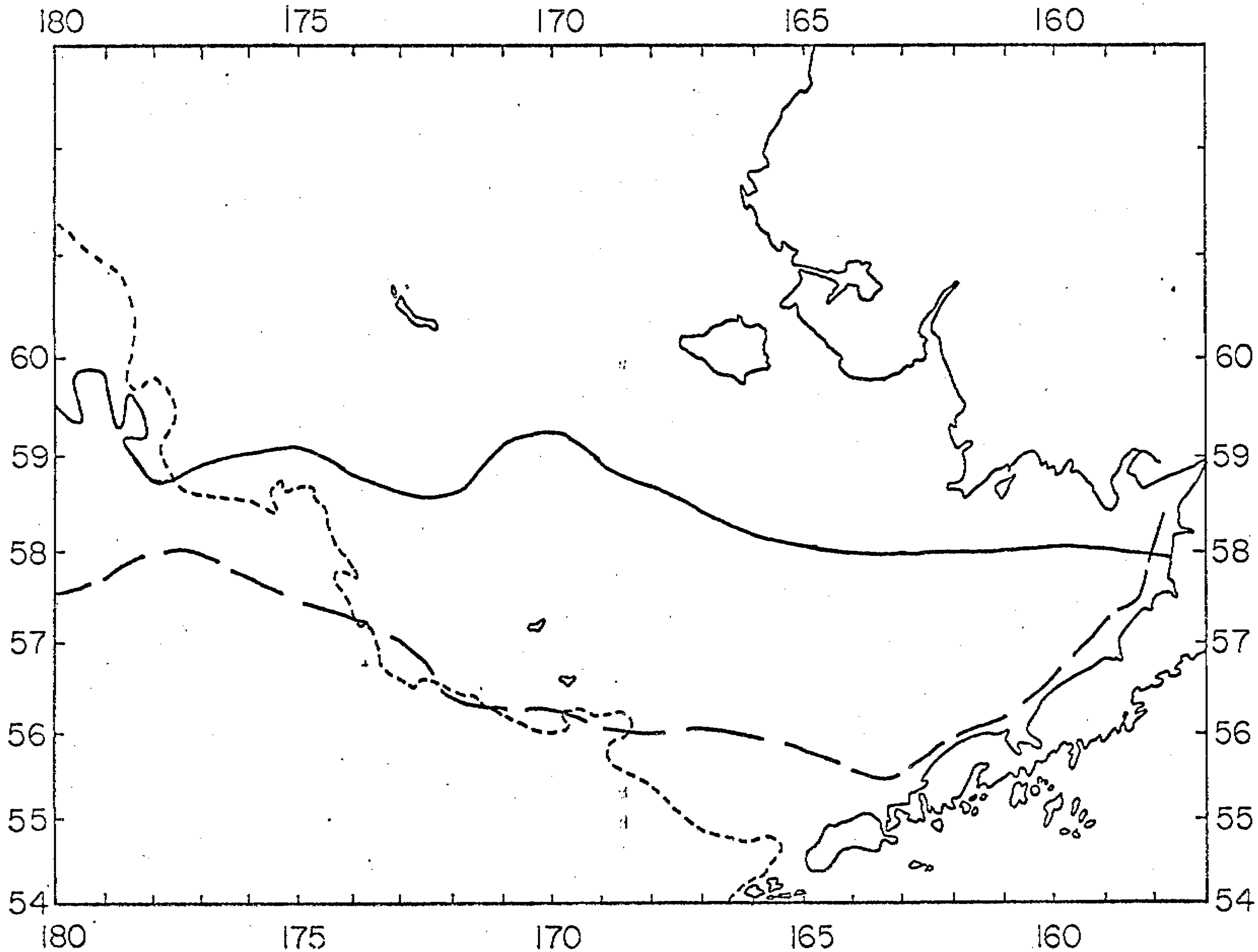

Fig. 6 Location of ice edge during March - April 1976 (----) and on 23 March 1977 (——).

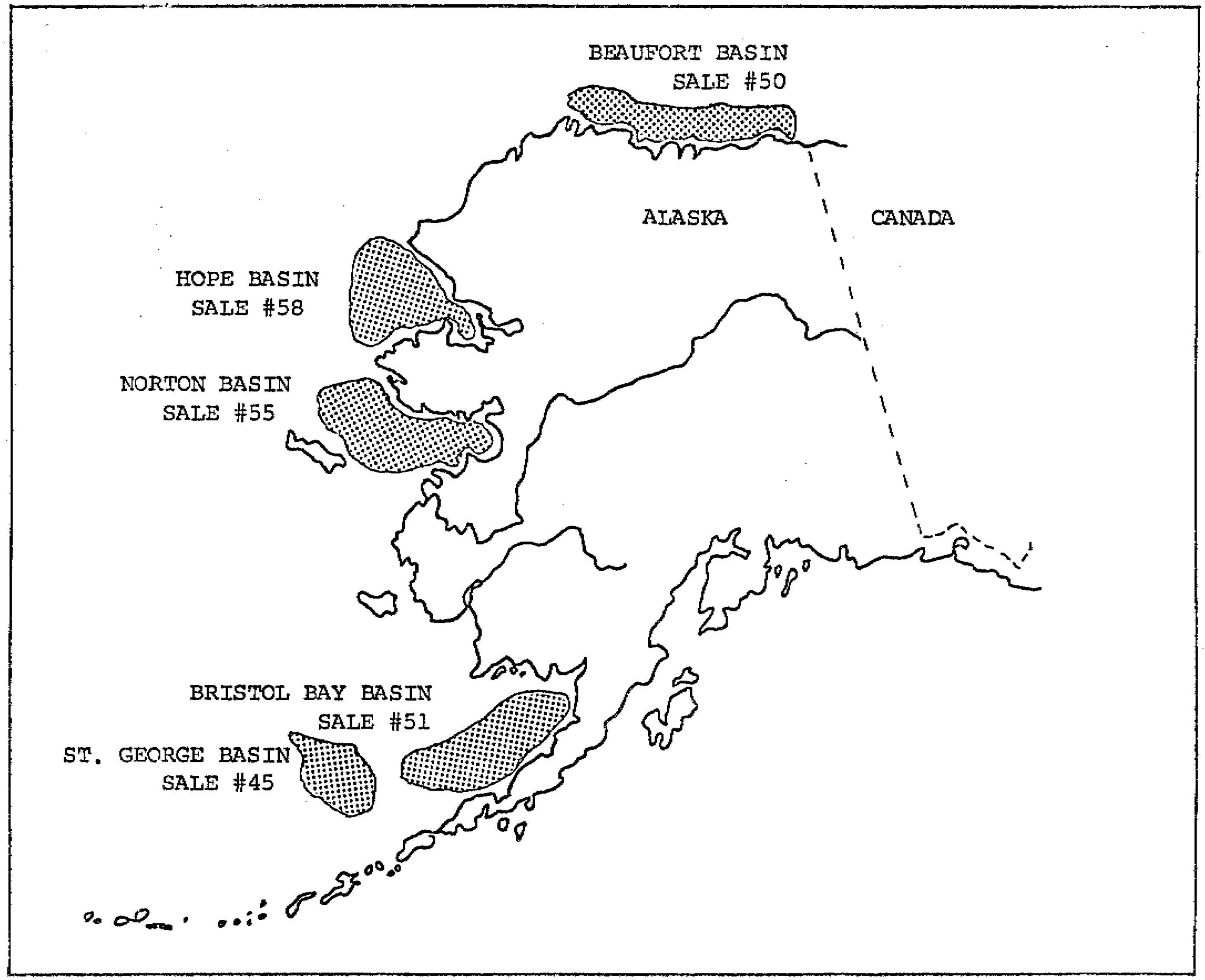

Fig. 7. General locations of proposed OCS leases in the Bering, Chukchi and Beaufort Seas. The Bristol Bay and St. George Basin leases are within areas surveyed for spotted seals and walruses.

Flight altitude was 300 feet at an air speed of 80 miles per hour. Low cloud cover occasionally required that the helicopter fly lower.

Transect width was checked at the beginning of each flight, using the ship as a reference point. This procedure was particularly useful because of daily differences in visibility. For purposes of recording observations, the transect was divided in half; the center line of the helicopter being the mid point. Each sighting was recorded, according to its occurrence, as being on the left or right side.

Information recorded included species and number of animals sighted, group size, animal activities, ice conditions, weather conditions and navigational information. All recorded information was annotated to include local time. Animals seen beyond limits of the transects were also recorded but those data were not included in statistical analyses. To the extent possible, a continuous record of events, by one minute time intervals, was maintained.

Personnel on board the helicopter during marine mammal surveys included an observer for the left side (occupying the left front seat), a pilot-observer in the right front seat and an observer-recorder in the right rear seat. A fourth person was occasionally included for purposes of familiarization, to obtain photographs or to record bird observations. Four flights made during April 1977 were for purposes of surveying and collecting seals. Only the pilot and one observer participated on these in order to make allowance for the weight of seals brought back to the ship. Helicopter survey flights were of relatively short duration and were usually within a 30 mile radius of the ship.

The Lockheed P-2V was utilized as a long range survey aircraft. Duration of some survey flights exceeded 9 hours and covered more than 1,200 miles of track line.

The observation and flight decks were separated and duties of the observers and flight crew did not interfere with each other.

As in the helicopter, the P-2V was equipped with a GNS which was the basic instrument for navigation during surveys. A separate repeater unit of the GNS was mounted in the forward observation bubble, providing instantaneous information to observers and the recorder. Two angle indicators were mounted in the observation bubble and were used to determine boundaries of the strip transects. Width of the strip was one-half mile on either side of the aircraft. This mile wide strip was subdivided into four segments: 0 to 1/4 mile and 1/4 to 1/2 mile on both sides of the plane. All sightings were recorded accordingly. Animals sighted beyond 1/2 mile of the plane were also recorded but these data were not statistically analyzed.

The same basic information was recorded during survey flights of the P-2V as during survey flights of the Bell 206 helicopter.

Flight altitude of the P-2V was 300 ft. Lower altitudes were occasionally necessitated by weather. Flight speed averaged 140 mph.

The P-2V flights of 8, 9 and 11 April were random although restricted mainly to the ice front. Our intent was to determine the general distribution, density and species composition of marine mammals in relation to latitude and longitude within the ice front. The birth period of spotted seals was well underway by 11 April, although it did not appear that most births had occurred. P-2V flights were discontinued until 17 April. Flights of 17 and 19 April were along pre-selected, random flight lines and were designed to achieve a replicate stratified random sample within the recognized area of highest seal density. This area extended generally from 161°30'W to 165°00'W and was between 56°10'N and 57°00'N.

Flights of 20 and 21 April were mainly in an east-west direction. They were not totally random in that the southern part of the front was covered on the 20th, and the northern part of the front (extending into the heavier pack) was covered on the 21st. The flight of 23 April was a traverse of western and northern Bristol Bay, enroute to Anchorage.

B. Procedures used to identify marine mammals on the ice

The greatly increased tempo of research and development activities in the Bering Sea is providing more people with the opportunity to observe marine mammals and to report their observations. We have frequently been asked to provide a resumé of how the various pinniped species can be distinguished from one another when they are hauled out on the ice. It is difficult for an untrained observer to properly identify some of the seals from the air. Our procedures are based on many hundreds of hours of observation from small boats and ships, as well as participation in numerous aerial surveys.

During aerial surveys of marine mammals the aircraft commonly flies at a low altitude (500 feet or less) and at a relatively slow speed (less than 150 knots). There is usually a period of several seconds during which an animal on the ice will be in view. Large, dark colored animals, such as sea lions and walruses, can be observed at far greater distances and are therefore visible for a longer period of time than are the smaller, light colored seals.

It is usually possible to correctly identify an animal on the basis of one or more characteristics including color, relative size, shape, and behavior or escape response. Additional considerations are the ice type, location, orientation of the animal on an ice floe and the season and area of the survey. Although the casual observer can concentrate on an individual animal or group of animals, persons conducting surveys cannot. The surveyor must train himself to constantly scan a transect area, periodically returning to an unidentified animal until an identification has been made or the animal is no longer in sight.

Sea lions appear brown, reddish brown or tan depending on sex and age of the animal and light conditions. They are large and are usually seen on the ice in small groups of three to eight. However, single animals are regularly observed. Larger groups are infrequent on the ice. The body of a sea lion appears long and tapered toward the head. This appearance is accentuated when they are alarmed and extend their long necks. Most sea lions respond to a low flying airplane within one-half mile by escaping into the water. They frequently "gallop" across the ice, at which time the long fore- and hindflippers are obvious. They dive into the water head first. During spring months when sea lions haul out on ice, they do so mainly on small floes at the extreme southern edge of the front or within a few miles of it. They are likely to be encountered at any location along the ice edge.

Walruses also appear dark brown to reddish brown, depending on light conditions. Walruses are large, and rest on the ice as solitary animals or in tightly packed herds. In the ice front during April they are usually seen in groups of between 2 and 15 animals. Large herds of 500 or more walruses are seen on the ice, usually in the northern Bering Sea.

Walruses do not have the sinuous outline of sea lions. They are very stout and seemingly truncated at both ends. The head terminates in a very broad and flat snout. Tusks are obvious at close range but are surprisingly difficult to see at a distance.

Their response to an aircraft is quite variable, apparently depending on weather conditions. On bright, calm days, they will usually remain on the ice unless the aircraft is immediately over them. Often, they will neither rouse nor change position. On cold overcast days walruses within one-quarter mile of a large aircraft will rouse and enter the water at any angle, rolling, sliding, backing or going in head first. They do not "gallop" across the ice floes as do sea lions.

During winter and spring, walruses haul out on a variety of different ice types from the small floes of the front to the large, heavy floes of the southern Chukchi Sea. They rest mainly around the edges of floes, close to cracks, leads or polynyii and may be found anywhere in regions where sea ice is present. Centers of abundance during early spring (depending on ice conditions) are Bristol Bay, outer Kuskokwim Bay and northcentral Bering Sea. They are not usually abundant near the ice edge.

Bearded seals are the largest true seals (Phocids) of the Bering Sea but are smaller than walruses or sea lions. From the air they appear almost uniformly grey (sometimes tan). The anterior part of the head frequently appears dark when seen at close range. The body is long and thick and the head appears unusually small. They appear to rest soundly, raising their heads infrequently.

These seals usually react mildly to an airplane, even at close range. They almost always raise their heads, frequently look up at the plane and usually remain on the ice unless the plane passes directly over them. They do not form herds nor, with the exception of females with pups, do they rest next to each other, with bodies touching. They are encountered mostly as singles, although several may rest on a single floe. They lie on their bellies and, almost without exception, their heads are within a few feet of open water. When several bearded seals are lying on a single ice floe they are at the edge and appear as if facing away from each other. If animals are resting on both sides of a narrow lead they also face the water and orient themselves perpendicular to the axis of the lead. They rarely rest farther than a few feet from water and, when alarmed, move toward it in a wriggling gait using both fore-flippers in unison. They slide head first into the water frequently raising their hind end high in the air as they dive. The hindflippers do not rotate forward and are not used for locomotion over the ice. Fore- and hindflippers are not obvious except at close range. Pups in association with adult females (mainly in April) appear dark.

Bearded seals occur throughout the pack ice where there are openings. However, they are not numerous in areas of extensive, large heavy floes or on shorefast ice.

Ringed seals are the smallest of the ice associated seals. From the air, during April, they appear short and fat. At a distance they look dark grey. At close range they are silver-grey on flanks and belly and dark grey on the dorsal surface. The dark rings, from which this seal derives its common name, are not obvious from the air, although they do account, in part, for the darker appearance of the back. These seals usually lie on their bellies and raise their heads frequently even when not disturbed. The head appears large compared to the body. Except for some very young animals (weaned pups in partially destroyed lairs along pressure ridges during late April and May) ringed seals seem always to haul out where the ice is flat. In areas where drifting ice is subject to considerable motion, they tend to use the rather large, heavy floes, usually coming out of the water through exit holes well away from the floe edge and in a flat area. They are common in the shorefast ice and the heavy drifting ice of the northern Bering and Chukchi seas. In spring they can be seen concentrated around an exit hole or lined up on either side of a narrow crack. When on the ice they orient themselves so that their heads are close to either an exit hole or a narrow lead. If alarmed they move a very short distance by wriggling, using both foreflippers in unison and slide, head first into the water. Exit holes can usually accomodate only one seal at a time. When several ringed seals are resting by a single hole and become alarmed, they sometimes block each other from access to the water. During cold weather their exit holes may refreeze, or the cracks close due to motion of the ice, thus barring re-entry into the water. This has been observed mainly in the thick, stable ice of the Beaufort Sea.

In our experience we have not observed ringed seals at any distance from a hole or crack. They normally do not "run" around on the ice when alarmed, nor are tracks observed except immediately adjacent to the opening through which they exit and enter the water.

