

Economics of Wild Salmon Ecosystems: Bristol Bay, Alaska

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Abstract—This paper provides an estimate of the economic value of wild salmon ecosystems in the major watershed of Bristol Bay, Alaska. The analysis utilizes both regional economic and social benefit-cost accounting frameworks. Key sectors analyzed include subsistence, commercial fishing, sport fishing, hunting, and nonconsumptive wildlife viewing and tourism. The mixed cash-subsistence economy of Bristol Bay supports a population of 7,611 (2000 census) that is 67 percent Alaska Native. Estimated expenditures and net economic values for all sectors were based on a literature review and available data, with the exception that original data was collected for 2005 on the sport fish sector using a random sample of licensed Alaska anglers. Methods included use of a regional input-output model maintained at the University of Alaska, and survey research and contingent valuation methods for the sport fishermen. Potential respondents included 886 resident anglers and 1,514 nonresident anglers contacted through a mail/internet approach. Additionally, 300 licensed anglers, 330 clients of Bristol Bay fishing lodges, and 46 lodge owners were contacted through a mail survey. Response rates ranged from 25.6 percent for resident anglers to 44.1 percent for nonresidents. Estimated direct expenditures/sales were \$234.4 million in 2005 for commercial fishing and processing, \$61 million for sport fishing, \$17.1 million for wildlife viewing, \$7.2 million for subsistence-related expenditures, and \$12.4 million for sport hunting. Nearly 100 percent of the private basic sector in Bristol Bay and 5,540 full-time equivalent jobs are supported by this \$324 million estimated direct economic impact associated with wild salmon ecosystem services. Direct net economic values are estimated at \$104 million to \$179 million per year, and are primarily associated with the subsistence sector.

Introduction

This paper provides estimates of the economic values associated with sustainable use of wild salmon ecosystem resources, primarily fisheries and wildlife, of the major watersheds of the Bristol Bay, Alaska region. This study reviews and summarizes existing economic research on

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the key sectors in this area and reports findings based on original survey data on expenditures, net benefits, attitudes, and motivations of the angler population.

The major components of the total value of the Bristol Bay area watersheds include subsistence use, commercial fishing, sport fishing, and the preservation values (or indirect values) held by users and the United States resident population. The overall objectives of this paper are to estimate the share of the total regional economy (expenditures, income and jobs) that is dependent on these essentially pristine wild salmon ecosystems, and to provide a preliminary but relatively comprehensive estimate of the total economic value (from a benefit-cost perspective) that could be at risk from extractive resource development in the region.

The Bristol Bay region is located in southwestern Alaska. The area is very sparsely populated and the large majority of its population is comprised of Native Alaskans. The region includes Bristol Bay Borough, the Dillingham Census Area, and a large portion of Lake and Peninsula Borough. Although median household income varies among census areas within the region, outside of the relatively small Bristol Bay Borough, income is somewhat lower than for the State of Alaska as a whole. Native Alaskans make up over two-thirds of the total population within the region as compared to approximately 16 percent for the entire state. The rivers that flow into the Bristol Bay comprise some of the last great wild salmon ecosystems in North America (fig. 1). The Kvichak River system supports the world's largest run of sockeye salmon. While these are primarily sockeye systems, all five species of Pacific salmon are abundant, and the rich salmon-based ecology also supports many other species, including Alaska brown bears and healthy populations of rainbow trout. The Naknek, Nushagak, Kvichak, Igushik, Egegik, Ugashik, and Togiak watersheds are all relatively pristine with very little roading or extractive resource development. Additionally, these watersheds include several very large and pristine lakes, including Lake Iliamna and Lake Becherof. Lake Iliamna is one of only two lakes in the world that supports a resident population of freshwater seals (the other is Lake Baikal in Russia). The existing mainstays of the economy in this region are all wilderness-compatible and sustainable in the long run: subsistence use, commercial fishing, and wilderness sport fishing. The commercial fishing is largely in the salt water outside of the rivers themselves and is closely managed for sustainability. The subsistence and sport fish sectors are relatively low impact (primarily personal use and catch and release fishing, respectively). Additionally, there are nationally important public lands

