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THE COMPARISON OF OFFSHORE AND ONSHORE TERMINAL FACILITY LOCATIONS ON ALASKA'S NORTHWEST COAST

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The area of consideration in this paper extends from Cape Krusenstern to Point Barrow along Alaska's northwest coast. This is one of the most difficult coastlines in the world on which to establish either onshore or offshore cargo loading facilities. This has not proven to be a major problem since the advent of aviation as the small population of the area can be supplied by air if sea transport is blocked by ice movements. However, the region is a repository of large known resources of coal and probably extremely large deposits of oil and natural gas.

These resources will someday be competitive on the world market and will require transportation systems that can move very large cargo flows on a year round basis. There are three basic alternative delivery systems which can be considered in the case of oil and gas. These are to build pipelines that will connect to those pipelines presently planned to serve the Prudhoe Bay oilfields in Alaska; to build a pipeline to a port further south on the Bering Sea coast of Alaska, and thence by tanker to market; and to transfer directly to tankers at the point of production.

The alternative systems for coal and other minerals are to build railroads to connect to the Alaska Railroad system in central Alaska near Fairbanks, to build a raliroad to a port on the Bering Sea coast further south, or to ship directly from the northwest coast by ore freighters.

The decision on which of these alternatives to use will rest in large part upon the location of the resource to be transported. At this time, it seems likely that the most economic means of transportation would be to utilize marine transport for those coal resources located near the coast, and for those

oil resources located well off shore. Onshore oil developments may likely be served better by ties to the planned pipeline systems further east.

The tonnages that may be developed by these resources will be very large. There are about 91,000 square kilometers of the North Slope of Alaska underlain with an estimated 19 billion tons of bituminous and 100 billion tons of subbituminous and lignite coals.[1] Most of these areas are concentrated towards the western end of the region and could be served through port facilities along the northwest coast. This is enough coal to satisfy the needs of the nearest major market, Japan, for some 3 centuries at that country's present rate of consumption if only the bituminous deposits are considered.

Of the 200,000 square kilometers of the North Slope, some 138,000 square kilometers are considered possible for petroleum exploration. Some of this area is presently in federal reserves and will likely remain there but most of it will probably be someday available for exploration and development. Estimates of Alaska oil production range from a low of 2 million to a high of 10 million barrels per day by the year 2000.[2]

Proved, indicated, and potential recoverable reserves have been estimated as ranging from 50 to 70 billion barrels on shore and from 60 to 140 billion off shore. Thus the total at present for total Alaskan production, on shore and off shore, ranges from a low of 110 to a high of 210 billion barrels that may ultimately by produced.[3]

A great part of the offshore total is expected to come from the Chukchi Sea offshore areas. A reconnaissance by the United States Geological Survey indicated some 305,000 square kilometers east of the international date line and south of the continental shelf break into the Arctic Ocean is underlaid by Late Cretaceous or Tertiary sedimentary rocks that may be prospective for gas, coal or oil.[4] The average depth of the broad and flat continental shelf is only some 50 meters and almost the entire area is within possible drilling depths. Using the average favorability for the entire United States some 125 billion barrels of oil would be in place and 2/5 of this would be recoverable for a total of 50 billion barrels.[5] These estimates are still in the realm of conjecture and are offered only to put the ultimate potential in some perspective. They are in all probability conservative, based upon the history of past predictions of potential oil reserves.

Marine traffic flows from the northwest coast would be substantial once these resources become competitive on the world market. If 2 million barrels of oil per day are shipped it will require about 1,000 trips per year by small

supertankers in the 150,000 ton range. Shipment of 50 million tons of coal per year would require about 1,500 trips by medium size coal freighters. The shallow waters of the Bering will inhibit use of the largest ships. Thus from a total of less than a dozen annual visits by ships and barges of various types the area would increase to ship movements of about 8 per day in each direction providing oil and coal were to develop simultaneously.

Joint utilization of some shipping facilities offers a strong argument for joint development of coal and petroleum since substantial transportation savings should result. There is little doubt that whatever types of terminals are used for shipping these fossil fuels the initial infrastructure costs will be substantial.

