Ecological Profile: Lake Clark National Park and Preserve

Physical Environment

Climate

The Chigmit Mountains divide the subpolar marine climate of Cook Inlet from the continental climate of Interior Alaska. Local climatic conditions within these two regimes vary with elevation and the distance from mountains and large bodies of water (National Park Service 1999c).

The coastal east side of the mountains is typically warmer and wetter than the west side, with an annual average precipitation between 15 and 20 in (38 to 51 cm). Precipitation increases dramatically, ranging between 40 to 80 in (102 to 203 cm) per yr, where the mountains immediately rise from Cook Inlet (LACL southeast coast). Mean coastal air temperature ranges from 10 to 32 °F (-12.2 to 0 °C) during January, typically the coldest month. Mean temperature for the warmest month, July, ranges from 48 to 60 °F (8.9 to 15.6 °C) (National Park Service 1983).

Port Alsworth, located west of the Chigmit Mountains, represents inland climatic conditions. Annual precipitation at Port Alsworth is approximately 17 in (43 cm). Mean air temperature ranges from 12 °F (11 °C) in January to 56 °F (13.3 °C) in July. From 1960–81, extreme air temperatures recorded at Port Alsworth were –55 °F (-48.3 °C) and 86 °F (30 °C) (National Park Service 1983).

Geology

The Chigmit Mountains are composed of a complex of multiple granitic stocks and batholiths that intruded after Triassic time into Paleozoic and Cenozoic rocks. The main batholith is elongated to the northeast, parallel to the structural trends of the region. The intruded rocks, which dip away from the Chigmits, are moderately to highly deformed volcanic and sedimentary rocks. Three volcanic piles of Tertiary to Recent age are still active: Mount Spurr, Redoubt Volcano, and Iliamna Volcano (National Park Service 1988).

The park has been extensively glaciated, with three known advances. All glacial deposits appear to be of Wisconsin age or younger (National Park Service 1988).

Hydrology

LACL encompasses approximately 4 million ac of public and private lands in southwestern Alaska and contains more than 6,000 mi of rivers and streams—some of the most diverse water resources in the National Park system. The Alaska and Aleutian mountain ranges form a continuous watershed divide separating the coast from the interior.

Glacial ice, much of it associated with Redoubt and Iliamna volcanoes, covers approximately 30% of the park. Most of the glaciers in the park have retreated dramatically in the last four decades (National Park Service 1999c). Silty meltwater from these glaciers and associated snowfields strongly influences the hydrologic cycle in the park.

The headwaters for five major drainage basins are located within LACL's boundaries: the Kvichak River, Nushagak River, Kuskokwim River, Chakachatna River, and Coastal basins. LACL also includes the sixth largest lake in Alaska, Lake Clark, and three river segments designated as "Wild Rivers": Chilikadrotna (11 mi), Mulchatna (24 mi), and Tlikakila (51 mi) (National Park Service 1999c).

Early limnological studies of the aquatic systems that include LACL were of a broad or general nature (Burgner et al. 1969, Mathisen and Poe 1969, ADF&G and National Park Service 1980). A 3-yr study of chemical, physical, and biological characteristics of surface waters in the park (Dale and Stottlemyer 1986, Stottlemyer and Chamberlain 1987, Chamberlain 1989) provided more specific water chemistry data on selected surface waters in LACL.

USGS-WRD monitored water quality and runoff characteristics for the Tlikakila River and other major Lake Clark tributaries over three runoff seasons, 1999–2001 (Brabets 2002). In 2001, USGS-WRD collected data on runoff components in the Tlikakila River basin to determine the relative contributions of springs, glaciers, rainfall, and snowmelt. Several airborne profiles of glaciers were flown to help construct a history of glacier change in the basin. Preliminary results indicate that from 1957 to 1996, the glaciers have been thinning at an average rate of between 1.5 ft/yr (0.46 m/yr) and 3.2 ft/yr (0.96 m/yr). However, the glaciers may have thickened from 1996 to 2001 (Brabets 2001a).

