ALASKA LEGISLATURE COMMITTEE FILES 1985-1986 8672

3394 HJUD HJR 71

270

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7/25/89

Date

# HJR

# 71

# STATE OF ALASKA
# THE LEGISLATURE

POUCH Y · STATE CAPITOL
JUNEAU, ALASKA 99811
907-465-3800

## LEGISLATIVE AFFAIRS AGENCY

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May, 1986

Copies of minutes listed below were originally included in this file. The minutes are available on the STAIRS date base CM 14. In order to save space copies of minutes have not been left in the files.

Jeanie Henry

| | | |
|---|---|---|
| House Judiciary | 4-23-86 | 1:30 pm |
| " " | 4-25-86 | 8:00 AM |

# HOUSE

# COMMITTEE REPORT

(7)
Date referred: 4/16/86

FURTHER REFERRALS: FINANCE

DATE: ________________

The JUDICIARY Committee has considered HJR 71

Proposing amendments to the Constitution of the State of Alaska creating the Alaska research development endowment.

and recommends:

[ ] do pass

[ ] do not pass

[ ] do pass with attached amendment(s)

[ ] no recommendation

[ ] replace with CSHJR 71 (JUD) [ ] same title

[ ] new title

and recommends ____________________

[ ] further referral to the ____________________ Committee

and attaches:
[ ] letter of intent
[ ] first fiscal note
[ ] new fiscal note
[ ] zero fiscal note

SIGNING DO PASS:

SIGNING OTHER RECOMMENDATIONS:

— No Rec.

— do not pass

Chairman

Original sponsor: Finance Committee

IN THE HOUSE BY THE JUDICIARY COMMITTEE

CS FOR HOUSE JOINT RESOLUTION NO. 71 (Judiciary)

IN THE LEGISLATURE OF THE STATE OF ALASKA

FOURTEENTH LEGISLATURE - SECOND SESSION

Proposing amendments to the Constitution of the State of Alaska creating the Alaska research development endowment.

BE IT RESOLVED BY THE LEGISLATURE OF THE STATE OF ALASKA:

* Section 1. Article IX, sec. 7, Constitution of the State of Alaska, is amended to read:

SECTION 7. DEDICATED FUNDS. The proceeds of any state tax or license shall not be dedicated to any special purpose, except as provided in section 15 <u>and section 17</u> of this article or when required by the federal government for state participation in federal programs. This provision shall not prohibit the continuance of any dedication for special purposes existing upon the date of ratification of this section by the people of Alaska.

* Sec. 2. Article IX, Constitution of the State of Alaska, is amended by adding a new section to read:

SECTION 17. ALASKA RESEARCH DEVELOPMENT ENDOWMENT. Up to 20 percent of all royalties and royalty sale proceeds from North Slope natural gas received by the state shall be deposited in the Alaska research development endowment; however, the total deposits from royalties and royalty sale proceeds may no exceed $1,000,000,000. All income from investment of the endowment shall be deposited in the Alaska research development endowment. Appropriations may not be made from the Alaska research development endowment except for the conduct of research as provided by law.

* Sec. 3. The amendments proposed by this resolution shall be placed

before the voters of the state at the next general election in conformity with art. XIII, sec. 1, Constitution of the State of Alaska, and the election laws of the state.

WORK DRAFT WORK DRAFT WORK DRAFT

James
4/24/86 ✓

Original sponsor: Finance Committee

IN THE HOUSE BY THE JUDICIARY COMMITTEE

CS FOR HOUSE JOINT RESOLUTION NO. 71 (Judiciary)

IN THE LEGISLATURE OF THE STATE OF ALASKA

FOURTEENTH LEGISLATURE - SECOND SESSION

Proposing amendments to the Constitution of the State of Alaska creating the Alaska research development endowment.

BE IT RESOLVED BY THE LEGISLATURE OF THE STATE OF ALASKA:

* Section 1. Article IX, sec. 7, Constitution of the State of Alaska, is amended to read:

SECTION 7. DEDICATED FUNDS. The proceeds of any state tax or license shall not be dedicated to any special purpose, except as provided in section 15 and section 17 of this article or when required by the federal government for state participation in federal programs. This provision shall not prohibit the continuance of any dedication for special purposes existing upon the date of ratification of this section by the people of Alaska.

* Sec. 2. Article IX, Constitution of the State of Alaska, is amended by adding a new section to read:

SECTION 17. ALASKA RESEARCH DEVELOPMENT ENDOWMENT. Up to 20 percent of all royalties and royalty sale proceeds from North Slope natural gas received by the state shall be deposited in the Alaska research development endowment; however, the total deposits from royalties and royalty sale proceeds may not exceed $1,000,000,000. All income from investment of the endowment shall be deposited in the Alaska research development endowment. Appropriations may not be made from the Alaska research development endowment except for the conduct of research as provided by law.

* Sec. 3. The amendments proposed by this resolution shall be placed

before the voters of the state at the next general election in conform[illegible] with art. XIII, sec. 1, Cons[illegible]tution of the State of Alaska, and the el[illegible]t[illegible]on laws of the state.

# Alaska State Legislature

## House of Representatives
House Judiciary Committee

P. O Box V
State Capitol
Juneau, Alaska 99811
(907) 465-4990


TO: Rep. Al Adams, Chairman
House Finance Committee

FROM: Rep. M. Mike Miller, Chairman
House Judiciary Committee

RE: CSHJR 71 (Judiciary), "Proposing amendments to the Constitution of the State of Alaska creating the Alaska research development endowment."

The House Judiciary Committee held hearings on HJR 71 and adopted a committee substitute for that resolution. The companion bill for the resolution is HB 705, which is presently in your committee. The House HESS Committee adopted a committee substitute for that bill which provided that at least 20 percent of the royalties and royalty sale proceeds from North Slope natural gas would be deposited in the endowment up to a total of one billion dollars.

Even though the bill was not before the Judiciary Committee, when it considered the resolution, it was decided to try to conform the resolution to the bill. However, during discussion on the resolution, the committee voted to provide that instead of requiring that "at least 20 percent of royalties" be deposited in the endowment, that "up to 20 percent of royalties" must be deposited in the endowment.

The committee wanted you to be aware of this discrepancy between the resolution and the bill so that the Finance Committee can conform the conflicting provisions.

HB 705 appears to have another defect which your committee might want to correct. There is no effective date clause in the bill which ties the passage of the bill to the passage of the constitutional amendment.

# STATE OF ALASKA 1986 LEGISLATIVE SESSION
# FISCAL NOTE

Revision Date : ______

**REQUEST**

Bill/Resolution No. : HJR 71
Title : Proposing amendments to the Constitution of the State of Alaska creating the Alaska Research Development Endowment.
Sponsor : House Finance
Requestor : House Finance
Date of Request : 4/9/86

**FISCAL DETAIL**

Agency Affected : Alaska Research Development Endowment
BRU :
Components :

**EXPENDITURES/REVENUES : (Thousands of Dollars)**

| OPERATING | FY 86 | FY 87 | FY 88 | FY 89 | FY 90 | FY 91 |
|---|---|---|---|---|---|---|
| PERSONAL SERVICES | | | | | | |
| TRAVEL | | | | | | |
| CONTRACTUAL | | | | | | |
| SUPPLIES | | | | | | |
| EQUIPMENT | | | | | | |
| LAND & STRUCTURES | | | | | | |
| GRANTS, CLAIMS | | | | | | |
| MISCELLANEOUS | | | | | | |
| TOTAL OPERATING | | | | | | |
| CAPITAL | | | | | | |
| REVENUE | | (800.0) | (800.0) | (800.0) | (800.0) | (800.0) |

**FUNDING : (Thousands of Dollars)**

| | FY 86 | FY 87 | FY 88 | FY 89 | FY 90 | FY 91 |
|---|---|---|---|---|---|---|
| GENERAL FUND | | 800.0 | 800.0 | 800.0 | 800.0 | 800.0 |
| FEDERAL FUNDS | | | | | | |
| OTHER | | | | | | |
| TOTAL | | 800.0 | 800.0 | 800.0 | 800.0 | 800.0 |

**POSITIONS :**

| | FY 86 | FY 87 | FY 88 | FY 89 | FY 90 | FY 91 |
|---|---|---|---|---|---|---|
| FULL-TIME | | | | | | |
| PART-TIME | | | | | | |
| TEMPORARY | | | | | | |

**ANALYSIS :** Attach a separate page if necessary This bill dedicates 1/3 of all state royalties and royalty sale proceeds from North Slope natural gas to the Alaska Research Development Endowment. Currently, approximately $2.4 million is received by the state from those sources. Consequently, $800.0 would be dedicated. (2.4 million ÷ 3 = $800.0)

Prepared by : Representative Steve Frank
Phone : 465-3706
Division : Resources Committee Chairman
Date : 4/9/86
Approved by Commissioner : Dick Shultz [signature]
Date : 4/16/86
Agency :

Distribution (by Agency preparing fiscal note) :
- Legislative Finance
- Legislative Sponsor
- Requestor
- Office of Management and Budget
- Impacted Agency(ies)



10/25/85

BILL SHEFFIELD, GOVERNOR

**DEPARTMENT OF REVENUE**

OFFICE OF THE COMMISSIONER

P.O. BOX S
JUNEAU, ALASKA 9981 0400
PHONE: (907) 465-2300

April 23, 1986

The Honorable Steve Frank
Alaska State Legislature
P.O. Box V
Juneau, AK 99811

Re: HCR 71 and HB 705

Dear Representative Frank:

I have reviewed the fiscal notes prepared for both HCR 71 and HB 705 and have found the estimates to be consistent with the North Slope Gas Royalty revenues projected by the Department of Revenue in the March 1986 Revenue Forecast.

Sincerely,

Mary A. Nordale
Commissioner of Revenue

MAN:ml1
86-99

04-D2LH

# Alaska State Legislature

**STEVE FRANK**
DISTRICT 20A
Finance Committee

1125 Sunset Drive
Fairbanks, Alaska 99701
(907) 452-3421

While in Juneau
P. O. Box V
Juneau, Alaska 99811
(907) 465-3709

# House of Representatives

MEMORANDUM

TO: House Judiciary Committee Members

FROM: Representative Steve Frank

DATE: April 22, 1986

RE: Alaska Research Development Endowment
HCR 71 & HB 705

---

HCR 11, approved by the legislature last year, set the stage for the introduction of HCR 71 and HB 705 creating the Alaska Research Development Endowment (ARDE).

Under HCR71, ARDE is designed to be a vehicle to determine and fund the necessary research to meet the challenge of Alaska's future. The idea is to constitutionally dedicate to research a small percentage of our total resource revenues, specifically our natural gas resources north of the Brooks Range, most of which are not currently being developed.

The Alaska Research Development Corporation, which would be created by the passage of HB705, would identify those projects which could unlock the knowledge necessary for the development of the state's natural resources, preserve the heritage and culture of Alaska's people and fund research necessary to protect the health and welfare of the people of our state. ARDE would merely identify and fund the research projects, not perform the actual research. The research would be conducted by grant recipients including individuals, universities, companies, and governmental agencies.

The scope of ARDE's efforts would be directed toward the <u>entire</u> state, not just the Arctic region, as the Federal Arctic Science and Policy Act is. ARDE would dovetail the Federal Act as well as compliment research currently being done through the University of Alaska's Organized Research. As envisioned, ARDF could be a significant future funding source for the University's research projects related specifically to Alaska.

The Corporation's Board of Directors would be composed of eleven members, four each from the business community and academic community, and three with professional recognition in government, in addition to the Governor and the president of the University of Alaska as ex officio members. The board would employ a limited staff to aid in grant determination and administration. The Corporation would be subject to the Executive Budget Act providing the Legislature with an annual review, much in the same way we review the budget of the Alaska Permanent Fund Corporation.

Offered: 3/13/85
Referred: Rules

Original sponsors: Boucher, Ringstad, Gruenberg, et al

IN THE HOUSE

BY THE HEALTH, EDUCATION AND SOCIAL SERVICES COMMITTEE

CS FOR HOUSE CONCURRENT RESOLUTION NO. 11 (HESS)

IN THE LEGISLATURE OF THE STATE OF ALASKA

FOURTEENTH LEGISLATURE - FIRST SESSION

Relating to the University of Alaska Foundation.

BE IT RESOLVED BY THE LEGISLATURE OF THE STATE OF ALASKA:

WHEREAS art. VII, secs. 4 and 5 and art. VIII, secs. 1 and 2 of the Constitution of the State of Alaska call for the promotion and protection of public health, providing for the public welfare, the settlement of lands and the development of resources, and the utilization, development, and conservation of all state natural resources; and

WHEREAS although the Arctic Science and Policy Act of 1984 is commendable and its passage long overdue, the Act focuses on federal interests and priorities solely and it is directed only at part of the state; and

WHEREAS the economic viability of the state, the well-being of its inhabitants, and the promise of a reasonable future for coming generations depends upon the support of applied and fundamental research directed at specific Alaskan problems; and

WHEREAS these physical, biological, medical, and social problems are only partially, or not at all, addressed by conventional sources of support resulting in significant gaps in both scientific and technical research endeavors;

BE IT RESOLVED that the Alaska State Legislature commends and supports the University of Alaska Foundation in its endeavors to forecast research needs and to find and fill the gaps in the current research effort, and be it

FURTHER RESOLVED that the Alaska State Legislature encourages the University of Alaska Foundation to seek support for long-term and stable

# STATE OF ALASKA 1986 LEGISLATIVE SESSION
# FISCAL NOTE

Revision Date :

**REQUEST**

Bill/Resolution No. : HJR 71
Title : Proposing amendments to the Constitution of the State of Ak. creating the Alaska Rese rch Development Endowment.
Sponsor : House Finance
Requestor : House Finance
Date of Request : 4/9/86

**FISCAL DETAIL**

Agency Affected : Alaska Research Development Endowment
BRU :

Components :

**EXPENDITURES/REVENUES : (Thousands of Dollars)**

| OPERATING | FY 86 | FY 87 | FY 88 | FY 89 | FY 90 | FY 91 |
|---|---|---|---|---|---|---|
| PERSONAL SERVICES | | | | | | |
| TRAVEL | | | | | | |
| CONTRACTUAL | | | | | | |
| SUPPLIES | | | | | | |
| EQUIPMENT | | | | | | |
| LAND & STRUCTURES | | | | | | |
| GRANTS, CLAIMS | | | | | | |
| MISCELLANEOUS | | | | | | |
| TOTAL OPERATING | | | | | | |
| CAPITAL | | | | | | |
| REVENUE | | (800.0) | (800.0) | (800.0) | (800.0) | (800.0) |

**FUNDING : (Thousands of Dollars)**

| | | | | | | |
|---|---|---|---|---|---|---|
| GENERAL FUND | | 800.0 | 800.0 | 800.0 | 800.0 | 800.0 |
| FEDERAL FUNDS | | | | | | |
| OTHER | | | | | | |
| TOTAL | | 800.0 | 800.0 | 800.0 | 800.0 | 800.0 |

**POSITIONS :**

| | | | | | | |
|---|---|---|---|---|---|---|
| FULL-TIME | | | | | | |
| PART-TIME | | | | | | |
| TEMPORARY | | | | | | |

**ANALYSIS :** Attach a separate page if necessary

This bill dedicates 1/3 of all state royalties and royalty sale proceeds from North Slope natural gas to the Alaska Research Development Endowment. Currently, approximately $2.4 million is received by the state from those sources. Consequently, $800.0 would be dedicated. (2.4 million ÷ 3 = $800.0) See Dept. of Revenue letter dated 4/17/86.

Prepared by : [signature] Phone : 3706
Division : House Finance Committee Chairman Date : 4/9/86

Approved by Commissioner : Date :
Agency :

Distribution (by Agency preparing fiscal note) :
- Legislative Finance
- Legislative Sponsor
- Requestor
- Office of Management and Budget
- Impacted Agency(ies)

page ___ of ___

10/25/85

STATE OF ALASKA

DEPARTMENT OF REVENUE

PETROLEUM RESEARCH DIVISION

BILL SHEFFIELD, GOVERNOR

550 W. 7TH AVENUE, SUITE 550
ANCHORAGE, ALASKA 99501
PHONE: (907) 276-5364

April 17, 1986

The Honorable Steve Frank
Alaska State Legislature
PO Box V
Juneau, Alaska 99811

Dear Representative Frank:

Unfortunately many of the cost and pricing issues concerning the Trans Alaska Gas System (TAGS) are not easy to pin down. I have attempted to answer your questions about expected gas royalties using the best data we have available which includes information from the Department of Natural Resources and gas prices used in our petroleum production revenue forecast.

1. Assuming that a TAGS is built how much gas would be transported annually through the line?

   We estimate roughly 1.8 bcf/day.

2. How much royalty is currently received by the State from North Slope gas?

   We received $163,350 for January 1986 production.

3. What wellhead values are currently reported for North Slope gas and what values would you expect to be reported if an economically feasible TAGS was built?

   The prices vary considerably by producer. No doubt legal action will be undertaken at some time to determine what price is correct. This January at Prudhoe Bay SOHIO reported a price of $.25/mcf while Exxon reported a price of $3.37/mcf. The average price reported for royalties was $.51/mcf. ARCO reported a price of $1.91/mcf for Kuparuk production.

   The wellhead price assuming TAGS in place will depend on the world gas price and the transmission system cost. Given the high cost of the transmission system and the poor outlook for energy prices, the wellhead price may be quite close to zero.

4. How much in royalties would you expect the State to receive annually from North Slope gas if TAGS is built?

   For every $1.00/mcf at the wellhead with an assumed production level of 1.8 bcf/day, the State would receive $82.125 million in royalties annually.

04-D7LH

In our March 1986 Forecast we estimated North Slope gas royalties equal to $212 million in FY 2000 (adjusted for probability of system completion).

Sincerely yours,

Charles L. Logsdon
Petroleum Economist

CLL:ds

4/14

# HOUSE
## COMMITTEE REPORT

(9)

Date referred: 4/1/86

JUDICIARY

FURTHER REFERRALS: FINANCE

DATE: April 15, 1986

The RESOURCES Committee has considered HJR 71

Proposing amendments to the Constitution of the State of Alaska creating the Alaska research development endowment."

and recommends:

[XX] do pass

[ ] do not pass

[ ] do pass with attached amendment(s)

[ ] no recommendation

[ ] replace with ______________ [ ] same title

[ ] new title

and recommends ______________

[ ] further referral to the ______________ Committee

and attaches:
[ ] letter of intent
[XX] first fiscal note Supp 117
[ ] new fiscal note
[ ] zero fiscal note

SIGNING DO PASS:

Shultz Dick Shultz

Jenkins Roger L Jenkins

Pearce [signature]

Sund [signature]

Miller(NP) M.W. Miller

SIGNING OTHER RECOMMENDATIONS:

Adelheid Herrmann No Rec
Herrmann

Bette Cato No Rec
Cato

David W. Thompson NO REC
Thompson

Dick Shultz

Co-Chairman Shultz

AVERAGE EXPECTED AND RISK ADJUSTED CONTRIBUTION TO THE
ALASKA RESEARCH DEVELOPMENT ENDOWMENT AS PROPOSED BY HCR 71 AND HB 705
BASED ON DEPARTMENT OF REVENUE MARCH 1986 PETROLEUM REVENUE FORECAST
(millions $)

| Fiscal Year | Average Expected North Slope Gas Royalties | 30% Case North Slope Gas Royalties | Average Expected Contribution to ARDE | 30% Case Contribution to ARDE |
|---|---|---|---|---|
| 1987 | 2.72 | 2.72 | .907 | .907 |
| 1988 | 2.84 | 2.82 | .947 | .940 |
| 1989 | 2.74 | 2.70 | .913 | .900 |
| 1990 | 2.47 | 1.31 | .823 | .437 |
| 1991 | 2.54 | 1.64 | .847 | .547 |
| 1992 | 2.64 | 1.13 | .880 | .377 |
| 1993 | 3.83 | 0 | 1.277 | 0 |
| 1994 | 4.73 | 0 | 1.577 | 0 |
| 1995 | 29.95 | 0 | 9.983 | 0 |
| 1996 | 31.45 | 0 | 10.483 | 0 |
| 1997 | 53.14 | 5.98 | 17.713 | 1.993 |
| 1998 | 56.25 | 6.16 | 18.750 | 2.053 |
| 1999 | 59.72 | 6.46 | 19.907 | 2.153 |
| 2000 | 95.79 | 6.46 | 31.930 | 2.153 |

# A CHALLENGE TO ALASKA

University of Alaska Foundation

June 1985

# A CHALLENGE TO ALASKA

**Report of the Alaska Research Development Project**
**From the Scientific Advisory Commission**
**To the University of Alaska Foundation**

**June 1985**

"To survive—to continue and to enhance the good life its people now enjoy—what does Alaska need to know about itself, its total environment, its people? No other state has ever had the opportunity nor the responsibility to investigate critically its resources, determine where it wants to be fifty or a hundred or more years from now, and program a sustained, coordinated, and long-range effort to accomplish these goals."

