ECONOMIC IMPACT OF REINDEER-CARIBOU INTERACTIONS

ON THE SEWARD PENINSULA

By

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A

THESIS

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Abstract

The reindeer industry has persisted on the Seward Peninsula in western Alaska for more than 100 years. Since the mid 1990's the industry has been increasingly threatened by changes in Western Arctic Caribou Herd (WACH) migration paths and winter range. Free-range reindeer (Rangifer tarandus tarandus) intermingle with caribou (Rangifer tarandus granti) and migrate off designated reindeer ranges. As of spring 2003, eleven of fourteen Seward Peninsula reindeer operations were no longer commercially viable as a result of caribou induced reindeer losses. This loss is significant to an economically depressed region with few development opportunities. An economic input-output model was constructed in this study to analyze the reindeer industry's economic role in the regional economy prior to the loss of reindeer to caribou. Impact scenarios were used to estimate the effect of WACH on the regional economy through decreased output from the reindeer industry. Results show a per annum negative impact of $1.4 million (2000 dollars) on the regional economy with 11 non-operational reindeer herds. If reindeer losses lead to complete elimination of the commercial reindeer industry on the Seward Peninsula, study results show the region would incur a total negative economic impact of more than $17 million.

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Acknowledgements

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1.0 INTRODUCTION

1.1 Description of current problem

The reindeer industry has played a significant role in both the cash and non-cash sectors of the regional and village economies of the Seward Peninsula, Alaska throughout the last century (Arobio, 1979). However, recent reindeer losses in northwestern Alaska caused by changes in caribou migration are impacting the viability of the industry. Reindeer (Rangifer tarandus tarandus) from farmed herds are co-mingling and out-migrating with the Western Arctic Caribou Herd (WACH) as caribou migration and winter range extension encroach on reindeer range allotments. Seward Peninsula reindeer move freely across designated ranges with limited herder contact. The ranges are large, remote, and impassible at some times of the year, eliminating the ability to protect reindeer herds from a significant influx of caribou.

A drastic decrease in reindeer herd size has forced some reindeer herders out of business and is causing others to forgo corralling and slaughtering activities central to their business. As of 2002, more than half of all reindeer on the Seward Peninsula have out-migrated with caribou and have not returned (ADF&G, 2002). Over 12,000 reindeer have been lost (Finstad et al., 1999). The reduced output is negatively impacting the already stagnant or declining economies of the region. This study is designed to quantify the value of the reindeer industry to the Seward Peninsula regional economy and the changes felt by the communities in the region as the presence of caribou increases and continues to impact cash income on the Seward Peninsula.

The economic impacts caribou have had on the Seward Peninsula reindeer industry extend far beyond the reindeer herders and their families. The reindeer industry produces meat, antlers, and hides which are sold in markets on the peninsula, throughout Alaska, the continental United States, and Asia. The reindeer industry is one of the few industries importing cash to a region burdened by high unemployment and few private sector opportunities.

Many herders live in small villages in close proximity to their ranges. They rely on local people to help corral and process animals and to harvest meat and antler. Laborers receive cash and/or reindeer meat as compensation. Moreover, herders purchase many supplies from local village stores and from retail stores in the regional hub, the city of Nome. Economic benefits brought to the region through the reindeer industry's regional spending activity have a broad reach.

Over the last decade the proportion of the WACH wintering on the Seward Peninsula has increased. In 1996-1997 the herd began shifting its winter range to the Seward Peninsula (Dau, 2003). The WACH's range has expanded westward through the central Seward Peninsula reindeer ranges. The presence of caribou has had a negative impact on reindeer industry output through reindeer co-mingling and out-migrating with the caribou, leaving only three commercially viable reindeer herds by spring 2003 (ibid). The end result is less cash brought into Seward Peninsula economies through a decline in

reindeer industry production. This study will focus on identifying and quantifying the significance and impact of the loss given different impact scenarios.

Following a discussion of the history of the reindeer industry in Alaska, this study defines the Seward Peninsula reindeer industry inputs and outputs during the period leading up to significant losses of reindeer to caribou migration and encroachment on reindeer grazing allotments. The reindeer industry is then developed and introduced into a regional economic model for the Seward Peninsula, using the Nome U.S. Census Area as a proxy for the region. The change in output resulting from caribou induced loss of production is estimated and entered into the model as a direct effect to the reindeer industry. The model is used to capture the overall economic impact (including direct, indirect, and induced effects) on the regional economy. The goals of this study are as follow:

1.) Provide an economic description of the reindeer industry, including the inputs obtained from support industry sectors and the outputs sold in and out of the region.
2.) Construct an input-output regional economic model for the Seward Peninsula using IMPLAN databases. Development of the model will focus on the reindeer industry sector and support sectors.
3.) Estimate the direct economic effects caribou have had on the reindeer industry in recent years.
4.) Using the modified IMPLAN model, conduct impact analyses to assess economic impacts given different caribou-reindeer interaction scenarios.

1.2 Proposed research

While urban areas in Alaska have been experiencing expansion and are planning for long-term growth, rural communities in Alaska appear to be experiencing stagnation and decline. The well being of rural residents, the social structure within communities, and the fiscal resources of local governments are all affected by economic change in rural Alaska communities (Geier et al., 1997). Changes in policy or resource management may be documented in rural communities, but the economic effects are often not analyzed. The most significant barrier to developing an understanding of rural Alaskan community economies and conducting impact analyses is the lack of data. Documentation of rural Alaska economies, including subsistence and non-cash activities that are uncommon in urban Alaska and the rest of the United States, is not readily available (ibid). The fact that many significant components of rural Alaska economies are unique; compounded with the remoteness, language, and cultural barriers common to many of the communities, often makes data collection difficult.

Documentation specific to the economic aspects of the reindeer industry on the Seward Peninsula is consistent with the above discussion. The turbulent history of the industry has been described in detail by researchers and historians (Abrahamson, 1968; Olson, 1969; Stern et al., 1980). Studies have also been done on potential profits, optimum herd size, and optimal management strategies (Workman et al., 1991; Stern et al., 1980; Greenberg et al., 1990; Prichard and Finstad., 1999); however, the actual total economic contribution that the reindeer industry has made to the area has been overlooked. Though

the reindeer industry has been a $1.5 million industry on the Seward Peninsula as recently as the mid-1990s, little information is available on actual industry costs and earnings. Discussing impacts of an event such as the change in caribou migration on the reindeer industry necessitates a view of the industry prior to the impact.

The economic aspects of the reindeer industry on the Seward Peninsula will be developed using information gathered directly from reindeer herders, people who work with the herders, and existing research. An IMPLAN (IMpact PLANning) input-output model will be used to study the impact of changes in caribou migration on the reindeer industry. IMPLAN models are available for Alaska on a statewide, U.S. Census Area, borough, or zip code level. The majority of the Seward Peninsula landmass and villages fall within the Nome U.S. Census Area, which will be used to represent the region for the purposes of this study (see Figure 1). The northeast quadrant of the Seward Peninsula falls within the Northwest Arctic U.S. Census Area. The villages of Deering and Buckland, along the northeast coast of the peninsula absent from the map, are the only two Seward Peninsula villages outside of the Nome U.S. Census Area.

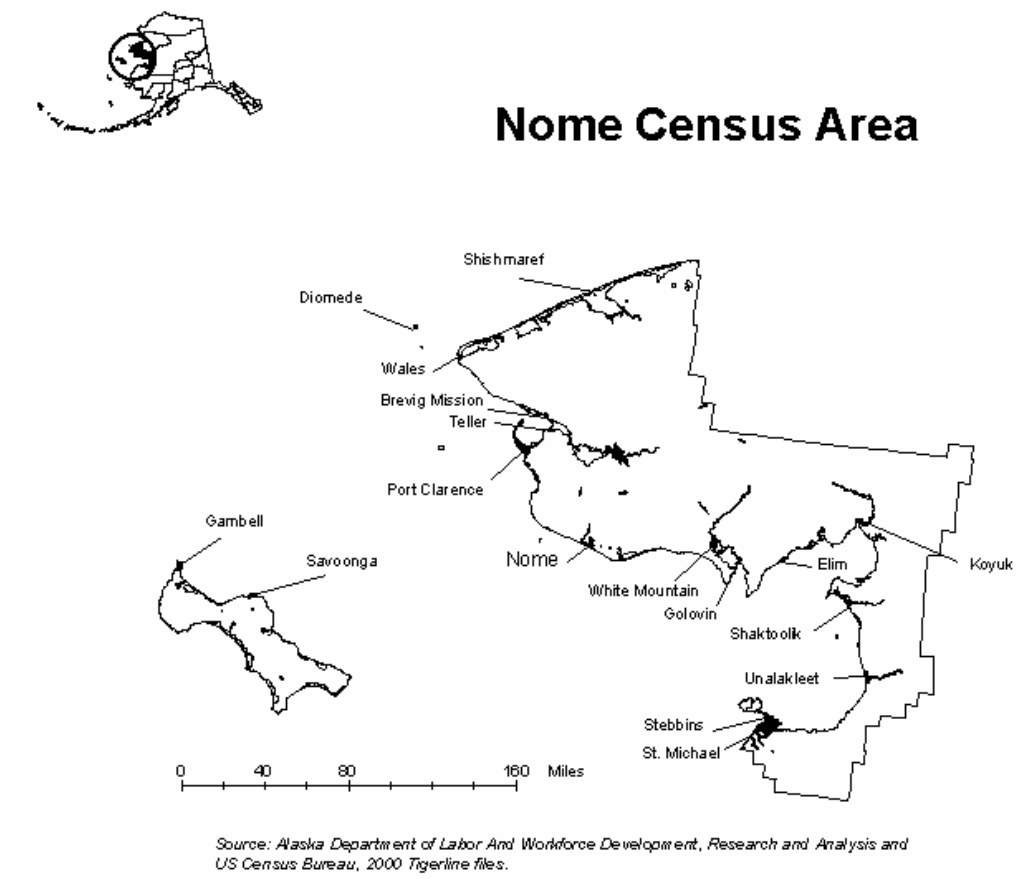

Figure 1. Nome U.S. Census Area.

2.0 BACKGROUND

2.1 History of the reindeer industry

Reindeer (Rangifer tarandus) are a domesticated Rangifer subspecies. They are members of the deer (Cervidae) family. Reindeer were first introduced in the Territory of Alaska in 1891 for the purpose of providing a stable food supply to remote regions. Reverend Sheldon Jackson, Presbyterian missionary and General Agent for Education in Alaska, successfully sought funding for an importation program that brought 1,280 reindeer into Alaska from Siberia between 1892 and 1902. The Russian government ended the exportation program in 1902, but by that time, the number of reindeer in Alaska had grown to 6,505 (Olson, 1969).

The idea of transporting reindeer from Siberia to the Seward Peninsula has been credited to Captain Healy of the United States Revenue Cutter *Bear*. Healy had witnessed starvation among St. Lawrence Island Eskimo in years prior to 1890, when he proposed his idea to Dr. Sheldon Jackson who was a passenger on the cutter. Dr. Jackson's 1893 annual report to the Commissioner of Education includes the following summary of conditions reported by Healy (Abrahamson, 1968):

> I have also seen with apprehension the gradual exhaustion of the native food supply. From time immemorial they have lived principally on whale, seal, walrus, salmon, and wild reindeer (caribou). But in the persistent hunt of white men for the whale and walrus, the latter has largely disappeared and the former driven beyond the reach of the Natives. The

> white men are also erecting canneries on their best fishing streams, and the usual supply of fish is being cut off; and with the advent of improved firearms the wild reindeer (caribou) are migrating farther and farther away. With the disappearance of the whale, walrus, salmon, and reindeer (caribou) a very large portion or their food supply is taken away, and starvation and gradual extinction appear in the near future.

In 1902, 2,841 reindeer belonged to 68 Eskimo herders; 2,176 were on loan to or owned by eight missionary societies; 1,150 were on loan to or owned by five Laplander herders; and 338 remained under Bureau of Education control (Olson, 1969). Jackson pursued a policy of giving ownership of the reindeer to mission churches for their use and distribution to Alaska Natives. Additionally, Jackson supported differential treatment of Lapp and Native owners, which led to Lapps enjoying more privileges of the reindeer program than Natives.

During the summer of 1905, a special agent for the U.S. Department of the Interior traveled to several villages in the region to investigate Jackson and the Bureau of Education. Investigations centered on Jackson's policies linking schools and the reindeer service to missions in the Territory. The investigations uncovered ambiguity between the ownership status of government, mission, and private reindeer. Jackson's resignation followed (Olson, 1969). Starting in 1906, policy shifted to the placement of reindeer directly in the hands of Natives and reducing mission and Lapp ownership, as

recommended by the Department of Interior investigator (Stern et al., 1980). As a result, government and mission ownership of reindeer declined. During the same period, however, Lapp herds increased in size. Between 1907 and 1914, ownership patterns shifted significantly. The table below, provided by Olson (1969), shows the change.

Table 1. Reindeer ownership by group in years 1907 and 1914. (Olson, 1969).

	Ownership distribution in year:	
Ownership	1907	1914
Government	23%	7%
Missions	22%	10%
Lapps	14%	17%
Natives	41%	66%

While the distribution of reindeer to Natives improved during this period, average herd size (already low relative to other ownership groups) declined. In 1907, 114 Native herders owned 6,406 reindeer for an average herd size of 56 reindeer. In 1914, 980 Natives owned 37,828 reindeer for an average herd size of less than 39 reindeer (Olson, 1969).

A major period of non-Native ownership began in 1914 when Carl Lomen of Nome purchased a herd of 1,200 reindeer from a Laplander (Alaska Department of Natural Resources, 1988). The Lomens went on to purchase more than 14,000 reindeer between 1914 and 1929 (Olson, 1969). In 1923, the Lomen Reindeer Corporation (later know as

the Northwest Livestock and Packing Company) was formed. Money from New York financial circles was largely used to purchase the shares. The company constructed slaughter plants and cold storage facilities, organized a steamship company with coastal vessels, and purchased freezer ships to transport reindeer meat to the contiguous 48 states (Alaska Department of Natural Resources, 1988). By 1929 the Lomens were shipping more than 2 million pounds of reindeer meat annually to outside markets. Carl Lomen's promotional campaigns led to the availability of reindeer meat in hotels from coast to coast. While it was the Lomens' policy to export reindeer meat and to leave local markets to Native reindeer owners, conflicts between the Lomen Corporation and Natives went unresolved (ibid).

During this period of expansion for the Lomens and abundance of reindeer, local markets were on the decline. Native herds were formed into associations and stock companies. Several thousand Natives had an ownership interest under this structure, but it was impossible to determine how many reindeer any single individual owned (ibid). Reindeer were left to roam unchecked for increasing periods of time. Herd mixing, localized overgrazing, and a rise in losses to caribou and predators hurt the Native segment of the industry. Additional problems for the Native segment of the industry stemmed from lack of capital and the Lomens' monopoly on slaughtering plants and shipping services. The industry, which was established to benefit Natives of northwest Alaska, was now viewed as primarily benefiting whites (Greenberg, 1984).

At the start of the Great Depression, the export market sharply fell. Throughout the 1920s, however, the growing export market had driven an increase in population to an estimated 640,000 reindeer in Alaska by 1932 (Stern et al., 1980). The population peaked on the Seward Peninsula in the 1930s at 127,331 reindeer (Finstad and Prichard, 2000). By the late 1930s however, the industry was afflicted by range deterioration, predation, disease, and a decline in interest in herding.

