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BIOENVIRONMENTAL FEATURES OF THE OGOTORUK CREEK AREA, CAPE THOMPSON, ALASKA

A First Summary by The Committee on Environmental Studies for Project Chariot

December 1960

Division of Biology and Medicine, AEC
Washington, D. C.

UNITED STATES ATOMIC ENERGY COMMISSION • OFFICE OF TECHNICAL INFORMATION

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NUCLEAR EXPLOSIONS—PEACEFUL APPLICATIONS
BIOLOGY AND MEDICINE

BIOENVIRONMENTAL FEATURES OF THE OGOTORUK CREEK AREA

CAPE THOMPSON, ALASKA

A First Summary

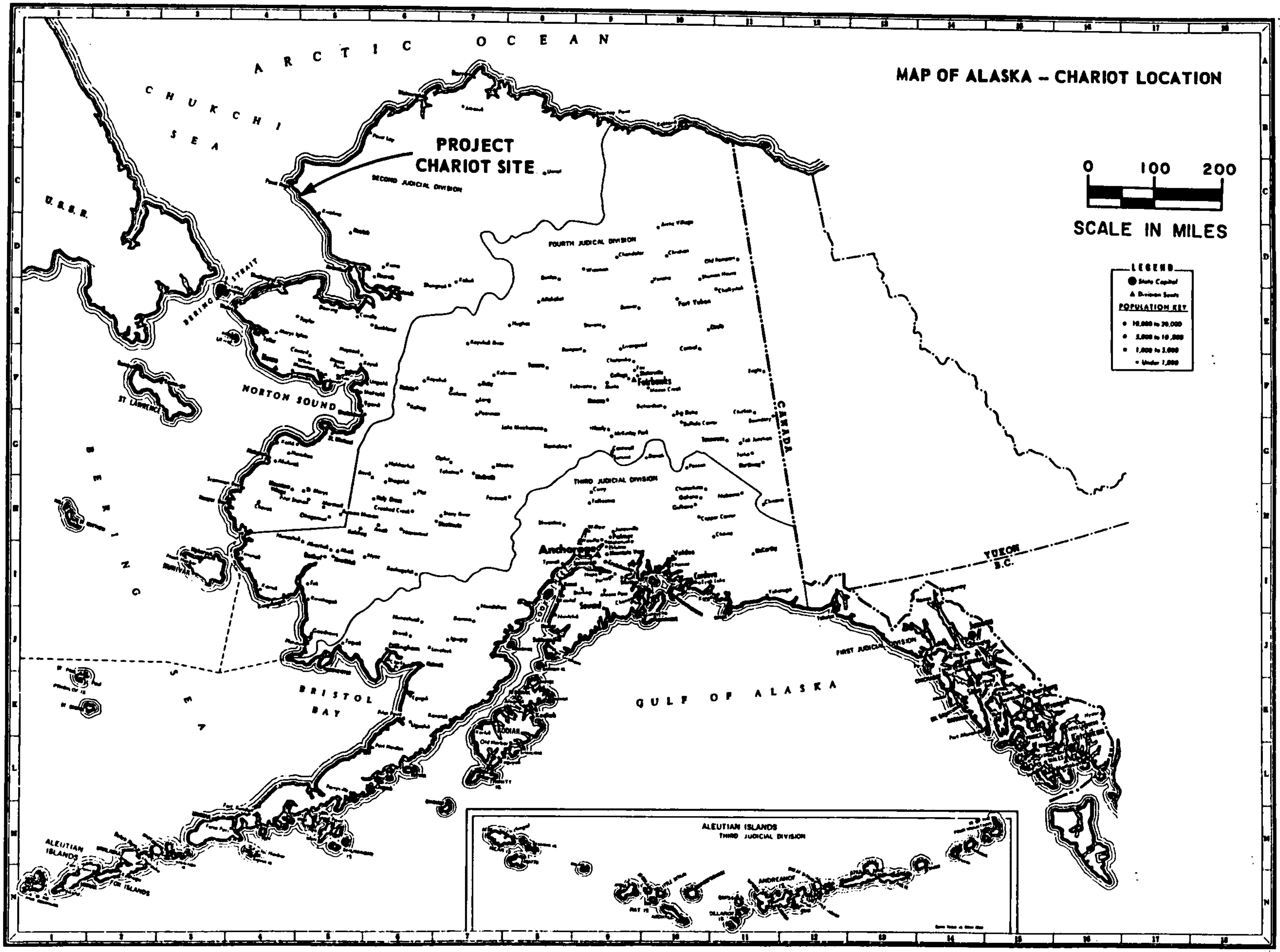
by

The Committee on Environmental Studies
for
Project Chariot

PLOWSHARE PROGRAM

THE UNITED STATES ATOMIC ENERGY COMMISSION

December, 1960


MAP OF ALASKA – CHARIOT LOCATION
PROJECT CHARIOT SITE
ARCTIC OCEAN
CHUKCHI SEA
U.S.S.R.
BERING STRAIT
ST. LAWRENCE
NORTON SOUND
BERING SEA
BRISTOL BAY
GULF OF ALASKA
CANADA
YUKON
B.C.
SECOND JUDICIAL DIVISION
FOURTH JUDICIAL DIVISION
THIRD JUDICIAL DIVISION
FIRST JUDICIAL DIVISION
Fairbanks
Anchorage
KODIAK
ALEUTIAN ISLANDS
ALEUTIAN ISLANDS
THIRD JUDICIAL DIVISION
0 100 200
SCALE IN MILES
LEGEND

FOREWORD

This summary is based on the reports on more than 30 bioenvironmental investigations carried out in the Cape Thompson area in Alaska since late spring of 1959. Final reports of the first year's work and some of the progress reports of the second year of investigation have been utilized in preparing this summary. Most of these studies will be the source of many scientific papers in the years to come and the stimulus for further researches because of numerous problems brought to light. No program of this scope is ever "completed."

This summary has been prepared for the U. S. Atomic Energy Commission by the members of the Committee on Environmental Studies for Project Chariot from the reports listed in Appendix IV. It is intended that a complete scientific report of these studies will be published. The Committee assumes responsibility for inadvertant omissions and will maintain a continuing effort to update this document in order to keep the Commission informed.

The Committee wishes to thank the principal investigators, and their colleagues, not only for their diligent scientific labors, but for their efforts in making their findings available promptly. Their cooperation and achievement in the scientific phases of this program have been noteworthy. Their commentaries on this summary will be sought and will be useful in the preparation of any future revisions.

To Ralph Chase, Holmes and Narver; James Sugden, Myrl Smith, and Henry Schlacks of AEC; Porter Lockard, Wiens Airlines pilot, we express gratitude for cooperation and assistance at the campsite.

Finally, we appreciate the helpfulness of Dr. G. W. Johnson and his scientific staff at the University of California Lawrence Radiation Laboratory; and to many consultants, advisors, authors, and scientists whose contributions go unmentioned here, we express thanks.

This scientific report with committee commentary supersedes all other tentative statements or reports, internal or otherwise, that have been prepared by the Committee on Environmental Studies for Project Chariot.

John N. Wolfe, Chairman
Allyn Seymour, Deputy Chairman
Max E. Britton
Arthur H. Lachenbruch
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Norman J. Wilimovsky
Ernest D. Campbell, Secretary

December 20, 1960
Ed. Rev. March 31, 1961

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CONTENTS

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INTRODUCTION

In May, 1959, the United States Atomic Energy Commission approved a program of environmental studies to be conducted in conjunction with a proposed excavation project using nuclear explosives (Project Chariot, Plowshare Program) at the mouth of Ogotoruk Creek in northwestern Alaska.

The proposal, not approved by the Atomic Energy Commission at the time of this report, involves the simultaneous detonation of five nuclear devices. Four 20 KT devices would be buried to about 400 feet, and one 200 KT device buried to about 800 feet. The detonation would be expected to produce a channel about 900 feet wide and about 2000 feet long, with an additional basin of about 1800 feet in diameter resulting from explosion of the larger device. It is expected that about 95 per cent of the fission products will be entrapped underground.

The Commission's decision to conduct pre-detonation bioenvironmental researches provided the first substantial opportunity for scientific appraisal of ecological systems[1/] prior to the detonation of nuclear devices and the chance to provide bioenvironmental baselines by which after-effects could be evaluated and measured. Earlier plans for a continuing environmental investigation in the Chukchi Sea and on the land in the valley of Ogotoruk Creek and adjacent areas near Cape Thompson, Alaska, were set in motion.

Biological considerations in relation to the project were formally inaugurated on March 13, 1958. At that time a Sandia Corporation representative contacted the Division of Biology and Medicine relative to participation by the University of Washington Laboratory of Radiation Biology (UWLRB) in the proposed Alaskan nuclear excavation.[2/]

1/ There was, however, a fish study prior to the 1946 Bikini experiments. An effort was made to determine the populations of fish on the Bikini reefs for the purposes of comparison after the event. The collections resulted in an excellent list of fishes, but efforts to determine population changes could not be achieved because there was insufficient time for pre-shot study.

2/ The USGS was doing planning work as early as February 1958, and carried out initial field work in the same year directed toward an understanding of the geological environment. Geological work later became a part of the Committee's environmental program.

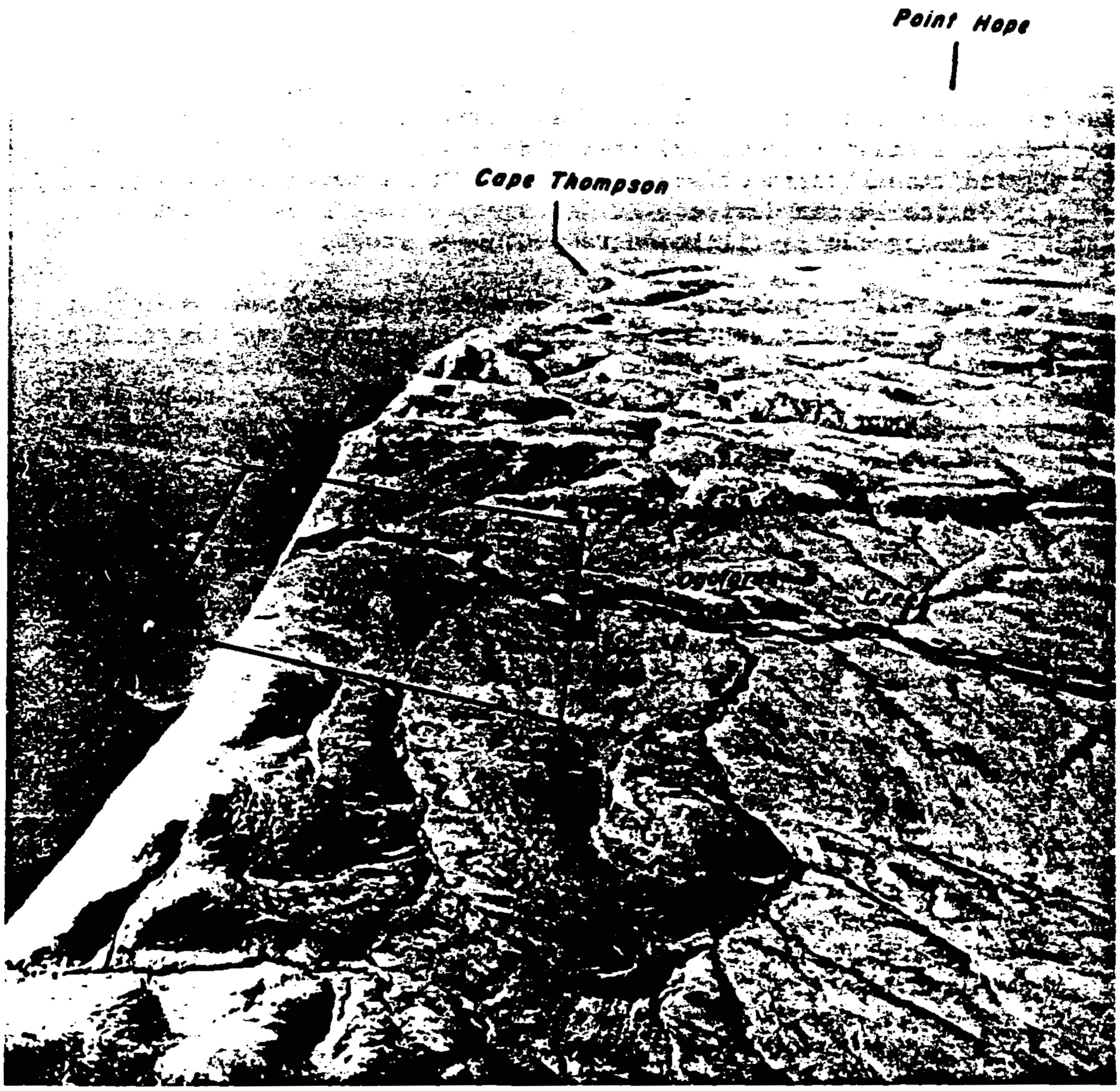

Figure 1. Aerial view of Ogotoruk Valley and Vicinity.

Fig. 2. View of section of bird cliffs at Cape Thompson

On April 8, 1958, a meeting was held at the University of California Lawrence Radiation Laboratory (LRL), Livermore, California, "to outline projects, set dates and locations, and formulate an operations unit." On April 29, 1958, Lauren Donaldson, Director of UWLRB, outlined a program of biological emphasis which he considered an essential part of the Chariot Project.

A meeting was held in Washington on May 5, 1958, with Atomic Energy Commission representatives and those from the Department of Interior, including Fish and Wildlife, Geological Survey and other agencies of the Department. This meeting was held to consider biological problems relating to the proposed project as well as others, but no formal plans were developed.

The first public announcement of the Plowshare Program was made June 9, 1958, by the Commission.