Lyle D. Perrigo, Senior Science Director
University of Alaska Foundation
590 University Avenue, Suite 101
Fairbanks, Alaska 99701

**Members of the Scientific Advisory Commission***

Wilmot N. Hess, Director
National Center for Atmospheric Research
Box 3000
Boulder, Colorado 80307

David M. Hickok, Director
Arctic Environmental Information and Data Center
University of Alaska-Fairbanks
707 "A" Street
Anchorage, Alaska 99501

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University of Washington School of Medicine
Seattle, Washington 98195

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La Jaquiere
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SWITZERLAND

Robert R. Richards, Vice Chairman
Alaska Pacific Bancorporation
P.O. Box 100420
Anchorage, Alaska 99510

James W. VanStone
Department of Anthropology
Field Museum of Natural History
Roosevelt Road at Lake Shore Drive
Chicago, Illinois 60605-2496

*Consultants to the Scientific Advisory Commission: Vera Alexander, Director, Institute of Marine Science; Vincent S. Haneman Jr., Dean, School of Engineering; and Juan G. Roederer, Director, Geophysical Institute, all from the University of Alaska-Fairbanks, Fairbanks, Alaska 99701

**At the time of appointment, Dr. Johnson was stationed in Anchorage with the SOHIO Alaska Petroleum Company.

***At the time of appointment, Dr Myers was Director of the WAMI (Washington, Alaska, Montana, Idaho) Medical Education Program, in Fairbanks, Alaska.

# PREFACE

The challenge to Alaska printed on page iii is the starting point of a major and continuing effort to give Alaskans the best possible future for their state, themselves, and their children and grandchildren. An essential part of that effort will be to learn more about Alaska—its natural resources; its environment; the health and medical problems of living and working in the state; the important physical, geological, oceanographic, and biological processes that influence and control human activities; and the social and economic arrangements that will facilitate the use of these several kinds of knowledge.

Alaska can carry out such a program because much of the development that is now past history for most states still lies in the future for Alaska. Alaskans of today are, therefore, trustees of Alaska's future. This project is intended to help them to be wise and successful trustees.

This report is aimed toward that end. Its purpose is to identify and briefly describe the areas in which future research will be required in order to fill in gaps in knowledge, to understand more fully the processes and problems involved, sometimes to correct misinformation, and to learn how to apply what is known to achieve better conditions in the state. The report does not try to provide all that information; that task will be the responsibility of future investigators. What the report tries to do is to serve as a guide to where to look for the needed information.

The whole project is sponsored by the University of Alaska Foundation, a private, nonprofit organization formed in association with the University. Members of that Foundation conceived the idea, formulated the challenge, and planned the project. Funds to support the project came entirely from the contributions of several hundred private citizens who were inspired by the Foundation's idea and wanted to help make it a reality.

In writing this report, we have had the help of many people: the authors of earlier studies of Alaska and its research needs; advisors who wrote memoranda or supplied information on their areas of special interest; many consultants whose discussions with the project's Director helped inform us about the state's needs, opportunities, and problems; and scores of critics who read and commented on earlier drafts of the report. We are grateful to all of them. Their names, except for the authors of published works, whose contributions are recognized in the bibliography and list of references, are given on page 91. Such a list always runs the danger of being incomplete; help has come from so many sources we may have inadvertently overlooked some. If so, we hope they will understand and accept this apology.

Finally, the we in this preface should be identified. The project was sponsored by the University of Alaska Foundation, and this report is addressed to that organization. To identify the kinds of research that will be most needed to ensure the best achievable future for the state, and to prepare this report, the Foundation appointed a Senior Science Director and a Scientific Advisory Commission. They are named on page iv, and they—not the University of Alaska Foundation or any of the consultants and critics—are responsible for the statements and recommendations of the report.

Lyle D. Perrigo
Senior Science Director

Dael Wolfle, Chairman
Scientific Advisory Commission

June 1985

# CONTENTS

# EXECUTIVE SUMMARY

The Alaska Research Development Project was planned and initiated by the University of Alaska Foundation for the purpose of obtaining the research information that will be needed to give the state the best attainable future over the next 50 to 100 years or more. This report is a first step toward that goal. Its objective is to identify the kinds of research information that will be most needed. The recommended studies are described under four headings.

1. Research needed for the wise development and use of the state's natural resources. These research areas include energy, defense, mineral resources, fisheries, forestry, and food and agriculture; and also the collection, storage, and dissemination of information; the state's transportation systems; and materials research and engineering.

2. Research needed to provide for the care and preservation of the state's natural resources and the culture and heritage of its diverse peoples. These research areas include manmade changes in weather and climate, including the possibility of a warming trend of the whole earth; environmental protection; and archaeological, anthropological, and linguistic studies of the Native populations.

3. Research needed to protect the health and well-being of Alaskans. Three topics are considered: health and disease; social pathology; and building construction and maintenance.

4. Research on topics for which Alaska is a "natural laboratory" compared with other parts of the nation, and research on topics that support and contribute to improvements in many of the topics listed above. These research areas are: the upper atmosphere; weather and climate; geology; natural hazards; snow, ice, and permafrost; northern oceans; and human resources.

Research on these topics will continue for many years. Detailed decisions concerning priorities can therefore better be made gradually, by the research groups that will be involved. At this time, however, ten major conclusions and recommendations can be stated. They are given in approximately the order of discussion in the report, not in priority order.

1. Some time within the next century, or less, the U.S. will switch from petroleum and natural gas to some other major source of energy, most probably coal or nuclear fission. As oil and gas become too expensive to burn as fuel, Alaska will have several opportunities to contribute to the nation's energy needs by developing its coal, geothermal, or hydroelectric resources. As the smaller scale use of these resources for Alaska's own need continues, opportunities should be grasped to gain information and experience that will be valuable in planning later and larger scale developments (see pages 7 and 9).

2. The coordinated study of oceanography and the basic biology of marine food chains and the harvested species that depend upon those food chains, and the concurrent collection of information on which to base permanently effective and profitable management practices constitute an important area of needed research (see pages 11-13).

3. The relatively new field of genetic engineering gives promise of making major contributions to the improvement of agriculture (see page 14).

4. There are strong indications that the earth will become a few degrees warmer in the next century or less, due to the increase of carbon dioxide, methane, and other "greenhouse" gases in the atmosphere. If so, Alaska and its surrounding seas will warm up considerably more than will more temperate latitudes; the Arctic Ocean may become largely ice-free in the summer months; and Alaska will be one of the places where the warming trend will first become clearly evident. Unlike much of the world, the warming trend may have some advantages for Alaska. The changes that would be necessary to adapt to that condition, for example those involved in agricultural practice, are generally desirable in any event (see pages 20-22).

5. Damage to the environment is slower to heal in cold climates than in warm ones. Toxic pollutants to land or water last longer than in a warmer region; and in Alaska and its surrounding seas some dangers, such as an oil spill at sea, are most likely to occur at the same sites that are biologically most productive. Research directed toward environmental protection is therefore even more essential in Alaska than in many other regions (see pages 22-23).

6. Native speakers of Alaska's Aleut-Eskimo, and Indian languages are rapidly disappearing, and archaeological sites are being destroyed by erosion, industrial or other development, and clandestine excavation. If better knowledge of the culture, history, and protohistory of these peoples is to be obtained,

there is an urgent need to identify and protect archaeological sites and to accelerate the collection, recording, and analysis of cultural traditions and Native languages (see pages 20-25).

7. A major need in the field of health is for more accurate, detailed, and comprehensive health data of two kinds: (a) systematic analysis and dissemination of health information relevant to Alaska's special needs; and (b) epidemiological data that can be used to monitor the health of Alaskans and to improve their health services (see page 28).

8. Residents of Alaska are subject to relatively high levels of stress. The state also has high rates of suicide, violence, and accidents. Research on the climatic, environmental, and social factors leading to stress deserves high priority in order to determine the causal relationships that may be involved, and to determine how suicide, violence, and accident rates may be reduced (see pages 28-30).

9. Most of the research recommended is of a practical nature, applied to recognized problems of the development of resources or the protection of the environment and the health and well-being of citizens. In addition, however, Alaska has a special opportunity to study those scientific and technical issues for which its high geographic and geomagnetic latitudes give it special advantages. The results will be a contribution to the world's knowledge, and will aid in understanding and coping with many practical problems (see pages 33-34).

10. The most insistent single recommendation of the many people consulted in preparing this report was for better basic data, over time, and from throughout the state. Public health workers need better epidemiological information. Those working on the understanding and mitigation of natural hazards need continuing statewide information on seismicity and so do scientists working on basic problems in geology. Geologists need more detailed maps. The prospective warming trend and the need for environmental protection make it highly desirable to develop a more thorough, more comprehensive, and long continuing system of monitoring environmental variables throughout the state in order to understand trends and to be able to take remedial action early enough to be effective at reasonable cost. Students of snow, ice, or permafrost, those primarily concerned with weather and climate, the fisheries experts, and others make a strong case for the need for better base line data so that trends and changes can be monitored and so that the effects of human intervention—whether intended or accidental—can be distinguished from natural fluctuations. Again and again, the plea has been for better base line information, more systematically collected and analyzed, made more easily available to those who need it (see pages 15, 22-23, 28, and 36-37).

Because of overlapping needs of the several fields of work and because of interrelationships among the types of data needed, it will obviously be desirable for a good bit of joint planning by specialists from several areas to decide upon the kinds of data that are most needed and the methods of collection, reduction, and reporting that will be most useful.

Positive methods must then be developed to make certain that the data and information get to those who can use them in the many kinds of studies, planning activities, and decisions that will determine how successfully Alaska actually achieves the future it considers most desirable.

Finally, adoption by the federal government of the Arctic Research and Policy Act of 1984, appointment of the Arctic Research Commission and the Interagency Arctic Research Policy Committee called for in that Act, and the beginning formulation of the national Arctic research program plan to implement the Arctic research policy will all be of benefit to the state. However, the emphasis of the Act is on national needs, not the needs of the state. There is, of course, much overlap. Yet if the state's priorities are to be given full weight in planning future research, the state needs an organization of its own to formulate policy, sponsor research, establish priorities, and make certain that the kinds of studies called for in this report are emphasized. Appointment of a science advisor to the Governor is a good move in this direction. What remains to be done is to decide upon the nature, organization, financial support, and authority of an organization to support and carry out the expectations of an "Alaska Research and Policy Act" dedicated to the best attainable future for the state.

The Foundation's challenge to the state—to look ahead 50 to 100 years—poses a difficult problem: How can one look that far into the future and plan for the kind of knowledge that will be needed under the different conditions of those future years. One of the most essential foundations for looking well into the future is to understand as thoroughly as we can how current conditions are changing and what current trends forecast for future years. Accurate, comprehensive, and soundly analyzed base line data are essential for that purpose. So is a clearly reasoned vision of what future is wanted. Employing the most highly qualified persons the state can attract for research and for management and planning will help to supply the state with persons of vision.

# CHAPTER 1
# INTRODUCTION

Ever since Alaska was purchased from Russia the rest of the United States has been learning what a treasure the nation bought for $7.2 million. The U.S. gained vast resources of oil, gas, and coal, gold and other minerals, forest and potential agricultural land, one of the most productive fisheries in the world, and more varied and magnificent scenery than can be found in any other state.

With all these riches, and its strategic location, it is quite understandable that the rest of the nation looks upon Alaska as a source of materials for the national economy, a base for military defense and for surveillance of the rival colossus across the Arctic Ocean, a way station for international travel, and Alaskan waters as a source of food.

Viewing Alaska from these standpoints has emphasized the question: What can Alaska do for the rest of the nation? Answers to that question are usually made in government offices or industrial board rooms in Washington, D.C., New York, Houston, or somewhere else thousands of miles from Alaska. The question is appropriate enough; Alaska is part of the United States. But Alaska is not simply the nation's largest state, with most of the nation's continental shelf and offshore resources. Alaska is also a diverse collection of people. Its citizens came from successive waves of immigration, first in relatively small numbers from Siberia and, much later and in larger numbers, from the rest of North America, Europe, and elsewhere. These varied peoples have their own interests in how Alaska is developed and used. So there is another question to ask: What future of Alaska will be best for Alaskans?

A small group of civic, commercial and educational leaders of the state, joined together under the banner of the University of Alaska Foundation, decided to put that question as a challenge to the whole state. The objective is clear: What knowledge does Alaska need to help ensure the best possible future for itself and its citizens?

To gain that knowledge will require a sustained and comprehensive research program, a program guided by the current and future needs of the state. Interest in conducting such research already exists within several departments of the state government; the University of Alaska; several departments and agencies of the United States government; some oil companies and other industrial research groups; and those scientists throughout the United States and other countries who are interested in problems of the North. All will contribute to the gaining of the needed knowledge.

Knowledge itself, however, is not enough. It must be wisely applied. Decisions will have to be made about what is feasible and what has highest priority. Plans and decisions about the state's future will also depend upon human values, economic conditions, political agreements, compromises, the social and cultural machinery that plans and controls activities within the state, and on human wisdom. Yet the more that can be learned about the physical, biological, and social processes, trends, and interrelationships involved, the better will be the factual and informational basis for making the decisions that will determine the nature of the state's future.

Fortunately, there is already a good start on acquiring the needed knowledge. Although there was relatively little organized research on problems of the region until the time of World War II, research programs have increased substantially since that time. Organizations that have continuing interests in planning or conducting research on Alaskan or arctic problems include:

- Several departments of the state government;
- The National Science Foundation, the National Oceanic and Atmospheric Administration, the U.S. Army's Cold Regions Research and Engineering Laboratory, the U.S. Geological Survey, and several other agencies of the federal government;
- The Polar Research Board and the Polar Oceans Climate Panel of the National Academy of Sciences;
- Scientists and engineers of Sohio Alaska Petroleum Company, ARCO Alaska, Exxon Corporation, other industrial companies, and several engineering and technical societies with interests in the development of some of Alaska's rich natural resources;
- Several universities that have developed strong programs of research on Arctic or Alaskan issues;
- Still other agencies and institutions, including the American Public Health Association, the Congressional Office of Technology Assessment, and the Environmental Protection Agency, to name only a few at the head of the alphabet.

The bibliography on pages 92-93 lists some of the major publications of these and other organizations and authors.

A new participant in the list of organizations involved in Alaskan research was added by passage of the Arctic Research and Policy Act of 1984. That act instructed the agencies of the federal government with interests in the Arctic to cooperate in a survey of existing arctic research in order "to help determine priorities for future arctic research." Following that survey, those agencies are then directed to prepare a comprehensive five-year plan "of national needs and problems regarding the Arctic and the research necessary to address those needs or problems." That study (Ad Hoc Committee on the Arctic Research and Policy Act, 1985) resembles this report in its wide coverage of research needs, and adds to it by presenting a large number of recommendations concerning research needed in the near future.

Note, however, that the emphasis in these instructions is on the Arctic, not on Alaska, and the objective is to help meet national needs, not Alaska's needs. Moreover, the primary interests of most of the organizations listed above—federal agencies, the Polar Research Board, some of the oil companies, etc.—are in the Arctic, not in Alaska. Alaska, however, is only part of the Arctic, and only partly in the Arctic. There should be close agreement in many of the problems studied and much of the information gained, for there is a large overlap between Alaska and the Arctic. Yet the state cannot rely entirely on studies directed by national interests or purely arctic interests. Alaska needs its own sustained program of research if its citizens are to have the best attainable future.

The objective of this report is, therefore, to identify the kinds of information that will be most helpful in making decisions about the future of the state. The research that will be needed can be classified under four broad questions.

1. **What research information would be most useful to assure the wise development and use of the state's natural resources, both renewable and nonrenewable?**

2. Selective development is sure to come; indeed it is already well started. But development always involves conflicts of interest, and sometimes brings real or potential damage. Therefore, it is necessary to ask: **What research information is needed to provide for the care and preservation of the state's natural environment and the culture and heritage of its diverse peoples?**

3. Alaska is a land of extremes of temperature, of great seasonal changes in light and darkness, of natural hazards. **What information does the state need to protect most fully the health and well-being of Alaskans?**

4. All three of the above questions are focused on practical affairs—development of resources, environmental protection, or human health. Some of the needed information can be gained by direct, frontal attacks on specific, practical questions; however, there is a deeper level of knowledge that will often be useful, that is knowledge about the fundamental physical, geological, or biological processes involved. For example, more thorough understanding of permafrost can be useful in improving building construction, in developing and maintaining transportation systems, and in other ways. Fuller understanding of weather and climate and better ability to forecast their changes would be advantageous to agriculture, forestry, health, transportation, and much besides.

Moreover, what happens in Alaska sometimes has influences that go far beyond its borders. Alaska and its neighboring seas are the breeding ground for much of North America's weather. Alaska is also the easiest and most natural place to study some issues that are important over a far wider geographic range: the effects of the solar flux on the earth's magnetosphere and ionosphere; potential changes in global climate; human adjustment to cold; and the effects of cold on some disease conditions are examples of research areas in which Alaska is a kind of natural laboratory with advantages over other parts of the nation.

For these reasons there is a fourth broad question to ask: **What basic knowledge and understanding of physical, biological, and social processes and changes will contribute most effectively to the solution of engineering and scientific problems either in Alaska or beyond?**

Within each of these four areas of inquiry there are many more specific topics. For example, the topic of natural resources includes oil, gas, coal, hydroelectric, geothermal, and still other sources of energy, as well as fisheries, agriculture, forestry, and other natural resources. Although something is known about these and all the other subtopics under the four broad questions, additional knowledge is needed for all. Pointing out that fact runs a risk, and some reviewers of an earlier draft of this report complained that the research recommendations constituted a great shopping list, with research needs indicated for every topic mentioned. That is exactly the right impression; it is desirable to learn more about every one of the topics.

Yet there must be priorities, and throughout the report, and particularly in the *Executive Summary*, we have identified some. At a more detailed level, however, the priorities must be decided later and locally. There are two reasons. First, the needed research will be conducted by industry, universities, agencies of the state and federal governments, and other research groups. In each case, the people who are actually planning the research and expecting to carry it out should decide how to go about their work, what needs doing first, and what can come later.

Second, is the matter of time. The Foundation's challenge is to think of "fifty or a hundred or more years from now." Research will therefore be conducted over many years, and many of the conditions that will exist are not yet known. They will depend upon national economic conditions, international relations, unanticipated technological developments, and a variety of other events. And some major aspects of the future can be anticipated with considerable confidence. The population will be larger. With present techniques the Prudhoe Bay oil field will have long been pumped out, and, more generally, the United States will have reduced its usage of petroleum and gas and turned to some other major source of energy. There will still be conflicts over alternative uses of the state's resources. Knowledge in some fields will have expanded substantially. For example, advances in biotechnology, or genetic engineering as it is sometimes called, will have opened up new possibilities in agriculture, forestry, and probably also in animal husbandry and the treatment of some diseases. Many of the important changes will come about gradually, and the institutions and individuals planning research can establish priorities based on fuller information than is available now.

In the future, as in the past, acceptance of responsibility for particular studies and the setting of priorities will be largely decentralized, with each agency or institution tending to emphasize research on those problems that are most directly related to its particular responsibilities. Agencies of the state government will support some of the research. Other studies will be supported by agencies of the federal government, industry, or other research organizations. Consequently, no effort is made in this report to state which studies should be conducted by the state government, the university, a particular agency of the federal government, or any other particular sponsor. Emphasis here is on the knowledge that will be needed, not upon the agency that will be responsible for securing that knowledge.

Within this system, if Alaska's special needs are to be fully represented, there should be a continuous and stable organization that will give sustained attention to the question of what new knowledge Alaska most needs. Operating always from the standpoint of Alaska's primary needs for information, this organization should be able to support some research directly. If it does that, it can also exercise a guiding hand in the planning of some of the research that will be conducted by other sponsors. Under these arrangements, the state can have a large influence in determining its own future.

# CHAPTER 2
# DEVELOPMENT AND USE

The Alaskan economy rests primarily upon the export of petroleum and other natural resources, and upon its service industry. In the longer future, the state's economy may come to rest more largely upon industrial processes or other means of adding to the value of natural resources, but for the next several decades the harvesting and export of its rich natural resources will probably continue to be the major contributor to the state's economy. Alaska should therefore remember that the resources of the world's resource-rich regions have usually been developed not for the benefit of local citizens, but rather for the benefit of people living somewhere else, in centers of finance, manufacturing, or government (Meeker, 1976). To some extent, that condition is inescapable; the state can derive no income from its natural resources unless there is an external market. Yet how well the state can capitalize on external markets will depend substantially upon how well it understands its own resources and knows how they may be best developed and used.

How well the state can capitalize on external markets will also depend upon the service industries involved and upon the nature and consistency of the governmental policies and regulations involved. In Alaska, nearly all of the land that might be used for agriculture, forestry, or other forms of management is owned by the state or the federal government or by Native corporations. If private industry is to find it attractive to make the capital investments that will be necessary for developmental or management projects, there must be stable, dependable government policies and regulations. Thus, one of the first and most important kinds of knowledge needed is an examination of the economic and social consequences of past policies, and their changes to gain information on which to establish constructive and well coordinated policies to encourage and control future development.

This chapter will briefly describe each of the major types of resources and the kinds of information most needed to guide its future development, and will then turn to three undergirding topics on which more knowledge is needed because that knowledge will contribute to the more effective and economical development and use of all or several of the resource areas.

## Energy

### Future Energy Exports

Worldwide, and within the U.S., the annual use of petroleum now exceeds the rate of discovery of new oil. Alaska and its surrounding seas are generally thought to include most of the still undiscovered oil and gas in the U.S., but the results of exploratory drilling since 1978 have been disappointing. As a result, the Department of the Interior has reduced its estimates of economically recoverable offshore oil by 55 percent and natural gas by 44 percent (Office of Technology Assessment, 1985). As the remaining supply diminishes, petroleum will become too expensive to use as the nation's major source of energy for transportation, heating, and commercial use. The U.S. will then have to switch to some other major source. The timing of that transition will depend upon the extent of future fields that may be discovered and upon how much the country is willing to become dependent upon imported oil. Yet the necessity to change to a new major source of energy will inevitably come, probably somewhere from a few decades to a century from now (Hafele, 1981).