In 1932, the U.S. Secretary of Interior sent two representatives to Alaska to investigate the complaints over non-Native ownership in reindeer industry. The investigations resulted in passage of the Reindeer Act. The Reindeer Act of 1937 restricted ownership to Natives and authorized appropriations for the purchase of all reindeer and improvements owned by non-Natives. The purchases of 84,000 reindeer at a cost of $332,991 and improvements for $112,925.72 were completed in 1940. Initially, the Lomens were opposed to the Reindeer Act, but collapse of export markets following the start of the Great Depression changed the Lomens' view of the Act from opposition to support, as it appeared to be an attractive alternative to potential bankruptcy (Greenberg, 1984).

Figure 2 on the following page shows the rise and fall of the reindeer population statewide and local to the Seward Peninsula as provided by Stern et al. (1980). In 1940, an estimated 250,000 reindeer remained in all of Alaska, and only 25,000 in 1950. Following the implementation of the Reindeer Act, herds were reestablished throughout

Alaska, but the eastern herds failed by 1966. Caribou herd migrations through the newly established reindeer ranges were the main reason for the failures. By the late 1970s, only fifteen herds remained in northwestern Alaska. With the exception of one, they were all on the Seward Peninsula, which was free of caribou. There were approximately 20,000 reindeer on the peninsula with individual herd sizes of ranging from 100 to 4,000 reindeer.

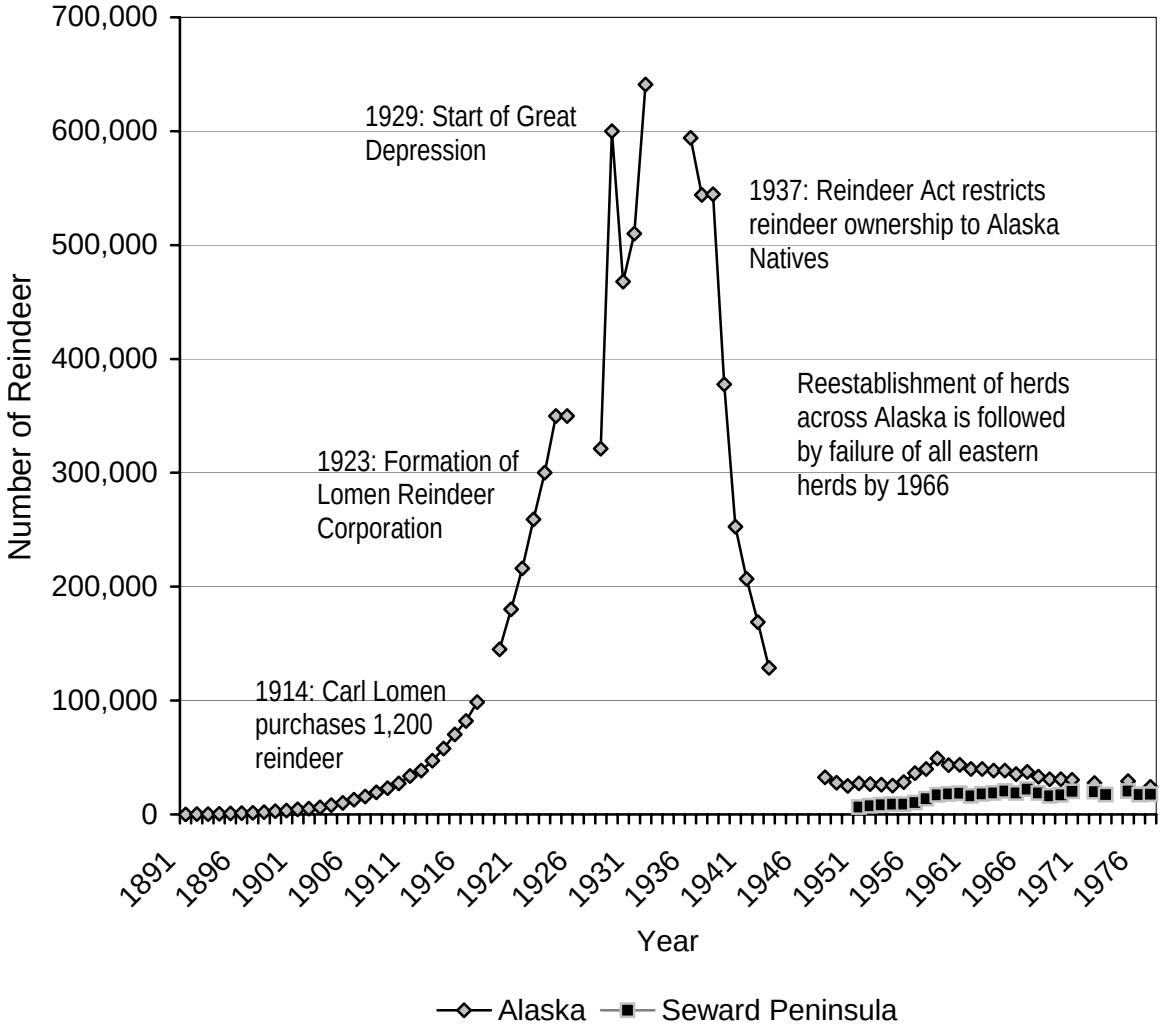

Figure 2. Historic population of reindeer in the Seward Peninsula region, 1951-1977 and statewide, 1891-1977. (Stern et al., 1980).

In the 1980s and 1990s, there were fourteen herds scattered across approximately 25,000 square miles of available rangeland on the Seward Peninsula, with an average individual grazing permit area of more than 1,500 square miles. In the early 1990s the total Seward Peninsula reindeer population was estimated to be approximately 30,000 animals (Finstad and Prichard, 2000).

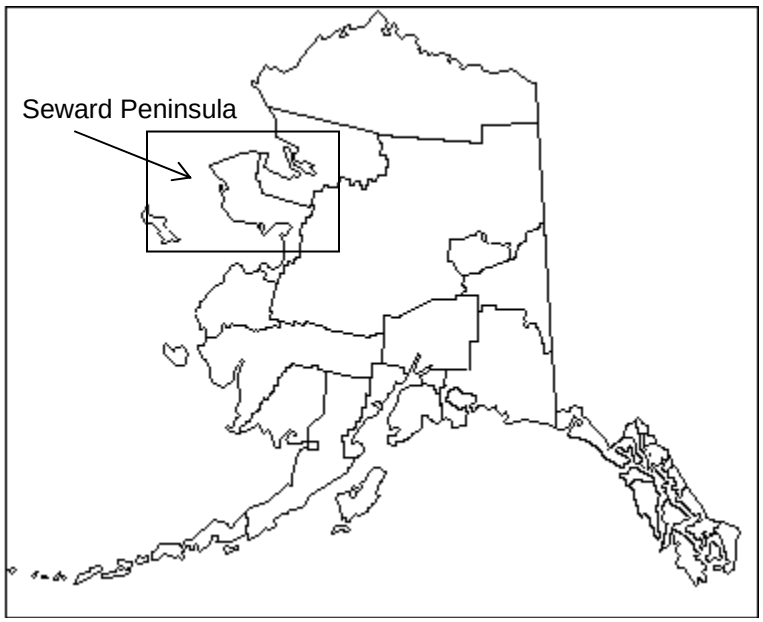

Figure 3. Seward Peninsula.

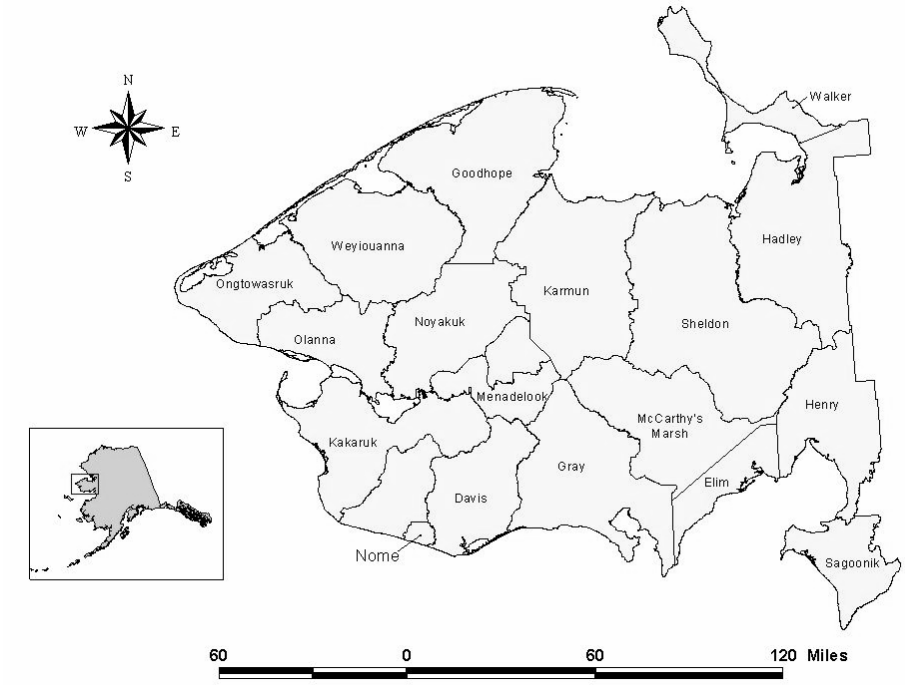

Figure 4. Seward Peninsula reindeer range allotments.

Recent caribou co-mingling and out migration has led to a dramatic decline in the Seward Peninsula reindeer population. In 2000 and 2001, the population across all ranges on the peninsula was estimated to be fewer than 20,000 reindeer. Several herders, from the eastern and central ranges of the peninsula are no longer able to locate or herd their reindeer (Finstad et al., 1999). As caribou have continued to winter on the Seward Peninsula, significant numbers of reindeer have been lost from central and western herds. Only three commercially viable herds remain on western ranges as of spring 2003 (Dau, 2003).

The late 1980s marked the period during the last half of the 20th century of greatest reindeer concentration in the eastern portion of the Seward Peninsula. The decline, and ultimate disappearance, of the eastern reindeer herds was the first sign of the severity and persistence of recent changes in caribou migration paths.

The central reindeer herds of the Seward Peninsula reached their peak herd size in the early to mid 1990s when by 1995, caribou migration extended into the central portion of the Seward Peninsula. During the same period, the population of western reindeer herds on the peninsula was stable or on the rise. The WACH, however, continued expanding the western boundary of their winter range (Finstad et al., 1999). Caribou are now impacting all Seward Peninsula reindeer herders. Currently, the herders who still have reindeer are focusing on protecting the reindeer on their ranges with the hope that the

caribou migration paths will resume to their traditional routes and the herder will subsequently be able to reestablish their herding operations.

2.2 Reindeer-caribou interaction

The WACH is Alaska's largest caribou herd with a range that spans 140,000 square miles bounded by the Arctic Ocean, the lower Yukon River and the trans-Alaska pipeline. Following a population crash in 1975, the herd's population expanded from just 72,000 animals to 463,000 animals in 1996. The herd population had been thought to be in decline when the 1999 ADFG survey estimated the population to be 430,000 animals (ADFG, 2002). However, the most recent ADFG survey estimates that the herd's population has increased to at least 490,000 animals and that the herd has grown on average one percent per year over the last decade (Woodford and Dau, 2004).

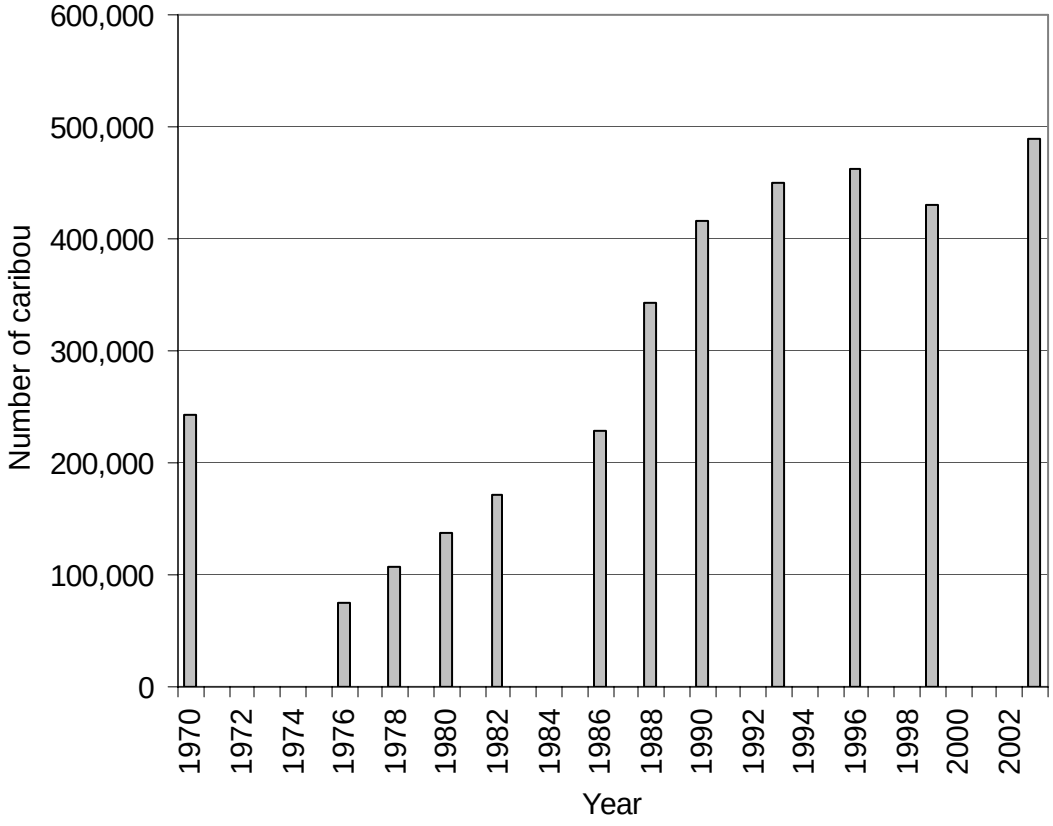

Figure 5. Western Arctic Caribou Herd photo-census population estimates, 1970-2003. (Alaska Department of Fish and Game, 2002; Woodford and Dau, 2004).

Throughout the 1990s, the WACH seasonal migratory routes shifted from the eastern edge of Seward Peninsula reindeer ranges westward through established reindeer ranges of the Seward Peninsula where caribou had been absent for more than 150 years (ADFG, 2002). Caribou use the peninsula for winter range and then return north to their calving grounds each spring. While caribou are on the reindeer ranges, they intermingle with the reindeer. Reindeer that are surrounded by caribou intermix with the herd, begin to move

with them, and finally out-migrate with the herd in the spring. In addition to the loss of reindeer to out-migration, caribou also impact range condition on the peninsula. Large numbers of caribou feeding on reindeer rangeland will have an affect on the plant communities, decreasing productivity of the range (Finstad et al., 1999). The availability of winter forage, primarily lichen, is the limiting factor in establishing carrying capacity of Seward Peninsula reindeer ranges (Greenberg et al., 1990). Lichen is very slow growing, thus recovery from overgrazing may take decades (Finstad and Prichard, 2000). Decreased range productivity brought on by migrating caribou is a consequence for reindeer herders that will outlast the presence of caribou.