From an aircraft, ringed seals can be mis-identified as spotted seals or recently weaned ribbon seals if judgments are based solely on relative size, shape and color.

Spotted seals, at a distance, also appear dark grey against a background of snow covered ice. In bright or sunny conditions and within distances of 1/2 mile of an airplane some variation in color can usually be noted. Most individuals have a straw colored or yellowish cast, at least on the flanks, and are darker on the back. However, individuals vary in color, some being entirely straw-yellow, and others dark on the back and flanks. If the yellow coloration is not noticeable, the two-toned grey appearance of back and sides resembles that of the ringed seal.

As adults, spotted seals are larger than ringed seals, but the younger age animals overlap in size. Shape of the two seals is different; ringed seals appear football shaped and spotted seals less rotund and longer. However, this is extremely difficult to perceive from an aircraft unless there is ample opportunity to observe both species within a close period of time. Spotted seals appear to have a long, dog-like snout.

Based on behavioral characteristics, spotted seals are easily identifiable. During spring they haul out as singles, as breeding pairs with an off-white colored pup or in large but loose aggregations of all age classes. These aggregations may occupy several adjacent ice floes. They do not commonly use holes as do ringed seals, but leave and re-enter the water at the floe edges. Spotted seals are very active on the ice. They rest almost anywhere on floes and, during cool windy weather, seek the shelter of ice ridges or depressions, often several meters from the floe edge. They rest on their bellies or flanks.

When snow and light conditions are good, the tracks of spotted seals are quite obvious, crisscrossing the ice.

Spotted seals generally react strongly to the sound of aircraft even at considerable distances. Their activity makes them quite noticeable as they race across the floes, often changing direction and finally diving off the floe edge head first. They move in the same wriggling motion as do the bearded and ringed seals. The foreflippers are moved mostly in unison. During April, the white-coated pups remain on the ice and can be seen as they move about. If a pup is on a floe with ridges or snow drifts, it will often be in or among them.

During spring, spotted seals are most abundant in the ice front, utilizing the smaller floes near the southern terminus of the pack. In April 1976, they were abundant in the first 30 miles of ice, but mainly from about 2 to 15 miles inside the ice margin. However, they may also be encountered some distance north of the front in areas where currents or winds keep the ice thin and broken.

As sea ice recedes and disintegrates in late spring and spotted seals move north, become more common along the coast and appear in bays and estuaries, hauling out on land.

Ribbon seals can be the easiest or the most difficult species of seal to identify from the air. Males and females, although marked similarly, are different in color. Males older than one year are black or dark brown with white ribbons around the neck, posterior abdomen and encircling each foreflipper. In favorable light conditions their markings are highly visible within one-fourth mile of an airplane. Color pattern of the females is similar to the males. However, instead of white on black, they show white on a background of grey. They frequently appear uniformly grey. Females are often very difficult to identify based on color. At a distance the males appear uniformly dark and the females grey.

Unweaned pups are white (noticeably whiter than spotted seal pups) and have a dark muzzle. By the time they are weaned (late April to early May) and have shed their white hair, they develop a two-toned color pattern, dark on the dorsal surface with silver-grey flanks and belly. They have no noticeable ribbons.

Adult female ribbon seals are commonly misidentified as young bearded seals or spotted seals and the weaned pups as ringed or spotted seals.

Adult ribbon seals are larger than ringed seals and about the same size as spotted seals. They are usually more slender than spotted seals and the comparison of shape with ringed seals is therefore striking to an experienced observer. There is little difference in relative shape of young animals of these three species and, unfortunately, there is considerable overlap in size of subadults.

With the exception of the strikingly marked adult males (and some females), identification of ribbon seals is based on some rather unique behavioral characteristics. These seals usually haul out on relatively thick, clean, rough, snow covered ice floes in the ice front. In April, they are most numerous between 20 and 50 miles north of the southern terminus of seasonal ice. They do not make exit holes like ringed seals but leave and enter the water at the floe edges, similar to spotted seals. They are active on the ice, move well away from water and can be found on any part of a floe, even amidst rough, pressure ridged areas at a considerable distance from water. They commonly rest on their sides. These seals are usually encountered as single animals or in April as mother-pup pairs. White-coated pups are often unattended on the ice. They rest for long periods of time without raising their heads and usually react mildly, if at all, to an aircraft. Their position on the ice, reaction to aircraft and their manner of moving across the ice are the best criteria for identifying ribbon seals which are not distinguishable based on color.

As an airplane approaches, these seals often move around rapidly. Their movements are markedly different from those of the other seals as they do not wriggle but slide along by alternately extending each foreflipper and vigorously moving the posterior torso from side to side. When moving, the head is extended forward and is kept low to the ice. This movement can perhaps best be described as slithering. They commonly appear quite confused, move in circles or abruptly change direction, and often do not go into the water. If they do go into the water they slide, head first.

Ribbon seals are associated with the ice front during spring and become pelagic as the ice disappears from Bering Sea. They are seldom encountered near the coast and sightings in the Chukchi Sea are infrequent.

In summary, the most common misidentification of pinnipeds is likely to be adult female ribbon seals as young bearded or spotted seals, young ribbon seals as spotted or ringed seals and single spotted seals, especially young ones, as ringed seals. Misidentification can be minimized by noting behavior, position on the ice and in relation to holes, cracks or other openings, manner of movement and association with other seals. Color patterns are not always noticeable in "average" or marginal survey conditions.

C. Statistical Procedures

1. Spotted seals

Surveys conducted with the Lockheed P-2V provided broad coverage of the ice front. The total survey area was subdivided into 17 sectors in order to test, if possible, for geographical differences in distribution and density. Observations from all strip transects (or parts thereof) within each sector were analyzed. Density was calculated based on a weighted or ratio estimator. The variances generated were those appropriate for a ratio estimator. Variances were calculated when survey design included a number of randomly selected transects flown on the same day within a sector (i.e. sectors 1 and 2) or when the combination of number of transects flown on the same day and sightings of seals warranted generation of a variance.

Several factors resulted in our reluctance to subject all of the spotted seal data acquired from the P-2V surveys to rigorous statistical analysis. These factors included: the clumped distribution of large aggregations of seals; lack of an indication of measurement error (sightability of seals); the occurrence of surveys on different days in different parts of a sector; and potential problems associated with serial correlation of transects. No attempt was made to estimate size of the spotted seal population in the various subareas.

The data base provided by the P-2V surveys was very useful in providing information about relative density of spotted seals throughout the ice front and the ratio of pups to animals older than pups in the different areas. Comparisons were mainly of derived densities. More rigorous tests of differences are based on results of helicopter flights conducted in 1976 and 1977.

Results of all surveys made with the helicopter were statistically analyzed. Estimated density of seals observed in strip transects and the variance of density were derived as indicated above. Comparisons between pairs of flights in different regions were made utilizing the two-tailed, nonparametric Mann-Whitney test. Comparisons of more than two flights were based on the Kruskal-Wallis analysis of variance by ranks (Zar 1974).

Analysis of the helicopter survey data for spotted seals provides an excellent basis for interpreting results of the more extensive P-2V flights.

Some estimates of the proportion of seals in the water versus on the ice were obtained during seal collecting excursions in small boats immediately prior to conducting a survey with the helicopter.

2. Walruses

As with our analysis of data for spotted seals obtained from the P-2V aircraft, the walrus data were treated by sector. Nine sectors were established covering the total survey area in the ice front extending from Bristol Bay to 180°W longitude. Densities and variances of densities for transects in each sector were derived. Total number of walruses in each sector was estimated by extrapolating the derived density of walruses observed in all transects within a sector, to size of the total sector north of the ice edge.

Estimates of total numbers were made because, unlike spotted seals, walruses were highly visible, groups were well defined and usually small, counts were more accurate and a much higher proportion of animals were apparently resting on the ice during the hours when surveys were conducted.

VI. Results

A total of 25 separate survey flights were made during March-April 1976 and 1977. Seven helicopter flights were made in 1976. These are discussed as surveys 1 through 7. Eight flights were made during April 1976 in a Lockheed P-2V. All of the P-2V flights are treated in relation to transects within sectors. Ten helicopter flights were made during March-April 1977 and are discussed as surveys 16 through 25. The navigation information for all flights is attached as Appendix I.

Participants on the 25 surveys are indicated in Table 1. Flight routes of surveys from the P-2V are illustrated in Figs. 8 through 15. Surveys with the P-2V resulted in 6,593 nautical miles of transects which were treated in our analysis of spotted seals. The total number of transect miles utilized in our analysis of walrus distribution and abundance was 6,858.

Spotted seal surveys from the P-2V

The 17 sectors considered in our analysis of spotted seal distribution are shown in Figs. 16 and 17. Exact locations of these sectors are included in Appendix II. Results of the surveys are summarized in Tables 2 and 3.

A very low density of seals occurred in the eastern part of Bristol Bay (sector 12) and in the southcentral part of the bay (sector 11). Moderate densities occurred in the western part of the bay, between 161°35'W and 162°45'W (sectors 1 and 13). The highest densities found during our P-2V surveys were immediately to the west of 161°35'W and extended to 165°00'W. This area included sectors 2, 3 and 14. The region of the front between 165°00'W and 169°00' (sectors 4 and 15) was generally one of low density, while that west of 169°00'W and extending to 180°00'W was an extensive area of moderate seal density.

Estimates of density for sectors 5, 16 and 17 probably reflect a degree of error associated with sampling. As an example, sector 16 is essentially a combination of sectors 6 and 7, but shifted slightly to the south. Seal densities in sectors 6 and 7 are considered to be moderate whereas in the larger area of sector 16, with its southern extension into the very fringe of the ice front, density of seals appeared to be low.

The general pattern of relative abundance of spotted seals is evident from results of the P-2V surveys.

There was a marked difference in the proportion of pups in various sectors. The proportion of pups was very low in eastern Bristol Bay (sectors 11 and 12). In the sectors of moderate and high seal density in western Bristol Bay (sectors 1, 2, 3, 13 and 14) the proportion of pups was also low, ranging from 1.7 percent to 12.0 percent of the number of spotted seals seen in these sectors. This indicates that most of the seals in these areas of concentration were either subadults or non-breeding adults.

West of 165°00'W (sectors 4-10, 15 and 17) where seal densities were also moderate, the proportion of pups was much higher, ranging from 18.8 percent to 37 percent (sector 16 is considered an anomaly for the reasons indicated above). Apparently the vast majority of seals occurring in the ice front west of 165°00'W are breeding age adults.

Table 1. Personnel who participated in aerial surveys during March-April 1976 and 1977*

A. Bell 206 Helicopter launched from OSS SURVEYOR, 1976

Date	Flight No.	Survey Personnel
27 March	1	J. Burns (ADF&G)
20 April	2	K. Frost (ADF&G), J. Hall (USFWS)
23 April	3	K. Frost, J. Hall
24 April (1st flight)	4	K. Frost, J. Hall, P. McGuire (NMFS)
24 April (2nd flight)	5	K. Frost, J. Hall, L. Shults (UofA)
25 April (1st flight)	6	K. Frost, J. Hall, L. Lowry (ADF&G)
25 April (2nd flight)	7	K. Frost, J. Hall, L. Lowry

B. P2V Aircraft, 1976

Date	Flight No.	Survey Personnel
8 April	8	J. Burns, D. James (ADF&G), S. Harbo (UofA)
9 April	9	J. Burns, D. James, S. Harbo
11 April	10	J. Burns, D. James, S. Harbo
17 April	11	J. Burns, D. James, B. Everitt (NMFS)
19 April	12	J. Burns, D. James, B. Everitt
20 April	13	J. Burns, D. James, B. Everitt
21 April	14	J. Burns, D. James, B. Everitt, G. Harry(NMFS)
23 April	15	J. Burns, D. James, B. Everitt, G. Harry

C. Bell 206 Helicopter launched from OSS SURVEYOR, 1977

Date	Flight No.	Survey Personnel
28 March	16	K. Frost, L. Shults
30 March	17	K. Frost, R. Dieterich (UofA)
21 April	18	J. Burns, K. Frost
23 April (1st flight)	19	L. Lowry
23 April (2nd flight)	20	L. Lowry
24 April (1st flight)	21	J. Burns, E. Muktoyuk (ADF&G)
24 April (2nd flight)	22	K. Frost
25 April	23	J. Burns
27 April (1st flight)	24	J. Burns, E. Muktoyuk
27 April (2nd flight)	25	J. Burns, K. Frost

*In 1976, flight crew for the ship based helicopter included D. Winter (pilot), W. Harrigan (pilot), G. Mitchell (mechanic), all with the National Oceanic and Atmospheric Administration. Flight crew aboard the P-2V included L. Caulkett (chief pilot), T. Belleau (pilot) and W. Bean (engineer), all with the USDI, Office of Aircraft Services. Helicopter flight crew in 1977 included W. Harrigan (pilot), T. Leyden (pilot) and G. Mitchell (mechanic), all with NOAA.

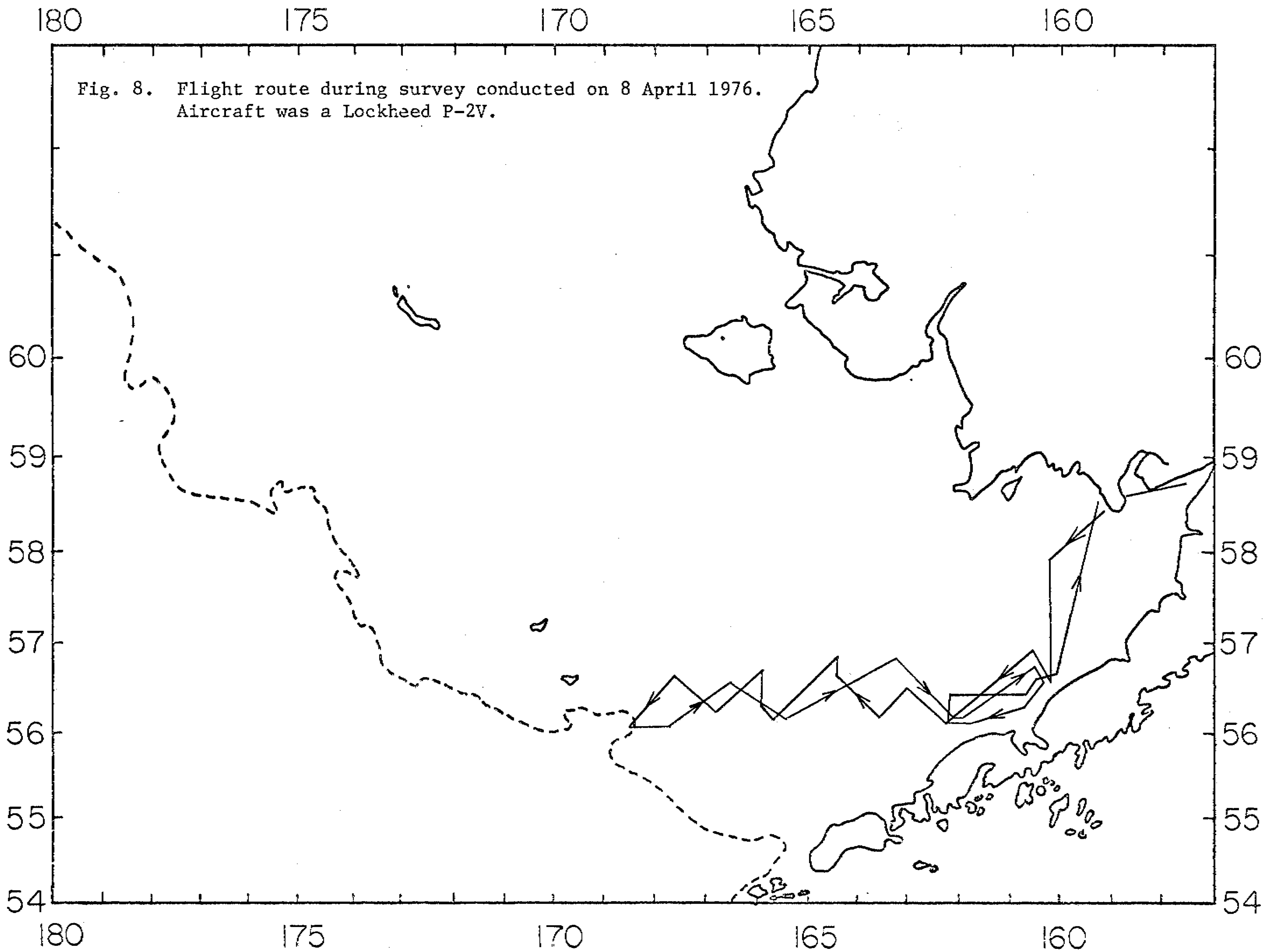

Fig. 8. Flight route during survey conducted on 8 April 1976. Aircraft was a Lockheed P-2V.