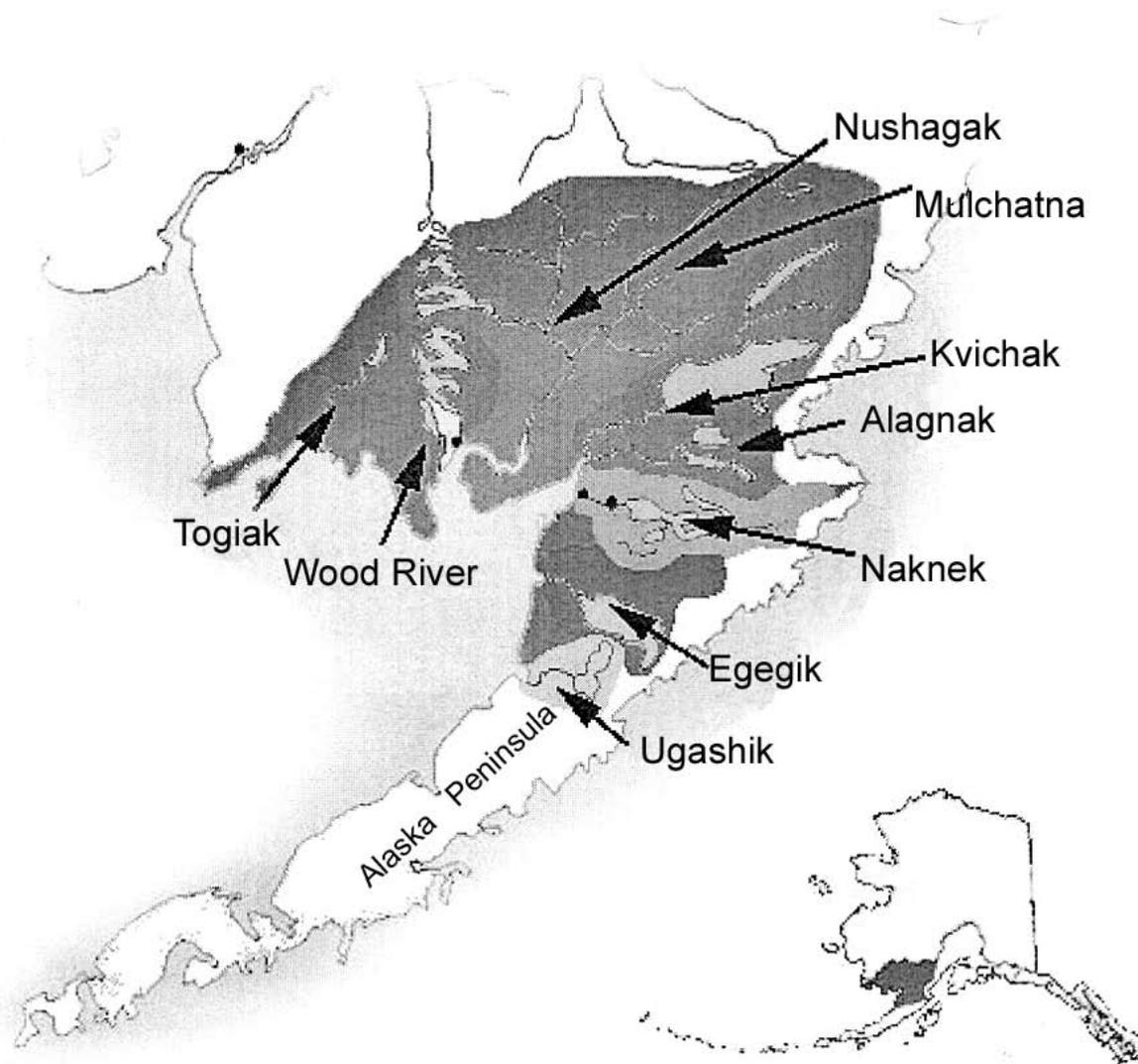


Figure 1—The Kvichak River system, in the Bristol Bay Region, supports the world's largest run of sockeye salmon.

in the headwaters, including Lake Clark National Park and Preserve, Katmai National Park and Preserve, Togiak National Wildlife Refuge, and Wood-Tikchick State Park (the largest state park in the U.S.).

There are currently proposals for major changes in these drainages that could significantly impact fisheries and related ecosystem services: a proposed major copper-gold mine in the headwaters and a proposed road connecting Bristol Bay to Cook Inlet through the heart of this region.

A complete economic analysis would be conducted in several phases. This paper focuses on: (1) an overview of values based on existing data and previous studies, (2) original data collection focused on the sport fish sector, including angler surveys, and (3) estimation of both the regional economic significance (focusing on jobs and income) of these ecosystems using an existing regional economic model, as well as total value in a social benefit-cost framework. The objective is to provide a preliminary but relatively comprehensive estimate of the range of fishery-related values that are at stake in this region. Within the larger study area (fig. 1),

the Kvichak and Nushagak drainages are currently at the most risk from proposed development. However, the entire study area could be either directly or indirectly impacted.

Methods

The National Research Council in their 2005 publication, *Valuing Ecosystem Services: Toward Better Environmental Decision Making*, provides a model for valuing ecosystem services. The conceptual framework for this paper is summarized by figure 2, which diagrams the flow of ecosystem services and associated economic values. Both passive use values (Krutilla 1967; Weisbrod 1964) and direct use values, including fishing and hunting are included in a total value framework (Hoehn and Randall 1989; Randall and Stoll 1983).