All reindeer herders on the Seward Peninsula have practiced an extensive form of herd management to keep their costs and time commitment to their herding operation low. Most herders supplement their income with subsistence activities, and some with other businesses or employment (Stern et al., 1980; Alaska Department of Natural Resources, 1988). Reindeer move freely throughout a large allotment and only have sporadic contact with herders. Under current extensive style management practices, protecting reindeer from large numbers of caribou would be impossible (Finstad et al., 1999).

The increasing presence of caribou on eastern Seward Peninsula reindeer ranges from 1991 to 1995 led to the complete loss of three reindeer herds (a loss of more than 5,000 reindeer). During fall 1996, an estimated 90,000 to 100,000 caribou migrated through central Seward Peninsula ranges. Four reindeer herders lost 50-75 percent of their herd

to out-migration with these caribou. Open water and lack of snow that season made overland pursuit and attempts to segregate the reindeer from caribou impractical (Finstad et al., 1999).

Three of the aforementioned four herders lost additional reindeer to caribou that returned to the Seward Peninsula during the winters of 1997 and 1998. By the summer of 1999, these herders had lost over 7,000 reindeer in total and could not economically justify corralling their remaining reindeer (ibid). Each winter, additional reindeer have joined WACH. Only three commercially viable herds remain on the Seward Peninsula as of spring 2003, all located on western ranges (Dau, 2003).

2.3 Policy

Four significant pieces of national legislation have shaped the complex management structure the reindeer industry faces on the Seward Peninsula today. The centerpiece of United States reindeer policy is the Reindeer Act of 1937 (Public Law 75-413), which restricted the right to own reindeer in Alaska to Natives.

The purpose of the Reindeer Act as stated in Title 25 Chapter 14 subchapter VII sec. 500 is as follows:

> A necessity of providing means of subsistence for the Eskimos and other natives of Alaska is hereby declared to exist. It is also declared to be the policy of Congress, and the purpose of this subchapter, to establish and

> maintain for the said natives of Alaska a self-sustaining economy by acquiring and organizing for and on behalf of said natives a reindeer industry or business, by encouraging and developing native activity and responsibility in all branches of said industry or business, and by preserving the native character of the said industry or business thus established.

In addition to restricting reindeer ownership to Natives, the Reindeer Act provided authority and appropriations for the Secretary of Interior to acquire reindeer, reindeer-range equipment, slaughterhouses, cold-storage plants, warehouses, and other property determined to meet the purpose of the Act. This provision led to the acquisition of non-Native reindeer industry holdings and redistribution to Natives. The Act also authorized and directed the Secretary of the Interior to organize and manage the reindeer industry to establish and maintain a complete and self-sustaining economy for Natives of Alaska, and to encourage and develop the activity and responsibility of Natives in all branches of the industry. The Act further authorized the Secretary of Interior to regulate grazing of reindeer on public lands in Alaska, which includes defining reindeer ranges and regulating their use for grazing reindeer; issuing grazing permits; and regulating and controlling all round-ups, handlings, markings, and butcherings of reindeer.

Alaska became a state in 1959. As part of the Statehood Act (Public Law 85-508), Alaska was given rights to select approximately 30 percent of the land within its

boundaries. As part of its overall entitlement, the state selected approximately 45 percent of the Seward Peninsula (Thomas and Arobio, 1983). These lands are managed by the State of Alaska, Department of Natural Resources. Beginning in 1962, the management of federally held reindeer rangeland changed hands from the United States Department of the Interior, Bureau of Indian Affairs to the Bureau of Land Management.

The Alaska Native Claims Settlement Act of 1971 (Public Law 92-203) allowed Alaska Natives to select lands from the public domain and created twelve, regional, for-profit corporations owned by the Native peoples associated with each region within the state. Two of these corporations have lands within Seward Peninsula reindeer ranges. The Bering Straits Native Corporation lands are located in the western and southern portion of the Seward Peninsula, and the NANA Regional Corporation lands are in the northeast portion of the peninsula.

Alaska National Interest Lands Conservation Act of 1980 (Public Law 96-487), led to the transfer of approximately 30 percent of the peninsula to the United States Department of the Interior, National Park Service. This land is now the Bering Land National Preserve, located in the northwest and north central portion of the Seward Peninsula.

Since the 1970s, there have been 14 reindeer range allotments in use on or adjacent to the Seward Peninsula. Those 14 allotments now fall under a complex mix of land management agencies including State of Alaska Department of Natural Resources

(DNR); United States Department of Interior, National Park Service (NPS); United States Department of Agriculture, Bureau of Land Management (BLM); two regional corporations, and several village corporations. DNR, NPS, and BLM issue permits through a single lead agency to simplify the permitting process. The state and federal permits are issued on five-year cycles. The DNR recently increased their filing fee from $50 per herder to $100 per herder every five years; however, has since waived the fee due to the caribou crisis. The NPS also has waived their small filing fee. The BLM charges herders $10 every five years, and has not waived the fee.

Each reindeer range allotment includes lands of one or more village corporations. Herders pay the village corporation local to their allotment a small fee for use of their rangeland. The fees required vary from village to village, but several herders indicated they are able to pay village corporations with meat instead of cash.

Currently seven reindeer range allotments fall, to some degree, within the boundaries of the Bering Land Bridge National Reserve. The NPS manages the Reserve. Use of low flying aircraft, snow machines, and corrals in reindeer herding operations puts those herders on NPS lands in direct conflict with the conservation agency's management approach (Thomas and Arobio, 1983). In general, the NPS limits the interference of human beings in designated natural or historical environments. The NPS is faced with traditional use patterns conflicting with their tradition of resource preservation in the Bering Land Bridge National Reserve.

The multi-agency patchwork that currently makes up the Seward Peninsula reindeer ranges creates great uncertainty for the future of reindeer herding on the peninsula. Before the recent caribou problem, reindeer herd size was increasing (Prichard and Finstad, 1999). Furthermore, many herders had developed and began to implement long-term rotational grazing plans to manage their ranges for improve lichen production (Swanson and Colville, 1999). Thomas and Arobio emphasize that the success of the reindeer industry would cause the 1980s to be a period of conflict among land management agencies and between agencies and herd owners. Tensions did begin to rise as the potential for wealth in the reindeer industry prompted interest in raising range fees on public lands.

The sudden loss of reindeer has not only put plans to raise fees on hold; but also warranted a waiver of state and NPS grazing permit filing fees in recent years, as mentioned above. During the fall 2000 Kawerak Reindeer Herders Association meeting, reindeer herders expressed concern that permits may not be re-issued if herders were unable to keep reindeer on their range.

2.4 Region

The city of Nome serves as the regional transportation and service hub for many surrounding villages, and is the center of the Seward Peninsula regional economy. The population of Nome is approximately 3,500. The next largest community in the region is

the village of Shishmaref with a population of 562. The village with fewest residents on the Seward Peninsula, Wales, has 152 residents. Nome can be accessed via regularly scheduled flights from Anchorage, which is 539 miles to the southeast. Once in the region, several small air charter businesses service the villages.

Within Nome, government service, retail trade, transportation, mining, medical service, and other business sectors provide year-round income. According to year 2000 U.S. Census data, nearly 40% of the 2,547 persons who made up the total potential work force in Nome were not working. Eleven percent of the work force was unemployed and seeking work while 28.4% of the potential work force was not seeking work. Year 2000 per capita income in Nome was $23,402 and the median household income was $59,402.

Nome and all but the northeast portion of the Seward Peninsula fall within the Nome U.S. Census Area. The Nome U.S. Census Area covers 23,000 square miles and includes St. Lawrence and Diomede Islands in the Bering Sea. According to Bureau of Economic Analysis Regional Economic Information System reports, the population of the Nome U.S. Census Area in 2000 was 9,185 and ranked tenth of twenty-seven areas in Alaska while total personal income for the Nome U.S. Census Area ranked twelfth in the state. Total personal income in the Nome U.S. Census Area was $197,033,000 in 2000, accounting for only 1.1 percent of the state total. Of the Nome U.S. Census Area total personal income in 2000, earnings (wages and salaries, other labor income, and proprietor's income) accounted for 59.7 percent; dividends, interest, and rent made up

11.0 percent; and transfer payments made up 29.3 percent of the total personal income. In comparison, statewide earnings were 67.0 percent of total statewide personal income; dividends, interest, and rent were 16.8 percent of total statewide personal income; and transfer payments were 16.2 percent of total statewide personal income. The comparison between Nome U.S. Census Area and statewide personal income statistics show transfer payments play a more prominent role in the Nome U.S. Census Area economy than statewide.

Per capita, the Nome U.S. Census Area had a personal income of $21,452 in 2000, ranking nineteenth of twenty-seven areas in the state. This per capita personal income for the area was 72 percent of the state average, $29,642, and 73 percent of the national average, $29,469. In comparison, the Anchorage Borough had a per capita personal income of $39,950. The Anchorage Borough is part of the Anchorage Metropolitan Area and is the most populous area in Alaska with an estimated 260,596 persons in 2000. The below-average personal income is exacerbated by the extraordinary high cost of living associated with rural Alaskan communities, particularly those away from the road system.

Earnings of persons employed in the Nome U.S. Census Area increased at an average annual growth rate of 2.8 percent from 1990 to 2000, compared to a rate of 3.0 percent statewide and 3.4 percent in the Anchorage U.S. Census Area. The largest industries in the Nome U.S. Census Area in 2000 were state and local government, 36.8 percent of

earnings; services, 32.3 percent; and retail trade, 8.1 percent. In comparison, the state and local government sector was accountable for only 16.7 percent of 2000 earnings of all persons employed in Alaska and 12.1 percent of earnings for persons employed in the Anchorage Borough (Bureau of Economic Analysis, 2002).

The primary source of year round employment in the outlying villages in the region is with schools, health clinics, and city and village organizations. Seasonal activities such as reindeer herding, hunting, trapping, fishing, fish processing, and native art offer important commercial and subsistence opportunities in the region (Alaska Department of Labor and Workforce Development, 2003 (1)).

The total Nome U.S. Census Area annual average labor force was 3,337 in 2000, and the average annual unemployment rate was 12.0 percent. In 1990, the annual average labor force was 3,176, with an unemployment rate of 8.9 percent (Alaska Department of Labor and Workforce Development, 2003 (2)). Between 1990 and 2000, the monthly unemployment rate peaked in June in eight of the eleven years. In the other three years, including 1994, 1993, and 1990, the unemployment rate peaked in May. In each of the years, 1995-2000, the monthly unemployment rate in May, June, and July exceeded the annual average rate. Note that the most labor-intensive reindeer herding activity, summer handling, occurs during this period.

Immense land area and low population levels characterize rural Alaska. Low population density and large land area prevent development of an inexpensive means of ground transportation. Ground transportation is limited to travel by snow machine, local road systems, boats, and barges. During winter months, an extensive system of snow machine trails develops, connecting many Seward Peninsula villages. The largest road system in the region surrounds the city of Nome. Local roads extend from Nome northwest to Teller, east to Council, and northeast to the Kougarok River. The roads are not maintained in the winter. Water transportation is inexpensive, but also only seasonally available since waters surrounding the Seward Peninsula are ice-free only during the summer months. Air transportation is widely available, but costly. The savings enjoyed in using less expensive water transportation over air transportation for shipping supplies are somewhat offset by a high cost of inventory forced by the limited barge schedule. The regional market economy is constrained by these high transportation costs associated with limited inter and intra regional land access and by the availability and cultural importance of non-market alternatives.

The influence of traditional culture is prevalent throughout rural Alaska. Alaska Natives, primarily Inupiaq Eskimos, are the majority population in the region. In Nome, 58.7% of residents are all or part Alaska Native. Populations of other Seward Peninsula communities are between 86.2% and 96.8% all or part Alaska Native (Alaska Department of Community and Economic Development, 2002).

A traditional subsistence lifestyle is important to many Alaska Natives and some non-Natives who choose to live in rural Alaska. Subsistence is an economic as well as a cultural activity (Tuck and Huskey, 1986). Hunting, fishing, and gathering activities are important sources of real income for rural Alaska residents, providing a reliable economic base for many rural regions in the state (Tuck and Huskey, 1986; Wolfe and Walker, 1987). In much of rural Alaska, residents rely on subsistence products for as much as half of their food consumption, which emphasizes the reliance on non-market alternatives (Tuck and Huskey, 1986). A study conducted in the 1980s found that in many regions of Alaska, subsistence harvest levels were as much as two to four times the U.S. average use of meat, fish, and poultry (Wolfe and Walker, 1987). Tuck and Huskey call attention to the fact that economic well-being of rural Alaska residents is a function of both the market and non-market sectors. This type of economy is referred to as a "mixed, subsistence-market economy" (Wolfe and Walker, 1987).

In Alaska's rural mixed economies, fishing and hunting are central activities conducted by domestic family groups with efficient small-scale technologies such as fishwheels, gillnets, skiffs, and snow machines. Subsistence activities are directed toward meeting the needs of families and small communities, not for profit. Subsistence productivity has become more dependent on cash input since the introduction of modern, western technology. A study of four communities in western Alaska found that households devoted 11% of their income to subsistence related expenditures, including fuel used in subsistence related activities, purchase of supplies, and equipment repairs. This figure

does not include the households' major expenditures such as boats and motors, snow machines, rifles, traps and snares, set gillnets, and chainsaws, which are necessary to maintain the subsistence sector in the region studied. Residents of the study region expended $1 million in the subsistence equipment that was used during a one-year period. In the same area, total income for a year was $1.7 million (Geier et al., 1997).

A study by Wolfe and Walker (1987) examining the productivity and geographic distribution of subsistence harvests in Alaska during the 1980s found subsistence productivity linked to four factors: distance from the urban population centers, roads, degree of settlement entry, and community income. Wolfe and Walker's findings are summarized below.

- In general, subsistence productivity increases as the distance from the urban population centers increases.
- Subsistence productivity decreases with the presence of roads. In the 1980s, communities along the main road or the marine highway system were found to have harvested 69% less than communities off of the road network.
- Subsistence productivity decreases as the percentage of non-Natives in a community's population increases.
- Subsistence productivity decreases as a community's average personal income increases. In addition, a community's non-Native population and mean income were found to be positively associated, rising together.

All Seward Peninsula communities are far from urban centers and off of the main road network. In addition, the Native population dominates the region. These factors are associated with a high level of subsistence harvests.

A subsequent study by Robert Wolfe of Alaska Department of Fish and Game Division of Subsistence (1987) further examined the correlation between cash income and subsistence activities. Wolfe discusses a general phenomenon he refers to as the super-household. Wolfe's findings support the "30-70 rule": thirty percent of the households produce about seventy percent or more of the community's subsistence harvest. This portion of high production households is made up of super-households. Three principal reasons Wolfe found for the super-household phenomena include the need to harvest for dog teams, the developmental cycle of households, and the subgroup phenomena in culturally diverse communities. It is the second explanation that is of interest in this study.

Households generally experience a regular developmental cycle as time passes. Newly established households are characterized by inexperienced household heads, young children, incomplete subsistence equipment holdings (nets, motors, smokehouses, and caches), and a relatively light burden of social obligations. In contrast, a mature established household is characterized by experienced household heads, teenage children and young adults (laborers), complete holdings of subsistence equipment, and a relatively large set of social obligations in regards to subsistence production. It is these mature

households that serve as the core household in a multi-household kinship group. The final stage of the developmental cycle is characterized by an experienced household head, an absence of children (an incomplete pool of labor), and variable equipment holdings. These elderly households also have a reduced social obligation to produce food (Wolfe, 1987).