When that time does arrive, will Alaska have other forms of energy to export to an energy-hungry world? For a time, more natural gas may be used, for the world supply is large. However, gas from Prudhoe Bay or other known Alaskan reserves would now cost twice as much delivered in the central U.S. as gas produced in the Lower 48 (Grant, 1984). In the longer future natural gas will probably become too valuable as a feedstock for the chemical industry to have much of it used as fuel (Seifert, 1977). Heavy oil and gas hydrates—snow-like crystals of water and natural gas that remain stable well above the freezing point—are not now economically viable sources of energy, but when the supply of gas begins to diminish, they may become so if the necessary research and development—and the education of engineers about these possibilities—provide the essential base of knowledge for their commercial development (Ehlig-Economides and Combellick, 1981).

For the nation as a whole, however, the two most likely replacements for petroleum seem to be coal and nuclear power. Each has its disadvantages, but improved technology can probably overcome some of the difficulties. Fluidized bed or other methods of burning coal cleanly and without large and damaging stack emissions can probably be successfully scaled up from experimental demonstrations to commercial generator size. And inherently safe nuclear fission plants should have become attainable (Weinberg, 1984).

Alaska has geologic formations containing uranium and thorium, but the quality and quantity are not known. The state has vast resources of coal with low sulfur content, most of it bituminous or sub-bituminous in nature, and much of it in the far north, under permafrost and far from present transportation facilities. Some coal from the central region is now being exported, but in the long run, the better opportunity for commercial export of most of the state's coal is probably through *in situ* gasification and the production of an easily exportable product such as hydrogen or methane (Davis, 1984a; 162).

In the magma-heated rocks lies a geothermal resource of unknown but possibly vast size (Rey, 1983; Turner and Westcott, 1983). So far, use has been spotty, and wholly local, for space heating, agriculture, and recreation. There are additional possibilities for use in village heating, greenhouses, warmed-ground farming, and aquaculture. Or, with more expensive and advanced facilities, there is a long-range possibility that geothermal resources, especially in the Aleutian chain, could be developed and used to produce hydrogen for export (Davis, 1984).

As a still different possibility, the state might export electricity generated by the power of some of its rivers. Alaska has a third of the nation's undeveloped hydropower (Rey, 1983; Davis, 1984a), although much of it is located in parks, reserves, scenic areas, or wild rivers. There are also uncertainties about the reliability of potential hydropower reservoirs because of the variability of annual snow packs and glacier runoff, and about the amount of ice damage that might occur to reservoirs and to structures, turbines, and power lines. All of the ice-formation modes are possible sources of difficulty for reservoirs and power plants in really cold regions. So far, most of Alaska's experience with hydroelectric projects has been in relatively warm coastal areas. That experience and analysis of the Susitna project can be supplemented by some of the engineering experience gained in Canada, Switzerland, the Scandinavian countries, and the U.S.S.R. in dealing with ice problems (Osterkamp, 1977). Even so, it will be difficult to predict the long-term reliability of generating capacity with confidence until more is known about the effects of the potential global warming trend on Alaskan precipitation and glacier balances.

If these several problems can be satisfactorily worked out, the state contains a large hydroelectric potential. The Lower 48 has increased its importation of electricity generated by Canadian rivers some sixfold since 1970, and is hungry for more cheap and reliable hydroelectricity. Canadian generators are closer than the potential ones in Alaska, and Canadian power is already being used as far south as Los Angeles. With appropriate tie lines Alaskan hydroelectric power could be fed into North American distribution networks.

**Energy for Alaska**

In addition to oil, gas, and coal, which can be burned locally, there are other resources that can only be used locally. Biomass is too bulky to export. The wind blows locally. And solar energy is a most unlikely export to sunnier regions.

**Solar Power**

Within Alaska, the demand for energy shows greater seasonal variation than in other states, low in summer and very high in winter. Although the availability of solar energy is quite out of step with that annual demand cycle, even in Alaska the passive solar heating of homes, buildings, and water heaters is effective, and photovoltaic conversion to electricity is attractive for a few highly specialized uses at remote sites without other reliable sources (Gentry, 1982).

**Wind**

Most wind in coastal areas occurs in the winter when demand for energy peaks. Along much of the coast, near passes and at selected other sites, there is opportunity for the increased use of wind power, probably in connection with hydropower, diesel, or some other source that can be used when wind power is not sufficient, and if the resulting noise and interference with electronic communications are not too disruptive.

**Hydropower**

Most of the annual river run-off is in summer when demand for energy is low. Thus, run of the river generation is often unattractive. On the other hand, construction of large dams and storage reservoirs may not become economically viable until Alaska has a considerably larger population and more extensive interties among several generators, or until the development of an export market justifies construction of the long lines necessary to carry the power south.

**Tidal Power**

An interesting and unusual possibility would be to dam tidal channels in southeast and southcentral Alaska that have high tidal amplitude and water volume and use the tidal flow to generate electricity. The basic power source (the tidal flow) is free, utterly dependable, and fairly uniform the year-round. The capital costs, however, would be very high. With present materials, so would maintenance costs. Glacial silt is a powerful scouring agent. Special designs or new materials will be necessary to avoid problems of rapid wear of turbine blades and bearings.

### Low Differential Temperature Sources

Rankine power systems can make use of much lower differences between the high temperature of a working fluid and the low temperature at which heat is ejected from the system than is often found in conventional power systems. At lower temperatures, Rankine systems are low in efficiency, but almost any kind of fuel can be used; coal, peat, propane, diesel fuel, or garbage; or the waste heat from a diesel generator or warm water from a geothermal source can be used.

Most of the commercially produced low temperature difference Rankine cycle units "have been used as electric power supplies for remote microwave repeaters and other communications facilities where high reliability is required, and where maintenance and operations costs and logistics are critical factors in the selection of equipment" (Leonard, 1980). This description fits a number of Alaskan situations. Although the total potential for Alaskan use is not clear, larger units might well prove to be the system of choice for generating electricity for many small communities, because of their simplicity of design, reliability, and great versatility in use of various fuels. They might, for example, be what is needed to extract power from low temperature geothermal sources. Or, Rankine cycles might be used along the Beaufort Sea coast where warmer deep water currents may exist with cold ambient air temperatures in the winter months.

The development and use of waste heat power recovery cycles from Fairbanks steam plants in the winter might: (1) provide extra power; and (2) reduce the intensity of ice fog. Temperature boosting via absorption cycles may also have applications in Alaska, but research is needed on more efficient absorption cycle equipment and processes. The low winter temperatures in Central Alaska and small size of lower temperature heat sources place special demands on energy recovery systems. Special designs will be needed for reliable and effective use.

### Strategy for the Future

For the near future, local markets will provide the primary justification for developing the state's geothermal, hydroelectric, or tidal resources. Further ahead, some national energy scenarios may make large-scale developments economically attractive; for example, gasification of coal, high voltage electric interties, or production of hydrogen for a hydrogen-based energy system.

However, for each energy source there are problems specific to the particular source and sometimes to the particular site: rock dynamics, ice and permafrost, corrosion, wind velocity, and even such mundane matters as transportation facilities or availability of sand, gravel, or other construction materials. Moreover, each will create problems. For example, surface mining will inevitably cause extensive damage, but neither the details of the damage nor the best methods of reclamation can be inferred from experience with strip mining in the Lower 48. In response to a request from Congress, the National Research Council conducted a study of the difficulties of surface mining in Alaska. The committee recommended a slow and cautious approach, starting with small scale (and almost certainly unprofitable) experimental operations to test and develop appropriate methods of mining and reclamation (Committee on Alaskan Coal Mining and Reclamation, 1980).

Substantial study and much engineering experimentation will be needed before any source is ready for large-scale development; and, because of increasing costs, there is considerable need for improved utilization and conservation, whatever the original source of energy, and these aspects also call for further research.

At any particular time, it will make sense to try to pick the winners in the energy field—oil, gas, hydropower, or some other. Under present conditions, petroleum products have become the favorite because they are found in concentrated resource pools and because of their ease of transportation, storage, and use. However, as petroleum and gas prices increase and resources diminish—as they inevitably will—other sources will have to be used. To prepare for that time, a useful strategy will be to maintain diverse options by trying out and gaining experience with a number of alternatives. In contrast with that foreword looking policy, the present policy of the state has been described as being very generous in distributing current oil revenues while disregarding most of the other energy sources available to the state and neglecting the opportunity for technical innovation and the acquisition of new knowledge as to how those resources can be most effectively used (Davis, 1984b).

**Over the next several decades there will be opportunities to try out geothermal, tidal, pumped storage, and other means of securing energy when and where it is needed in Alaska. If the opportunities are grasped, it will be possible to use these local-use developments to learn much before large-scale developments are needed. Over the next several decades it will be prudent to try out a variety of energy developments, even including some that are not yet economically competitive with current favorites. The practical engineering knowledge gained will be useful, and a few relatively small losses in the next several decades could be good insurance against the later construction of a highly expensive failure built in the wrong way or at the wrong place because the state had passed up opportunities to learn how to avoid such a mistake.**

## Defense

Geographically, the shortest distance between North America and the Soviet Union is across the Bering Strait; but geopolitically, the shortest distance lies directly across the Arctic Ocean. The obvious military implications have made arctic studies an area of military interest, and army, navy, and air force have all conducted studies related to their ability to operate under arctic conditions.

The defense interests of the United States include detection or prevention of missile attacks from the Soviet Union or from submarines operating in the Arctic Ocean; control of the two exits from that ocean—the Bering Strait and the Greenland/Iceland/United Kingdom gap; protection of the rich resources of Alaska; and protection of airbase, weather, and communication stations in the north. All involve operations under the difficult conditions of cold, darkness, storms, ice, and the magnetospheric conditions of the arctic that sometimes interfere with radio and satellite communications and surveillance systems. Thus, military research on the health, efficiency, and performance of personnel, on the performance and maintenance of equipment, on communications, detection, and warning devices, and on other problems of military operations can be expected to continue. So long as submarines continue to be used as platforms for the potential launching of intercontinental missiles, and so long as those submarines continue to improve in their technological capabilities and performance, the navy will continue to want firmer and more detailed knowledge about ice thickness (for possible emergency surfacing) and about the topography of the arctic basin, ocean currents, and the characteristics and anomalies of sound transmission under ice and in the open Arctic Ocean and its surrounding bays and straits (Johnson, Bradley, and Winokur, 1984; Shusterich, 1984).

Although the motivation for military research has been intensely practical, the seriousness of the problems and the lack of information concerning the basic physical processes involved has resulted in military support for a substantial amount of fundamental research on geophysical, oceanographic, atmospheric, and magnetospheric phenomena.

Nevertheless, United States research in the Arctic is much smaller than that of the Soviet Union as measured by the number of scientists involved, the number of research institutes and stations, or the number of ice-strengthened vessels. In fact, Soviet activities in this area are larger than the combined efforts of all the other nations bordering on the Arctic Ocean. U.S. defense interests will remain, however, and research supported or conducted by the military services can be expected to continue. Some of the information gained by that research will be much the same whether the activities involved are military or civilian. One example is the disruption of communications that occurs periodically within the polar regions due to perturbations of the earth's magnetic field. The disruption of signals due to an atomic explosion or any other strong electromagnetic pulse would raise havoc with both civilian and military communication systems. Another problem is that of obtaining reliable performance of equipment in remote, difficult to reach, and often unmanned observation stations. A mean time to failure of 500 hours, or of 5,000, for a delicate piece of recording or sensing equipment may be quite acceptable in Anchorage where resupply is easy. But such a short life is intolerable in a remote location where resupply is hazardous, expensive, and dependent upon ice or weather conditions. Other problems common to military and civilian responsibilities are to be found in logistics, the quantitative comparison of the performance, reliability, and maintainability of alternative systems and types of equipment; the operation and maintenance of equipment under water, on land, and in the air; human engineering or the human factors in the performance of vehicles, equipment, and other technological systems; and the care of personnel in cold regions. Even such an ordinary matter as clothing seems to call for study. In the winter war games of 1985 in Central Alaska, members of the army, navy, air force, and marines were wearing heavy wool clothes designed 35 years earlier for the Korean War. Although interested in lighter weight clothing, the services had not yet begun to utilize the light-weight winter gear that was already familiar to sportsmen (TIME, 1985).

On all these matters, Alaska can provide a variety of cold weather conditions for research and testing of equipment and technological systems and the performance of personnel.

## Mineral Systems

Alaska contains from moderate to vast supplies of many kinds of minerals. There are large quantities of sand, gravel, and building stone—the industrial minerals—which, as elsewhere, are normally used near their sources and are not likely candidates for long distance export. Within Alaska, however, extensive developments, including construction of gravel islands, buildings and homes, and streets and highways are keeping the use of industrial minerals at high levels. Because future economic development and population expansion can be expected to maintain high demand for these industrial minerals, there are technical and policy questions that merit study (Davies, 1984). What are the key factors affecting gravel island stability? Can gravel from abandoned pads be reclaimed economically? And, on the policy side, how should state-owned sand and gravel be allocated, priced, and managed?

### Coal and Peat

There are also huge amounts of coal and peat. Coal was discussed in the section on energy, and the peat is typically of fairly low quality, containing large percentages of water and ash. Peat will not be a competitive source of energy for large scale power production in the near to intermediate future, but there are local situations in which it is useful for cooking and heating and may even be a viable alternative to other sources for generating electricity. A key factor in filling such an economic niche will be the availability of small, simple, peat-fired power systems—if engineering research and demonstration can provide them. More esoteric, high-technology uses are now only matters of future speculation (Davis, 1984a), although direct conversion to oil has been proposed for early development (Molton, Fassbender, and Brown, 1984). However, before there can be any large scale development of peat, it will be necessary to address the environmental effects that would result from extensive mining.

### Hard Minerals

There seems to be little likelihood of early need for the extensive development of the state's resource of the more highly valued, strategic, or critical minerals. In addition to gold, which was the first of Alaska's minerals to attract widespread attention, there are also known deposits of platinum, silver, copper, zinc, molybdenum, and many other minerals. Although the total potential for future discoveries is largely unknown, "so far, eight 'world-class' deposits, each containing more than $1 billion in strategic or other important minerals, have been found" (Barnwell and Pearson, 1984). It is also known that "the zinc-lead and copper deposits are sufficiently large that they may well influence the worldwide mining of these commodities in future years" (Miller, 1984). At the present time, however, world markets are depressed. From 1950 through 1974, annual consumption of most commercial metals (steel, copper, aluminum, etc.) was increasing by several percentage points a year. Since 1974, increases have been much smaller and for some metals there have been small annual declines (Lansberg, 1985). Because local costs frequently add to Alaska's geographic disadvantage, and because some of the deposits are located far from adequate transportation facilities, the large-scale expansion of Alaskan mining is a valuable resource for the more distant rather than the near term future.

However, as some mining does go on, opportunities should be sought to investigate ways of improving the various steps in the mining process. Are there simpler and more effective pollution control systems for mining operations? Can more efficient and cost-effective techniques be developed for processing Alaskan ores? Answers to such practical questions will help determine future decisions concerning the merits of starting and operating mining operations throughout the state.

### Mapping

There are several opportunities for gaining information that will be useful at some later time when world markets make exploitation attractive. The mineral industry would welcome a general catalog of the location, quantity, and quality of the state's mineral resources. Most of the state has not yet been mapped geologically at a scale large enough to be clearly adequate for in-depth understanding of mineral districts (Buntzen, 1984).

In addition to the technological questions, there are problems of policy and management. Most mining in Alaska has been placer mining. Extensive development of some of the coal resources would involve strip mining. The environmental damage resulting from these processes is one of the problems to consider, but there are others: the variety of federal, state, borough, and Native and private lands, each with different attendant water rights, the fragmentation of mining among many small units, and the problems of educating miners on legal requirements. The Minerals Committee Workshop of the Alaska Council on Science and Technology gave these management and policy issues first priority, agreeing that "the basic issue in Alaskan mineral development and research is the need to establish underlying state policy for the development of those minerals" (Alaska Council on Science and Technology, 1980b). Needed are policies that will take account of land status, water rights, environmental effects, leasing and royalty agreements, transportation requirements, and other factors necessary for an orderly and profitable development of the state's varied and dispersed mineral resources.

## Fisheries

The Bering Sea and the Gulf of Alaska include some of the richest fisheries resources of the world. There is considerable craft knowledge of how to harvest the fish and shellfish of these regions, and also the whales, seals, and walruses that have served as major food sources for Native populations on the western and northern coasts of Alaska. But craft knowledge is not enough. The huge stocks are subject to substantial year-to-year fluctuation. The decline of the king crab population is a recent example, but sizable fluctuations occur in other species as well. Overfishing of some of the salmon stocks has brought widely recognized evidence of how easy it is to deplete and even extinguish some stocks, and has demonstrated that there is still much to be learned to ensure maximum continuing harvests of the live resources of the sea. Two kinds of knowledge are needed: fundamental knowledge of the biological processes involved; and practical or applied knowledge of how better to manage these resources.

### Marine Biology

At the level of basic biology, more research is needed on the food chains upon which the harvested species depend; of the critical periods for food availability; of the geographic distribution of those food chains; and the dependence upon ocean currents, temperature, salinity, and other water conditions. A good foundation for the needed studies is already available from earlier work, for example, from the baseline studies of the Outer Continental Shelf Environmental Assessment Program (OCSEAP) of the Bureau of Land Management and the National Oceanic and Atmospheric Administration. Coordinated studies of selected areas are needed in order to understand better the processes that determine the size and location of a particular fisheries stock. These studies should combine work on oceanographic dynamics with studies of ice movements, the transport of sediment and pollution within the area, food chain relationships, and all of this with studies of the management of the important renewable resources.

The PROBES Study (Processes and Resources of the Bering Sea) conducted over six seasons by the University of Alaska and eight other universities, can serve as an example of what is needed. That study included coordinated physical, chemical, and biological research on the southeastern portion of the Bering Sea. Included were analyses of water circulation and mixing, current strengths and directions, the flow of nutrients, growth of the floating plant life, and the whole ecological system of the area. As a result, there is substantially better understanding of why pollock (the commercial resource given special attention in the study) are plentiful in some years and much less so in other years, which means there is a better basis for managing the commercial pollock fishery.

Similarly coordinated studies are needed for other major marine areas, and here, as in some other fields, there will be opportunities for international cooperation. The Norwegian study called Pro Mare planned as a six-year-long comprehensive study of the Barents Sea may provide comparative data from a northern sea that is quite different from the Bering Sea, but that is also richly productive; and can also provide information on the comparative merits of different scientific approaches and techniques in studying marine biology.

### Fisheries Management

Along much of the coast, from the southeastern panhandle to the Beaufort Sea, fish and sea mammals have constituted important parts of the Native diet. The sea mammals are still an important part of the subsistence use of Alaska's living resources (Brower and Stotts, 1984) and there are strong Native pressures to preserve those customs.

Conflicts between commercial fishermen and Native groups have already arisen, and there are other conflict-of-use problems. Developments such as mining, hydroelectric generation of power, or urbanization may degrade the quality of water and spawning beds that are necessary for freshwater and anadromous species. Such multiple use conflicts are bound to become more severe as population and development increase.

The existence of conflicts should not be minimized, but it would also be desirable to investigate the interrelationships among commercial and sport fishing, aquaculture, and oil or gas developments, or among other apparently competing activities. Are there positive as well as negative interactions? What are the relative costs and benefits over the long run? Are there opportunities for mutually supportive developments?

Overfishing, international competition, the necessity of assigning quotas to countries that fish within the U.S. 200-mile economic zone, and conflicts between commercial fishermen based in Alaska and those based in other U.S. or Canadian west coast ports have all shown the need for better information on which to base management decisions. Better data on the nature and extent of natural year-to-year variation in the abundance of commercial species and more accurate counting of both foreign and domestic catches would provide improved bases for assigning quotas to different countries, and for understanding the effects of particular management practices.

For salmon, there will be an improved climate for long-range programs to enhance the stocks now that the treaty negotiated by Alaskan, Canadian, and Washington fishing interests in 1984 has been ratified by the two countries. Although none of the three regions got all it wanted in the negotiations, removal of uncertainty over the rights to some of the salmon stocks now makes it more attractive to consider other management issues and to move forward on the coordinated enhancement programs and research studies that are needed.

### Research on Methods and Products

One problem of immediate concern to commercial fishing interests is the need for better means of locating and tracking the desired species. Another is the need for improvement throughout the whole field of processing technology, from catch to market. For example, the fishing industry would like to see research leading to the development of gear and handling methods that would reduce the current wastage from abrasion and crushing. Also desirable are studies leading to the improvement of quality of fish products and the development of new ones (especially from underutilized species) that are suitable for exploitation by coastal communities. A third problem area is the management of waste. How can some portion of current waste be transferred into useful by-products? And how can the remaining waste be handled with least cost in energy and time?

### Aquaculture

Much more research is also desirable on the pen-rearing of chinook and coho salmon. One possibility is to retain the young fish for longer than usual before they are released to the sea. Their larger size at that age increases their survival rate and the rate of return at maturity. However, depending upon the age at the time of release, they tend to remain at sea for a shorter period or even to remain close to the point of release. Some of the salmon handled in this fashion in Washington never leave Puget Sound. They grow to a very satisfactory size for sports fishermen. For commercial purposes, however, studies are needed of the relative costs and advantages of a larger numerical return vs. a larger average size.