A comprehensive economic evaluation of these Bristol Bay wild salmon ecosystems needs to include two accounting frameworks: (1) regional economics or economic significance, focused on identifying cash expenditures that drive income

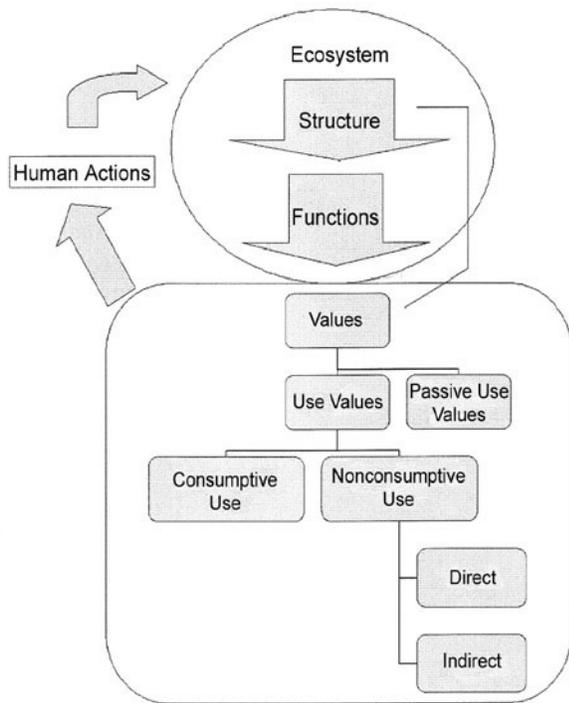


Figure 2—Flow of ecosystem services and associated economic values (adapted from NRC 2005).

and job levels in the regional economy; and (2) a net economic value framework that includes all potential costs and benefits from a broader social (usually national) perspective. The latter necessarily includes nonmarket and indirect benefits, such as the benefits anglers derive from their recreational activity, over and above their actual expenditure. Further details on methods and data collection are omitted here for the sake of brevity.

The remainder of this paper provides a brief characterization of each of the major sectors, followed by summary economic findings.

Characterization of Key Sectors

Subsistence Use

The Bristol Bay economy is a mixed cash-subsistence economy. The primary features of these socio-economic systems include use of a relatively large number of wild resources (on the order of 70 to 80 specific resources in this area), a community-wide seasonal round of activities based on the availability of wild resources, a domestic mode of production (households and close kin), frequent and large scale noncommercial distribution and exchange of wild resources, traditional systems of land use and occupancy based on customary use by kin groups and communities, and a mixed economy relying on cash and subsistence activities (Wolfe and Ellanna 1983; Wolfe and others 1984). The heart of this cash-subsistence economy is the resident population of 7,611 individuals (in the year 2000) located in 25 communities

(table 1) spread across this primarily un-roaded area (fig. 3). Archeological evidence indicates that Bristol Bay has been continuously inhabited by humans at least since the end of the last major glacial period about 10,000 years ago. Three primary indigenous cultures are represented here: Aleuts, Yupik Eskimos, and the Dena'ina Athapaskan Indians. The share of the population that is Alaska Native is relatively high at 70 percent, compared to Alaska as a whole, with 16 percent.

Wild renewable resources are important to the people of this region and many residents rely on wild fish, game, and plants for food and other products for subsistence use. Total harvest for these 25 communities is on the order of 2.4 million pounds based largely on surveys undertaken in the late 1980s and early 1990s, as summarized in the Alaska Division of Subsistence community profile data base. A new round of surveys is now underway to update these data. Estimates for the 2004 study year (Fall and others 2006) for five communities (Newhalen, Nondalton, Iliamna, Pedro Bay, and Port Alsworth) are included in the data presented in table 1. Per capita harvests average about 315 pounds. Primary resources used include salmon, other freshwater fish, caribou, and moose. Subsistence use continues to be very important for communities of this region, based on a new round of community-level subsistence harvest surveys being conducted by the Division of Subsistence (Fall and others 2006). Participation in subsistence activity, including harvesting, processing, giving and receiving is quite high. Compared to other regions of Alaska, the Bristol Bay area has some characteristic features, including the great time depth of its cultural traditions, its high reliance on fish and game, the domination of the region's market economy by the commercial salmon fishery, and the extensive land areas used by the region's population for fishing, hunting, trapping and gathering (Wright and others 1985).

The primary source of cash employment for participants in Bristol Bay's mixed cash-subsistence economy is the commercial salmon fishery. The compressed timing of this fishery's harvesting activity makes it a good fit with subsistence in the overall Bristol Bay cash-subsistence economy. Many commercial fishing permit holders and crew members, as well as some employees in the processing sector, are residents of Bristol Bay's dominantly native Alaskan villages. In 2004, there were 952 resident commercial fishing permit holders in the Bristol Bay study area, as well as 920 crew members. This is a significant share of the area's total adult population. An Alaska Department of Fish and Game (ADF&G) summary of subsistence activity in Bristol Bay (Wright and others 1985) noted that as of the mid-1980s traditional patterns of hunting, fishing, and gathering activities had for the most part been retained, along with accommodations to participate in the commercial fishery and other cash-generating activities. In the abstract to this 1985 paper, the authors characterize the commercial salmon fishery as "a preferred source of cash income because of its many similarities to traditional hunting and fishing, and because it is a short, intense venture that causes little disruption in the traditional round of seasonal activities while offering the potential for earning sufficient income for an entire year." Commercial fishing is a form of self-employment requiring many of the same skills, and allowing nearly the same freedom of choice as traditional subsistence hunting and fishing (Wright and others 1985: 89).