On August 25, 1958, at the request of the Commission's Division of Biology and Medicine, Dr. M. E. Britton, plant ecologist, Max Brewer, geophysicist, and Dr. Henry Childs, animal ecologist, visited the Ogotoruk Valley, collected some specimens and obtained a large number of photographs. In November 1958, Dr. Britton reported on this reconnaissance before the Advisory Committee for Biology and Medicine. At this same meeting Dr. Allyn Seymour reported on a literature survey that had been carried out in preceding months and discussed the development of the general program outlined earlier by Dr. Donaldson.

On February 20, 1959, another meeting was held at the Lawrence Radiation Laboratory, Livermore, to discuss further the biological implications of the excavation operation. In March a group of University and AEC scientists visited various agencies and organizations in Juneau, Anchorage, and Fairbanks, Alaska, to obtain additional opinions and suggestions relative to an environmental survey of the Chariot Site at Ogotoruk Creek.

A committee (Appendix I) was formed by the Commission's San Francisco Operations Office: to plan the scope of studies necessary to obtain sufficient information for prediction of the effects of the project on the biosphere; to recommend organizations to carry out the investigations (Appendix II); to receive and review reports; to analyze and summarize the findings; and to make further recommendations. The Committee's charter appears as Appendix III.

The objectives of the environmental program are:

1. To become sufficiently familiar with arctic ecological systems in the project area to permit: (a) estimates of the biological cost of the excavation operation, and (b) judgments as to whether or not there will be effects that could result in widespread damage to or major disruption of biological systems.

2. To become sufficiently familiar with the biological and physical environments that the findings can be used as baselines in studies to be conducted in post excavation time.

3. To determine radiation levels and distribution of radioisotopes in the biota and physical environment in pre- and post-detonation time.

4. To conduct all studies in such manner that the results constitute a significant contribution to scientific knowledge.

The scope of the program is outlined in the contents and brief summaries of progress in each area form the body of this report.

As of this time more than 30 studies (Appendix IV) are in varying stages of progress. Descriptive work such as areal geological mapping, cataloging of birds, fishes, mammals, plants, etc., is essentially complete (insofar as it is possible ever to "complete" biological inventories).

On the other hand, investigations of dynamic processes (soil movements, plant and animal migrations, succession, etc.) are continuing and it has been recommended that these receive such support as is necessary to maintain the records unbroken until immediately before detonation, if such is approved.

General Statement. The arctic tundra, circumpolar in extent, is a unique environment on this planet, having no counterpart in the southern hemisphere. Not infrequently it is described as remote, desolate, barren, and climatically rigorous. Probably none of these adjectives is accurate, and very possibly they are misleading.

The tundra is vast in extent, but more uniform in biotic composition, ecological structure, and physiognomy than any other terrestrial biological organization at landscape scale on earth. It is not remote to the Eskimo, the arctic fox, or the ptarmigan; the flowering plants blooming by the thousands per acre in certain areas in brilliant colors during the early growing season, belie its barren-ness and desolation; and the tundra climate is most salubrious to dwellers there, including man.

Ogotoruk Valley and the adjacent Chukchi Sea (see Frontispiece) are the centers of attention in this report. Here, about 100 miles north of the Arctic Circle, 125 miles northwest of Kotzebue, landscapes are dominated by various communities of plants, their constituents all small or dwarfed by genetic and/or environmental conditioning. Predominant are sedges, grasses, heathers, mosses and lichens. These are the primary food producers of terrestrial habitats and together with algae, the primary producers of the sea, form the broad base for the entire human economy.

The Chukchi Sea is shallow and lies over a floor characterized as the largest area of low relief on earth. In summer inshore temperatures reach 50° F.

The catalog of plants and animals that live all or parts of their lives in this area is already impressive even though the numbers of species in the following lists most certainly will be increased as studies continue.

Of approximately 60 known species of mammals in Alaska, 23, including polar bear, walrus, seals, whales, and caribou are known from this area. There are 280 recognized species of flowering plants. Numbers of species in other groups include 55 freshwater and marine fishes, several of which were not enumerated by a Russian expedition of a quarter of a century ago. Inland birds include 111 species, 58 of which are known to breed in the area. Seven species of cliff birds number almost a quarter million individuals.

Some other groups include: 200 species of marine invertebrates, 680 fresh and brackish water algae, 45 zooplankton, 43 mosses and liverworts, and 58 lichens.

It is from this biota that all the human inhabitants of the area derive most of their living needs, directly or indirectly. Kivalina, 40 miles to the southeast, and Point Hope, 32 miles to the northwest, together have a total population of about 500 people. Noatak, 75 miles to the ESE has a population of about 270 people.

Here at the mouth of Ogotoruk Creek, in a climate characterized by long, cold winters and short, cool, spring-like summers, both marked by high winds, it is proposed to excavate an inlet by means of nuclear explosives, as an experiment in "geographical engineering."

It is with the living aspects of geography and their relations to projects of this magnitude that this first report is concerned.

TERRESTRIAL INVESTIGATIONS

GEOLOGY AND SOILS

Areal Geologic Mapping

A geologic map has been completed which shows the distribution of the various bedrock units and types of surficial deposits together with faults, folds, and related structural features. It covers a 340-square mile area within a 15-mile radius from indicated ground zero.

The rocks in the area are limestone, dolomite, chert, and clastic sedimentary rocks laid down in marine environments from Early Mississippian to Cretaceous times. They crop out in north-trending bands, generally with progressively younger beds exposed from west to east across the area. The geologic structure of the western half of the area is dominated by north-trending imbricate thrust faults along which the upper sheets have moved eastward over the rocks below. The eastern half of the area is dominated by complex north-trending folds and high-angle faults. The deformation probably ended by early Tertiary time and the region has been the site of no recent earthquake epicenters.

Unconsolidated deposits of Pleistocene and Recent age overlie the bedrock in more than 50 percent of the area. These deposits are generally less than 10 feet thick but are as much as 50 feet thick in a few places. Slope debris (colluvium) is the most widespread material, and terrace gravel, flood-plain alluvium, ancient beach deposits, peat, and windblown sand and silt are prominent in some places.

The material to be excavated consists of folded and faulted mudstone and siltstone with minor amounts of sandstone, in part highly fractured. From within a foot or two of the surface to depths of 900 to 1,150 feet it is perennially frozen, and open fractures are filled and cemented with ice. Rocks from the highly fractured zone may crumble to gravel-size particles or smaller when thawed.

Seismic compressional waves in the rocks near ground zero have a velocity ranging from 11,500 to 14,500 ft/sec with an average of about 13,500.

Soils Classification and Mapping

Soils mapping and classification in the Ogotoruk area did not get underway until the summer of 1960. However, a tentative classification enumerates eight soil groups:

Zonal Soils

1. Arctic brown
2. Arctic brunizem
3. Tundra low humic gley-arctic brown intergrade

Intrazonal Soils

4. Tundra low humic gley
5. Tundra humic gley
6. Tundra half-bog

Azonal Soils

7. Regosol
8. Rockland

These soil types have been described on the basis of 51 profiles examined, sampled, and analyzed. Chemical and physical analyses have been completed for 16 profiles.

A preliminary map of the soils has been prepared by assembling the aerial photo field sheet prints at a scale of 1:20,000. The uncorrected mosaic is undergoing revision. In addition to showing the Great Soil Group classification the mapping units also indicate the kind of parent material, the ground pattern, texture of soil, slope gradient, and proportion of bare soil surface resulting from congeliturbation.

A typical soil profile in a cotton sedge (*Eriophorum vaginatum*) tussock vegetation type follows:

Location: 5 miles NNE of campsite, 200 yds. west of fork of Ogotoruk Creek; air photo No. H-3.

Physiography: Raised polygon area on broad, (200 yards) nearly level interfluve, lower part of long nearly level colluvial slope. Elevation: 150'

Parent material: Loess mantle, about 4 ft. thick, over mudstone colluvium.

Topography and slope: Nearly level (0-2%) crest with raised polygons, about 12" higher than the borders, hummocky micro-relief.

Drainage: Imperfect.

Vegetation: Tussock with ice scars, *E. vaginatum*, *Salix pulchra*, *Ledum* sp., *Betula nana*, *Rumex arctica*, mosses and lichens.

5-0 inches, root mat of white cotton grass (tussock), Ledum, willow, moss, lichens etc.; roots extend into horizon below.

1 0-5 inches, dark reddish born decomposed peat; weak fine granular structure; pH 4.5.

2 5-19 inches, compressed very dark brown decomposed peat with inclusions of thin layers of very dark gray silt loam mineral soil material, some inclusions of the peat are quite raw under the tussock; massive structure; roots noted to 14 inch depth; frozen, with lenses of ice 1/4 to 1/2 inch thick and about 5 inches apart.

sampled at 5-12" pH 5.0
12-19" pH 5.2

3 19-30 inches, very dark gray silt loam with inclusions of thin layers of compressed very dark brown decomposed peat, some layers appear to be a mixture of very dark brown compressed peaty masses and very dark gray silt loam mineral soil material; frozen with ice constitution about 50 per cent of volume as horizontal seams and lenses about 1/2 inch thick; pH 5.6.

4 30-42 inches, very dark gray (N 3/) silty clay loam with common inclusions of compressed brown and very dark brown organic matter; frozen, the ice lenses and soil appear to be in horizontally laminated form; no rock fragments apparent; ice constitutes about 75 per cent of volume; pH 5.8.

5 42-48 inches, very dark gray (N 3/) silty clay loam with small fragments of very dark gray mudstone fragments and occasional inclusions of dark brown organic matter; frozen, ice constituting 25 to 50 per cent of volume; pH 6.2.

Movement of Slope Materials

One of the striking characteristics of arctic soils is their motion, involving both vertical and horizontal mixing, and effects of these processes on the soils themselves, physiographic patterns, and vegetation and vegetational processes.

These studies, along with the other soils investigations, were inaugurated the second summer of the program, in 1960.

Six sites were selected and at each site soil temperatures, moisture, and movement are being recorded. The stations selected include:

1. a moist environment of earth hummocks

2. a peat ring

3. a frost boil

4. a dry environment of a downslope peat roll of an upperslope

5. a very wet environment

6. a peat roll on a lower contour step

Data on actual motion and rates of movement are still in process of analysis, and thus far are insufficient for any general conclusion. Additional observations this year will probably clarify the relations of temperature, soil moisture, and soil movement.

Coastal Processes and Characteristics

This investigation included the studies of longshore transport, sediment deposition, and physical and chemical characteristics of sediment along the beaches and in lagoons to provide a physical background for ecological studies for coastal waters, and baselines for post-shot evaluation of modifications of the coastal environments.

A 160-mile coastal strip from the Kukpuk River, 10 miles northeast from Point Hope, to Sheshalik Spit, 25 miles southeast of Cape Krusenstern was examined in considerable detail in 1959 and 1960. In addition, a dozen lagoons in the vicinity of the Chariot site were studied by geologists, biologists, and oceanographers.

Over the 160 miles of coastline from the Kukpuk River to Sheshalik Spit, deposition is occurring on the south sides of Point Hope, east sides of Cape Krusenstern, and Sheshalik Spit. Active erosion is taking place at the north side of Point Hope and the west side of Cape Krusenstern.

Several of the lagoons studied drain directly to the sea but water of others percolates through the gravel to the sea. Almost all are reached by at least occasional waves during severe storms. As a consequence the lagoon water varies from fresh to saline, often with distinctive stratification depending in part, upon the rate of freshwater movement through the lagoons and its mean level above the sea. In a sense they form restrictive or even endemic habitats which are of interest not only to the biologist but to the geologist, because of their sediment-trapping characteristics. Sedimentation is slow (estimated to be on the order of 5 to 10 mm per century) in lagoons that are not fed by rivers and streams. Summer measurements of pH of lagoon waters and lagoon sediments were respectively about 7.4 and 6.3. Reducing conditions exist at the base of the 10 ≁ cm section of recent lagoon sediments. Lagoon currents are controlTed largely by local winds. Although several lagoons support fish, only one lagoon (north of the Chariot site) enters into local subsistence economy of the Point Hope people, who obtain whitefish from this lagoon.

The width of the beaches is related to their exposure to the surf. Sheltered beaches such as the one in front of the Chariot site are broad; exposed beaches tend to be narrow. The energy available in the waves striking the coastline is principally expended in moving sediment first from the beach toward the sea at time of heavy surf and then restoring it to the beach during periods of calm.

The beach at the mouth of Ogotoruk Valley, like 85 per cent of the beach between Point Hope and Kivalina, is neither prograding seaward nor eroding rapidly. However, single storms may cause alongshore transport in the order of several hundred cubic yards per hour. These processes are effective in the strip bounded on the seaward side by the 10-meter submarine contour.

Estimates of the amount of transport between various portions of the coast have been calculated, and empirical factors have been derived from the relationship between sediment transport and wave characteristics. The controlling factor is the angle of wave attack during storms. Average net transport during the last 400 years, as estimated from the volume of sediment on a spit of known age, was 5 cubic yards per hour to the southeast during the ice-free period. But 1960 was an atypical year in which net transport was 14 cubic yards per hour to the northwest.

The ultimate source of the beach gravel is from the cliffs at Cape Thompson, but during years with reverse drift, such as 1960, the gravel is derived from sediment previously deposited between the Chariot site and Cape Krusenstern.

Winter and breakup investigations indicate that sea-ice has little effect on beach material except to arrest its normal movement for 8 months of the year. The presence of the ice and the short growing season prevent the establishment of the seaweed characteristic of many other shorelines.

Redistribution of sediments by wind can be important. Sea-ice is discolored by silt to about a mile offshore.

Permafrost Analysis

Temperature measurements made in exploratory boreholes in Ogotoruk Valley reveal that permafrost is about 1,150 feet deep at points more than 1,000 yards inland but that it thins toward the shore, being about 900 feet deep at points 100 yards inland. Existing departures from calculated equilibrium thermal effects of the ocean indicate that permafrost exists under the margin of the Chukchi Sea and that the sea has encroached on the land in the last few thousand years.

