

13th
Copper
River
Delta 
Science
Symposium
Cordova, Alaska 2011



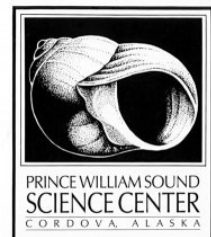


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Welcome to the 13th Copper River Delta Science Symposium



Alaska's Copper River Delta is the largest contiguous wetland on the Pacific Coast of North America and an important region for both fish and wildlife. The Delta provides vital salmon habitat, serves as a key shorebird stopover and breeding site, and is the primary nesting area for Dusky Canada Geese.

Alaska's Copper River Delta has a long and rich research history to better understand the many ecological, biological and physical systems that make up this unique venue.

Twelve Delta research conferences have occurred beginning in the early 1970's. The U.S. Forest Service and the Cordova Ranger District, the Pacific Northwest Research Station, Ducks Unlimited and the Yale School of Forestry and Environmental Studies supported the most recent conference in 1999. Since 1999, many research projects have come to fruition, new initiatives have been put in place, and many issues have come to the fore including climate change impacts.

To better integrate current knowledge and plan future research efforts, the Copper River Delta Science Symposium focuses on the Delta as a system, covering topics from hydrology and geomorphology to avian nesting ecology and trophic relationships. During this symposium, we hope to provide an opportunity for inter-disciplinary examination of the Delta and to identify future research needs to help manage and conserve this ecologically significant area in the face of climate change and other environmental transformations.

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Agenda



Monday, March 21, 2011

18:00 *Welcoming Social*

Location: Powderhouse Bar

Tuesday, March 22, 2011

07:30 *Informal Breakfast*

08:30 *Opening Remarks*

08:50 *Plenary Talk - Aquatic Ecology of the Copper River Delta*
Ken Cummins

Morning Session – Lynn Fuller, Chair

09:20 A Unique 5,600-Year History of Great 1964-Type Earthquakes
Recorded in the Stratigraphy of the Copper River Delta
George Plafker

09:40 Response of Marine Deltaic Surfaces to Major Earthquake
Uplifts in Southcentral Alaska
Keith Boggs

10:00 The Invasive Plant Situation on the Copper River Delta
Robert DeVelice

10:20 *Break*

10:40 Application of the USGS Precipitation Runoff Modeling
System in Assessing Glacier Runoff in the Copper River Basin,
Alaska
Tim Brabets

11:00 Copper River Channel Migration and Its Effects on the Copper
River Highway
Jeff Conaway

11:20 Seasonal Changes in Productivity in the Copper River Plume
and Coastal Gulf of Alaska
Robert Campbell

11:40 Community Structure and Secondary Production of Aquatic
Macroinvertebrates in Coastal Wetland Ponds of the West
Copper River Delta, Alaska
Martin Berg

12:00 Contribution of Benthic and Riparian Macroinvertebrates to
the Diet of Juvenile Coho Salmon and Dolly Varden in Tribu-
taries of the Copper River Delta, Alaska
Emily Campbell

12:20 *Lunch*



Afternoon Session #1 – Erin Cooper, Chair

- 13:20 Cordova and the Trumpeter Swans
James King
- 13:40 A Long-Term Assessment of Trumpeter Swan Populations and Habitat Preferences in Alaska
Joshua Schmidt
- 14:00 Avian Habitat Relationships in a Changing Landscape on the Copper River Delta, Alaska
Alan Hitch
- 14:20 Reproductive Success and Foraging Ecology of the Rusty Blackbird on the Copper River Delta
Erin Cooper
- 14:40 Spring Migration on the Pacific Flyway: Piecing Together the Big Picture from Radio-Marked Shorebirds
Mary Anne Bishop
- 15:00 *Break*
- Afternoon Session #2 – Tim Joyce, Chair*
- 15:20 Dusky Canada Geese: What Have We Learned Since the Last CRD Science Symposium?
Thomas Fondell
- 15:40 Productivity of Dusky Canada Geese Nesting on the Copper River Delta and on Middleton Island, Alaska
Michael Petrula
- 16:00 Dusky Goose Predator Management
Dave Crowley
- 16:20 27 Years of Artificial Nest Islands for Dusky Canada Geese
Jason Fode
- 16:40 Beaver Influence on Surface Water Changes Over Time on the West Copper River Delta, Alaska
Erin Cooper
- 17:00 Selecting Sites to Improve Moose Winter Forage with Hydroaxe Treatment
Milo Burcham
- 18:00 *Banquet Dinner*
Location: Reluctant Fisherman





Wednesday, March 23, 2011

- 07:30 *Breakfast and Poster Session*
Morning Session – Rob Campbell, Chair
- 09:40 Climate Change and Fish on the Copper River Delta: Challenges and Opportunities
Gordon Reeves
- 10:00 Complexity in Food Webs of Copper River Delta Juvenile Salmon as Revealed by Natural Stable Isotope Abundance
Thomas Kline
- 10:20 *Break*
- 10:40 The Influence of Fall-Spawning Coho Salmon on Growth and Production of Juvenile Coho Salmon Rearing in Beaver Ponds on the Copper River Delta, Alaska
Dirk Lang
- 11:00 Assessing Residence Time and Habitat Use of Coho and Sockeye Salmon in Alaska Estuaries
Mary Anne Bishop
- 11:20 Spatial Variability in Egg-Incubation Temperature Regimes on the Copper River Delta, Alaska: Implications for Understanding Likely Climate Change Impacts
Steve Wondzell
- 11:40 Coastal Cutthroat Trout in the Copper River Delta and Prince William Sound, Alaska: A Summary of Recent Research
Gordon Reeves
- 12:00 *Lunch*
Afternoon Session #1 – Torie Baker, Chair
- 13:20 Migration, Movement, and Habitat Use of Humpback Whitefish (*Coregonus pidschian*) in McKinley Lake and the Copper River Delta
Gordon Reeves
- 13:40 A Survey of Sport Fish Use on the Copper River Delta, Alaska
Ken Hodges
- 14:00 Copper River Fisheries Resource Monitoring Program
Keith Van Den Broek
- 14:20 Imaging Alaska's Coastline: Fly the Copper River Delta Like a Shorebird
Mandy Lindeberg
- 14:40 Copper River Knowledge System Web Portal
Robert Bochenek



Wednesday, March 23, 2011 (continued)

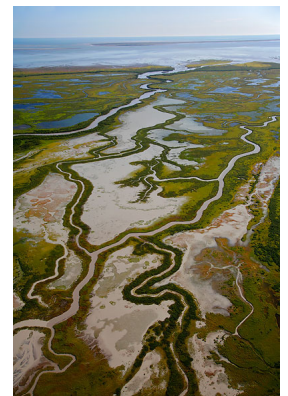
- 15:00 Mapping Vegetation on the Copper River Delta
Mark Riley
- 15:20 *Break*
Afternoon Session #2 – Allison Bidlack, Chair
- 15:40 Ranking Culverts for Maximum Benefit from Restoration Dollars
Kate Alexander
- 16:00 Wetlands Ecology Media Expedition
Erica Thompson
- 16:20 Copper River Stewardship Program: A Showcase of a Watershed Education Collaborative
Kate Alexander

Dinner on Your Own



Thursday, March 24, 2011

- 07:30 *Breakfast*
Morning Session – Allison Bidlack, Chair
- 08:40 Copper River International Migratory Bird Initiative
Erin Cooper
- 09:00 USFS Alaska Region's Key Coastal Wetlands
Deyna Kuntzsch
- 09:20 Pan-Boreal Conservation: North America's Opportunities
Frederic Reid
- 09:40 *Break*
- 10:00 *Round Table Panel Discussion – Erin Cooper, Moderator*
Gordie Reeves, Marty Berg, Rob Campbell, Deyna Kuntzsch, Fritz Reid
- 11:00 *Closing Remarks*



Aquatic Ecology of the Copper River Delta

Kenneth W. Cummins

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The Copper River Delta offers a unique opportunity for research leading to management strategies for endangered, economically important, and charismatic fish and wildlife species. Research on the Delta is well positioned to inform the goal of sustaining present stocks and preparing for future changes in climate. The presence of large glaciers and gradients of temperature and water chemistry provide the setting for broad scale comparisons. Wetland characteristics grade from outwash wetlands at the base of the glaciers to uplifted wetlands that resulted from the 1964 earthquake to the remaining saline coastal wetlands and there are distinct differences between the east and west Delta. These gradients and differences provide the ideal template upon which to use space for time substitution studies that can yield inferences about aquatic ecosystem succession.

Complete coverage of the Delta by low elevation infrared remote sensing allows for evaluation of thermal differences in streams and ponds related to groundwater heterogeneity and estimates of relative cover of pond surfaces by the several dominant aquatic vascular plant taxa. A net work of thermal recorders provides for normalizing temperature data as degree days in order to compare the temperature effects on the biology of ponds and stream at any time during the annual, seasonal, or diurnal cycle. Data on freshwater invertebrates collected on a unit surface (pond plant beds) or bottom (streams) area can be used to estimate pond- or habitat-specific abundance of invertebrates on a broad spatial scale. These data together with digitized analyses of taxa-specific plant bed cover in ponds or stream bottom habitat cover (e.g. riffles, pools, side channels and back waters) will allow the calculation of estimates of invertebrate community composition and abundance on a large scale. In fact there is no reason the estimates cannot be made for broad regions of the Delta (outwash, uplifted, and coastal wetlands) or the entire Delta. Invertebrate data from ponds and streams can be linked to information on stream salmonid and pond avian food webs which will have important long term management value.