Utilization of common terminals and routes will minimize ice breaking costs. The more traffic that can be maintained over each route the easier it will be to keep channels open. Convoying behind ice breakers will be easier to achieve under a joint use system also. Since fossil fuel have a relatively constant market demand it will be necessary to maintain shipping on a year round basis once markets are developed. Ice breaker costs from the northwest coast are estimated at $375.00 per average round trip at this time for a 20,000 SHP vessel.[6]

The northwest coast from Cape Krusenstern to Point Hope consists of a long strand line with lagoons behind the sand reefs in the area of Krusenstern, Kivalina, and Cape Seppings. Around Cape Thompson the western end of the Brooks Range begins to dip beneath the sea and a steep coastline with many spectacular cliffs occurs from there to Cape Beaufort, except for the area around Point Hope where a long sandspit reaches into the Chukchi Sea with an extensive lagoon area behind it.

After Cape Beaufort the hills along the coastline begin to decrease in magnitude until the Arctic coastal plain is reached. The coast has been uplifted in recent geologic time and two main effects occur. Where wind and wave action directly affect the mainland there has been an undercutting of banks to form cliffs. Where the shoreward slope is about the same as the submarine slope there has been a building of offshore bars and islands. This latter action has occurred from Point Lay to Wainwright where the enclosed Kasegaluk Lagoon provides a protected waterway for well over one hundred miles reaching past Icy Cape almost to Wainwright. Another extensive system reaches well inland behind Wainwright. This section of coast ends at Peard Bay and from that point to Barrow the coast has been undercut to form prominent cliffs.

Unfortunately, all of these protected waters are extermely shallow and the entrances are normally not navigable for anything but small boats. Nowhere does a suitable natural harbor site for ocean going commerce exist. Several years ago the Atomic Energy Commission proposed to blast a deep draft harbor in the vicinity of Cape Thompson with nuclear explosives to overcome this lack and provide the area with a port but this operation, known as Project Chariot, was brought to a halt by the general opposition of much of the scientific community working in the Arctic at that time.

In any case, these shallow seas will require use of either shallow draft vessels, offshore terminals, or extensive dredging to make suitable onshore terminals. A successful resolution of these terminal problems will be one of the prime determinants as to which of the previous transportation options would be utilized for onshore resources, marine transport direct from source or transport overland via pipeline or railroad.

The use of shallow draft vessels would provide only incremental gains since there are no protected harbors that could be utilized by ships or barges drawing more than six feet. Present marine traffic unloads in open roadsteads at the villages along the coasts with no protection from ice movements being afforded at any site. The long distance to the possible markets for these resources in East Asia and the United States would require development of a special class of barge and tug to achieve economic cargo sizes for resources such as coal and oil.

The present barge systems have proven very successful for the present level of traffic but they are difficult to load and unload under present conditions. This problem alone would create unacceptable costs for traffic flows of the magnitude envisoned for the northwest coast resources. If special facilities must be built for shallow draft vessels it might prove more feasible to make the investment in deep draft facilities.

The problem with onshore terminals will probably be simply the costs of dredging to make possible the channel depths necessary for tankers and ore freighters of the size that will be common in world trade in the future. Dredging in areas of underwater permafrost may create an entire new set of problems presently unknown to us. The main advantage of onshore facilities is that transportation of commodities to offshore terminals for loading is avoided. In a coastal area subject to a good deal of bottom scour from ice movement and extensive disturbance to the beach itself this may present the major problem for offshore terminals.

Another problem for onshore terminals will be to make their entrances of sufficient size so that large vessels will have the maneuvering room necessary to battle ice movements. This could require dredging much larger areas than those necessary on non ice stressed coasts especially in a situation where a constant cargo flow must be maintained.

Intensive dredging of harbors and harbor entrances could cause major erosional problems of both onshore and offshore permafrost that would require stabilization. There are no presently accepted methods of stabilizing underwater permafrost and the costs of stabilizing even small areas where the permafrost must be penetrated, as in drilling oil wells, has proven to be quite high. The accepted method of insulation used in building roads and airstrips is to put a blanket of gravel or other material over the permafrost. If this method is used in constructing harbors it means that very large amounts of material will have to be used to extend the landmass into deeper water rather than dredging into the land. There may be sites where this is possible along the northwest coast of Alaska but they have not been identified as yet.