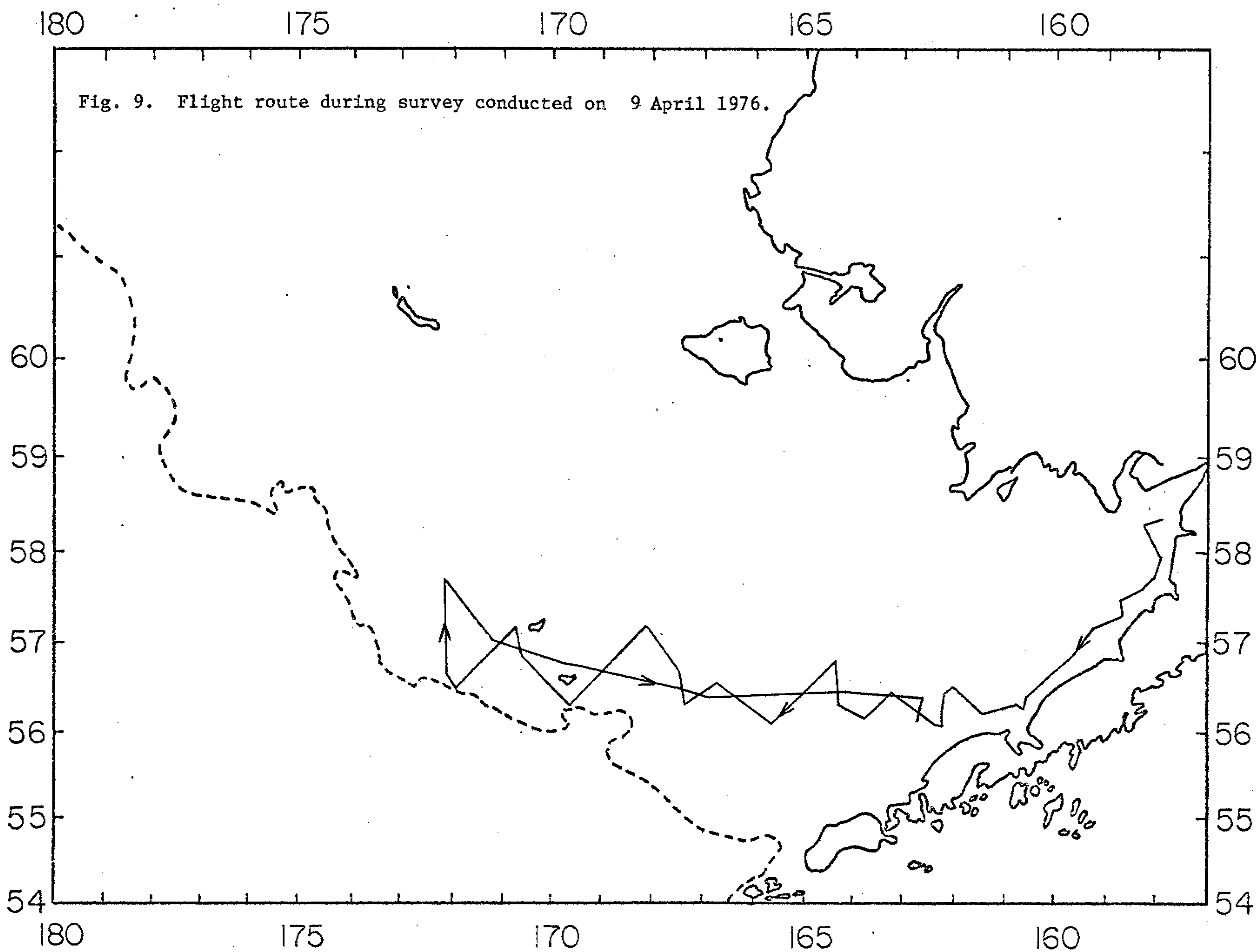

Fig. 9. Flight route during survey conducted on 9 April 1976.

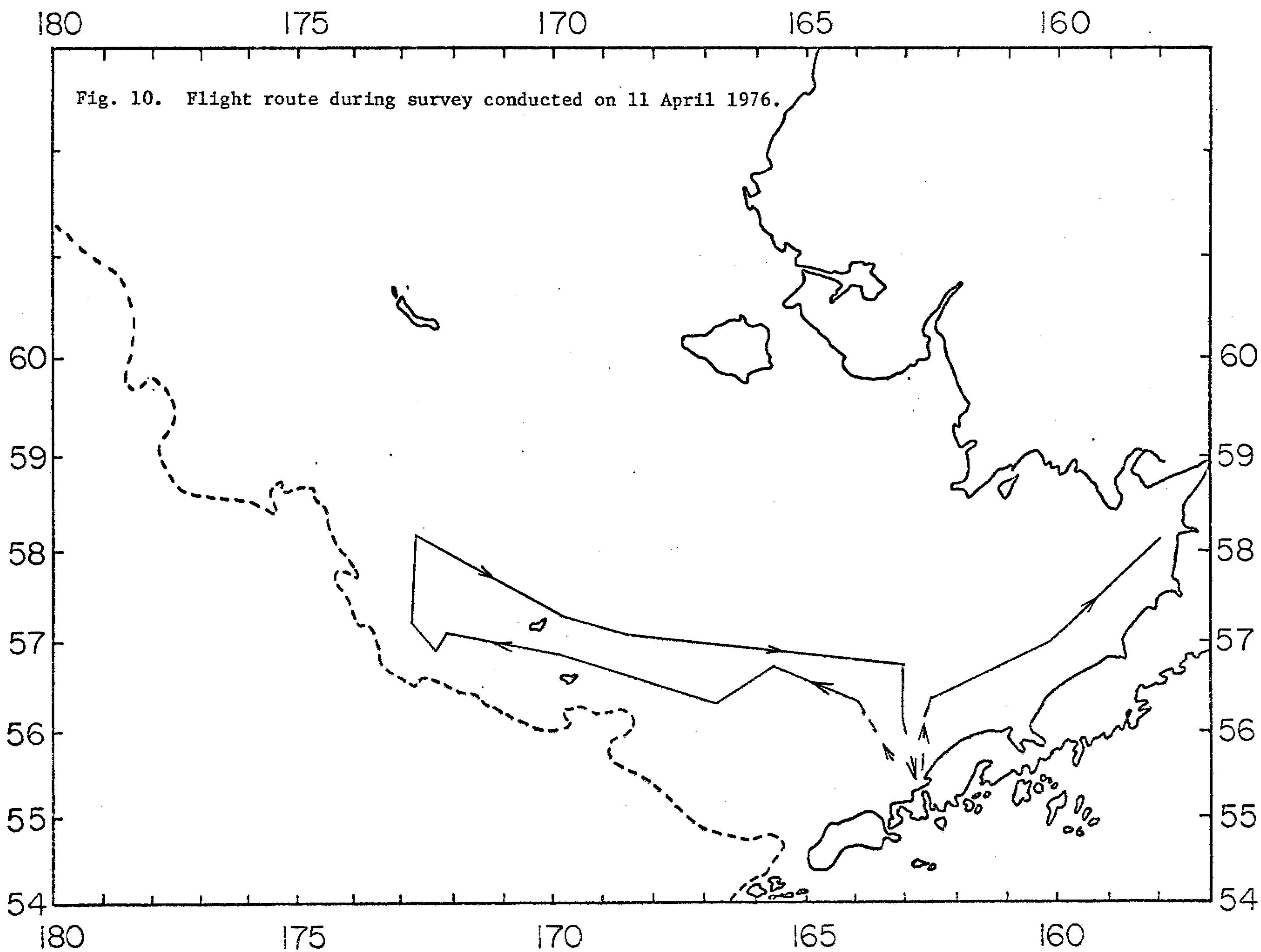

Fig. 10. Flight route during survey conducted on 11 April 1976.

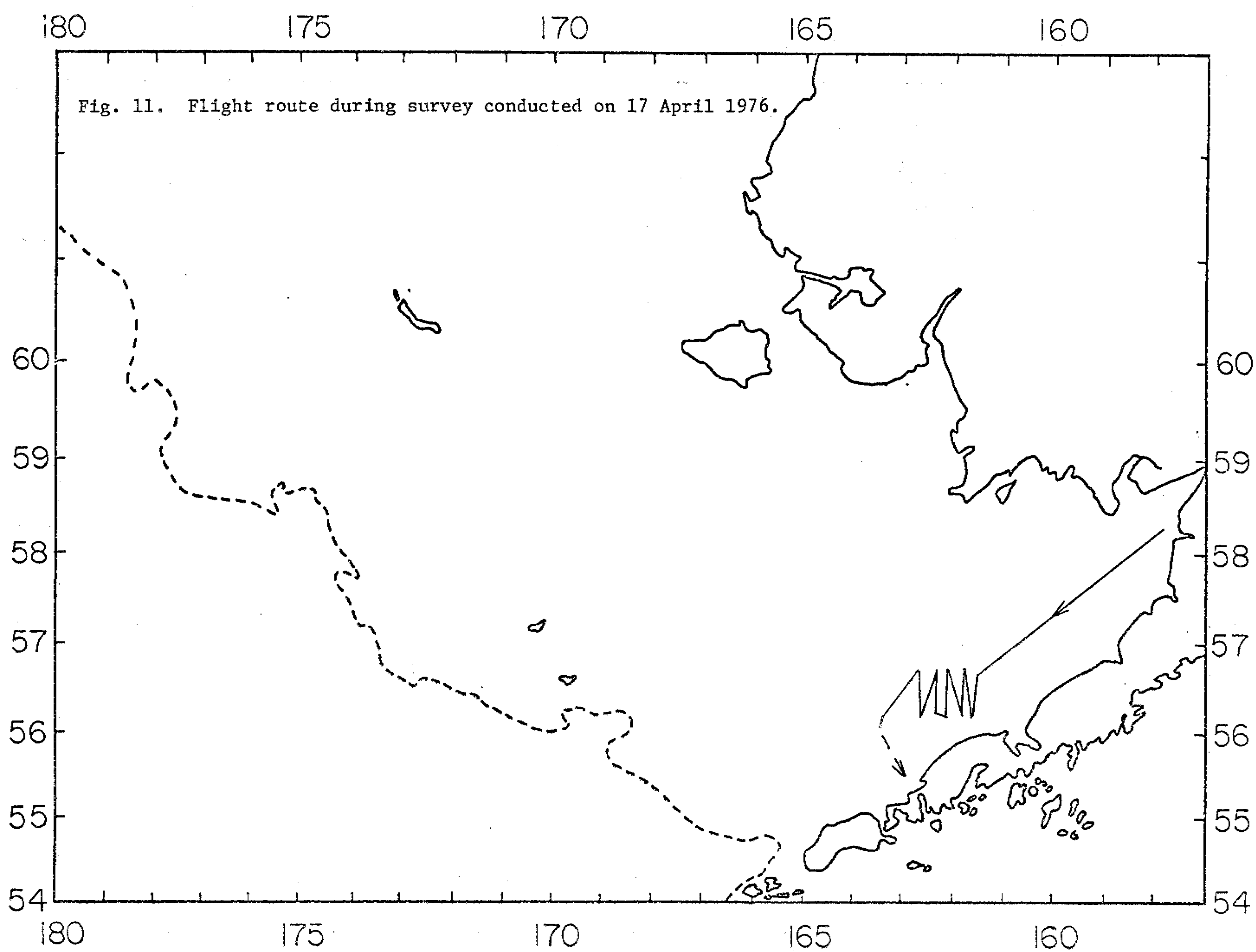

Fig. 11. Flight route during survey conducted on 17 April 1976.

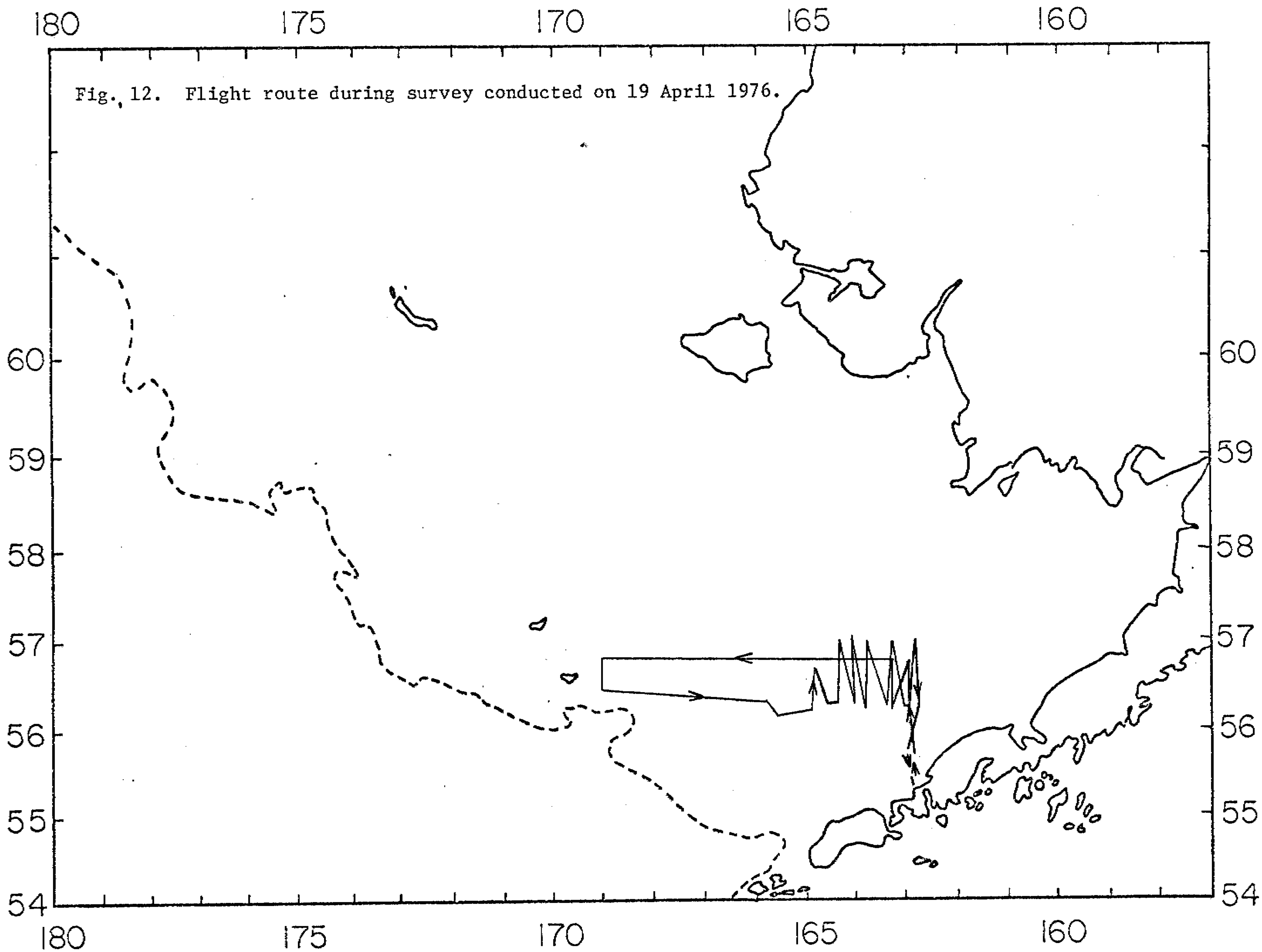

Fig. 12. Flight route during survey conducted on 19 April 1976.