Wolfe found the highest third households in subsistence productivity to have characteristics of mature households. The high producing households tended to be older and larger. Importantly, equipment holdings were also larger in the most productive households. The upper third producers in Wolfe's study held approximately twice as much total equipment in comparison with the middle and lower thirds. Subsistence foods flow out of high producing households and into low and middle producing households.

Generally reindeer herders fit the characterization of mature and elder households. Due to demands of their reindeer operations, reindeer herders maintain large holdings of equipment that can be used to support both their reindeer business and subsistence activities. Moreover, reindeer herders take on great social responsibility, as they are known as a source of reindeer meat and employment for members of their extended family and other households in their community.

A summary of constraints to economic development in rural Alaska, offered by Tuck and Huskey (1986), provides a commonsensical description of several problems associated with economic development on the Seward Peninsula.

> Physical and cultural characteristics of the region define constraints to economic development. Low density of population means that only the few types of goods and services, which can efficiently serve low levels of population, can profitably be produced locally, and that only limited infrastructure will be available. These conditions imply that cost of production will be high for goods produced in the region. The importance of subsistence affects both the residents' demand for market products and their willingness to work. The importance of seasonal resource harvesting increases the opportunity cost of market work when work is available (Tuck and Huskey, 1986).

The reindeer industry is one of few private commercial development opportunities with several characteristics falling outside the constraints of the region. The reindeer industry produces meat for residents of the peninsula from rangeland that has little to no competing commercial interests. Inputs are minimal and labor and management demands are seasonal as well as somewhat flexible, allowing herders and labors to continue to take advantage of subsistence opportunities. In addition, the reindeer industry has been able to profitably produce meat and velvet antler for export from the region, bringing much needed cash into remote villages to support the increasing cost of equipment used for subsistence activities.

3.0 REINDEER OPERATIONS

3.1 Reindeer herd management

Reindeer herding is just one of several cash and income-producing activities for Seward Peninsula reindeer herders. In addition to herding activities, herd owners participate in subsistence hunting, fishing, and gathering; wage labor; and entrepreneurial enterprises. Herd sizes of roughly 1,000 to 2,000 animals on the Seward Peninsula have, in past years, produced enough income to cover production costs and provide income while allowing time for these other activities (Arborio, 1979).

Smaller herds have been maintained primarily to supply meat to the herd owner with little or no cash return. These operations of fewer than 1,000 animals generally were not long-standing. All herds require some capital and labor, and owners who operate very small herds and yield higher returns participating in other activities may not be left with enough resources to devote towards the survival of their herd (Arborio, 1979; Stern et al., 1980).

Subsistence activities, other income producing opportunities, and seasonal weather all influence the extent and timing of herding activities. Seward Peninsula reindeer herds are left unattended for long periods of time. The herding activities that occur routinely include checking the condition and location of the herd and reducing the threat from predators. Herders have generally allowed their reindeer to move freely on the range, though they may move them in response to forage conditions or predators. Herders check on their reindeer using snow machines, air charters, and radio-telemetry and

satellite collars. In addition, other villagers and pilots notify herders of reindeer locations if they encounter a herd while traveling. Travel across the tundra of the northwestern Alaska during the summer months is much easier for reindeer than for the herders who depend on snow machines, all-terrain vehicles, and travel by foot. Reindeer move easily across the exposed tussocks, shrubs, and open water of summer, while herders' mobility is impeded.

Summer handlings occur in June or July primarily for the purpose of harvesting velvet antler for cash income and marking and tagging calves. Reindeer are located and herded into a corral area using a helicopter or snow machines and a work crew on foot. Reindeer are processed through the corral through a controlled chute where an inventory is taken of each animal, ears of unmarked adults and calves are tagged and notched, antlers are cut from adults, and any necessary drugs are administered. Most often, many reindeer are castrated or butchered at summer handlings.

Most slaughtering occurs November through February. Commercial slaughtering necessitates frozen, snow-covered ground on which the animals can be field slaughtered and dressed. Carcasses freeze quickly during this time of year, reducing the risk of spoilage and need for cold storage during transport. Herders and workers use snow machines to approach the reindeer herd. The reindeer are then shot and dressed in the field. Sleds pulled behind snow machines are used to transport carcasses which are sold

locally, traded for labor, or delivered to the owner's village store. For further distances, air charters are typically used to transport carcasses at the buyer's expense.

Though a herder may plan to butcher a certain number of steers and old bulls, several factors could prevent the plan from being carried out successfully once in the field. Subzero temperatures common throughout the winter months, difficulty in locating the herd, or a scattered herd each could result in smaller harvest or butchering reindeer of a less appropriate sex and age class (Stern et al., 1980).

3.2 Availability of information

There is little recently published documentation on the economics of the Seward Peninsula reindeer industry, though there are several individuals who are knowledgeable of the industry labor and supply inputs and of the primary industry outputs. The reindeer herders, Kawerak Reindeer Herders Association staff, University of Alaska Fairbanks Reindeer Research Program staff, University of Alaska Cooperative Extension Service Northwest District staff, and meat and antler buyers are most familiar with the reindeer operations and serve as valuable resources for collecting information on the industry.

A detailed description of Seward Peninsula reindeer operation inputs and outputs in the late 1970s is provided in a report titled *Eskimos, Reindeer and Land*, which was based on an interdisciplinary research project carried out by the University of Alaska Fairbanks to examine the social, economic, and cultural aspects of reindeer herding in northwestern Alaska (Stern et. al., 1980). Additionally, Greenberg (1984) used a profit maximizing

linear programming model to determine whether the economic performance of a reindeer operation could be improved through more intensive herd management.

The Kawerak Reindeer Herders Association conducts annual surveys to gather cost and earnings information from Seward Peninsula reindeer herders. Throughout the 1990s, response rates to the annual survey were low. With the exception of 1996, fewer than half of the herders completed the surveys. In all years, among those who did provide information on surveys, there is a high rate of either item non-response or occurrence of responses that are difficult to interpret. For example, when asked how much labor was used in one year for butchering, the types of answers that herders provided differed. In response to the butchering labor question, the following types of answers are found in a single year of annual survey responses: 1) total number people that participated, 2) total number of hours worked, and 3) total number of reindeer butchered. It would be impossible to convert all of the responses into a common measure of labor without follow up interviews.

The small number of responses and inconsistent quality of responses diminish the value of formal statistical analysis on the Kawerak Reindeer Herders Association annual surveys. The survey results do, however, serve as a helpful check against information gathered from other sources.

3.3 Outputs

A reindeer herding operation generates two main products: velvet antler and meat. All velvet antler harvested on the Seward Peninsula is sold to buyers and processing facilities outside of the region. Some antler is processed in Anchorage, but during years of high prices, many herders sold their antler to buyers in California.

Preceding the recent influx of caribou, revenues from velvet antler far outweighed revenues from meat sales. In the late-1990s, however, the price paid for antler and the associated earnings declined to levels equal to earnings from meat sales. Table 2 below provides estimates of total earnings from antler sales and Figure 6 presents changes in the price paid for velvet antler, 1991-2000.

Table 2. Estimated total Seward Peninsula reindeer antler harvested and associated earnings, 1991-2000.

Year	Pounds harvested	Estimated revenue
1991	32,727	$1,251,156
1992	22,729	$900,820
1993	21,595	$773,215
1994	30,897	$1,077,595
1995	27,817	$886,813
1996	24,118	$691,772
1997	31,099	$379,408
1998	7,242	$59,322
1999	12,213	$143,261
2000	23,104	$386,628

Source: Estimates of pounds harvested provided by University of Alaska Fairbanks Reindeer Research Program. Revenue estimates based on data shown in Figure 6.

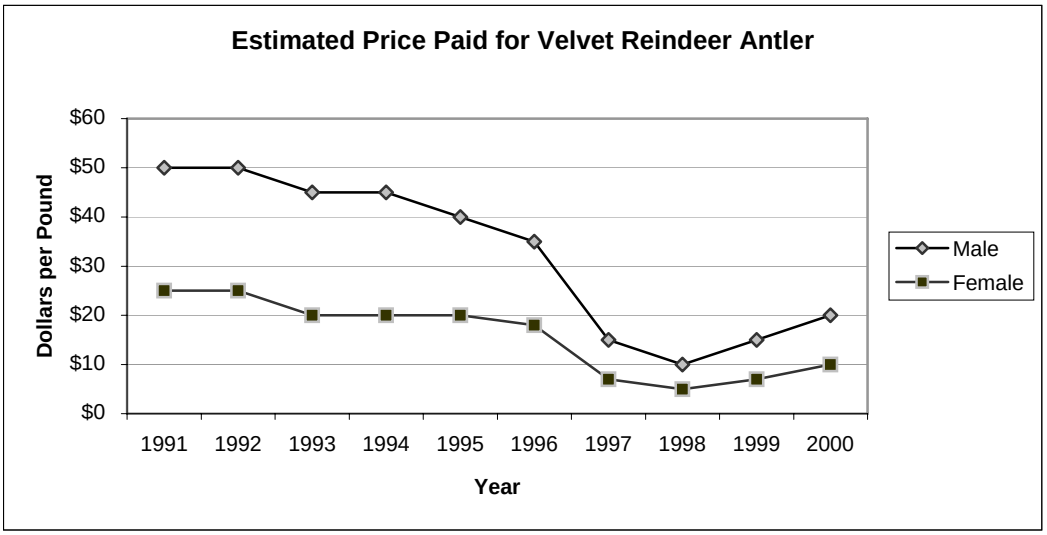

Figure 6. Estimated price paid for Seward Peninsula velvet reindeer antler, 1991-2000.

Source: Price data initially provided by antler buyer was adjusted and validated through personal communication with Seward Peninsula reindeer herders and survey data.

There are three distinct markets for meat supplied by Seward Peninsula reindeer herds: the village stores local to each herd, grocery stores and processors in Nome, and grocery stores and processors outside of the region. Because there is currently no federally inspected slaughter facility in the region, meat produced by Seward Peninsula reindeer herders must not be sold outside the state. Some of the carcasses sold to Nome grocers/processors are processed and shipped to other areas of the state, but most of the meat is sold locally.

Generally, local village stores are charged a lower price per pound for carcasses than the larger stores in Nome and outside of the region. The exception to this rule is a processor

in Nome who offers credit to herders so they can buy needed equipment before their reindeer are harvested. In exchange for the credit, the processor pays a lower price for product. At the time of this study, grocery stores in Nome were paying herders $2.20 to $2.50 per pound. Some herders remaining in operation have begun asking for a higher meat price as caribou encroachment has reduced available supply of reindeer carcasses. Asking prices reached as high as $2.95 per pound in 2000. Grocers in Nome prefer to purchase meat from herders who have access to the road system to keep cost down, but will use air charters to fly meat in from more remote ranges. Surveys showed that local village stores have purchased carcasses for $1.75 to $2.50 per pound in recent years, and most meat sold locally for $1.75 to $2.00 per pound.

Preliminary revenue estimates attributable to meat sales were constructed by combining information obtained from informal interviews with meat buyers, personal communication with reindeer herders at the fall 2000 Kawerak Reindeer Herders Association meeting, and Kawerak Reindeer Herders Association survey data. The resulting estimated number of pounds sold, price herders received per pound (year 2000 prices), and total value of the meat at 2000 prices are provided below (Table 3). The production level shown in Table 3 is not representative of any single year, but the sum of typical annual production for each herd prior to significant losses to caribou. For those herds not yet impacted at the time of the fall 2000 Kawerak Reindeer Herders Association meeting, 1999 or anticipated 2000 meat production estimates were used. Kawerak Reindeer Herders Association annual survey results supplemented data gathered

from herders in-person to estimate typical annual sales to local villages. Meat buyers located in Nome provided rough estimates of their total annual Seward Peninsula reindeer meat purchases, and some broken out by herd. They also provided information on sales off of the peninsula.

Table 3. Seward Peninsula reindeer industry estimated meat sales for years preceding caribou impact, all herds combined.

Buyer:	Estimated pounds sold	Price per pound (year 2000 prices)	Estimated total value at year 2000 prices
Local villages	55,000	$1.75-$2.00	$100,000
Nome stores/processors	70,000	$2.00-$2.50	$155,000
Outside of the region	60,000	$2.20-$2.50	$140,000
Total	197,500	$1.75-$2.50	$395,000

Source: Personal communication with local meat buyers and reindeer herders and Kawerak Reindeer Herders Association survey data.

The above estimates of meat sales are considered to be conservative estimates. Not all reindeer meat buyers or sellers participated in constructing the estimates, which weakens the accuracy of the estimates. Information obtained directly from herders showed a high level of variability between herders and between years in the amount of meat they produced and sold, so the average across several herders may not be representative of the meat sales for herds missing information. Additionally, of the information that was provided by herders, the quality varied. To report meat harvest levels prior to impact

from caribou, several herders had to recall harvest information from more than five years ago. This recalled information is expected to be less accurate than if it had been collected at the time of harvest. Since there is no recent documentation of total meat sales from Seward Peninsula reindeer to serve as a more accurate source of meat harvest data, historic Bureau of Indian Affairs records are used to estimate a reasonable range in annual meat production prior to the influx of caribou.

Bureau of Indian Affairs, Juneau Area Office, Branch of Land Operations published annual reports that included summary information for each reindeer herd in the state (Bureau of Indian Affairs, 1966-1970). One of the tables appearing in each of the annual reports includes the number of reindeer on hand, the number of carcasses sold, and the number of carcasses used in home or in herd operations for each herd. Since the annual reports provide information by herd, the ranges located on the Seward Peninsula could be broken out from the rest of the state. Summary data specific to the Seward Peninsula herds from the most recent five years of BIA reports, 1966 through 1970, are compiled and shown below (Table 4).

Table 4. Seward Peninsula reindeer herd summary information as presented by Bureau of Indian Affairs annual reports, 1966-1970.

Time period	Reindeer on hand	Carcasses sold	Carcasses used in home and herd operation
1966	23,768	2,850	870
1967	20,310	2,480	945
1968	17,894	3,807	668
1969	18,388	1,979	542
1970	21,701	2,355	446
1966-1970 Average	20,412	2,694	694
1966-1970 Range	5,874	1,828	499
1966-1970 Standard deviation	2,417	696	212

A comparison of the number of reindeer on hand during the five-year period, 1966 to 1970 (Table 4), to the five-year period leading up to the influx of caribou (Table 5) shows remarkable similarities. The Seward Peninsula reindeer population during the period documented by BIA averaged 20,412 reindeer per year. According to Kawerak Reindeer Herders Association tally data, the average number of reindeer on the peninsula in the more recent five-year period was only slightly higher (20,723 reindeer).

Table 5. Seward Peninsula Reindeer herd population as provided by Kawerak Reindeer Herders Association tallies, 1988-1992.

Time period	Reindeer on hand
1992	20,477
1991	21,400
1990	24,374
1989	18,886
1988	18,477
1988-1992 Average	20,723
1988-1992 Range	5,897
1988-1992 Standard deviation	2,359

Since the Seward Peninsula reindeer population during the most recent five-year period of BIA harvest data approximates the population in years leading up to the recent influx of caribou, BIA 1966-1970 harvest data are used in this study as a substitute for the total meat sales estimate shown in Table 3. As noted, the total meat sales estimate constructed using information obtained from meat buyers, herders, and Kawerak Reindeer Herders Association survey results was thought to be an inaccurate, underestimation of actual total meat sales leading up to the influx of caribou. Historic BIA harvest data are combined below with year 2000 meat prices to provide industry-wide meat revenue data for this study (Table 6).

