

## CHAPTER 12. FISH-MEDIATED EFFECTS

Large-scale mining, as described in the mine scenarios (Table 6-1), could have both direct and indirect effects on wildlife and Alaska Native cultures (Figures 12-1 and 12-2). In this chapter, we primarily consider indirect effects, focusing on how wildlife and Alaska Native cultures may be affected by any mining-associated changes in salmon resources. Direct effects on these endpoints—defined here as effects that are independent of impacts on fish populations—could be significant, and would need to be fully evaluated as part of a comprehensive environmental impact statement for any proposed future development. However, these direct effects are generally considered outside the scope of the current assessment (Chapter 2) and are only mentioned briefly here (Box 12-1). Potential cumulative effects that multiple mines in the region may have on wildlife and Alaska Native cultures are discussed in Chapter 13.

### 12.1 Effects on Wildlife

As discussed in Chapters 7 through 11, a large-scale mine and its associated transportation corridor would likely affect the abundance, productivity, and diversity of Pacific salmon. These changes in salmon resources could stem from direct habitat losses and downstream flow alterations resulting from the mine footprint, or from changes in the physical and chemical habitat characteristics resulting from mine operations and potential accidents or failures. Wildlife species in the Nushagak and Kvichak River watersheds that depend on salmon could be affected by decreases in salmon abundance. Interactions between salmon and other fish and wildlife, and the potential for disruption of these interactions, are complex (Section 5.2.5). In this section, we qualitatively consider how a decrease in salmon abundance may affect wildlife—that is, salmon-mediated effects on wildlife—via the loss of salmon as a food source and the loss of marine-derived nutrients (MDN) as a source of productivity.

**BOX 12-1. POTENTIAL DIRECT EFFECTS OF MINING**

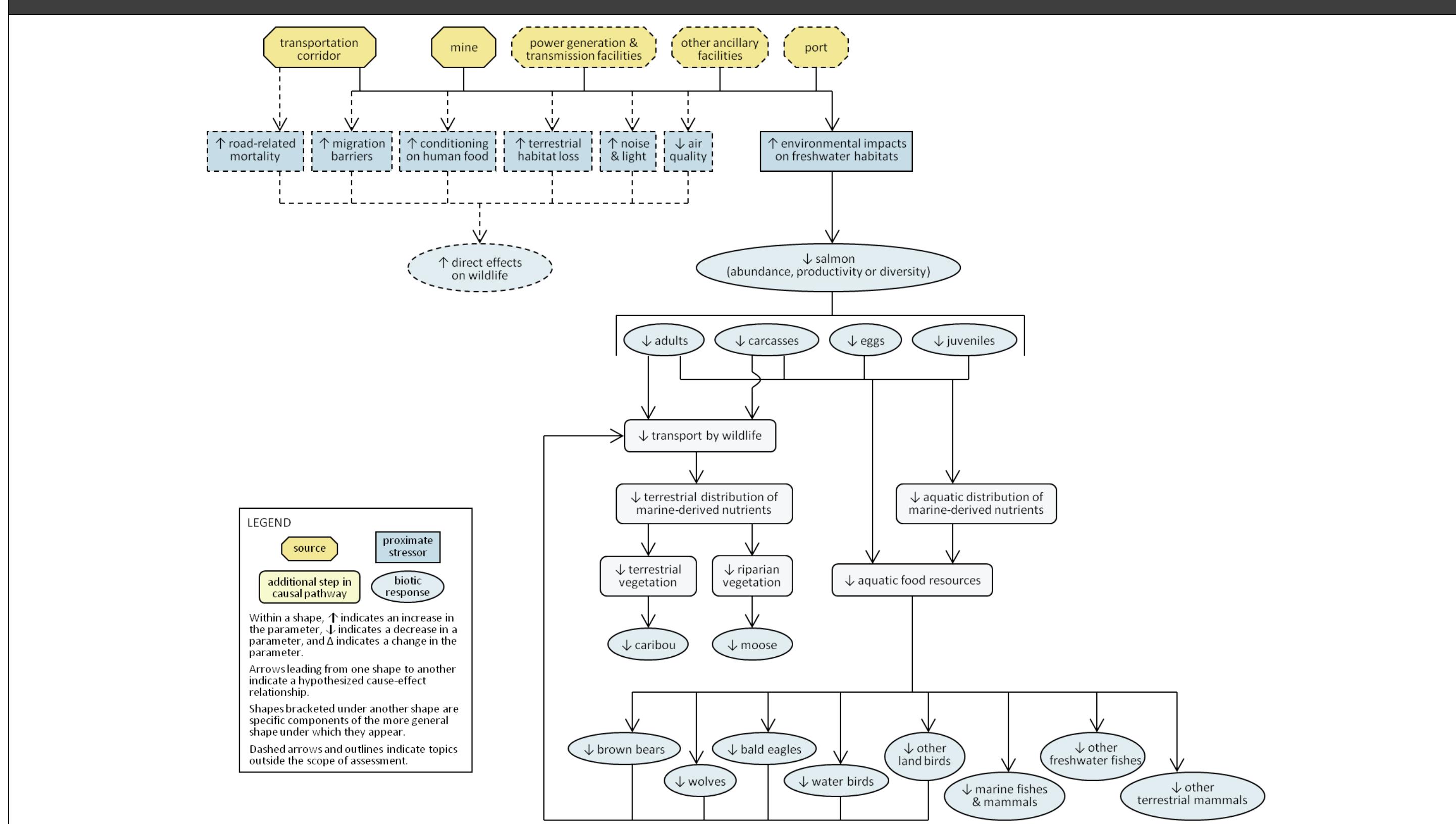
The salmon-mediated effects considered in this assessment represent only one component of potential large-scale mining impacts on wildlife and Alaska Natives. Both wildlife and Alaska Natives would likely experience direct impacts, the magnitude and extent of which could be significant. For example, direct impacts on wildlife would include loss of terrestrial and aquatic habitat, reduced habitat effectiveness (e.g., in otherwise suitable habitats adjacent to mine area), habitat fragmentation, increased stress and avoidance due to noise pollution, and increased conditioning on human food (Figure 12-1).