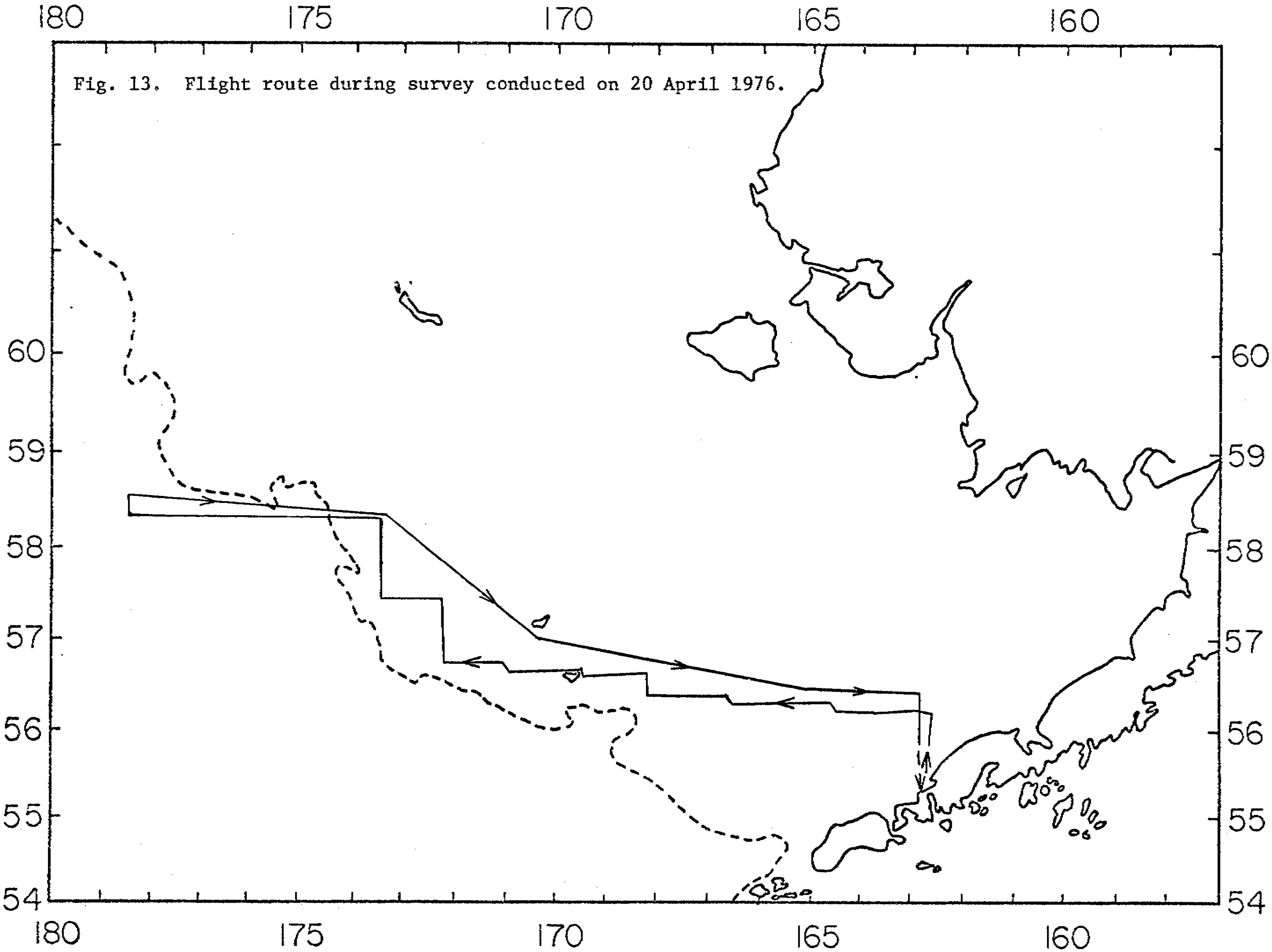

Fig. 13. Flight route during survey conducted on 20 April 1976.

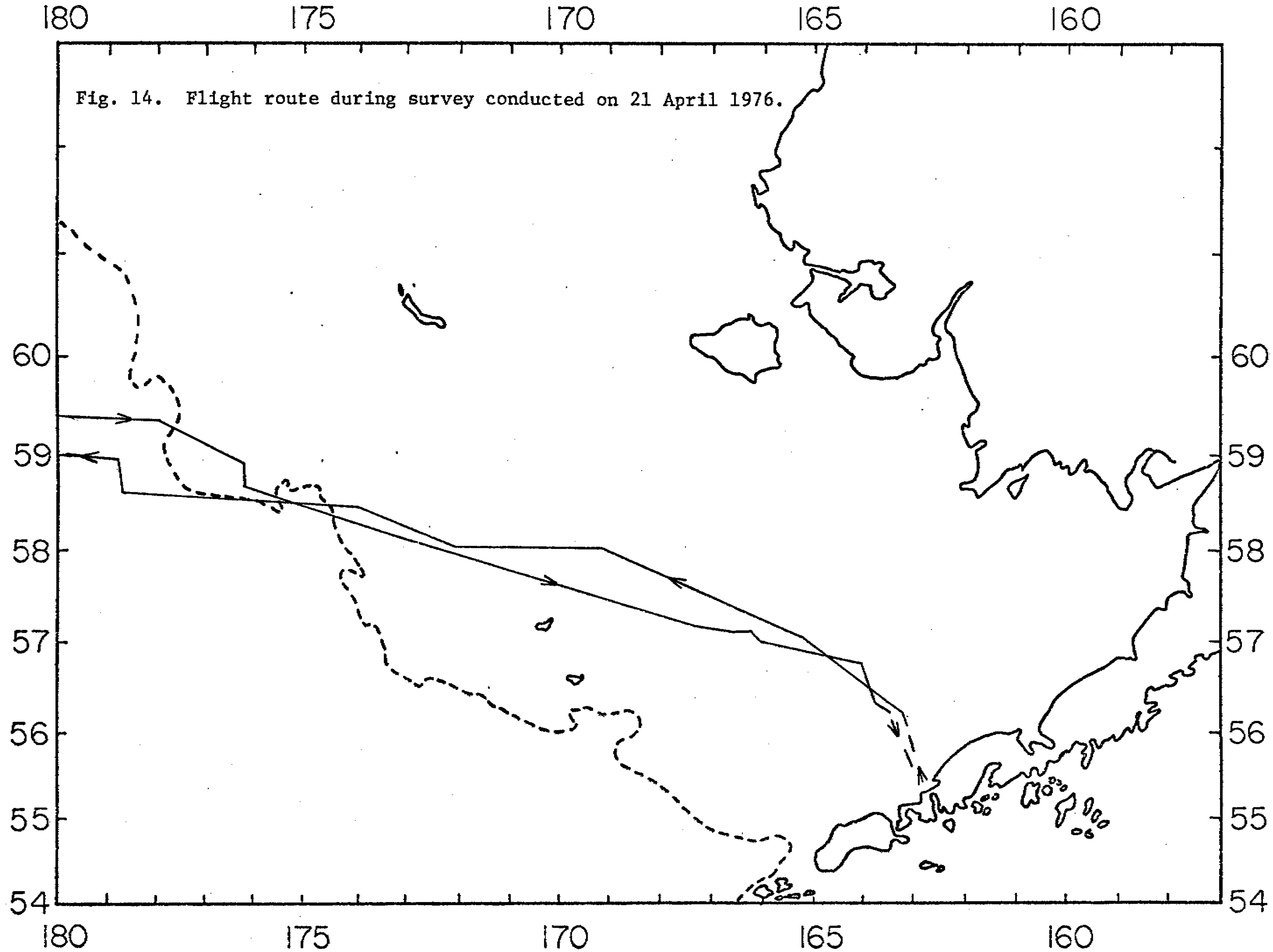

Fig. 14. Flight route during survey conducted on 21 April 1976.

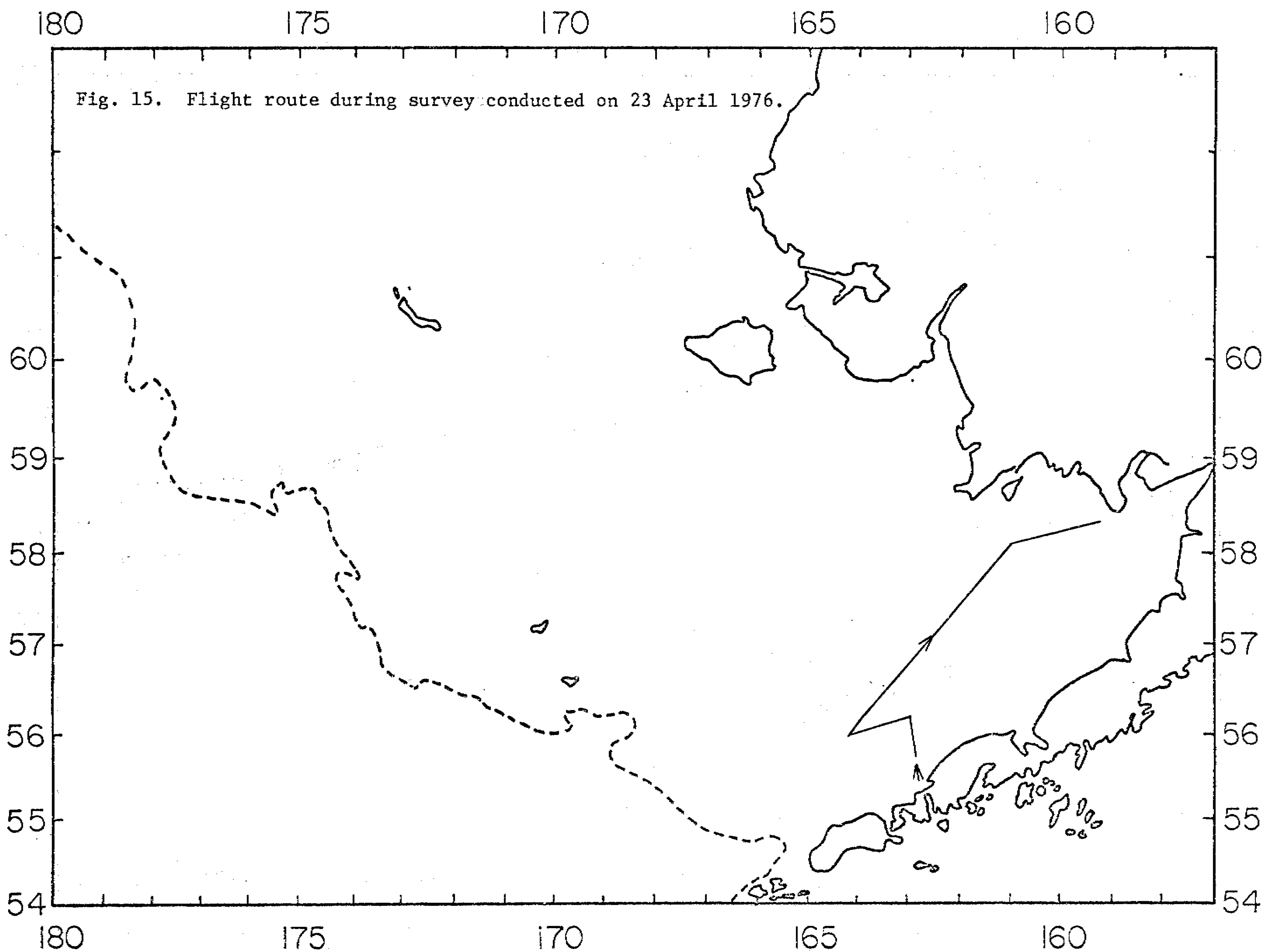

Fig. 15. Flight route during survey conducted on 23 April 1976.

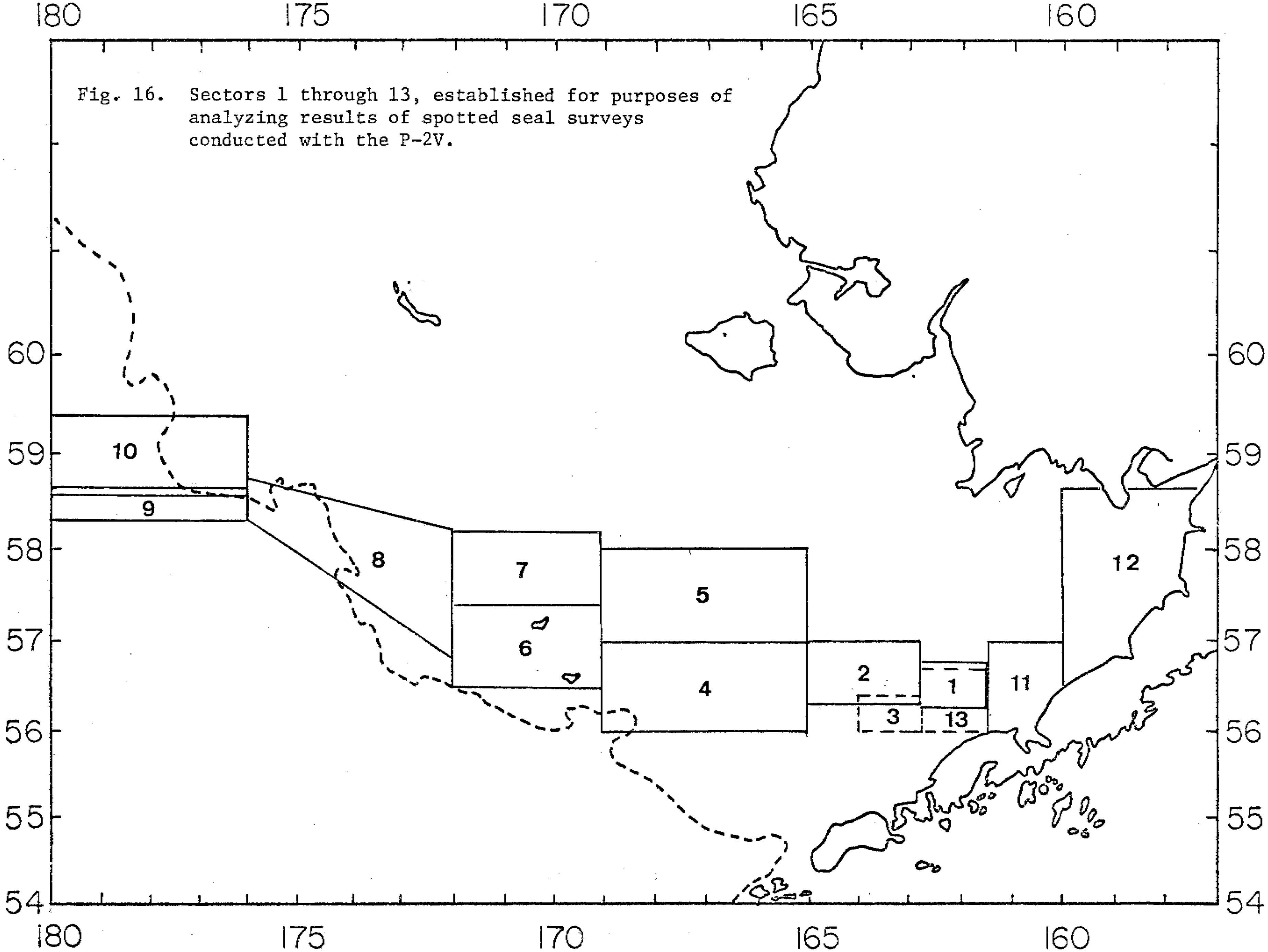

Fig. 16. Sectors 1 through 13, established for purposes of analyzing results of spotted seal surveys conducted with the P-2V.

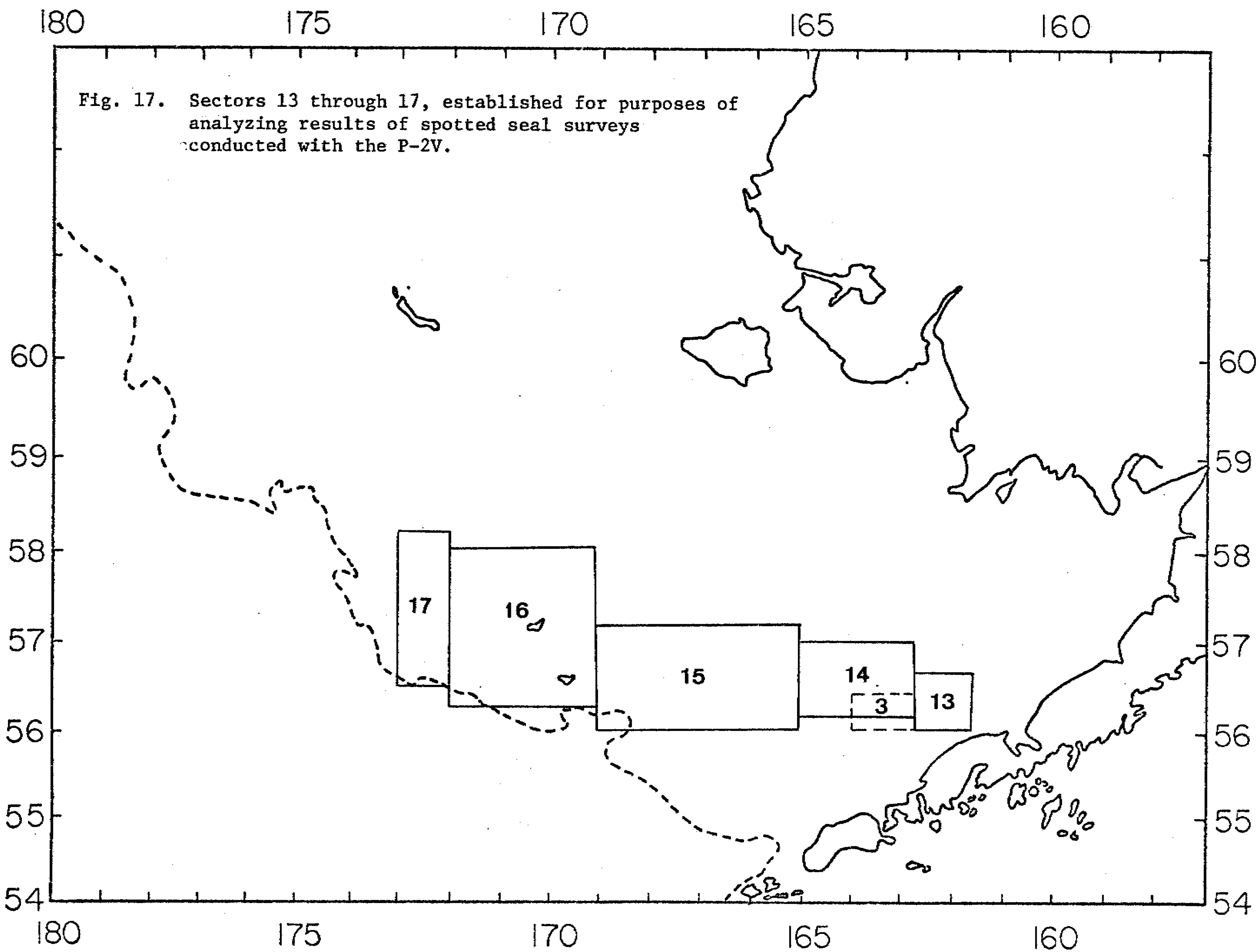

Fig. 17. Sectors 13 through 17, established for purposes of analyzing results of spotted seal surveys conducted with the P-2V.