Table 6. Translation of the historic levels of meat production on Seward Peninsula reindeer ranges to year 2000 revenues.

Time period	Carcasses sold	Meat revenue (2000 value)
1966	2,850	$684,000
1967	2,480	$595,200
1968	3,807	$913,680
1969	1,979	$474,960
1970	2,355	$565,200
1966-1970 Average	2,694	$646,608

At $2.00 per pound and an average of 120 pounds per carcass, the average annual income for a level of meat production equal to that of the five-year period, 1966-1970, is $646,608. The 120-pound average carcass weight figure has been used in past studies to estimate the quantity of meat sold or consumed, including Arobio (1979), Stern et al. (1980), and Bureau of Indian Affairs annual reports (1960-1971). The fewest carcasses sold during the period were in 1969 at 1,979. The most carcasses sold in one year during the period were in 1966 at 2,850. As the table above shows, this would translate to a range of approximately $474,960 to $913,690 if sold in 2000.

In addition to velvet antler and meat production, the Seward Peninsula reindeer industry produces byproducts including reindeer hides, leggings, heads, and tongues. It could also be argued that Seward Peninsula reindeer industry activities provide recreational and

educational value to those who view reindeer ranges as sightseeing attractions and to persons who attend reindeer handlings with the intention of learning about local animal husbandry. Though these byproducts of the industry should be recognized, they were not included in this study because much of the value is recovered through non-market transactions and would be difficult to estimate.

3.4 Inputs

Cost and earnings estimates used in this study were gathered from herders at annual Kawerak Reindeer Herders Association meetings (held annually in March); a fall 2000 Kawerak Reindeer Herders Association meeting convened specifically to discuss the caribou/reindeer conflict; personal participation in and observation of a summer 2000 handling near Nome; communication with antler and meat buyers; and discussions with the University of Alaska Reindeer Research Program staff. Survey results supplemented the estimates and served to substantiate data used in the input-output model. For example, personal communication with Reindeer Research Program staff and a few herders revealed that all-terrain-vehicles are no longer used for summer herding because they proved to be less efficient than snow machines on the tussocks that cover much of reindeer ranges in summer months. In contrast, surveys indicated that some herders owned all-terrain-vehicles. Further examination of survey responses showed that none had been purchases in recent years.

Data compiled for use in this study were presented at the 2001 Kawerak Reindeer Herders Association annual meeting during a session that was closed to non-members. Feedback on the cost and earnings data was invited, and served to ensure the data to be used for modeling the industry was representative of the group of Seward Peninsula herders. When comments were made questioning any specific cost or earnings estimate, discussion was encouraged. Some cost estimates were changed based on comments made at the March 2001 meeting. Significant changes included the cost of food for volunteers and hired help at handlings, the cost of burlap, and the cost of fuel. In all cases, herders pointed out that the amount of product consumed was underestimated.

Discrepancies between initial estimates and comments made by Kawerak Reindeer Herders Association members can be easily explained. First, the food expense was initially underestimated due to the weight given to observations made while participating in a handling where food was not provided. The handling was atypical with respect to food for laborers and visitors. Second, the cost of burlap was initially based on survey responses. At the 2001 meeting with herders, Kawerak Reindeer Herders Association (RHA) staff pointed out that RHA staff order the burlap for herders, therefore, many herders where not aware of how much was ordered nor its actual cost. Finally, the fuel cost is dependent on the herder. There are a variety of factors that go into the amount of fuel each herder consumes for their reindeer operation. Some herders have more intensive management plans than others, which requires them to spend additional time with their herds than other herders. The threat of predators, the proximity of caribou, and

the condition and availability of winter range are some of the most influential factors over the intensity of a herding operation. Despite the diversity among the group, however, there seemed to be consensus at the 2001 meeting that the fuel estimate should be higher than initially specified.

The primary annual expenses of a typical reindeer operation include: air charters used to locate the reindeer and herd reindeer into the corral at times of handlings; snow machines, all-terrain vehicles, and/or boats for transportation across the range; fuel; food for volunteers and paid labor at handlings; vehicle maintenance and repair; corral maintenance and repair; and supplies for the handlings and butchering. The following table shows cost estimates obtained through personal observation, communication with herders, Kawerak Reindeer Herders Association herder surveys, and the University of Alaska Reindeer Research Program staff.

Table 7. Annual expenditures for a typical reindeer operation (year 2000 dollars).

Item	Cost per herder/year	Industry-wide outlay/year
Air charters and shipping	$14,500	$203,000
Snow machines/ATVs	$10,500	$147,000
Vehicle repair services	$1,765	$24,710
Fuel and oil	$3,500	$49,000
Food for handlings	$2,000	$28,000
Handling/butchering supplies	$2,000	$28,000
Corral maintenance	$1,575	$22,050
Veterinarian instruments, drugs, ear tags	$1,750	$24,500
Record keeping, leases, credit	$1,460	$20,440
Miscellaneous supplies and services	$460	$6,440
Labor (paid with cash)	$2,500	$35,000
Total annual cost estimate:	$42,010	$588,140

Source: Cost data were gathered from reindeer herders, meat and antler buyers, personal observation, Kawerak Reindeer Herders Association staff, and University of Alaska Reindeer Research Program staff. The industry-wide annual cost estimate is obtained by multiplying the total per herd cost estimate by 14 herds.

The cost estimates presented in Table 7 are for a typical herd, constructed by aggregating information collected for several different herds. A typical Seward Peninsula reindeer herd is roughly 1,000 to 2,000 reindeer and can be operated by an individual herder on a part time basis with occasional assistance from family and other local village members for one to two annual handlings and for slaughtering. Industry-wide costs are obtained by multiplying the total number of ranges on the Seward Peninsula by the estimated total inputs for a single reindeer operation. Since detailed records of reindeer operation

expenses are not kept for most herds and confidentiality would be difficult to maintain for those few herders with complete records, this approach of estimating typical expenses across all herds was preferred to modeling each herd.

The disadvantage of basing industry costs on a single operation model is the misleading assumption of homogeneity among Seward Peninsula reindeer herders. In reality, each of the herders make unique decisions on how to best use their time and money based on the size of their herd, the location of their deer, threats by predators, the terrain of their range, and weather. In addition, many of the herders commit time to subsistence activities and to alternative occupations. Those herders may incur significant opportunity costs while spending time and money on their reindeer operation.

Air charter was the input category with the greatest variability across operations. A range of $0 to approximately $25,000 per herder is spent annually on air charters. The 1996 Kawerak Reindeer Herders Association annual survey revealed the greatest annual air charter expense among respondents was $28,000, the low was $2,000 and the average was $8,350. While most operators spend several thousand dollars on air charters to spot and move their deer, one herder consistently chose not to use air charters. He opted instead to spend a few months of his time with the herd each year when the herd was most vulnerable to predators and migrating caribou. That particular herder moved his herd by foot and snow machine, leaving no need for air charters. As reflected in Table 7, personal communication with reindeer herders revealed that air charters are used more

extensively in recent years and have become a larger component of the operating expenditure.

Labor needs include working on the corral, rounding up and driving reindeer, bringing reindeer into a handling area or chute and securing them, castrating, earmarking and tagging, record keeping, administering shots, cooking for the crew, cutting antler, boxing antler, and butchering. There are a variety of sources for herders to draw upon for labor. Family members and others in the herder's local community are the primary source of paid and volunteer labor. The Kawerak Reindeer Herders Association staff and the University of Alaska Fairbanks Reindeer Research Program staff and volunteers provide some general labor to herders, but first fill a few of the specialized positions at handlings. Generally, at least one member of Kawerak Reindeer Herders Association staff is present at each handling to keep a tally. Reindeer Research Program staff administer vaccinations and record the ear tag number of each reindeer handled. They also gather and record data specific to each animal for research and management purposes. Each animal is given a unique eartag identification number and all data recorded is entered into a database administrated by the Reindeer Research Program.

The herder and adult family members generally take leadership roles at the handlings. Labor provided by family and members of the nearby communities may be compensated by payment in meat or cash. In several communities, however, handlings are seen as opportunities for a community gathering. Many villagers come to watch and help with

handlings without the expectation of receiving compensation. Children help by moving and boxing antler after it has been harvested, and they help handle calves. Children take pride in being able to handle calves by themselves. They carry calves away from the corral, determine the sex of each calf, and then mark and tag the calf's ear appropriately. Younger children who are not able to hold and secure a calf by themselves can help others in the area by getting ear tags ready and by passing ear tagging and ear notching tools between handlers.

Kawerak Reindeer Herders Association provides a tally person at each handling. They record the number of reindeer that are handled by marking a tally sheet each time the crew releases an animal from the corral area. Reindeer Research Program staff focus on recording individual ear tag numbers, ear tagging, and administering shots. If additional staff and volunteers are available, they help with all tasks. University staff and volunteers are not able to attend all handlings due to the fact that more than one herder may be handling at roughly the same time. Additionally, it is impossible to know and plan for an exact date when a herder will be ready to conduct their handling.

Herders often can approximate a date for handling, but the date and time may change with weather conditions, the location of their herd, and the condition of the terrain. For example, a high water year may make driving a herd across a stream very difficult or impossible because calves are swept away and separated from their mother. The inability to schedule a date and time for a handling or butchering can lead to labor problems.

Generally a herder does not know that they are ready for a handling until their herd is roundup and approaching the corral. The herder must depend on a potential labor force to be ready and willing to respond at short notice. In many villages, members of the community are anxious to participate in handlings. They keep in touch with the herder so as not to miss the driving and corralling.

A strong and experienced labor force that can pace themselves through the long hours of work is necessary for a quick and smoothly run handling. Work does not stop until all of the reindeer in the corral are handled. To minimize stress on the animals, cooler evening and nighttime handlings are preferred to the heat of midday handlings. It is common for handlings to start in the evening, continue through the night and extend into the following morning. Midsummers on the Seward Peninsula allow handlings to go through the night without pause for darkness. It is light enough to continue work from sunset to sunrise. Generators and batteries are used to power lights at spring, fall, and winter handlings.

Herders generally provide food, prepared on site, for their handlings. Note the length of summer handlings may require a significant food expenditure to fuel laborers performing physical work through the night.

As with other inputs, the amount of cash paid to crew varies widely. According to annual surveys, the number of laborers, the proportion of paid laborers to volunteers or those working for meat, the hourly rate of paid, and number and length of handlings all vary

from herder to herder. Most herders trade meat in exchange for some portion of their labor needs. Most who do trade meat for labor report trading between one and six carcasses a year.

According to the most thorough Kawerak Reindeer Herders Association annual survey responses, the amount of labor used per operating herder is approximately 500 hours (excluding Kawerak and University assistance). Rates of pay vary from $2 to $20 per hour, depending on the herder and on the task. Annual surveys and interviews reveal, however, only a portion of the hours worked are worked in exchange for cash. Because each herder pays a different hourly rate and has different labor needs, a total labor expense of $2,500 was estimated instead of estimating a typical number of hours and a typical rate of pay. The $2,500 estimate was presented to the Kawerak Reindeer Herders Association members as a total annual labor estimate expense, knowing that each herder may arrive at the total in a different way and at different times of year. Herders agreed upon the estimate.

In addition to roundups and handlings, some herders hire people to act as herders during the times of year that the reindeer need extra protection from predators and caribou, or to help move the reindeer to summer or winter range and keep them in the desired area. Annual surveys show that those who hire herders use from one to three people to find, monitor, or move their herd between eight and twenty-four weeks in a typical year. The amount of time herders are needed varies from herd to herd and from year to year. As

with other paid labor, hired herders are often compensated with meat or a mix of meat and cash. The use of radio collars, satellite collars, air charters, and snow machines to locate and check on herds have been effective substitutes for full time herders of the past.

4.0 IMPACT ANALYSIS

4.1 Regional economic development theory

Export base theory is one of the oldest regional development theories. It provides support to several common economic development strategies such as import substitution; export promotion; and natural resource development. At the core of export base theory are the concepts that 1) a region's export base drives economic growth in the region and 2) imports represent economic leakages from a region (Klosterman, 1990). Growth in export sectors requires more inputs from support sectors thereby increasing production within support sectors and increasing pay available to local employees within the export producing and the local support sectors. Money brought into a region through exports will circulate throughout a regional economy as industries and households purchase goods and services locally. This activity further stimulates local production and earnings.

Goods and services sectors that sell a large portion of their product to industries or consumers outside the region form the export base of a regional economy. These industries are known as basic, or city-building, industries. Non-basic, or city-filling, industries serve industries and consumers located within the region. According to export base theory, support and expansion of basic industries in which the region has a comparative advantage is the key to regional economic growth. Expansion of basic industries leads to the expansion of non-basic industries through the multiplier effect. Examples of basic industries in the Seward Peninsula region include mining, tourism, commercial fishing, and reindeer herding.

The importance of basic industries becomes clear when looking more closely at their role in the regional economy. The reindeer industry, for example, has historically produced velvet antler and a portion of the industry's total meat production for sale outside of the Seward Peninsula regional economy. These sales activities bring new dollars into the regional economy, expanding the pool of wealth that is available for local circulation. New dollars that are spent locally by the reindeer industry in non-basic sectors such as retail or service industries generate an increase in production and earnings in the regional economy. In contrast, if the reindeer industry were a non-basic industry that only produced meat for sale to local sectors (and not for export), only dollars already available in the region would be spent on reindeer meat. This type of transaction is important to regional economies as it continues to circulate existing dollars in the regional economy. However, according to export base theory, this type of transaction does not generate growth since new dollars are not being brought into the region.

Production of goods in one region is often dependent upon inputs produced outside the region. Receipts from sales to outside markets must be used to pay for imported inputs, reducing the amount of money available to local sectors. These payments for imported goods or services are economic leakages. Replacing imported goods and services with goods and services produced locally (import substitution) can reduce economic leakages. At a regional level, import substitution can be an effective economic development strategy. Of all current imports, goods and services with large regional sales or high rates

of past growth that are believed to be sustainable are typically viewed as possible candidates for import substitution. On the Seward Peninsula, reindeer meat and subsistence foods are import substitutes for beef, chicken, pork, and other foods imported and sold by food stores for household consumption.

The combined contribution the reindeer industry makes to the regional economy through 1) bringing new dollars into the economy, and 2) through plugging economic leakages by providing an import substitute can be measured using economic multipliers. Regional economic models are commonly used to quantify the extent to which resource and economic changes impact an entire economy. While export base model can be used to estimate a highly aggregated multiplier for a region, more detail can be obtained through input-output regional economic modeling (Richardson, 1972).

4.2 Input-output regional economic analysis

Input-output analysis is used to develop a detailed view of the structure of an economy and economic interdependence. Input-output models are typically constructed for a specific geographic region such as a nation, state, census area, or county. The model is made up of economic activity by industries that produce goods or services in the region and consume goods or services from other industries as inputs to each industry's output (Miller and Blair, 1985).

In 1936, Professor Wassily Leontief, of Harvard University, published the first input-output table for the United States economy (Miernyk, 1965). While development of national input-output models proceeded, application of input-output analysis moved from the national level to the regional level. In the 1950s, regional input-output tables were developed using unadjusted national input coefficients. Inter-industry transaction flow tables were derived from a combination of these early input-output tables and regional control totals gross output (Richardson, 1972). Richardson (1972) points out that there was no reason to expect national and regional input structures to be identical. He describes these initial regional input-output tables as miniature versions of the national table.