The University of Alaska at Fairbanks initiated a limnology study of Lake Clark in 1999 (Wilkens 2002). This study looked at the physical and chemical characteristics of Lake Clark to its full depth of 860 ft (262 m) and examined the zooplankton species and biomass in cooperation with contemporaneous studies on the tributaries and the sockeye salmon in the lake.

While most studies have focused on Lake Clark, water quality data have also been collected at the Johnson River, a coastal watershed explored in the 1980s and early 1990s for potential mineral extraction. During 1998–2001, the Johnson River was included in the Cook Inlet National Water Quality Assessment Program. Results indicate good water quality and a "low acid-generating potential/high neutralizing potential" of the ore deposit (Brabets 2001b).

Coastal/Marine

LACL contains 130 mi (209 km) of coastline in western lower Cook Inlet, an extremely dynamic, high-energy estuarine environment. The normal tidal cycle has an average height ranging from about 18 ft (5.5 m) in Kachemak Bay to 29 ft (8.8) m at Anchorage. Extreme high tides can be in excess of 36 ft (11 m), making the tidal ranges in Cook Inlet among the largest in the world (Britch 1976, Brower et al. 1977).

The rivers emptying into Cook Inlet carry very high loads of suspended sediments, mainly fine glacial flour. Average concentrations of suspended sediments in Cook Inlet are about 200 mg/l with maximum concentrations in excess of 2,000 mg/l (Sharma and Burrell 1970, Feely and Massoth 1982).

Winter ice formation can be extensive in Tuxedni Bay and Channel. Estuary ice that forms in Tuxedni Bay consists of freshwater and is much harder than sea ice. Due to a combination of ice structure, lower air temperatures, and shelter from wind, this bay can remain ice covered for 3-4 mo during winter (Bennett, pers. obs.). When the bay ice breaks up in late winter, ice flows that are moved by tides and winds gouge shorelines, cause shoreline erosion, and exert significant forces on offshore structures (B. Woods, pers. comm.).

Forty-three percent of the LACL coastline is either very protected or protected from high energy waves (Schoch 1996). Salt marsh accounts for 22% of the total shoreline length and 42% of the total intertidal area. The combined soft substrates (salt marsh, sand, and mud flats) account for 90% of the total coastline length and 98% of the total area (Schoch 1996). Combinations of rocky shores (ramps, platforms, cliffs) are a very small percentage of the total habitat type on the LACL coastline.

Biological Resources

Flora

There are no threatened or endangered species of plants listed by the USFWS (2005) in LACL. The Alaska Natural Heritage Program Rare Vascular Plant Tracking List for April 2000 identifies 25 plant species that are classified by the State as critically imperiled (S1), imperiled (S2), or rare or uncommon (S3). Several rare species are exclusively associated with wetland, riparian, or lakeshore habitats.

Coastal side: The Cook Inlet coast has a narrow fringe with coastal salt marshes in Tuxedni and Chitintna Bays and scattered marshes and lagoons along the Inlet coast. Coastal zones without marshes have long gravel beaches or bedrock cliffs rising abruptly out of Cook Inlet. The salt marshes are a rich zone of sedges

and some grasses with varying tolerance to saltwater flooding, and form an early spring food source for bears grazing along the beaches. Much of the LACL coast appears to be rising from tectonic movements, and narrow bands of young spruce are establishing themselves into the *Elymus* grass community in back of the beaches. The depositional flats and lower mountainsides behind the beaches are covered with spruce forests and alder thickets. Both white and Sitka spruce grow along the coast, with Sitka generally south of the Johnson River, and white spruce to the north. Conifer forests have multiaged trees with thick moss understory, devil's club, salmonberry, and scattered alder. Scattered stands of spruce rise out of a sea of alder, especially around the Tuxedni coast and above the dense spruce forest. Alder thickets grow above the spruce zone, thinning out into *Calamagrostis* meadows at the upper limits. The alpine tundra zone is very narrow on the coastal side of the mountains, dominated by *Luetka*, *Empetrum*, and forbs. Tundra yields to bedrock and ice.