Offshore terminals offer several different options. They can be created through dredging artificial islands, by utilizing structural design aimed at maximum ice deflection, by underwater terminal facilities that minimize the problems of ice movements or by combinations of all of the above.

The creation of artificial islands in the Arctic has finally begun to receive some attention. Imperial Oil has attempted to dredge an island in MacKenzie Bay that they hope will stabilize itself through creation of permafrost conditions in the dredged material. This operation is in essence taking unfrozen material and hoping to convert the central core of the dredged material to a permanently frozen condition. Attempts to dredge permafrost were too slow and increased costs too much and it was necessary to use only unfrozen bottom sediments. Little data is available at present on the suitability of Chukchi Sea seabed materials for use as artificial islands. Gravels are generally considered better than clays and silts at this time but studies are underway on methods to achieve stabilization of silty materials long enough for the permafrost action to take affect.[7] Also, little is known of the effects of the intensive dredging that would be necessary to create large islands. There are extensive marine mammal populations in the Chukchi Sea whose selfare must be considered in addition to the fisheries of the area which while not extensively utilized at present are being prospected by Japan, the Soviet Union and the United States. Dredging in immediate onshore areas in the location of the lagoons would affect waterfowl

habitat that is important to several countries since the species that summer there, spend the winter through a good part of North America and the Pacific Basin.

Another method of creating artificial islands that received a limited test at Prudhoe Bay was to capture large ice islands or floes, ground them and stabilize them in place by pumping sea water over the top and freezing it. Obviously during summer months an intensive refrigeration system would be necessary to maintain the integrity of the island's mass. The study at Prudhoe is still ongoing and only limited data is available from it at present.

Structures powerful enough to deflect ice are possible but the costs of building them may prove prohibitive in this remote area. Certainly it is difficult to envision the Chukchi Sea dotted with drilling platforms that are built to withstand the immense pressures of the Arctic icepack. While experience in Cook Inlet has shown that drilling platforms there can withstand substantial ice buildup, the pressures of Cook Inlet ice are in no way comparable to those that will be experienced in multi-year Arctic ice.

Submarine terminal facilities are feasible in deeper water and would probably prove to be the cheapest alternative in those areas. The main problem here would be for the ship to maintain position during heavy ice movements and the necessity for frequent disconnect would have to be taken into account. Failure of loading and unloading systems has veen a frequent cause of oil spills in Cook Inlet where disconnects are frequently necessary due to ice masses moving down upon vessels moored to the loading terminal.[8]

In determining the most logical transportation alternative for the resources of northwest Alaska, choices should be based upon systems that will have minimum investment in fixed infrastructure since there will be little or no use for the system after the resource is exhausted. It is probable that the resources are of such magnitude that they will justify the necessary investment in transportation systems at some future time.

Most estimates of the time when development of Chukchi Sea offshore oil resources will be needed range from 2000 to 2025. Great increases in demand over present projections or a loss of present supply sources in the Middle East could speed this development date.