Regional model development improved throughout the 1950s. The most significant improvements included the use of adjusted national coefficients and of data obtained through surveys. In the 1960s, survey-based input-output tables were commonly used, but costly and time intensive to construct. For this reason, effort was placed on developing adjustment techniques to use on the national input-output coefficients (Richardson, 1972). In recent years, input-output analyses have been widely used for analyzing the structure of state and regional economies and sensitivity to economic impacts. A regional economic input-output model was constructed in the late 1990s to evaluate the regional economic impact of changes in fishery policy for the same U.S. Census Area included in this study (Natcher et al., 1999).

An input-output model is based on a system of accounts, encompassing all transactions within an economy. The input-output transactions table is at the core of input-output analysis. Table 8, reproduced from Richardson (1972), is a simplified table layout representing the way in which national or regional tables may be constructed. An input-output transactions table shows how the output of each industry is distributed among other industries and sectors in the economy. Row *i* of the table shows sales of industry *i* to each industry and sector identified in the top row of the table. In sum, the sales equal the total gross output of industry *i* (in the far right column of the same row). At the same time, the table shows inputs to each industry from the other industries and sectors. Column *j* of the table shows all inputs for industry *j*, summing to the industry's total gross outlays (in the bottom row of the same column). Industries one through *n* are shown in the input-output table layout shown in Table 8. The actual number of industries will depend on the desired degree of aggregation in the model and on the number of industries operating in the region of interest.

Input-output models act in response to final demand, shown in the right half of the transactions table. As demand changes, industries react directly or indirectly. Those who produce the good or service for which demand changed will react directly. In turn, they will demand more or less from their support industries, forcing support industries to respond (indirectly) to the change in final demand. Multipliers are used in input-output models to describe responses triggered by changes in final demand.

Multipliers can be derived from the transactions table. Each input for an industry is divided by the industry's total gross outlay (column total) to produce a coefficient matrix. Each column of the coefficient matrix is a production function, describing all inputs and value added associated with one dollar of output in the industry. Multipliers, the core of the predictive portion of regional input-output models, are derived from the coefficient matrix.

Table 8. Standard layout of an input-output transactions table. (Richardson 1972).

Outputs / Inputs		Purchasing sectors					Local final demand			Exports	Total gross output
		1	…	j	…	n	Households	Private investment	Govern-ment		
Producing sectors	1	X_{11}	…	X_{1j}	…	X_{1n}	C_1	I_1	G_1	E_1	X_1
	.	.	…	.	…	.	.	.	.	.	.
	.	.	…	.	…	.	.	.	.	.	.
	.	.	…	.	…	.	.	.	.	.	.
	i	X_{i1}	…	X_{1j}	…	X_{1n}	C_i	I_i	G_i	E_i	X_i
	.	.	…	.	…	.	.	.	.	.	.
	.	.	…	.	…	.	.	.	.	.	.
	.	.	…	.	…	.	.	.	.	.	.
	n	X_{n1}	…	X_{nj}	…	X_{nn}	C_n	I_n	G_n	E_n	X_n
Labor		L_1	…	L_j	…	L_n	L_C	L_I	L_G	L_E	L
Other value added		V_1	…	V_j	…	V_n	V_C	V_I	V_G	V_E	V
Imports		M_1	…	M_j	…	M_n	M_C	M_I	M_G	M_E	M

Multipliers are used in predictive modeling to quantify three types of effects triggered by a change in a regional economy at a given time. As introduced above, direct effects are changes in the industry that produces the good or service for which final demand has changed. Indirect effects are changes support industries make in response to the actions of the directly affected industry. Induced effects are changes in spending by households as income increases or decreases in response to changes in production. Together, these three types of effects sum to the total regional economic impact of a change in final demand.

These three types of effects can be illustrated by a reduction in reindeer industry output of $100 (producer price). The direct effect is equal to the initial change of -$100 in the reindeer industry, which is the industry immediately effected. Suppose 100% of the reindeer industry's inputs are purchased locally. These inputs are products like groceries for handlings, fuel, snow machines. Also suppose that for every dollar of reindeer industry output, 35 cents is spent on supplies. Indirect effects capture inter-industry transactions. As reindeer industry output decreases, the reindeer industry's demand for inputs also decreases. Under the stated assumptions, the indirect effect in this case would be -$35 because the reindeer industry demand for inputs would be reduced by 35 cents for each dollar of $100 decline in production. Induced effects reflect the reduction in demand due to reduced household income. Reductions in reindeer industry inputs and transactions between support sectors lead to a decline in employment across all of the affected sectors. A reduction in payments to employees leaves less money available in

the household sector for activities such as eating out. Suppose the induced effects in this case are 25 cents for each dollar of reduced output in the reindeer industry: -$25 dollars overall. The total effect is the sum of direct, indirect, and induced effects, which is -$160 in this example.

Input-output modeling is based on several assumptions. Each is listed, with discussion to follow.

- First, an input-output model is a representation of an economy at a single point in time.
- Second, production functions are assumed to have constant returns to scale: an industry's expenditures increase proportionately to increases in the industry's output.
- Third, there are no supply constraints. An industry's output is only limited by the demand for its products.
- Fourth, a fixed commodity input structure assumes changes in the economy will not influence the mix of inputs required to make an industry's products.
- Similarly, input-output models assume homogeneous sector output. This implies that an increase in output for any industry that produces more than one commodity will always increase production of each commodity by equal proportions.

- Finally, an assumption is made that an industry has a primary product and all of its other products are byproducts of the primary product. Within any industry, this forces a single technology on the production of all products (MIG Inc. 2000).

These assumptions inherent in input-output analysis limit the ability to realistically model the impact of changes in the reindeer industry on the Seward Peninsula regional economy. A number of the assumptions raise concerns for this study. The fact that the impact analysis is constrained to a single model year led to the development of the reindeer industry with all herders functioning at the same point in time and all losses to caribou occurring at the same time, when in fact, caribou migration began impacting eastern reindeer ranges in the late 1980s and did not reach some central and western ranges until recent years. Secondly, the constraint of constant returns to scale may be problematic in measuring the multiplicative effect of the reindeer industry economic activity, as it is likely that as a reindeer herder reduces or completely suspends producing due to the presence of caribou on their range, their costs may not be reduced proportionately. For example, they may continue to charter aircraft and use snow machines to locate and move their reindeer, at a significant cost to the herder. In the model constructed for this study, the constant returns to scale constraint may lead to an underestimate of the reindeer industry's contribution to the regional economy. Thirdly, the assumption of no supply constraints may cause an over estimation of the reindeer industry's contribution to the regional economy. In the model, any product or service sectors that are present in the Seward Peninsula regional economy are assumed to supply

all of the reindeer industry's input demands for that product or service. A more realistic approach would constrain the amount of inputs available locally. This is not believed to be a significant problem in this study since it is a decrease in reindeer industry production that is of interest in the study and not an increase. Input demands for the reindeer industry are thought to be at reasonable levels at their maximum in this study.

The final assumptions listed above related to a fixed mix of inputs and commodity output and a forced single technology on all products within a sector are not believed to be as large of a concern as the other assumptions. Over the 100 years of activity on the Seward Peninsula, the reindeer industry has experienced few industry-wide changes in technology and product mix. The changes that have occurred, such as a shift from foot and dog team travel to the use of snow machine and aircraft in locating and moving reindeer herds, were not instantly accepted by all herders.

4.3 IMPLAN

IMPLAN (IMpact Analysis for PLANning) is a software program and regional database widely used to construct regional economic accounts and to assess regional economic impacts. IMPLAN data are available for every state and county of the United States. For Alaska, regional data are available at the U.S. Census Area or borough level. For this study, IMPLAN data for the Nome U.S. Census Area were used.

IMPLAN was originally developed by the USDA Forest Service in the 1970s to aid in land and resource management and planning (MIG Inc., 2000). The development of IMPLAN data and software has since been privatized and made available by the Minnesota IMPLAN Group, Inc. Today, IMPLAN users include federal, state, and regional agencies, private consultants, and educational institutions across the United States.

The IMPLAN system includes descriptive accounts of transactions between producing and purchasing sectors in a region and given time period. IMPLAN recognizes 528 producing sectors and 15 final demand sectors. Through manipulation of descriptive accounts, the IMPLAN system is capable of providing estimates of employment, output, and income changes resulting from changes in product demand, supply-side constraints, or industry production (Maki et al., 1989).

Not all 528 IMPLAN sectors that exist in the U.S. economy are active in the Nome U.S. Census Area. The IMPLAN model, unmodified, for the Nome U.S. Census Area includes only 75 producing sectors. The model assumes a population of 8,933 in 3,175 households, with an income per household of $51,719 and total personal income of $164,217,000. The data provided with the IMPLAN model are for a model year of 1997, the most recent available data when this study was initiated.

4.4 Adjustments to IMPLAN database

The regional economic IMPLAN databases are built from secondary (non-survey) data sources. The following government data sources are used to develop IMPLAN databases: U.S. Bureau of Economic Analysis Benchmark I/O Accounts of the United States, U.S. Bureau of Economic Analysis Output Estimates, U.S. Bureau of Economic Analysis Regional Economic Information System (REIS) Program, U.S. Bureau of Labor Statistics ES-202 Program, U.S. Bureau of Labor Statistics Consumer Expenditure Survey, U.S. Census Bureau County Business Patterns, U.S. Census Bureau Decennial Census and Population Surveys, U.S. Census Bureau Economic Census and Surveys, U.S. Department of Agriculture, and U.S. Geological Survey (MIG Inc., 2000).

For small economies, government data sets are likely to be incomplete due to non-disclosure rules designed to protect the confidentiality of reporting establishments. Minnesota IMPLAN Group's *Database Guide* (2000) describes the procedures developed to use national data to help estimate state and county level non-disclosed sectors in

IMPLAN databases. Despite the sophisticated estimation procedures and validation processes incorporated into the development of IMPLAN databases, it is recommended that users of IMPLAN examine the study area. Data can be modified using IMPLAN editor.

A review of Nome U.S. Census Area data revealed an absence of the reindeer industry. The first modification was to add the industry. Addition of an industry to the IMPLAN system required an estimate of the following: total output, number of employees, employee compensation, proprietor income, and industry inputs. The reindeer industry was added to the regional model as the "other meat and animal product" sector, a recognized IMPLAN agricultural industrial sector that was inactive in the original IMPLAN Nome U.S Census Area database. The minimal data required to add an industry to the study area include value added, employment and output (Minnesota IMPLAN Group, Inc. Support, 1999).

Reindeer industry output was estimated using historic production figures presented in the industry output section of this report. As shown, the Seward Peninsula reindeer industry is capable of sustaining meat production levels of approximately $650,000 (producer price, year 2000 dollars). Additionally, the industry was able produce close to 33,000 pounds of velvet antler in early years of the caribou crisis. At a recent average price of $15 per pound (producer price, year 2000), 33,000 pounds of velvet antler would contribute $495,000 towards total output for the industry. The sum of these meat and

antler output figures, $1,145,000, is used in the regional model as the reindeer industry output estimate for the baseline case. The term baseline case refers to the pre-impact regional economy. For this study, the baseline case provides a picture of the reindeer industry's contribution to the regional economy prior to the impact caused by caribou.

The model year provided by the IMPLAN system is 1997, but the reindeer industry output and employee compensation estimates to be added to the model are in year 2000 dollars. Hence, the estimates need to be adjusted for inflation before being introduced into the model. For impact analysis, IMPLAN will adjust an impact value for any year and sector to model year dollars, so deflators are available for each sector in the regional model. The deflator provided by the IMPLAN system for the "other meat animal products" sector used to adjust 2000 dollars to model year (1997) dollars is 0.951. Before adding the reindeer industry to the Nome U.S. Census Area IMPLAN database, 2000 dollars are adjusted downward to the 1997 model year.

Input-output model values are reported in producer prices. Reporting values in producer price allows for tracking an item through all sectors that receive income from the final sale of that item. When an individual purchases an item from a retail outlet, they pay a retail markup, a wholesale markup, a price received by the producer of the item, and all transportation costs from the producer to the retail outlet.

For example, a reindeer herder may purchase dimensional lumber for corral maintenance from a retailer local to the region. Though the reindeer herder purchased the lumber locally, the retailer has to pay the wholesaler or distributor for the lumber, and the wholesaler has to pay the milled lumber manufacturer for the product. In addition, the retailer and wholesaler incur shipping costs. Only a portion of the money paid to the retailer by the reindeer herder is kept by the retail sector located on the Seward Peninsula. The wholesale trade sector, transportation sectors, and sawmills and planing mills sector are the beneficiaries of the remaining expenditure paid by the reindeer herder. All of the non-retail sectors in this example are not local to the Seward Peninsula, so allocating the entire expenditures to a retail sector would dramatically inflate the actual economic benefits that the reindeer industry brings to the region. In this example, the local economy will not benefit from the non-retail payments associated with the purchase of dimensional lumber.

Estimates of reindeer industry inputs (see Table 7, page 49) were obtained through interviews with herders, Reindeer Research Program data, past Kawerak Reindeer Herders Association surveys, personal observation and discussion at Kawerak Reindeer Herders Association meetings. All estimates were made in nominal (year 2000) retail dollars. The values associated with each broad input category were distributed among the specific manufacturing and/or service sectors receiving payment for items that reindeer herders purchase within the category. The retail value assigned to each sector is then converted to a producer price as follows: For non-service sectors, estimated retail

margins, wholesale margins, and transportation cost are subtracted to arrive at the producer price. The amount subtracted for the retail margin is placed into the appropriate retail sector. Likewise, the amount representing the wholesale margin is placed in the wholesale trade sector and the portion subtracted for transportation is split among the transportation sectors. For service sectors, the cost paid by the reindeer operation is equal to the value received by the producer of the service.

The United States Census Bureau's *Annual Benchmark Report for Retail Trade and Food Services: January 1992 to December 2000* includes estimates of gross margins as a percent of sales by business type, 1993 through 1999. The reported total retail gross margin to sales ratio (retail margin) across all types of business has ranged from a low of 27.5 in 1997 to a high of 28.1 in 1994. For all businesses except motor vehicle and parts dealers, the retail margin ranged from 32.5 to 34.0 and averaged 33.2 from 1993 to 1999. Over the same period, the retail margin for motor vehicle and parts dealers ranged from 19.1 to 21.4 and averaged 20.5. The average total retail gross margin to sales ratio for all sectors (excluding motor vehicles and parts dealers) and for motor vehicle and parts dealers are used in this study to estimate the absorption coefficient for the retail sectors included in the reindeer industry production function.

Similarly, the *Annual Benchmark Report for Wholesale Trade: January 1992 to March 2001* includes estimates of gross margin to sales ratios for merchant wholesalers by business type. The reported total gross margin to sales ratio across all wholesalers

(wholesale margin) ranged from a low of 20.2 in 1993 to a high of 21.2 in 1995. The wholesale margin averaged 23.5 for all durable goods, and 17.7 for all nondurable goods from 1993 to 1999. The 1993 to 1999 wholesale margin averages for durable goods and for nondurable goods are used in the analysis to estimate the absorption coefficient for the wholesale trade sector in the reindeer industry production function.