Table 1—Bristol Bay area communities, populations, and subsistence harvest.

Bristol Bay area community/ year of harvest data	Population (2000 census)	Per capita harvest	Total annual harvest	Native population <i>percent</i>
Aleknagik 1989	221	379	54,079	81.9
Clark's Point 1989	75	363	20,325	90.7
Dillingham 1984	2,466	242	494,486	52.6
Egegik 1984	116	384	37,450	57.8
Ekwok 1987	130	797	85,260	91.5
Igiugig 1992	53	725	33,915	71.7
Iliamna 2004	102	508	51,816	50.0
King Salmon 1983	442	220	81,261	29.0
Kokhanok 1992	174	1,013	175,639	86.8
Koliganek 1987	182	830	154,705	87.4
Levelock 1992	122	884	97,677	89.3
Manokotak 1985	399	384	118,337	94.7
Naknek 1983	678	188	72,110	45.3
New Stuyahok 1987	471	700	247,494	92.8
Newhalen 2004	160	692	110,720	85.0
Nondalton 2004	221	358	79,118	89.1
Pedro Bay 2004	50	306	15,300	40.0
Pilot Point 1987	100	384	24,783	86.0
Port Alsworth 2004	104	133	13,832	4.8
Port Heiden 1987	119	408	41,985	65.6
South Naknek 1992	137	297	39,893	83.9
Ugashik 1987	11	814	8,144	72.7
Togiak City	809	--	--	86.3
Portage Creek	36	--	--	86.1
Twin Hills	69	--	--	84.1
Total communities	7,447	--	--	--
Unincorporated areas	164	--	--	--
Total (interpolated to include unincorporated areas)	7,611	315	2,397,970	69.6

Sources: U.S. Census Bureau (2000 census statistics), Alaska Department of Fish and Game, Division of Subsistence Community Profile Data Base, and Fall and others 2006. Note: percent Native indicates those who classify themselves as Native only.

Commercial Fishing and Processing

The Bristol Bay commercial fisheries management area encompasses all coastal and inland waters east of a line from Cape Menshikof to Cape Newhenham (fig. 4). This area includes eight major river systems: Naknek, Kvichak, Egegik, Ugashik, Wood, Nushagak, Igushik and Togiak. Collectively these rivers support the largest commercial sockeye salmon fishery in the world (ADF&G 2005). This is an interesting and unique fishery, both because of its scale and significance to the local economy, but also because it is one of the very few major commercial fisheries in the world that has been managed on a sustainable basis.

The five species of pacific salmon found in Bristol Bay are the focus of the major commercial fisheries. Sockeye salmon are the primary species harvested both in terms of pounds of fish and value. Annual commercial catches between 1984 and 2003 averaged nearly 24 million sockeye salmon, 69,000 Chinook, 971,000 chum, 133,000 coho, and 593,000 (even year only) pink salmon (ADF&G 2005). Prices for sockeye salmon are typically higher than for other salmon species, making the Bristol Bay fishery the most valuable of Alaska's salmon fisheries (see Commercial Fish Entry Commission at www.cfec.state.ak.us). Nearly one-third of all earnings from

Alaska salmon fishing come from the Bristol Bay fishery (table 2). This is also the largest Alaska fishery in terms of the number of permit holders. In 2004, there were 1,857 potentially active entry permits in the drift gillnet fishery and 992 in the set gillnet fishery (CFEC 2004).

The fishery is organized into five major districts (fig. 4) including Togiak, Nushagak, Naknek-Kvichak, Egegik, and Ugashik. Management is focused on discrete stocks with harvests directed at terminal areas at the mouths of the major river systems (ADF&G 2005). The stocks are managed to achieve an escapement goal based on maximum sustained yield. The returning salmon are closely monitored and counted and the openings are adjusted on a daily basis to achieve desired escapement. Having the fisheries near the mouths of the rivers controls the harvest on each stock, which is a good strategy for protection of the discrete stocks and their genetic resources. The trade-off is that the fishery is more congested and less orderly, and the harvest is necessarily more of a short pulse fishery, with most activity in June and early July. This has implications for the economic value of the fish harvested, both through effects on the timing of supply, but also on the quality of the fish. Most fish are canned or frozen, rather than sold fresh.