Preliminary thermal properties measurements made on frozen cores, used in conjunction with field temperature data, suggest that heat is flowing from the earth's interior at the rate of about 10^{-6} cal/cm^2/sec.

All five nuclear devices will, according to present plans, lie within rock whose temperatures are perennially below 0°C (permafrost by definition). Some interstitial moisture might be unfrozen however, owing to effects on the freezing point of overburden pressure, pore size, and dissolved solids.

Soils in vegetated tundra areas of the valley generally thaw to a maximum depth of one or two feet by late August. Refreezing is usually complete in late October or November. Exposed bedrock can thaw seasonally to four feet or more.

The long range mean annual ground surface temperatures averaged over areas of a few acres or more is generally in the range from -5°C to -6°C in vegetated tundra areas of the lower valley. Observed variations in this mean are evidently due to local differences in soil, soil moisture, vegetation, and microclimate. An active climatic change, now in progress, has raised the mean annual ground surface temperature on the order of 2°C in the last six or eight decades.

Surface Waters

Impermeable permafrost close to the surface generally causes water from rain and snow-melt to drain rapidly from the landscape. Melting of seasonal frost during warm spells can also have an important effect on stream discharge rates which fluctuate rapidly and widely.

Spot measurements of discharge rate were made at all streams at which chemical samples were taken (see Quality of Water). A stream gauging station 1.2 miles from the mouth of Ogotoruk Creek maintained almost continuous discharge records over the following intervals:

August 27, 1958	to	September 25, 1958
May 27, 1959	to	October 11, 1959
May 24, 1960	to	September 30, 1960

Greatest flow occurred in 1958 and the least in 1960.

The magnitude of the spring peak in late May or early June varies considerably because of variations in winter snow accumulation and rate of spring warming. Large flow rates are associated with late summer storms.

Some flow data for Ogotoruk Creek follow:

Maximum instantaneous flow:	1,260	cubic	ft.	per	sec.	7/9/59
Maximum daily flow:	700	"	"	"	"	7/9/59
Minimum daily flow:	1	"	"	"	"	late Sept.
Mean daily flow (summers)	60 ±	"	"	"	"	'59 and '60

In general there is little or no flow in Ogotoruk Creek from late October to early May.

The following observations are pertinent to the question of possible contamination of surface drinking water sources:

In spring, 1960, much of the early discharge of the Kukpuk River passed directly to the sea through a channel in grounded ice of Maryatt Lagoon (observation).

In fall, winter and spring natives of Point Hope depend on snow and ice for drinking water both at home and during hunting excursions.

Until early May, Point Hope natives use ice from Maryatt and Aiaugotuk Lagoons as well as from small lakes near Beacon Hill. In summer water is obtained from shallow wells and from open gullies between the beach ridges.

Snow mixed with sand blows great distances during severe storms at Point Hope.

Natives on the trail generally use snow as a primary source of water in the spring. This is of course true of huntingactivities on the sea as well as land. (The possible redistribution of radioactivity by wind-blown snow is under study).

Ground Water

Ground water (that which occurs beneath the ground surface in interstices or caverns) occurs in two distinct types of aquifers in this area: (a) shallow aquifers in sediments beneath creek beds and large lakes, and (b) deep aquifers which carry water through and below permafrost.

Shallow equifers are recharged primarily from stream-flow resulting from rainfall and snow-melt. In some cases flow may be augmented by springs and seepage from other ground water sources. Most shallow aquifers discharge during low water in the fall and carry little or no water during the winter months.

High mineral content is suggestive of a deep aquifer source. On this and other bases, springs are inferred in many localities neighboring Ogotoruk Valley. The largest known spring (Covroeruk Springs) is 27 miles southeast of Ogotoruk Creek. Its variation in discharge has been observed to be out of phase with that of surface water. Its winter and summer temperatures are +2 or +3°C (about those at a depth of 1400 feet beneath Ogotoruk Valley).

The sources of recharge for the deep aquifers are not known, although the problem is under study. They are believed to be along the Kukpuk River and upper reaches of the Kivalina River; and by percolation of surface water through permeable and fractured exposed bedrock.

Radioactive fallout could contaminate shallow aquifers directly, and if in recharge areas, could possibly affect deep aquifers with some time delay. Dilution and ion exchange would reduce the levels of radioactivity, but to what limits has not yet been determined. The nearest permanent settlements having subsurface sources of water supply are Cape Lisburne (70 miles away) and Kotzebue (120 miles away). Their recharge sources are believed to be more than 50 miles from the Chariot site.

Point Hope has a summer well that is believed to be recharged by snow-melt and rainfall on the beach.

Water Quality and Radioanalysis

U.S.G.S. has made chemical and comprehensive radiochemical analyses were made of at least one sample from each of the following bodies of surface water (collected August 4, 1959 to September 9, 1959).

East fork Ipewik River
Kukpuk River
Chukchi Sea
Ahgahyoukuk Creek
West pond at head of Ogotoruk drainage
East pond at head of Ogotoruk drainage
Ogotoruk Creek
Lagoon at mouth of Ogotoruk Creek
Kisimulowk Creek
Covroeruk Springs
Noatak River
Wulik River

In addition, chemical analyses (without radiochemical) were made on samples from the following:

Singoalik River
Creek entering S.E. end of Tusikpuk Lagoon
Nusoaruk Creek

Samples from Ogotoruk Creek were collected daily for chemical quality and suspended sediment measurements throughout July and August of 1959.

Waters reflect the chemical characteristics of rocks, soil, and vegetation cover in the terrain they traverse. Waters of Ogotoruk and Kisimulowk are soft and low in mineral content, with total dissolved solids less than 50 ppm. Waters from the other streams (except Nusoaruk Creek) were relatively hard with total dissolved solids in the range of 100-200 ppm. Nusoaruk Creek (about 3 miles N.W. of the Chariot site) contained about 15,000 ppm dissolved solids. About the same value was obtained from Covroeruk Springs, suggesting that Nusoaruk Creek is spring fed from a deep source.

The west pond at the head of the Ogotoruk drainage has a low mineral content as expected for such a body. The east pond, by contrast, has a high mineral content, and a chemical composition suggesting that it might be, in part, spring fed.

The amount of suspended sediment in a stream depends strongly on the discharge rate, and hence is very variable. In Ogotoruk Creek, measured values vary from zero to 1530 ppm. Estimated capacity at flood stage is 2500 ppm. At high water virtually all suspended particles in Ogotoruk Creek were smaller than 1 mm. At 210 cubic feet per sec. al were less than 1/4 mm.

Except for the two ponds at the head of Ogotoruk drainage, concentration of alpha and beta activities were generally similar to those in waters elsewhere in the U.S. The high beta activity measured in the two ponds is probably the result of worldwide fallout coupled with incomplete seasonal flushing. In all samples Cs^{137} was low and Sr^{90} was below detectable limits. Uranium and radium concentrations were very low in all fresh water. The measured beta activity of sea water can be accounted for by the K^{40} present.

Gravity Survey

The acceleration of gravity was measured at a number of points in Ogotoruk Valley and along the coast from Point Hope to Kotzebue.

A broad gravity low of 30 milligals (about 0.003% at normal gravity) centered around Kivalina suggests that the lighter Mesozoic sediments thicken southeast of Ogotoruk Creek and thin again near Cape Krusenstern.

The gravity data suggest that faults northwest of Ogotoruk Creek displace a relatively shallow sequence of rocks. The density contrasts among the various rock types is small, and the gravity data may provide a poor indication of the geologic structure. However, the structural interpretation is consistent with the surface geological data.

Floristics and Plant Ecology

The plant ecology of the area, as well as the essential floristic studies fundamental to it, have been studied vigorously since early summer, 1959. This summary is based upon accomplishments of only the first year of study and, thus, mainly represents results from the first summer of field work. The study contributes to the descriptive background of landscape features necessary to all of the terrestrial biology investigations.

The flora has been studied, and voucher specimens filed, for large areas in Ogotoruk Valley, the Kisimulowk Valley, at Cape Thompson, and in the Kukpuk River region. Vascular plants are represented by 493 collections including 280 identified species. In Ogotoruk Valley, an area of some 80 square miles[3/], the floristic list is considered to be essentially complete, but it is predicted the total flora for all areas studied will reach 300 species. The cryptogamic flora includes 101 identified species. Among these are 43 species of liverworts and mosses and 58 species of lichens identified from field collections totalling 102 and 131 respectively. The floristic list is arranged in tabular form and the individual entities are keyed to their known distribution within one or more of eleven vegetation types.

The vegetation is tentatively classified into twelve categories which are designated by code symbols keyed to a vegetation map. Nine of the vegetation units are designated as "types" and four of these include two or more "sub-types." Three categories include assemblages of species related to snow beds, gravel bars and benches, or those falling within a miscellaneous grouping of diverse and relatively less important vegetation.

The vegetation classification is largely physiographic in character, the named units depending upon habitat classification as much as upon plant composition *per se.* Descriptions are recorded in terms of dominant and sub-dominant species, the latter often including named species of mosses and lichens. Although the treatment is not entirely uniform most of the vegetation types are analyzed in relation to a broad range of habitat conditions including rock types, soils, water supply, snow cover, depth to permafrost, solifluction phenomena, types of patterned ground, microrelief features, degree of slope, animal effects, and others. In cases the density of vegetation is estimated.

3/ Actual area of the Ogotoruk watershed is 39.8 square miles; some field studies extended beyond these limits.

A 1:20,000 map of Ogotoruk Valley gives the distribution of the major classified plant communities. With minor variations the mapped units are those of the communities listed in the report text and of the floristic list. This map combined with descriptive materials and extensive photographic documentation of plant species, vegetation types, habitats, landscape view and numerous other features constitute an invaluable record of existing conditions against which post-detonation comparisons may be made. The photographic documentation includes 190 kodachrome and 216 black and white pictures which are in the possession of the investigators. A list of these photographs occurs in reports.

Permanent study plots have been established within all of the major types of vegetation. Fifty-four one-acre plots are marked for identification, mapped, and their geographic coordinates listed in the report. These plots are distributed at varying distances from the proposed shot-site and are being studied in detail preparatory to any necessary post-shot evaluation.

Vegetation-soil relationships are under investigation. During 1959 soil samples were collected in seven of the vegetation study plots for subsequent laboratory analysis.

Seed collections were made from populations of 35 species occurring in 14 of the permanent study plots and 7 additional areas. These are being utilized for germination experiments in the laboratory at the University of Alaska.

An evaluation of the importance of winter snow cover to vegetation was made in early April, 1960. In addition to general observations in Ogotoruk Valley detailed inspection and descriptions of snow patterns were made within forty of the fifty-four permanent vegetation study plots. Although a fair amount of descriptive information is given it is difficult at this time to generalize from it or to come to any definitive conclusion relative to total snow cover. Snow cover is highly variable depending upon surface characteristics of the ground, kinds of vegetation and exposure to winds which are of high average velocities.

Extremes in snow cover are represented on the one hand by the ridges bordering the Valley which are kept essentially barren by high winds and, on the other, by side valleys, tributary to Ogotoruk Valley, which may be filled with several feet of snow. The general aspect of the valley in April is stated to be brown and this is borne out by descriptive material and photographs insofar as the ridges are concerned. Tussocks, hummocks and other micro-relief structures as well as a great deal of vegetation protrude through the thin snow cover. Many measurements of snow depth are given but all in all it is not certain at this point of the general applicability of these numbers. On May 15, 1959, for example, photographs taken at an altitude of

1,000 feet show general snow cover except on the upper rocky slopes.

Land Mammals (except Caribou)

Small land mammals and caribou are being intensively studied in the Ogotoruk area. Caribou studies are reported separately.

Eighteen species of land mammals are reported for the Ogotoruk area. In addition, it is reported that Dall's sheep and marmot have only recently been extirpated, and that the moose is extending its range into Arctic regions, one having been observed within four miles of the camp site in 1959.

The catalog of land mammals includes:

1. Arctic Shrew (*Sorex arcticus*)
2. Grizzly Bear (*Ursus horribilis*)
3. Polar Bear (*Thalarctos maritimus*)
4. Wolf (*Canis lupus*) See caribou discussion.
5. Red Fox (*Vulpes fulva*)
6. Arctic Fox (*Alopex lagopus*) 1 track, 1 active den.
7. Wolverine (*Gulo luscus*)
8. Weasel, Ermine (*Mustela erminea*) 1 collected.
9. Least Weasel (*M. rixosa*) Several in '59, none in '60.
10. Arctic Ground Squirrel (*Citellus parryi*)
11. Porcupine (*Erethizon dorsatum*)
12. Red-backed Vole (*Clethrionomys rutilus*)
13. Muskrat (*Ondatra zibethica*) 2 collected. Accidental?
14. Tundra Vole (*Microtus oeconomus*)
15. Alaska Vole (*M. miurus*)
16. Brown Lemming (*Lemmus trimucronatus*)
17. Collared Lemming (*Dicrostonyx groenlandicus*)
18. Barren-ground Caribou (*Rangifer arcticus*)

In addition, lynx, mink, and land otter are known in the Kivalina area, especially southward. These along with wolf, wolverine, arctic fox, and muskrat are trapped by the natives.

Of the seven species of small mammals in the Ogotoruk area, the four most abundant in 1959 were: brown lemming, red-backed vole, tundra vole, and Arctic ground squirrel.

Study plots have been established in different habitat types, and standardized trapping methods provide data on the relative abundance of the various species. Absolute densities can be best obtained by trapping and marking individuals and releasing them. Retrapping then makes it possible to determine populations.

The nine types of plots have been located on the basis of vegetational types. Findings during 1959, based on study plots, are as follows:

1. *Dryas* fellfield: 4,788 acres in the valley producing approximately one each per acre of brown lemming, tundra vole, and ground squirrel.

2. *Eriophorum*-*Carex* wet meadow: 2,695 acres in valley producing 8,085 tundra voles and 539 red-backed voles.

3. *Eriophorum* tussock: 8,429 acres in the valley producing 5,057 shrews, 25,287 red-backed voles, 1,685 brown lemmings, and 3,371 tundra voles.