The other possibility is to raise the fish to maturity. Economically, pen-rearing to maturity appears to be attractive for Alaska, but future developments will face several problems that need to be studied. One is political; opposition from commercial fishermen of wholly wild stocks is to be expected, and the state's maze of permits and regulations should be examined to see what improvements can be made. Problems of disease control can be anticipated whenever a single species of plant or animal is grown in large numbers in a confined monoculture. Finally, because Atlantic salmon seem to be better adapted to pen rearing than are Pacific salmon, the probable consequences of the accidental release of a foreign species into Pacific salmon areas should be studied (Bevan, 1985).

## Forestry

Historically, most timber cut for lumber or wood products has come from the coastal forests of southeastern Alaska, and most of that has been from federal lands. There is little opportunity now for much growth in the lumber and pulp industry of that region, for the allowable cut is unlikely to exceed the present level (Davis, 1984a, 79).

Farther north there may be opportunities for the commercial production of timber for the lumber or pulp industries, but the economic attractiveness of that possibility is not clear. Ownership of the land is widely divided among Native groups, government, and private owners. Active management, including thinning, fertilization, and replanting after harvest would often be necessary. And firm commitment of the land to forest use for many years into the future would be essential (Gasbarro, 1982).

In either region, more should be learned about reforestation practices, and the long-run effects of clear cutting or other forest practices, both upon soil fertility and on the fish and wildlife that depend upon forests and their lakes and streams. The problems themselves are reasonably well understood, but continuous monitoring of cut over and reforested sites will be required for several cycles of growth and cutting in order to secure the information needed for very long-range planning.

### Fuel Wood

Although gas and oil are usually preferred for home heating, there are local areas in which wood is still a major source of fuel. Elsewhere, for example in the Fairbanks area, the number of stoves installed to reduce home heating costs has increased the demand for firewood to ten or more times the amount burned in 1973, and also greatly increased the amount of smoke and fine ash in the atmosphere. Firewood can be secured from the thinning and the cutting of overage trees from among those being grown for the lumber or pulp industries, and in the Fairbanks area the market is willing to pay enough for firewood to cover a good part of the cost of active forest management (Richmond, 1982). Whether or not commercial forestry should be encouraged will depend upon careful analysis of the relative merits of different uses of the land, and those comparisons will have to look well into the future, for the cycle upon which profitable forestry depends is a long one.

## Food and Agriculture

Historically, Alaskan Natives lived off the land and the adjoining seas. Now in many regions of the state over 90 percent of the food is imported. Yet there is enough arable land to produce much of the needed plant and animal food, and other agricultural products as well. A study by the Division of Agriculture of the Alaska Department of Natural Resources concluded that under expected market conditions local agriculture could by the year 2000 be producing substantially more of the food consumed in the Railbelt area, with much better prospects for some farm products than for others. Substantial increases in beef and pork production would apparently require the price of grain in Alaska to fall while the national price of livestock rose. More promising are the prospects for local production of 75 percent of the milk and cream, 60 percent of the eggs, and approximately 50 percent of the vegetables for the Rainbelt area. However, in order to achieve these goals the state would have to transfer to private hands an additional 54,000 acres of farm land (Division of Agriculture, 1983). Achievement of those food goals will also require research to determine the species and varieties than are or could become best adapted to Alaskan conditions—a job involving plant and animal breeding, genetic engineering or biotechnology, soil chemistry, and economics.

### Plant Selection

The practice of saving the best of one year's harvest for the next year's planting is as old as agriculture. Improved by more scientific and systematic selection in the past two centuries, this method plus hybridization has given us most of the plants of farm and garden. More recently, selection has moved from the level of the seed or whole plant to the level of the individual cell or tissue. In those plants that can be propagated from individual cells or tissue cultures, the most desired genetic characteristics can be quickly selected and developed. A "naked" barley is being grown in the Delta barley project. Some hard-to-root conifers, such as Douglas fir, white spruce, and jack pine, have been modified to enable them to grow more rapidly and successfully in reforestation projects (Durzan, 1982). There are still further opportunities for this kind of work. For example, only a few of the many wild potato types found in Peru have been developed into recognized and frequently cultivated types for commercial or home use. Is there an Alaskan potato waiting to be developed from one of the other wild types?

Still more recent has been the development of techniques of gene splicing or genetic engineering—a research area with much promise for the future. Announcements of new products of biotechnology are now appearing frequently: a bacterium to inhibit frost formation on plants; one that serves as a pesticide against the black cutworm; another that converts the waste lignin of pulp and paper mills to methyl alcohol or other useful products; and other results of bioengineering that serve useful functions in agriculture, medicine, or other fields.

If the warming trend discussed in Chapter 3 develops as expected, Alaska in the next century may have a warmer and possibly a longer growing season than it now does and may have an atmosphere more conducive to agricultural development. If the changed precipitation patterns are favorable, it will thus have an opportunity to increase substantially its agricultural production. **Much research will be needed in applying the newer techniques to Alaskan agriculture, but the time is ripe for that effort. The present is an exciting time in plant genetics (Abelson, 1983) and the Alaskan effort can benefit from much research being conducted elsewhere. Locally, genetic engineering may provide more cold-resistant plants or may modify indigenous plants so that they provide grains or tubers for human or animal consumption.** Some scientists working in this field are optimistic that plants can be modified so that they will use fertilizer more efficiently and will not require as much pesticide and fungicide as are now used (Brill, 1985). In short, the opportunities ahead seem sufficiently attractive to make agricultural research a topic of high priority that can benefit Alaska's future. As one indicator of rising commercial interest, BioSciences Information Service has recently established a new online data base called *BioBusiness* to provide agriculture, forestry, food technology, pharmaceutical products, and other industrial users with abstracts and indexed references to commercially significant developments in biotechnology.

### Agricultural Methods

More information will also be needed about the most appropriate agricultural methods. Some of the arable land is loess, soil blown in by wind over the ages. If improperly tilled, if disturbed too much and too frequently, it could easily be blown away. Thus, a special type of tillage is sometimes called for, which may involve leaving crop residues on the ground to protect the soil, instead of plowing them under (Lewis, 1983). The recycling of nutrient elements into the soil is slow because the cold retards microbial disintegration of plant detritus and animal or fisheries wastes used as fertilizer. However, genetic engineering or enzyme research may provide additives that could accelerate the breakdown of these plant or animal materials and thus hasten enrichment of the soil. Thus, practical experimentation on tillage, crop management, and microbial action will be needed to support the research on the most desirable plant species and varieties for growth in Alaska.

### The Danger of Creating Deserts

In other parts of the world, overgrazing, removal of the natural ground cover, slash and burn farming, and other unwise practices have sometimes made deserts of land that with better treatment would have continued to be useful for agriculture, forestry, or grazing. The same factors that in Alaska call for special agricultural methods also give warning of the need for careful monitoring to avoid loss of soil or loss of soil nutrients. Because of the nature of the climate, these dangers may be greater in Alaska than in most of the other states. As agriculture expands into new areas and virgin soil, the enthusiasm of the agricultural developer should therefore be tempered with the cautious skepticism of the soil scientists. From the very beginning, studies should be undertaken of the changes in the soil resulting from commercial agriculture so that trends can be understood and ecological and other problems resulting from agricultural usage identified and corrected early.

### Animal Husbandry

Animal protein is an important part of most diets, and animal husbandry is a symbiotic partner of agriculture. In Alaska, a significant amount of the animal protein comes from marine mammals, fish, shellfish, and sometimes from caribou and other land animals. Problems involved in the maintenance of adequate stocks of the marine sources are discussed elsewhere in this report. In the future, as the population continues to grow, it seems likely that dairy herds will increase. Cattle, swine, and sheep husbandry could become more important than in the past, and there may be commercial raising of some other species. Currently, however, high transportation costs and relatively small markets are barriers to extensive development, and a cheap protein supplement to winter rations is needed. For the future, research on agriculture should include studies of food for domestic animals, as well as foods for human consumption.

In addition to the research needed to gain new knowledge about each of the above fields of economic development, there are three areas of infrastructure or engineering in which improvements would support all forms of development. The three are: improved systems for collecting, storing, and communicating relevant information; the transportation system; and materials research and engineering.

## Collecting, Storing, and Communicating Information

Useful information is already available on all of the above topics and more is constantly being obtained by research groups in the United States and other countries. In the past, the people working on any particular topic have often been few enough so that the relevant scientific and engineering journals and the informal networks of investigators have served quite adequately to store and communicate new knowledge; however, this kind of informal exchange will become less and less adequate as the number of people, amount of information, and variety of problems studied all increase.

The primary problem is not an inadequate amount of information, for even though there are many gaps in knowledge, much is already known. "A tremendous amount of information, data, and knowledge about the Arctic region presently exists and is lodged in libraries, computer data banks, and the minds and files of individuals scattered throughout North America and, indeed, the rest of the world" (Hickok and Sokolov, 1985, 1).

Information obtained by universities, research institutes, and most government agencies (except the military) is open and available to anyone interested. But most of it is published in a wide variety of journals and report series, some of which have small circulation and many of which publish only an occasional article on an Alaskan topic. Moreover, some of the information that would be useful in Alaska was gained in Canada, the USSR, or one of the Scandinavian countries, for in some research areas those countries have better facilities or more effective research and engineering programs than does the United States.

Some of the information obtained by industry is kept in secret for proprietary reasons, although not all, and some that is proprietary need not be kept secret for long. Some—the "gray" literature—was never refereed and exists only in project files or in reports that had little circulation. Some of the information is inadequate, and some is wrong.

For all of these reasons, time is often wasted before data—sometimes questionable data—are found. Whatever is available, even if inadequate or incomplete, is used and reused, manipulated or otherwise "massaged" in attempts to provide reasonable designs for equipment and facilities. All of this extra effort costs money.

The primary problems are the reliable and efficient synthesis of what is well substantiated; of relating available information to the problems at hand; and the effective communication of that information to the people who need it most.

Thus, there is need of studies of information recording, storage, transfer and dissemination; studies of how the potential users can most effectively be informed or educated about the availability and use of the information system; and studies of how best to organize and maintain the computer files that will be involved and to protect them against misuse, loss, or destruction.

In developing or improving information and communication systems, several advantages can be gained by using the channels already developed by engineers and scientists. The meetings and publications of the Alaska Academy of Engineering and Science, the Arctic Institute of North America, and other professional organizations provide forums for the rapid dissemination and critical discussion of new and useful ideas and information.

The even more positive approach of seeking out potential users will be more difficult and costly, but also more effective. The experience of field agents of the Department of Agriculture and the agricultural experiment stations is surely the most widely known example, but other federal agencies have also found that the authority to take a new technique or type of equipment out into the field, test it there under practical working conditions, and allow it to be seen and evaluated by potential users results in more rapid and widespread adoption than has been obtained by merely providing reports, blueprints, or other easily stored and conveyed forms of information (Stewart, 1948). Industrial experience has been "that publications and reports are a much less effective way of transferring technology than the movement of people. To transfer 'know-how,' much of which is not written down in any event, there is frequently no substitute for person-to-person training and assistance" (Mansfield et al., 1982, 29). Effective technology transfer requires push as well as pull.

All of this will be too much for a single information source or center. The types of information involved are too diverse, including biological, seismological, climatic, public health, economic, social, and educational data and trends. Moreover, the number of agencies and institutions already assigned responsibilities for collecting and disseminating particular types of information are already too numerous "to place all arctic information and knowledge within a single pragmatic repository. Nevertheless, it has been equally well concluded that the establishment of an "arctic information transfer network' is completely practical and should be done" (Hickok and Sokolov, 1985, 5). Information sources working together within such a network can be of great value to many kinds of future research and to the making of many policy and operating decisions concerning Alaska's future.

**The development of a network of efficient and positively active information resources is probably the most basic and widely useful recommendation of this report. Accurate, reliable, and appropriately selected base line data are necessary for most of the kinds of research studies recommended throughout the report, and such data are always useful in establishing policies, engineering standards, and regulations.**

## Transportation

Roads, railroads, air service, marine transport, and pipelines are all involved. Snow, ice, permafrost, distance, remoteness, and high cost complicate the development, use, and maintenance of all these transportation modes. Much use of the airplane for transporting material that elsewhere would go by truck or train; barge trains, often dependent upon ice conditions; remoteness of some of the state's resources from ice-free ports—problems of this kind characterize transportation in Alaska, and make the state's transportation problems quite different from those of other states.

### Transportation Modes

The appropriate transportation mode depends upon the characteristics, weight, amount, and value of whatever is to be moved from one place to another, on the type of terrain to be crossed, whether the need is for summer, winter, or year-round use, and sometimes on the desire to maintain the wilderness character of the area to be traversed. On the other hand, the type of transportation that is available frequently determines the nature of the development that can take place along a transportation corridor. A Prudhoe Bay oil field may justify a dedicated new pipeline and haul road, but in most cases mining, agriculture, or other developments are unlikely until there is adequate ground transportation to take the products to market (Westermeyer, 1984).

The existing transportation modes have been developed and used on an ad hoc, common sense basis, for there has been little research on the most effective means of designing, constructing, and maintaining transportation systems for Alaskan conditions. In fact, the first recommendation of the 1980 workshop on Alaskan transportation was to conduct an examination of the state's market structure, the needs for various types of transportation, the available technology, and the integrated transportation systems that would serve the state most effectively (Alaska Council on Science and Technology, 1981b).

### Transportation Research

In the nation as a whole, although there has been much research on airplane design and operation and a considerable amount on automobiles, transportation research in a larger, systematic context has had low priority. In fact, most of the low technology industries, such as textiles, food, or lumber, spend more on research relative to their total expenditures than is spent on highway research. When corrected for inflation, even the small amount spent by state and federal governments has been cut in half since 1973. Consequently, federal funds allocated to Alaska have been reduced, and state appropriations have been erratic (National Research Council, Transportation Research Board, 1984; Sweet, 1984a).

Even if transportation research gained higher priority on a national scale, Alaska is too small a market to expect that much industrial and federal expenditure would be devoted either to systems or components specifically designed for Alaskan conditions. Alaskan research, therefore, will have to concentrate on adaptations of airplanes, automobiles, and some other components that were designed for more temperate regions, on the specific conditions of operation found in Alaska, and on the development of maintenance technologies that are specifically adapted to the problems encountered in a cold climate. As one example, marine transportation will necessarily increase as tourism, fisheries, and off-shore oil developments increase. Unless better techniques are developed, these increases are likely to lead to increased losses. The coast guard has reported that marine accidents now cost Alaska more than 100 lives a year and that "In 1983, one major insurance company cancelled all policies for Alaskan fisheries vessels after paying claims in excess of $50 million" (Pennington, 1984).

Another specifically Alaskan transportation question needing study is expansion of the railroad system. Transfer of ownership to the state provided for extension of the line by 800 miles. But where? That is a classic economic problem. Should it be extended to the north and west to give access to additional resource areas? Or should the extension be to the south and east to link up with transportation routes to market outlets?

The transportation workshop organized by the Alaska Council on Science and Technology grouped the state's problems under three headings: the technological characteristics and Alaskan adaptations of aircraft, automobiles, and freighter vessels; construction of foundations for roads, airfields, and other structures and the characteristics of the soils involved; and analysis of the state's market structure and its implications for the location, scale, and nature of transportation development (Alaska Council on Science and Technology, 1981b). Of these three, the third must logically come first, for reasonable estimates of demand are essential for planning and designing all of the facilities involved.

Sometime in the future there may be more exotic possibilities to consider. Floating bridges have been found practicable over water; would a floating road be feasible over tundra (Cox, 1984)? Would a monorail be the least intrusive mode of transportation over tundra or through other terrain that should be left with the least possible disturbance?

For the present, however, the first order is to study the nature of the integrated transportation system that will best serve Alaska's economic and other needs as they exist now and as they will increase to accommodate a larger population and the state's expected lines of development.

## Materials Research and Engineering

The effectiveness of a project, and sometimes the difference between success and failure, often depends largely upon the facilities, machines, tools, instruments, or other tangible objects involved. How well those objects perform depends in substantial measure on the characteristics of the materials from which they were made. Engine parts, measuring instruments, oil drilling equipment, pipes, girders, coatings, lubricants—all such products are included (R.S. Johnson, 1984). Yet research on the characteristics and uses of materials has been neglected. That past mistake is now being corrected on a national basis, and needs correction in Alaska.

### Corrosion

Many machines, instruments, and other objects are made of iron or steel, aluminum, copper, or other metals. Gold and copper nuggets have long been treasured evidence that some metals are sometimes found in relatively pure form. Usually, however, metals exist in nature as oxides, as chemical compounds of the metallic element with oxygen. Consequently, more or less elaborate and expensive processes are necessary to refine the ore, remove the oxygen, and secure the wanted metal in relatively pure form. From then on, there is a struggle with nature to prevent or retard the metal from going back to its oxide form. Iron rusts. Copper corrodes. And in the far north some of the corrosion is initiated by the arcing induced by geomagnetic electro forces. However, exposure to air is not the only cause of corrosion. Some bacteria that flourish in the absence of air produce acids that corrode the metal of water or sewage systems or other hidden metal parts. Corrosion is rampant, and although higher rates can generally be expected in warm rather than cold climates, there are significant exceptions. For example, corrosion in Cook Inlet is two to three times as great as in the Gulf of Mexico. The cold water of Cook Inlet contains more oxygen, which fosters development of a protective metal oxide layer, but the heavy load of silt and the ice scouring with tidal rise and fall remove that protective layer about as rapidly as it forms, so the metal is destroyed rapidly. All told, the cost of corrosion in Alaska has been estimated to be $790,000,000 a year, enough to justify a substantial effort to learn how to reduce corrosion (Perrigo, 1985).

As the number of permanent oil production structures erected in the Beaufort, Bering, and Chukchi seas increases over the next decade and more the need for protection against metallic corrosion will also increase.

On land, many of the leaks from oil, water, and sewer pipes result from corrosion. One method of trying to prevent corrosion of pipes is by cathodic protection. However, getting the electric current into frozen ground is a sizable problem, and there is still much to be learned about preventing corrosion under cold conditions (Crevolin, 1985).

Another method of slowing or reducing corrosion is to cover the metal with paint or a plastic coating, or to alloy it with another metal, as in making stainless steel. These methods are more or less effective, but they raise new problems. Some coatings deteriorate rapidly under severe or changing temperature conditions; some cannot be applied when it is cold; and some alloys have unwanted characteristics.

Plastics and other materials are sometimes used to avoid the problems of metallic corrosion. Plastics are often the material of choice because of their light weight or lower cost, but plastics have generally been produced in and designed for more temperate climates, and many become brittle or fail in other ways when employed under conditions of extreme cold.

### Instruments

Failure to perform satisfactorily when cold is also true of some instruments, devices, and machines. In general, they too were designed in and for use in more temperate climates. Every automobile owner in arctic and subarctic regions knows the necessity of winterizing a car to keep it running well in winter months. Tractors, engines, pumps, valves, some electronic equipment, some measuring instruments all present special problems of operation, maintenance, or accuracy when the thermometer drops to subfreezing ranges. Special lubricants, warming devices, temperature adjustments, or other methods of protection or correction become necessary and those methods raise further questions about the characteristics of the materials involved; for example, the nature of the best lubricants for different temperatures and conditions of operation.

### Needed Research

The processes of corrosion, the characteristics of metals, plastics, and other construction materials, the operation of machines, instruments, containers, and other devices—questions about all of these matters are so pervasive that a better understanding of the characteristics and limitations of materials would be of widespread and continuing usefulness to the oil industry, automobile maintenance, transportation, and building construction; to kitchens, garages, and workshops; and to much else besides.

Yet the whole subject of materials research has been given less attention than it deserves. That condition is changing however; at the national level it has been increasingly recognized that the results of engineering research on materials will be a widely applicable public good. Although the emphasis is not on Alaskan needs, some of the work will deal with materials that are used in Alaska, and some research in other countries, for example Finland, is quite directly related to Alaskan conditions. It is also noteworthy that the National Association of Corrosion Engineers recently formed a committee to study the nature of arctic corrosion and to provide a forum for consideration of the special factors involved (National Association of Corrosion Engineers, 1984). Thus, local attention can concentrate on gaining a better understanding of how different kinds of materials are affected by cold, on the possibility of developing better plastics for use under cold conditions, in defining atmospheric corrosion rates at various places in the north, developing new coatings and methods of application for cold climate use, developing alloys with improved cold weather fracture performance, and on studies of the most effective local adaptations and uses of existing or new materials.

# CHAPTER 3
# CARE AND PRESERVATION

Alaska is the nation's last terrestrial frontier, and that is one of the state's assets—for recreation, for tourism, and as a place for study of natural physical/biological/human relationships. Even on the frontier, however, change is constantly taking place. Natural geological processes lead to change. So do human activities that pollute air and water or disturb land and water systems. Yet the economic development that brings these effects is widely desired and will surely continue. From the policy standpoint, the state's problem is the familiar one of balancing objectives, balancing the intended gains against their cost, and the consequences of undesired side effects. Maintaining that balance is a test of factual understanding and of political wisdom, for reaching a balance among competing objectives is inherently a problem of political judgement, in the best sense of the word *political.*

Political discussions, however, can be illuminated by knowledge [illegible] their probable consequences and understanding of the alternatives and issues involved. The purpose of this chapter is to outline the kinds of information needed for the care and preservation of two of the state's assets: the variety and magnificence of its physical and biological environment; and the rich linguistic and cultural diversity of its people (Ahmaogak, 1985). But first, however, it is necessary to consider the most far ranging changes resulting from human activities—changes in the world's, and Alaska's, weather and climate.