Ken W. Cummins is Co-Director of the Institute for River Ecosystems, Senior Advisory Scientist, California Cooperative Fishery Research Unit, and Adjunct Professor, Fishery Biology Department at Humboldt State University. Born in Chicago, Dr. Cummins received a B.A. (Biology) from Lawrence University, Appleton, WI. He received his M.S. (Fisheries) and PhD. (Zoology/Limnology) from the University of Michigan in Ann Arbor. Cummins' areas of expertise include freshwater ecosystem structure and function (especially streams); general aquatic ecosystem theory, especially riparian interactions, and functional analysis of freshwater systems. His numerous books and publications include the classic *An Introduction to the Aquatic Insects of North America* (coedited with R.W. Merritt).

A Unique 5,600-Year History of Great 1964-Type Earthquakes Recorded in the Stratigraphy of the Copper River Delta

George Plafker

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The stratigraphic sequence underlying the Copper River Delta (CRD) records 9-10 repeated sudden uplift events of ~1-2+ m during great to giant earthquakes caused by large slip events on the Aleutian megathrust fault that underlies the CRD region at a depth of ~15 km. The most recent CRD uplift of 2 m occurred during the giant 9.2 Mw Alaska earthquake of 3/27/64, the second largest earthquake in history. As a result, a belt of intertidal mudflats to 4 km wide was abruptly raised above tide level and converted into subaerial freshwater peat marsh.

Surface and core-hole geologic study of the delta sediments to 13.5 m below the marsh surface shows 8-9 pre-1964 layers of freshwater peat 15-30 cm thick, that have sharp basal contacts overlain gradationally by sequences of gray intertidal silt 0.2-2.3 m thick. Each peat and silt "couplet" is interpreted as a complete earthquake cycle of sudden earthquake-related uplift above the highest tides, followed by accumulation of freshwater peat, and finally, gradual submergence during which the peat was buried beneath intertidal sediment.

The pre-1960 uplift events, or "paleoseismic" events, are dated by ^{14}C ages on organic material from at or near the base of the peat layers. The CRD data indicate repeat times for uplift events range from about 300 to 1,000 years and average ~600-700 years for the ~5600-year stratigraphic record. We do not find evidence of small earthquake uplift events in the CRD stratigraphic record.

Response of Marine Deltaic Surfaces to Major Earthquake Uplifts in Southcentral Alaska

Keith Boggs

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Michael Shephard

U.S. Forest Service, Tongass National Forest, Sitka, AK

Major earthquake uplifts in southcentral Alaska of marine deltaic surfaces, to an intertidal or supratidal status, cause drastic shifts in processes and vegetation. To assess long-term ecosystem changes as a deltaic landscape converted from a tidal marsh to a supratidal wetland, we studied a four-stage chronosequence of deltaic surfaces (30-yr-old intertidal surface, 352-yr-old intertidal surface, 30-yr-old supratidal surface, and 280-yr-old supratidal surface). Plots were used to gather landform, soils, and vegetation information, and landform schematics and aerial photo interpretation were used to determine their spatial distribution. Succession progressed on intertidal surfaces from pioneer species (principally *Carex lyngbyei*) on newly uplifted mudflats, to a mature tidal marsh with channels, levees, and basins dominated by *Carex lyngbyei* with thick root mats. Uplift of the mature tidal surface to a supratidal status allowed freshwater tolerant species (*Equisetum fluviatile*, *Sphagnum* spp.) to invade the basins, and trees and shrubs displaced herbaceous vegetation on levees. On the oldest supratidal surface, basins developed peatlands (*Andromeda polifolia*, *Sphagnum* spp.), and pH decreased. Levees supported trees or shrubs on mineral or peat soils. Vegetation zonation within a basin-levee complex was evident and repeated, with some variation, across the surfaces. At the landscape scale moving inland, gradients in vegetation occurred on all surface ages.

The Invasive Plant Situation on the Copper River Delta

Robert L. DeVelice and Kate Mohatt

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Compared to the contiguous United States and Hawaii, Alaska currently has fewer and less abundant invasive plant species. Existing surveys on the Chugach National Forest found that most areas of invasive plants are in areas of intensive human-caused disturbance such as road edges, visitor facilities, trailheads, and trails. Invasive plants are currently rare within natural communities in the Chugach National Forest. By geographic area, non-native plant richness and abundance is highest on the Kenai Peninsula, lowest in Prince William Sound, and intermediate on the Copper River Delta.

Non-native plant species were monitored at 28 sites in the Copper River Delta area in 1997 and 2005. A total of 29 non-native plant species were observed. Two of these species are currently ranked as highly invasive (i.e., rank ≥ 70 on a 0 to 100 scale) and are regarded as being potentially more deleterious to ecological sustainability than species of lower rank. These species, found in 2005 but not reported in 1997, are *Hieracium aurantiacum* (orange hawkweed, rank of 79) and *Phalaris arundinacea* (reed canarygrass, 83). In addition, in 2010 three *Polygonum × bohemicum* (Bohemian knotweed, 87) occurrences were found in Cordova on private property. An invasive plant inventory on the Copper River was also completed in 2010, with no high-ranking species occurrences identified between Chitina and the Million Dollar Bridge. Management treatments are ongoing to prevent spread of existing infestations, and in the case of *P. arundinacea*, tarps are being used to smother larger infestations.

Application of the USGS Precipitation Runoff Modeling System in Assessing Glacier Runoff in the Copper River Basin, Alaska

Tim Brabets and Ashley Van Beusekom

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The Copper River Basin (CRB), a 24,200 mi² watershed located in southcentral Alaska, has an average annual discharge of 63,000 ft³ per s and is one of the most prolific salmon producers in Alaska. Monthly runoff varies considerably, averaging about 11,500 ft³ per s during the winter months—November through April—and 113,000 ft³ per s during the summer months. Glaciers, which make up about 20% of the CRB, play a significant role in the annual water budget. For example, the upper and middle portions of the CRB, defined by the hydrologic unit codes, total about half of the CRB (12,700 mi²), have approximately 9% glacier cover, and account for 27% of the average flow. However, the remaining portion of the CRB, which consists of the Chitina River, the largest tributary in the CRB, and the lower portion of the CRB, have approximately 32% glacier cover, and account for the remaining 73% of the total runoff.

Climate change has and will continue to affect glaciers in the CRB, resulting in changing flow characteristics. To analyze these changes, we are utilizing the USGS Precipitation Runoff Modeling System (PRMS). PRMS is a deterministic, distributed-parameter, physical process watershed model used to simulate and evaluate the impacts of various combinations of precipitation, climate, and land use on watershed response. By developing a glacier runoff component to PRMS we can now more accurately determine the glacier component in the water budget as well as examine whether future climate changes will increase or decrease this runoff component.

Copper River Channel Migration and Its Effects on the Copper River Highway

Jeff S. Conaway and Tim P. Brabets

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The Copper River Highway traverses a dynamic and complex network of braided and readily erodible channels via 11 bridges. Over the last decade, several of these bridges and the highway have sustained serious damage from both high and low flows and channel instability. An investigation studying channel migration and the impact to the highway is incorporating data from scour monitoring, LIDAR surveys, bathymetry, hydrology, time-lapse photography, and hydrodynamic modeling.

Flow distribution through the bridges was relatively stable until the mid 1990s. In 1991, up to 68% of the Copper River flowed through three bridges on the western side of the delta. In 2004, these same bridges conveyed only 8% of the flow while 90% of the overall discharge flowed through three bridges on the eastern side of the delta. Migration of the river across the delta and redistribution of discharge has resulted in streambed scour at some bridges, overtopping of the road during high flows, prolonged highway closures, and formation of new channels through forests. Scour monitoring equipment and channel soundings at the eastern bridges have recorded up to 44 feet of fill at one pier and 33 feet of scour at another. In 2010, flow in excess of four times the design discharge scoured the streambed at bridge 339 to a level such that constant on-site monitoring was required to evaluate potential highway closure. Channel alignment and analysis of flow distribution as of October 2010 indicate that these hydrologic hazards will persist in 2011.

Seasonal Changes in Productivity in the Copper River Plume and Coastal Gulf of Alaska

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Andrew Schroth and John Crusius

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The Copper River is the largest point source of fresh water to the northern Gulf of Alaska, but the hydrography, biogeochemistry, and biology of the region are not well described. Oceanographic surveys were conducted in April, May, June, and July 2010, along a transect line stretching from the mouth of the Copper River, across the plume, to well past the shelf break. In April, the water column was well mixed, with a very low freshwater signal nearshore, phytoplankton biomass was low, and macronutrient (nitrate, silicate, and phosphate) concentrations were high. By early May, weak temperature and salinity stratification were present, and phytoplankton biomass had increased, while nutrients showed indications of being drawn down. Although the spring bloom was at an early stage, phytoplankton biomass and nutrient drawdown were more pronounced onshore, indicating an earlier onset to production in the nearshore region. By June, the spring bloom was completed, and all nutrients were depleted in the surface water, except for silicate, which was elevated in the less saline water in the vicinity of the plume. Surface trawls for forage fish along the transect line caught none in April and gravid eulachon were collected near shore in May. Juvenile salmon (primarily coho and sockeye) and herring were collected in June, and abundances were low near shore, largest immediately at the river plume front, and smallest offshore of the front. No salmon were caught in July, and large numbers of stickleback were captured at the shelf break.