4. *Carex bigelowii* frost scar: 446 acres producing 446 collared lemmings, 1,338 brown lemmings, and 743 tundra voles.

5. *Eriophorum*-*Carex* solifluction slope: 450 acres producing 225 shrews, and 5,637 tundra voles.

6. *Carex bigelowii* high-center polygons: 57 acres producing 114 red-backed voles and 57 collared lemmings.

7. Ericacious shrub polygons: 222 acres producing 222 ground squirrels.

8. Snow bed: 192 acres producing 192 collared lemmings.

9. Gravel bars and benches: 758 acres producing 252 shrews, 4,042 tundra voles, and 252 brown lemmings.

The area under study comprises about 19,000 acres. The total number of small mammals is about 72×10^3 individuals. This represents an average population per acre of about three to four of these small animals. Levels in terms of biomass per species are indicated to be:

Species	Number	Biomass
Shrews	5,534	48.6 kg
Red-backed Voles	25,940	525.5 "
Brown Lemmings	8,063	264.7 "
Collared Lemmings	695	33.5 "
Tundra Voles	26,666	885.3 "
Ground Squirrel	5,010	3,381.7 "
	72,000	5,100.0 "

Total biomass of these animals is thus calculated at about 275 grams per acre in 1959.

It is noted that the populations of most small mammals were much lower in 1960 than in 1959. In the Ogotoruk Valley marked changes in the frequency of several species of different habitats occurred. This population cycling has long been known, but it is not understood completely.

Data have been collected on fluctuations, reproduction, food habits, and other aspects of the biology of the available species.

Caribou

The caribou (Rangifer arcticus) are the most widespread and numerous of the large animals in this region of the continent. A number of observations and estimates have been made during various years. For example: one observer estimated that 200,000 animals crossed the Kobuk River in 1955 and by the end of May all the caribou had moved north of the Brooks Range. A similar movement is reported to have occurred in the winter 1950-51.

The winter of 1957 represents the other extreme. No caribou were reported south of the Brooks Range. Animals were present in early winter along the coast between Point Hope and Kivalina and small groups were scattered throughout the drainage system of the upper Noatak and Kivalina Rivers.

In 1959 one estimate of the caribou population of Arctic Alaska was 230,000. Lent (June 1960) estimates the population in excess of 200,000.

Lent reports that by the last of June 1960, a large loose congregation of caribou had formed in the high country at the headwaters of the Pitmegea, Kukpuk and Kivalina Rivers. This population was estimated to be well in excess of 200,000 individuals and apparently included a large majority of all caribou in Arctic Alaska. About the first of July, this population split into two groups. One group of approximately 125,000 moved south then east along the south side of the DeLong Mountains, through the Noatak drainage. Tracks indicated that the other group was of similar size, although it was never actually seen after division. This second group continued east along the north side of the DeLong Mountains and was reported to have crossed the Colville River, heading north, later in July.

Descriptions of late summer movements along the coast apparently are confusing and conflicting. Ordinarily, a large number of cows and calves enter the area between the Ipewik and the Kukpuk Rivers in June immediately after calving. Small groups of bulls spend the summer in the hills nearer the coast between Cape Lisburne and Cape Thompson. Caribou are usually present inland from Cape Thompson and south to the Kivalina River from late September to November.

Ogotoruk Valley is one of the few areas in northwestern Alaska in which caribou are traditionally found. The observed distribution in February 1960 is given in Table VI.

On the basis of information collected to date, caribou may be expected to be common in the Ogotoruk Valley from late October to early May, with the population in the valley reaching peaks of 300 or more in November and March. During the summer months movements involving several thousand animals may be expected to cross the upper part of the valley, but the date of such events cannot be predicted far ahead of time because of lack of an understanding of the factors controlling caribou movements. Rarely, small stray bunches may break off from these summer movements and enter the lower part of the valley. Caribou, with the possible exception of rare stray bulls, are absent in May and June.

The principal calving area in 1960 was in the vicinity of the upper Utukok River, about 175 miles northeast of the Chariot site. Calving in 1960 occurred between May 20 and June 3.

There were no reports of caribou in the Ogotoruk watershed during May, June, or the first half of July.

Of the observations made thus far there are none on the early winter range for the caribou.

The present day people of Kivilina, Noatak and Point Hope depend on the caribou for a major share of their food and for a moderate portion of their clothing. Also some caribou, or its parts, are used as dog food, the amount is dependent on other dog food reserves such as fish and seal.

Caribou hunting is apparently influenced by three factors: (a) the location of the animals with respect to the village, (b) relative ease of travel, either by boat until freeze-up of rivers in the fall or by dogteam after a relatively smooth ice or snow cover is available and (c) wind and its influence on the hunter and caribou. In the winter of 1959-60, there were apparently two principal hunting periods - one was October-November and the second from February to April.

At Kivalina, caribou were first sighted from the village on October 14, 1959, however, the first kill did not occur before October 20. Ninety-six animals were killed by November 7, a total of 19 days. From November 8, 1959 to May, 1960 there were 311 caribou killed. Twenty-five households benefited.

At Noatak, for the period October-November 1958 to October-November 1959, 1778 caribou were killed benefiting 51 households.

At Point Hope, for the period October-November 1958 to October-

Table VI - Caribou Distribution on Winter Range
Northwestern Alaska, Feb. 1960 (From Lent, June, 1960)

Location	Average Density per sq. mile	Estimated Number of Caribou in Area
Mulgrave Hills, lower Kivalina and Wulik Rivers, DeLong Mtns.	1	1,000
Coastal hills, Ogotoruk Creek to Singoalik River	10	2,500
Singoalik River to head of Kukpuk River	25	8,800
Upper Kivalina River to upper Wulik River	10	3,000
Kelly River	--	9,300
Head of Kelly River to head of Kugururok River	--	4,100
Trail Creek to Nimiuktuk River	5	1,100
Valley of upper Noatak River	3	2,500
Western Baird Mountains	4	2,900
Central Baird Mountains	10	14,000
Western Baird Mountains & north side of upper Kobuk River	5	8,000
Timber and Cross Creeks	--	12,000
Shungnak River	--	750
Waring Mountains	2	2,200
Estimated Total		72,000

November 1959, 696 caribou were killed benefiting 39 households.

Each village obtains most of its caribou from within a radius of 50 miles. The total number of caribou required by the people of Kivalina and Point Hope is apparently less than 1200 per year during a seven month period (October to May) each year.

Recapitulation of the data in Table VII indicates that all of the spring kill in 1960 (361 animals) was within 25 miles of the Chariot camp site.

% within 20 miles:	93.6
% within 15 miles:	66.7
% within 10 miles:	30.7
% within 5 miles:	9.4

Total man days hunting amounted to 182. The data do not indicate the number of individual huntsmen represented by this figure.

Freshwater Fish

The area about the site contain a very limited number of freshwater fishes all characteristic of a "typical" Arctic freshwater community. The species collected are Dolly Varden and Arctic chars (Salvelinus malma, S. alpinus); three whitefishes (Coregonus autumnalis, C. larvaretus pidschian); grayling (Thymallus arcticus) a cottid (Cottus cognatus); and two sticklebacks (Gasterosteus aculeatus, Pungitius pungitius.) In addition to these species, the important anadromous salmon spend their early and very late life history stages in fresh water.

Except for the cottid and sticklebacks, all of the aforementioned species are important to the indigenous human population of the region. These species are chiefly in the rivers and larger streams, but the whitefish and char also inhabit some of the lakes and lagoons in the area under consideration.

The species are ordinarily utilized when they are congregated into dense schools or "runs." The anthropologist at Kivalina reports that the char make up a major portion of the fish catch in the subsistence economy of the Kivalina people. Some fishing takes place in June but the major activity occurs in the fall. In 1959 over 85,000 pounds of char, 12,000 pounds of whitefish and 400 pounds of grayling were taken. The grayling and whitefish are taken for human consumption, but the major portion of the char, along with other marine fishes, are used as dog food. (See mammal report re the necessity of dog-teams for caribou hunting.)

Table VII - Caribou Hunting Pressures Near Ogotoruk in Spring 1960
February 3 - May 12 (incl.) 100 days

Distance from Camp Site: No. Hunters/Kill

Date	0 - 5 mi.		5 - 10 mi.		10 - 15 mi.		15 - 20 mi.		20 - 25 mi.	
2/4			2	7						
2/5	6	0	2	0			2	8		
2/6			6	16			2	0		
2/7									2	0
2/8									2	3
2/14					1	0				
2/15	2	0					1	10		
2/16					3	16				
2/17					3	0				
2/18					6	14				
2/21			6	17						
2/24	3	3			6	0				
2/25							6	22		
2/27									2	0
3/2							2	10		
3/7					8	7				
3/8					8	60	1	5	3	16
3/9					3	14				
3/10					1	0	4	0		
3/11							6	29		
3/12							8	0		
3/13							5	0	1	4
3/17							2	1		
3/18							2	2		
3/19							2	4		
3/20							2	6		
3/21					2	0				
3/23					1	0				
3/24	1	0	2	7	1	5				
3/25	1	0	2	0						
3/26	1	0	2	0						
3/27			4	16						
3/28	5	9			4	8				
3/29	5	0								
3/30			6	11						
3/31	5	14	2	0						
4/1			3	0						
4/7									2	0
4/19			1	3						
4/25	6	8								
5/10					1	6				
5/11					2	0				
5/12					2	0				
TOTALS	35	34	38	77	52	130	45	97	12	23

According to one investigator approximately 20,000 pounds of freshwater fish were utilized by fourteen households at Point Hope whereas an estimated 111,000 pounds of freshwater fish plus more than 32,000 pounds of salmon were utilized at Noatak, a village 75 miles from the Chariot project area.

Although the total poundage of fish used in the economy is considerable, the abundance of fish is probably not great enough to support commercial utilization. There is probably an adequate surplus to maintain the fish stock and to permit some additional utilization by the indigenous population. However, in comparing the relative fish population size with such areas as the west coast of the United States, or Great Lakes area, the total freshwater fish catch in the Point Hope - Kivalina area is minute.

Studies to date have established the extent of utilization of fish by the Eskimo. Admittedly the statistics are in need of refinement, but the dependence of the local population on this source of food is evident. Additional investigation of the freshwater fish fauna is not anticipated at this juncture; however, in the course of study of the salmon population in the area, an attempt should be made to gather additional statistics on the utilization of the important freshwater fishes.

Inland Birds

The studies have been carried on through one partial field season (1959) and one complete field season (1960).

One hundred eleven (111) species have been recorded; 58 species are known to breed in the area; 17 additional species probably breed there.

The remainder are species that occur casually or as migrants only.

The density of breeding birds was determined by counting the birds on census plots located in representative stands of the vegetation types.

The arrival and departure times of the birds by species, were found to be as follows:

April -- one species arrived
May -- 54 species arrived
June -- 7 species arrived
July -- 1 species departed
August -- 25 species departed, 1 arrived
September -- 21 species departed, 1 arrived
October -- 10 species departed, 1 arrived
November through April -- 7 resident species

The number of species in residence each month is as follows:

January through April -- 7 or 8 species
May -- 55 species
June -- 66 species
July -- 66 species
August -- 66 species
September -- 48 species
October -- 28 species
November and December -- 7 or 8 species

The ecological distribution of the terrestrial birds is related to 13 ecological formations, as follows:

Aquatic types: Pelagic waters, marine littoral waters, lacustrine waters, fluviatile waters.

Geologic types: Inland cliffs, sea cliffs, sea beach, streamside alluvium.

Vegetational types: *Eriophorum* tussock tundra, wet meadow tundra, riparian willows, *Dryas* community.

Work on density and productivity has been concerned mainly with species associated with the following major vegetational types of the valley floor, as follows:

Eriophorum tussock tundra -- 8032 acres

Carex meadow tundra -- 4171 acres

Riparian willows -- 500 acres

Of the 31 species that breed in the valley, 14 species make up the bulk in numbers. After the fledging of young, these 14 species comprise approximately 37,000 individuals, with a biomass of 1,200 kilograms. The remaining species breeding in the valley comprise not more than 1000 additional individuals.

As a part of the study of productivity, the course of events in 250 nests was followed. Average annual reproductive rates were computed for the common species, and for the small passerine species this rate (young fledged per pair of adults) varied from 1.06 to 3.61.

Over 700 specimens of birds were collected for laboratory study. Data were obtained from these on food habits, physiological state, etc.

Data obtained from the first full season of study when combined with the data from at least one additional season will make possible comparisons of year to year changes essential for establishing a baseline from which post-detonation findings could be evaluated.

Limnology

Limnological investigations of streams and ponds of the Chariot area were begun in 1959 and have continued to date. This summary is based upon qualitative and quantitative data accruing from the investigations of July and August, 1959. Stream studies were conducted on Ogotoruk Creek and its tributaries for a distance of 10 miles from its mouth. Emphasis was placed on two sampling stations selected to represent different potential exposures to detonation effects. These sites are at 1.5 and 5.5 miles from the stream mouth. Ponds investigated are located about 6.5 to 7.0 miles from the coast at an elevation of 265 feet.

Streams. Ogotoruk Creek receives the drainage from a watershed approximating 40 square miles. It has a gradient of about 2.5 feet per mile and bottom materials generally consist of angular gravels with sand in the deeper pools. Discharge rates during the 1959 field season ranged from a minimum of 2cfs to a maximum of 700cfs with a mean value of 90cfs (plus or minus) for June-September 1959. Water is clear in summer except during periods following storms. Suspended sediments varied from 1-142 ppm. in 1959 and at low flow were usually less than 10 ppm. Other physical data include mineral constituents presented in average ppm. and temperatures in the form of continuous plots for the period between August 6 and 13, 1959.

On the basis of 54 qualitative and quantitative biological samples collected by standard techniques the stream is shown to be essentially barren of biota. Periphyton is sparse and dominant animals are bottom-living, immature stages of insects and turbellaria. Chironomids, stoneflies, mayflies and tipulids are most common among insects. Fish are very scarce and in 1959 represented only by a total collection of four Dolly Varden.