Table 2. Results of surveys for spotted seals conducted from a Lockheed P-2V aircraft in the ice front of Bering Sea, April 8-23, 1976. Data include sector number, area surveyed, number of seals observed, proportion of pups, density of seals and, where appropriate, variance of density of seals older than pups.

Sector	Area surveyed (NM^2)	Number of seals sighted older than pups	Number of pups sighted	Proportion of pups (%)	Density of seals older than pups/(NM^2)	Density of all seals /(NM^2)	Variance (seals older than pups)
1	111.3	14	1	6.6	0.13	0.13	0.5600
2	109.8	134	16	10.7	1.22	1.37	2.4803
3	142.9	366	27	6.9	2.56	2.75	*
4	249.4	16	7	30.4	0.06	0.09	-
5	106.9	16	9	36.0	0.15	0.23	-
6	91.8	13	3	18.8	0.14	0.17	-
7	85.9	19	7	26.9	0.22	0.30	-
8	273.1	90	25	21.7	0.33	0.42	*
9	78.7	17	10	37.0	0.22	0.34	-
10	161.4	38	12	24.0	0.24	0.31	*
11	178.7	4	0	0	0.02	0.02	-
12	183.1	10	1	9.0	0.05	0.06	-
13	122.9	22	3	12.0	0.18	0.20	-
14	244.8	229	4	1.7	0.94	0.95	*
15	415.2	18	6	25.0	0.04	0.06	-
16	210.9	10	1	9.1	0.05	0.05	-
17	82.9	4	2	33.0	0.05	0.07	-

*Variances for selected data sets within these sectors are included in Table 3.

Table 3. Results of analysis of selected data sets from spotted seal survey of 8-23 April 1976. Aircraft utilized was a Lockheed P-2V.

Sector number	Date	Number of transects	Area surveyed (NM^2)	Number of seals older than pups	Density	Variance
3	April 19	10	38.32	104	2.71	0.9814
8	April 20	8	156.6	47	0.30	0.0026
	April 21	5	116.5	43	0.37	0.0186
10	April 21	8	161.4	38	0.24	0.0026
14	April 8	7	92.0	30	0.34	0.024
	April 9	7	91.17	101	1.11	0.088
	April 11	4	61.64	98	1.59	2.5843

Walrus surveys from the P-2V

The nine sectors examined in our analysis of walrus distribution are shown in Fig. 18. Exact locations of these sectors are included in Appendix III. Results of the walrus surveys are summarized in Table 4.

Walrus densities were very low in the ice front of eastern Bristol Bay (sector 1), between 162°45'W and 165°00'W (sector 5) and in the region west of 172°00'W. Highest densities were in central and western Bristol Bay (sectors 2, 3 and 4), immediately east of the region of high spotted seal densities. The central portion of the survey area (sectors 6, 7 and 8) were areas of comparatively moderate density.

The estimated number of walruses in the areas surveyed was 10,055.

Spotted seal surveys from the helicopter

Areas within which helicopter surveys of spotted seals were made during 1976 and 1977 are shown in Figs. 19 and 20 (the same as Figs. 4 and 5; duplicated here for the reader's convenience). The results of these survey flights are summarized in Tables 5 and 6.

Results of surveys conducted during March of both years (surveys 1, 16 and 17) were not compared with results of surveys made in April. However, they are included as information of general interest.

Five of the six helicopter flights in April 1976 (flights 3 through 7) were within the region of moderate to high seal density as indicated by the P-2V flights. Some southward movement of sea ice occurred after April 23 when surveys with the P-2V were completed, but we consider helicopter flights 3 through 7 to have been in sectors 1, 2, 3 and 13 as shown in Fig. 16.

Application of the Mann-Whitney test in paired comparisons of flights 3 through 7 do not support rejection of the hypothesis that observed seal densities were significantly different for these flights at either the 90 or 95 percent probability level.

Application of the Kruskal-Wallis test also indicated that densities as observed on these five flights were not statistically different $H_c = 7.629$; chi-square 0.05, 4 df = 9.488; chi-square 0.10, 4 df = 7.779).

No seals were observed on survey number 2, which occurred in sector 8 (an area of moderate seal density as indicated by P-2V flights).

Helicopter surveys of April 1977 were conducted in the ice front which was considerably farther north than it was in 1976 (see Fig. 6). The pattern of seal distribution in the front as it existed in 1977 closely approximated that in the front as it existed in 1976: A high density of seals in the vicinity of 165°W

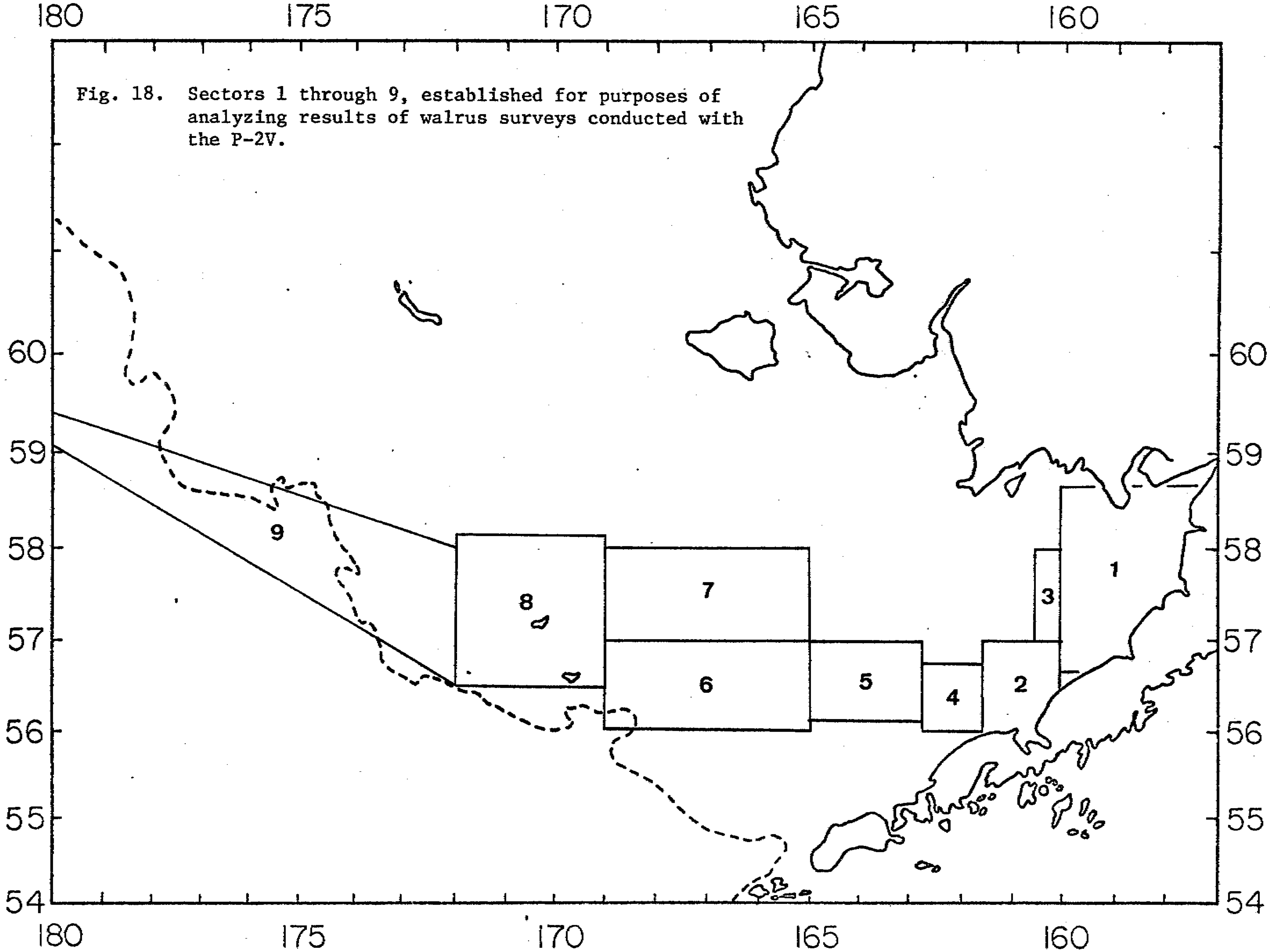

Fig. 18. Sectors 1 through 9, established for purposes of analyzing results of walrus surveys conducted with the P-2V.

Table 4. Results of walrus surveys in the ice front, April 8-23, 1976. Aircraft used was a Lockheed P-2V. Data included are sector number (refer to Fig. 18), number of strip transects within each sector, area surveyed, walruses observed in strip transects, density of walruses in transects, variance of density, total area of sector[1] and estimated number of walruses in each sector.

Sector	Number of transects	Area surveyed (NM^2)	Number walruses counted	Density of walrus in transects ($/NM^2$)	variance	Area of sector (NM^2)[1]	Estimated number of walrus in sector
1	14	433.0	9	0.021	0.4427	6382	134
2	16	356.8	215	0.603	0.3814	2708	1633
3	3	81.4	156	1.917	0.1923	966	1852
4	28	494.4	630	1.286	0.3770	1764	2269
5	51	1399.8	94	0.067	0.0010	3869	259
6	39	1364.3	219	0.161	0.0213	7932	1190
7	11	268.3	46	0.171	0.0342	7728	1321
8	19	777.2	100	0.129	0.0038	9675	1248
9	27	1167.0	13	0.011	0.0040	13504	149

[1] Exclusive of the area within each sector which was beyond the southern margin of sea ice during the survey period.

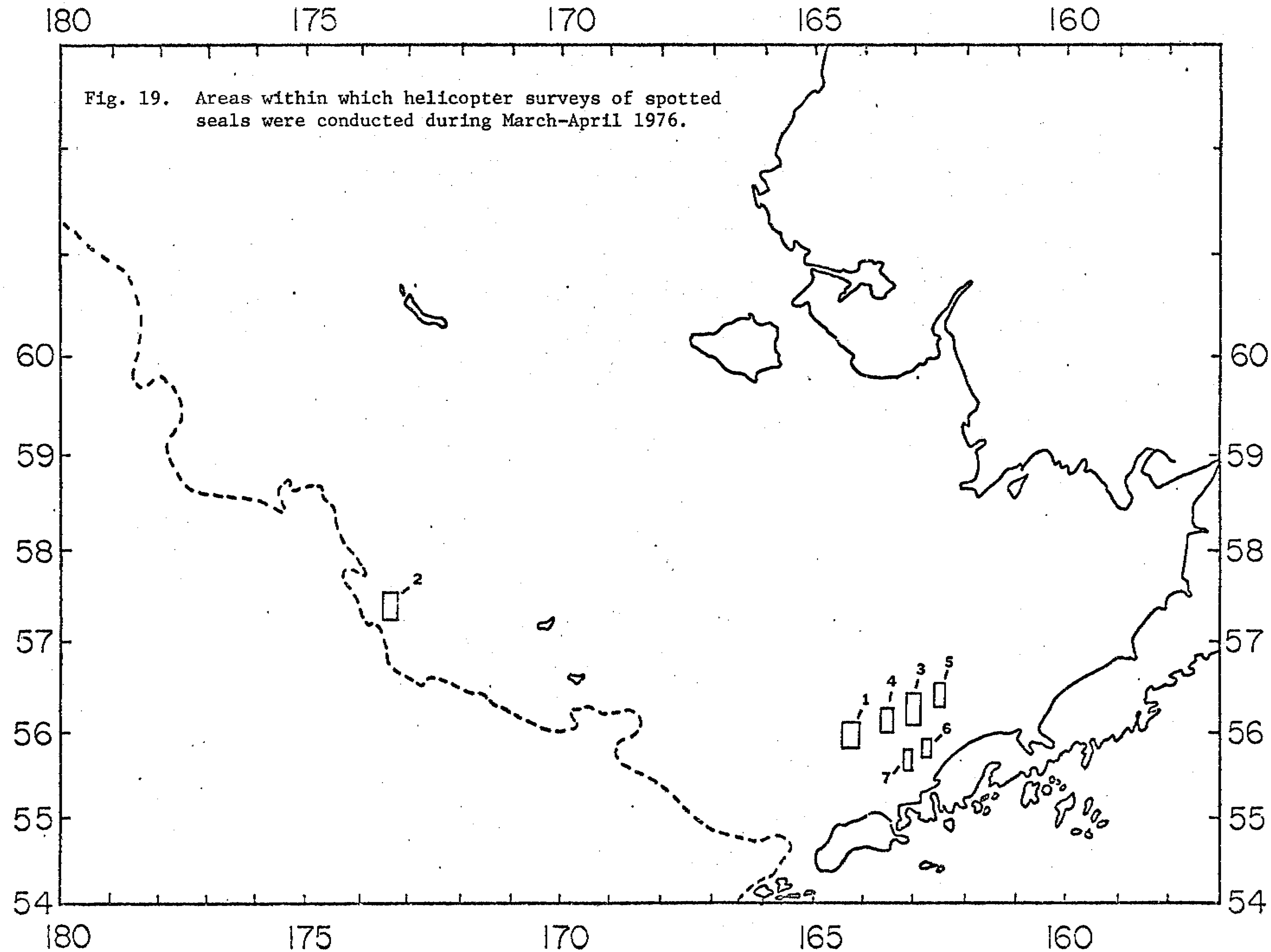

Fig. 19. Areas within which helicopter surveys of spotted seals were conducted during March-April 1976.

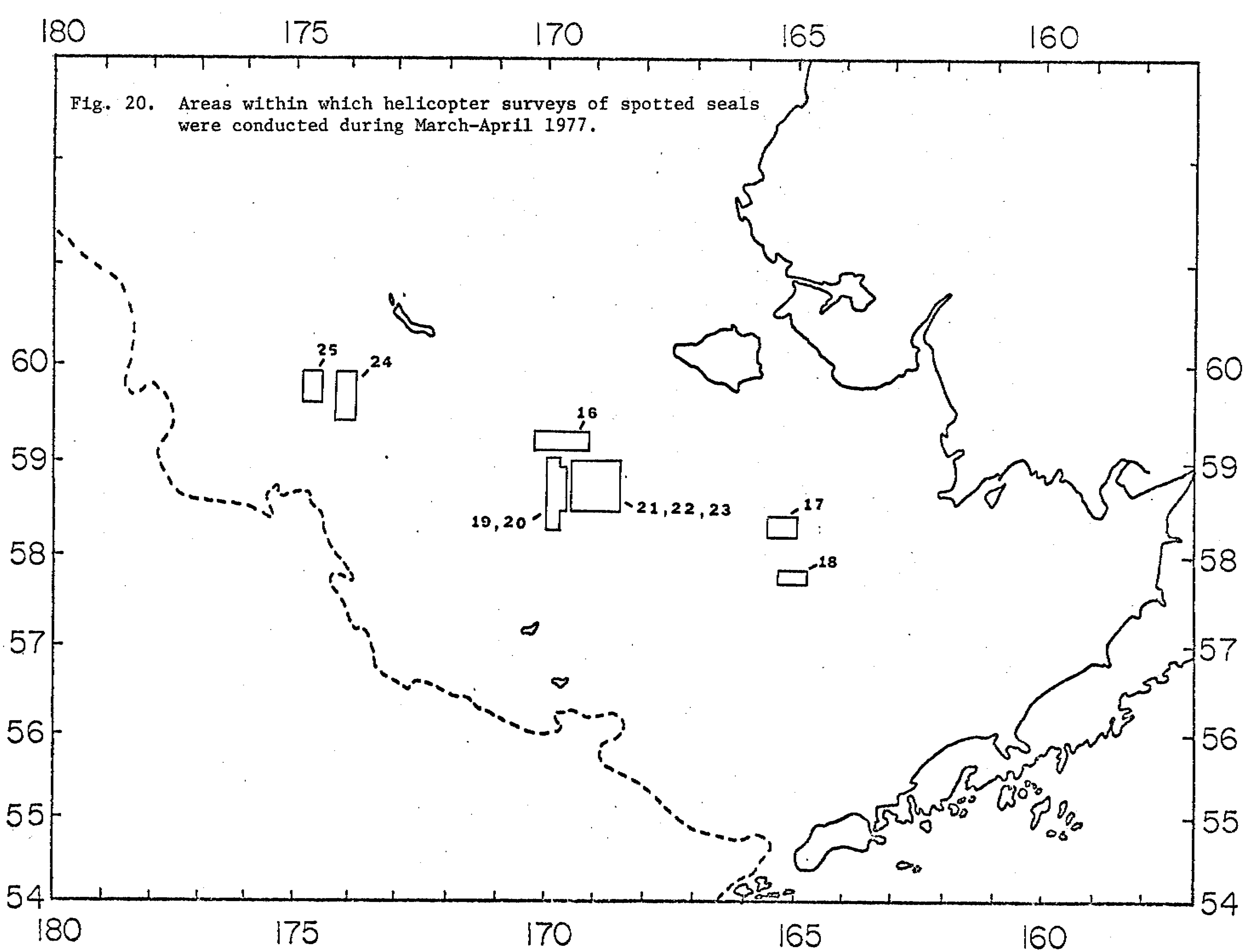

Fig. 20. Areas within which helicopter surveys of spotted seals were conducted during March-April 1977.