Community Structure and Secondary Production of Aquatic Macroinvertebrates in Coastal Wetland Ponds of the West Copper River Delta, Alaska

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Copper River Delta (CRD) ponds are crucial habitats to a myriad of migrating songbirds, shorebirds, and waterfowl as nesting and feeding sites. Ponds in the coastal tidal marsh underwent dramatic changes in 1964 as a result of tectonic activity associated with the Great Alaska Earthquake and were transformed into perched freshwater habitats. Although considerable research has focused on bird communities of these ponds, little is known about the biology of the ponds, particularly with respect to potential invertebrate food resources for birds. This study was conducted to characterize the general ecology of CRD ponds, with particular focus on non-dipteran aquatic insects.

Six ponds in each of two geomorphologic zones, uplifted marsh (UM) and outwash plain (OP), were studied to compare physicochemical characteristics, aquatic insect community structure, and annual secondary production. Basic physicochemical parameters were similar in both types of ponds. The numerically dominant taxon in 11 of 12 study ponds was the omnivorous water boatman *Callicorixa vulnerata*. Densities and secondary production of the numerically dominant predators, the dragonfly *Aeshna* spp. and the damselfly *Enallagma* spp. were higher in OP ponds compared to UM ponds. In contrast, secondary production of aquatic insect primary consumers, the caddisflies *Agrypnia* spp. and *Nemotaulius hostilis*, was higher in UM ponds than in OP ponds. Overall, annual secondary production was greater in UM ponds than in OP ponds.

Results from this study indicate distinct differences in aquatic insect community structure, secondary production, and functional feeding group composition in UM and OP ponds.

Contribution of Benthic and Riparian Macroinvertebrates to the Diet of Juvenile Coho Salmon and Dolly Varden in Tributaries of the Copper River Delta, Alaska

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The Copper River Delta is the largest contiguous wetland on the North American Pacific coast, and supports economically important commercial and recreational fisheries including all five species of Pacific salmon. Some biological factors influencing salmon populations in the Copper River Delta have been previously investigated, but little effort has been made to establish baseline information on freshwater aquatic communities in the region. During the summers of 2005 and 2006, seven stream segments within the Copper River Delta, southcentral Alaska, U.S.A. were sampled, via trapping and gastric lavage, for juvenile coho salmon and Dolly Varden stomach contents in order to investigate the role of benthic and riparian macroinvertebrates in juvenile salmonid diet prior to habitat enrichment by returning adult spawners. Over the two summers, 926 juvenile salmonids were sampled for stomach contents.

Results of sample enumeration and identification indicate that winged adult riparian insects and winged adult aquatic insects make up the majority of the stomach contents of juvenile coho salmon (50-90%) with Rhagionidae, Cecidomyiidae, Aphididae, Hymenoptera, and Chironomidae being the dominant taxa. Juvenile Dolly Varden stomach contents were dominated by benthic organisms (50-80%), specifically larvae of Chironomidae, Simuliidae, Limnephilidae, and planorbid snails. Results of this study suggest that riparian macroinvertebrate inputs into freshwater habitats within the Copper River Delta are an important portion of the diet of juvenile coho salmon during the summer period, and that juvenile coho salmon and Dolly Varden may alleviate interspecies food resource competition during the summer via adaptive feeding strategies.

Cordova and the Trumpeter Swans

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In 1959 Jim King (USFWS biologist/pilot) and Peter E.K. Shepherd (WSC graduate student) flew an August trumpeter swan census between Cordova and the Suckling Hills tallying 371 (45%) of the 829 swans in the statewide counts as published in *The Trumpeter Swans in Alaska* (Hansen et al. 1971). Procedures we developed from that census were used in eight comparable statewide censuses showing a steady increase to 23,692 trumpeters in fall 2005. Since 1978 both a spring nest search and a fall brood search have been done annually on the Chugach National Forest. The data are archived in the USFWS Alaska Swan Database, in Juneau, which have been used for location and numbers by those writing impact statements for large projects. The natural history aspects have not been well analyzed. Possible opportunities include: comparisons between production on the 11 distinct Alaska regions; correlations with production and weather data; density studies; indicated nesting territories; mortality rates; and so forth. Because both nest and brood data are more consistent, the Cordova area would be a good place to begin experiments with these data.

A Long Term Assessment of Trumpeter Swan Populations and Habitat Preferences in Alaska

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Mark Lindberg

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Approximately 70–80% of the entire population of the trumpeter swan (*Cygnus buccinator*) depends for reproduction on wetlands in Alaska. This makes the identification of important habitat features and the effects of human interactions important for the species' long-term management. Through the collaborative efforts of many agencies and personnel, the wetlands in and around the Copper River Delta have been surveyed annually since 1978 providing a unique opportunity to assess the habitat preferences of this species on a large scale. We found that swan broods occupied some wetland types, especially larger closed-basin wetlands such as lakes and ponds, at rates much higher than they occupied other wetland types, such as shrubby or forested wetlands. Trumpeter swan surveys have also been conducted statewide at ~5 year intervals since 1968, providing a large scale perspective on population growth and distribution. Through an analysis of these data it appears that although swan populations have continued to expand into new habitats in northern areas, population growth has slowed around the Copper River Delta. The continuation of this unique and extensive data set will allow researchers to address questions about trumpeter swan populations far into the future.

Avian Habitat Relationships in a Changing Landscape on the Copper River Delta, Alaska

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James B. Grand

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It is likely that the changes in habitat in the Copper River Delta (CRD) have induced changes in avian community composition and abundance. We used a stratified random sampling approach to select sites. At each of these sites we conducted avian point count surveys and quantified the vegetation associated with the sites. We also measured the boreal ponds that were in close proximity to the survey sites. We used occupancy analysis in a multi-model approach to assess habitat relationships between landscape, fine scale habitat, and boreal pond characteristics and avian species. We found that the presence of a boreal pond was an important factor in determining the probability of occupancy of 7 avian species. We also found that landscape scale characteristic such as habitat (outwash plain, uplift marsh) explained most of the variation in the habitat model for 12 avian species. When habitat class was the best model, generally speaking the second best model included a fine scale habitat characteristic such as density of grass or trees. Our research shows that landscape scale characteristics may determine the probability of occurrence of avian species on the CRD.

Reproductive Success and Foraging Ecology of the Rusty Blackbird on the Copper River Delta

David M. Loomis and Katie M. Dugger

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The rusty blackbird (*Euphagus carolinus*) has suffered significant population declines across its entire geographic range and the mechanisms associated with this decline are poorly understood. Although much of the rusty blackbird breeding habitat in Alaska has remained relatively unaffected by anthropogenic impacts, this species continues to decline by an estimated 5% annually statewide. As part of a collaborative effort to obtain data on the reproductive ecology, breeding success, and habitat requirements of this species, a total of 42 nests were found and monitored over two consecutive breeding seasons (2009-2010) on the Copper River Delta in southcentral Alaska. Nests were monitored every 2-4 days to calculate nest success, clutch initiation date, clutch size, egg viability, and fledge rates. Clutch size ranged from 5 to 7 (mean 5.41, SE 0.618) in 2009 and 4-7 (mean 5.59, SE 0.666) in 2010. Apparent nest success for this species was high 87% (2009) and 91% (2010). In 2010 the foraging ecology of this species was also investigated. Chick provisioning rates and nestling diets were determined. Aquatic samples were taken along the margins of ponds and emergent vegetation to document relative food availability where birds were observed foraging. Large odonate nymphs were found to make up the bulk of the food items provisioned; therefore availability and emergence patterns of these invertebrates may be important to rusty blackbird reproductive success.

Spring Migration on the Pacific Flyway: Piecing Together the Big Picture from Radio-Marked Shorebirds

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We successfully radio-tracked migrant western sandpiper, dunlin, and long-billed and short-billed dowitcher during five spring seasons between 1995 and 2004. We radio-marked birds at a series of inland and coastal sites ranging from Sinaloa, Mexico, to the Yukon-Kuskokwim Delta in western Alaska. Our results provide an unprecedented opportunity to evaluate where, when, and how long these shorebird species stop at major Pacific Flyway stopover sites. Based on relocations, the Copper River Delta, Alaska, is the single most important coastal stopover site for all four species. San Francisco Bay is the second most important site, based on results from two years when we banded birds south of this site. Washington's Willapa Bay/Grays Harbor wetlands complex is the third most important coastal site. Mean length of stay among stopover sites varied significantly (1-8 d), depending on species and location. At both San Francisco Bay and the Copper River Delta, length of stay was negatively related to arrival date. Our studies reveal both the importance of conserving linked stopover sites and the complexity of migration strategies used within and among shorebird species along the Pacific Flyway.