Data are recorded on population densities (No. organisms/sq.ft.) of ten categories of bottom fauna collected at five sites. These populations are discussed in terms of water depths and velocities.

Ponds. Two ponds, designated #1 and #6, among the group of 20, were studied intensively in terms of physical and chemical properties, qualitative composition of plankton, and qualitative and quantitative characteristics of the bottom biota. Physical data include information on average and maximum water depths, drainage, bottom materials and temperature. Chemical constituents of both ponds are tabulated and it is demonstrated that Pond #1 differs strikingly in chemistry from all other surface waters which have been studied in the Chariot area.

Biological studies include quantitative analyses of bottom populations at 15 sites in the two ponds. These sites are mapped and related to water depth and distribution of emergent vegetation. Population densities (No. organisms/0.25 sq.ft.) of twelve categories or organisms--about half chironomids--are recorded.

Benthonic communities differ markedly in the two ponds. The genus Cryptochironomus occurs only in Pond #1 and various species of chironomids are peculiar to one or the other of the ponds. Larvae of the chironomid genera Calospectra and Procladius are more abundant in Pond #1. An ostracod species present in one-third of the samples from Pond #1 was absent from Pond #6.

Phytoplankton is extremely scarce in all ponds and zooplankton, which is dominant, consists principally of crustacea. Seven Orders and three Subclasses of crustacea are represented and thirteen genera and eleven species have been identified.

Populations of three copepod species, two phyllopod species and a cladoceran appear to the investigators to be useful for the investigation of any disturbances to population dynamics which may occur in the future.

A new species of caddis fly is reported and the investigators anticipate the occurrence of other novelties among insects of the area. A conchostracan collected, previously known from the Siberian Arctic, constitutes a new North American record.

Phycology

Phycological studies have included collection of data on abundance, kinds, and productivity of algae in brackish and freshwater habitats. Data have been collected also on the zooplankton.

According to the results of work to date, qualitative findings on algae and zooplankton are as follows:

Algae

Myxophyceae
22 genera -- 43 species

Chlorophyta (principally Chlorococcales)
31 genera -- 68 species

Desmideae
15 genera -- 116 species

Bascillariaceae
43 genera --383 species

Eugleneaceae
2 genera -- 2 species

Rhodophyta
1 genus -- 1 species

In all, 138 genera with 660 species, forms, varieties have been identified thus far.

Zooplankton

Cladocera
8 genera -- 13 species

Copepoda
15 genera -- 23 species

Harpacticoida
9 genera -- 9 species

In addition, members of 11 other major groups have been found: Ostracoda, Anostraca, Conchostraca, Tardigrada, Hydracarina, Nematoda, Rotaria, Oligochaeta, Protozoa, Isopoda, and Hydra.

Productivity studies using the C^{14} method for determining net photosynthesis have been carried out in one freshwater lake and in one brackish lagoon.

Preliminary examination of data shows that the freshwater lake was more productive in terms of carbon assimilated than was the brackish lagoon:

During July and August, the lake had peak readings of about 27 and 65 mg. C/m^3/ day respectively, while during the same period the highest value obtained for the lagoon was only 4 mg. C/m^3/day.

For the season, carbon uptake was generally greater in the spring and summer, with a rather precipitous decline by mid-October, when total carbon uptake was less than .001 mg. C/m^3/day.

There was only a vague correlation between numbers of phytoplankters and corresponding C^{14} data.

Although the lagoon was more productive than the lake in terms of algal organism, carbon utilization was less. Zooplankton production was greater in the freshwater lake.

Considerable activity was noted in algae of some genera in the lagoon after ice cover had reached a thickness of 24 inches. At this time, there were over 10^6 Dinobryon per liter. Algae were not observed in the lake following ice cover. Total zooplankton was as great or greater after ice cover in both fresh water and brackish water, although this production was dependent upon fewer species than was the case during the summer.

Entomology

Insect studies have been carried out in conjunction with ornithological and limnological work, but time-consuming taxonomic work precludes further reporting at this time. These studies are being intensified to include the total insect fauna.

Peat Analysis

Microfossils (pollens, spores, microsticks, fibres, etc.) are being identified from samples taken from a 15-foot peat deposit in the valley of Ogotoruk Creek.

Interpretation of these data should throw light on the climatic, vegetational, and perhaps the human history of the area.

At this time the investigation is incomplete.

Pleistocene Paleontology

This work consisted of collecting and exhuming the partial skeleton of a Proboscidian (mammoth or mastodon) in the early fall of 1959. Certain bones were exposed. A number of others were embedded in a muck slide which had carried the fossils from a 60 foot bank to the bottom of a creek valley.

While most of the long bones, viz., femur-humerus, tibia and a small piece of a skull, were exposed on top of the muck slide, other parts of the skeleton such as pelvis, scapula, ribs and miscellaneous smaller pieces had to be excavated with pick and shovel from under the surface. No fossils were encountered below a depth of two feet. The ground above was, owing to the lateness of the season, frozen down six to seven inches. Below that depth the ground was very soft, and the specimens embedded in this soil had deteriorated to some extent. Most of the fossil material was repaired and after drying, shipped to the Department of Vertebrate Palaeontology at the University of Alaska. Neither skull, mandible, nor loose teeth were found in this deposit and the portion of tusk was so small, it was impossible to identify the remains as those of either mastodon or mammoth.

Laboratory studies will answer the question.

This work added to the Alaskan collections "a wonderful series of long bones, pelvis and scapula, ribs, etc., of a Pleistocene Proboscidian. ....It is not often that so many bones belonging to one and the same animal are collected."

Also collected in the same area were a few bones of musk ox, a ramus of a fox, a ramus of a bear, and miscellaneous other fossil material which indicated that further search could easily yield many more desirable fossils. The continuous "sloughing" of the various muck banks, especially after the spring thaw, makes such an opportunity possible.

MARINE INVESTIGATIONS

OCEANOGRAPHY

Oceanographic surveys during August 1959 and August 1960 in the southern Chukchi Sea and adjacent portions of the Bering Sea were accomplished by the University of Washington research vessel Brown Bear. This investigation was supported by the Atomic Energy Commission and Office of Naval Research and was supplemented by data obtained from the U. S. Fish and Wildlife Service vessel John N. Cobb. Some applicable winter data were also collected from icebreakers and from drift stations located on the northern Polar pack ice. Although some oceanographic data from previous expeditions were available, the Chariot effort has provided a sound basis for the understanding of a significant portion of Arctic Sea oceanography. The sections which follow contain a synopsis of the 1959-1960 investigations.

Currents (Water Movement). Direct current measurements carried out during the open water period of 1959 and 1960 indicate a northward flow through Bering Strait of from 0.5 to 1.0 knots. North of Bering Strait, the current turns and flows eastward toward Cape Krusenstern and then northward again paralleling the coast to the vacinity of Point Hope where available evidence indicates the current tends to spread eastward and westward. Because of the rotation of the earth, as the current converges on a westward extending coastline such as Point Hope, it accelerates and due to its momentum, some of the water tends to overshoot and moves to the west. After it has passed some distance beyond the point, the water again curves to the east in clockwise eddies. The observed currents in the Chukchi Sea tend to follow bottom configuration. At most stations the speeds averaged between 0.5 and 1.0 knot with little variation in speed and direction from surface to just above bottom. From these data it is evident that most of the water in the Chukchi Sea is in transit and remains only a relatively short time in the area.

In 1960, drift bottles were released to provide information on longer term surface water movements.

It is estimated that tidal currents in most of the Chukchi Sea do not exceed 0.1 knot. The effects of wind on currents are complex and require detailed analysis of data and a study of weather maps. It is known that considerable changes in sea level along coasts occur due to wind. These slopes must modify current patterns that would exist in the absence of winds. A long series of measurements at selected stations is essential before the effects of winds can properly be evaluated.

There are virtually no data available on winter water movements of the area.

Temperature and Salinity Distribution. As waters move northward through the Chukchi Sea in summer they are modified in various ways. They may be warmed, diluted by river run off and mixed. These processes are move effective in the surface layers near the coast. Below the thermocline and in the offshore waters it is possible that the isotherms and isohalines on a horizontal surface represent trajectories of water moving through the area. The isotherms and isohalines are closely spaced in Bering Strait, but horizontal gradiants are relatively large in the zone paralleling the coast at distances of 20 to 40 miles from the beach. This transition zone separates the warm and dilute coastal waters from the colder and more saline waters offshore.

The surface layer of relatively uniform and warm water is separated from the deeper water by a thermocline located at the depth of about 15 meters. The temperature change in the thermocline in the coastal waters is great, but in areas of strong mixing and in certain offshore areas, the thermocline was absent with temperatures being uniform from surface to bottom.

The changes in salinity in the vertical water column are similar to that of temperature, but the salt content and the temperature are inversely related. The halocline usually occurs at the same depths as the thermocline and where the temperatures were uniform from top to bottom, the salinities also tended to be constant.

Above the thermocline, the salinities ranged from 20^{o}/oo in Kotzebue Sound to almost 33^{o}/oo in offshore waters. The temperatures varied from 3.5°C in offshore areas to a maximum of 13°C near Cape Krusenstern. The poleward transport of relatively warm waters is of scientific interest to oceanographers and to biologists.

Chemical Studies. In addition to the analysis of salinity conditions, oxygen determinations were made throughout the study area. Phosphate and silicate analyses also were accomplished on more than 400 samples. Used in conjunction with temperature and current information, such data are valuable in "labelling" and tracing water types.

Surf Characteristics. Waves 3 to 5 feet high are common during storms in the Chukchi Sea with one report of waves over 8 feet high. Since 1959, daily notations of surf and swell characteristics have been collected at the Chariot base. In addition, the U.S.G.S. has made sporadic observations in other areas in connection with studies of sediment transport. This information in conjunction with available meteorological and oceanographic data would permit prediction of surf conditions for the Chariot area, but a longer series of observations at a number of sites in the Chukchi Sea would improve the reliability of such predictions.

Sea Ice. Until the present, little effort of the Chariot Environmental Program has been directed toward the study of sea ice conditions and winter currents in the sourthern Chukchi Sea. There is a body of general background information from Cape Price of Wales, Point Barrow and the Ice Drift Stations. Sea ice inshore conditions have been recorded at Point Hope and the Chariot base at daily intervals in winter but such data do not reflect the overall offshore conditions.

It is imperative that aerial observations at regular intervals of ice conditions in the Chariot area be inaugurated as soon as possible and that measurements of under ice currents be made throughout the Chukchi Sea. Such observations should include the extent of ice cover, type of ice, degree of compactness, direction and speed of winter and water currents. Open water leads offer the only areas in winter for the whale catch, and leads and other openings are possible seal hunting areas.

Marine Meteorology. Standard marine meteorological observations were recorded by the Brown Bear during August of 1959 and 1960 and by the John N. Cobb during August 1959. In addition, data for limited periods from the few ships passing through the area are available at the National Weather Records Center. The body of information, however, is too limited to be of any significant value in prediction. Summer conditions are extremely variable and stormy periods of two to four days separated by only two or three days of improved weather are common. In 1959 such storms gave winds of 20 knots or greater on 15 days, and a maximum of 35 knots. The daily maximum average was 23 knots. Low clouds and fog were very frequent during the open water period.

Submarine Topography. Until the Chariot investigations relatively few detailed data were available on the submarine topography of the Chukchi Sea. Because of the lack of soundings in the area, particular emphasis was placed on collection of depth information. Sounding data were obtained with a depth recorder over 2,600 traverse miles in 1959 and 3,100 in 1960. As a result, a general bathymetric map of the area was compiled.

The bottom configuration of the eastern Chukchi Sea is characterized by a monotonous regularity. Except in the northern and sourthern parts of the region, the bottom is smooth with depths between 90 and 180 feet. The greatest depths were only 200 feet (near 169°W. in the latitude of Point Hope and north of Diomede Island). Several minor features of relief were also discovered, the Point Hope submarine valley being an example.

Studies of bottom samples are still in progress. Superficial examination has permitted the preparation of a sediment map of the Chukchi Sea. Of particular interest is a core sample of 730 cm (obtained with a Kullenberg piston sampler) which is undergoing special analysis. This core should yield a detailed stratigraphic history of the Chukchi shelf.

The submarine topography in the immediate area of the Chariot site has been examined in detail by both the Geological Survey and the various oceanographic parties. Charts showing sediment and petrographic features are available. A minute submarine valley or extension of Ogotoruk Creek has been traced 15 miles seaward. The accuracy and horizontal control with which this chart has been prepared will allow assessment of any change in the area, over time intervals, including artificially induced changes in the surrounding area.

MARINE BIOLOGY

Primary Productivity

The productivity of the sea, or more properly the standing crop of the area, has been measured during the open water period at several points throughout the eastern Chukchi Sea. Pertinent measurements include the volumes of phyto- and zooplankton, Chlorophyll-A measurements and carbon 14 activity records of photosynthesis, determination of light penetration and turbidity. The majority of the data has not yet been reported upon, but superficial analysis indicates high concentration of photosynthetic organisms in Bering Strait and in the transition zone between coastal and offshore waters. Values in Kotzebue Sound were low. The entire distributional pattern however is related to water movements and any assessment of standing crop must be made on that, or a time basis. In general productivity in the Chukchi Sea is comparable to other shallow water Arctic regions. Analysis of the many factors, such as diurnal variation, wind effect, etc., are still in progress and no detailed conclusions will be available until these various parameters have been considered.

Marine Invertebrates

A list of the marine invertebrates in the vicinity of the Chariot site is being prepared from over 100 collections made with otter trawls, biological dredges, midwater trawls, gill nets, shrimp pots and beach seines during the August 1959 cruise of the "*John N. Cobb*." The area sampled extended from the Bering Straits northward to Cape Lisburne and from the eastern coast of the Chukchi Sea westward to longitude 169°W. (approximately 20,000 sq. mi.).