Transportation expenditures vary widely from sector to sector, and are dependent on the weight and/or dimension of the goods being shipped and the type of transportation used. In addition, due to differences in quantities handled and location, there is variation in the amount paid for freight by individual wholesalers and retailers. Generally, retailers in Nome pay a higher percentage of the value of any product than retailers in the lower 48 states. Snow machines are responsible for most of the freight expense; therefore, accuracy was most important in the shipping estimate associated with this sector. Snow machine retailers were contacted in two remote regional centers in Alaska and asked what the estimated shipping expense for a $5,000 (retail value) snow machine from production to consumer, as a percentage of retail value. The response was ten percent. Fifteen percent of the wholesale value, which is roughly equal to ten percent of retail value plus allowance for shipping from the producer to the distributor (in the case of snow machines), is used to estimate freight costs within each sector.

There are close to 70 food-producing sectors in the IMPLAN system, ranging from crop specific agricultural sectors to manufacturing sectors such as rice mills, meat packing

plants, and cookies and crackers production. Reindeer herders have a food expenditure for feeding volunteer and paid laborers during handlings. Generally, one or two individuals prepare food on-site. An estimate of $2,000 per herder was made for food purchases by consulting with herders, but a detailed distribution of the food expenditure among the range of possible food-producing sectors was estimated by looking to other IMPLAN sectors with food expenditures. IMPLAN sector 501, Residential Care, was used as a model to distribute the portion of herder's food expenditure allocated to producers through the following steps. Food producing sectors thought to be peripheral to the reindeer herder's objective of providing sustenance to their laborers were removed from the list of food producing sectors found in the Sector 501 production function. The sectors removed included chewing gum, and ice cream and frozen desserts. The absorption coefficients for food producing sectors that remained in the Sector 501 production function were converted to percentages. The $2,000 per herder food expenditure (retail value) was adjusted to producer price by subtracting estimated transportation, retail, and wholesale margins. The total remaining value was allocated to food production sectors by multiplying total value by the percentages calculated from Sector 501 absorption coefficients.

Producer prices were converted to absorption coefficients by rescaling producer prices with the total output estimate for a typical reindeer operation using the following equation:

$$\frac{\text{Reindeer operation expense (producer price) in sector } i}{\text{Reindeer operation total output}} = \text{Sector } i \text{ absorption coefficient}$$

Sectors to which reindeer industry inputs were allocated are listed in Tables 9 and 10. The absorption coefficient, which determines the allocation of total output to each sector, is also provided. Since expenditure coefficients are dependent on total industry output, it is important to note that a total output of $1,145,000 was used to calculate the technical coefficients. Thus, for the baseline case, the reindeer industry's expense in any sector listed in the tables is equal to the absorption coefficient multiplied by $1,145,000 (year 2000 dollars).

Table 9. Estimates of reindeer industry inputs per IMPLAN sector, grouped by major expense category.

Handling, butchering, and veterinarian, and corral maintenance supplies:

IMPLAN Sector	IMPLAN Classification	Absorption Coefficient
108	Broad woven fabric mills and finishing	0.002009
122	Cordage and twine	0.000176
123	Textile goods, NEC	0.000603
134	Sawmills and planing mills, general	0.001005
139	Veneer and plywood	0.001633
164	Paperboard containers and boxes	0.002748
166	Paper coated and laminated, NEC	0.000550
167	Bags, plastic	0.000192
168	Bags, paper	0.000044
170	Sanitary paper products	0.000055
171	Envelopes	0.000011
182	Blank books and loose-leaf binders	0.000055
195	Drugs	0.008245
196	Soap and other detergents	0.000055
219	Fabricated rubber products, NEC	0.000100
220	Misc. plastics products	0.000075
256	Steel wire and related products	0.001005
275	Cutlery	0.000251
276	Hand and edge tools, NEC	0.000377
277	Hand saws and saw blades	0.000151
278	Hardware, NEC	0.000126
284	Fabricated plate work (boiler shops)	0.000628

289	Screw machine products and bolts, etc.	0.000176
297	Small arms ammunition	0.001005
299	Small arms	0.002009
304	Misc. fabricated wire products	0.000402
322	Power driven hand tools	0.000753
343	Calculating and accounting machines	0.000075
367	Electric lamps	0.000402
369	Lighting fixtures and equipment	0.000502
379	Storage batteries	0.000251
407	Surgical and medical instruments	0.000502
422	Pens and mechanical pencils	0.000050
432	Manufacturing industries, NEC	0.001055
480	Electrical repair services	0.002445
482	Miscellaneous repair shops	0.001223

Food provided at handlings:

IMPLAN Sector	IMPLAN Classification	Absorption Coefficient
8	Reindeer industry (added sector)	0.000737
2	Poultry and eggs	0.000254
16	Fruits	0.000049
18	Vegetables	0.000494
58	Meat packing plants	0.000531
59	Sausages and other prepared meats	0.000980
60	Poultry processing	0.001511
61	Creamery butter	0.000119
62	Cheese, natural and processed	0.000391
63	Condensed and evaporated milk	0.000071
65	Fluid milk	0.000109
66	Canned specialties	0.000404
67	Canned fruits and vegetables	0.000404
68	Dehydrated food products	0.000095
69	Pickles, sauces, and salad dressings	0.000232
70	Frozen fruits, juices and vegetable	0.000502
72	Flour and other grain mill products	0.000057
73	Cereal preparations	0.000588
74	Rice milling	0.000156
75	Blended and prepared flour	0.000166
76	Wet corn milling	0.000015
79	Bread, cake, and related products	0.001191
80	Cookies and crackers	0.001356
81	Sugar	0.000233
82	Confectionery products	0.000079
83	Chocolate and cocoa products	0.000013
85	Salted and roasted nut and seeds	0.000017
90	Shortening and cooking oils	0.000295
95	Bottled and canned soft drinks	0.000280

96	Flavoring extracts and syrups, NEC	0.000007
98	Prepared fresh or frozen fish or seafood	0.000331
99	Roasted coffee	0.000241
102	Macaroni and spaghetti	0.000402
103	Food preparations	0.000518

Snow machines and vehicle repair services:

IMPLAN Sector	IMPLAN Classification	Absorption Coefficient
217	Rubber and plastics hose and belting	0.000251
218	Gaskets, packing and sealing devices	0.000251
350	Carburetors, pistons, rings, valves	0.000753
351	Fluid power cylinders and actuators	0.000176
352	Fluid power pumps and motors	0.000201
357	Motors and generators	0.000879
381	Engine electrical equipment	0.000502
386	Motor vehicle parts and accessories	0.004334
399	Transportation equipment, NEC	0.062770
479	Automobile repair and services	0.002934
482	Miscellaneous repair shops	0.001223
210	Petroleum refining	0.018140
213	Lubricating oils and greases	0.001099
215	Tires and inner tubes	0.000502

Air charters, transportation, and shipping:

IMPLAN Sector	IMPLAN Classification	Absorption Coefficient
433	Railroads and related services	0.004556
435	Motor freight transport and warehousing	0.006075
436	Water transportation	0.010670
437	Air transportation	0.175736
440	Transportation services	0.003038
513	U.S. Postal Service	0.007594

Record keeping, leases, and credit:

IMPLAN Sector	IMPLAN Classification	Absorption Coefficient
494	Legal services	0.000611
507	Accounting, auditing, and bookkeeping	0.001834
512	Other state and local government enterprises	0.000611
520	Federal government, non-military	0.000122
441	Communications, except radio and TV	0.001834
443	Electric services	0.001223
456	Banking	0.001223

457	Credit agencies	0.013450
372	Telephone and telegraph apparatus	0.000050

Wholesale trade and retail sectors:

IMPLAN Sector	IMPLAN Classification	Absorption Coefficient
447	Wholesale trade	0.043954
449	General merchandise stores	0.021251
450	Food stores	0.008119
451	Automotive dealers and service stations	0.045185
Total Absorption Coefficient		**0.484926**

In addition to the inputs listed, coefficients were estimated for the value added sectors in the IMPLAN model. The value added coefficients are shown in the following table. All coefficients were calculated for a total industry output of $1,145,000 (year 2000 dollars).

Table 10. Estimates of reindeer industry employment and value added coefficients.

Employment and value added:

	Coefficient
Employment	0.030568
Value added (proprietor income)	0.484507
Total Employment and Value Added Coefficient	**0.515074**

In addition to the input-output modeling assumptions described in the input-output analysis section, selection of a trade flow assumption is required before running the IMPLAN system. There are three options in IMPLAN for describing movements of

goods and services between the region and economies outside of the region. Regional purchase coefficients (RPCs) allow maximum control over trade flow. An RPC represents the portion of each dollar spent locally to fill local needs for any commodity. For example, an RPC of 0.80 indicates that for each dollar of local need for a commodity, 80% will be purchased from local producers and 20% will be purchased from producers outside of the region. Alternatively, supply/demand pooling assumes all needs that can be filled by local producers will be, and only supply that is in excess of local demand will be exported. Supply/demand pooling maximizes local purchases of locally produced commodities. The third possible trade flow assumption is that based on location quotients. A location quotient is a ratio between local output of a single commodity to total local commodity output and national output of the same commodity to total national commodity output.

For this study, supply/demand pooling was used as the trade flow assumption. The rationale for choosing this specification, which minimizes imports, follows. In most regional modeling, consideration must be made for individuals working within study region but living and spending the majority of their income outside of the region. Regional purchase coefficients for any commodity can be adjusted to force dollars out of the region. In remote Alaska communities, however, commuting between regional centers is not practical. Generally, businesses producing goods and services in rural Alaska will sell those commodities to local consumers. High energy costs, high costs of transportation, spatial isolation from other population centers, and limited seasonal

tourism sector diminish the likelihood for non-specialty businesses to survive in remote communities if they do not cater to local demand. Informal conversations with individuals working and living in the region indicated that when possible, they buy locally available products. It is more convenient for locals to purchase supplies from local stores than to mail order. A limited local supply of many commodities will allow for purchases from outside the region under the supply/demand pooling assumption. Supply/demand pooling fits the trade flow characteristics evident in the Seward Peninsula region.

4.5 Impact scenarios and results

The level of economic activity in the reindeer industry prior to the most recent influx of caribou onto the Seward Peninsula was estimated using a variety of survey, interview, and secondary data sources, as discussed throughout Chapter 3. The pre-impact reindeer industry input and output estimates make up the baseline case of the IMPLAN model. At year 2000 prices, the sum of an estimated $650,000 in meat revenues and an estimated $495,000 in antler revenues was used as the level of output in the baseline case. Reindeer industry outlay estimates include the following: $35,000 to paid laborers; $203,000 to air charters and shipping; $220,710 to snow machine dealers, vehicle repair services, and fuel and oil supplies; and $129,430 to corralling, handling, and miscellaneous supplies. The total reindeer industry expenditure in the baseline case is $588,140. The reindeer industry was estimated to have employed 140 individuals in the baseline case.

Proprietary income makes up the difference between the estimated revenue and expenditures (profit) in the baseline IMPLAN model.

Table 11 summarizes the reindeer industry's economic effect on the Seward Peninsula regional economy prior to the recent WACH influx through an impact analysis of the baseline case. A direct effect of $1,145,281 (2000 dollars) through the reindeer industry in the model year is equal to the estimated reindeer industry output in years preceding the significant influx of caribou. The resulting per annum total impact to the regional economy is $1,804,149. This result shows the dollars brought into the region through reindeer industry activities circulate in the regional economy, having a multiplicative effect. The Type II multiplier for the reindeer industry has a value of 1.572. Type II multipliers capture the direct, indirect, and induced effects of economic impacts within a region. Interpretation of this multiplier is simple. For each dollar of output generated by the reindeer industry, $1.572 in regional income is generated.

Table 11. Estimated per annum effect of the Seward Peninsula reindeer industry on the regional economy, baseline case (2000 dollars).

IMPAN Sector	IMPLAN Classification	Baseline
Direct effects:		
8	Reindeer industry	$1,145,281
Indirect effects:		
437	Air transportation	$203,835
449	General merchandise	$23,795
436	Water transportation	$12,848
447	Wholesale trade	$12,754
451	Automotive dealers & service stations	$12,170
450	Food stores	$9,015
512	Other state and local government enterprises	$8,472
441	Communications except radio and TV	$5,017
462	Real estate	$3,585
479	Automobile repair and services	$3,391
507	Accounting, auditing, and bookkeeping	$3,262
435	Motor freight transportation and warehousing	$2,737
511	State and local electric utilities	$2,274
456	Banking	$2,187
439	Arrangement of passenger transportation	$2,067
	Other indirect effects	$14,162
	Total indirect effects	$321,571
Induced effects		$337,294
Total effects		$1,804,149

The effects of changes in reindeer industry output are concentrated in a few key sectors. Indirect effects, or the response of support industries to the direct change in the reindeer industry, are greatest in the following sectors: air transportation ($203,835), general

merchandise stores ($23,798), water transportation ($12,848), wholesale trade ($12,754) and automotive dealers and service stations ($12,170). The total indirect effect under this scenario is $321,571. Because the air transportation sector is the largest single expense for the typical modern reindeer herder and the service is local to region, changes in reindeer industry activity transfer strongly to the air transportation sector. Transactions involving other inputs to the reindeer industry result in total or partial economic leakages from the region. For example, a snow machine purchased locally benefits the local retailer only by the amount of the retail mark-up. The remaining amount of the transaction is attributed to transportation, warehousing, and manufacturing sectors mostly outside of the Seward Peninsula regional economy. Therefore, the total change in reindeer industry demand for snow machines will not appear as an indirect effect in the regional model.

Induced effects in the regional economic model result from an adjustment in household spending as income increases or decreases in response to a change in reindeer industry activity. Induced effects are strongest in the following sectors: owner-occupied dwellings ($73,377), eating and drinking ($29,764), real estate ($24,094), doctors and dentists ($17,382), other state and local government enterprise ($15,318), banking ($14,777), communications ($14,431), and food stores ($12,463). The total induced effect under this scenario is $337,294 (2000 dollars).

Because input-output modeling is based on assumptions of constant returns to scale, no supply constraints, fixed commodity input structure, and homogenous sector output, the value of this multiplier remains the same as that for the baseline case in each of the four impact scenarios analyzed in this study.

The reindeer industry has been greatly reduced by the recent influx of caribou onto the Seward Peninsula. To examine this impact and provide insight into the economic impact to the Seward Peninsula of a reduced reindeer industry, three scenarios were constructed. These range from a 50% reduction in the industry, to its complete elimination. Prior to the influx of caribou, Seward Peninsula reindeer herds were increasing in size (Finstad et al., 1999). A fourth scenario was constructed to consider the effects of lost potential growth in the industry. This was achieved by increasing reindeer industry output. The University of Alaska Fairbanks Reindeer Research Program estimated an average growth rate for Seward Peninsula reindeer herds of eight percent prior to the disturbance caused by migrating caribou (ibid). The estimated herd size growth rate, however, is not clearly linked to the rate of growth in industry output.

Four scenarios are analyzed using IMPLAN impact analysis. The scenarios are

1) reduction of the number of operating Seward Peninsula reindeer herds from the baseline case of fourteen herds to seven herds;

2) reduction from the baseline case to three herds;

3) total elimination of the industry; and

4) twenty-percent increase in Seward Peninsula reindeer industry output.

The first scenario represents the industry following the elimination of the herds on eastern and central Seward Peninsula ranges, which were most vulnerable to the WACH migration. The industry fell from the original 14 herds to seven operational herds in the mid to late 1990s. The second scenario represents the state of the Seward Peninsula reindeer industry by 2001, when only the western most herds remained in operation while other herders focused on locating and protecting the reindeer that remained on their range from intermixing with migrating caribou.