Mountainous spine: The center of the park is primarily glacial ice and bedrock or till. Most valley glaciers are in retreat, leaving large expanses of moraines and ground till, which are slowly revegetating with mosses and lichens, fireweed and Dryas, willow and alder. An ecosystem of note is the expansive shallow wetlands along the Neacola River, which runs into Chakachamna Lake. The valley provides rich habitat for beaver, moose, nesting waterfowl, and bear. The wetlands appear to be dominated by sedges and willows, and are maintained by flooding and beaver activity.

Lake side: The western side of the park is dominated by a series of large long lakes with their eastern extents in the Alaska Range and their western edge bounded by terminal moraines from the most recent advances of large valley glaciers. Low ridges and subdued mountains lie between the lake systems. The northern part of the park, by the Stony River, is boreal in character, with black spruce, muskeg, aspen and birch, and subject to wildfire. Further south, vegetation is a mosaic of spruce and mixed spruce/birch or cottonwood forests, paper birch, low shrubs dominated by dwarf birch, dwarf shrub tundra with ericaceous shrubs, scattered wetlands, and alpine tundra. Vegetation patterns are arrayed in response to soil texture and drainage patterns from a complex glacial and alluvial history.

Fauna

Marine Invertebrates

Intertidal sand flats in some locations within LACL support dense populations of mollusk bivalves, including razor, littleneck, and soft-shell clams. Intertidal mud flats in Chinitna and Tuxedni bays support large to moderate standing crops of suspension- and deposit- feeding invertebrates (Lees 1977). Eighteen species of Polychaeta, 7 species of Mollusca and 12 species of Crustacea have been identified in Chinitna Bay (Bennett 1996). Infauna in both bays are dominated by the pink clam (*Macoma balthica*).

The trophic relationship between shorebirds, sea ducks, diving ducks, and Macoma may be the most significant near-coastal predator-prey linkage along the LACL-Cook Inlet coastline (Bennett 1996).

Fish

Forty-six species of fish are listed as present or probably present in LACL. In marine waters, small pelagic schooling fish, including capelin, sand lance, eulachon, and Pacific herring, occur in nearshore and estuarine waters, while halibut and gray cod are found offshore (Bennett, pers. obs.). Dominant species during summer in Tuxedni Bay include juvenile pollock, sand lance, osmerids, and herring (Piatt et al. 1999). No information exists on seasonal abundance or distribution.

Sockeye salmon are a keystone species in the LACL aquatic and terrestrial ecosystem. Nutrients from spawned-out salmon carcasses play a crucial role in sustaining the productivity of riparian and lacustrine ecosystems, including the perpetuation of future salmon runs (Kline et al. 1990, 1993). Sculpin, least cisco, lake trout, rainbow trout, and burbot all derive nutrients from sockeye salmon in one form or another. Salmon influence the seasonal distribution and abundance of birds and mammals that prey on them. In the interior of the park and preserve, bald eagles are exclusively associated with river-lake systems that support salmon. Bears depend on abundant salmon to bolster fat reserves vital to survival

during hibernation. Because much of Lake Clark remains ice-free until February, salmon carcasses support overwintering bald eagles and are an important food resource for an array of vertebrate predators and scavengers, including wolves, coyotes, red fox, wolverine, and lynx.