The invertebrate fauna was extremely rich in both number of species and number of individuals although no economically valuable species were found in commercial quantities with the possible exception of scallops in the Point Hope area. The 5,000 to 10,000 specimens in the collection include an estimated 200 species representing fourteen phyla and is the most extensive collection made in the eastern Chukchi Sea. Published reports of the marine fauna of the Chukchi Sea are meager and therefore the identification of species is time-consuming. To assist in the identification specimens have been sent to specialists in Denmark, Netherlands and elsewhere in the United States. Although the identification of all specimens is not complete the 1959 collection is believed to be adequate to provide a nearly complete list of the marine invertebrates in the vicinity of the Chariot site.

Inventory of Marine Fishes

The U. S. Fish and Wildlife Service, in conjunction with the U. S. Atomic Energy Commission carried on a field survey of the marine fauna of the Chukchi Sea in August of 1959, employing the John N. Cobb.

Objectives were to determine abundance and distribution (areal and bathymetric) of marine fish, shellfish, and sea mammals. Standard commercial, as well as exploratory fishing gear including gill nets, trawls, drags, seines, etc. was used in the operation. Over 70 stations were occupied. Study of the 2,500-plus fish returned to the laboratory indicated that the fish fauna was composed of only about forty of the over 350 species of marine fish known from Alaska.

The majority of the forms are benthic or demersal types. The pelagic element of the biota is limited to about eight species, some of which (as polar cod and capelin) are important items of food for birds and other predacious animals.

Because of the shallow depth of the Chukchi Sea deep sea fish are not present; the species are all sublittoral or littoral inhabitants. Apparently the distribution of various species is more directly related to temperatures and salinity than to depth. Some very definite preferences have been noted; for example, the saffron cod (*Eleginus gracilis*) is found only in the warmer waters of the area and is replaced in the cold water by the polar cod (*Boreogadus saida*). Salinity may be a limiting factor in the distribution of other species; for example, the starry flounder (*Platichthys stellatus*) apparently is found more commonly in low salinity water, being replaced by other forms in high salinity water. The same general relationship exists for the four-horned sculpin (*Myoxocephalus quadricornis*).

The species list, as might be expected, is dominated by far northern types. However, the Chariot collection is unique in that it contains at least a dozen forms which heretofore have not been known to occur north of Bering Straits. As parts of the Chukchi Sea were studied by Russian expeditions[4] in 1932 and 1933, the presence of these forms now may represent either a general warming of the area or a temporal extension of the range of Bering Sea fishes, owing to local oceanographic phenomena.

4/Anatoly P. Andriashev. A contribution to the knowledge of fishes from the Bering and Chukchi Seas. Translation of Russian original. Special Science Report: Fisheries 145. May 1955.

The field data give some order of abundance of the different species. Numerically, the 10 dominant marine forms within the area of the current exploration of the Chukchi Sea are:

Boreogadus saida	Hippoglossoides robustus
Clupea harengus pallasi	Osmerus dentex
Gymnocanthus tricuspis	Myoxocephalus scorpius
Artediellus scaber	Triglops pingeli
Mallotus villosus	Eleginus gracilis

By frequency of occurrence within the station pattern, the 10 dominant marine forms are:

Boreogadus saida	Podothecus acipenserinus
Gymnocanthus tricuspis	Lumpenus fabricii
Hippoglossoides robustus	Artediellus scaber
Myoxocephalus scorpius	Osmerus dentex
Triglops pingeli	Lycodes sp.

No definite pattern of abundance is indicated within the marine area studied. However, several of the species show distinctive trends of association. These ecological relationships are being analyzed through the use of mathematical tests of association.

Commercial Fishing Potential. Fishes of commercial importance that were caught in the eastern Chukchi Sea commonly harvested in world fisheries included species of salmon (and char), flatfishes, herring, and smelt.

Six species of Pleuronectids (flat fishes) Atheresthes stomias, Hippoglossoides robustus, Limanda aspera, Pleuronectes quadritubercu-latus, Liopsetta glacialis, and Platichthys stellatus were identified from the Chukchi Sea catches. The aggregate of all flounders taken during the survey was 283 individuals. The small catches indicated a low population density as compared with other areas in which commercial fisheries operate for flatfish.

Three of the flatfishes (Limanda, Hippoglossoides, and Pleuronectes) are extensively fished by the Japanese and the Russian trawl fisheries operating in the eastern Bering Sea. A striking characteristic of the flatfishes taken in the Chukchi Sea was their relatively small size. Only one specimen (Platichthys stellatus) exceeded 30 cm. in length.

Both the average size of the two major species, Hippoglossoides and Limanda, was less than 20 cm., and the maximum sizes of any individuals for these species were 21 cm. and 19 cm., respectively.

Both the average and maximum sizes of flatfish taken were below those accepted by the U. S. Fisheries markets. The average size of Limanda aspera taken by the John N. Cobb in the eastern Bering Sea during its northward journey was 32.5 cm. These fish were taken in the general area of the large Russian trawl fishery operating in the area. Ellson, et al[5] reported that commercial-size Hippoglossoides taken in the eastern Bering Sea ranged from 37 to 48-5 cm. with the average noted in several areas being in excess of 40 cm.

The extreme low density of individuals encountered in the Chukchi Sea and the small maximum sizes attained suggest the physical climate of this Arctic Ocean area may be limiting the population size of flatfish to a low level and depressing normal growth patterns.

The entire catch of demersal fishes taken at 74 stations in the Chukchi Sea region during the current investigation was estimated at less than 400 pounds and often the trawl hauls brought in less than five pounds of "commercial" fish. The level of productivity for these species as compared with areas in which commercial trawling operates was extremely low. By comparison, aggregate catch records from the Washington trawl fishery which operates between Columbia River and southeastern Alaska show that the catch is about 1,000 pounds per hour fishing, which is at least 100 times greater than in the Chukchi Sea.

The only marine fish utilized to any great extent by the local population is the Polar Cod. One investigator estimates that almost 7,000 pounds were caught during the winter of 1959-60 at Point Hope and another indicates 1,400 pounds used at Kivalina. These amounts which are of great importance to the local populace are minute by commercial standards. The fact that these totals are greater than those taken by the John N. Cobb indicates that there may be some faunal change between open water periods and the winter, or perhaps in the light of summer, pelagic fishes were successful in avoiding the nets.

The composition, relative abundance and distribution of fishes under the ice in the Chariot area is presently unknown. An effort to determine such data will be made in conjunction with the study of sea ice and under ice currents.

Salmon Studies

Because of their importance in Alaska a special study was made of salmon resources. Two species of Pacific salmon occur in some numbers in the Cape Thompson area. These are the pink salmon (Oncorphynchus gorbuscha) and the chum salmon (O. keta). In addition, other species occur in the area either as stragglers or in extremely limited numbers

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[5] Ellson et al. Exploratory fishing expedition to the Northern Bering Sea in June and July 1949. USFWS Fishery Leaflet No. 369. pp. 1-56.

(these are the king, red and silver salmon). Most of the river systems in the area are ecologically inadequate to support substantial salmon runs. Only the Kukpuk and Wulik rivers support runs utilized by the local inhabitants. Because of their life history and cyclic nature, the runs of salmon vary from year to year, but it appears quite certain that in comparison with other fishes of the area salmon contribute only a small amount to the basic economy of the region. No great numbers of drying salmon were observed at Point Hope or Kivalina. In 1959, perhaps 7,000 fish, chiefly pink salmon, made up the runs in the Cape Thompson area. This run takes place in August. However, later a smaller number of chum salmon enter the area and in 1960 some silver salmon were taken in the Kukpuk River, near Point Hope.

As noted in the previous section on the utilization of freshwater fish, salmon enter the subsistence economy. However, the limited productivity of the streams is such that the extent of dependence upon salmon alone is little. In comparison, Bering Sea villages to the south (Unalakleet, Naknek, etc.) are highly dependent on the annual runs of salmon. A conservative estimate of one million salmon in the Noatak River in 1960 indicates that this population could support a commercial fishery, whereas it is highly unlikely that streams north of the Noatak (including those in the Cape Thompson area) will ever be important on a commercial basis. The present utilization by the local population is probably less than the maximum that the stock can withstand.

Nevertheless, because of their cyclic nature it is important to continue assessment of the occurrences, numbers, and timing of salmon runs in the Chariot area.

Sea Cliff Birds

The studies have been carried on through one partial field season and one complete field season.

Three species comprise the great bulk of the avian population of the sea cliffs: Thick-billed murre, Common murre, Black-legged kittiwake.

A few other species occur in relatively small numbers: Pelagic cormorant, Horned puffin, Guillemots, Tufted puffin.

The birds arrive and occupy the cliffs during the month of May, with the earliest arrival records for murres being May 2 (1960). Murres construct no nests; egg-laying and incubation extends from about July 1 to early August; and the period of hatching and nestling life extends to early September.

Black-legged kittiwake arrive just after mid-May and nest construction is completed during the last half of June. Egg-laying and incubation occurs during all of July. This species departs the nesting grounds by late October.

The glaucous gull and both species of murre are present in small numbers in nearby areas the year around. The Horned puffin occurs in relatively small numbers from early June to early October.

Five major colonies of sea birds are distributed along 7 miles of cliffs, including Cape Thompson and its immediate vicinity. These are comprised essentially of the three species mentioned above, with a minimum total of 220,000 birds present during the breeding season.

Of these, the murres comprise about 195,000; the black-legged kittiwake about 25,000.

These birds constitute a biomass of about 179,000 kilograms.

A study of food chains has been undertaken, and an estimated 28,000,000 grams of food are consumed by these birds daily. This is comprised of marine fishes and invertebrates.

Data on egg-laying, incubation, hatching time, and fledging of young have been collected.

Marine Mammals

This work is being carried on primarily in the village of Point Hope, where the hunting activities of the Eskimos result in the availability of a very large number of marine mammals. Some observations are made also at the village of Kivalina.

Basic information has been obtained through a survey of the literature.

The following species are important to the investigation.

Pinnipedia: Bearded seal, Ringed seal, Harbor of Spotted seal, Walrus.

Cetacea: White whale, Grey whale, Bowhead whale.

The only important other marine mammal is the Polar bear.

Other species of marine mammals occur in the region, but are casual or rare and are little utilized by the Eskimos. Among these are killer whale, harbor porpoise, and ribbon seal.

Two species, the bearded seal and the ringed seal are closely associated with the pack ice, and are hunted only during the time when this ice is present in the sea. During the winter of 1959-60, the following approximate numbers of these animals were killed by hunters in Kivalina:

Ringed seal -- 950 Bearded seal -- 160

These figures for Point Hope are:

Ringed seal -- 820 Bearded seal -- 26

In early spring, particularly during April, as leads open in the pack ice, the bowhead whales migrate northward and are hunted during this period by the Eskimos of Point Hope. Up to 15 of these whales are killed annually at Point Hope. Four bowhead whales were taken in early 1960. About 40 white whales were killed at Point Hope during 1959-60.

Polar bears are also associated with the pack ice, upon which they travel widely. As many as 30 bears per year are killed by Point Hope hunters, during the period November-May.

Walrus are associated with floating ice in late spring and occur irregularly in the Point Hope region. A few of these animals may be killed annually at Point Hope.

The harbor seal is found in the region during the ice-free months and usually reamins in the vicinity of the mouths of rivers. It is generally distributed but does not occur in large numbers.

The important marine mammals are present during the year in the Cape Thompson area as follows:

Bearded seal:	January through April -- Occasional May and June -- Common July through December -- Rare
Ringed seal:	December through June -- Abundant July -- Occasional August and September -- Not present October -- May be present November -- Sometimes common
Harbor seal:	December through May -- Rare June -- Common July through October -- Occasional November -- Sometimes common
Walrus:	November through May -- Rare June -- Common July -- Rare August through November -- Occasional individuals
White whale:	December through February -- Not present March -- Rare April through July -- Common August through October -- Occasional November -- Rare

Grey whale:	November through June -- Not present July -- May be present August and September -- Rare October -- May be present	
Bowhead whale:	July 1 through September -- Present in some years October through February -- absent March -- Rare April and May -- Common June -- Sometimes common	
Polar bear:	November through March -- Occasional April and May -- Rare June through October -- No present	

With biologists stationed at Point Hope, it is now possible to examine and obtain desired data and materials from most of the marine mammals killed by Eskimo hunters. The following materials are being regularly collected.

Stomach contents
Reproductive organs
Skulls (for age determination)
Miscellaneous materials

From such data and from daily observations and interviews, it is possible to determine the basic information needed for the purpose of Project Chariot. This will include seasonal abundance, migrations, data on reproduction, etc.

WEATHER AND CLIMATE

Precipitation. Average annual precipitation at Ogotoruk Valley is estimated to be about 8 inches, with an expected range between 6 and 13 inches, although continuing measurements will refine these figures.

Variability of monthly precipitation is quite considerable as is indicated by the 18 year record at Kotzebue and also the 13 months of continuous observation at Ogotoruk. Summer precipitation at Ogotoruk is expected to vary from tenths of inches to several inches from month to month in one year or from one month in one year to the same month in the next. For example, September precipitation in 1959 was .50 inches; for September 1960, 1.58 inches.

Precipitation varies within the micrometeorological network within the valley, comprising 12 to 14 stations which are in operation throughout the year. In June 1960, when the base station reported a total of 1.2 inches, the micromet measurements varied from 1.0 to 1.5 inches; but in August when the base station sample was 2.4 inches, all of the micromet stations recorded higher amounts, from 3.0 to 4.1 inches. The micro patterns of precipitation at Ogotoruk are not yet well-explained, but topography and winds are considered to be the important factors.

During the 1959-60 season, precipitation in the form of snow at Ogotoruk occurred from October 1 through May and the total was about 23 inches. This compares with 29 inches at Kotzebue for the same period. Depths of accumulation were greatly different, attaining 22 inches in April at Kotzebue and a maximum of eight inches at Ogotoruk the same month. About 25 to 30 per cent of the annual precipitation at Ogotoruk was due to the liquid equivalent of snow.