Table 5. Results of helicopter surveys of spotted seals conducted during March-April 1976 (surveys 1-7). Data include flight number, date, type of flight, area surveyed, density of seals and variance.

Survey number	Date	Type of flight	Area surveyed (NM^2)	Density of seals/NM^2*	Variance
1	March 27	survey	82.7	6.75	14.2786
2	April 20	survey	40.0	0	0
3	April 23	survey	27.5	3.16	0.1392
4	April 24	survey	26.0	5.77	0.4272
5	April 24	survey	13.0	2.60	0.0688
6	April 25	survey	24.5	3.06	2.1952
7	April 25	survey	24.5	6.61	5.0944

*Includes all age classes of spotted seals observed on surveys.

Table 6. Results of helicopter surveys of spotted seals conducted during March-April 1977 (surveys 16-25). Data include flight number, date, type of flight, density of seals (pups, seals older than pups and all seals combined), variance, corrected density[1] and proportion of pups.

Survey number	Date	Type of flight	Area surveyed (NM^2)	Observed density of seals/NM^2			Variance of totals	Corrected density (pups /NM^2	Corrected density (seals/NM^2)	Proportion of pups(%)
				pups	older than pups	total				
16	March 28	survey	103.3	0	1.13	1.13	0.1646	0[2]	1.13	0[2]
17	March 30	survey	81.2	0	0.05	0.05	0.0010	0[2]	0.05	0[2]
18	April 21	survey	40.5	0.47	6.25	6.72	1.9056	0.47	6.72	7.0
19	April 23	survey	85.0	0.04	0.08	0.12	0.0053	0.04	0.12	30.0
20	April 23	survey	85.3	0	0.06	0.06	0.0008	0	0.06	0
21	April 24	survey	15.0	0.13	0.27	0.40	0.0256	0.13	0.40	33.3
22	April 24	tag/collect	30.6	0.16	0.72	0.88	0.0160	0.08	0.44	18.5
23	April 25	tag/collect	43.9	0.14	0.23	0.36	0.0064	0.09	0.23	37.5
24	April 27	tag/collect	31.2	0.38	0.48	0.87	0.0112	0.19	0.43	44.4
25	April 27	tag/collect	24.7	0.57	0.65	1.21	0.0496	0.29	0.61	46.6

1 Corrected density is adjusted in accordance with ice conditions in general area when flights were restricted to searches of ice fields only.

2 Surveys occurred prior to birth period.

longitude, low to moderate density north of the Pribilof Islands and moderate density west of the Pribilofs.

Considering that all surveys occurred in the ice front during both years, and disregarding the latitudinal differences in position of the "edge," the proportion of pups observed in areas of the same longitude were strikingly similar. In 1976, the proportions of pups in sectors of high seal density (sectors 1, 2, 13 and 14) were 1.7 percent to 12.0 percent. In 1977 (flight 18) it was 7.0 percent. In the vicinity of the Pribilof Islands in 1976, pups accounted for 18.8 percen e seals in sector 6 and 29 percent in sector 7. This compares with 18.5 percent to 37.5 percent as observed on flights 19, 21, 22 and 23. A similar correlation exists for the region west of 172°W during both years.

The Mann-Whitney test was used for paired comparisons of surveys 19 through 25 (results of survey 18 were obviously significantly different from those of 19 through 25).

These paired tests showed that densities obtained on flights 19 and 20 were not significantly different (U = 55.5, table value 0.10 = 76); 21 and 22 were not significantly different (U = 113, table value 0.10 = 115); 22 and 23 were similar (U = 156, table value 0.10 = 172); 21 and 23 were similar (U = 109.5, table value 0.10 = 130) and 24 and 25 were similar (U = 22, table value 0.10 = 29).

Surveys 18 through 25 consisted of four significantly different groupings as follows: 1, survey 18; 2, surveys 19 and 20; 3, surveys 21-23 and 4, surveys 24 and 25.

An interesting comparison of the survey resulting in the highest density of seals in 1976 (survey 7) with survey 18 made in 1977 indicated no significant difference in densities (U = 41, table value 0.10 = 54).

The tests discussed above also suggest that there was little variation attributed to time of day during which our surveys were conducted, or that significant day to day variation occurred during the period of our April surveys by helicopter (April 20-25, 1976 and April 21-27, 1977).

Tests of the comparative efficiency of the P-2V versus the Bell 206 helicopter were made by comparing results obtained from each in 1976. As expected, observers in the helicopter saw slightly more seals than those in the faster flying aircraft. Comparable segments of transects from the two aircraft, flown on April 20, resulted in an observed density of 0.03 seals/NM^2 with the helicopter and 0 with the P-2V. On 23 April the comparison was 2.17/NM^2 vs 1.53. A transect flown on 21 April in the P-2V resulted in a density of 4.59 seals/NM^2.

In 1977, several attempts were made to determine the proportion of seals which were in the water versus on the ice. On April

20, when small boats were used to collect seals, 14 were seen in the water and one pup was seen on the ice. On April 21, during a small boat trip, which preceded survey 18, 21 seals were seen of which 3 were on the ice. The survey resulted in an observed density of 6.72 seals/NM^2. The actual density of seals in the region of this survey (most were subadults) may well have exceeded 40/NM^2.

In areas farther to the west, occupied primarily by adult spotted seals with pups, the ratio appeared to be more on the order of 1 to 3 seals in the water to each one on the ice. The high proportion of pups seen on the surveys of 25 and 27 April 1977 reflects the fact that the older pups are not as closely attended on the ice by the adults.

VIII. Discussion

The effects of precipitation on hauling out behavior of seals was a priori, considered to be significant. We did not conduct surveys when it was snowing. Other components of local weather conditions during our April surveys in 1976 and 1977 did appear to have some influence on the results. Some trends, especially during the last week of April, are suggested.

Appendix IV is a summary of weather conditions as officially recorded at weather stations near the survey area (King Salmon, Cold Bay and St. Paul Island) or from the OSS SURVEYOR. Records of air temperature and wind velocity were used to crudely estimate a corrected temperature (reported dry bulb thermometer temperature minus the wind velocity). The corrected temperatures are considered in this discussion.

As indicated in the previous section, helicopter surveys 3 through 7, conducted during the 3 day period of April 23-25, can be considered as producing similar results. Wind velocities during these five surveys varied from 7 to 10 knots and corrected temperatures from 10° to 25°.

In a general sense, these variations in winds and temperatures apparently did not significantly influence the survey results (i.e. the number of seals hauled out on the ice).

A little more insight can be gained by examination of the 1977 data and interpretation of the possible significance of differences in the observed proportion of pups.

Helicopter surveys of 27 April 1977 (surveys 24 and 25) indicated that pups comprised 44.4 to 46.6 percent of all seals seen. We attribute this to two things; 1) adult seals do not normally attend their pups on the ice as closely during the later stages of the nursing period and 2) the adults are therefore likely to exhibit a lower threshold tolerance for marginal weather conditions. During surveys 24 and 25 winds were recorded at 22 and 30 knots respectively and corrected temperatures were 7° and 1° respectively.

Although weather conditions in April apparently did influence estimates of the proportion of pups observed on a survey, the derived densities of all seals were less obvious and probably more significantly affected by errors associated with sampling.

Geographical differences in density of pups (as opposed to proportion of pups) are directly related to the density of all seals. Thus, areas of high seal density exhibit a high density of pups although the proportion of pups may be low. Table 6 illustrates this relationship. As examples, survey number 18 resulted in a high observed density of 6.72 seals/NM^2, 0.47 pups/NM^2, but only 7.0 percent of the seals were pups. Survey number 21 resulted in a moderate observed density of 0.4 seals/NM^2, 0.13 pups/NM^2 but 33.3 percent of all seals seen were pups.

In our opinion one of the most significant factors influencing the distribution of spotted seals during April 1976, was the rapid and persistent southward movement of ice during the March-April period. This produced a very wide front zone and also resulted in favorable conditions for spotted seals well north of where they would be expected to occur. Results of our surveys in April 1976 together with those of H. Braham (Braham et al., 1977) showed that in eastern Bering Sea spotted seals occurred in an area extending from 56°N to 59°30'N (210 nm north to south).

Our P-2V surveys in April 1976 indicated similar or slightly higher densities of seals in sectors which could be compared on a north-south basis. Seal densities in sectors 9 and 10 were 0.34 and 0.31/NM^2 respectively; sectors 6 and 7 were 0.17 and 0.30 and sectors 4 and 5 were 0.09 and 0.23 respectively.

This is in marked contrast to previously reported information (Shustov 1965; Kosygin 1966) and our own observations based on ship board expeditions in 1968, 1971 and 1972 (Burns, unpublished) when spotted seals were mainly confined to the narrow ice front during March-April.

In April 1977, distribution of spotted seals was again restricted to the ice front. Our helicopter surveys and collecting flights indicated that few spotted seals occurred beyond 30 miles north of the ice edge.

It seems plausible to conclude that greatest concentrations of spotted seals occur in the ice front during those years when it becomes more or less stabilized during the February-April period at latitudes where it "usually" occurs (between 57°N and 58°N).

VIII. Conclusions

Spotted seals are distributed continuously throughout the ice front although there are significant regional differences in density and general age composition. The highest density of these seals in 1976 and 1977 occurred in western Bristol Bay between 162°W and 165°30'W longitudes.

A high proportion of the seals in Bristol Bay are subadult animals whereas farther to the west the proportions of adults and pups are higher.

Observed density of seals on the ice reflects regional differences in relative abundance but is a poor and very variable indication of actual numbers. Our data indicate that in areas where subadult seals are numerous only 14 percent or less of the seals may be hauled out on the ice where they can be seen by observers in an aircraft. In regions where adults and pups predominate, 25 to 50 percent of the seals may be on the ice.

Aircraft surveys in general can be utilized to determine distribution, relative abundance and population composition of spotted seals although it is not yet possible to estimate the actual number of seals by these techniques. Observers see more seals from helicopters than from fixed-wing aircraft. The differences in results, although consistent, are not very great.

Weather conditions during the survey periods in April of 1976 and 1977 were of lesser significance than was error associated with sampling procedures and factors affecting sightability of seals.

Location and characteristics of the ice front appear to have a significant influence on the distribution of spotted seals. In most years spotted seals are concentrated in a relatively restricted front zone. During April 1976 they were broadly distributed over a wide area of southeastern Bering Sea.

Aerial surveys of walruses provide a more accurate approximation of the total number of animals in a survey area. During April 1976, the highest density of walruses in the ice front occurred in central Bristol Bay. The estimated number of walruses in the total area we surveyed was 10,000.

Critical Areas

Fig. 21 illustrates the observed distribution of sightings of spotted seals (groups) in the ice front as determined by aerial surveys with the P-2V during April 1976. Fig. 22 shows observed densities of spotted seals and walruses plotted in relation to degrees of longitude.

Based solely on consideration of relative density, it is apparent that central and western Bristol Bay are areas critical to the support of spotted seals and walruses.

However, density of animals per unit of area is only one consideration. Areas within which seals give birth and nurture their pups is another. From the standpoint of pupping areas the entire ice front, with the exception of the extreme eastern portion of Bristol Bay, is very important. Based on the results of our surveys, areas critical for the successful production of pups are: (1) central and western Bristol Bay (162°W to 165°W) and (2) the entire ice front west of 169°W longitude.

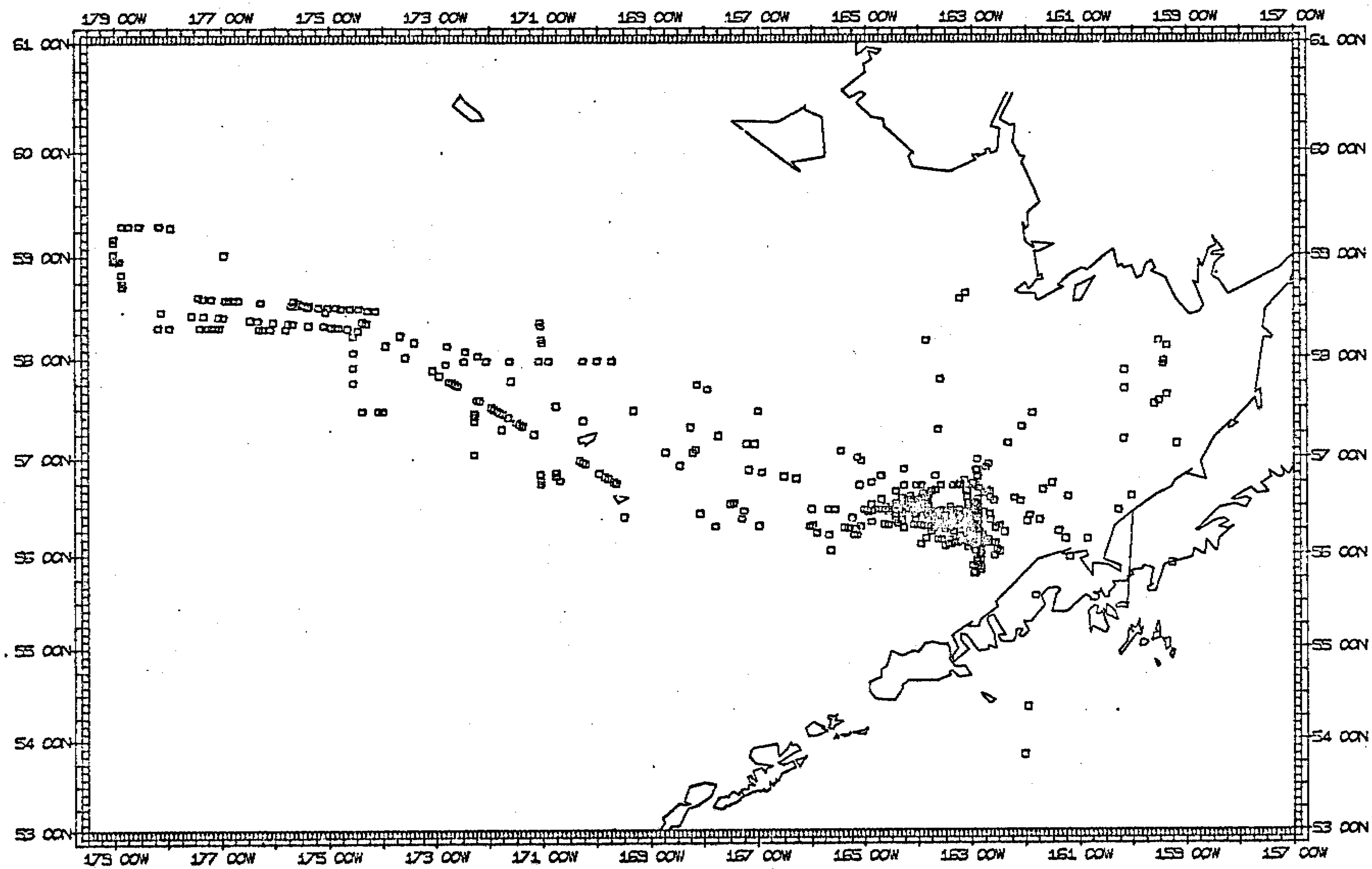

Fig. 21. Sightings of spotted seals recorded during surveys from the P-2V, April 8-23, 1976. (Figure prepared by B. Krogman, NMFS, Seattle. Anomalus indicated sightings outside of the area surveyed have not been corrected.)