Terrestrial Mammals

Thirty-six species of terrestrial mammals are documented or expected to occur within LACL. Moose occur throughout LACL, but due to deep snow, are less common on the coast. Dall sheep reach the southern extent of their range in LACL and occur along the western slopes of the Chigmit Mountains on the common boundary of the park and preserve. The Mulchatna caribou herd calves adjacent to the western boundary of the preserve and ranges through the foothill lakes and tundra plains of the western preserve. This herd is one of the most important for local subsistence and nonlocal Alaska hunters and heavily supports Alaska's guide and transporter industry. Brown/grizzly bears, common in all habitats, are most numerous along the coast, where an estimated 180–230 bears graze in salt marshes during the summer (Bennett 1996).

Black bears use all areas of the park and preserve except the higher elevations. Other terrestrial mammals—wolves, lynx, coyotes, and wolverines—range widely throughout the forests and low alpine areas, also populated with porcupines and snowshoe hares. Hoary marmots, arctic ground squirrels, and pikas occur in alpine meadows and boulder fields. Twelve species of vole, lemming, and shrew probably occur, of which the redback vole is most abundant. Mink, beaver, and river otter inhabit ponds, lakes, and rivers. River otters are particularly common along the coast. Red squirrel, American marten, shorttail weasel, and least weasel are also found throughout the park and preserve.

Marine Mammals

Harbor seals (200–250 animals) haul out at three sites (Tuxedni Bay, Chinitna Bay, and Johnson River) and pup near the mouth of the Tuxedni River (Bennett 1996). Beluga whales seasonally occur off the mouths of glacial rivers in both bays and are most numerous (160–200 animals) during August and September (Bennett 1996, Speckman and Piatt 2000). Sea otter occasionally stray into park waters, but are more common in the clearer waters south of the park (Bennett 1996).

Birds

One hundred eighty-nine species of birds are documented or expected to occur in the park and preserve. Of these, 70 are landbirds, and many are neotropical migrants. Raptors, including bald eagle, golden eagle, northern goshawk, sharp-shinned hawk, northern harrier, and merlin, breed in the area. About 50 pairs of bald eagles and 5–10 pairs of golden eagles are known to nest in the park and preserve. Two pairs of osprey also nest in the preserve. Peregrine falcons occupy eyries on cliffs along interior lakes and rivers, and at Tuxedni Bay (Haugh and Potter 1975, Bennett 1996).

Waterfowl nest and molt in wetlands throughout the area. Large migratory flocks of ducks, swans, and geese rest and feed in the park and preserve before flying from Nikabuna Lakes to Lake Clark through low mountain passes in the Chulitna River drainage.

Sea ducks, primarily white-winged scoters and surf scoters, are the most abundant waterfowl on the coast, numbering more than 18,000 in mid-August. The coast also provides important breeding habitat for mallards, American widgeon, Barrow's golden-eye, and red-throated loons. Diving ducks, primarily greater and lesser scaup, stage along the coast in spring. Other ducks include green-winged teal, northern pintail, harlequin, common golden-eye, black scoter, common eider, bufflehead, and long-tailed duck. About 30 pairs of trumpeter swans nest in the park and preserve, the farthest west breeding population. Canada geese occur in Tuxedni Bay and can number about 4,400 during fall migration.

Seabird breeding colonies occur along Cook Inlet and concentrate at Tuxedni and Chinitna Bays (Bennett 1996). Of the seven seabird colonies surveyed from 1994 to 1996, the largest contained 2,700 black-

legged kittiwakes. Less numerous seabirds include horned puffins, double-crested cormorants, pelagic cormorants, glaucous-winged gulls, tufted puffins, common murres, and pigeon guillemots.

During spring migration, 86,000 to 122,000 shorebirds, primarily western sandpipers and dunlin, use intertidal mud flats in Tuxedni and Chinitna bays (Bennett 1996). Rock sandpipers, designated as a "Species of Moderate Concern," (National Audubon Society 2002) winter in Tuxedni Bay. Tuxedni Bay qualifies as an International Reserve in the Western Hemisphere Shorebird Reserve Network (Andres and Gill 2000).