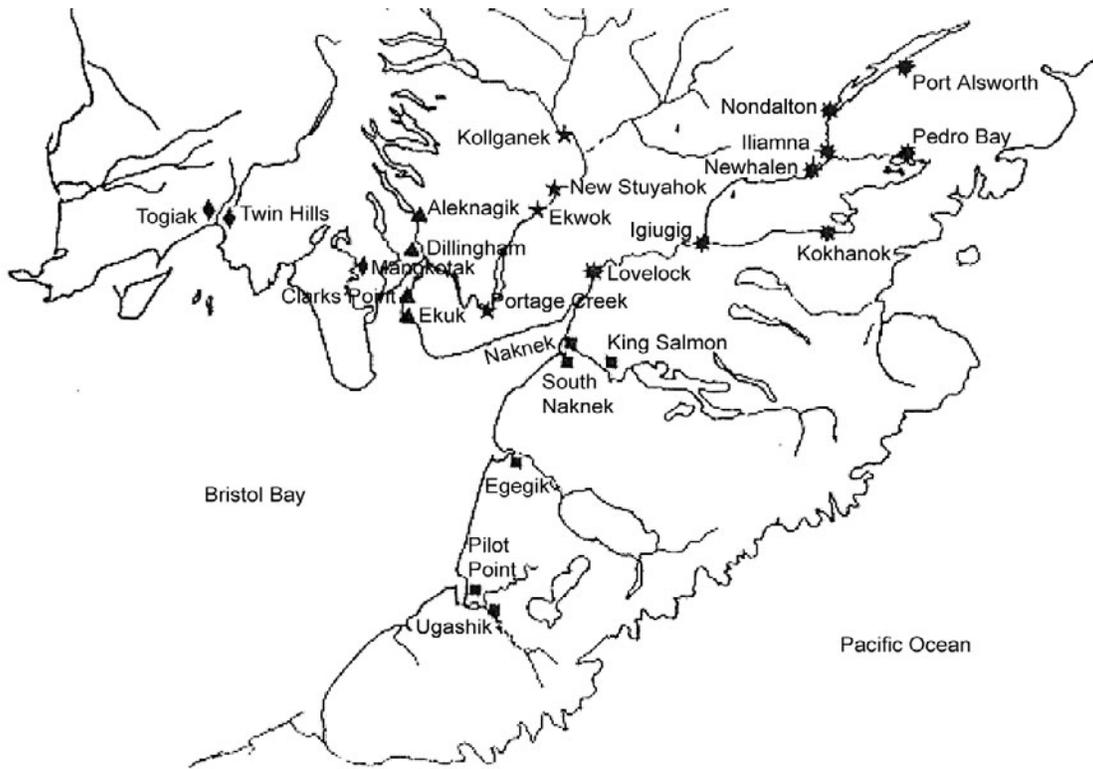


Figure 3—Nearly 8,000 residents are distributed across 25 communities in the primarily un-roaded Bristol Bay Region.

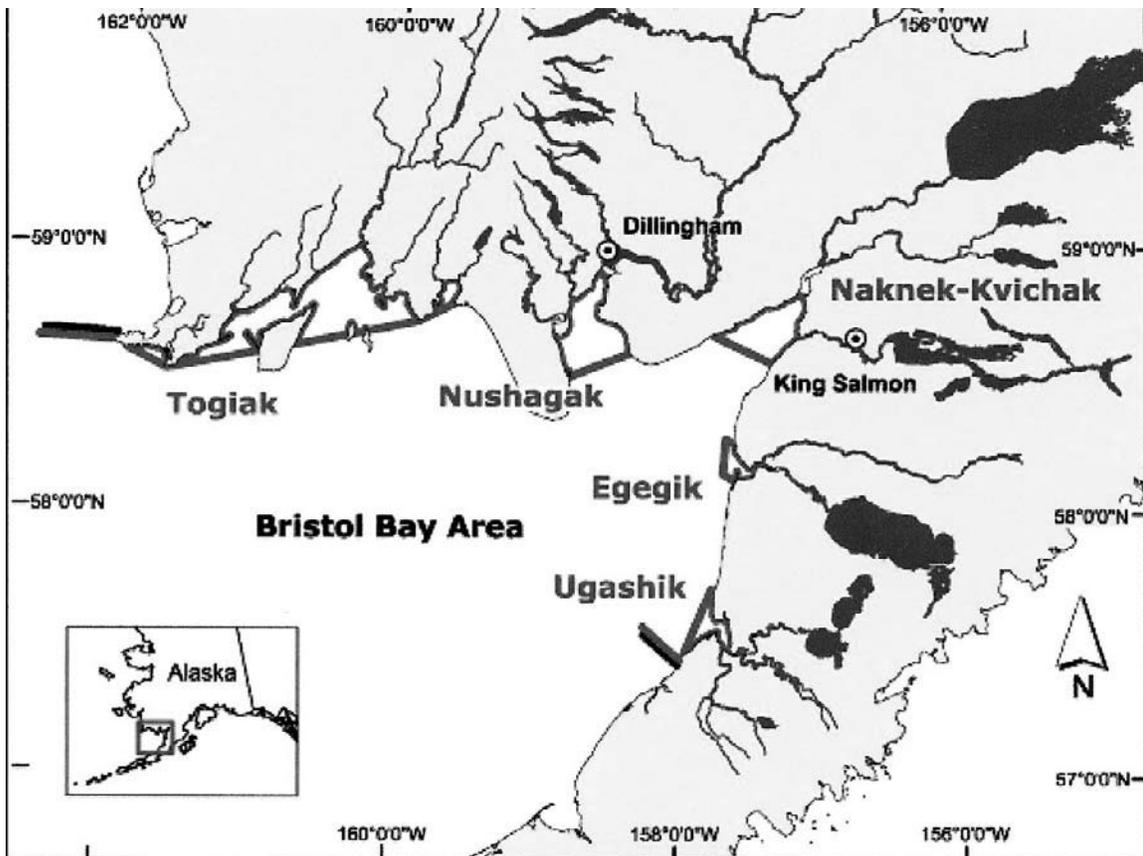


Figure 4—Bristol Bay area commercial salmon fishery management districts.