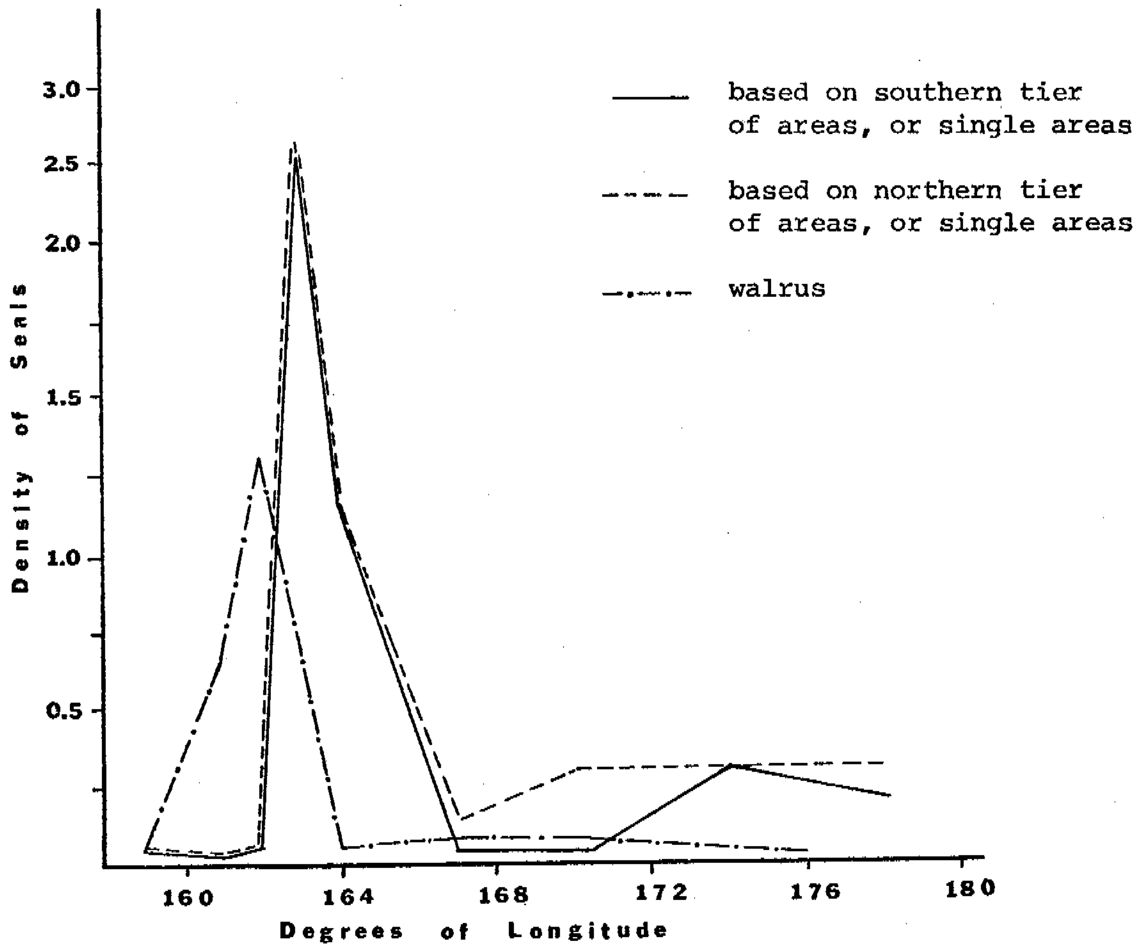

Fig. 22. Observed densities of spotted seals (——— and -----) and walrus (—.—.) in the ice front plotted in relation to longitude. (From P-2V surveys, April 8-23, 1976).

IX. Needs for Further Study

The most obvious needs for further investigation which are pointed out by the results of this study are:

1) to determine what physical and biological factors contribute to the support of the concentrations of spotted seals and walruses in central and western Bristol Bay;

2) to determine how OCS development in the areas of high seal and walrus densities will impact the marine mammals or the habitats which support them;

3) to more clearly understand the diurnal activity patterns of spotted seals as a basis for converting the indices of abundance, derived through surveys of various kinds, into estimates of actual population size;

4) to understand how and to what extent the annual variations in sea ice conditions influence the seasonal movements and distribution of marine mammals occurring in the ice front.

X. Acknowledgments

We are greatly indebted to each person who participated in our surveys. These people are indicated in Table 1. Our special thanks are expressed to Ms. Kathryn Frost for her involvement in this effort, particularly with the tedious tasks of data compilation and "data management." Other persons who contributed significantly to this effort and have not been identified are H. Braham, B. Krogman, and D. Day. We wish to thank collectively the officers and crew who served aboard the OSS SURVEYOR during March-April of 1976 and 1977.

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Appendix I. Aerial surveys for spotted seals (and walrus), undertaken in 1976 and 1977. Information includes aircraft types, dates and transect check points (time, number and position of each).

Time	Checkpoint No.	Position	
I. Helicopter Survey, Bell 206, 27 March 1976			
1411	1	55°49'N	164°26'W
1427	2	56°00'N	164°07'W
1444	3	56°10'N	164°07'W
1448	4	56°10'N	164°15'W
1457	5	56°00'N	164°14'W
1500	6	56°00'N	164°21'W
1510	7	56°10'N	164°22'W
1514	8	56°10'N	164°30'W
1522	9	56°00'N	164°28'W
1528	10	56°00'N	164°35'W
1538	11	55°49'N	164°26'W
II. Helicopter Survey, Bell 206, 20 April 1976			
1635	1	57°19'N	173°19'W
1641	2	57°24'N	173°19'W
1646	3	57°24'N	173°28'W
1652	4	57°29'N	173°28'W
1657	5	57°29'N	173°19'W
1703	6	57°34'N	173°19'W
1708	7	57°34'N	173°28'W
1714	8	57°39'N	173°28'W
1720	9	57°39'N	173°19'W
III. Helicopter Sruvey, Bell 206, 23 April 1976			
1620	1	56°05'N	163°01'W
1625	2	56°10'N	163°00'W
1630	3	56°10'N	163°09'W
1636	4	56°15'N	163°09'W
1645	5	56°15'N	162°52'W
1652	6	56°20'N	162°52'W
1701	7	56°20'N	163°09'W
1706	8	56°25'N	163°09'W
1716	9	56°25'N	162°52'W
IV. Helicopter Survey, Bell 206, 24 April 1976			
1335	1	56°00'N	163°22'W
1348	2	56°12'N	163°22'W
1350	3	56°12'N	163°24'W
1360	4	56°00'N	163°24'W
1401	5	56°00'N	163°26'W

1415	6	56°12'N	163°26'W
1416	7	56°12'N	163°28'W
1426	8	56°00'N	163°28'W
1427	9	56°00'N	163°29'W

V. Helicopter Survey, Bell 206, 24 April 1976

1642	1	56°24'N	162°27'W
1654	2	56°36'N	162°27'W
1655	3	56°36'N	162°29'W
1708	4	56°24'N	162°29'W
1710	5	56°24'N	162°31'W

VI. Helicopter Survey, Bell 206, 25 April 1976

1330	1	55°53'N	162°57'W
1333	2	55°48'N	162°57'W
1334	3	55°48'N	162°55'W
1344	4	55°58'N	162°55'W
1346	5	55°58'N	162°53'W
1354	6	55°48'N	162°53'W
1356	7	55°48'N	162°51'W
1414	8	55°58'N	162°51'W
1416	9	55°58'N	162°49'W
1425	10	55°48'N	162°49'W

VII. Helicopter Survey, Bell 206, 25 April 1976

1642	1	55°50'N	163°00'W
1649	2	55°55'N	163°00'W
1650	3	55°55'N	163°02'W
1658	4	55°45'N	163°02'W
1660	5	55°45'N	163°04'W
1711	6	55°55'N	163°04'W
1712	7	55°55'N	163°06'W
1720	8	55°45'N	163°06'W
1721	9	55°45'N	163°08'W
1752	10	55°55'N	163°08'W

VIII. P2V Survey, 8 April 1976

0905	1	58°43'N	157°27'W
0921	2	58°32'N	158°46'W
0924	3	58°26'N	158°58'W
0943	4	57°55'N	160°07'W
1018	5	56°34'N	160°08'W
1031	6	56°57'N	160°47'W
1058	7	56°12'N	162°15'W
1113	8	56°34'N	162°59'W
1126	9	56°13'N	163°37'W
1143	10	56°38'N	164°22'W

1150	11	56°52'N	164°22'W
1218	12	56°07'N	165°43'W
1225	13	56°14'N	165°56'W
1239	14	56°44'N	165°55'W
1258	15	56°15'N	166°48'W
1315	16	56°40'N	167°30'W
1334	17	56°06'N	168°17'W
1342	18	56°06'N	167°44'W
1404	19	56°40'N	166°30'W
1421	20	56°07'N	165°31'W
1458	21	56°52'N	163°07'W
1519	22	56°17'N	162°06'W
1521	23	56°17'N	161°55'W
1543	24	56°51'N	160°43'W
1552	25	56°35'N	160°16'W
1603	26	56°18'N	160°40'W
1606	27	56°13'N	160°48'W
1610	28	56°19'N	161°00'W
1615	29	56°17'N	161°14'W
1621	30	56°13'N	161°40'W
1631	31	56°13'N	162°10'W
1637	32	56°28'N	162°09'W
1700	33	56°29'N	160°26'W
1703	34	56°36'N	160°20'W
1707	35	56°39'N	160°02'W
1758	36	58°31'N	159°08'W

IX. P2V Survey, 9 April 1976

1031	1	58°18'N	157°56'W
1035	2	58°14'N	158°14'W
1042	3	57°58'N	158°57'W
1047	4	57°46'N	158°00'W
1050	5	57°39'N	158°11'W
1058	6	57°26'N	158°42'W
1102	7	57°15'N	158°41'W
1109	8	57°09'N	159°13'W
1121	9	56°48'N	159°44'W
1137	10	56°18'N	160°31'W
1140	11	56°10'N	160°35'W
1141	12	56°12'N	160°37'W
1152	13	56°11'N	161°26'W
1204	14	56°34'N	162°06'W
1207	15	56°31'N	162°14'W
1217	16	56°09'N	162°20'W
1220	17	56°03'N	162°20'W
1222	18	56°04'N	162°25'W
1236	19	56°30'N	163°11'W
1251	20	56°08'N	163°55'W

1300	21	56°23'N	164°23'W
1310	22	56°46'N	164°22'W
1337	23	56°03'N	165°38'W
1358	24	56°36'N	166°47'W
1408	25	56°21'N	167°21'W
1419	26	56°45'N	167°25'W
1433	27	57°09'N	168°03'W
1503	28	56°21'N	169°36'W
1523	29	56°49'N	170°42'W
1534	30	57°11'N	170°46'W
1558	31	56°31'N	171°59'W
1603	32	56°39'N	172°12'W
1630	33	57°43'N	172°14'W
1654	34	57°00'N	171°18'W
1714	35	56°50'N	169°58'W
1753	36	56°34'N	167°27'W
1800	37	56°30'N	166°57'W
1840	38	56°30'N	164°19'W
1904	39	56°28'N	162°40'W
1912	40	56°09'N	162°46'W

X. P2V Survey, 11 April 1976

0924	1	56°19'N	163°49'W
0925	2	56°20'N	163°52'W
1007	3	56°20'N	166°42'W
1101	4	56°47'N	170°00'W
1136	5	57°00'N	172°13'W
1140	6	56°53'N	172°26'W
1150	7	57°11'N	172°52'W
1218	8	58°09'N	172°46'W
1259	9	57°19'N	169°57'W
1317	10	57°03'N	168°31'W
1357	11	56°45'N	165°35'W
1431	12	56°46'N	163°00'W
1447	13	56°12'N	163°00'W
1627	14	56°12'N	162°32'W
1630	15	56°19'N	162°31'W
1708	16	57°00'N	160°00'W
1747	17	58°12'N	157°54'W

XI. P2V Survey, 17 April 1976

1307	1	58°15'N	157°48'W
1339	2	57°16'N	160°18'W
1356	3	56°42'N	161°37'W
1407	4	56°14'N	161°41'W
1421	5	56°45'N	161°52'W
1435	6	56°15'N	161°51'W

1452	7	56°45'N	162°02'W
1505	8	56°14'N	162°03'W
1507	9	56°15'N	162°10'W
1522	10	56°45'N	162°09'W
1537	11	56°14'N	162°37'W
1554	12	56°45'N	162°37'W
1608	13	56°16'N	163°23'W
1611	14	56°08'N	163°22'W

XII. P2V Survey, 19 April 1976

1002	1	55°52'N	162°50'W
1012	2	56°18'N	162°56'W
1026	3	56°52'N	162°55'W
1043	4	56°18'N	163°10'W
1059	5	56°53'N	163°10'W
1129	6	56°53'N	165°06'W
1204	7	56°53'N	167°29'W
1225	8	56°54'N	169°00'W
1237	9	56°30'N	168°59'W
1250	10	56°27'N	168°02'W
1310	11	56°24'N	166°38'W
1320	12	56°19'N	165°52'W
1323	13	56°18'N	165°38'W
1335	14	56°18'N	164°49'W
1349	15	56°50'N	164°50'W
1403	16	56°25'N	164°24'W
1405	17	56°24'N	164°16'W
1422	18	57°00'N	164°16'W
1438	19	56°25'N	164°00'W
1456	20	57°01'N	163°59'W
1512	21	56°25'N	163°47'W
1531	22	57°00'N	163°45'W
1550	23	56°19'N	163°12'W
1607	24	57°00'N	163°10'W
1626	25	56°19'N	162°56'W
1629	26	56°22'N	162°54'W
1647	27	57°01'N	162°52'W
1710	28	56°09'N	162°50'W
1716	29	55°55'N	162°52'W

XIII. P2V Survey, 20 April 1976

1127	1	55°53'N	162°35'W
1136	2	56°09'N	162°30'W
1142	3	56°11'N	162°56'W
1152	4	56°11'N	163°40'W
1201	5	56°10'N	164°17'W
1203	6	56°14'N	164°19'W
1231	7	56°15'N	166°24'W
1235	8	56°20'N	166°34'W
1245	9	56°23'N	167°13'W

1255	10	56°23'N	168°02'W
1301	11	56°35'N	168°04'W
1319	12	56°35'N	169°27'W
1330	13	56°37'N	169°50'W
1339	14	56°36'N	170°55'W
1346	15	56°50'N	171°01'W
1402	16	56°50'N	172°14'W
1419	17	57°29'N	172°14'W
1448	18	57°31'N	174°30'W
1509	19	58°20'N	174°31'W
1605	20	58°20'N	178°39'W
1611	21	58°31'N	178°40'W
1712	22	58°20'N	174°29'W
1740	23	57°48'N	172°43'W
1824	24	57°03'N	170°23'W
1942	25	56°20'N	165°00'W
2014	26	56°20'N	162°49'W
2025	27	55°52'N	162°47'W

XIV. P2V Survey, 21 April 1976

1102	1	56°06'N	163°01'W
1105	2	56°10'N	163°03'W
1138	3	57°02'N	165°05'W
1153	4	57°17'N	166°03'W
1237	5	58°01'N	169°03'W
1310	6	58°01'N	172°02'W
1336	7	58°30'N	174°00'W
1434	8	58°41'N	178°48'W
1441	9	58°59'N	178°51'W
1506	10	59°00'N	178°58'E
1515	11	59°20'N	178°58'E
1550	12	59°20'N	177°59'W
1609	13	58°55'N	176°24'W
1614	14	58°42'N	176°22'W
1635	15	58°24'N	174°26'W
1655	16	58°06'N	172°58'W
1806	17	57°11'N	167°09'W
1815	18	57°07'N	166°30'W
1819	19	57°05'N	166°09'W
1821	20	57°00'N	166°00'W
1845	21	56°49'N	164°00'W
1859	22	56°22'N	163°38'W
1903	23	58°18'N	163°24'W

XV. P2V Survey, 23 April 1976

1115	1	55°50'N	162°55'W
1123	2	56°12'N	163°01'W
1141	3	56°00'N	164°09'W
1148	4	56°07'N	163°58'W
1246	5	58°01'N	161°00'W
1315	6	58°27'N	158°18'W

XVI. Helicopter Survey, Bell 206, 28 March 1977

1352	1	59°08'N	169°35'W
1410	2	59°08'N	170°10'W
1413	3	59°10'N	170°10'W
1437	4	59°10'N	169°00'W
1438	5	59°12'N	169°00'W
1515	6	59°12'N	169°51'W
1517	7	59°14'N	169°50'W
1524	8	59°14'N	169°30'W
1530	9	59°08'N	169°33'W