Winds. The most prominent feature of wind patterns at Ogotoruk is the occurrence of strong northerlies during all seasons of the year. Only four times out of 1,096 observations for 1959-1960 reported calm. As compared to nearby areas, Ogotoruk winds are unique in their intensities. In general, observed peak wind speeds were almost twice those at Kotzebue and Cape Lisburne, and much higher than those to the northwest at Point Hope and Cape Seppings to the southeast.

Example:	Peak gusts	Ogotoruk	Kotzebue	Cape Lisburne
	1/9/60	64	25	25
	1/20/60	60	6	13
	1/31/60	70	23	42
	4/12/60	68	18	28
	8/15/60	62	24	40

Temperatures. The mean monthly temperatures at Ogotoruk were below freezing in October 1959 through April 1960, with the Chariot site means always lower than those at Kotzebue. From late October through early April daily maximum temperatures were very rarely above freezing.

Highest temperature of the year was 72 degrees in July, but freezing could occur on any day of the year. Minimum temperature was -38 degrees in January. Other temperature data are given in Table I.

Light. Then the sun sets at approximately noon on December 8, it remains below the horizon until about noon January 3, a period of 26 days.

In summer the sun rises shortly after midnight on May 26 and remains above the horizon thereafter until almost midnight of July 17, a total of 54 days. However, this period is also the most overcast, cloudiness prevailing 65 per cent of the time with only a total of 25 clear days reported for 1960.

Least cloudy part of the year is the period from November through March, averaging 25 per cent cloudiness and having 97 clear days. March and December are the least cloudy months with 48 of 62 days characterized as clear in 1959-1960.

TABLE I - OGOTORUK WEATHER AND CLIMATE

	1959 Sept.	1959 Oct	1959 Nov	1959 Dec	1960 Jan	1960 Feb	1960 Mar	1960 Apr	1960 May	1960 June	1960 July	1960 Aug	1960 Sept
Maximum Temperature	56	45	33	9	32	34	29	44	53	57	72	68	47
Mean Temperature	37.4	21.3	5.8	-15.6	-11.2	4.0	2.0	1.2	32.5	36.5	48.3	47.5	32.4
Minimum Temperature	14	-4	-15	-37	-38	-19	-28	-21	15	24	28	32	16
#days min. 32 or below	21	28	30	31	31	29	31	30	29	17	2	4	24
#days min. 0 or below	0	2	19	29	27	18	25	24	0	0	0	0	0
#days max. 50 or above	7	0	0	0	0	0	0	0	1	6	23	27	0
#days max. 33-49	21	12	2	0	0	2	0	1	25	24	8	4	25
#days max. 32 or below	1	19	28	31	31	27	31	29	5	0	0	0	5
#days max. 0 or below	0	0	6	27	18	12	6	3	0	0	0	0	0
State of ground	wt-fr	wt-fr	fr	fr	fr	fr	fr	fr	fr-wt	wt	wt	wt	wt-fr
Winds SE-W. (on shore)%	20	22	5	1	7	20	18	4	41	70	33	36	24
Winds N or NNE (offshore)%	66	71	75	75	81	50	66	75	38	23	50	47	56
Other Offshore winds %	14	7	20	24	12	30	16	21	7	7	17	17	20
# days w/wind speed (av)													
10 knots or below	9	12	5	2	2	0	9	5	13	17	9	9	5
11-20 knots	17	15	8	18	11	17	15	9	13	12	15	19	11
21-30 knots	1	1	10	8	8	8	7	12	3	1	7	2	11
Over 30 knots	2	3	7	3	10	14	0	4	2	0	0	1	3
% cloudiness/Mo	46	52	30	14	31	37	15	41	63	77	52	63	70
Days clear	13	7	18	27	19	12	21	11	6	1	5	7	6
Snowfall (inches)	T	5.0	7.5	T	2.8	1.9	0.5	2.9	2.0	T	T	0	3.2
Snow accumulation (inches)	0	2.5	5.0	5.0	5.0	6.0	6.0	8.0	2.0	T	0	0	1.0
Precipitation (inches)	.50	.46	.57	T	.10	.12	.04	.27	.73	1.22	1.13	2.41	1.58
No. days with ppt.	1	10	4	1	4	4	2	3	11	10	6	8	15
Shortest day (hours)	1110	0710	0238	0000	0000	0552	0947	1352	1804	2400	1954	1516	1110
Longest day (hours)	1508	1112	0702	0044	0534	0939	1343	1554	2400	2400	2400	1944	1508

RADIOLOGICAL ANALYSES

Radiological analyses of animal, plant, water and bottom samples have been made to determine the present levels of radioactivity from both fallout and naturally occuring radioisotopes. Fallout isotopes were present in samples collected on land but absent or in scarcely detectable amounts in samples from the sea.

In 1959, 128 samples from collections made on land were analyzed for the following fallout radioisotopes; Ce-141, Ce-144-Pr-144; Ru-103, Ru-106-Rh-106; Mn-54; Cs-137; Zr-95-Nb-95; Zn-65; and Sr-90. The samples were collected in the Ogotoruk Creek watershed, within eight miles of the Chariot site, and were chosen to represent a diversity of habit and habitat associations. The radioactivity of the samples decreased in the following order: land plants, insects (midges), land birds, aquatic plants, water birds, mammals and fish. More than one-half of the radioactivity was from the rare earth isotopes Ce-141, Ce-144-Pr-144. The relatively high values for cerium, an element that is poorly absorbed, suggests that much of the radioactivity of the samples was adsorbed to the outer surfaces of the specimens. The values for gamma emitters ranged from 190 micro-microcuries per gram wet weight for lichens to practically zero for fish (char). The analyses of additional samples collected in 1960 are not complete.

More than one-half of the radioactivity was from the rare earth isotopes Ce-141, Ce-144-Pr-144. The relatively high values for cerium, an element that is poorly absorbed, suggests that much of the radioactivity of the samples was adsorbed to the outer surfaces of the specimens.

Samples of marine fish and invertebrates collected by the *John N. Cobb* in 1959 and within 50 miles of the Chariot site also were selected for radiological analyses. Seventy-three samples including from one to ten specimens per sample were analyzed for gamma emitting isotopes, gross beta activity or both. Samples chosen for analyses included total plankton and selected tissues from seven species of fish and from one to four species of crabs, shrimp, clams, barnacles, scallops, snails, sea urchins and basket stars. In addition, eight bottom samples were analyzed. Fallout radioisotopes were either absent in the samples or present in scarcely detectable amounts. Two naturally occurring radioisotopes were found in expected amounts, K-40 in biological samples and Ra-226 in mud. The values for Sr-90 in herring bone, crab skeleton and snail shell were essentially zero.

The presences of fallout isotopes in the land samples and their virtual absence in the marine samples is not unexpected. Fallout on land is retained on the surface of the tundra whereas fallout on the sea is greatly diluted by mixing and transport in the strong, northward moving current.

BIOGEOGRAPHY AND ECOLOGY

ARCHAEOLOGY

Archaeological excavations in Ogotoruk Valley began in the summer of 1959 and were terminated August 8, 1960. It is the considered opinion of the principal investigator that there is no need for further archaeological work at the mouth of Ogotoruk Creek. The possibility of damage or destruction of archaeological materials by nuclear detonation has been virtually eliminated by the systematic removal of the greater part of those originally present.

The focus of excavation, House 2 of the site called CT2 had, in 1959, been taken down to the level of a second, older floor. The superimposition of one upon the other is interpreted as a rebuilding of an older house. The 1959 season closed with the second floor still in place. As a result of 1960 work, a third floor was found to underlie the second and a fourth beneath this. Excavation beyond the latter revealed sterile beach gravels.

Recovery of artifacts in 1960 was unusually high, exceeding that of all the work in 1959. Twelve boxes of specimens were collected. With but few excretions, the artifacts are all of recent aboriginal Eskimo manufacture. Included were a number of objects that could only have been preserved in the peculiar frozen soil conditions of arctic, e.g., a chipped stone knife with its wooden handle and baleen lashing still intact. Other objects of normally perishable materials (wood, horn, bone, and ivory) were also found. While none of these pieces is exceptionally elaborate, the aggregate may be taken as a quite representative sampling of recent Eskimo material culture.

Pottery making, use of the fire drill, chipping of stone points, and the use of the bow are all rather critical generally in a situation of contact between European-derived culture and that of native peoples. They are critical in the sense that they are among the first to be supplanted by elements of western culture--flint and steel or matches, iron blades, and firearms.

It is suggested that the bottom levels of House 2 at Ogotoruk Creek may be no older than 1850 or so. The upper levels (represented by the second floor of the living room) and upwards probably represent an occupation sequence from some time in the 1880's through at least the first decade of this century and possibly beyond a bit.

Evidence indicates a short period of occupation of Ogotoruk Valley, extending possibly over a 90-year range. Equally evident is the fact that at any one time there would have been found very few people in residence there.

Two problems are raised: (1) Why was the population of the valley so sparse? and (2) Why was there no earlier occupation? The answer to the first query must be sought in the ecology of the valley. The answer to the second question remains, at this time, elusive.

The two villages nearest Ogotoruk Valley are Point Hope, 32 miles to the northwest, and Kivalina, 40 miles to the southeast. They are comprised almost wholly of native Eskimo populations. Comparisons of the two communities are made in Table II.

Table II. Villages Near Cape Thompson

	Kivalina	Point Hope
Location: Latitude	67° 43' N	68° 21' N
Longitude	164° 32' W	166° 47' W
Distance from Ogotoruk Camp	40 mi. SE	32 mi. NW
Population (1959) Eskimo	134	290
Whites	2	6
Residences (occupied)	24	51
Construction of homes - mostly	sod	frame
Churches	2	1
Village Income	$45,216	$109,732
% Earned	77.6	90.7
% Welfare	22.4	9.3

Economically the two communities are quite different, with Kivalina being described as a village that maintains itself on a subsistence level only.

Food gathering with associated activities including travel seems to be the major activity throughout the year at both villages.

But change in manner of living and way of life appears evident. Of the 77 men between the ages of 20 and 65 who claim Point Hope residence, some are away attending school, many are active members of carpenters', laborers', or metal workers' unions; and the majority can operate engines, install electric wiring and repair machinery. Eighteen are members of the National Guard, the native store employs two full-time people and an assistant, a private store is operated by one man; and perhaps a dozen others are locally employed at the Post Office, Department of Health, village administration, etc. A century ago the economy was self-supporting and imported items were not vital to existence. Today at Point Hope and Kivalina imported goods are said to be absolutely necessary to daily welfare.

For a large majority of men at Point Hope, however, hunting is the major occupation.

Caribou hunting in fall and spring is important. Kivalina hunters operate as far north as Cape Seppings and inland. In autumn 1959 and 1960 and in spring of 1960 Point Hope hunters concentrated in the upper reaches of Ogotoruk Valley and immediate vicinity (Appendix V). In the spring almost all of their harvest was within 25 miles of the mouth of the creek (Table III; also section on Caribou).

Table III. Caribou Harvests, October 1959 to April 1960

Kill in:	Kivalina	Point Hope
October	30	92
November	100	6
December	29	
January	41	
February	53	126
March	117	241
April	37	11
Totals	407	476

Whaling begins as early in the spring as weather conditions permit, reaching a peak in the Point Hope area in late April and early May. Hunting parties from Kivalina and Noatak commonly join in this activity.

Gathering of bird eggs occurs on the Cape Thompson cliffs in late June and July and appears to be the primary motivation for boat travel from both Kivalina and Point Hope.

Plant gathering is an occupation pursued in August and September, usually by the women, and usually in conjunction with inland fishing in the Kukpuk and Wulik rivers. Collection of berries, roots and "greens" result in one of the few supplements to the meat and fish diet of the native Eskimo (Table IV).

Table IV. Plants used for food at Kivalina

Species	Eskimo Name	Common Name	Part Used
Empetrum nigrum	Pohnrock	Blackberry	fruit
Vaccinium uliginosum	Ahsayvik	Blueberry	fruit
V. vitis-idaea	Kimingnak	Cranberry	fruit
Rubus chamaemorus	Ahpik	Salmonberry	fruit
Hedysarum alpinum	Masue	Eskimo potato	root
Rumex arcticus	Koach	Wild spinach	leaves
Salix pulchra (?)	Surah	Willow	leaves
Angelica lucida	Eegoosik	Wild celery	leaves,stems
Allium schoenoprasum	Aneak	Wild chives	leaves

Ice fishing at Kivalina begins at the time of freeze-up and continues to November. At Point Hope polar-cod are sought from January through March; trout, salmon, and grayling are obtained from the Kukpuk from September through November.

Trapping of fox, wolverine and land otter seems to be common near Kivalina, in the late fall with muskrat and ground squirrel sought in the spring. Point Hope men trap mostly for fox along the coast or on the sea ice.

Seal hunting is the focal point of activity at Kivalina and Point Hope in February but seals may be taken from late November and sporadic kills are made in March through May (Table V).

Disruption of hunting activities and attendant harvests without substitute in any month could result in hardship to the Eskimo, but especially in the period mid January - July and September to December, in the opinion of one of the investigators in human geography.

Table V. Seal Harvests at Point Hope and Kivalina

Kill in:	Kivalina	Point Hope
October	0	4
November	52	80
December	7	135
January	77	236
February	135	331
March	48	73
April	65	30
Totals	384	889

RELATIONS OF OPERATION TO BIOTA AND ENVIRONMENT

A primary function of the Committee on Environmental Studies for Project Chariot is to estimate the biological cost of the detonation of the project area. To this end a broad scientific program has been designed and is in progress to provide that necessary factual background which will permit estimates of biological costs. This summary report sets forth the salient features resulting from the research program to date and provides the major basis for biological cost estimates at this time. These estimates which will be refined as additional information becomes available, will ultimately, when integrated with other knowledge available to the Commission, be valuable in its final decision.