Table 2—Bristol Bay and Alaska commercial fishery permits, harvest, and gross earnings (2002).

Sector	# Permit holders	# Permits	Pounds	Gross earnings
Bristol Bay salmon				
Drift gillnet	1,862	1,447	135,549,944	77,243,936
Set gillnet	988	829	30,032,259	17,327,819
All Bristol salmon	2,850	2,276	165,582,203	94,571,755
All Alaska salmon	10,594	7,508	872,577,336	293,147,368
All Alaska fisheries	14,318	13,463	3,842,853,863	990,099,365

Source: Derived from ADF&G 2005.

The fishery is quite cyclical in terms of run size and potential harvest. For example, harvests were as low as only several million fish in the early 1970s, but exceeded 45 million fish in the early 1990s. Prices have also varied quite dramatically historically. In real terms (constant 2005 dollars) prices peaked at \$3.15 per pound in 1989 and reached a recent historical low of about \$0.40 a pound in 2002. Prices are currently low because of competition with farmed salmon and other factors. For the period 1985 to 2005, total production value for processors averaged about \$288 million, with a low of \$95 million in 2002. Total production value in 2005 was \$225 million. According to the Commercial Fish Entry Commission (2004) the total salmon return to Bristol Bay is strongly influenced by sockeye returns to the Kvichak River, which is historically the largest salmon resource in the region, and perhaps the largest in the world. The sockeye return to the Kvichak is highly variable, and exhibits a pattern of oscillating cycles. In recent years the Kvichak sockeye return has been weaker, and the river has been classified as a “stock of management concern” by the Alaska Department of Fish and Game and the Alaska Board of Fisheries.

Sport Fishing

Next to commercial fishing and processing, recreational angling is the most important economic sector in the Bristol Bay region. The 2005 Bristol Bay Angler Survey, which was undertaken for purposes of this report, confirmed that the freshwater rivers, streams, and lakes of the region are a recreational resource equal or superior in quality to other world-renowned fisheries.

In their survey responses, Bristol Bay anglers consistently emphasized the importance of Bristol Bay’s uncrowded, remote, wild setting in their decisions to fish the area. Additionally, a significant proportion of respondents to the survey specifically traveled to the region to fish the world-class rainbow fisheries. These findings indicate that Bristol Bay sport fishing is a relatively unique market segment, paralleling the findings of Romberg (1999) that angler motivation and characteristics vary significantly across Alaska sport fisheries.

Recreational fishing use of the Bristol Bay region is roughly divided between 65 percent trips to the area by Alaska residents and 35 percent trips by nonresidents. These nonresidents (approximately 13,000 trips in 2005 (personal communication, ADF&G, 2006)) account for the large majority of total recreational fishing spending in the region. It is estimated that in 2005 approximately \$48

million was spent in Alaska by nonresidents specifically for the purpose of fishing in the Bristol Bay region. In total, it is estimated that \$61 million was spent in Alaska in 2005 on Bristol Bay fishing trips.

Sport Hunting and Nonconsumptive Wildlife Viewing

While sport fishing within the Bristol Bay region comprises the largest share of recreational use and associated visitor expenditures, several thousand trips to the region each year are also made for the primary purpose of sport hunting and wildlife viewing.

Regional Economic Analysis

Table 3 through table 8 detail the summary results of this preliminary analysis. Table 3 shows estimated direct expenditures related to harvest or use of Bristol Bay area renewable resources. Total estimated direct expenditures (that drive the basic sector of the economy) were estimated to be \$324 million in 2005. The largest component is the commercial fishing harvesting and processing sectors. These estimates were obtained from the Alaska Department of Revenue and the Commercial Fishing Entry Commission. The range shown of low and high estimates reflects the cyclical nature of this sector, and is based on a 95 percent confidence interval for total earnings in this sector 1985-2005. The next most significant component is sport fishing at \$61 million in 2005. This estimate is derived from original survey data. A 95 percent confidence interval for this 2005 estimate is relatively imprecisely estimated at zero to \$123.2 million (this includes the statistical uncertainty in Alaska Fish and Game total angler trips estimates). Sport hunting and non-consumptive wildlife viewing are less important economically. The wildlife viewing and tourism estimates are approximate, and reflect a small share of the visitation at Katmai National Park. Most of the visitation at Katmai is expected to be picked up in the sport fishing use estimates and is excluded here to avoid double-counting.

Table 4 provides additional detail on the recreation expenditure estimates, including number of trips and spending by residence of the participants. A large share of sport fish expenditures, and hence of total recreation expenditures, is by nonresident anglers (at \$48 million of \$61 million sport fish expenditures). This reflects the high quality of this fishery, in that it is able to attract participants from a considerable distance in the Lower 48 States as well as

Table 3—Summary of regional economic expenditures based on wild salmon ecosystem services (million 2005 dollars).