Direct effects of large-scale mining on Alaska Native populations could result from multiple stressors, including noise pollution, air emissions, changes to water supply and quality, an influx of new residents, and induced development. Mine construction and operation also would have direct economic and social effects, both positive and negative, on Alaska Native cultures. For example, an influx of new residents in response to mine development could decrease the local population percentage of Alaska Natives and have a corresponding effect on local culture. A shift from part-time to full-time wage employment in mining or mine-associated jobs would provide additional employment opportunities and income, but would affect subsistence-gathering capabilities by reducing the time available to harvest and process subsistence resources.

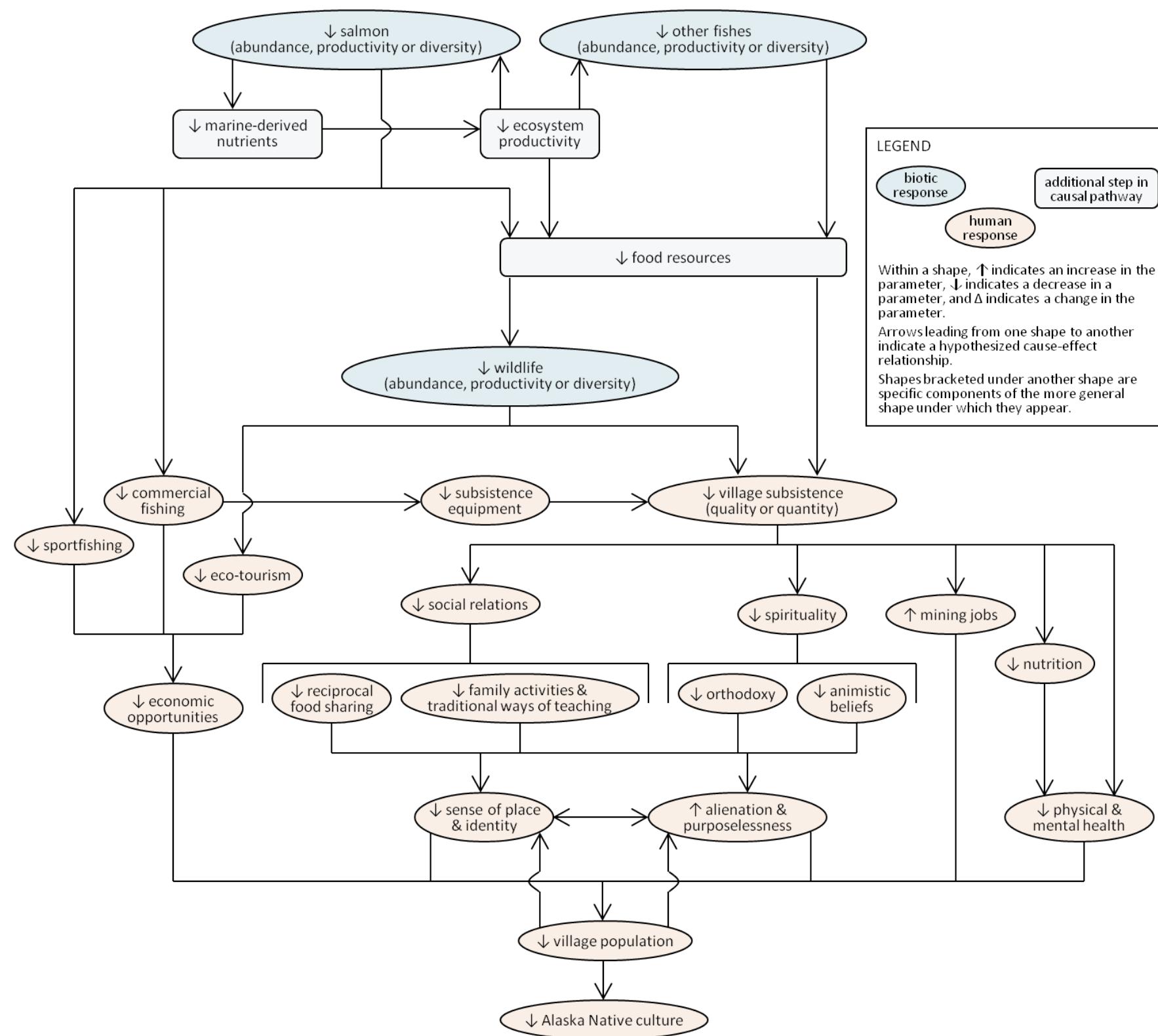
At this time, it is difficult to determine what, if any, effects routine operations at the Pebble deposit would have on drinking water sources in the Nushagak and Kvichak River watersheds. Private wells are a primary drinking water source for many residents of the Nushagak and Kvichak River watersheds, and communities also rely on groundwater for their public water supply. The extent to which surface water influences the quality or quantity of the groundwater source for these wells is unknown. There are also communities in the area that rely on surface water sources, which may be more susceptible to mine-related contamination.

Although a thorough evaluation of potential direct effects of large-scale mining on wildlife and Alaska Native populations is beyond the scope of this assessment, these examples illustrate just a few of the complex ways in which wildlife and Alaska Natives could be affected by large-scale mine development.

Lower salmon production would likely reduce the abundance and production of wildlife in the mine area and presumably in the range areas of the affected species, but the magnitude of those effects cannot be quantified. The Bristol Bay region is home to a complex foodweb that includes salmon and salmon predators and scavengers (Box 5-3, Figure 12-1). Annual salmon runs provide food for brown bears, wolves, bald eagles, other land birds, and water birds, and it is likely that these species would be directly affected by a reduction in salmon abundance. Waterfowl prey on salmon eggs, parr, and smolts and scavenge on carcasses. Salmon carcasses are an important food source for bald eagles, water birds, other land birds, other freshwater fish, and other terrestrial mammals. Aquatic invertebrate larvae also benefit from carcasses and are an important food source for water birds and land birds.

**Figure 12-1. Conceptual model illustrating potential effects on wildlife resulting from effects on salmon.**

**Figure 12-2. Conceptual model illustrating potential effects on Alaska Native cultures resulting from effects on salmon and other fishes.**



Salmon predators and scavengers then deposit MDN on the landscape, as either carcasses or excreta. These nutrients contribute to the plant production that supports caribou, birds, and other terrestrial wildlife. Caribou are, in turn, prey species for wolves and brown bears. The link between increased vegetation and MDN distributed by brown bears has been documented (Hilderbrand et al. 1999, Helfield and Naiman 2006), but additional research is needed to confirm and quantify the links between moose, caribou, and MDN.