Threatened and Endangered Species
Currently no federally listed species are known to occur in terrestrial areas of LACL (USFWS 2005). Federal species of concern (formerly category 2 candidate species) that occur in terrestrial areas of LACL include the harlequin duck, olive-sided flycatcher, and lynx.

American peregrine falcon, olive-sided flycatcher, gray-cheeked thrush, Townsend's warbler, and blackpoll warbler are State of Alaska Species of Special Concern that have been documented or are expected to occur in LACL (http://www.wildlife.alaska.gov/index.cfm?adfg=concern.main [Accessed 25 August 2005]).

Natural Resources Management Issues

- **Air quality.** Quantitative air quality data are limited throughout Alaska, and currently no baseline air quality data exist for LACL (National Park Service 1999c). The park includes environments extremely susceptible to contaminants because of poor buffering geology. Numerous sources for airborne contamination exist in the Lake Clark region, including emissions from offshore oil/gas development in Cook Inlet and coal extraction at the Beluga coal fields northeast of the park.
- **Climate change.** LACL's environment is thought to be very susceptible to climate change. In 1938, a glacial toe 5 mi wide filled Lake Clark Pass (Alaska Geographic Society 1986). Today the glaciers in Lark Clark Pass have receded into the higher mountain valleys, suggesting that the climate has warmed.
- **Mining.** Under the Alaska Native Claims Settlement Act of 1976, the Cook Inlet Region Corporation (CIRI) received title to approximately 21,000 ac of land known as the "Johnson River Tract" located on the west side of Cook Inlet in LACL. Based on the current size estimate of the ore body, approximately 270,000 tons of ore would be mined and transported annually over a 3-yr mine life (National Park Service 1999c; CIRI and WestMin 1994). Due to the proximity of the planned mine and support network of roads and ore stockpiles to the Johnson River, there is a high potential for contaminants to reach the Johnson River estuary and be transported along the coastline by prevailing tidal currents (Bennett 1996).
- **Petroleum development, storage, and transportation.** State oil and gas lease sales for upland and marine tracts in Cook Inlet, held in 2004 and 2005, were moderately to highly successful, and another sale is scheduled for 2006. A 2004 federal lease sale for lower Cook Inlet was cancelled, and a sale scheduled for 2006 has been postponed due to lack of interest by the oil industry. The strong currents and high tidal ranges along the Alaskan coast can transport oil spills great distances from their source, as evidenced by the *Exxon Valdez* oil spill of March 24, 1989. Numerous petroleum facilities occur along the north gulf coast, including the Valdez oil terminal in Prince William Sound, terminus for the TransAlaska Pipeline. Cook Inlet supports 15 production platforms, the Drift River Marine Terminal (a privately owned offshore oil loading platform in Cook Inlet with an onshore storage facility), and the Nikiski oil terminal and refinery.
- **Residential development.** Residential subdivision and economic development on private lands within LACL's boundary can conflict with the park's enabling legislation and NPS management objectives. About 617,000 ac (250,000 ha) are in private or state ownership, or are being adjudicated. This includes approximately 75% of Lake Clark's shoreline (National Park Service 1999c).

- **Commercial fishing.** The number of adult salmon returning to this watershed has declined in recent years and in 1996 was 75% below the previous 10-yr average. Commercial fishing of mixed stocks of sockeye salmon, such as occurs in the Bristol Bay Naknek-Kvichak Commercial Fishing District, has the potential to overharvest or eliminate small populations (Willson and Halupka 1995). Due to the mix of glacial and clear-water aquatic habitats within this vast system, genetic differentiation is likely (Wood 1995).
- **Sport and subsistence fishing.** The NPS estimates that about 1,600 sport hunting days, 3,500 angler days, and 30 to 35 river trips occur in LACL annually (National Park Service 1999d), and this number is increasing. In addition, the number of subsistence fishing permits issued for this system has tripled during the past 10 yr. This increase in visitor and subsistence use has also increased resource impacts.

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