Ecosystem service	Estimated direct expenditures	Low estimate	High estimate
	<i>sales per year</i>		
Commercial fish wholesale value	226.0	226.0	346.0
Subsistence harvest expenditures	7.2	7.2	7.2
Sport fisheries	61.2	0	123.2
Sport hunting	12.4	12.4	12.4
Wildlife viewing / tourism	17.1	17.1	17.1
Total estimated direct annual economic impact	323.9	262.7	505.9

Table 4—Total estimated recreational direct spending due to Bristol Bay wild salmon ecosystems, 2005.

Sector	Local residents	Nonlocal residents	Nonresidents	Total
(A) Trips				
Sport fishing	19,488	4,450	12,966	36,904
Sport hunting	—	1,538	2,310	3,848
Nonconsumptive recreation	—	1,000	9,000	10,000
Total trips	19,488	6,988	24,276	50,752
(B) Spending				
Sport fishing	\$6,606,432	\$6,397,747	\$48,207,588	\$61,211,767
Sport hunting	—	\$2,214,720	\$10,870,860	\$13,085,580
Nonconsumptive recreation	—	\$970,010	\$16,168,280	\$17,138,290
Total direct spending	\$6,606,432	\$9,582,477	\$75,246,728	\$91,435,637

foreign countries. From a regional economic perspective this is a positive feature in that nonresidents are bringing new cash into the region and Alaska from the outside.

Table 5 summarizes the full time equivalent employment associated with the sectors of the Bristol Bay economy that are dependent on wild salmon ecosystems. A total of 5,540 full-time equivalent jobs are supported, with 1,598 of these held by local residents of Bristol Bay, 1,829 by non-local Alaskans (for a total of 3,430 Alaska jobs) and 2,110 by nonresidents. Three-fourths of these jobs are in the commercial fish sector and about one-fourth in recreation. A small number of jobs (49) are also shown for subsistence, based on expenditures made by subsistence participants for supplies and equipment to support subsistence activity. However,

this perspective on subsistence is somewhat misleading, as it is only from the cash side of the mixed cash-subsistence economy. The level of full-time equivalent subsistence jobs was estimated for a similar sized population of Bristol Bay residents by Goldsmith and others (1998) at 762 jobs. This is based on the approximation that the average Alaska Native (3,048 in Goldsmith's population) participates in subsistence activities a total of three months a year, and that non-natives participate not at all. Unfortunately, there is not much evidence to support or refute this estimate, but it does indicate the possible significance of subsistence employment from a broader perspective than that of just the cash economy.

The overall structure of the Bristol Bay economy is shown in table 6. This estimate was derived by starting from the

Table 5—Total 2005 estimated full time equivalent (FTE) employment dependent on Bristol Bay wild salmon ecosystems.

Sector	Local Bristol Bay	Nonlocal Alaskan	Total Alaska	Nonresident	Total FTE jobs
Salmon commercial fishing	689	667	1,357	1,172	2,529
Commercial processing	465	449	914	796	1,710
Commercial fish total	1,155	1,116	2,271	1,968	4,238
Sport fishing	288	435	723	123	846
Sport hunting	60	105	165	2	167
Nonconsumptive wildlife & tourism	82	139	222	17	239
Recreation total	430	679	1,110	142	1,552
Subsistence	14	34	49	0	49
Total FTE jobs	1,598	1,829	3,430	2,110	5,540

obviously incomplete official employment data reported by the U.S. Bureau of Economic Analysis and the Alaska Department of Labor, which primarily focus on wage and salary employees and only resident local proprietors. This revised data developed for purposes of this study shows that the annual average employment in the Bristol Bay economy is 7,691 jobs. It is apparent that the private sector basic employment in this economy is almost entirely dependent on Bristol Bay's wild salmon ecosystems. The only other major basic driver is government employment (here including hospitals, which are publicly funded). There are also some private sector jobs in mineral exploration, which are not readily identifiable in existing data. As a share of all basic employment, the salmon ecosystem-dependent sectors account for 64 percent of all the basic employment that essentially drives this cash economy. A good share of the non-basic employment is also derived through induced and indirect effects (multiplier effect) from the ecosystem sectors as well. Furthermore, although government is here considered a BASIC sector activity because it brings money into the local economy, in the absence of the salmon ecosystem, regional population would surely be smaller and the government presence would also shrink.

It is very interesting to note the extreme seasonal nature of this economy. Summer employment climbs by almost 13,000 jobs to a total of 16,631 jobs, and declines in winter to 3,640 jobs. It is useful to recall that the entire resident population (including children and the elderly) is only about 7,600. Subsistence users are not the only hunter-gatherers in this economy. Essentially the entire private economy is "following the game" (or, in this case, the fish), with many commercial fishers, processors, sport anglers, sport hunters and wildlife viewers coming from elsewhere in Alaska or the Lower 48 to be part of this unique economy at the time that fish and game are available. The most stable component of the economy is government, which actually declines by about 300 jobs in summer, probably reflecting the academic year schedules of teachers. The winter employment pattern reveals the bare bones of the local cash economy, absent almost all of the cash employment jobs associated with fishing

and recreation, except for about 200 jobs in commercial fish processing.