Factors such as the magnitude, seasonality, duration, and location of salmon losses would influence the specific wildlife species affected and the magnitude of effects. Generally, the loss of salmon as food resources in any area of the mine scenario watersheds would be expected to create displacement or loss of wildlife species dependent on those food resources. If the loss were of a sufficient magnitude and duration, there may be additional indirect effects, such as loss of vegetation from lack of MDN and consequent loss of food resources for species such as moose and caribou. Should riparian vegetation be reduced by long-term loss of MDN, there would be decreased food resources for moose, particularly in the Nushagak and Mulchatna River systems, which have large riparian zones (Brana and Verbrugge 2013).

Seasonality of salmon resources is also important for wildlife species. Brown bears, wolves, bald eagles, and other species depend on salmon for a large fraction of their summer diet. Mine failures that reduced or eliminated a salmon substock would be expected to reduce or displace wildlife species that depend on those particular salmon nutrients during important life-history periods such as breeding, nesting, and pre-winter feeding.

Alaska Natives have expressed concerns that wildlife may be affected by consuming contaminated fish. Two potential contaminants of concern are copper and selenium. The primary aquatic contaminant of concern from a porphyry copper mine is copper, which can cause both acute and chronic toxicity to salmon and other fishes (Chapter 8). However, copper is relatively weakly accumulated by fish in both aqueous and dietary exposures and does not bioaccumulate. In fact, in the Clark Fork River, copper concentrations were lower in fish than in invertebrates, and lower in invertebrates than in periphyton (ARCO 1998).

Data for copper toxicity to wildlife are not available, because direct toxicity has not been a problem—the indirect effects of reduced aquatic prey are likely to be greater than direct toxic effects. However, the dietary maximum for pigs and poultry of 200 mg/kg dry weight can be used as a surrogate benchmark (Eisler 2000). If we use the highest reported fish bioconcentration factor (290 for fathead minnows, from an unpublished manuscript cited in USEPA 1985) as a conservative value, we obtain a safe water concentration of 690 µg/L. This safe level for wildlife is much higher than both the toxic levels for aquatic biota (Section 8.2.2.1) and the estimated instream concentrations for a wastewater treatment plant failure (Table 8-20). It is a little higher than the estimated concentration in the concentrate transport water and return water (655 µg/L, Section 11.3.2), but is not a concern because of dilution and the short duration of exposures to spills. The copper concentration in the product concentrate leachate is 12 times that value. However, a product spill would be localized at the mine site or along the

transportation corridor. Most important, if copper concentrations were so high that the leachate was not diluted by a factor of 12, there would not be a sufficient aquatic community remaining after a spill to attract species such as mink, river otters, or belted kingfishers, which may forage in a particular stream or river for fishes such as trout, char, or salmon fry. Hence, copper toxicity to fish-eating wildlife is improbable.

Selenium is a well-characterized avian toxicant that has been a concern for waste rock leachate at other mines (USEPA 2011). It does biomagnify and the primary route of exposure for fish is diet (Chapman et al. 2010). However, selenium bioaccumulation depends on biogeochemical conditions that occur in slowly flowing (lentic) ecosystems such as ponds and wetlands, and is much less prevalent in the streams that are the likely receptors for effluents with elevated selenium levels. In addition, the selenium concentrations in wastes identified in the mine scenarios would be relatively low. Mean selenium (the appropriate measure for a biomagnifying chemical) expected in waste rock leachates is below the water quality criterion, and leachates from tailings and product concentrate are only 1.5 times the criterion concentration (Section 8.2.2.2). Hence, minimal dilution would bring these concentrations down to safe levels. Although fish and birds are sensitive to selenium, mammals are not. The body burdens of adult salmon are almost entirely due to marine exposures; because salmonid eggs take up contaminants relatively slowly, body burdens of eggs and larvae would also be expected to reflect marine sources. Local sources of selenium are therefore not relevant, and bioaccumulation of selenium would only be a concern for wildlife consuming resident fish or older salmon fry. Fish-eating birds feeding on resident fish also may forage in more than one stream or other water body, potentially providing further dilution. For these reasons, aqueous selenium is unlikely to pose a risk to wildlife via fish consumption.

## 12.2 Effects on Alaska Natives

As discussed in Chapters 7 through 11, routine development and operation of a large-scale mine, as well as potential mine accidents or failures, would likely affect salmon resources in the Nushagak and Kvichak River watersheds. The importance of salmon to Alaska Native cultures is well documented (Section 5.4, Appendix D). Because these cultures are so intimately related to the local landscape and the resources it provides, any changes to salmon or other subsistence resources would likely result in changes to the cultures. The magnitude of these changes could be assumed to be dependent on the magnitude and duration of both the loss of subsistence resources and the disruption to the landscape itself. Changes in salmon resources may affect indigenous health, welfare, and cultural stability in several ways (Appendix D).

- Because the traditional diet is heavily dependent on wild foods, particularly salmon, diets would move from highly nutritious wild foods to increased reliance on purchased processed foods.
- Social networks are highly dependent on procuring and sharing salmon and wild food resources, so the current social support system would be degraded.

- The transmission of cultural values, language learning, and family cohesion would be affected because meaningful family-based work takes place in fish camps or similar settings for traditional ways of life.
- Values and belief systems are represented by interaction with the natural world through salmon practices, clean water practices, and symbolic rituals. Thus, core beliefs would be challenged by a loss of salmon resources, potentially resulting in a breakdown of cultural values, mental health degradation, and behavioral disorders.
- The region exhibits a high degree of cultural uniformity tied to shared traditional and customary practices, so significant change could provoke increased tension and discord both between villages and among villagers.

Human health and cultural effects related to potential decreases in salmon resources would depend on the magnitude of these reductions. A small reduction in salmon quality or quantity may not have significant impacts on subsistence food resources, human health, or cultural and social organization, but a significant reduction in salmon quality or quantity would certainly have significant negative impacts on these salmon-based cultures.