Dusky Canada Geese: What Have We Learned Since the Last CRD Science Symposium?

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The precipitous decline in numbers of dusky Canada geese, and the resulting constraints on hunting programs and efforts to limit crop depredation, motivated a research effort to broaden our knowledge for improved conservation and management activities. Since the mid-1990s studies have been conducted to define and delineate the population, improve inventory methods, understand breeding ecology and population dynamics, identify causes of mortality and population decline, and assess the effects of breeding ground habitat change. Although genetic variation suggests population differentiation between Copper River Delta (CRD) and Prince William Sound (PWS) geese, morphology and winter sympatry argue for managing these populations as a single entity. Evidence suggests that the major challenge to this population is insufficient recruitment as a result of problems occurring on the breeding grounds, largely poor nest success and gosling survival. The population decline is linked to the uplift of the CRD (1964 earthquake) and the habitat changes that resulted, but an increasing PWS bald eagle population is also a likely cause; eagles are the most important dusky predator, taking adults, nests, and goslings. Eulachon are an important alternative prey for bald eagles and timing and intensity of the eulachon run dramatically affect eagle predation of duskies. Our increased ability to predict the future population trajectory suggests that our understanding of the system has greatly increased, but this has yet to translate into improved management options to enhance the population.

Productivity of Dusky Canada Geese Nesting on the Copper River Delta and on Middleton Island, Alaska

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Dusky Canada geese (*Branta canadensis occidentalis*) nest on the Copper River Delta (CRD) and have declined in abundance to historically low levels of 5,392-8,281 birds. The population is considered vulnerable because of its current small size and long-term decline. The decline has been attributed to recurrent low productivity and recruitment resulting from increased depredation of adults, eggs, and goslings. The proportion of young (adjusted for visibility) since 1992 varied considerably, averaging 20.5% (SD = 12.3; range = 3.9%-47.2%) with an estimated average annual production of 1,244 goslings (SD = 957; range = 227-3,416 goslings). Productivity during the last five years was high, averaging 33.5%. Years of high gosling output have just recently led to an increase in the number of adults.

Canada geese nesting on Middleton Island (MI) are considered a sub-population of the dusky goose and were not always summer residents on MI. A breeding population established and grew rapidly to its current size (1,400 adults). Productivity is high because mammalian predators are absent. The proportion of young (no visibility adjustment) is consistently high, averaging 39% (SD = 5.5; range = 31.0%-48.2%) with average production of 890 goslings (SD = 173; range = 673-1,220 goslings). The rapid growth of the population to its current size indicates previously high recruitment. However, the number of adults has stabilized during the last 12 years. Years of high gosling output have not led to an increase in adults.

Dusky Goose Predator Management

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The dusky Canada Goose (*Branta canadensis occidentalis*) nests primarily on the Copper River Delta (CRD), Alaska, and winters in the Pacific Northwest. Predation on the breeding grounds increased as earthquake uplift and long-term succession changed former marsh habitat into large areas of shrub and tree cover favorable to predators. Low recruitment caused by nest and gosling predation was primarily responsible for long-term population decline. On the wintering grounds harvest restrictions on dusky geese limit managers' ability to control population size and costly crop depredation of other Canada goose subspecies. As a result, Alaska managers have come under pressure to assess predator management to date and recommend control options on the breeding grounds.

Since 1987 ADFG has increasingly liberalized harvest regulations for dusky predators. Hunting and trapping have limited the population sizes of brown bears and wolves on the west CRD, and probably mink and coyotes along the highway corridor. Bald eagles are now the primary predator of duskies, responsible for more than 70% of observed nest depredations, compared to approximately 13% for brown bears and 5% for canids. Eagles and mink are the primary gosling predators. With no regulatory authority over eagles, and given record-high dusky productivity during the last three years, ADFG proposes the following limited actions: (1) maintain Egg Island as a coyote-free, brood-rearing area; (2) promote the harvesting of mink and coyotes by trappers to help conserve duskies; and (3) control mink by spring trapping if deemed necessary and feasible.

27 Years of Artificial Nest Islands for Dusky Canada Geese

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From 1983 to 2010, 956 artificial nest islands were installed on the west Copper River Delta in southcentral Alaska, to decrease nest predation on dusky Canada geese (*Branta canadensis occidentalis*). Eight types of islands were constructed and monitored annually from 1983 to 2010. A total of 2,339 nests were initiated during this period on 441 different islands. Artificial island use averaged 30% and nest success averaged 61%, while nest success on natural sites averaged less than 35%. In the last five years artificial island use averaged 47% and nest success averaged 63%. Islands greater than 2 m² in size, located 30-60 m from shore, with freeboard greater than 15 cm, and with aerial shrub cover greater than 35%, were preferred. We recommend the continued maintenance of the islands and the installation of additional fiberglass rounds if the dusky population continues to decline.

Beaver Influence on Surface Water Changes Over Time on the West Copper River Delta, Alaska

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Since the 1964 Alaska earthquake and geologic uplift, beavers (*Castor canadensis*) have expanded their historic range from the inland Copper River Delta (outwash plain) to the once tidally influenced areas of the outer delta (uplifted marsh). The uplift presented a unique opportunity to observe how beaver influenced the transitioning hydrologic structure of a coastal wetland ecosystem after a major disturbance. Here, I quantified the influence of beaver on the surface waters of the west Copper River Delta using remote sensing. Water features were documented from digitized aerial photographs from 1959, 1974, 1986, 1992-1993, and 1996. Surface water area in beaver-influenced water impoundments increased from 0 to 20% of total surface water area from 1959 to 1996, concurrent with beaver colonization of the uplifted marsh. These results suggest that beavers altered the trajectory of wetland change on the west Copper River Delta by raising the water table within open water basins and flooding areas that would have otherwise drained.

Selecting Sites to Improve Moose Winter Forage with Hydroaxe Treatment

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Mowing stands of woody vegetation using a hydroaxe has been shown to increase willow moose browse in areas where alder, spruce, and cottonwood have overtaken willow stands. In 2007, the Cordova Ranger District initiated a project to identify stands that would respond well to future hydroaxe treatment.

On a GIS, 63 polygons representing shrub stands with potential to respond to hydroaxe treatment were identified. I developed criteria that could be measured quickly at nonrandom plots within stands to differentiate the suitability of stands for treatment.

Within five days, representing approximately 40 2-person crew hours, 75 of 83 sample points were measured within 58 of the 63 polygons. The sampled polygons totaled 2,800 acres and include 1,109 acres, 943 acres, and 748 acres, of habitat that was rated as high, medium, or low suitability for hydroaxe treatment, respectively.

Climate Change and Fish on the Copper River Delta: Challenges and Opportunities

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Climate change could potentially have major ecological implications for fish on the Copper River Delta. Freshwater environments are likely to experience altered thermal and hydrologic regimes. Warmer seasonal temperatures will influence all life-history stages of anadromous salmon with impacts at one stage cascading to the next, compounding impacts. Flows could be higher in the winter as a result of precipitation falling as rain rather than snow. Decrease in the snowpack could also result in lower spring flows. Effects could be both positive (more available habitat, extended growing season) and negative (displacement of recently emerged fry, altered time of smolting). The marine environment is likely to be more acidic and have reduced areas of suitable temperatures. These effects could reduce survival and growth rates, resulting in fewer and smaller adults returning to freshwater. These will in turn affect population dynamics and survival of developing eggs and embryos. The response of the two primary species, coho and sockeye salmon, could vary. It is important that monitoring efforts recognize that the interaction of effects in freshwater and marine environments will have cumulative effects on fish, and that the different species will respond differently and in ways that are novel and unexpected.

Complexity in Food Webs of Copper River Delta Juvenile Salmon as Revealed by Natural Stable Isotope Abundance

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Anadromous sockeye salmon, coho salmon, and eulachon spawn and then die supplying the Copper River Delta with marine derived nutrients (MDN). MDN can be used directly (e.g., scavengers) or be remineralized contributing to the dissolved inorganic nutrient pool.

Adult salmon carcass stable nitrogen, carbon, and sulfur isotope analysis suggested systematic nitrogen and carbon isotope differences consistent with coho salmon being about one trophic level higher on the food chain than sockeye salmon. Isotopic values of periphyton reflected the uptake of remineralized MDN varying spatially with respect to spawning.

Juvenile sockeye and coho salmon were sampled in rivers and estuaries. X-Y plots of their stable isotope values were circumscribed into sets; riverine salmon were subsets of estuarine salmon; riverine sockeye salmon were generally (some sockeye were carbon-13 enriched) a subset of riverine coho salmon. A relatively small proportion of salmon were indicated as having fed directly on MDN, and a minority had very low MDN. The range in isotope values for both species did not vary from April through October, and it varied none at all for riverine salmon; however, the small portions of estuarine sets that were indicative of low MDN were mainly in April and May and those indicative of direct MDN were mainly in May and June. Stable isotope values plotted with respect to length suggest a maternal signal until about 40 mm with coho salmon having higher values consistent with the adult carcasses. Isotopic ranges increased for salmon >70 mm; smaller salmon >40 mm ranged much less.