## Manmade Changes of Climate

The winter temperature inversions in the lower layers of the atmosphere give Alaskan cities a high pollution risk and a low rate of dispersal of pollutants (Weller, 1982). In Anchorage and Fairbanks, meteorological conditions are such that the winter air simply cannot clean itself of the heavy load of carbon monoxide from cold starts of automobiles. As one evidence, Anchorage had its first formal smog alert on December 14, 1984. Automobile emissions, and locally generated heat, smoke, and steam raise the temperature of a city a few degrees above that of the surrounding country, creating a local heat island. In weather colder than about $-30°$ these atmospheric pollutants produce ice fog.

To avoid the dangers to health from carbon monoxide will require reduction of the amount released to the air by cold starts of automobiles. Engineering studies may help on that problem, but the solution is likely to be more a matter of the education and cooperation of citizens than it is of acquiring new knowledge (Hoyles and Moyer, 1980).

In addition to pollution from local sources, Alaska's air is also being polluted from far away. In the years since World War II the Arctic has lost its crystal clear atmosphere, at least in winter months when global wind patterns bring in small particles from the world's industrialized areas farther south. Sooty, unburned carbon particles and sulfates, primarily from the smokestacks of coal-fired smelters in central Eurasia account for most of the haze over Alaska (Shaw, 1983). Near Barrow, the winter concentration of sulfates reaches half as high as in New York City. The effects of these pollutants on human health have not yet been fully evaluated, but surely merit study. Even in much smaller amounts than actually found, they are known to damage the lichens on which caribou feed. More generally, sulfates, lead, acid precipitation, and some organic pollutants give a highly acid character to the spring precipitation falling on the tundra. This high acidity plus the stagnant acid meltwater call for further study to assess the ecological consequences (Brown, 1984).

## Global Climatic Change

There is another manmade climatic change that is not yet a[illegible] as local smog or arctic haze, but that is potent[illegible]re consequential: the predicted warming of th[illegible] that is frequently referred to as the "greenhouse effect." Carbon dioxide ($CO_2$), methane, water vapor, and some other gases are largely transparent to the sunlight coming to the earth, but are more opaque to the longer wavelength energy that radiates away from the earth and into space. Over past eons, this effect has been highly beneficial. In fact, if it were not for the carbon dioxide in the atmosphere, the temperature at the surface of the earth would be too cold for liquid water to exist, and too cold for life.

### A Warmer Earth

The small particles that produce arctic haze and the gases that have a greenhouse effect are working against each other; the first tending to cool the earth by reflecting sunlight away; the second to warm it by trapping solar energy in the earth and its atmosphere. The expectation of specialists on the earth's climate is that the warming trend will prevail. This possibility has gained widespread scientific attention in the past couple of decades and has led to intensive study of past climatic changes and of mathematical models of the generation and use of $CO_2$ and the storage and transfer of heat throughout the earth's atmospheric/ocean/land mass/biotic system. Among half a dozen or more major recent reports, one published by the School of Agriculture and Land Resources Management of the University of Alaska-Fairbanks and the Alaska Humanities Foundation, reported on the potential Effects of Carbon-Dioxide Induced Climatic Change in Alaska (McBeath, et al., 1984; Clark, 1982).

For some decades the amount of atmospheric $CO_2$ has been increasing because of the increased burning of coal, petroleum, natural gas, and wood, and to a lesser but significant extent as a result of the cutting down of more and more of the world's forests. If present trends continue, the amount of $CO_2$ in the atmosphere will double by some time in the next century. Moreover, methane, Freons, nitrous oxide, and some other gases also tend to increase the earth's temperature as their concentrations in the atmosphere continue to increase. Methane is now increasing by more than one percent a year, and within a decade or two these other gases could become more important than $CO_2$ in raising the earth's temperature (Kerr, 1984; World Meteorological Association, 1982).

Although there is some tentative evidence that the warming trend has started, the amount of increase is too small to be detected with confidence against the background of the natural variability of climate. However, if the calculations are reasonably correct, three classes of effects will become increasingly important within the next 50-100 years: the physical changes resulting from a warmer earth; the biological implications of those changes; and the societal consequences of the physical and biological changes.

### The Physical Changes

If the whole earth warms, the greatest effect will be in the polar and subpolar regions. If the average global temperature rises by the predicted three or four degrees Fahrenheit by around 2050, the increase would be upward of ten degrees over most of Alaska. This increase would be most evident during the winters, while summer temperatures would be only slightly changed. Overall, precipitation would be expected to increase, but just how that increase would be distributed geographically within the state and within the annual precipitation cycle is much harder to predict. Precipitation patterns are determined by the intricate interrelationships of the world's oceans, land masses, air, and biota, and those interrelationships are not yet understood well enough to permit confident predictions of just what the changes would be for any particular local region. However, there are reasons to expect (Manabe, Weatherald, and Stouffer, 1981) that in the northern latitudes most of the increased precipitation would come during winter months; spring snowmelt would occur earlier than it now does; spring run-off would be greater; summers would be drier; and soil moisture would be greater during most of the year, but less in the summer months. There would also be more water vapor in the air most of the time and this condition would reinforce the warming trend, for water vapor itself has a greenhouse effect.

With all of these changes, the ice cover of the Arctic Ocean would become substantially thinner (Flohn, 1981; Parkinson and Kellogg, 1979). A number of the people working on climate models are now estimating that there is a fifty-fifty or better chance that the Arctic Ocean would either be free of ice during the warm summer months or that the ice would be restricted to a much smaller central region than is now ice-covered year-round. If ice cover is substantially reduced in the summers, that too will enhance the warming trend, for the dark ocean water would absorb much of the solar energy that is now reflected away by ice and snow.

As sea ice gradually melts, so will glaciers and permafrost. Initially, however, glacial melting will be partially offset and maybe even more than offset by increased snowfall, so the effects are hard to predict.

Farther in the future lies the possibility of a rise in sea level, a possibility that will depend primarily upon the amount and timing of melting of ice sheets in the Antarctic. The amount of rise is quite speculative; some estimates say that within a century or so it might be as much as a meter. Even that amount would flood some coastal villages and installations.

All of these changes, it must be remembered, would be superimposed on the effects of volcanic eruptions, future El Nino events, particulate emissions of the kind that produce arctic haze, and whatever natural changes in climate develop during the next century. However, the bulk of the current thinking leads to the expectation of a warming trend. If that does occur, the warming will be gradual, marked by increasing seasonal melting of sea ice, permafrost, and glaciers; the warming of oceans and the atmosphere; and changes in cloud cover and precipitation.

### Biological Implications

If the warming does occur as projected, the biological and societal consequences will be what Kellogg and Schware (1981) have called a cascade of uncertainties. In Alaska, the consequences for agriculture, forestry, and fisheries will probably be less damaging than in most of the world, and may include some benefits, but there are many uncertainties. Warmer soil and a probable lengthening of the growing season would favor agricultural production. However, summers may be drier than they are now, and for plant growth soil moisture is more critical than temperature. Some of the changes that would favor agriculture would also favor the growth of weeds, plant diseases, and pests. If herbicides, pesticides, and fertilizers are used extensively, that usage would increase plant sensitivity to differences in soil moisture. Perhaps more significant than any of those changes would be the increase in atmospheric $CO_2$ itself. The current level of $CO_2$ is below optimum for most plants, and the oxygen level above optimum. Altogether, there are too many interactions among these variables to permit confident predictions about their combined effects (Dinkel, 1984; Nelson, 1984; Wittwer, 1984; Pimental, 1985).

Although the net effects are still uncertain, many of the variables can be controlled in greenhouse studies and there are therefore opportunities to determine the effects of possible temperature/moisture/atmospheric combinations. As the nature and extent of the changes become clearer, there will also be opportunities for research designed to determine the plant varieties that are best adapted to the new conditions, and to develop those modifications of valuable plant species that will improve their ability to withstand the added stresses the new conditions may bring.

The natural ecological systems of the land, as distinct from commercial agriculture, would probably change very slowly. Forests might become more productive, but the native vegetation would probably persist for many years. Studies at other locations found that plants that have once colonized an area "continue to exist there long after the [climatic] conditions suitable for their establishment have disappeared." A kind of natural 'biological inertia' means that any potentially invading species would have to outcompete an established species "literally on its own turf" (Cole, 1985, 299).

At sea, the warmer waters would result in changes in the location and amount of upwelling of the energy rich waters that now feed the rich fisheries, and the locations of the biologically important zones at the edge of the sea ice would move. It is quite likely that some of the present fisheries would be degraded as a result. Other areas might benefit, but, again, not enough is known about the detailed physical effects to make confident predictions of the geographical changes in the numbers and distribution of fish, shellfish, and sea mammals.

#### Societal Consequences

Just as the biological implications are more uncertain than the physical changes, so the societal consequences are more uncertain than the biological implications of a warmer earth. Yet some of the possible societal consequences must be considered in order to know what to look for as the changes gradually develop.

Subsistence economies around the Arctic Ocean would be affected, sometimes adversely as marine mammals and their food resources moved or were diminished in the warmer waters.

Oil and gas developments north of Alaska would become easier and safer.

Sea transportation would become easier because the ice would be both less extensive and thinner at any time of the year. At least for part of the year, the transpolar route could become the favored sea lane between European and Pacific Ocean ports. A major seaport on the Alaskan coast would become a possibility. If the U.S. and the USSR are still military rivals, their defense strategies would change and some Alaskan ports might become naval bases.

Any of these changes would result in changes in population size and distribution and in the state's economy, but the specific effects are too uncertain to permit anything other than speculation about their size and timing.

#### Policy Issues

For policy makers, the two most important aspects of all of the current study of the warming trend are: (1) that the resulting changes will be gradual; and (2) that it is altogether unlikely that effective action will be taken to stop the warming trend. The energy conservation measures instituted since the OPEC rise in petroleum prices of 1973 can slow that trend, but that is all. The incentives are simply not strong enough to induce an industry, a state, or a nation to stop using the fuels that add to atmospheric $CO_2$ concentration, and there is no international authority that could enforce such a drastic change. Societal response will therefore be adaptive rather than preventative. We will learn to live on a slightly warmer earth and will adapt to the physical and biological consequences of that condition (Meyer-Abich, 1980).

The changes will come gradually enough so that rational adjustments can be developed if the climatic and climatic-induced changes are carefully monitored. Moreover, many of the most useful adjustments will be "things that should be done anyway—better cultivation to conserve moisture, environmentally sound weed and pest control, efficient irrigation...development of genetic strains better able to deal with environmental variation" (Cooper, 1982, 311; see also Kellogg and Schware, 1981, 113-119). Optimal adjustment will require some new knowledge, but perhaps even more will require educational programs to persuade people to use constructively what is already known.

**If the global warming trend does in fact develop as predicted, one analysis has concluded that some of the changes should begin to be clearly evident during the 1990s (J. Hanson, et al., 1981). Alaska will be one of the first places in which those changes could be**

**measured with confidence. Alaska is therefore one of the best places on earth to verify or negate the projections, and if they are verified, to monitor the rates of temperature increase and the changes induced by that increase (Polar Research Board, 1984).**

## Environmental Preservation

Industrial, agricultural, and other kinds of development always lead to some effects in addition to the intended ones. Some of these other effects are harmful; others are not. Some are anticipated; others come as surprises. Some are local, and some are geographically widespread. Always, however, there are additional or side effects. As Garrett Hardin has summarized, "We can never do merely one thing," an aphorism *Fortune Magazine* christened as Hardin's Law (Hardin, 1963).

### Needed Knowledge

In Alaska, as elsewhere, perturbations or abuses of the environment are increasing in pace with the growth of population, the consumption of natural resources, and the development of new agricultural and industrial enterprises. The problems of environmental preservation continue to grow even as the search for answers goes on. Effective environmental management will require a more complete understanding than is now available of the complex physical, chemical, and biological processes that keep tl earth's life support systems working effectively (Du 1984).

Even with additional knowledge there will be some severe conflicts of interest, perhaps most evidently the conflicts between oil production and preservation of the native animal, bird, and fish populations and their habitats. There are both tangible and intangible goods involved in these conflicts. Some of the dangers are almost certain to develop and some are probabilistic. Methods of conflict resolution will be necessary (Young and Osherenko, 1984), but so will information and knowledge.

Fortunately, there is already widespread awareness of the importance of environmental care and preservation. "Standards for Prudhoe Bay development, for the design of the Valdez terminal, and for the design and operational requirements for tankers in the Valdez trade were the most rigorous ever imposed; operational experience has proven their effectiveness" (Dugger, 1984).

Within Alaska, some of the ecosystems, such as the wet coastal tundra and taiga forests at the lower trophic level, have been studied in some detail. Much is already known of basic ecological processes and relationships, enough that with properly selected future studies within these ecosystems and the careful monitoring of trends the state can have timely warning of the need for action to prevent the kind of apparently irrevocable damage that has sometimes occurred elsewhere. Nevertheless, major damage can occur. Large-scale strip mining of coal or peat would bring extensive damage to tundra, forest, or other ground cover, and regeneration would be slow. Placer mining may degrade water quality and silt up gravel beds where fish spawn, although the relations between the amount of turbidity in a stream and the resulting biological damage are not clear.

Consequently, further studies are needed; studies of how various kinds of development influence native plants and animals and the animals higher in the food chain that depend upon them; studies of how best to reclaim damaged areas, which may be made attractive and useful even if restoration to their original state is impossible or not desired; and studies of some of the factors that are peculiar to the Alaskan scene.

Environmental preservation or restoration poses some special problems in arctic regions. Damage takes longer to heal when the ground is underlaid with permafrost, annual precipitation is small, and the growing season short. The edge of the sea ice, leads, and polynyas are areas where sea life concentrates and also regions where oil spills would collect (Brown, 1984). The cold environment on land or sea retards both the physical disintegration and dispersal and the biological degradation of pollutants.

### Priorities

Priorities among possible studies will vary over time and place as various kinds of development are considered or instituted. At the request of the U.S. Environmental Protection Agency, the Battelle Memorial Institute developed a list of priorities for cold climate research (States, 1983). It identified a total of 49 research topics divided among air pollution, the modification of habitats, contamination of water supplies, and the treatment and disposition of waste, plus a few items that did not fit into any of these categories. Nine of the 10 topics judged to be of highest priority were in the air pollution category, with the other one of the top 10 being the presence of asbestos in rural drinking water supplies. Bligh (1984) has criticized the list as reflecting primarily the institutional responsibilities of the Environmental Protection Agency rather than the most urgent needs of Alaska. It can, however, serve as a starting point or check list for developing an Alaskan set of priorities, with the understanding that priorities will change as new developments occur.

### Need for Monitoring

Of more wide ranging importance than any of the individual topics, however, is the need for improved monitoring of environmental change in Alaska. There are, of course, already some records of precipitation, temperature, ice coverage, earthquakes, and other historical information. However, more systematic records of selected environmental measures are needed, records that will permit accurate comparisons over time and space. Even for such a dramatic annual event as the breakup of the ice on the Yukon River, dates have not been recorded with sufficient frequency or accuracy to permit valid conclusions as to whether there has been a trend toward earlier or later breakup (Fountain, 1984).

Records should not be kept just for their own sake, and the type of record may change over time. Yet the **state needs a long-term, continuing, statewide ecological monitoring system to keep track of trends and subtle changes. One tends to think of the physician's chart of the vital signs of a patient as an analogy. A year-round, decades-long monitoring system is needed in order to learn how much change, of what kind, can be tolerated; to warn when the amount of change seems to be approaching a danger point; to help keep Alaska healthy.**

### Natural Reserves and Genetic Banks

In addition to protecting and sometimes restoring areas that are being or have been scarred by some form of development, some parts of the natural environment should be preserved as nearly as possible in their pristine state. That is the intent of setting aside substantial areas of Alaska as natural wilderness areas. This is a wise provision for the future, but only selected parts of the land can or should be so set aside.

There are several reasons for keeping some areas as undisturbed as possible. One important reason is the pleasure and satisfaction of being able to experience the variety, magnificence, and primeval character of the world's topographic, geological, and biological nature. Alaskans have this opportunity in richly varied abundance. They want it for themselves and for their children for generations to come. Another reason is to serve as a baseline of naturally occurring changes, a baseline for the monitoring of changes resulting from human developments. Still another reason arises from the nature of commercial agriculture, forestry, and animal husbandry. Specialists in these fields have selected and developed those varieties of plants and animals that best satisfy human needs for food and for other plant and animal products. As a result, the commercial varieties have become more and more homogeneous genetically, and that means they have become more susceptible to devastation by parasites or pathogens that would affect only part of a diverse natural ecosystem, but that can wipe out a monoculture. Preservation of natural ecosystems in a relatively undisturbed state is insurance against loss of the world's fundamental genetic resource: a rich and varied gene pool.

## Language, Culture, and Heritage

Among all 50 states, Alaska has the strongest reasons to study its own history. In no other state can as large a fraction of the citizens trace their own ancestry directly back to the indigenous population that was present before new migrants began coming from Western Europe or the United States. Because Alaska is generally considered to have been the gateway to the Americas, there should be older archaeological sites in Alaska than anywhere to the east or south. Yet so far no human sites found in Alaska are as old as well dated sites elsewhere on the continent.

Moreover, the Native Alaskan cultures provide rare opportunities to study the early history of cultural development. Prior to some ten thousand years ago, the world was occupied by small bands of hunting-gathering peoples. Throughout most of the world, as an agricultural and later an industrial way of life developed, the surviving bands of hunter-gatherers were surrounded by and influenced by these very different cultures. But not in Alaska, northern Canada, or Australia. In those regions European contact came late, with little before the 19th Century. "This means that the precontact societies in these regions are within reach of ethnographic and ethnohistorical research techniques, which can greatly enrich the findings of archaeological investigations. Furthermore, in each of these three areas, it is possible to relate historic to prehistoric peoples with an unusually high degree of reliability over a span of at least a thousand years. Each area thus provides a natural laboratory for the study of human organization as it must have been throughout most of human existence. And, of the three areas, Alaska has the greatest cultural diversity, hence it offers the greatest opportunity for exploring a wide range of organizational forms within the general hunting-gathering class" (Burch, 1985). Most hunter-gatherers lived a nomadic life, but in southeastern Alaska and parts of the Aleutian Chain and western Alaska the abundance of salmon and other foods from the sea permitted development of that rarity in cultural history-permanent communities not dependent upon cultivated agriculture.

There is yet one more reason for studying Alaska's past. In occupying the long coastal area that stretches from the Aleutian Islands across Alaska and Canada to Greenland, and in making this land their own and developing the technologies to exploit it, the Aleut and Inupiat peoples have developed what the Polar Research Board has called "the world's best example of human adaptability" (Polar Research Board, 1977).

### Earlier Studies

In a frontier region it is not unusual to find neglect of the region's history and cultural heritage; a good part of the recent history still lives in the memories of older citizens, and the longer memories of the Native groups have always been passed on as oral history. Yet formal records are desirable to support and sometimes to correct personal memories; and as time goes on, formal records become essential for historical scholarship and for the understanding and teaching of cultural traditions.

There are two major and somewhat different problems. One is to ensure the systematic recording and retention of the more recent history, say since the time of Russian occupation or of American purchase. The other is the preservation of the languages, histories, traditions, and cultural artifacts of the Native groups. The latter problem is the more pressing one.

Early archaeological studies of Alaska were largely organized about the problem of establishing the chronology of development of Eskimo and Indian cultures. That basic chronology is now known, and is available to serve as a framework for current studies. Current funding, however, is largely concentrated on the collection of whatever artifacts are to be found as development uncovers or threatens archaeological sites.

The importance of preserving the languages was recognized by the legislative establishment in 1972 of the Alaska Native Language Center. With support from the state, the National Science Foundation, and the National Endowment for the Humanities, that center has made good progress in recording vocabularies, grammars, and textual materials of some of Alaska's Native languages. But some are not yet recorded; external funding has decreased; and Native speakers of some languages are becoming old and few. For some languages, the basic documentation must be completed within the next few years or the language will be gone forever.

Information about the early period of contact with whalers, traders, missionaries, and others coming to Alaska from Russian, European, or American backgrounds is available from the traditional knowledge of the Native groups, notes by early explorers, and more systematic studies by anthropologists. For the very recent period, the Man in the Arctic Program supported by the National Science Foundation provides information about the impact of the Prudhoe Bay and pipeline developments on the Native inhabitants of the North Slope (Kruse, Kleinfeld, and Travis, 1981).

**Difficulties**

Reconstruction of the past becomes more and more difficult as time goes on and those who knew the recent past disappear. Many of the archaeological sites that have been studied are shallow, which suggests that others have probably already been destroyed by flooding, wave action, ice, and other natural erosive forces. Some of the known sites are being destroyed by amateur collectors or greedy ones hunting for artifacts to sell. For these reasons archaeologists have placed very high priority on a systematic assessment of the archaeological resources of the state in order to locate, identify, and protect the remaining sites, determine the threats to their safety and their rate of attrition, and have a solid basis for planning future studies (Workman, 1985). What is most immediately needed is preservation of the sites. They can be studied later only if they are preserved now.

A quite different difficulty is the fact that available funds are too largely concentrated in the support of collecting, with too little money available for analysis, study, and comparison. State and federal interest in protecting antiquities from destruction by various kinds of development is clearly commendable. However, that effort has not been matched by adequate support for analyzing and studying the newly collected materials. As a result, there are collections of poor quality; talent is being drained into one part (collecting) of the whole archaeological-anthropological endeavor; and accounts are appearing in an ephemeral "gray" literature that is difficult to acquire, evaluate, or reference (Dixon, 1985).