Salmon-mediated effects from potential accidents and failures associated with large-scale mining would likely have much greater effects on human welfare and Alaska Native cultures than the effects from routine operations. It should be assumed that any negative impact on salmon quantity or quality resulting from mine failures or accidents would affect human health and welfare, both from loss of or change in food resources and from cultural disruption. Because all aspects of Alaska Native cultures in the Nushagak and Kvichak River watersheds are closely tied to salmon and other fishes, cultural vulnerability to long-term environmental disruption is very high (Appendix D). A major failure or accident that resulted in long-term disruption of salmon habitat and ongoing toxicity to salmon or their food would significantly affect both subsistence resources and cultural identity. Potential causes of salmon-mediated effects on Alaska Native cultures would differ across the two watersheds. For example, villages near the transportation corridor could be negatively affected by road and culvert failures (Chapter 10) or pipeline spills (Chapter 11). Villages downstream of the mine would be more affected by any water collection, treatment, and discharge failures (Chapter 8), and impacts from these failures would likely be much greater than impacts from routine operations.

This assessment focuses on potential effects on Alaska Native cultures, but other groups would also be particularly vulnerable to mining-associated impacts on salmon. Many of the non-Alaska Natives that reside in the area practice a subsistence way of life and have strong cultural ties to the landscape that go back generations (Box 12-2). Many seasonal commercial anglers and cannery workers also depend on these resources and have strong, multi-generational cultural connections to the region.

In this section, we discuss the range of potential salmon-mediated effects on Alaska Native cultures from large-scale mining in the Nushagak and Kvichak River watersheds. We also reference key impacts that other mining, oil, and gas development activities in Alaska—including northwest Alaska's Red Dog Mine

and oil and gas development on Alaska's North Slope—have had on Alaska Native cultures, especially in terms of losses of or changes to subsistence resources. Although not directly applicable to large-scale mining, information about oil and gas extraction activities provides insight into potential effects of large-scale mining on Alaska Native culture in the Nushagak and Kvichak River watersheds.

#### BOX 12-2. TESTIMONY ON POTENTIAL EFFECTS OF MINING ON ALASKA NATIVE CULTURES

The U.S. Environmental Protection Agency (USEPA) held a series of public meetings to collect input on the May 2012 draft of this assessment. Many Alaska Natives, including tribal Elders and other tribal leaders, provided testimony on concerns about potential effects of large-scale mining in the Bristol Bay watershed, as well as the desire for economic development. The following are selected quotes representative of this testimony. To view the full public meeting transcripts, visit [www.epa.gov/bristolbay](http://www.epa.gov/bristolbay).

- “Salmon has been part of our Native spiritual food; and without the food and waters we will die slowly, we'll be here existing, but our spirit will be gone.”
- “I urge you to pay especially close attention to the voices of our Elders across Bristol Bay. They have instilled in them the deepest of our roots, and our God given way of life; our culture that has been slowly fading away. It is the adaptation to modern civilization that we have embraced so far that is causing our cultures to become lost.”
- “We support the science of this document as it in turn supports what the Elders of this area and their traditional knowledge have said all along. We are preparing our boats, we are mending our nets, we are cleaning our smokehouses and we are sharpening our knives. However, by testifying at these meetings and missing out on one day or maybe several days of preparation for those who attended multiple meetings here in the region, we hope that this will prevent, with the help of the EPA, missing out on a lifetime of salmon and missing out on a way of life that we have treasured for thousands of years.”
- “Bristol Bay is much different. Everyone who lives here has a deep and strong sense of place. There is a powerful connection to the lands and waters and resources of Bristol Bay. It is a connection that starts before birth. It is genetic. It is handed down through the generations and it is also learned from a very young age. A connection told in stories from parents and Elders and experienced firsthand. Toddlers accompany parents and grandparents fishing, hunting, berry picking. They participate at home to store that food and save it. It is part of the family experiencing for anyone who grows up in Bristol Bay, and as a result, this land its water and its resources become a part of who you are. This is a connection without a price tag and it cannot be replaced. If it lost, it is lost forever.”
- “My family does subsistence. We like our fish. But still, nobody is going to give my boys jobs. Nobody is going to pay my bills. I'm not for or against. I want clean water, but we need jobs around here. Who is going to pay for my bills?”
- “I work for Pebble. I have a big family who loves the outdoors and enjoy their subsistence way of life. Subsistence is good, but it is not paying for my bills and does not clothe my kids.”

#### 12.2.1 Subsistence Use

As discussed in Chapter 5, subsistence foods make up a substantial proportion of the human diet in the Nushagak and Kvichak River watersheds and likely contribute a disproportionately high amount of protein and certain nutrients. The percentage of salmon harvest in relation to all subsistence resources ranges from 29 to 82% in the villages (Appendix D).

The mine scenario footprints would have some effects on subsistence resources. Although no subsistence salmon fisheries are documented directly in any of the mine scenario footprints, other fish are harvested in these locations, and the areas are identified as being important for the health and abundance of subsistence resources (PLP 2011: Chapter 23). Negative impacts on downstream fisheries

from headwater disturbance (Section 7.2) could affect subsistence salmon resources beyond the mine footprints. Those residents using the mine area and immediate areas downstream of the mine pit and tailings storage facilities (TSFs) for subsistence harvests would be most affected (Figure 5-2). Access to subsistence resources is also important. A reduction in downstream seasonal water levels caused by mine-related withdrawals during and after mine operation could pose obstacles for subsistence users who are dependent on water for transportation to fishing, hunting, or gathering areas.

There could also be effects from the footprint of the transportation corridor. A review of Alaska Department of Fish and Game data (Appendix D: Table 13) indicates that some residents use the area along the transportation corridor considered in the assessment for subsistence salmon harvest. Of the villages in these watersheds, reliance on salmon is highest in Pedro Bay, where salmon provides 82% of per-capita subsistence harvest. The estimated annual per-capita subsistence harvest for Pedro Bay, the village closest to the transportation corridor considered in this assessment, was 306 pounds in 2004. Thus, this village is particularly vulnerable to losses of salmon resources.

The effects of the transportation corridor on subsistence resources would be complex and unpredictable. Based on the analysis in Chapter 10, we anticipate that routine transportation operations would have some negative effects on salmon habitat in streams along and downstream from the transportation corridor. Some subsistence users in these areas could be affected. The corridor also would increase accessibility of the area, which could increase subsistence use of nearby streams but also create greater competition for resources.