The Influence of Fall-Spawning Coho Salmon on Growth and Production of Juvenile Coho Salmon Rearing in Beaver Ponds on the Copper River Delta, Alaska

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This study examined the influence of fall-spawning coho salmon (*Oncorhynchus kisutch*) on the density, growth rate, body condition, and survival to outmigration of juvenile coho salmon on the Copper River Delta. During fall 1999 and 2000, fish rearing in beaver ponds that received spawning salmon were compared with fish from ponds that did not receive spawners and also with fish from ponds that were artificially enriched with salmon carcasses and eggs. The response to spawning salmon was variable. In some ponds, fall-spawning salmon increased growth rates and improved the condition of juvenile coho salmon. The enrichment with salmon carcasses and eggs significantly increased growth rates of fish in nonspawning ponds. However, there was little evidence that the short-term growth benefits observed in the fall led to greater overwinter growth or survival to outmigration when compared with fish from the nonspawning ponds. One reason for this result may be that nutrients from spawning salmon are widely distributed across the delta because of hydrologic connectivity and hyporheic flows. The relationship among spawning salmon, overwinter growth, and smolt production on the Copper River Delta does not appear to be limited entirely to a simple positive feedback loop.

Assessing Residence Time and Habitat Use of Coho and Sockeye Salmon in Alaska Estuaries

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Substantial variability in the early life history and migratory behavior of coho (*Oncorhynchus kisutch*) and sockeye (*Oncorhynchus nerka*) salmon exist on both local and regional scales. For both species, juveniles have been found in estuaries as age 0 fry, 0+, 1, and 1+ year old smolts. Once in the estuary, an area seldom studied in regard to salmon, residence time is highly variable (days to months) and is probably correlated to the age of outmigration (i.e., longer residence has been reported for age 0 salmon). We quantified estuarine residence time of coho and sockeye salmon using traditional fisheries sampling (midwater trawls, fyke nets, and seine samples) and microchemical analysis of strontium concentration in otoliths of juvenile and adult coho and sockeye within the Copper River Delta. Our project demonstrated the usefulness of the latter technique in examining the duration of freshwater, estuarine, and marine residence time. Overall, there was general agreement between results of the intensive field collections and otolith chemical signatures with respect to estuarine residence time. Both techniques indicated a relatively brief period in estuarine waters (10-45 days, average 30 days) for both species. Because estuarine habitats are critical for osmoregulatory adjustment to marine waters and offer rich foraging opportunities for smolt, estuarine habitats represent essential habitat for salmonid fisheries. Consequently, alteration or degradation of these habitats resulting from natural (e.g., tectonic activity, climate regime shifts) or anthropogenic perturbations (e.g., oil spills, coastal development) may have serious consequences for sustainable harvest of salmonids.

Spatial Variability in Egg-Incubation Temperature Regimes on the Copper River Delta, Alaska: Implications for Understanding Likely Climate Change Impacts

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Egg incubation and emergence timing of salmonids are closely linked to overwinter temperature regimes in the redd. Global climate models project warmer future climates, with relatively more warming occurring in northern latitudes and during the winter. Thus, climate change could significantly affect duration of incubation and emergence timing of salmonids on the Copper River Delta. As a baseline for understanding future changes, we are examining spatial heterogeneity in water temperature of shallow groundwater across the Copper River Delta. We established shallow groundwater "wells" at four sites in November 2009. Well screens were located approximately 17 to 23 inches below the streambed. We found surprising spatial heterogeneity in water temperatures. At some sites, water temperatures were stable at $\sim 4^{\circ}\text{C}$ throughout the winter of 2009-10, probably indicating locations of regional groundwater discharge. Other sites appeared to reflect the local ambient environment, cooling to near $\sim 0^{\circ}\text{C}$ early in the winter although short warming periods were observed at these sites in response to warm winter storms. We do not know if we have sampled the full range of potential temperature regimes on the delta. Consequently, we added eight monitoring sites in October 2010. Although we have collected only one year of data to date, the spatial heterogeneity in the observed thermal regimes does offer an interesting context in which to consider the evolutionary adaptations of local salmon stocks to particular thermal regimes for overwinter incubation of their eggs.

Coastal Cutthroat Trout in the Copper River Delta and Prince William Sound, Alaska: A Summary of Recent Research

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In the past 15 years, the Pacific Northwest Research Station and the Cordova Ranger District of the Chugach National Forest conducted four studies involving coastal cutthroat trout on the Copper River Delta (CRD) and in Prince William Sound (PWS), which is the northern distribution limit of these fish. These studies considered spatial scales from the distribution range of coastal cutthroat trout to individual streams, and biological levels of organization from metapopulations to local populations. Populations from this area are genetically unique relative to populations from other parts of the distribution range. Populations in PWS are generally isolated from each other except for populations that are connected by areas of shallow water. Hybridization with *Oncorhynchus mykiss* varied from more than 60% in a few populations to no hybridization in most populations. A range of movement and life-history patterns were observed in populations on the CRD. The rich levels of genetic diversity and life histories are likely a result of the environmental diversity and complexity of the CRD and PWS and the unimpacted status of populations in these areas.

Migration, Movement, and Habitat Use of Humpback Whitefish (*Coregonus pidschian*) in McKinley Lake and the Copper River Delta

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We examined the movement and behavior of humpback whitefish (*Coregonus pidschian*) in McKinley Lake, the first documentation of whitefish on the Copper River Delta. Forty-five fish were tagged with radio transmitters in 2006 and 2007. Twenty-nine were tagged with acoustic tags in 2009. These fish were 2-9 years old. Fish moved into McKinley Lake in late spring and left in late summer and early fall. Nine fish tagged in 2007 and four tagged in 2008 returned to the lake the following year, suggesting some fidelity to summer feeding sites. They occupied a large portion of the lake at any time, and were most active in the early morning but there was no clear movement pattern. Migration from the lake tended to be by an individual or a group of 2-3 fish. There was a noticeable increase in activity of individuals 48 hours prior to migration from the lake. We attempted to monitor the movement of fish once they left McKinley Lake, presumably to overwintering and spawning areas in the upper Copper River. Fish appeared to either stay in freshwater the entire way or move to the Gulf of Alaska and then into the Copper River. Otolith microchemistry indicated three patterns of movement: (1) only in freshwater movements; (2) a marine migration on one occasion; and (3) multiple marine migrations.

A Survey of Sport Fish Use on the Copper River Delta, Alaska

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Aerial counts, in-person interviews, and mail-in questionnaires were used to survey sport fish use during the coho salmon (*Oncorhynchus kisutch*) season on the Copper River Delta from 2002 through 2006. Aerial counts provided an index of use on individual streams and were used to develop a spatial database exhibiting patterns of use. Interviews and questionnaires were used to estimate effort, catch, and harvest of salmon by Cordova residents and nonresident anglers. Annual effort for nonresidents ranged from 5,230 to 5,663 angler-days from 2004 through 2006 and use appeared to be relatively constant over that time. Effort by Cordova residents on the delta ranged from 2,372 to 4,720 angler-days, and steadily declined over time. Sport fish use was concentrated on three streams: Eyak River, Ibeck Creek, and Alaganik Slough. Other streams had little to no use. Anglers were generally not found to use areas of streams with key spawning habitats. Coho salmon was the targeted species, and nonresident anglers caught and harvested more fish than Cordova resident anglers. Nonresident angler catches ranged from 15,192 to 28,473 coho salmon and harvests ranged from 6,887 to 10,554 fish over 3 years. Annual catch and harvest of coho salmon by Cordova residents ranged from 2,116 to 6,033 and from 1,454 to 3,493 fish, respectively. Selective harvest was widely practiced. Visiting anglers released 56% of the coho salmon they caught, whereas Cordova residents released approximately 33% of their catch. The information provided with this survey will assist in the management of fisheries resources on the Copper River Delta. Some applications include directing habitat monitoring and protection efforts, focusing interpretive and educational materials to user populations, assessing access and infrastructure needs, and permitting.

Copper River Fisheries Resource Monitoring Program

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The Native Village of Eyak has been involved with salmon fisheries research and monitoring on the Copper River since 2001. This presentation will provide a history and overview of the programs, highlighting key results and accomplishments from the past decade of work.

Copper River Knowledge System Web Portal

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This presentation will detail work to date on the next generation Copper River Knowledge System interactive web-based data integration and visualization tool. The tool will provide a common platform for stakeholders—including managers, industry, regulatory agencies, scientists, and the public at large—to access relevant information about the ecology, climate, biology, and human activities in the region. Development of the portal synthesizes in-depth stakeholder input, streamlined and integrated data from multiple sources, and an open source, non-proprietary data management system. This functional, cost-effective data integration and visualization tool will be used for spatial planning, data discovery, and knowledge transfer in the Copper River watershed for all potential user groups.

Imaging Alaska's Coastline: Fly the Copper River Delta Like a Shorebird

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The Alaska ShoreZone program has been imaging and habitat mapping Alaska's coastline since 2001. Currently over 60% has been imaged from southeastern Alaska north along the Gulf of Alaska to Kodiak and Bristol Bay. What makes this project unique is that all the imagery, video, and high resolution still photos, are accessible online to the public. The Copper River Delta was imaged in 2007 and I will give a brief tour of how to use the online tools and fly the coastline.