**The Language Groups**

Alaska is home to 20 different Native languages, of two broad families. Of the Eskimo-Aleut family, Inuit or Inupiaq has spread into Canada and Greenland, while almost all speakers of the Yupik and Aleut branches of the family are in Alaska, with a few in inaccessible Siberia.

The other great linguistic family of Alaska is the Athapa[illegible]k-Tlingit language group. These languag[illegible] spread through Canada and as far south[illegible] Apache and Navajo. To add to the variety, [illegible]nd Tsimshian languages are found in the south[illegible]part of the state.

Use of these languages is disappearing. English has been the language of the schools, of commerce, and of television. English speakers have moved into the territorial regions of many of the Native languages. As a result, few Eskimo and Indian children are now learning their native tongues, and in some regions none at all. For most of the languages, the youngest remaining speakers are in their fifties, and for several there are only a few left even of that age. Only two speakers of Eyak remain, aged 67 and 74 (Krauss, 1984).

Although the cultures of the groups that spoke those 20 languages have already been greatly changed, much of the vocabulary, grammar, and style of the languages, and the associated traditions, customs, myths, and values can still be recorded for study by anthropologists and linguists. Those studies will enrich the heritage and background knowledge of future generations of the Native groups. But more than those groups would be enriched. To lose the history and the understanding of how these peoples adjusted to the harsh environment of the far north would be a loss to the whole world.

**The Subsistence Economy**

Although the Native languages are disappearing, some of the cultural traditions continue. Not uncontaminated and in their original form, for contacts with whalers, missionaries, Russian and then American settlers, and military personnel have been changing Native ways for well over a century. Yet some of the old ways are deliberately retained. Ninety percent of North Slope Inupiat regularly consume wild foods, and "98 percent of Native households on the North Slope consume subsistence foods and can be said to participate in the subsistence economy" (Kruse, 1984, 149). Increasingly, however, subsistence foods are gathered with the help of outboard motors, snowmobiles, and rifles, and often the hunt—speeded by modern technology—is an after work or weekend activity. Yet interest in maintaining the traditional subsistence hunting practices remains strong, for sharing the catch and giving away food are deeply entrenched in Inupiat culture, and much more than the gathering of food is involved. The hunting practices include cultural traditions, organizational patterns, bases for prestige, opportunities for camaraderie, and preservation of legends and the language (Brower and Stotts, 1984).

Consequently, there is much worry that the noise and structural changes of offshore oil development will drive away marine life such as the bowhead whale, and that oil spills will bring much destruction to marine life over substantial areas. In part, therefore, the need for environmental protection is also a need for protection of Native cultures.

### Needed Research

**Needed are problem-oriented studies, of various groups, directed toward achieving a better understanding of how the environment has shaped culture and organization, of how cultural change has come about, and of the intercultural influences as contacts among different groups have increased. These are studies that require methodological sophistication and coordination among specialists in linguistics, anthropology, and archaeology. The overarching objective should be an understanding of the continuity of development, from prehistoric times to the present, of accommodation to the changing environment in which the Native populations have lived.** Most immediately urgent is work on the relatively recent past—say since the beginning of Russian occupation—work that must be conducted soon while some of the artifacts are still available and some of the elders can still recall stories and events related by their immediate ancestors.

If the Native languages are to be preserved, the work must be done in Alaska and it must be done soon. The Alaska Native Language Center, Alaska Native Heritage Project, Alaska Native Studies Program, and others are making efforts to record the languages and cultural heritages, and an accelerated schedule of systematic recording would be desirable. But a tape recorder and a convenient Native speaker are not enough. Linguistics is in essence a comparative field, and has become an intellectually more demanding one with evidence of cross-linguistic similarities in the acquisition and development of language by children and the indications of some built-in biological bases for language formation (Bickerton, 1984; Slobin, 1984).

In addition to linguistic studies, what is needed for a better understanding of the continuity of development and adaptation "is a broad and sustained effort to study the structure of Alaska Native societies as they existed during the late prehistoric/early historic period—perhaps A.D. 800-1800. If it is to be successful, this effort must include ethnographers (emphasizing oral history), ethnohistorians, and archaeologists working on related problems. It should be initiated soon, while qualified Native historians are still available to participate in the project" (Burch, 1985). Closely coordinated investigations should be made of earlier customs, art, and technologies as evidenced by artifacts, the living arrangements and cultural continuity shown by permanent settlements, as in the Aleutian Islands; the dating of artifacts, housing remains, etc., as indicated by their relation to ash falls or other geological and biological calendars of past time; and the diversity that existed among what from this distance are likely to be treated as similar patterns of culture. So are studies oriented to specific problems of cultural comparisons and interactions among the groups and their adaptations to the influx of European-American influences (VanStone, 1974; 1984). But all of this must be approached with careful preparation, for it requires the expert knowledge of cooperating scientists from the biological, physical, and social sciences. The study of linguistic and cultural change is a difficult and specialized field of research, one that requires qualitatively strong investigation.

Much of this is now a salvage operation, to gain what can be learned before the opportunities have all disappeared. If the languages, archaeological remains, and cultural memories are not preserved now, they can not be recaptured later. If the work is not encouraged in Alaska, it is unlikely to be done at all.

# CHAPTER 4
# HEALTH AND WELL-BEING

The health and well-being of Alaskans depend upon their economic status, the availability of medical and health facilities, the buildings in which they live and work and play; and upon the schools, churches, social services, police and fire protection, legal controls and services, and the other parts of the social, economic, governmental, and cultural machinery that serve the needs of the state's diverse population. All these factors are important, but the three that now seem most in need of research to obtain new knowledge are health, crime control, and building construction. These three topics are the subjects of this chapter.

## Health and Disease

No disease has yet been found that is unique to arctic conditions. Every ailment found in Alaska is also found elsewhere, sometimes more frequently, sometimes less frequently. But if there are no uniquely polar diseases there are health problems that are peculiar to the far north. Conditions in Alaska influence the transmission or communication of diseases, some of their symptoms, and their rates of healing. Impure water supplies and inadequate sewage systems spread viral and bacterial diseases. It is widely believed that the rapid changes of weather that occur during spring breakup and fall transition from summer to winter are responsible for the unusually high incidence of viral infections that apparently occur during those periods. Nowhere else in the U.S. can one fall ill or suffer an accident so far away from a well equipped and well staffed hospital. In cases of hypothermia, attempts to revive the victim in the field often result in fibrillation of the heart, and death. But if revival is not attempted until the victim reaches a hospital, it is often too late (Bligh, 1984). Genetic characteristics of the Native groups and the use of subsistence diets are also likely causes for some of the peculiarly Alaskan aspects of the medical picture. And cold itself plays a role; it is no surprise that snow blindness occurs more frequently in the Tanana Valley than in the Valley of the Tennessee. Finally, the special stresses of life in the north, apparently including the annual cycle of light and darkness, appear to be responsible for some of the special problems of medical care and the maintenance of good health in Alaska.

Within Alaska there are also some substantial ethnic differences in disease frequency. As one example, Eskimos are reported to have fewer heart attacks and strokes than do other North American populations (American Public Health Association, 1984, 13-14). Is the Eskimo's relative freedom from these diseases due to the specific characteristics of the polyunsaturated fats that predominate in the fish and marine mammals that make up much of their diet? The Indian Health Service and the Center for Disease Control are investigating this possibility (Heyward, 1984). A positive finding could improve health not only in Alaska, but elsewhere as well. And a general acceptance of the wisdom of eating more fish and less of land animals would increase the value of Alaska's fisheries (Neve' and Pickering, 1985). There are also ethnic differences in the frequency of several types of cancer, acute gall bladder disease, and other diseases, but why these differences occur is not altogether clear. Whether the explanation be genetic, dietary, or in life style, the differences may be substantial even in as closely related and associated groups as the Inuit and Danish residents of Greenland which have quite different patterns of frequency of some diseases (Polar Research Board, 1982a). Studies of such ethnic differences in frequency could provide important information on the etiology of the disease involved.

### Needed Research

Recognition of some of the special health problems of the far north early led to research on selected topics. The tuberculosis epidemic among Alaska Natives in the late 1940s, the most intense such epidemic ever documented anywhere in the world, led to development of the Arctic Health Research Center of the U.S. Public Health Service and the formation of two health care delivery systems, one territorial and the other federal. Their campaign to combat the epidemic is still regarded as a major triumph of public health service (State Health Plan for Alaska, 1984). When modern drug therapy brought tuberculosis under control, the Arctic Health Research Center was closed. Also now closed are the Arctic Aeromedical Laboratory and a laboratory of the Environmental Protection Agency. Still active, however, are the Alaska Department of Health and Social Services and its allied activities, the Indian Health

Service, and the Arctic Investigations Laboratory of the U.S. Department of Health and Human Service's Centers for Disease Control.

Alaskans, albeit sometimes with different frequencies, are susceptible to the same kinds of communicable diseases, cancers, strokes, and other ailments that are of widespread national concern. With increasing urbanization and changing lifestyles, even the traditional vigorous physical fitness of Alaskans may be giving way to a flabbier lack of exercise, lower fitness levels, and health problems. Consequently, much of the research conducted by the National Institutes of Health and other biomedical research organizations in the U.S. will be applicable to Alaska. Alaskan work in this field can therefore concentrate on the interpretation and application to its own needs of already existing and newly acquired medical knowledge gained elsewhere. For this purpose, two recent reports provide a good foundation for planning. One is the assessment of polar biomedical research conducted by the Polar Research Board of the National Academy of Sciences (Polar Research Board, 1982a). The other is the statement of "National Arctic Health Science Policy" prepared by a task force of the American Public Health Association (American Public Health Association, 1984). These two reports agree that top **priority should be given to two types of work: better maintenance and dissemination of information resulting from biomedical and clinical research and better epidemiological or public health data about Alaska.**

### Use of Existing Information

The results of biomedical research are published in so many different ways and places that special efforts are needed to bring the relevant portions to the attention of public health authorities and others working on health problems in Alaska. In fact, the Polar Research Board concluded that "a top priority, taking precedence over even the initiation of new research, is to foster awareness of" the information that already exists in numerous data banks of private institutions and government agencies (Polar Research Board, 1982a, 2). The American Public Health Association task force also emphasized the need for a repository and clearinghouse of health information and unpublished reports and articles relevant to arctic conditions (American Public Health Association, 1984). The University of Alaska Health Science Library and the regional health science library program may provide a foundation for this service.

### Epidemiological Data

The other type of needed information concerns the ongoing and changing health of Alaskans. By law, the Alaska Department of Health and Social Services requires the providers of health care to report regularly on 40 specific diseases, epidemics, and some other health related matters. Unfortunately, much of the reporting and record keeping appears to have been fragmentary, of poor quality, or missing. On this point, the American Public Health Association's policy paper called for means to "assure maintenance of a system for collection, analysis, and prompt reporting of vital and other health statistics necessary to accurately monitor morbidity and mortality" of the populations involved, and to "assure a system of collecting and reporting of demographic data of arctic populations that are timely, accurate, and sufficiently detailed to provide baseline data to monitor health and to use as a guide for appropriate distribution of health care resources and personnel" (American Public Health Association, 1984, 2). The stability of population of some Alaskan communities should foster epidemiological studies for these purposes.

The better preservation, storage, and analysis of data, better access to what is already known about a problem, better communication to those who need the information—all of these are desirable in order that trends and conditions can be better monitored and measured and better health care provided throughout the state. However, the experience of previous programs of technology transfer indicates that it is not immediately evident how these improvements can best be achieved. The establishment or improvement of an information system and its management and use should be approached as an experimental problem.

In gathering demographic and public health data and in studying disease and accidents special efforts will be necessary to protect the confidentiality of sources and to assure continued cooperation. Diverse populations, with different values and different patterns of disease frequency are involved. Many communities are small and distinctive; their records would sometimes be easy to identify without special precautions to mask their identity. Privacy of individual reports must be assured; informed consent of participants will be essential; and the populations involved should participate in the planning and selection of procedures to be followed if reliable data are to be obtained over the long term.

### Public Health Measures

In addition to gaining new knowledge, there is still much to do in applying what is already known. In many of the rural areas there is still need for such basic improvements as uncontaminated water supplies, less costly sewage treatment processes, and sewage disposal systems that do not spread disease. Over much of the state, problems of delivering health services are complicated by distance and isolation and sometimes by weather conditions. A good deal of ingenuity has been shown in meeting some of these problems—from the original Iditarod race to carry diphtheria serum to Nome to the recent use of satellites to deliver surgical and health care instructions to isolated villages.

Further ingenuity will be needed in developing the best methods of delivering preventative health care as relevant new knowledge is acquired, for measures that reduce the incidence of disease will also reduce the need for remedial efforts. And this, too, is likely to be an Alaskan responsibility for its far flung delivery systems are necessarily quite different from those of cities and medical centers in the contiguous states. However, as the American Public Health Association (1984, 14-15) has pointed out, there is also an opportunity to be of wider usefulness: "In many ways, the American Arctic is similar to developing countries. Innovative approaches to the cross-cultural delivery of health services under extremely rural conditions provide an opportunity to test models for the organization of health services—models that might be replicated in rural areas in the United States as well as in developing countries."

#### Accidents and Violence

Compared with the rest of the country, Alaska has a high accident rate. In part, that fact reflects the age distribution of the population: Alaska has a larger than average percentage of teenagers and young adults, the groups with the highest accident rates. Moreover, the people who choose to move to Alaska are in general more adventuresome than their stay-at-home relatives. Cold also makes a contribution, for icy roads, poor visibility, and the breakdown and difficulty of handling equipment all increase accident rates. Partly, the high incidence comes from a way of life that includes much use of small aircraft, much boating and hunting, and frequent construction work under hazardous conditions.

Together with accidents, there is also an unusually high level of violence. In fact, the leading causes of death and disability in Alaska are not germs, viruses, or purely biological malfunctions, but rather malfunctions of behavior, alcohol and drug abuse, violence, accidents, and their direct consequences (Polar Research Board, 1982a).

#### Environmental Stresses

Many Alaskans live in a stressful environment. Cold itself is not the primary culprit. As the Eskimos have demonstrated over the centuries, warm clothing, shelter, and fire have been effective buffers (Steegman, 1983). However, there are indications that the annual cycle of light and darkness and the associated annual changes in daily physiological and behavioral rhythms influence psychological balance, increase anxiety, and exaggerate the swings of mood and attitude that are found more mildly elsewhere (American Public Health Association, 1984; Rosenthal et al., 1984; Rosenthal et al., 1985).

Associated with the long periods of darkness in the more northerly regions are cabin fever in the spring and rapid changes of weather in spring and fall and the twice-a-year switches between winter and summer times that complicate the body's circadian rhythm. There also appear to be sleep differences associated with the annual cycle; the residents of Tromso, Norway, which is at about the latitude of the North Slope, are reported to spend about an hour longer in bed in winter than in summer, but typically to have more disturbed and less restful sleep in the winter months (Kleitman and Kleitman, 1953). The changes in daily rhythm are also evident at basic physiological levels; they alter the effectiveness, and even some of the effects, of standard drugs and remedies.

In addition to the stresses imposed by the physical environment, there are psychological or social stresses arising from cultural changes and cultural clashes. The stabilizing norms and customs of the Native populations have been greatly disturbed by contact with European-American groups and by the adoption of some of their goods and ways. Many of the recent immigrants are removed from the supporting influences of their families and accustomed surroundings. Workers at remote sites, such as oil drilling platforms, go through repeated cycles of absence from and return to home and family, and their families experience complementary cycles. Efforts to economize on heating often lead to small, crowded homes with inadequate ventilation and few opportunities for privacy.

That stress is a major factor in the health problems of Alaska is supported by statistics showing that accidents, alcohol abuse, and violence rank high among the causes of illness and death. In 1978, the 15- to 44-year-old group in Alaska had a death rate nearly twice the national average (American Public Health Association, 1984). In view of this record, the Office of Technology Assessment concluded that "research is needed into the etiology and prevention of the complex patterns that lead to accidents, alcoholism, suicide, homicide, and domestic violence" (Office of Technology Assessment, 1982, 52).

**A major gap in knowledge is the fuller understanding of the conditions that lead to stress and the effects of those stresses on biological and psychological aspects of health and disease. The environment is involved, and so are the social and cultural conditions and clashes that have characterized life in Alaska. The causes and consequences that are so prominent in the Alaskan scene are unlikely to be studied in major health centers of temperate zones; work on their better understanding and solution are primarily Alaskan responsibilities.**

## Social Pathology and Justice Research

The amount of violence and strife also lead to problems in the design and administration of the state's legal agencies and justice system. Rape, homicide, and other crimes of interpersonal violence are higher in

Alaska than in 90 percent of the other states. Crimes within families, white collar crime, and prison populations per capita are high and increasing. In these respects, Alaska has a quite unenviable reputation. And, as crime and violence increase, the cost of correctional institutions and justice agency activities are growing more rapidly than any other major area of the state's budget (Angell, 1984).

Some of the needed changes are in policy or management, for example, the need for better coordination of the various authorities and services that are responsible for law enforcement and for the treatment of offenders—police and other law enforcement agencies, the juvenile and adult correctional systems, and tribal and state government policies, regulations, and practices.

There is also need for research, for research in a field that does not have much of a research tradition as do industry, the natural resources, education, and a number of other fields. Accordingly, the Justice Center of the University of Alaska, Anchorage has initiated a "research capacity building project" to help the numerous agencies within the justice community of the state increase their own research capabilities (K. Johnson, 1983).

As one of its early activities, the Justice Center conducted a survey of over 200 police departments, legal service agencies, private security organizations, and other agencies or institutions involved in the enforcement of laws and regulations or in efforts to prevent offenses and to help offenders and their victims. All were asked to describe their major needs for information and research. The highest priority was usually assigned to studies directly aimed at crime prevention, analysis of crime patterns, citizen needs for police services, availability of community services that can be used by the police, and other matters involved in the direct relationships between the several kinds of agencies involved and the people with whom they deal –the general public,offenders, or victims.

Analysis of the many specific requests indicated that the "research needs relate primarily to quantitative results. Most apparent is...a need for analyzing data being collected and maintained by justice agencies; evaluating programs or organizational operations; and surveying citizens' attitudes and needs" (K. Johnson, 1983, 17). In short, they wanted to know what is actually happening in the various parts of the whole legal/judicial/correctional system. This first priority question, "What are the facts?" is reminiscent of similar needs for better data expressed by seismologists, public health officials, geologists, climatologists, and others.

The problems are difficult. They involve legal, sociological, psychological, administrative, policy, economic, and other aspects. In the history of research, it is not surprising that such intricate interdisciplinary problems have been late starters. But the problems are important; important economically because crime is rapidly becoming more costly to the state, and sociologically important because a high and rising crime rate is surely not the kind of future most citizens want for their state.

## Building Construction and Maintenance

Building in most of Alaska is more complex than it is in the rest the U.S. Special foundations are necessary over permafrost. Greater seismic and wind loading are sometimes necessary. Heavier insulation is a must. Some conventional building products are not suitable for cold weather conditions. Some of the customs and regulations of the building trade and the insurance provisions have been developed and proven for temperate zone structures, but are not appropriate for Alaskan conditions (Sweet, 1984b; Leonard, 1984). A glaring example is the standard that calls for exterior doors to open outwards. Fire, however, is an ever present danger, and two feet of snow can prevent a door from being pushed open.

Efforts to construct buildings more appropriate for Alaska have also had their problems. Super-insulation has caused temperature and moisture content of wooden structural members to vary from inside to outside with resultant warping. The retention of more moisture has peeled the paint from interior surfaces and caused electrical systems to corrode at higher than normal rates. Where the insulation has inhibited air circulation, dry rot has developed. Tight construction has concentrated construction chemicals and other pollutants indoors. In fact, most of the airborne pollution one experiences is indoors, consisting of a long list of particulates and organic chemicals resulting from cooking, heating, and smoking, or from building materials, coatings, and cleaning fluids (Grimsrud, 1985; Rezek, 1980). Their concentration depends primarily upon their rates of emission, and secondarily upon building ventilation. However, unless air-to-air heat exchangers are installed, odor levels have been much greater and have affected human responses to living in the more heat-efficient structures.

Moreover, maintenance of super-insulated buildings has proven difficult because piping, ventilating and heating ducts, and electrical systems have often been tightly sealed into the heavily insulated walls, making access for repair or replacement difficult and costly.

These faults have become evident from experience, and some designs have sought to avoid them. Periodic articles on house construction in *The Northern Engineer* and a collection of such articles by Rice (1975) provide examples. Nevertheless, as a research area, building construction has been neglected. There is need for better information about building in the high latitudes - information for the guidance of architects and construction engineers. What methods will minimize heat loss without making maintenance and repair more difficult? What heat-exchanger ventilation methods will minimize pollution and odor problems? How should floors, walls, and roofs be ventilated to avoid moisture retention without undue loss of insulating ability? What improvements can be made in building standards and construction codes? The performance of various kinds of building materials and equipment need coordinated study as efforts are made to solve these problems. Dependable answers can improve future homes, schools, office buildings, and other structures.

## THE BRIGHTER SIDE

Major attention in this chapter has been given to the need to rectify faults and improve matters, but, in conclusion, it should be noted that not all of the attention should be given to the negative aspects of current conditions. There is also a challenging opportunity to study the positive side of the picture. What are the environmental and social factors, the health aspects, and the desirable conditions that lead to the kind of life that many Alaskans want for themselves and their children? How can the quality of life be improved? This is a primary objective of the whole effort to secure information that will improve Alaska's future.