The initial effect of a mine accident or failure on Alaska Native cultures would be the loss or decrease of subsistence salmon resources downstream. It is not possible to quantify the magnitude of subsistence resources that would be lost, nor is it possible to evaluate the geographic extent of disruption to subsistence resources. However, this assessment provides examples of the potential magnitude of salmon impacts from failures. One such example is the potential effect of a tailings dam failure on Chinook salmon in the Nushagak River. As described in Chapter 9, a tailings dam failure at TSF 1 could significantly affect Koktuli River Chinook runs, which constitute up to 29% of the larger Nushagak River Chinook runs. Stuyahok River and Mulchatna River Chinook runs, which constitute up to 17 and 10% of the Nushagak River Chinook runs, respectively, could also be affected. The Alaska Native villages on the Nushagak River (Koliganek, New Stuyahok, Ekwok, and Dillingham) (Figure 2-4) are culturally and nutritionally dependent on Chinook salmon. Thus, a tailings dam failure would have negative and potentially significant effects on the ability of subsistence users to harvest salmon downstream of the mine area.

It is not possible to predict the magnitude of effects from the loss of salmon as a subsistence food, nor is it possible to predict what level of subsistence resource loss would be necessary to overcome the adaptive capacity of these cultures. On a physical level, the loss of salmon as a highly nutritious wild food and the consequent substitution of purchased foods would have negative effects on individual and public health (Appendix D). Salmon is especially valued around the world for nutrition and disease prevention. Dietary transition away from subsistence foods in rural Alaska carries a high risk of

increased consumption of processed simple carbohydrates and saturated fats. This has occurred in urban communities that have low availability and high cost of fresh produce, fruits, and whole grains (Kuhnlein et al. 2001, Bersamin et al. 2006). Also, alternative food sources may not be economically viable and are certainly not as healthy. Compounding the shift to a less healthy diet, the physical benefits of engaging in a subsistence lifestyle would be reduced (Appendix D).

In addition to the salmon-mediated effects of large-scale mining considered here, there could be effects from the loss of non-salmon subsistence resources, such as land mammals, birds, and other fishes. Subsistence use of the mine area is high and centers on hunting caribou and moose and trapping small mammals (Braund and Associates 2011 in PLP 2011). Because no subsistence salmon fisheries are documented in the mine scenario footprints, direct loss of non-salmon subsistence food resources likely would represent a greater direct effect than loss of salmon harvest areas in the mine footprints. Tribal Elders have expressed concerns about ongoing mine exploration activities directly affecting wildlife resources, especially the caribou herd range (Appendix D).

Experience with existing development in Alaska supports the contention that development of a large-scale mine operation would directly affect subsistence resources within and around the mine scenario footprints during routine operations and in perpetuity, from both loss of habitat and disturbance related to routine operations. For example, the supplemental environmental impact statement for the Red Dog Mine (USEPA 2009) documented multiple subsistence impacts, including reduced harvest of beluga by Kivalina harvesters, likely related to port activities. Related to transportation corridors, traffic along the Delong Mountain Regional Transportation System road was found to cause “limited, localized” effects on caribou movement and distribution, and nine caribou fatalities occurred because of traffic collisions. Kivalina harvesters and harvest data also indicated that traffic along the road has likely resulted in fewer caribou harvested by Kivalina harvesters than would otherwise be the case.

A study of the cumulative environmental effects of oil and gas activities on Alaska’s North Slope included a summary of hearings held with North Slope residents, who are predominantly Alaska Natives. Community members provided testimony on both positive and negative effects of these activities. North Slope residents recognize that oil production in the region has brought benefits such as money to spend on community facilities, schools, modern water and sewer systems, village clinics, child emergency shelters, and behavioral outpatient and residential programs that provide mental health care and counseling for substance abuse and domestic violence. However, they also reported that traditional subsistence hunting areas have been reduced, the behavior and migratory patterns of key subsistence species have changed, and there is increased incidence of cancer and diabetes and disruption of traditional social systems.

Residents also reported experiencing significant increases in the time, effort, and funding necessary to respond politically and administratively to the increased number of projects proposed in their communities (NRC 2003). The stress of integrating a new way of life with generations of traditional teachings and the associated impacts of rapid modernization and loss of tradition is known as acculturative stress. This stress has been linked to a wide variety of health outcomes, ranging from

impaired mental health and social pathology (such as substance abuse, violence, and suicide) to cardiovascular disease and diabetes. For the Inupiat on the North Slope of Alaska, the greatest defense against acculturative stress is the continued practice of the bowhead whale hunt, which involves the entire community (NMFS 2013).

Changes in diet and nutrition are common potential effects of oil and gas exploration and production activities where populations rely on subsistence resources. These changes can lead to a number of important public health outcomes. For example, a traditional diet has been shown to be strongly protective against chronic diseases for indigenous populations. A shift away from subsistence diets is associated with food insecurity, or the inability to secure sufficient healthy food for a family. Studies of food insecurity and health have found a variety of detrimental health impacts, including obesity, poor psychological function among children, poor cardiovascular health outcomes, and lower physical and mental health ratings (NMFS 2013). The high cost of store-bought food, the costs associated with harvesting of subsistence resources, and the year-to-year variation in subsistence resource availability are all implicated in the high food insecurity rates experienced by many northern indigenous populations.

Alaska Native residents also report subtle changes in species harvested by subsistence hunters, including changes in color, texture, and taste of the flesh and skin of several subsistence species. Transportation corridors associated with resource extraction activities can also increase competition for local subsistence resources. For example, hunting by non-local residents along the Dalton highway has been reported to have increased after the development (and later public opening) of the road (NRC 2003).

The experiences of subsistence users near Red Dog Mine and Alaska's North Slope indicate that localized changes in resource movement can affect that resource's availability and predictability to subsistence users, even when the overall pattern or abundance of the resource may not be affected by development activities. From a biological standpoint, changes in caribou related to the Red Dog Mine may be viewed as minimal. However, because residents rely on only a portion of the expansive range of the Western Arctic caribou herd to harvest caribou, small and localized changes in caribou availability can have large effects on subsistence uses. Subsistence users have observed changed or diverted migration routes, reduced harvests of caribou, decreased size of caribou individuals and groups, and increased disease and infection since mine operations began, and cite both mine-related and other causes (USEPA 2009).