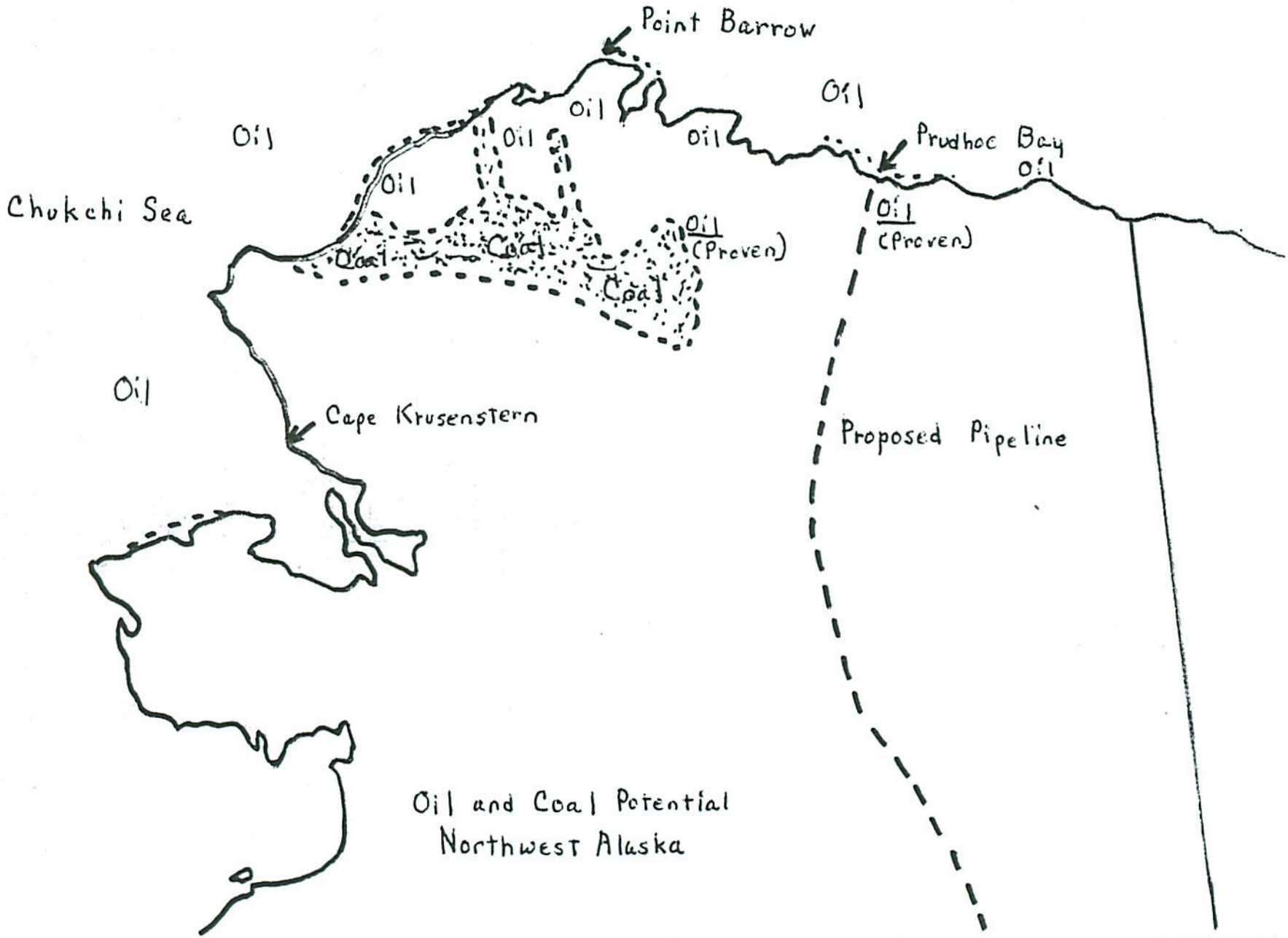
It is more difficult to predict any date for development of the coal resources. Alaskan coal must compete with Australian coal in the Japanese market and the United States has ample domestic reserves which will be more cheaply available than the coal of northwest Alaska. While, there are reserves of coking coal on the northwest coast that may be needed in Japan and other

East Asian markets before the turn of the century, large scale utilization of these coal resources is dependent at this time upon achieving a delivery system that can compete with those in use in other coal producing centers. It seems likely that major development of northwest coal for export is sometime beyond the development period for oil unless the savings entailed in joint development with oil make possible an earlier exploitation.

If and when successful techniques for drilling the offshore areas of the Chukchi Sea are developed these same techniques will be available for the development of offshore terminals for tankers. The major question that must be answered is whether it is economically more feasible and environmentally safer to bring the oil onshore and ship it via pipeline to an ice free port or whether tankers can load from offshore terminals and proceed directly to market. Answering this question will require studies on how best to protect pipelines that must be laid through the 2 to 10 mile wide zone of shallow water along this ice stressed coast. It will also depend upon the cost of maintaining year round tanker service in an area that will require some form of icebreaking for eight to nine months of the year.