Mapping Vegetation on the Copper River Delta

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Current and accurate vegetation maps are needed for monitoring and evaluating wildlife habitat within the Copper River Delta. Vegetation maps currently available for the area are outdated, too coarse in scale, or inaccurate for the analysis of habitats used by moose, dusky Canada geese, trumpeter swans, and other species of interest. This is a priority data need for both the moose and dusky Canada goose monitoring protocols of the Chugach Forest Plan to assess habitat change. In addition to wildlife habitat assessment, a map of existing vegetation will be useful in a wide range of applications including land management planning, inventory and monitoring, recreational activity management, and climate change analyses.

In order to meet these management needs the Forest Service collected SPOT 5 imagery in 2009 with complete Copper River Delta coverage. This imagery will serve as a fundamental base layer for mapping vegetation throughout the delta. In 2010, Ducks Unlimited and the Forest Service cooperatively determined ecological unit mapping classes and conducted a robust and comprehensive field data collection. The field data, when combined with satellite imagery, image segmentation to identify floristic landscape patterns, and auxiliary inputs, will be used in a data mining and accuracy assessment to provide an accurate, precise, and defensible inventory product.

Ranking Culverts for Maximum Benefit from Restoration Dollars

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Improperly designed or installed culverts can block fish passage and degrade water quality in fish streams. In 2002 the Alaska Department of Fish and Game surveyed all culverts on state roads in the Copper River drainage and determined 64% of them were inadequate for passing juvenile fish at all flows. With the potential for a single failed culvert to block miles of upstream spawning habitat and limit productivity of that fish stream, the Copper River Watershed Project (CRWP) and partners saw a need for evaluating which culverts should be replaced first to achieve the maximum benefit for fish habitat in relation to the anticipated cost of replacing a culvert.

The CRWP has developed a culvert ranking protocol that factors in ecological conditions and culvert conditions, assigning point values for conditions in each category. Additional points are awarded for cost estimates and partnership potential. We are applying this scoring system to culverts in the upper Copper basin and Copper River Delta and will have results in March 2011. These results will present priority fish passage improvement projects for the Copper River Delta that maximize the benefit for fish and use limited resources efficiently.

In the future, the culvert ranking protocol will be used by the CRWP and public and private partners to evaluate failed culverts and habitat conditions objectively for prioritizing restoration efforts, to help form partnerships, and to seek funding. We are also developing a web-based culvert visualization tool with Eco-trust to catalog culvert and habitat data.

Wetlands Ecology Media Expedition

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The Wetlands Ecology Media Expedition (WEME) is an adventurous, summer field-based learning opportunity for high school students to study the ecology of wetland ecosystems on the Copper River Delta. Students are recruited from communities within or near the Chugach National Forest and are recommended by teachers, advocates, and supervisors. Student participants do not pay a fee; the goal of WEME is to provide an opportunity to youth who may not be able to pursue such an expedition unless sponsored. WEME is the result of collaboration of educators and researchers from Alaska Geographic, the U.S. Forest Service, and the Prince William Sound Science Center.

During the 10-day course, participants explore the Copper River Delta on foot, and by canoe, poke boat, and air boat. Participants spend five days based at Pete Dahl field camp off the Alaganik Slough. Students focus on documenting the impacts of climate change on a large wetland ecosystem while exploring the plants, soils, hydrology, and birds and other wildlife associated with North America's largest contiguous wetland using audio/video recording and still photography. A variety of scientists and local experts, including botanists, wildlife biologists, soil scientists, and GIS analysts, work side by side with the students, cultivating a deep sense of ecological responsibility and building interest in science-based careers.

Upon returning to Cordova at the end of the trip, participants have two days to work on final media projects based on the lessons learned and experiences during this expedition.

Copper River Stewardship Program: A Showcase of a Watershed Education Collaborative

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The Copper River Stewardship Program is a program that takes ten youth from communities throughout the region on an in-depth exploration through the Copper River watershed to investigate the contrast and links between the Copper basin and the Copper River Delta. During this adventure-based program, students have the opportunity to learn traditional ecological knowledge, current challenges, and social, natural and cultural history first-hand from a wide range of stakeholders, including Alaska Native elders, community members, resource managers, and industry representatives. Participants also learn valuable outdoor and leadership skills from adventures such as river rafting, backpacking, and/or canoeing.

Students can register for an environmental science credit through Prince William Sound Community College and throughout the course complete written reflection assignments and participate in group discussions. Assignment topics include explaining the student's approach to managing a declining sockeye salmon run if they were a member of the Board of Fish, and addressing the potential need and challenges to managing the entire watershed as a complete system. After finishing their journey each participant creates a unique project to share their lessons and experience with others. Past projects include art installments on salmon and the watershed, lesson plans for teaching salmon ecology to elementary students, newspaper articles, and multimedia projects to be posted online to reach broader audiences (www.copperriver.org).

This project is a demonstration of a successful watershed-wide education collaboration that helps future leaders of the region better understand the interconnectedness of the dynamic natural and human systems of the watershed.

Copper River International Migratory Bird Initiative

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The Copper River International Migratory Bird Initiative (CRIMBI) was founded in 2001 by U.S. Forest Service (USFS) International Programs, the Cordova Ranger District, and Ducks Unlimited. This group of partners founded CRIMBI because they recognized that conserving the migratory birds of the Copper River Delta requires an international effort. Over the years CRIMBI has connected conservation organization with shared birds from Colombia to Alaska along the Pacific Flyway. Collaborative projects have not only increased capacity and conservation efforts in Latin American organizations but have increased awareness of vital conservation needs throughout the flyway. Currently, CRIMBI has expanded its partners to include organizations in Colombia, Panama, Peru, and Ecuador. Future projects include flyway-wide shorebird surveys, wetlands education, and on the ground conservation.

USFS Alaska Region's Key Coastal Wetlands

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Coastal wetlands are familiar to Alaska residents, both human and animal, but three large National Forest System wetlands in particular are important global and local resources. The Copper River Delta, Yakutat Forelands, and the Stikine River Flats make up the recently designated Alaska Region's "Key Coastal Wetlands" (KCW). These wetlands systems support world-class fisheries and wildlife resources. They play an important role in the survival of many species of shorebirds and waterfowl in their seasonal migrations. These wetlands also support subsistence, commercial, and recreational lifestyles of local rural residents.

The Copper River Delta, Yakutat Forelands, and the Stikine River Flats are jewels of the Pacific Rim. They have international significance in their role as stopover locations for migrating shorebirds that range along the Pacific Rim. These three KCW are large, intact natural ecosystems that cover a diversity of habitats. The wetlands are dynamic and subject to impacts from natural and human-related factors. Sources of change include natural processes such as extreme tidal fluctuations, surface uplift, and subsidence from earthquakes, glacial retreat, and associated rebound of land surfaces, as well as the more subtle effects from global climate change. Human forces acting on these wetlands include primarily subsistence, sport, and commercial harvests of fish and wildlife, with indirect effects from mining and recreation. The Key Coastal Wetlands are essential to maintaining long term productivity of fish and wildlife throughout the Pacific Rim. The KCW were designated in order to maintain high quality resources for future generations, to gain a better understanding of how these wetlands are changing, and to use these large intact ecosystems as context for future scientific reference.

Pan-Boreal Conservation: North America's Opportunities

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The boreal forests of the Northern Hemisphere make up 45% of the remaining frontier forests of the world. North America's boreal area consists of over 1.5 billion acres of forests, wetlands, rivers, and meadows. Few areas on the globe are as important for carbon storage. A great synergy exists among the boreal watersheds and coastal deltas.

With changes in climate, large landscape protection from extraction industries is necessary to preserve habitat for a variety of boreal fauna and flora. Alaska and Canada provide two very different strategies—one driven by federal protection (specifically NPS and FWS) the other driven by First Nations, industries, and provincial governments. Russia and Finland provide examples of weak protection.

Odiak Pond Field Study

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The Copper River Watershed Project (CRWP) and Cordova High School teamed up to develop the Odiak Pond Field Study as part of the 7th grade science curriculum. During 2009-2010, CRWP and guest scientists led monthly field trips with small groups of students to collect water quality data from Odiak Pond and Odiak Stream. At the beginning and end of the school year the entire class participated in field trips to retrieve minnow traps to assess fish populations and to use a kicknet to inventory macroinvertebrates. Prior to the field study there was anecdotal evidence that salmon were living in the ecosystem. The students captured coho salmon in the minnow traps and successfully had the pond and stream added to the *Catalog of Waters Important for Spawning, Rearing or Migration of Anadromous Fishes*. The State of Alaska manages this catalog to ensure minimal degradation to waterbodies known to be important for spawning, rearing, or migration of anadromous fish. During the 2010-2011 school year, students are categorizing, counting, and collecting trash that would be carried into Odiak Pond via stormwater. At the conclusion of each school year, students are required to develop an outreach project to share their lessons and experiences with the broader community through various presentations and festivals. Projects are also posted online.

This project demonstrates how to use an outdoor setting to support the science curriculum, meet Alaska State Science Standards, and contribute valuable scientific information to Alaskans. Furthermore, this project demonstrates how to integrate multimedia into education programs.