The Exxon Valdez oil spill also resulted in reduced subsistence activities (Palinkas et al. 1993). These reductions resulted from the closure of many areas to subsistence activities, local concerns over subsistence food safety, voluntary abstinence from consumption after the spill, and reduced time for subsistence activities by Alaska Natives who participated in cleanup efforts.

### **12.2.2 Perception of Food Security**

Even a negligible reduction in salmon quantity or quality related to mining could decrease use of salmon resources, based on the perception of subtle changes in the salmon resource. Interviews with tribal

Elders and culture bearers indicate that perceptions of subtle changes to salmon quality are important to subsistence users, even if there are no measureable changes in the quality and quantity of salmon (Appendix D). Aside from actual exposure to environmental contamination, the perception of exposure to contamination is also linked to known health consequences, including stress and anxiety about the safety of subsistence foods and avoidance of subsistence food sources (Joyce 2008, CEAA 2010, Loring et al. 2010), with potential changes in nutrition-related diseases as a result. These health results arise regardless of whether there is contamination at a level that could induce toxicological effects in humans—rather, the effects are linked to the perception of contamination (NMFS 2011).

Literature on impacts from oil and gas development on Alaska's North Slope and ongoing operations at Red Dog Mine demonstrates that even perceived contamination could have a real effect on subsistence harvesters. In a recent survey, 44% of Inupiat village residents reported concern that fish and wildlife may be unsafe to eat (Poppel et al. 2007, NMFS 2011). Residents of Kivalina and Noatak, the communities closest to Red Dog Mine, also have expressed concerns about food safety, potential contamination of subsistence resources, and corresponding changes in subsistence foraging (USEPA 2009). Kivalina residents are concerned about potential contamination of the Wulik River, which is used both for subsistence and as the drinking water source for the village. These concerns persist even though studies by the Alaska Department of Health and Social Services found that heavy metal concentrations in drinking water were low and did not pose a risk (USEPA 2009).

### 12.2.3 Economic Impacts

Alaska Natives, as well as other local residents, participate in the salmon-based market economy, primarily via commercial fishing and tourism. Subsistence harvests also represent a significant economic value to local residents. A decrease in salmon that affected either of these sectors would be particularly burdensome to local residents dependent on the commercial fishery for income and the subsistence fishery for food. The necessity of purchasing expensive foods from outside the region, in conjunction with more limited opportunities to obtain paid seasonal employment in the region, could be extremely difficult for families. In many cases, income from commercial and recreational fishing provides money to purchase equipment for subsistence fishing, so lost or reduced income from commercial fishing would affect subsistence harvests even if subsistence fishing remains possible. For those able to benefit economically from mining and induced development, there would be increased cash resources to purchase equipment and supplies, resulting in more efficient subsistence activities. However, increased full-time employment could decrease the time available for subsistence activities and thus the social relationships based on these activities. Some residents have expressed a desire for jobs and development related to large-scale mining and a market economy, whereas other residents have expressed concerns that this type of economic shift would be detrimental to their culture (Box 12-2, Appendix D).

Although large-scale mining would inject some market-based economic benefits for some period of time, resource extraction experiences in other rural Alaska areas suggest it would likely have only modest direct employment benefits in the local region (Goldsmith 2007). At the Red Dog Mine, ownership of the

resource empowered the NANA Regional Corporation, Inc. (NANA) to negotiate a development agreement with strong protections and benefits to Northwest Alaska Natives (Storey and Hamilton 2004). NANA shareholders account for approximately 56% of the mine's 464 full-time employees and 91% of its 78 part-time employees. Although first preference in hiring and most of the training slots go to shareholders, shareholders disproportionately occupy the mine's lower-skilled positions (Storey and Hamilton 2004). Additionally, the supplemental environmental impact statement showed that employment at the Red Dog Mine may have facilitated the relocation of community residents to Anchorage for lifestyle or economic reasons (Storey and Hamilton 2004, USEPA 2009).

A disproportionately low number of Inupiat people are employed by the oil and gas industry on Alaska's North Slope, although this may partially result from the large percentage of young people in the population (NRC 2003). The Alaska Department of Labor reported that, of the 7,432 people who reported working in the oil and gas sector on the North Slope in 1999 (and worked for companies that collected and reported residency information), only 64 lived in the state's Northern Region (i.e., the Nome, North Slope, and Northwest Arctic boroughs). A variety of factors affected both male Inupiat willingness to work in the oil fields and the desire of companies in Prudhoe Bay to hire them (Kruse et al. 1983, NRC 2003).

There may be decreased participation in a subsistence way of life for those benefiting from any employment opportunities. The cash economy and the subsistence economy are intertwined, and subsistence is a full-time job for those fully engaged in it. However, it is necessary to supplement subsistence with cash from part-time wage labor or commercial fishing to defray the costs of subsistence activities (Appendix D). Despite differences in the types of subsistence and traditional cultural practices between the people of the Nushagak and Kvichak River watersheds and the people of the North Slope, studies from the North Slope region can provide some insights. A study of Alaska's North Slope Inupiat people found that there is an inverse relationship between active subsistence harvesting and wage labor time for the individual worker, but that cash from employment is often used for subsistence inputs (e.g., gasoline, boats, ammunition) (Kerkvliet and Nebesky 1997).

One of the mitigation measures that can address the impact of full-time employment on subsistence activities is the implementation of subsistence leave policies. For the development of the Red Dog Mine supplemental environmental impact statement, interviews were conducted that included questions asking Noatak and Kivalina residents about their employment history related to the Red Dog Mine and their employer's subsistence leave policies. Responses were mixed regarding whether or not interviewees were aware of a subsistence leave policy and whether or not the policy worked. Some of the companies did not have subsistence leave policies, so workers conducted subsistence activities during their weeks off or would take personal time. Where the companies did have policies for subsistence leave, an average of 46% of respondents were unsure whether or not the policy worked (USEPA 2009).

The creation of mining-related jobs for local residents and attendant increases in the region's cash economy are often mentioned as potential benefits of large-scale mining development. However,

increases in personal income may not be the best measure of benefits in a subsistence-based culture and should be considered over the long-term, as oil, gas, or mineral resources are exhausted and future opportunities—including subsistence resources—are potentially damaged. These types of damages persist, even when resource extraction ceases (NRC 2003).