# CHAPTER 5
# KNOWLEDGE AND UNDERSTANDING

Most of the research recommended in the three preceding chapters is practical, research dealing with recognized problems of resource development, environmental protection, or health and well-being. The motivation of such research is to solve a recognized problem, or to produce a new or improved product or process.

There is, however, another kind of motivation for research—the desire to know more about the fundamental processes that operate throughout nature. Usually called basic or fundamental research, this is the type of study that is most often conducted in a university, but some basic research is carried out by the military services, engineering organizations, medical centers, and other scientific and technical organizations. There are two reasons for conducting basic research. One is to satisfy human curiosity, to gain a better understanding of how stars and planets are formed, of the dynamics of the world's oceans and continents, of the prehistoric development of human life and culture, or of some other naturally occurring physical, biological, or social system. The other reason is because the information gained through basic research usually turns out to be necessary and useful. No one can predict with confidence just what the uses of a particular basic research study will be, yet time and time again the results have later turned out to be valuable in quite practical ways that the researchers did not foresee. A still rapidly expanding example is the ever-widening use of microchips that developed out of basic research on solid state physics.

In Alaska, there is another reason for conducting basic research in several scientific areas. It is because Alaska is one of the best places in the world to conduct such research. The American Association for the Advancement of Science (Hickok, Weller, Davis, Alexander, and Elsner, 1981) and Weller (1984a) have provided lists of research topics on which Alaska has a natural advantage over other parts of the world:

* The Arctic is a natural laboratory for studying the effects of charged particles from the sun as they enter the earth's magnetosphere and ionosphere, producing the aurora, magnetic storms and substorms; interfering with electronic communications; and perhaps influencing global weather.

* In the low pressure area of the Arctic and sub-Arctic much of the weather of North America is generated.

* Nowhere else in the U.S. are snow, ice, and permafrost so abundant and so easily studied.

* Alaska is one of the most tectonically active regions of the world, with many volcanoes, frequent earthquakes, the active subduction of the Pacific Plate, and a complex geologic history of parts assembled from widely separated earlier locations.

* Alaska has a rich and widely varied fauna and flora. It is the breeding ground of many migratory birds, home of one of the world's largest fisheries, and home to plants and animals with highly successful and varied adaptations to cold and to great seasonal changes in light and temperature.

* The earliest inhabitants of Alaska, who came from Siberia thousands of years ago, have developed some of the most successful accommodations to a harsh environment to be found anywhere on earth.

In studying these and other matters, scientists and engineers in Alaska utilize and build upon the research findings of other investigators throughout the nation and the world. As good citizens of their professional communities, they should and do contribute to the world's knowledge as they study problems of particular importance to Alaska or problems in which Alaska is one of the world's natural laboratories because of its high geographic and geomagnetic latitude.

Thus, there is sound reason why research in Alaska should go beyond attempts to solve the immediate problems of resource development, protection of the environment, or improvement of health in order to increase the basic knowledge and understanding of the physical, biological, and social systems that can most appropriately be studied in Alaska. Accordingly, this chapter describes several areas of research that can contribute importantly to fundamental knowledge and understanding of how the world operates, as well as providing new knowledge that is useful in practical applications.

## The Upper Atmosphere

Solar-terrestrial physics is the branch of space physics that studies the components of the energy emitted by the sun, especially the corpuscular fluxes in the solar wind and the particles ejected in solar flares; their propagation through space; and their effects upon the earth's environment. In addition to providing a better understanding of the dynamics of sun/earth relationships and of physical processes in near space, research in solar-terrestrial physics may lead to better methods of designing and protecting earth-based communication equipment and the satellites on which we increasingly depend for communications; for current information about weather, crops, and land use; and for military surveillance.

### The Earth's Window to Outer Space

Corpuscular emissions from the sun enter the earth's magnetosphere primarily at two points, called cusps; one in the Arctic, and the other in the Antarctic region. For that reason, the upper atmosphere at high latitudes has been called the "earth's window into space." Alaska sits right under the northern window, and is therefore the best place in the U.S. to study many geophysical effects that are the direct consequences of phenomena occurring in deep space, and to study the effects of those phenomena on the earth.

The most obvious effect of the solar particle flux is the aurora, but in addition to producing those spectacular night displays, the variable emissions from the sun also interfere with radio transmissions, with signals from orbiting satellites, and with defense surveillance devices. The solar flux can trigger chemical changes that destroy some of the earth's protective ozone and change the gas composition and temperature of the very high altitude winds that blow equatorward from the polar latitudes. Under some circumstances those emissions can also cause power surges in long conductors, such as power lines and pipelines. And, perhaps, although this is still very much a matter of continued research, the solar particle flux influences the weather and climate. Large amounts of energy are involved in magnetospheric storms, but how, or if, that energy release is coupled to the lower levels of the atmosphere is not clear. Alaska is a crucial place to look for answers to those questions.

This field of research is expensive, partly because of the location of the ground-based observations and partly because of the necessity of sending probes into space. It is of such importance, however, that since 1978 the Polar Research Board has issued six reports that include discussions of needed research on the upper atmosphere of the polar regions and near-earth space. Those reports make quite specific recommendations on research priorities (Polar Research Board, 1982b).

## Weather and Climate

Weather and climate patterns of the whole earth are connected through the earth's atmosphere and oceans. Events starting in one region may have repercussions far away; for example, the warming of Alaskan waters in 1982-83 resulted from "the most prolonged and catastrophic El Nino visitation of recent times" (Rasmusson, 1985, 175), an event that spread its effects far beyond its origin in the Pacific Ocean west of Peru. The oceans and atmosphere are global in their exchanges of energy, but some regions of the earth are more important than others in generating weather and climate patterns. Alaska, and particularly the low pressure area of the Gulf of Alaska, is one such region; events there cause disturbances as far away as Europe and regularly forecast events over much of North America.

For this reason and also because weather in Alaska is important to Alaskans, there are two sets of weather and climate issues to study: the local weather and the Alaskan influence on weather patterns through North America and even beyond.

### Alaska Weather

Alaska has three major climatic zones: the Arctic Zone climate north of the Brooks Range; the Interior Zone climate of the area between the Brooks and Alaska ranges; and the Coastal Zone climate of the area south of the Alaska Range. Study of these three climatic zones will lead to better understanding of a variety of issues, for the nature of the region's climate has such widely varying influences as determining the extent and characteristics of permafrost, the length of the growing season, the distribution of pollution, the risks of superstructure icing on ships, and river flow and glacier balance and their implications for prospective hydroelectric power generation in different parts of the state (Weller, 1984b).

As one basis for such studies, weather records have been collected under the auspices of the federal government and through manned weather recording stations in Alaskan villages. However, the federal government is currently trying to diminish its involvement in weather records and measurements, and the local record keeping has not been sufficient. More systematic recordingand reporting of weather variables are needed, and there is an especially severe lack of observations at higher altitudes. One immediate objective of research would be to develop reliable, automatic observing and reporting equipment that could be stationed at strategic locations, including higher altitude locations, throughout the state.

### Effects on Weather Elsewhere

The low pressure area off the coast of Alaska initiates major changes that influence the weather of much of North America and the Northern Hemisphere. Changes in the temperature of the sea surface, unusual ice conditions in the Bering Sea, or a change in the jet stream pattern can generate perturbations that extend widely beyond Alaska. The causes, effects, and interrelationships among such changes are far from being fully understood. Research that led to a better understanding of these phenomena could improve longer-range weather forecasting, both for Alaska itself and for the rest of North America.

#### External Influences

Just as Alaska exports weather to the rest of North America, so Alaskan weather is influenced by events elsewhere. Arctic haze comes primarily from coal-fired smelters and other industrial activities of Eurasia. The potential global warming due to an increase in carbon dioxide and other "greenhouse" gases in the atmosphere results primarily from the burning of fossil fuels and other activities all over the earth. All of these external influences affect the weather of Alaska. They also affect the processes there that influence the weather and climate of the rest of the Northern Hemisphere. Their continued study is necessary, therefore, both to have a better understanding of Alaskan weather and a better understanding of weather and climate changes of the rest of the Northern Hemisphere.

### Geology

Many of Alaska's present resources are products of its geological past, and that past has been complex, varied, and surprising. Alaska is not a single part of a continental block, as is most of Canada or the contiguous states of the U.S. Instead, it is a mosaic of separate pieces called terranes—physically separate and geologically different blocks of continental types of rock—that originated elsewhere, mostly much farther south, and that, over the ages, have been rafted into their present locations on top of oceanic plates. Indeed one terrane, the Yakutat Block, is still in the process of arriving and colliding with adjoining terranes (Stone, 1984).

Evidence for this mosaic nature of Alaska—and for a similar history of the western continental margin of much of North America—has come from a variety of sources. Key parts of the evidence came from work at the University of Alaska on paleomagnetism. Many rocks record the direction of the earth's magnetic field at the time the rocks were formed. Studies of these paleomagnetic records from different parts of Alaska demonstrated that they could not possibly have been formed in their present locations, but must have come from elsewhere, usually much farther south. This evidence, plus detailed geological examinations of the rock strata of different terranes, together with information about plate tectonics and the movement of land masses over the earth's surface have fitted together to provide the current view of the nature of Alaska's geological history.

This whole concept of the history of Alaska is important to the state because the area where terranes collide or slide past each other are likely to be seismically active and are the areas that have the greatest potential for mineral deposits, and often for oil deposits. In fact, the terrane concept is now the dominant framework on which industry's exploration strategies are based.

Because this whole concept is still young, there is much detail still to be learned. Detailed geological mapping across terrane boundaries, mapping of the individual terranes to learn more about their history, additional paleomagnetic work to determine ages more accurately—studies of this kind are needed to understand the state's geological history more fully, to aid in searching for more of its potential resources of oil, gas, and minerals, and to be better able to identify hazardous areas.

Studies of earthquakes and identified faults, and studies of the processes of accretion being exhibited by the Yakutat Block and its relations with its neighboring terranes are also needed to understand better what must have happened in the past as the many parts of Alaska were coming together.

#### Recent Geological History

More recently, geologically speaking, glaciers of past ice ages have shaped and reshaped the surface of much of Alaska. Glacial deposits cover about half of the state, and glacier fluctuations controlled the deposition of sediments, the location of lake beds, and the deposition of loess through much of the rest of the state. The deposits range from stable gravels to ice-rich silts and unstable clays. The deposits also include records of other events, ash falls from volcanic eruptions, earthquakes, fault movements, sea-level changes, erosion, and other aspects of geological history. Moreover, the patterns and changes of glacier coverage over past time provide a record of past changes of temperature and snowfall and thus give evidence about past changes in climate. Ice cores from current glaciers provide information about snowfall, climatic change, ash fall from volcanoes, and atmospheric composition over recent geologic time. For all these reasons, surficial geological mapping of more of the state and in finer detail than is now generally available would be desirable. In addition to providing information about recent geological history and paleomagnetic changes, such maps would identify areas of major instability on mountain and hill slopes and thus show likely landslide, earthflow, and avalanche areas. That information could aid engineers and planners in locating transportation routes, pipelines, hydroelectric dams, and other structures, and in avoiding areas of special hazard (Hamilton, 1985).

## Natural Hazards

A few old timers still remember the Novarupta-Katmai eruption of 1912 and the resulting Valley of 10,000 Smokes. More remember the Good Friday earthquake of 1964 and the destruction at Kodiak, Valdez, and Anchorage. Future eruptions and earthquakes of comparable size are likely, for Alaska contains 90 percent of the explosive volcanoes in the U.S. and is one of its most seismically active states. But when?

Likely locations are known, for both volcanic and seismic zones are generally recognized, but the timing is quite uncertain. Recent studies at the University of Alaska and elsewhere indicate that about every thousand years—on the average—there has been a volcanic eruption large enough to deposit 10 centimeters or more of ash over a large area. Lesser eruptions and major earthquakes have been much more frequent; the arc of southern Alaska has experienced a large earthquake about each decade for the past two centuries.

All of this makes Alaska an obviously good place to study volcanic eruptions and earthquakes, and the hazards that are sometimes associated with them: tsunamis, the wreckage of buildings and other structures, and sometimes the triggering of avalanches or rock or mud slides. These have all been topics of interest to agencies of the federal government; for example, the U.S. Geological Survey. But, for understandable reasons nearly all of their studies have been of more heavily populated areas, such as California (Davies, 1983).

### Hazard Mitigation

Some of the risks can be reduced by proper construction. For centuries Chinese architects have supported upper stories and roofs with intricate corbel bracketing to absorb and dissipate the forces of earthquake shaking. Building codes in some earthquake zones—as along California's San Andreas fault—specify construction methods that will withstand expected amounts of shaking. In Alaska, design criteria for the two dams of the proposed Susitna hydroelectric project call for ability to withstand an 8.5 earthquake.

Yet some of the dangers are quickly forgotten. People continue to build on flood plains, in slide areas, or over known fault lines. We do not use all the knowledge we have. Although there have been precautions and earth stabilizing changes in Anchorage, one recent review summarized "It is the opinion of many scientists and planners that if a major earthquake were to occur today in Alaska, the state and its major communities would be at a level of readiness no better than that of March 27, 1964" (Fitzgerald, 1984, 17).

### Research and the Avoidance of Damage

Basic to substantially improved ability to forecast time and location of these natural hazards, and to reduce their damage, is a fuller understanding of the underlying geology, for the first step toward better prediction and damage limitation is better knowledge of the physical processes involved (Alaska Council of Science and Technology, 1980a). A first recommendation for research is, therefore, to move ahead on the kind of studies recommended in the section on geology.

In addition, there are opportunities for studies aimed more directly at some of the hazards themselves. We do not live in a hazard-free world. Risks must be taken, but it would be helpful to know more about the odds for particular hazards in particular places. For example, when a hydroelectric project is being contemplated, what is the region's seismic history? Are there fault lines nearby? What will be the effect of the loading of a full reservoir on the underlying geological structures? Is there a history of volcanic eruptions that might produce rock or mud flows or large ash deposits in the reservoir/generator/outflow area?

Two Alaskan studies have already provided relevant sets of recommendations concerning hazards. In 1979 and 1980 the Alaska Council on Science and Technology held 11 workshops to outline research priorities and recommendations in a number of fields. The first to be published dealt with needed research on seismicity. The workshop's first recommendation was that the state establish a comprehensive state policy concerning seismic activity—a policy that would establish codes and standards for building construction, especially for dams, hospitals, and schools; make plans for land-use controls, preparedness, and post-disaster recovery; and plan research on seismic activity.

Three years later the Alaska Division of Geological and Geophysical Surveys convened another workshop of seismologists from federal and state agencies, universities, and industry to plan methods of improving the availability of critical seismological information. The workshop recommended that the State Geologist establish a continuing working group that would study Alaskan earthquakes, volcanoes, and tsunamis and annually would "assess the future needs of seismic research, hazards mitigation, and hazards education in Alaska and...be available to evaluate earthquake and eruption predictions" (Davies, 1983, 1).

### Research Recommendations

The first research recommendation of the Alaska Council of Science and Technology workshop was for the establishment of an "integrated statewide system to collect, process, and archive seismic data." At the time of the workshop, 10 different federal agencies, universities, and private organizations were collecting seismic data from some 200 stations, but, except briefly (Davis, 1978), there was no systematic collation and organization of the data from these several sources. Some of the networks were temporary; they were put in place for different reasons; and although there was cooperation among some of the groups, there was no systematic and continuing arrangement for coordination of the networks or the collection and archiving of the data.

The workshop of the Alaska Division of Geological and Geophysical Surveys also called for establishment of a permanent, coordinated, statewide program to collect, organize, and disseminate seismic data (Davies, 1983). The U.S. Geological Survey and the National Oceanic and Atmospheric Administration, as well as the state's Division of Geological and Geophysical Surveys, the University of Alaska's Geophysical Institute, and industry all have permanent interests in such a network, for continuous monitoring over time is essential to improvement in the evaluation of risks. High priority should go to establishment of the proposed statewide system.

Although the network should be statewide, the Alaska Council on Science and Technology workshop recommended that special attention initially be devoted to three tectonic corridors of highest priority: "the Fairweather corridor in the eastern Gulf of Alaska ... the Kodiak corridor in the Western Gulf of Alaska ... the Shumagin corridor in the eastern Aleutian arc" (Alaska Council on Science and Technology, 1980a, 29).

## Snow, Ice, and Permafrost

Alaska and its surrounding oceans provide an ideal laboratory for the study of snow, ice, and permafrost. Nearly all of the state is covered by snow for six to nine months of the year. Permafrost is distributed over 80 percent of the land area and is found under some of the surrounding seas. Alaska has almost a total monopoly on American glaciers; they cover nearly 30,000 square miles, whereas the next most glaciated state, Washington, has only about one-half of one percent as much. Alaska's glaciers range from small to huge; some are fairly stable and some show periodic surges. The mountains bordering the North Pacific Ocean, including those in Yukon Territory and British Columbia, as well as those in Alaska, constitute the fourth largest ice mass in the world. With all of the snow, ice, and permafrost in the state, frozen water in one form or another strongly influences the weather, the growth and life cycles of plants and animals, the development of natural resources, and most of the other human activities within the state.

In all, there are four topics to consider: permafrost; the local ice that forms on lakes and rivers, on any outflow or overflow of water, and on various above-ground structures; glaciers; and—the most areally extensive of all—snow and sea ice. Although much has been learned about these matters as a result of studies made in the past few decades, there are still major gaps that need filling.

### Permafrost

"Permafrost is defined as ground that remains continuously at a temperature below 0 °C for a period of two years or more" (Polar Research Board, 1983b, 1). At its maximum thickness, the frozen layer may be as much as 700 meters deep. The permafrost contains various amounts of frozen water and there are sometimes substantial ice wedges or ice masses within the frozen ground. During summer months, there is likely to be a shallow layer of thawed, wet, and marshy ground above the frozen layer.

The importance of research on permafrost is indicated by the fact that since 1974 the Polar Research Board of the National Academy of Sciences has published four reports and sets of research recommendations on the topic (Polar Research Board, 1983b). Close collaboration between scientists and engineers will be needed in planning and conducting future research on permafrost, for two kinds of information are needed. One is to gain a better understanding of some of the basic physical properties involved, such as the transport of heat and water within the permafrost and between permafrost and the adjacent unfrozen earth. Better understanding of these properties and processes can lead to greater ability to predict the response of permafrost to changes of climate and to natural or human disturbances of the permafrost or the surrounding soil.

At the same time, there is a large engineering interest in the characteristics and location of permafrost, for permafrost creates numerous problems for all forms of transportation—highways, pipelines, railroads, and air strips. It also creates problems for any structures that require foundations in or on the soil—buildings, towers, water and sewage systems, etc.

Current research opportunities given high priority by the Polar Research Board include improvements in "methods of detecting ground ice," the development of better methods of "predicting heat and mass transport within permafrost and across its boundaries from adjacent media," and the monitoring of prototype or existing facilities constructed in permafrost regions "in order to advance engineering technology." In these and other studies, the Polar Research Board recommended "that maximum advantage be taken of opportunities for international cooperation" and that arrangements be made for the active and positive transfer of permafrost-related information and technology to those who can use that information.

### Local Icing

In addition to the extensive glaciers and sea ice, ice also forms in smaller amounts in particular local areas, sometimes with serious problems and damage. The icing of rivers and lakes can form jams both at the time of freeze-up and at the time of breakup, with resulting local flooding and damage. Melting of ice or snow near a highway and refreezing of the melt water can produce sudden and unexpected ice patches on an otherwise dry highway. Ice forming on drilling platforms or on fishing boats operating during winter months can lead to instability, breakage, and, in the worst cases, to capsizing and loss of boats and crew members. All of these forms of ice present scientific problems of understanding better the mechanisms involved and the properties of the resulting ice, and practical engineering or design problems to avoid or overcome the dangers involved. Thus, studies of the freeze-up of ice, including the several methods of ice formation, frazil-, anchor-, and aufeis-formation are called for, as are studies of the breakup processes, the formation of ice jams, and the ice loading of structures projecting above the earth or sea.

### Glaciers

The sheer mass of ice locked up in glaciers affects North American weather. The location, size, and heat balance of glaciers are important for the planning of hydroelectric projects because the growth and melting of glaciers is a major factor in determining seasonal and year-to-year variability in the amount of water available to flow through the turbines. Outbursts from glacier-dammed lakes and glacier surging may lead to flooding and damage to anything downstream.

In 1970 the Committee on Polar Research (now the Polar Research Board) ranked studies of the surging and sliding of glaciers among the highest priority research needs in the whole field of snow and ice studies. Although the detailed study of the 1982-83 surge of Variegated Glacier and its presurge behavior (Kamb, Raymond, and Harrison, 1985) has done much to answer questions about glacier surging, studies of the basic glacial processes in a representative sample of Alaska's glaciers remains as one of the priority recommendations of the Polar Research Board (1983a).

Tidewater glaciers produce icebergs, and icebergs may be hazards to shipping and sometimes to shore structures. Studies are needed to be able better to predict the calving of icebergs, their movement through or near shipping lanes, and the ablation and other processes that change their shape, size, and distribution of mass.

There are also rock glaciers, "glacierlike tongues of angular rock waste usually heading in cirques or other steep walled amphitheaters" with ice as a core or ice cementing the rock together (Washburn, 1973, 195). Moving slowly, but inexorably—commonly less than a meter per year—rock glaciers could influence the location of a highway, a reservoir, or some other construction intended to last for a long time. Yet so far there is no inventory of the number, location, or extent of rock glaciers that could be used as warning information when new constructions are being considered.