On the question of bioenvironmental cost, at least two degrees of effects are recognized. The first involves broad geography and ecological phenomena such as elimination of species, reduction of individual populations below recovery potential, destruction of food chain links, irreparable harm to habitats on a wide geographical basis, elimination or dispersal of populations of plants or animals essential to the livelihood or culture of the Eskimo. The chance of significant biological costs at this level appears exceedingly remote.

The second level of biological cost involves individual organisms instead of species, local areas instead of regions, local process modification instead of elimination. Here most assuredly there will be biological change as there would be if a new human population invaded the valley or if the proposed excavation were being carried out by conventional methods. There will be at least three areas of environmental perturbation, very largely confined to the lower reaches of Ogotoruk Creek and the area at its mouth. These are:

(1) Redeposition of an estimated 30 million cubic yards of debris.
(2) Possible local shore current modifications with the filling of the basin with sea water.
(3) Venting of radioactive materials and deposition on land and sea.

The first two categories involve problems no different from those that would result if conventional techniques were employed in excavation. Radiation effects pose a different problem, even though it would appear that they would be negligible, undetectable, or possibly nonexistent in areas distant from the excavation.

Possible radiation effects upon the biota of the Chariot site have been estimated from the Nevada Test Site and the Pacific Proving Ground data. Considering the predicted distribution and characteristics of fallout--morphological abnormalities, pathological effects, or population changes as a result of radiation, are not expected to occur in the biota of the environment beyond the throw-out area. Nonetheless, possibility of such effects must be the subject of intensive continuing pre- and post-shot studies.

It is predicted that the major bioenvironmental changes will be those associated with the production of the crater and the distribution of throw-out material over the surrounding terrain. On the basis of engineering data provided by the Lawrence Radiation Laboratory the maximum depth of debris at the crater edge is expected to be on the order of 100 feet diminishing to an average of about one-half inch at a radial distance of about one mile from ground zero. Existing habitats and their plant and animal populations will be totally destroyed in the area surrounding the crater and new habitats created, both terrestrial and aquatic. Modification of habitats will be diminished outward from the area surrounding the crater and should be nonexistent beyond the limits of throw-out.

The Committee is aware that not every environmental condition will be optimal for the excavation operation or biotic populations at any given time. Certain bioenvironmental problems are evident, not all of them totally restrictive. One of the problems is that connected with Eskimo mobility because:

(1) The indigenous human population of this region is largely dependent on on the bioenvironment directly for food, shelter, and clothing. Satisfaction of livelihood needs requires mobility by dogsled, boat or foot. Any restriction imposed on their travel must therefore be considered in evaluating environmental cost of the operation.

(2) Dog team traffic follows the stream courses but when conditions are suitable, routes overland and on the sea are also utilized. During October 1959 through May 1960, 140 teams with 167 people crossed Ogotoruk Creek. Ninety per cent of this traffic occurred in the period February through May; the February-March travel is associated with caribou hunting, and the April-May traffic primarily with Point Hope whaling. Travel by boat is done on the sea and in the Kukpuk River before ice forms in the fall.

(3) Caribou have been reported in the Ogotoruk watershed for all months in 1960 except May, June, and early July. Two peak caribou hunting seasons (February-March and October-November) are reported for Point Hope huntsmen. In the spring of 1960, all of the caribou killed by Point Hope hunters were taken within 25 miles of the mouth of Ogotoruk Creek: 30 per cent within 10 miles, 70 per cent within 15 miles, and 90 per cent within 20 miles. Kivalina hunters do not as a rule hunt caribou in Ogotoruk Valley in either fall or spring, and fall hunting out of Point Hope appears to be lower than in spring near the site.

(4) Hunting of marine mammals such as the whale, polar bear, and seal occurs most intensively in spring, but seals may be sought all winter. Most of these activities take place near the coastal villages although these animals have been observed seaward from the mouth of Ogotoruk Creek.

(5) Bird populations on the cliffs, numbering over 200,000 are present from early May. Almost all are gone by late September. These animals are a source of food for the Eskimos who gather eggs during the early summer.

Another problem concerns water and snow data in relation to drinking supplies and they are still undergoing analysis. Although no major problem is anticipated, additional work is required to eliminate the remaining uncertainty.

One of the other problems or complex of problems is weather. It should be mentioned that Ogotoruk Valley weather is characterized by high winds from the north and northeast at all seasons, which carry sand and snow at velocities up to 73 knots, preventing travel. The lowest 1960 temperature was -38^{o} in January. Weather conditions at Ogotoruk are considered unique in the northwest Alaska region.

Appendix I

Committee on Environmental Studies for Project Chariot
Plowshare Program
U.S. Atomic Energy Commission

Chairman: John N. Wolfe, Chief, Environmental Sciences Branch, Division of Biology and Medicine, U. S. Atomic Energy Commission, Washington 25, D.C. Plant ecology, bioclimatology. Ph.D. Ohio State University.

Deputy Chairman: Allyn Seymour, Associate Director, Laboratory of Radiation Biology, University of Washington, Seattle 5, Washington. Marine ecology, radiation biology. Ph.D. University of Washington.

Max E. Britton, Geography Branch (Arctic research), Office of Naval Research, Washington, D.C. Ecological plant geography; micrometeorology. Ph.D. Northwestern University.

Arthur H. Lachenbruch, Theoretical Geophysics Branch, U.S. Geological Survey, Menlo Park, California. Geophysics, permafrost, geology. Ph.D. Harvard University.

Kermit H. Larson, Chief, Environmental Radiation Division, Laboratories of Radiation Biology, University of California at Los Angeles, Los Angeles 24, California. Soil chemistry, radiochemistry, fallout phenomenology. M.Sc. University of North Dakota.

Robert L. Rausch, Chief Zoonotic Disease Section, Arctic Health Research Center, U.S. Public Health Service, P.O. Box 960, Anchorage, Alaska. Mammalogy, animal ecology, parasitology. Ph.D. University of Wisconsin.

Norman J. Wilimovsky, Professor of Zoology, Institute of Fisheries, University of British Columbia, Vancouver, B.C., Canada. Ichthyology, hydrobiology, sea ice. Ph.D. Stanford University.

Secretary: Ernest D. Campbell, Program Coordinator, Special Projects Division, San Francisco Operations Office, U.S. Atomic Energy Commission, 2111 Bancroft Way, Berkeley, California. B.S. Chemistry. University of California (L.A.).

Appendix II

Participating Agencies and Institutions and Representatives

1. University of Alaska, Departments of Biology, Anthropology, College, Alaska (Brina Kessel)

2. U. S. Weather Bureau, Research Station, 1233 Main Street, Las Vegas, Nevada (Philip W. Allen)

3. Corps of Engineers: Snow, Ice, and Permafrost Research Establishment, 1215 Washington Avenue, Wilmette, Illinois. (W. K. Boyd, G. Robert Lange)

4. The Ohio Agricultural Experiment Station, Wooster, Ohio (Nicholas Holowaychuk)

5. University of Washington: Department of Oceanography (Richard H. Fleming); Laboratory of Radiation Biology (Lauren R. Donaldson). Seattle 5, Washington

6. U. S. Geological Survey, Alaska Geology Branch, 345 Middlefield, Menlo Park, California (G. Donald Eberlein, Ruben Kachadoorian)

7. General Electric Company, Hanford Laboratories, Biology Operation, Radioecology Section, Richland, Washington (Jared J. Davis)

8. U. S. Public Health Service, Arctic Health Research Center, P.O. Box 960, Anchorage, Alaska (Robert L. Rausch)

9. Don Charles Foote, (Personal Contractor), Point Hope, Alaska

10. U. S. Fish and Wildlife Service, Bureau of Commercial Fisheries, 2725 Montlake Boulevard, Seattle, Washington (Dayton L. Alverson)

11. Institute of Polar Studies, The Ohio State University, Columbus 10, Ohio (Richard P. Goldthwait)

Appendix III

CHARTER

Committee on Environmental Studies
for Project Chariot
Plowshare Program

It shall be the purpose of the Committee on Environmental Studies for Project Chariot to:

a. Be generally aware of all plans for Project Chariot including those for research, safety and effects programs. Advisors to the Committee shall provide this information. The Committee shall accord particular attention to those factors which may affect or have potential influence on the biosphere.

b. Plan the scope of bioenvironmental studies in support of Project Chariot, to obtain sufficient information for prediction of the effect of the project on the biosphere, both immediately following the detonation and for the future.

c. Recommend to the Manager of the San Francisco Operations Office (SAN) the scope of bioenvironmental studies which the Committee considers essential in fulfilling paragraph b. above.

d. Recommend to the Manager, San Francisco Operations Office, the organizations which, in the opinion of the Committee, can best fulfill the various parts of the bioenvironmental studies, taking into due account the capabilities of these organizations and the requirements for competent, economical and expeditious conduct of the work. This consideration shall include governmental, industrial, university and other non-profit and private organizations.

e. Receive and review the reports issued on the studies performed in the environmental program. The Committee shall analyze the findings of the various studies and shall summarize these findings to the Manager, SAN, together with the Committee's recommendation for further action, if any.

After appropriate coordination, the Manager, San Francisco Operations Office, will authorize public dissemination of the Committee's consolidated report to interested public officials, the scientific community, and news media.

The Manager, SAN, shall appoint the members of the Committee, name the Chairman and provide special advisors to the Committee.

The Committee shall have the power to call advisors as necessary in the conduct of its business.

The Chairman of the Committee shall have the authority to call meetings and conduct the business of the Committee in such a manner as to meet approved project schedules.

Approved /S/ E. C. Shute
E. C. Shute, Manager
San Francisco Operations Office

Appendix IV

LIST OF CONTRIBUTORS AND REPORTS

This list does not include all reports of researches available in the open literature nor other sources and experience available to the Committee. Status reports and letters are also omitted. Most of the reports contain bibliographies.

Most reports dated December 1960 are cited although the data contained in these are not all included in the summary.

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Appendix V

Running totals for two-week periods - 1960 - showing numbers of hunters and their caribou kill. Ogotoruk Valley, Cape Thompson, Alaska[1/]

Date	No. of Teams	Total Hunters	Total Kill	Running totals for two-week periods Hunters	Kill
Feb. 1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	1	2	7	2	7
5	3	10	8	12	15
6	2	8	16	20	31
7	1	2	0	22	31
8	1	2	3	24	34
9	0	0	0	24	34
10	0	0	0	24	34
11	0	0	0	24	34
12	0	0	0	24	34
13	0	0	0	24	34
14	1	1	0	25	34
15	2	3	10	28	44
16	2	3	16	31	60
17	2	3	0	34	60
18	1	6	14	38	67
19	0	0	0	28	59
20	0	0	0	20	43
21	1	6	17	24	60
22	0	0	0	22	57
23	0	0	0	22	57
24	2	9	3	31	60
25	1	6	22	37	82
26	0	0	0	37	82
27	1	2	0	39	82
28	0	0	0	38	82

1/ Compiled from data in Table, p. 44, and accompanying map, of Report by D. C. Foote, June 1960: The Eskimo Hunter at Point Hope, Alaska. The data on map and in table are not in precise agreement, but patterns presented here are not modified by this factor. These data reflect the number of man days hunting but the total number of hunters is not indicated.

Date	Teams	Hunters	Kill	Hunters	Kill
Feb.29	0	0	0	35	72
Mar. 1	0	0	0	32	56
2	1	2	10	31	66
3	0	0	0	25	52
4	0	0	0	25	52
5	0	0	0	25	52
6	0	0	0	19	35
7	3	8	7	27	42
8	5	12	81	39	123
9	2	3	14	33	134
10	2	5	0	32	112
11	2	5	29	37	141
12	3	7	0	42	141
13	3	5	4	47	145
14	0	0	0	47	145
15	0	0	0	47	145
16	0	0	0	45	136
17	1	2	1	47	136
18	1	2	2	49	138
19	1	2	4	51	142
20	1	2	6	53	148
21	1	2	0	47	141
22	0	0	0	35	60
23	1	1	0	33	46
24	3	4	12	32	58
25	2	3	0	30	29
26	2	3	0	26	29
27	1	4	16	25	41
28	3	11	17	36	58
29	2	4	0	40	58
30	2	6	11	46	69
31	3	7	14	51	82
Apr. 1	1	4	0	53	80
2	0	0	0	51	76
3	0	0	0	49	70
4	0	0	0	47	70
5	0	0	0	47	70
6	0	0	0	46	70
7	1	2	0	44	58
8	0	0	0	41	58
9	0	0	0	38	58
10	0	0	0	34	42

Date	Teams	Hunters	Kill	Hunters	Kill
Apr. 11	0	0	0	23	25
12	0	0	0	19	25
13	0	0	0	13	14
14	0	0	0	6	0
15	0	0	0	2	0
16	0	0	0	2	0
17	0	0	0	2	0
18	0	0	0	2	0
19	1	1	3	3	3
20	0	0	0	3	3
21	0	0	0	1	3
22	0	0	0	1	3
23	0	0	0	1	3
24	0	0	0	1	3
25	1	5	8	6	11
26	0	0	0	6	11
27	0	0	0	6	11
28	0	0	0	6	11
29	0	0	0	6	11
30	0	0	0	6	11
May 1	0	0	0	6	11
2	0	0	0	6	11
3	0	0	0	5	8
4	0	0	0	5	8
5	0	0	0	5	8
6	0	0	0	5	8
7	0	0	0	5	8
8	0	0	0	5	8
9	0	0	0	0	0
10	1	1	6	1	6
11	1	2	0	3	6
12	1	2	0	5	6
13	0	0	0	5	6
14	0	0	0	5	6
15	0	0	0	5	6
16	0	0	0	5	6
17	0	0	0	5	6
18	0	0	0	5	6
19	1	2	5	7	11
20	0	0	0	7	11
21	0	0	0	7	11
22	0	0	0	7	11