### 12.2.4 Social, Cultural, and Spiritual Impacts

The inability to harvest salmon from portions of these watersheds would result in some degree of cultural disruption, which goes well beyond a loss of food supply. Boraas and Knott (Appendix D) state, “The people in this region not only rely on salmon for a large proportion of their highly nutritional food resources; salmon is also integral to the language, spirituality, and social relationships of the culture.”

On a cultural level, a significant loss of salmon would result in negative stress on a culture that is highly reliant on this resource. Boraas and Knott (Appendix D) discuss and document several of the social values and activities that are integrated with subsistence, such as sharing and generalized reciprocity, fish camp, steam baths, gender and age equity, and wealth. Likewise, they document how spirituality and psychological health of the cultures are integrated with the natural world, especially salmon. Of particular importance is the sharing and passing along of traditional knowledge to future generations. This knowledge transfer occurs in several ways but one critical component is fish camp. According to Boraas and Knott (Appendix D):

Families typically view fish camp as a good time when they can renew bonds of togetherness by engaging in the physical work of catching and processing salmon. Family members who don't live in the villages often schedule vacation time to return home to fish camp, not just for the salmon but for family. The importance of sharing in vigorous, meaningful work cannot be overestimated. It creates cross-generational bonds between children, their parents, aunts, uncles, and/or grandparents that today are rare in Western culture because there are so few instances in which meaningful, multi-generational work occurs.

Some interviewees expressed fear of the future, that a traditional prophecy of “bad times” told by Elders might be coming true due to economic development resulting in cultural loss characterized as “anomie,” the loss of meaningfulness, sense of belonging, and direction in life. Anomie increases cultural and individual risk for social ills such as depression and suicide, alcoholism and drug abuse, domestic violence, and aggressive behaviors. Healing practices can include those used for trauma and post-traumatic stress disorders, including traditional practices that reconnect the individual to society and the natural environment through meditative rituals. Culture camps and other methods of cultural revitalization can be both preventative and healing for children and adults of indigenous cultures.

Acculturation is a commonly used concept to describe the psychological and cultural impacts of rapid modernization and loss of tradition. Identity and involvement in cultural activities provide numerous benefits to Alaska Natives. Participation in subsistence activities and consumption of subsistence foods include cultural, traditional, and spiritual activities that involve the entire community. One of the greatest risks to the Alaska Native communities in the Nushagak and Kvichak River watersheds with respect to acculturation would arise from a major and persistent decline in the subsistence salmon fishery. For the people on the Nushagak River who consider themselves the “King Salmon” people, any impact on the Chinook salmon fishery would stress their community and the cultural traditions that bind them together.

Studies on disruption to Alaska Native cultures from resource extraction industries illustrate the potential social and cultural impacts of large-scale mining on a key subsistence resource in the Nushagak and Kvichak River watersheds. Land use by Alaska Natives on the North Slope has been mostly non-intensive, leaving few traces on the landscape outside the established villages. In contrast, oil development has altered the landscape in ways that will persist long after resource extraction activities have ceased. Testimony repeatedly cited “scars on the land” that result from industrial development, and indicated that these scars have altered both the physical and spiritual elements of the landscape and thus the very basis of Alaska Native cultures on the North Slope (NRC 2003).

Alterations to the North Slope physical environment have had aesthetic, cultural, and spiritual effects on human populations (NRC 2003). These alterations have resulted primarily from the construction of roads, pipelines, buildings, and power lines and from off-road travel. Hunters report that they do not hunt in the oil fields for aesthetic reasons. North Slope residents have reported that the imposition of a huge industrial complex on the Arctic landscape was offensive to the people and an affront to the spirit of the land.

North Slope residents report that there has been a vast increase in the time, effort, and funding necessary to respond politically and administratively to the ever-multiplying number of projects proposed in the region (NRC 2003). Local residents must attend industry-related meetings and hearings and review documents, because they believe that decisions will be made that can significantly affect both their daily lives and future generations. Additionally, North Slope residents stated that increasing anxiety about offshore and onshore development is widespread in North Slope communities. Hunters worry about contamination of the food they consume and know that their health will suffer if they are unable to eat as their ancestors did. They worry about not being able to provide for their families, or about the added risk and expense if essential and traditional foods are harder to find. Elders who are no longer able to provide for themselves worry about the challenges younger hunters face. Families worry about the safety of hunters who must travel farther and more often if game is not easily accessible (NRC 2003).

According to the National Research Council (2003), increased alcoholism, drug abuse, and child abuse have resulted from the stresses inherent in integrating traditional and new ways of life. Health effects also are apparent, as the incidence of diabetes has increased with higher consumption of non-subsistence foods (NRC 2003). The North Slope Borough bears the costs of these social stresses and provides services such as counseling, substance abuse treatment, public assistance, crisis lines, shelters, and other social service programs. It also supports search and rescue services and the police force that respond to domestic violence and other situations arising when communities are subjected to long-term and persistent stress. The borough supports biologists, planners, and other specialists who review and offer recommendations on lease sale, exploration, and development project documents that are produced each year, and bears the expense of traveling to Fairbanks, Anchorage, Juneau, Seattle, and Washington, DC, where agencies with permitting authority make decisions that affect their way of life (NRC 2003).

The goal of a more recent study on the effects of oil and gas development on subsistence harvesters on the North Slope (Braund and Associates 2009, Braund and Kruse 2009) was to enhance benefits and mitigate impacts of development. This study reported that, despite raising concerns about oil development as early as 1975, the Inupiat have, until recently, been successful in maintaining their subsistence lifestyle. Since 2003, North Slope active harvesters have been experiencing impacts of oil development at higher rates and report that their wellbeing has declined. This has led to social problems, including higher rates of drug and alcohol abuse and suicide.

A study that looked at the social, cultural, and psychological impacts of the Exxon Valdez oil spill determined that the psychosocial impacts of contamination were as significant as the physical impacts on the environment (Palinkas et al. 1993). Reported issues included declines in traditional social relations with family members, friends, neighbors, and coworkers; perceived increases in the amount of and problems associated with drinking, drug abuse, and domestic violence; a decline in perceived health status; an increase in the number of physician-verified medical conditions; and increased post-spill rates of generalized anxiety disorder, post-traumatic stress disorder, and depression (Palinkas et al. 1993).