XVII. Helicopter Survey, Bell 206, 30 March 1977

1341	1	58°20'N	164°50'W
1357	2	58°20'N	165°26'W
1359	3	58°22'N	165°26'W
1418	4	58°22'N	164°50'W
1420	5	58°24'N	164°50'W
1436	6	58°24'N	165°26'W
1438	7	58°26'N	165°26'W
1457	8	58°26'N	164°50'W

XVIII. Helicopter Survey, Bell 206, 21 April 1977

1832	1	57°45'N	164°55'W
1841	2	57°45'N	165°11'W
1844	3	57°49'W	165°11'W
1859	4	57°49'N	164°34'W
1905	5	57°45'N	164°55'W
1916	6	57°45'N	164°34'W
1926	7	57°47'N	165°11'W
1942	8	57°47'N	164°34'W
1950	9	57°45.4'N	164°45.3'W

XIX. Helicopter Survey, Bell 206, 23 April 1977

1008	1	58°13.3'N	169°59.4'W
1018	2	58°24.3'N	169°55.1'W
1027	3	58°36.7'N	169°54.3'W
1040	4	58°49.5'N	169°50.3'W
1048	5	59°00.7'N	169°46.6'W
1140	6	59°00.0'N	169°53.4'W
1200	7	58°48.6'N	169°55.9'W
1222	8	58°40.0'N	169°59.1'W
1235	9	58°34.1'N	169°57.4'W
1258	10	58°27.3'N	169°42.2'W

XX. Helicopter Survey, Bell 206, 23 April 1977

1356	1	58°28.0'N	169°41.3'W
1407	2	58°41.6'N	169°51.1'W
1412	3	58°48.7'N	169°48.6'W
1418	4	58°52.9'N	169°50.1'W

1425	5	58°58.0'N	169°55.0'W
1440	6	58°57.5'N	169°56.6'W
1457	7	58°53.8'N	169°49.3'W
1506	8	58°49.2'N	169°48.6'W
1520	9	58°40.1'N	169°43.9'W
1523	10	58°37.5'N	169°42.8'W
1536	11	58°30.0'N	169°39.9'W
1610	12	58°29.1'N	169°41.9'W
1620	13	58°41.2'N	169°46.4'W
1623	14	58°43.8'N	169°47.7'W
1631	15	58°52.3'N	169°39.5'W

XXI. Helicopter Survey, Bell 206, 24 April 1977

1258	1	58°30.9'N	169°25.7'W
1303	2	58°31.6'N	169°18.8'W
1310	3	58°37.2'N	169°13.2'W
1312	4	58°38.6'N	169°11.3'W
1317	5	58°42.1'N	169°09.3'W
1321	6	58°43.6'N	169°05.6'W
1328	7	58°48.4'N	168°57.8'W
1335	8	58°51.8'N	169°02.0'W
1345	9	58°57.2'N	169°02.0'W
1351	10	58°56.3'N	169°09.5'W
1415	11	58°54.6'N	169°13.7'W
1508	12	58°33.9'N	169°25.5'W

XXII. Helicopter Survey, Bell 206, 24 April 1977

1550	1	58°29.3'N	169°25.7'W
1554	2	58°29.6'N	169°27.3'W
1556	3	58°31.2'N	169°31.2'W
1601	4	58°35.0'N	169°37.2'W
1606	5	58°40.2'N	169°40.5'W
1637	6	58°34.0'N	169°32.3'W
1640	7	58°30.6N	169°26.5'W
1720	8	58°34.9'N	169°28.8'W
1732	9	58°40.2'N	169°37.3'W
1737	10	58°44.1'N	169°38.7'W
1742	11	58°46.7'N	169°34.8'W
1749	12	58°50.3'N	169°32.7'W
1756	13	58°51.5'N	169°23.8'W
1802	14	58°49.2'N	169°24.6'W
1806	15	58°46.7'N	169°28.4'W
1810	16	58°44.6'N	169°27.6'W
1820	17	58°45.0'N	169°28.1'W
1825	18	58°40.3'N	169°28.9'W

XXIII. Helicopter Survey, Bell 206, 25 April 1977

1556	1	58°29.7'N	169°14.3'W
1558	2	58°32.2'N	169°16.3'W
1604	3	58°40.6'N	169°12.7'W

1609	4	58°48.2'N	169°12.7'W
1611	5	58°52.3'N	169°11.8'W
1613	6	58°53.0'N	169°07.9'W
1625	7	58°54.5'N	169°06.6'W
1634	8	59°00.9'N	168°48.7'W
1636	9	58°59.4'N	168°42.7'W
1638	10	58°58.0'N	168°40.1'W
1650	11	58°55.9'N	168°40.7'W
1702	12	58°55.3'N	168°42.3'W
1705	13	58°52.8'N	168°43.8'W
1708	14	58°51.5'N	168°39.3'W
1710	15	58°49.8'N	168°39.7'W
1720	16	58°49.4'N	168°39.3'W
1802	17	58°36.0'N	168°57.2'W
1825	18	58°25.4'N	169°23.1'W

XIV. Helicopter Survey, Bell 206, 27 April 1977

0808	1	59°54.4'N	173°54.1'W
0815	2	59°42.5'N	174°05.2'W
0818	3	59°39.5'N	174°05.6'W
0835	4	59°38.5'N	174°06.0'W
0842	5	59°36.9'N	174°04.5'W
0853	6	59°36.9'N	174°06.6'W
0900	7	59°35.8'N	174°03.9'W
0914	8	59°32.0'N	174°01.7'W
0929	9	59°31.8'N	174°00.2'W
0936	10	59°31.5'N	174°00.0'W
0943	11	59°28.8'N	174°01.9'W
0946	12	59°28.3'N	173°58.3'W
0958	13	59°26.2'N	173°56.4'W
1009	14	59°27.9'N	173°51.5'W
1031	15	59°32.0'N	173°57.3'W
1034	16	59°32.7'N	173°58.6'W
1045	17	59°35.0'N	174°00.4'W
1054	18	59°36.0'N	174°00.8'W
1101	19	59°44.4'N	173°59.3'W

XXV. Helicopter Survey, Bell 206, 27 April 1977

1835	1	59°46.7'N	174°23.7'W
1839	2	59°44.3'N	174°26.9'W
1846	3	59°44.0'N	174°26.3'W
1857	4	59°43.5'N	174°31.2'W
1858	5	59°44.0'N	174°32.8'W
1905	6	59°45.3'N	174°32.8'W
1908	7	59°46.3'N	174°32.4'W
1926	8	59°47.4'N	174°37.0'W
1951	9	59°50.3'N	174°37.5'W
1955	10	59°52.6'N	174°39.1'W
2001	11	59°52.2'N	174°40.1'W
2007	12	59°52.3'N	174°40.7'W

2022	13	59°52.8'N	174°37.4'W
2034	14	59°52.3'N	174°44.8'W
2041	15	59°46.8'N	174°47.0'W
2049	16	59°42.1'N	174°45.5'W
2100	17	59°44.9'N	174°33.7'W
2102	18	59°43.0'N	174°30.6'W
2115	19	59°47.4'N	174°25.3'W

Appendix II. Boundary points and area (nautical miles)^2 of sectors within which surveys for spotted seals were flown in the P-2V aircraft, April 8-23, 1976.

Sector Number	Boundary points: Longitude	Boundary points: Latitude	Area of sector (NM^2)	Dates of survey flights within sector	Total area surveyed (NM^2)	Total length of transects (NM)
1	161°35'00"W - 162°45'00"W	56°14'00"N - 56°45'00"N	1209	17 April 1976	111.3	252.9
2	162°45'00"W - 165°00'00"W	56°17'36"N - 57°00'00"N	3152	19 April 1976(am)*	51.0	115.9
				19 April 1976(pm)	109.8	249.6
3	162°45'00"W - 164°00'00"W	56°00'00"N - 56°25'00"N	1053	17 April 1976	9.37	21.3
				19 April 1976	38.32	87.1
				20 April 1976	44.97	102.2
				21 April 1976	18.30	41.6
				23 April 1976	31.94	72.6
4	165°00'00"W - 169°00'00"W	56°00'00"N - 57°00'00"N	8018	19 April 1976	127.1	288.8
				20 April 1976	107.8	245.0
				21 April 1976	14.5	33.0
5	165°00'00"W - 169°00'00"W	57°00'00"N - 58°00'00"N	7823	21 April 1976	106.88	242.9
6	169°00'00"W - 172°00'00"W	56°30'00"N - 57°30'00"N	5925	20 April 1976	91.78	208.6
7	169°00'00"W - 172°00'00"W	57°30'00"N - 58°10'00"N	3855	21 April 1976	85.9	195.3
8	172°00'00"W - 176°00'00"W	56°50'00"N - 58°10'00"N (at eastern end)	6310	20 April 1976	156.6	355.8
		58°20'00"N - 58°40'00"N (at western end)		21 April 1976	116.5	264.8
9	176°00'00"W - 178°55'00"E	58°20'00"N - 58°31'00"N	1757	20 April 1976	78.72	178.9
10	176°00'00"W - 178°55'00"E	58°35'00"N - 59°20'00"N	7088	21 April 1976	161.4	366.8

Appendix II. Continued.

11	160°00'00"W - 161°35'00"W	56°00'00"N - 57°00'00"N	3165	8 April 1976	122.9	279.2
				9 April 1976	30.5	69.3
				11 April 1976	25.3	57.6
12	157°40'00"W - 160°00'00"W	56°30'00"N - 58°40'00"N	9767	8 April 1976	79.4	180.4
				9 April 1976	60.2	137.6
				11 April 1976	43.6	99.0
13	161°35'00"W - 162°45'00"W	56°00'00"N - 56°40'00"N	1565	8 April 1976	63.1	143.3
				9 April 1976	41.3	93.9
				11 April 1976	18.5	42.1
14	162°45'00"W - 165°00'00"W	56°08'00"N - 57°00'00"N	3907	8 April 1976	92.0	209.0
				9 April 1976	91.1	207.2
				11 April 1976	61.6	140.1
15	165°00'00"W - 169°00'00"W	56°00'00"N - 57°10'00"N	9310	8 April 1976	146.8	333.7
				9 April 1976	149.8	339.9
				11 April 1976	118.8	270.0
16	169°00'00"W - 172°00'00"W	56°20'00"N - 58°00'00"N	9800	9 April 1976	119.0	270.5
				11 April 1976	91.8	208.7
17	172°00'00"W - 173°00'00"W	56°30'00"N - 58°10'00"N	3238	9 April 1976	38.2	86.9
				11 April 1976	44.7	101.6

*Data from this flight were not used.

Appendix III. Boundary points and area (NM^2) of sectors within which surveys for walruses were flown in the P-2V aircraft, April 8-23, 1976.

Sector Number	Boundary points: Longitude	Boundary points: Latitude	Area of sector (NM^2)	Dates of survey flights within sector	Total area surveyed (NM^2)	Total length of transects (NM)
1	157°40'W - 160°00'W	56°30'N - 58°40'N	6382	8 April	158.8	180.4
				9 April	120.3	136.7
				11 April	87.1	99.0
				17 April	67.7	76.9
2	160°00'W - 161°35'W	56°00'N - 57°00'N	2708	8 April	221.0	251.1
				9 April	61.0	69.3
				11 April	50.7	57.6
				17 April	24.2	27.5
3	160°00'W - 160°30'W	57°00'N - 58°00'N	966	8 April	48.3	54.9
				17 April	33.1	37.6
4	161°35'W - 162°45'W	56°00'N - 56°45'N	1764	8 April	126.2	143.3
				9 April	82.6	93.9
				11 April	37.0	42.1
				17 April	226.5	257.4
				20 April	22.1	25.1
5	162°45'W - 165°00'W	56°08'N - 57°00'N	3869	8 April	183.9	209.0
				9 April	182.3	207.2
				11 April	123.3	140.1
				17 April	611.5	654.9
				21 April	33	29
6	165°00'W - 169°00'W	56°00'N - 57°00'N	7932	8 April	293.7	333.7
				9 April	276.8	314.6
				11 April	207.0	235.2
				19 April	254.2	288.8
				20 April	303.6	345.0
				21 April	29.0	33.0

Appendix III. Continued.

7	165°00'W - 169°00'W	57°00'N - 58°00'N	7728	9 April	21.8	24.8
				11 April	30.7	34.9
				21 April	215.8	245.2
8	169°00'W - 172°00'W	56°30'N - 58!10'N	9675	9 April	238.0	270.5
				11 April	183.6	208.7
				20 April	183.6	208.6
				21 April	172.0	195.4
9	172°00'W - 180°00'W	56°30'N - 58°00'N	13504	9 April	98.5	102.1
		(at eastern end)		11 April	106.0	120.5
		59°00'N - 59°20'N		20 April	467.3	531.0
		(at western end)		21 April	503.8	572.5

Appendix IV. Weather conditions during survey periods recorded at indicated stations. Positions recorded in the column indicating reporting locations are for the OSS SURVEYOR, which was in the survey area.

Date	Location	Time	Sky	Visibiliby (nautical miles)	Wind Direction (degrees)	Wind Velocity (knots)	Temp (°F)	Corrected temperature*
27-III-76	55°51'N 164°24'W	1600	partly cloudy	7	330	8	18	10
8-IV-76	King Salmon	1100	cloudy	.75	260	06	32	26
	Cold Bay	1300	cloudy	.50	270	20	30	10
	St. Paul	1300	cloudy	7	330	19	16	-3
9-IV-76	King Salmon	1400	cloudy	30	270	7	35	28
	Cold Bay	1300	cloudy	1.25	130	14	31	17
	St. Paul	1300	partly cloudy	7	120	3	22	19
11-IV-76	King Salmon	1400	cloudy	13	250	13	35	22
	Cold Bay	1300	partly cloudy	25	240	10	36	26
	St. Paul	1300	partly cloudy	7	300	17	18	1+
17-IV-76	King Salmon	1100	partly cloudy	40	140	6	44	38
	Cold Bay	1300	partly cloudy	7	150	15	37	23
19-IV-76	Cold Bay	1300	cloudy	7	300	8	32	24
	St. Paul	1300	clear	7	040	7	23	16
	57°11'N 172°53'W	1300	partly cloudy	7	050	10	23	13

Appendix IV. Continued.

Date	Location	Time	Sky	Visibility (nautical miles)	Wind Direction (degrees)	Wind Velocity (knots)	Temp (°F)	Corrected temperature*
20-IV-76	Cold Bay	1300	cloudy	10	140	13	37	24
	St. Paul	1300	cloudy	7	040	10	22	12
	57°19'N 173°19'W	1300	cloudy	6	065	9	24	15
21-IV-76	Cold Bay	1300	partly cloudy	unlimited	180	12	41	29
	St. Paul	1300	cloudy	7	010	13	21	8
	57°04'N 173°08'W	1300	cloudy	3.5	050	11	20	9
23-IV-76	Cold Bay	1300	partly cloudy	7	350	7	20	13
	56°04'N 163°01'W	1300	partly cloudy	6	340	9	19	10
	King Salmon	1400	cloudy	20	260	15	30	15
24-IV-76	56°00'N 163°22'W	1300	partly cloudy	10	300	8	21	13
	56°24'N 162°27'W	1500	partly cloudy	10	310	7	26	19
25-IV-76	55°53'N 162°57'W	1300	partly cloudy	5	010	8	33	25
	55°50'N 163°00'W	1600	partly cloudy	5	355	10	30	21
28-III-77	55°08'N 169°35'W	1400	cloudy	5	255	10	35	25

Appendix IV. Continued.

Date	Location	Time	Sky	Visibility (nautical miles)	Wind Direction (degrees)	Wind Velocity (knots)	Temp (°F)	Corrected temperature*
30-III-77	58°22'N 165°26'W	1400	cloudy	0.8	035	9	29	20
21-IV-77	57°45'N 164°55'W	1800	cloudy	5	153	27.5	33	5.5
23-IV-77	58°13'N 169°59'W	1100	cloudy	6	213	6	32	26
	58°42'N 169°19'W	1400	partly cloudy	5	210	5	32	27
24-IV-77	58°30'N 169°19'W	1300	partly cloudy	15	259	10.5	30	19.5
	58°35'N 169°37'W	1600	clear	15	235	8.0	30	22
25-IV-77	58°40'N 169°13'W	1600	partly cloudy	8	135	11	30	19
27-IV-77	59°36'N 174°04'W	0900	cloudy	8	085	22	29	7
	59°45'N 174°33'W	1900	cloudy	8	080	30	29	1

*Corrected temperature, as used here, is the dry bulb thermometer temperature minus the recorded wind velocity.