Ecology of the Nearshore Areas of the Copper River Delta

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Nearshore areas serve as a critical connection between terrestrial and marine ecosystems. We characterized the temporal and spatial patterns in key physical and chemical parameters for the Copper River Delta and Orca Inlet (southeast Prince William Sound) in 2004. Surface and bottom water salinities throughout the Delta and Orca Inlet were significantly reduced during the summer in response to the large input of freshwater from the Copper River. At delta sites, lowest salinity values for both surface and bottom were recorded during August. The Copper River is also a source of nitrate to the Delta ecosystem as well as a source of nitrates to the Gulf of Alaska through exchanges between Egg Island and Pete Dahl channels. Highest nitrate concentrations occurred in late spring and late summer/fall. Ammonia inputs, primarily from the Copper River and Alaganik Slough, were associated with large eulachon returns during March and April.

Phosphate concentrations were influenced by both oceanic and riverine sources, whereas silicate appears to be delivered in large quantities primarily from riverine sources. *Chl a* concentrations in surface waters reflected an input of phytoplankton from the Gulf of Alaska during spring and early summer. In intertidal sediments, *chl a* concentration increased with distance from the Copper River. Our data set serves as the first description of the relatively pristine waters of the Copper River estuary, an area of significant economic and cultural value to the North Pacific.

The Effect of Riverine Discharge on the Distribution of Marine and Estuarine Fishes and Crabs of the Copper River Delta, Alaska

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Vast expanses of intertidal sand/mudflats serve as a critical link in the food web of nearshore communities along the southcentral Alaska coastline. The rich abundance of benthic invertebrates residing within the sediments of intertidal flats and the large network of subtidal channels that bisect these flats provide a significant prey resource for numerous species of fish, crabs, birds, and marine mammals. One of the largest expanses of intertidal mud/sand flats occurs in the Copper River Delta and southeastern Prince William Sound (Orca Inlet). From April 2002 through October 2006, we performed the first study of the demersal fish and mobile invertebrate community of the estuarine/marine waters of the Copper River Delta and adjacent Orca Inlet (southeastern Prince William Sound). At seven stations located throughout Orca Inlet and the Western Copper River Delta monthly otter trawl surveys were performed from April through October of 2002-2006. A diverse fish and invertebrate assemblage dominated by flatfish, sculpins, snake prickleback, and crangon shrimp is present on the Copper River Delta. Several of the demersal fish species and one crab species that occur within the Copper River Delta are of significant value to recreational and commercial fisheries. Pacific halibut, lingcod, English sole, and Dungeness crab use the extensive network of sloughs and tidal flats as nursery habitat. Spatial variability in the demersal fish and invertebrate community reflect two principal factors: distance from the Copper River and abundance of sea otters. Demersal fish and crabs generally increase with increasing proximity to the Copper River Delta, a west-east pattern opposite that of their chief prey and predators, benthic invertebrates, and sea otters.

Benthic Invertebrate Community Measures among Stream Channel Types of the Copper River Delta, Alaska

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The Copper River Delta extends 75 miles along the Gulf of Alaska and encompasses 700,000 acres of constantly changing river channels, marshland, tidal flats, and sloughs. The delta is located in one of the most seismically active regions of the world, experiencing major earthquakes every 600-1,000 years; the most recent event occurred in 1964. Current USDA Forest Service management assessments in the delta region have identified a critical need for baseline data on ecosystem processes and conditions in order to monitor and document physical and biological changes over time. In addition, understanding the natural processes that influence the delta's salmon populations has been designated as a research area of high priority because of the ecological and economic importance of the region's fisheries. In an effort to provide area managers with aquatic community measures for future comparisons, benthic invertebrate community structure was contrasted among 12 streams representing 6 stream channel types common to the area and important to salmonid development. In general, invertebrate density, taxa richness, diversity, and functional feeding group proportions were found to be greatest in channel types designated as high potential for salmonids. Significant variations in community measures between streams within common channel types illustrate the need for a stream-specific invertebrate sampling strategy for the Copper River Delta.

Abundant, Seasonally Variable Supply of Glacier Flour–Derived Iron Drives High Nitrate Consumption in Copper River Plume and Adjacent Gulf of Alaska Continental Shelf

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Recent work has suggested that high iron supply may contribute to a northward increase in phytoplankton biomass along the U.S. west coast, consistent with “bottom-up” control of these coastal ecosystems. We examine this hypothesis in waters of the Copper River plume and nearby continental shelf in the northern Gulf of Alaska. High concentrations (several hundred nM) of “total dissolveable” Fe (unfiltered, pH ~2) were present in surface-waters spanning the continental shelf in early April 2010, from resuspension of fine glacial flour. Concentrations decreased dramatically beyond the shelf break. This fine particulate matter represents a large source of “dissolved” Fe to these waters. Surface-water nitrate concentrations were fairly uniform (~15 μM) across the entire shelf at this time, due to deep winter mixing. By late July this shelf particulate Fe source is greatly diminished, owing to strong stratification. However, there is abundant “total dissolveable” Fe (several μM) at this time from the Copper River plume (largest single freshwater source to the GoA) and lower, significant concentrations in the Alaska coastal current (that reflect the cumulative impact of melting glaciers from further south). By late July this abundant supply of iron, together with strong stratification, lead to complete consumption of surface-water nitrate across the entire shelf (and extending tens of kilometers beyond the shelf). These data are consistent with the idea that high primary productivity in this region is fueled by abundant wintertime surface-water nitrate, together with iron supply from fine, labile, glacier-derived particulate matter from seasonally variable sources.

Methods for Estimating Avian Productivity on the Copper River Delta, Alaska

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We conducted standardized repeatable surveys of selected passerine species with the aim to estimate probability of breeding and to determine the effect of boreal ponds on avian productivity. Historical avian productivity research has used nest searching techniques; however, we used a multistate approach to estimate the probability of successful breeding. This methodology does not require the detection of avian nests, which can be difficult to detect. These surveys were conducted on preselected boreal ponds in the Copper River Delta from 4 June 2010 through 14 July 2010 as part of the ongoing U.S. Forest Service Pond Ecology project. Bird species were selected from abundance information gathered during avian point count surveys conducted in 2008. The species that were selected were orange-crowned warbler, Wilson's warbler, alder flycatcher, Lincoln's sparrow, Savannah sparrow, song sparrow, and fox sparrow. Of the individuals monitored, 89 were confirmed breeding, 75 were assessed as probably breeding, 25 were determined to be possibly breeding, and one was found to be not breeding. These data will be used to develop models that will describe the effect of boreal ponds on avian productivity on the Copper River Delta.

Stopping Invasive Plant Expansion to the Copper River Delta

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The Alaska Association of Conservation Districts and the CRWP are supporting efforts to identify and treat infestations of invasive weeds in Cordova, Alaska, before they spread east to the Copper River Delta. The Copper River Delta, east of Cordova, is designated a State Critical Habitat Area (Alaska Statute 16.20.600) and is known for the fish and wildlife it supports. Invasive plant infestations could change the face of the delta and consequently the habitat that it provides for migratory, resident, and nesting species.

In 2010, state and private forestry used federal stimulus dollars to fund an invasive weed coordinator position for one year in Cordova. The coordinator has contacted landowners and has begun to create a weed management plan with all local partners, conducted public outreach and education, coordinated weed removal efforts and started experimental treatments for local invasive plants. The coordinator is also credited with finding the first known location of giant knotweed (*Fallopia sachalinensis*) in the Cordova area. Cordova's Invasive weeds coordinator has identified the three most aggressive species as orange hawkweed, reed canarygrass (*Phalaris*), and giant knotweed.

The CRWP has been awarded grant funds to reduce and control the spread of orange hawkweed, reduce *Phalaris*, and eradicate giant knotweed. Long-term conservation outcomes include solidifying the partnerships—with appropriate equipment, expertise, and practices—for long-term invasive plant control. The final layer of long-term response to this problem is education of private and public property owners on identification of invasive plants and treatment options.

Wind Energy Feasibility Study of the Cordova Area

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The cost of energy in Cordova is a burden to the community. In summer, electricity costs are twice the rates in Anchorage. This disparity climbs to a 5X rate in winter months as streams freeze up and hydroelectric generation stops. Home heating oil and transportation fuel costs are twice as high because the products must be barged in.

At the same time, the Cordova region is blessed with many natural potential sources of energy, including hydroelectric, wind, biomass, fish waste, and tidal energy. Our vision is that in the near future Cordova's energy supplies can be generated with resources that are all local to the region. Achieving this goal will allow our forests and salmon to thrive and in turn, better provide for economic and cultural prosperity of our world-class fishing industry.

The wind energy program will (1) complete the Camp Hill wind farm project design and permits; (2) improve wind data maps through a mobile 10 meter anemometer tower project; (3) initiate a wind farm pilot project and a marine-based pilot project; (4) drive community involvement and education; (5) adopt best-known methods from other successful wind projects; and (6) set the stage for construction and implementation. The project will provide low-cost electricity for all members of the Cordova Electric Co-Operative power grid.

Eyak Lake: Cordova's Million Dollar Lake

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Eyak Lake is Cordova's Million Dollar Lake, generating \$800,000 to \$1,500,000 annually in seafood sales (ADFG). The Copper River Watershed Project received \$1,073,886 from NOAA in ARRA funds, as part of the 2009 stimulus program, to conduct habitat restoration work and restore health and resiliency to coastal communities.