Survival of the reindeer industry in the near term will depend on herder's ability to protect their remaining reindeer from caribou and the herder's ability to adjust to a much more intense management style as a free-range management style is becoming less and less compatible with the Seward Peninsula environment. The third scenario represents complete elimination of commercial reindeer industry activities due to reindeer intermixing and out-migrating with caribou. In contrast, the fourth scenario shows growth in the Seward Peninsula reindeer industry that may have occurred if WACH migration paths had not negatively impacted the industry.

Table 12. Estimated per annum impact of caribou on the Seward Peninsula regional economy, through decline of the local reindeer industry (2000 dollars).

IMPLAN Sector	IMPLAN Classification	Scenario 1 7 Herds Remain	Scenario 2 3 Herds Remain	Scenario 3 0 Herds Remain	Scenario 4 20% Increase
Direct effects:					
8	Reindeer industry	-$572,641	-$899,864	-$1,145,281	$229,056
Indirect effects:					
437	Air transportation	-$101,918	-$160,156	-$203,835	$40,767
449	General merchandise	-$11,898	-$18,696	-$23,795	$4,759
436	Water transportation	-$6,424	-$10,095	-$12,848	$2,570
447	Wholesale trade	-$6,377	-$10,021	-$12,754	$2,551
451	Automotive dealers & service stations	-$6,085	-$9,562	-$12,170	$2,434
450	Food stores	-$4,507	-$7,083	-$9,015	$1,803
512	Other state and local government enterprises	-$4,236	-$6,656	-$8,472	$1,694
441	Communications except radio and TV	-$2,509	-$3,942	-$5,017	$1,003
462	Real estate	-$1,792	-$2,817	-$3,585	$717
479	Automobile repair and services	-$1,696	-$2,665	-$3,391	$678
507	Accounting, auditing, and bookkeeping	-$1,631	-$2,563	-$3,262	$652
435	Motor freight transportation and warehousing	-$1,368	-$2,150	-$2,737	$547
511	State and local electric utilities	-$1,137	-$1,787	-$2,274	$455
456	Banking	-$1,093	-$1,718	-$2,187	$437
439	Arrangement of passenger transportation	-$1,033	-$1,624	-$2,067	$413
	Other indirect effects	-$7,083	-$11,130	-$14,162	$2,830
	Total indirect effects	-$160,787	-$252,665	-$321,571	$64,310
Induced effects		-$168,647	-$265,016	-$337,294	$67,460
Total effects		-$902,072	-$1,417,545	-$1,804,149	$360,831

Under impact scenario one, summarized above, reindeer industry output is reduced by one-half to simulate the loss of seven herds. A direct impact of -$572,641 (2000 dollars) to the reindeer industry in the model year is equal to a fifty-percent reduction in reindeer industry output. The resulting total impact to the regional economy is -$902,072.

The total indirect effect, or response of support industries to the decrease in reindeer industry output, under this scenario is -$160,787. The total induced effect, or change in household spending in response to a decrease reindeer industry output, under this scenario is -$168,647 (2000 dollars).

Because input-output modeling is based on assumptions of constant returns to scale, no supply constraints, fixed commodity input structure, and homogenous sector output, the multiplicative effect of changes in reindeer industry output stays the same under the additional three impact scenarios. Under impact scenario two, only 3 herders remain. The impact of -$899,864 (2000 dollars) is used to simulate a reduction of eleven herders. Resulting analysis shows a $1,417,545 (2000 dollars) loss to the regional economy. Impact scenario three, total elimination of the industry, shows a $1,804,149 (2000 dollars) loss to the economy as a result of the initial -$1,145,281 (2000 dollars) direct impact to the reindeer industry. Alternatively, scenario four shows what might have been if there were not a significant shift in the WACH migration path and the reindeer industry had continued to grow. Model results show a twenty-percent increase in reindeer

industry output ($229,056) would have led to an estimated $360,831 increase in regional economic growth through direct, indirect, and induced effects.

The above results estimate the impact of WACH migration on the Seward Peninsula reindeer industry on a per annum basis. Since the reindeer industry was considered to be a sustainable use of the local range resource, however, the actual impact echoes far beyond the year of initial impact. Table 13 shows the ongoing estimated total impact under each scenario for a 10-year period. The impact over the 10-year period is discounted to reflect present value. Present value calculations are strongly influenced by the value of the chosen discount rate. Higher discount rates reduce the present value of future benefits or costs. In this study, a discount rate of 4% was used. This approximates the real rate of return on risk-free assets such as government bonds. A rate of 3-4% is typically used in environmental economics literature (Michael et al., 2003).

Table 13. Estimated per annum and 10-year period total economic impact of caribou on the reindeer industry under each scenario showing the industry at different scales (2000 dollars).

Scenario	Total per annum effect	10 year effect
7 non-operational herds	-902,072	-7,316,612
11 non-operation herds	-1,417,545	-11,497,560
Elimination of industry	-1,804,149	-14,633,265
20% increase in industry output	360,831	2,926,663

The economic impact over the 10-year period is discounted at a 4% rate to reflect present value.

The results from the IMPLAN model suggest that the estimated total economic activity generated in the Seward Peninsula regional economy from the reindeer industry at levels equal to production pre-caribou impact was approximately $1.8 million per annum (2000 dollars). This total economic contribution to the region is equal to nearly 1% of total personal income for the Nome U.S. Census Area in 2000. While it is difficult to quantify lost potential growth in the Seward Peninsula reindeer industry, the final impact scenario shows growth in the industry would have a multiplicative effect in the region. It is appropriate to consider Scenario 4, the growth scenario, in an economic loss estimate summarizing the economic impact of caribou on the reindeer industry since it serves as a proxy for lost potential growth in the industry.

Moreover, the long-term or on-going loss should be considered since the industry was viewed a sustainable and growing industry. The elimination of the Seward Peninsula reindeer industry equates to an estimated $14,633,265 long-term (10-year) loss to the local economy. A sensible estimate of the total economic impact would combine the effects under Scenario 3 and Scenario 4 to account not only for the industry's contribution to the economy prior to the significant influx of caribou onto the Seward Peninsula, but also for lost potential growth in the industry due to the disturbance caused by the caribou. These combined considerations yield an estimated 10-year loss to the local economy of $17,559,928.

5.0 SUMMARY AND CONCLUSIONS

5.1 Summary

The Seward Peninsula reindeer industry began in the late 1890s with the introduction of domesticated reindeer from Siberia for the purposes of providing a stable food supply to Alaska Natives. With the Reindeer Act of 1937, Congress solidified the role of reindeer industry in Alaska by declaring the reindeer industry a tool with which to 1) provide a means of subsistence for Alaska Natives and 2) establish and maintain a self-sustaining economy for Alaska Natives.

In recent years, the reindeer industry that has persisted on the Seward Peninsula for more than 100 years has been threatened by changes in the migration paths of the Western Arctic Caribou Herd (WACH). Several of the fourteen Seward Peninsula reindeer herds have out-migrated with the caribou. Other herds have intermixed with or become surrounded by the caribou, preventing normal herding operations to continue. In addition to the disturbance caused by out-migration and intermixing, caribou are using some areas of Seward Peninsula winter range habitat in much larger and more concentrated numbers than have reindeer herds. This may be the most long-lasting impact of the caribou crisis, as it may take more than a decade for some winter range vegetation to recover.

The economic impact of the WACH's increased presence and activity on the Seward Peninsula has negatively impacted the regional economy through decreased reindeer

industry production. The reindeer industry generates direct employment and income for the herders, their family, and hired labor local to the herds. Additionally, the industry purchases many of their supplies locally, creating revenue for local businesses.

This impact can be estimated through input-output analysis of the local economy. Direct, indirect, and induced effects of the declining reindeer industry on the economy were estimated in this study using the Nome U.S. Census Area as a proxy for the Seward Peninsula regional economy. A regional economic model which includes the reindeer industry and associated economic inter linkages was built using IMPLAN software and database for the region, available through Minnesota IMPLAN Group, Inc.

To calculate technical coefficients, costs and earnings for a typical reindeer operation in an average production year were first estimated. Reindeer herders, members and staff of the Kawerak Reindeer Herders Association, and staff from the University of Alaska Fairbanks Reindeer Research Program all contributed to cost estimates for a typical reindeer operation in years prior to the most recent and extreme influx of caribou to the Seward Peninsula.

For purposes of this study, total industry output included only the value reindeer herders received from meat and velvet antler sales. Seward Peninsula reindeer herders also commonly give and trade away reindeer meat through non-market transactions, which were excluded from this report. There are additional byproducts from reindeer industry

activity, including reindeer hides, leggings, heads, and tongues. It could also be argued that Seward Peninsula reindeer industry activities provide recreational and educational value to those who attend reindeer handlings to learn more about local animal husbandry or who view reindeer ranges as sightseeing attractions. Moreover, educational and recreational opportunities created by the reindeer industry may be responsible for increased activity in industries such as transportation, lodging, and eating and drinking. Though these byproducts of the reindeer industry should be recognized, they were not included in the study because much of the value is recovered through these non-market and peripheral transactions and would be difficult to measure.

Industry output was estimated using historic data on the number of reindeer on the Seward Peninsula and the amount of reindeer meat harvested, informal interviews with meat and velvet antler buyers, and survey data from reindeer herders. The University of Alaska Fairbanks Reindeer Research Program used tally data collected from reindeer handlings to provide estimates of total pounds of velvet antler harvested by each herd in past years.

The estimated number of reindeer carcasses sold annually for meat in years prior to the impact from caribou approximated 2,700 animals. The value of the estimated 325,000 pounds of meat from these carcasses would be approximately $650,000 at year 2000 prices. An annual estimate of 33,000 pounds of antler harvested from Seward Peninsula reindeer, at a year 2000 average price estimate of $15, resulted in a total velvet antler

output estimate of $495,000. Note that the pounds of meat and antler harvested in the Seward Peninsula reindeer industry were based on historic data while the prices used to calculate the value of the output were estimated year 2000 prices. The purpose of this approach was to add the reindeer industry to the regional economic model with an average, apparently sustainable, level of output that may have occurred on the Seward Peninsula if the influx of caribou had not caused the decline the industry has experienced over the last several years.

With a total estimated reindeer meat and velvet antler output of $1,145,000 and absorption coefficients shown in Chapter 4, several impact scenarios were run using an IMPLAN input-output software regional impact model and database developed for the Nome U.S. Census Area. The first impact scenario was meant to simulate the elimination of half of the Seward Peninsula reindeer herds due to co-mingling and out-migration with caribou. Similarly, the second scenario was intended to simulate a loss of all except three herds. By 2001, it was apparent that all but the western most herds on the Seward Peninsula would be either eliminated or so heavily impacted by caribou that it would not be possible to continue operations. Only three of these herds were thought to have the ability to outlast the crises caused by westward movement of caribou. The results of these scenarios, plus total elimination of the industry and what a potential increase in the industry may look like are shown below in year 2000 dollars.

Results of impact scenarios using IMPLAN include estimates of direct, indirect and induced effects of an economic activity. The direct effect is a measure of production change in the industry affected by an impact. The indirect effects are changes support industries make in response to the actions of the directly affected industry. Induced effects result from changes in household spending as income increases or decreases in response to changes in production. All three of these estimated effects are quantified below.

Table 14. Estimated per annum impact of caribou on the Seward Peninsula regional economy, through decline of the local reindeer industry (2000 dollars).

Scenario	Direct effect	Indirect effect	Induced effect	Total effect
7 non-operational herds	-572,641	-160,787	-168,647	-902,072
11 non-operation herds	-899,864	-252,665	-265,016	-1,417,545
Elimination of industry	-1,145,281	-321,571	-337,294	-1,804,149
20% increase in industry output	229,056	64,310	67,460	360,831

Impact results show that for each one-dollar reduction in reindeer industry output, the Seward Peninsula region loses an estimated $1.572 through multiplier effects. With very few other producing industries in the region, the reindeer industry is an important part of the Seward Peninsula regional economy. The estimated multiplier effect for the reindeer industry is greater than the multiplier effect of all but four other sectors in the region. The four sectors with greater total multiplier effects are gold ore, prepared or frozen fish or seafood, leather tanning and finishing, and religious organizations.

The ongoing economic impact of WACH on the Seward Peninsula reindeer industry cannot be ignored since the reindeer industry was a sustainable use of the local range resource and was growing prior to the change in WACH migration. The long-term total regional economic impact is estimated under each scenario using a 10-year present value calculation (at a 4% discount rate). Table 15 shows the economic impact of the WACH on the Seward Peninsula reindeer industry may be as significant as $17,559,928 if the change in WACH migration leads to complete elimination of the industry. This total includes the combined 10-year total effect of Scenario 3 (elimination of the industry) and Scenario 4 (lost potential growth).

Table 15. Estimated 10-year period total economic impact of caribou on the Seward Peninsula regional economy through decline of the local reindeer industry (2000 dollars).

	Scenario 1 7 Herds Remain	Scenario 2 3 Herds Remain	Scenario 3 0 Herds Remain	Scenario 4 20% Increase
10-year effect	-$7,316,612	-$11,497,560	-$14,633,265	$2,926,663

5.2 Limitations of study

Limitations of this study are partially due to assumptions inherent to input-output models. Most notably, the static framework of input-output models restricts analysis to a single point in time. Secondly, intra and inter regional economic relationships are held

constant. Additionally, input-output models are linear, resulting in constant returns to scale. In the reindeer industry, if a herder reduces their production by half, the inputs used also are cut in half. In recent years, this may not actually reflect a herder's experience. A herder may reduce production because of difficulty in herding caused by caribou on the herder's range, but continue to monitor their herds at a significant cost to the herder.

Input-output models generally, and thus in this study, do not address optimization, efficiency, or equity in or between economic sectors. Instead, input-output models serve as a tool used to analyze the effect of an economic change on regional economy. This study examined the effect of lost production in the reindeer industry on the Seward Peninsula regional economy. The study attempted to restrict the impact to that caused by migrating caribou by using 2000 prices throughout the industry, despite varied prices across the time period herders lost their reindeer. There are short-term benefits to the regional economy that come with the return of caribou to the peninsula. Cost-benefit analysis is beyond the scope of this study.

The impact of changes in the reindeer industry in this study was restricted to the velvet antler and carcass production level. There are, however, value added activities taking place on the Seward Peninsula associated with the harvest of reindeer carcasses. Grocery stores and other processing facilities local to the region process reindeer meat and sell their product both in and outside of the region. The exclusion of value added production

from the model understates the total impact of changes in the reindeer industry on the regional economy. Collecting detailed economic data on the value added operations, including all inputs, outputs, and changes specific to the impact of caribou on reindeer operations was beyond the scope of this study. Further research and data collection on value added production would be a substantial contribution to the input-output model used in this study.

5.3 Recommendation for further study

This report represents one of few quantitative economic studies of the modern Seward Peninsula reindeer industry (see Stern et al., 1980; Greenberg, 1984; and Greenberg et al., 1990). The regional economic model built for this study provides a detailed view of the link between reindeer industry output and regional economic activity. This thesis provides a tool to quantify the economic importance of the reindeer industry to the region and the consequence of lost output from the industry. Knowing the economic value of the reindeer industry to the region is a critical component of an informed discussion on the future of the industry.

The ongoing challenge to the industry presented by the WACH necessitates a change in the industry to a more intensive management style. This presents an opportunity to explore the regional economic impact of the reintroduction of reindeer operations under a variety of management styles that may be compatible with the current Seward Peninsula landscape.

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