The problems of coal delivery systems are somewhat more difficult. Utilizing slurry pipelines to get the coal from the mine to an offshore terminal could present some problems in an Arctic climate. It may well be that coal ports will have to be onshore because of the immediate problems of getting it to the loading terminal.

The fossil resources of northwest Alaska are immense but they will not be developed easily. Systems which will be cost competitive in world markets must use the Arctic rather than combatting it. Luckily, the resources are of such magnitude that planning and development budgets of a size to do the job right are justifiable.[9]


Point Barrow
Oil
Oil
Oil
Oil
Oil
Oil
Prudhoe Bay
Oil
Chukchi Sea
Oil
Coal
Coal
Coal
Oil
(Proven)
Oil
(Proven)
Oil
Cape Krusenstern
Proposed Pipeline
Oil and Coal Potential
Northwest Alaska

References

1. Farrel F. Barnes, Coal Resources of the Cape Lisburne - Colville River Region Alaska, U.S. Geological Survey Bulletin 1242-E, Washington, 1967, p. 17.

2. Industry executives and consultants surveyed were very conservative in their predictions and ranged from 2 to 4 million barrels per day production. The Director of Alaska's Division of Oil and Gas was slightly more optimistic and estimates some 20 percent higher. Federal government officials and university experts estimated at the high end of the range. Everyone qualifies their estimate as highly problematical. The author feels that the level of production will be governed more by U.S. Government energy policy and by the needs of the State of Alaska for revenue as two prime factors. If both of these warrant high production it will probably be achieved. If the national and state interest indicate a stable level of production the low end of the scale will be most likely.

3. The following documents were utilized in summation of reserves:

   T.A. Hendricks, Resources of Oil, Gas and Natural-Gas Liquids in the United States and the World, U.S. Geological Survey Circular 522, Washington, 1965.

   National Petroleum Council, Future Petroleum Provinces of the United States, Washington, 1970.

   Little, Arthur D. Inc., The Timing and Size of OCS Petroleum Lease Sales, A report to the U.S. Bureau of Land Management, 1970.

   Public Land Law Review Commission, Study of Outer Continental Shelf Lands of the United States, Appendix 5-A, Nossaman, Waters, Scott, Krueger & Riordan, Los Angeles, 1968.

4. Arthur Grantz, S.C. Wolf, Lloyd Breslau, T.C. Johnson, and W.F. Hanna, Reconnaissance Geology of the Chukchi Sea as Determined by Acoustic and Magnetic Profiling, in Proceedings of the Ecological Seminar on the North Slope of Alaska, Pacific Section, American Association of Petroleum Geologists, Los Angeles, 1970. p. F-6

5. Op. Cit. Hendricks, A category of 2 was assigned to Alaska's outer continental shelf which is 1 billion barrels of oil per square mile. p. 15.

6. U.S. Coast Guard, Polar Transportation Requirements Study Report, Vol. II., Washington, D.C., 1968, This study estimated a round trip from Wainwright to Saint Lawrence Island as taking some 22 days. Icebreakers were estimated to be on station for 200 days per year. The author estimated 10 trips per year from the northwest coast oil and coal shipping locations. The Coast Guard estimated $2,580,000 per year as operating costs for each vessle which given $258,000 per trip in 1967 dollars. This figure was escalated 40 percent to reflect cost inflation over the past six years.

7. Donald M. Taylor, "Man-made Permafrost Islands for Offshore Drilling Sites," Ocean Industry, Vol 7 (11) November 1972, p. 41.

8. Charles Evans, and Eugene Buck, Richard Buffler, Greg Fisk, Robert Forbes, and Walter Parker, The Cook Inlet Environment, University of Alaska, Alaska Sea Grant Program, Anchorage, 1972, p. V. 16-17.

9. Based upon transportation investments currently estimated for Prudhoe Bay development, it seems reasonable that at least $4 billion in current dollars would be available to develop transportation systems necessary to exploit the oil resources of northwest Alaska.