Completed restoration projects include (1) excavating a spit on Power Creek Road to improve spawning and rearing habitat for salmon; (2) bank revegetation to address erosion concerns; and (3) culvert replacements on Eccles and Whiskey creeks to improve habitat quality for pink and coho salmon and cutthroat trout. Engineering is completed and we are awaiting installation of an oil and grit separator to address stormwater pollution from Lake Avenue. Data monitoring is being conducted pre- and post-restoration activities.

Educational activities have occurred through community involvement in revegetation projects. Additionally a series of six interpretive signs were designed and produced, highlighting the cultural and biological significance of Eyak Lake and providing information on how to minimize human impact in fragile shoreline habitat. These will be installed around the lake in spring 2011. We are working to create a foundation of community partners to secure future habitat protection for Eyak Lake.

Upcoming projects include the facilitation of a focus group to discuss how to best help contractors and equipment operators minimize and prevent construction site stormwater runoff and the development of a contractor/operator "Guide to Permitting for Construction Activity."

Distribution and Ecology of Zooplankton and Juvenile Salmon in the Copper River Plume

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The Copper River is the largest point source of freshwater to the northern Gulf of Alaska, and is an important spawning environment for all five species of Pacific salmon (*Oncorhynchus* spp.). When entering the marine environment, salmon smolts are known to subsist on zooplankton, but their location and feeding patterns are little studied in the region. Preliminary sampling suggests juvenile salmon may use the highly turbid Copper River plume to evade predation and take advantage of concentrated zooplankton populations. The influence of the plume biochemistry and physical dynamics can create a nonhomogeneous distribution of zooplankton that may correlate with smolt feeding behavior. Previous studies on salmon have proposed the critical size and period hypothesis, which suggests that after smolts enter the marine environment, they must achieve sufficient size within a certain time to survive their first marine winter. Fluctuations in marine conditions and changes in zooplankton concentrations and salmon behavior have been implicated as drivers of salmon year-class strength. This project will sample the Copper River plume for zooplankton and salmon smolts with bongo nets and trawling, and make concurrent measurements of salinity, temperature, and turbidity with an undulating towed vehicle to develop an oceanographic description of the plume. Further description of the trophic status of fish and zooplankton will be conducted via isotopic analysis, and salmon growth rates will be estimated from otolith measurements. I hypothesize that relationships between zooplankton and smolt concentrations will correlate with plume dynamics in a way that supports optimal juvenile salmon growth and survival.

Spatial Pattern of Population Change in Dusky Canada Geese on the Copper River Delta, Alaska

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The aerial index to the breeding population of dusky Canada geese on the Copper River Delta, Alaska, declined 55% in 25 years, 1986-2010, at an average annual growth rate of 0.968. However, the spatial pattern of population growth rate across the 693 km² surveyed area was not constant, suggesting that local conditions such as nesting success or proximity to brood rearing habitat influence population dynamics. We determined the fine-scale geographic pattern of population growth rate in aerial observation index density based on 1,852 m (one nautical mile) grid cells. We also divided the area into 42 strata based on similarity in physiographic appearance and land cover classes. We present habitat characteristics of strata, such as land cover type, land-water interspersion, percent water, and proximity to rivers and sloughs, as possible correlates either with goose density or change in density. We discuss limitations of existing data sets and identify data gaps.

An Examination of Data Gaps and Estimate of the Water Budget for Eyak Lake, Alaska

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Eyak Lake provides habitat for coho, pink, and sockeye salmon, cutthroat trout, and Dolly Varden. In 1981 Eyak Lake was recommended for designation as an "Area Meriting Special Attention" by the Alaska Coastal Policy Council; this designation was approved in 1986. Since the late 1800s, road building and commercial and residential development has occurred along two sides of the lake, increasing sediment run-off and disrupting fish access to streams. A weir at the mouth of the lake was constructed after the 1964 Good Friday earthquake to stabilize the water level, and it is unclear how this has impacted the natural functioning of the lake and its future as fish and wildlife habitat.

An understanding of the habitat and physical processes occurring in the Eyak Lake watershed are necessary to guide restoration and preservation work, particularly in regards to the maintenance of fish habitat, the transportation and dilution of pollutants, and flood control. Little hydrologic data has been collected in the basin, and in this context we attempt to model a surface water budget for the lake by using hydrology models and available flow, weather, and spatial data. Tributary inflows are modeled and compared to the few local stream flow records available. We also estimate evaporation, incidental precipitation, and Eyak Lake outflow using existing weather and river gauge data. The results from this project provide a rough baseline of the hydrologic conditions of Eyak Lake, identify data gaps, help prioritize issues, and will guide data collection and restoration efforts.

Avian Influenza Surveillance of Shorebirds and Gulls in Cordova

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Migratory birds from multiple continents pass through Alaska, providing opportunity for the introduction and generation of novel avian influenza virus. Understanding viral ecology and evolution in Alaska may be critical for understanding the capacity for birds to serve as vectors for novel or zoonotic strains of influenza that may pose a risk to humans. In spring of 2009, we initiated a multi-year surveillance study of shorebirds and gulls near the Copper River Delta to examine the prevalence and diversity of influenza viruses in this critical habitat. Here, we report the results of two years of surveillance collections and present data on several gull viruses sequenced from these samples that indicate birds in this region spread infection of viral strains with a high degree of intercontinental mixing.

Impacts of Seafood Waste Discharge in Orca Inlet

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In 1975 EPA produced effluent discharge guidelines for the seafood processor industry that required wastes to be ground to less than 1.27 cm in any dimension prior to discharge. Subsequently, several negative impacts were observed around Cordova, Alaska, including noticeable decreases in crab and halibut harvests and a substantial increase in numbers of Glaucous-winged gulls. We hypothesized that the change in discharge guidelines removed a food source for the large bottom-oriented animals and increased availability to the surface-oriented gulls. In 2004, we began a three year study to examine impacts of seafood waste discharge into Orca Inlet, including evaluation of alternative discharge and disposal methods that could be beneficial to fishermen, the processors and the community. The study included model development and control treatment experiments. We developed a dispersal model that incorporated both physical and biological transport mechanisms. The model predicted that sea lions, adult fish and crabs could assimilate and transport a substantial amount of fish wastes over a much larger area than physical processes alone. We dumped 300,000 lbs of salmon heads and carcasses at an experimental site and monitored the biotic response. Survey methodologies included underwater cameras, traps, fishing with hand lines, stomach content analysis, acoustic tags attached to salmon heads and visual surveys of birds and marine mammals. The results show that the heads and carcasses disperse rapidly and are efficiently incorporated into the food chain with no negative consequences, a very favorable contrast to the current EPA-mandated practice.

Temporal and Spatial Variability in the Partitioning and Flux of Riverine Iron Delivered to the Gulf of Alaska

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Iron (Fe) is a micronutrient that is thought to limit phytoplankton productivity in offshore waters of the Gulf of Alaska (GoA). However, it has been proposed that in coastal regions where offshore, Fe-limited, nitrate-rich waters mix with relatively Fe-rich river plumes, productive ecosystems and fisheries result. Indeed, an observed northward increase in phytoplankton biomass along the Pacific coast of North America has been attributed to higher input of riverine Fe to coastal waters, suggesting that many of the coastal ecosystems of the North Pacific rely heavily on this input of Fe as a nutrient source. Based on our studies of the Copper River (the largest point source of freshwater to the GoA) and its tributaries, it is clear that riverine Fe delivered to the GoA is primarily derived from fine glacial flour generated by glacial weathering, which imparts a unique partitioning of Fe species and Fe size fractionation in coastal river plumes. Furthermore, the distribution of Fe species and size fractionation exhibits significant seasonal and spatial variability based on the source of iron within the watershed, which varies from glacial mechanical weathering of bedrock to internal chemical processing in portions of watersheds with forest and wetland land covers. These findings are relevant to our understanding of the GoA biogeochemical system as it exists today and can help to predict how the system may evolve as glaciers within the GoA watershed continue to recede.

Melting Ice, Habitat Change and Nutrient Flux: Biogeochemical Linkages in a Rapidly Changing Glacier-dominated System

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The coastal Gulf of Alaska region is experiencing rapid and accelerating changes due to local and regional warming. Predicted high-latitude warming may result in rapid recession of glaciers with subsequent changes in river discharge, nutrient fluxes into the rivers, shifts in landscape vegetation cover, and altered CO₂ fluxes affecting the regional carbon balance. Here we present the scope of research for a new NASA-funded project focusing on the headwaters of the Copper River in the glacier-dominated Wrangell-St. Elias National Park and Preserve. This project will begin in the Spring-Summer of 2011 and will assess how time since de-glaciation (barren land to mature spruce forest) may affect terrestrial ecosystem biogeochemistry and ensuing fluxes of CO₂ to and from the atmosphere and nutrients into the Copper River system. We have identified three major research sites within the Wrangell-St. Elias National Park and Preserve where we will do chamber-based measurements of ecosystem fluxes in recently de-glaciated barren land areas and early-successional vegetation types, river water sampling and isotope analysis to assess nutrient discharge and fluxes, as well as landscape scale forest ecosystem CO₂ fluxes using eddy covariance.