### Snow and Sea Ice

Alaska includes three quite different snow zones. Along the southeast portion of the state, the thick and often wet snow piles up to many feet in depth each winter. In the interior, the "taiga snow" is dry, of low density, and often recrystallized. North of the Brooks Range, the sparse annual precipitation leaves dry, hard, shallow, wind-packed "tundra snow." Within each type there are complex processes of heat transfer between snow and ground and snow and atmosphere. Both animal and plant life of a region are largely shaped by the amount, duration, and characteristics of the annual snow cover.

There is also extensive annual change in the amount and some of the characteristics of the sea ice in the Beaufort, Chukchi, and Bering Seas. Together, the areal extent of snow and sea ice has a large effect on the earth's heat balance and weather. Snow reflects about 80 percent of the sun's radiation. When the snow is gone and sea ice is melted, the underlying ground and water absorb about 80 percent of the sun's radiation. Thus, the extent of "sea-ice profoundly affects the heat exchange between the atmosphere and the ocean, thereby influencing weather and climate" (Polar Research Board, 1977, 16). The large-scale coordinated study called AIDJEX (Arctic Ice Dynamics Joint Experiment) produced much new information on the energy balance and dynamics of sea ice. Further work is still desirable, however, because of the importance of sea ice to offshore activities and future developments.

An important reason for some of the needed research is to avoid or reduce damage. Thus, studies are needed of avalanche processes and hazards, and fuller information is needed about the forces and mechanisms involved in the interaction of sea ice with drilling platforms and artificial islands, and the potential damage resulting from ice scouring of shallow sea bottoms and ice ride-up on shores and their structures.

Satellites now provide extensive data on snow and ice cover, but improvements are needed in remote sensing techniques in order to be better able to determine thickness, age, brine content, and reflectivity of snow and ice coverage from satellite images.

Taking account of the knowledge gained in earlier studies, in 1983 the Polar Research Board grouped a total of 24 highest priority studies—more specific in nature than need be described here—under two major high priority categories: "The interaction of snow and ice with past and present climates"; and "The direct impact of snow and ice on society" (Polar Research Board, 1983a).

### Snow, Ice, and Climate

Ice cores, mostly from Greenland rather than Alaska, can give much information about past climate changes, temperatures, annual precipitation, and composition of the air. Ice cores plus tree-ring data and pollen counts from selected parts of Alaska compared with similar data from elsewhere in the world at the same times can not only give information concerning past climates, but can also help in the understanding of current trends or forecasts of future climatic changes.

Studies of the vertical transfer of heat between water and ice and between ice and air are needed to help interpret those past records and also to gain a fuller understanding of the heat exchanges that determine much of North America's current weather. Similarly, studies are needed of the interaction between seasonal snow cover and the global energy balance.

**Snow, Ice, and Society**

Among the types of research recommended to gain a better understanding of the direct impact of snow and ice on society were the forces and mechanisms involved in the development of pressure ridges, rubble piles, and ice ride-up; studies of the location, stability, and mechanics of ice jams; and studies of the physical bases for forecasting snowmelt, run off, soil-water reserves, and basin storage.

Annual precipitation is small over most of Alaska (southern and southeast Alaska excepted). Yet as the population continues to rise there is increased need for water for domestic, commercial, and industrial use, and for waste disposal. Thus, information about the amount of water available from snow or ice, its location, and its seasonal and annual variability becomes an ever increasing necessity.

## Northern Oceans

The northern oceans surrounding Alaska include the Beaufort, Chukchi, and Bering Seas. The total coastline involved is vast, and the continental shelf areas support some of the world's richest fisheries. Within those continental shelves may lie large reserves of oil and gas. Permanent or seasonal ice covers much of the northern oceans, and into their margins flow large amounts of fresh water bearing whatever natural silt and man made pollutants the rivers have picked up. Both onshore and offshore developments are influenced by the characteristics of the northern oceans and both tend to change those characteristics. Yet in all of these regions significant gaps in knowledge are restricting the ability to deal with problems encountered by or produced by the various forms of development that are occurring (Alexander, 1984).

The Arctic Ocean is unlike other oceans. It is a "mediterranean" sea, surrounded almost wholly by land. However, it is much colder than the real Mediterranean, and "there is probably no other ocean in which river input plays such a major role...[Thus], arctic seas cannot be understood by referring to information gathered from other areas" (Alexander, 1982, 53-54).

**Problems of Multiple Use**

Conflicts over multiple uses of the seas and particularly the continental shelf portions are inevitable. For example, the effects of oil-related activities in the Beaufort Sea on the migratory marine mammals that are critical to the culture of the coastal communities are certainly controversial. But the effects are not yet known; for even such basic information as the food organisms and feeding behavior of the bowhead whale are not known.

One kind of knowledge needed to maintain the rich biological productivity of the northern oceans and also to help solve the problems of multiple use is an understanding of the natural fluctuations that occur and the reasons for those fluctuations. The seas around Alaska are linked to the rest of the world's oceans, and Alaskan seas are influenced by large scale ocean circulation and global weather patterns. A dramatic example was the warming associated with the El Nino of 1982-83. Local differences such as the extent of snow and sea-ice coverage are also involved, and there is much still to be learned about how the local events and the global influences interact to account for the substantial fluctuations in biological production that have been observed. More needs to be known about those natural fluctuations in order to be able to assess the impact of deliberate interventions and policy changes on the biological productivity of the northern oceans.

**The Bering and Chukchi Seas**

The flow of fresh water into the arctic seas is extremely high, and is in part responsible for their low surface salinity. In particular, the Yukon River is a major source of water for the northern Bering Sea and the southern Chukchi Sea. Its influence on the biological processes in these seas needs to be evaluated, as does its transport of organic compounds to the Bering Sea, their composition, and the factors influencing their composition. Such geochemical work will be important in interpreting the influence and fate of atmospheric pollutants at high latitudes.

Because of its importance for Alaskan fisheries, a study of the deep circulation of the Bering Sea, including the annual and interannual exchange of water through the Aleutian passes and the wind-driven circulation over the deep ocean basin and its importance to shelf regions, should receive high priority. At the continental margin in this region is one of the largest and longest canyon-fan systems of the world. No information is available about the transport and deposition of sediments in this system, nor about the associated living community in those depths.

**The Beaufort Sea**

In general, the Arctic Ocean is not as biologically productive as the Bering and Chukchi seas. Yet in summer it supports large mammals such as the bowhead whale. This support must depend upon physical or biological processes that either concentrate their immediate prey or that provide a nutrient-rich environment for the plant plankton that serve as the base of the whole food chain. Potential mechanisms for such concentration include gyres, such as the Barrow Gyre formed by the northward-flowing current passing through the Bering Strait and on past Point Barrow. There is also evidence of upwelling along the Beaufort Sea shelf, and this may be important in concentrating nutrients outside the Barrier Islands and in the region near the Canadian border. The relationships between physical oceanographic dynamics and biological activity urgently need research.

**Ice and Biology**

A large portion of the seas surrounding Alaska is ice covered during at least part of the year. Of particular interest is the seasonal ice cover of the broad continental shelf of the Bering Sea, for few natural events produce such major oceanographic effects as does the annual advance and retreat of sea ice over that shelf. This seasonal cycle dramatically alters the physical and chemical nature of the underlying water, and those changes, in turn, have a strong influence on the biological system. Indeed, dramatic phytoplankton blooms occur each spring, stimulated by melting ice and upwelling at the retreating ice edge. Clearly, the ice-related production must be critical to the food chain, but how the transfers occur is not understood. In part, the intense blooms are known to supply nutrients to the benthic (sea bottom) community, and that factor must be related to the success of walrus in the region, but there is much that is not known. Studies of under ice fish, eggs, and larvae are needed. As a related issue, polynyas (open water areas surrounded by ice) tend to recur annually in the same regions, especially to the south of major islands and coastlines in the Bering Sea. Polynyas, leads, and the annually moving edge of the sea ice are regions of high marine mammal concentration, and regions rich in nutrients. At these locations, the ice itself appears to play an important biological role. At the edge of the seasonal sea ice in the spring, a very intense bloom of phytoplankton occurs. Moreover, "flora, mainly diatoms growing primarily in the bottom layer of the sea ice...," apparently account for "from ten to twenty-five percent of the total primary production...which is most active in spring and early summer" (Alexander, 1982, 53).

Other problems concerning sea ice also await attention, from its role in rafting sediments and their effects on its properties to prediction of its distribution and coverage. Here, satellite imagery and sophisticated modeling capability will help. A refined forecasting ability for storm surges, and a better understanding of their dynamics in ice-covered seas will be essential to safe development of offshore structures.

A few major themes in work on marine mammals can also be identified as having high priority: habitat ecology and food chain relationships; the bioenergetics of representative species; physiological work on temperature regulation, asphyxia, and metabolism; and the processes involved in navigation and orientation.

**Climatic Effects**

On a more global scale, other research in physical oceanography relates directly to the problem of global climate and the $CO_2$ problem discussed in Chapter 3. Contrary to previous thinking, recent evidence suggests that there is exchange of deep water from the Arctic basin with surface water from the continental shelf. Such deep ventilation could significantly reduce the ability of the Arctic Ocean to buffer atmospheric carbon dioxide. Although of a still speculative nature, the expected warming trend associated with an increase of $CO_2$ and other greenhouse gases dictates that the prospect of a warmer and maybe ice-free Arctic Ocean should be considered. A comprehensive study of its oceanography would be timely.

## Human Resources

The truism that people are a primary resource has already been supported by several of the recommendations presented earlier. Management studies, as well as biological and oceanographic research, were recommended to improve the state's fisheries. The military services have conducted research on human engineering and personnel performance in cold climates, and want more. Solution of some of the pollution problems will depend more upon education and changed behavior than upon new research findings. One workshop of the Alaska Council on Science and Technology (1980b, 25) concluded that "The basic issue in Alaskan mineral development and research is the need to establish underlying state policy for the development of those minerals"; and another workshop (Alaska Council on Science and Technology, 1981b) agreed that a primary need for development of the transportation system is an economic study of the state's existing and prospective market structure. Clearly, there is research to be done by behavioral and social scientists, as well as by engineers and physical and biological scientists.

When the Arctic Research and Policy Act of 1984 was being debated in Congress, one of the criticisms was that the bill "...ignores the importance of the human sciences in the Arctic. Arctic policy should include that research that will enhance economic, technical, resource, and social development" (Brower, 1983, 4). As the bill was enacted, it did include several references to social and psychological problems and called for national policies, priorities, and goals for research on "natural resources and materials, physical, biological and health sciences, and social and behavioral sciences" (Section 102 (b) (1)).

Research in four areas is recommended: (1) anthropological and archaeological research on cultural change and the social and cultural accommodations to conditions in the north, as discussed earlier in Chapter 3; (2) research on education; (3) research on some economic features of the state; and (4) research on policy and management processes and decisions.

**Alaskan Education**

In a spate of recent and usually critical reports, the nation's schools have been examined and re-examined in terms of their goals and objectives, accomplishments and failures, crime and violence, a ibility or inability to meet the needs of their students and of society. Some of the criticisms apply to some of Alaska's schools, but Alaska also has its own special school problems deriving from the need to provide education to a relatively small number of pupils scattered over a large geographic area.

The desirability of having schools easily accessible—a grade school and high school in every community—inevitably means that many schools are small, with few teachers, small libraries, and sometimes little equipment for teaching vocational and technical subjects or science courses. At last count Alaska had 162 high schools with fewer than 100 students (Fitzgerald, 1985). Radio and television can be used to supplement the local resources, and considerable money has been provided for the purchase of telecommunications equipment. But much less has been devoted to learning how to use that equipment most effectively. Studies are needed of the educational effectiveness of these media, of methods of coordinating their use with the teacher/classroom/ textbook/recitation activities of the local school, and of their impact on village life and adult learning (Floyd, 1985). More generally, studies of the effectiveness of rural school curricula and operations would be desirable, as would studies of the selection of teachers for small rural schools and studies of the cost and effectiveness of vocational/technical education and the employability and later activities of students trained in small vocational/ technical programs.

In 1980, the Alaska Council on Science and Technology convened a workshop on research priorities for the state's rural primary and secondary schools. Because federal funds for research on education are committed to problems of national concern—such as ghetto schools in large cities and the educational problems of Blacks and Hispanics—there is little likelihood of support from federal sources for studies of how to improve schools in Alaska. The workshop therefore appealed to the state government for support for four studies of high priority.

1. Defining and assessing "effective schooling" in Alaska's cross-cultural context. What are the diverse roles of schools in Alaska's urban and rural settings and how can they be most effective with pupils coming from diverse cultural backgrounds?

2. Effects of community participation in educational affairs on school functioning. How can local interest and participation in schools be most constructively used to improve educational effectiveness?

3. Providing educators with skills necessary to work effectively in Alaska's cross-cultural situation. What do teachers need to know not only about the subjects they will teach, but also about the cultural traditions and differences of the small and often isolated communities in which they will teach?

4. Developing educational approaches for village high schools. It is no longer necessary to leave home to attend high school, but the at-home schools are often small and inadequately equipped. How can education of good quality be provided in such schools and how do these village high schools score in terms of drop-out rates, attendance, the later success of their graduates in college, and their later success in the village or elsewhere? (Alaska Council on Science and Technology, 1981a.)

**Economic Organization**

Two aspects of the economic organization of Alaska provide opportunities for research that are not available elsewhere. One arose as a consequence of the Alaska Native Claims Settlement Act of 1971. That act granted some 44 million acres of federal land and nearly a billion dollars to the Native corporations that were established under the act. In doing so, some of the organizational, economic, and governance problems, advantages, and dilemmas of a capitalistic system were superimposed on traditional Native organizations. Because somewhat similar changes are taking place in some of the world's less developed countries, economists, sociologists, political scientists, business managers, and social planners will want to study the Alaska experience. What can be learned from the processes involved in the establishment and management of the Native corporations and from the experience of those corporations that can provide useful guidance as comparable changes take place in some of the world's less developed countries?

The other aspect of the Alaskan economic scene that presents special opportunities for study is its openness and comparative absence of institutional tradition and restriction. There are fewer established rules in a frontier area than in a long established one. In Alaska there is not yet as much institutional momentum that restricts freedom of entry into commercial, entrepreneurial, or professional activities. There appears to be more challenge, less conventionality, and perhaps more opportunity for Horatio Alger success stories, but also perhaps more personal stress, for while the lesser amount of institutional tradition may offer more wide open opportunity, it may also offer less support. Anecdotal observation suggests that stress levels are sometimes higher, that the psychic costs are greater than they are under more traditionally stabilized circumstances. Alaska is the nation's last frontier in which these questions can be studied.

**Policy and Management**

Every problem discussed so far exists in a social setting. Every program of resource development, environmental protection, or health services involves questions of policy, requires forms of management, encounters problems of regulation and law, of governmental controls, and sometimes of intergovernmental tensions and differences. Each set of techniques, such as those involved in fishing, mining, transportation, rural education, or building construction, has its own traditions, beliefs, regulations, standards, and perhaps its own ingrained set of false beliefs, out-of-date rules, errors, and inefficiencies.

Moreover, as pointed out several times before, there are many conflicts between one set of desirable activities and another set of desirable activities. Using a river or harbor, a piece of land, or an amount of money for one purpose may deny or diminish opportunities for another use.

Many of the necessary choices involve competition between present and future needs and values. For example, decisions about resource development vs. environmental protection inevitably raise the old dilemma of short term vs. long term benefits. The state has a constant need to raise revenue, and that need will become more urgent as the diminishing flow of oil from Prudhoe Bay builds pressure for the development of other oil or mineral resources, for hydroelectric dams, for road construction, or for other types of development. Decisions on these matters must necessarily consider the easily foreseen and immediate needs of the state, but thoswhether or not there is good information about their relative values.

Traditionally, the resolution of such problems has been by majority vote, by decision of someone in a position of authority, by following an established precedent, or by some other legally established or customary method of resolving conflicts. However, there is no assurance that these traditional methods always lead to optimal outcomes. In fact, optimizing one outcome may be the wrong objective. Neither is it assured that such problems are best handled on the basis of the individual values, experience, and biases of whoever happens to be in a position of responsibility for making a particular societal decision. Techniques have been developed for improving budgeting, for comparing probable costs with probable consequences, for assessing potential risks and potential benefits of alternative courses of action, for projecting future trends, for resolving value conflicts, for reaching a consensus, and for dealing with other aspects of the formation of policy and the direction and management of activities.

In some settings, such as university schools of business on governmental affairs and in some social science research institutes, these policy and management questions are subjects for research and analysis much as problems in engineering, biology, or physics are problems for other university departments or other research institutes. Alaska includes such an organization in the Institute for Social and Economic Research of the University of Alaska.

Two recommendations follow. One is that research on decision making, regulatory procedures, projections of economic and fiscal trends, and other aspects of policy and management should be encouraged. The knowledge obtained from such research will be valuable to policy makers, and participation in that kind of research will help educate some future public servants and business leaders in the best available methods of handling the kinds of public issues with which they will later deal.

The other recommendation is that, to as full an extent as possible, efforts be made to record, analyze, and study the experience gained in the programs that will be developed to deal with the kinds of problems discussed in the earlier parts of this report—the development of natural resources, preservation of the environment, improvements of health and well-being, and adding to the state's store of knowledge. How were decisions concerning those programs made? What organizational and administrative patterns were used? What government controls were involved? Did they aid or impede the program? How well did the program meet its goals? Experience may be a good teacher, but that is most likely to be true if the experience is critically analyzed to determine mistakes and successes, so that future decisions can be wiser and future experience more satisfactory than they have been in the past.

In the final analysis, the success and the usefulness of all of the research recommended in this report will stand or fall on the long-term wisdom and effectiveness of the systems the state uses to make decisions about its own future.

# CHAPTER 6
# CONCLUSION: ALASKA SCIENCE POLICY

The preceding chapters discussed 23 areas in which additional research is needed to help ensure a good future for the state. The number 23 is arbitrary, for each of these topics could have been divided into parts as several of them, in fact, were, and because the 23 topics and their subdivisions overlap and are inter-related. Research on natural hazards requires an understanding of geology. Mining and forestry depend upon transportation. Studies of climate and weather are relevant to studies of agricultural development. And so it goes; each of the topics is related to, dependent upon, or helps to illuminate some of the other topics.

In the past, however, research has too frequently been fragmented, conducted with a narrow focus by different investigators, for different reasons, in different locations. Consequently, the results have not fitted together or helped to interpret each other as well as they might have had there been more coordinated planning. This situation has been one of the results of the fact that there has been no coordinated policy concerning research for Alaska or on the Arctic. As the Alaska Council on Science and Technology (1982) pointed out, "Alaska does not have an articulated, comprehensive state science policy." Nor has the United States had a coordinated policy for research on problems of the Arctic (Hickok, Weller, Davis, Alexander, and Elsner, 1981). Instead, as the interests of federal government agencies have changed, so have the nature and extent of their studies of arctic problems.

True in the past, these statements may now be going out of date. Alaska now has a science advisor to the governor, and for several years had the Alaska Council on Science and Technology. The Arctic Research and Policy Act of 1984 calls for an integrated national Arctic research policy and a national research program to implement that policy. Members of the overseeing Arctic Research Commission have been appointed. The National Science Foundation, as the responsible lead agency, and the other interested agencies of the federal government have begun to organize a joint effort to develop an integrated program of arctic research (National Science Foundation, 1984). To support that program, the National Research Council has prepared a comprehensive report on "National Issues and Research Priorities in the Arctic" (Ad Hoc Committee on the Arctic Research and Policy Act, 1985).

This new surge of interest in arctic research will be beneficial to Alaska, but, as pointed out earlier, the federal interest is primarily arctic, not Alaskan.

Thus, the very existence of these new interests and activities increases the need for a coordinated and long-range policy for research on Alaskan problems. That does not mean that all of the research details should be planned by some central organization; the scientists and engineers who will conduct research must have a large measure of responsibility for planning the details. It does mean that some organization with the future well-being of the state and its citizens as its central interest should be keeping watch over the whole sweep of Alaskan research—an organization that can ask of any planned project "How can this study be coordinated with others in order to contribute the most to the whole of the information that is needed?" Ideally, that organization will have funds with which it can give full support to selected studies that score high in potential benefit to the state, but low in likelihood of support by the federal government or some other external sponsor. The budget should also be sufficient to permit the new organization to supplement the funds provided by another agency sponsoring research of interest to the state, for that sponsor may not wish or may not be able to use its own funds for anything more than its own particular needs and interests, whereas the policy organization may conclude that the study would be of increased value if it were enlarged or augmented in some state-oriented direction.

There is a second and closely related conclusion to be drawn from the 23 research topics discussed in the preceding chapters: much of the necessary research should be planned and conducted as interdisciplinary programs. Work on fisheries cannot be of maximum value if it is limited to the biological aspects alone. Physical oceanographers should also be involved, for the productivity of the state's fisheries is dependent upon the physical and chemical characteristics of the seas. Similarly, human stress is an environmental problem, a medical problem, and a psychological problem. Working alone, no one of these disciplines can accomplish as much as can the three working together. Or again, optimal development of a renewable or nonrenewable resource calls for joint study by specialists in the particular resource field, engineers, environmental specialists, and economists. The many inter-relationships of the problem areas and the ramifications of alternative means of handling them frequently call for joint study by representatives of several disciplines. This fact also means that the studies should not be planned solely to meet the needs of a single agency or institution that has a specific and limited area of responsibility. Thus, the inter-disciplinary nature of most of the problems reinforces the need for an organization that will look broadly at Alaska's future, and that can ask of each project "How can this study be conducted to be most useful in assuring the best attainable future for Alaska and its citizens?"

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