Community-wide pre-occupation with the spill and cleanup affected traditional social relations and resulted in conflicts and divisiveness, arguments about environmental effects of the spill, issues of fault and responsibility, issues of whether or not to work on the cleanup, and related monetary and employment issues (Palinkas et al. 1993). There were pervasive fears and increased fundamental concerns about cultural survival for many residents in the affected Alaska Native villages.

Palinkas et al. (1993) documented the profound impact that exposure to the oil spill had on social relations, traditional subsistence activities, the prevalence of psychiatric disorders, community perceptions of alcohol and drug abuse and domestic violence, and the physical health of Alaskan Native and non-native residents of the affected communities. Although the specifics of the Exxon Valdez oil spill may be quite different, a large-scale or long-term failure of mine waste collection, treatment, or containment systems would produce a similar reduction of subsistence activities, and similar social and cultural effects could be expected.

### 12.2.5 Mitigation and Adaptation

It is not likely that any direct or indirect loss of subsistence use areas resulting from the mine footprints could be avoided. In the mine scenarios, the mine pit, waste rock piles, and TSFs would remain on the landscape in perpetuity and thus represent permanent habitat loss for salmon and other subsistence resources. Some measures could be put in place to prevent and respond to accidents and spills. Small spills and releases that are contained in a timely manner may not affect the salmon subsistence resource. However, large-scale releases, even with active remediation, would have long-term effects on the salmon subsistence resource and Alaska Native cultures. Because the Alaska Native cultures in this area have significant ties to specific land and water resources that have evolved over thousands of years, it would not be possible to replace the value of lost subsistence use areas elsewhere, or to relocate residents and their cultures, making compensatory mitigation infeasible (Appendix J).

The ability of Alaska Native cultures to adapt to losses of subsistence use areas or to the larger impacts of a mine failure or accident is unknown. Several studies have considered adaptation related to subsistence resources. Holen (2009) studied the adaptations related to the Nondalton subsistence fishery and identified two major socio-cultural factors that could potentially affect the long-term resilience of the fishery: children and young adults are not actively participating in subsistence salmon fishing as they have in the past, and because summer is often when seasonal employment is available, some residents miss the subsistence fishing season because of work obligations. These factors interrupt the inter-generational transfer of existing knowledge and wisdom and suggest that permanent cultural change can result from cultural disruption. On Alaska's North Slope, the issue has not been a question of whether Alaska Natives adapt to oil and gas development, but rather the consequences of that adaptation (NRC 2003). There are two potential problems: the loss—sometimes quickly—of traditional languages, patterns of behavior, economic activities, skills and capital improvements that are no longer relevant; and the use of human and financial capital and non-renewable resources by the new development (NRC 2003).

As the cash economy develops and Alaska Natives become involved in discussions about how changes associated with oil and gas development affect their cultures, they increasingly must use English as their primary language. They lose fluency in their native language and the traditional ecological knowledge embedded in that language. Many North Slope residents expressed concern about the loss of their traditional way of life, while at the same time enjoying the benefits of the cash economy (NRC 2003). However, over-adaptation can also occur, leaving communities less able to survive in their environments when extraction activities decline or stop. The significant tax revenues that oil and gas development have provided North Slope Borough residents are now declining, and the current standard of living for North Slope residents will be impossible to maintain unless significant external sources of local revenue are found. If borough revenues decline, residents may face lower standards of living, or be forced to find other sources of economic activity or migrate to different areas (NRC 2003).

Offshore exploration and development and the announcement of offshore sales have resulted in perceived risks to Inupiat culture that are widespread and intense. People of the North Slope have a centuries-old nutritional and cultural relationship with the bowhead whale, and most view offshore industrial activity as a threat to bowheads and thus their cultural survival.

## 12.3 Uncertainties

The preceding sections provide a qualitative overview of how wildlife and Alaska Natives may be affected by mining-associated changes in salmon resources. Because we mention but do not evaluate direct effects of mining on wildlife and Alaska Natives (Box 12-1), this assessment represents a conservative estimate of how these endpoints could be affected by mine development and routine operations. We focused on a limited suite of wildlife species (Section 5.3), but additional species also could be affected by changes in salmon resources. We also did not consider mining-related changes to all subsistence species.

In addition to these scope-related limitations, there are several uncertainties inherent in our consideration of fish-mediated effects on wildlife and Alaska Natives.

- The magnitude of salmon-mediated effects on wildlife, subsistence resources, and indigenous cultures is uncertain and cannot be quantified at this time. Ultimately, the magnitude of overall impacts will depend on many factors, including the location and temporal scale of effects, cultural resilience, the degree and consequences of cultural adaptation, and the availability of alternative subsistence resources.
- Interactions between salmon and other wildlife species are complex and reciprocal, and the assessment did not comprehensively evaluate all potential linkages between endpoints. Many of these linkages have not been well-documented or researched (e.g., potential relationships between MDN, riparian vegetation, and moose and caribou), but may be significant. Therefore, this assessment likely underestimates salmon-mediated risks to wildlife.
- The magnitude of effects on Alaska Native cultures resulting from any mining-associated changes in salmon resources is unknown, but other studies related to resource extraction industries (North Slope, Red Dog Mine) or environmental contamination (Exxon Valdez) in Alaska confirm that there certainly would be changes in human health and Alaska Native cultures.
- The cumulative effects of mining and climate change represent a significant uncertainty in the region (Section 3.8, Box 14-2). Residents of the Kvichak River watershed have observed that social and cultural changes are occurring in an environment where they are also seeing rapid climate changes (Holen 2009). These changes, which include climate variability and unpredictable weather, make it difficult to plan for subsistence activities (Appendix D). On Alaska's North Slope, climate change and oil and gas development together result in greater cumulative effects on the environment and Inupiat cultural traditions (Braund and Associates 2009). The cumulative effects of climate change and potential effects on subsistence resources from large-scale mining are unknown.

Despite these uncertainties, the inability to mitigate or replace subsistence resources or cultural values lost to effects of large-scale mining is certain because of the significant and long-standing ties that Alaska Native cultures have to specific land and water resources in these watersheds.