The estimated payroll associated with the salmon ecosystem-dependent jobs is shown in table 7. The total is \$161 million in 2005, including \$46.8 million to Bristol Bay residents and a total of \$103.4 million to all Alaska residents.

Net Economic Values

Net economic values associated with the wild salmon ecosystem services are summarized in table 8. The preceding discussion has focused on a regional economic accounting framework. Table 8 introduces the value measures relevant for a social benefit-cost evaluation of the renewable Bristol Bay resources. Commercial salmon fishery net economic values are derived by annualizing permit values, which are exchanged in an open market and reported by the Commercial Fish Entry Commission. These are on the order of \$51,200 for a drift gillnet permit in 2005 in total, but have been as high as \$200,000 as recently as 1993. Subsistence harvests are valued based on the willingness-to-pay revealed through tradeoffs of income and harvest in choice of residence location (Duffield 1997).

Sport fisheries net economic values are based on original data collected for purposes of this study. Estimated willingness to pay per trip, using contingent valuation (payment card question format), range from \$455 for nonresident anglers to \$350 for resident anglers. These estimates are consistent with values from the extensive economic literature on the value of sport fishing trips (for example, see Duffield and others 2002). Sport hunting and wildlife viewing values are based on studies conducted about 15 years ago in Alaska, and which need to be updated (McCollum and Miller 1994). Direct use values total from \$104 million to \$179 million.

A major unknown is the total value for existence and bequest (also called passive use values). Goldsmith and others (1998) estimated the existence and bequest value for the Federal wildlife refuges in Bristol Bay at \$2.3 billion to \$4.6 billion per year (1997 dollars). There is considerable uncertainty in these estimates, as indicated by the large range of values.

Table 6—Structure of the Bristol Bay economy.

	Annual average	Summer	Winter	Swing
Total jobs by place of work	7,691	16,631	3,640	12,991
Basic	6,251	15,028	2,304	12,724
Harvesting	2,552	7,657	0	7,657
Processing	1,150	4,193	200	3,993
Recreation	311	933	0	933
Govt. + health	2,098	1,795	2,104	-309
Non-basic	1,440	1,603	1,336	267
Construction	64	80	56	24
Trade/transport/leisure	642	765	580	185
Finance	127	118	116	2
Other WS	180	213	157	56
Non fish proprietors	427	427	427	0
Resident jobs		5,741	3,640	2,101

Table 7—Total estimated payroll associated with use of Bristol Bay wild salmon ecosystems, 2005 (millions of 2005 dollars).

Population payroll paid to	Commercial fishing	Sport fishing	Hunting	Other recreation	Subsistence	Total
Local Bristol Bay residents	34.554	8.180	1.536	2.015	0.525	46.810
Nonlocal residents	33.242	14.491	3.392	4.235	1.183	56.543
All Alaska residents	67.796	22.671	4.929	6.250	1.707	103.353
All payroll (residents + nonresidents)	120.490	26.974	5.016	6.847	1.707	161.034

Table 8—Summary of Bristol Bay wild salmon ecosystem services, net economic value per year (million 2005 dollars).

Ecosystem service	Low estimate	High estimate
	<i>Net economic value per year</i>	
Commercial salmon fishery	9.4	18.8
Subsistence harvest	77.8	143.1
Sport fisheries	13.5	13.5
Sport hunting	1.8	1.8
Wildlife viewing / tourism	1.8	1.8
Total direct use value	\$104.3	\$179.0
Existence and bequest value	Not estimated	Not estimated

Goldsmith's estimates for the Federal wildlife refuges are based on the economics literature concerning what resident household populations in various areas (Alberta, Colorado) (Adamowicz and others 1991; Walsh and others 1984, 1985) are willing to pay to protect substantial tracts of wilderness. Similar literature related to rare and endangered fisheries, including salmon, could also be appealed to here. It is possible that from a national perspective the Bristol Bay wild salmon ecosystems and the associated economic and cultural uses are sufficiently unique and important to be valued as highly as wilderness in other regions of the U.S. Goldsmith and others (1998) estimates assume that a significant share of U.S. households (91 million such households) would be willing to pay on the order of \$25 to \$50 per year to protect the natural environment of the Bristol Bay Federal wildlife refuges. The number of households is based on a willingness to pay study (the specific methodology used was contingent valuation) conducted by the State of Alaska Trustees in the Exxon Valdez oil spill case (Carson and others 1992). The findings of this study were the basis for the \$1 billion settlement between the State and Exxon in this case. These methods are somewhat controversial among economists, but when certain guidelines are followed, such studies are recommended for use in natural resource damage regulations (for example, see Ward and Duffield 1992). They have also been upheld in court (Ohio v. United States Department of Interior, 880 F.2d 432-474 (D.C. Cir.1989)) and specifically endorsed by a NOAA-appointed blue ribbon panel (led by several Nobel laureates in economics) (Arrow and others 1993).

Goldsmith's estimates for just the federal refuges may be indicative of the range of passive use values for the unprotected portions of the study area. However, there are several caveats to this interpretation. First, Goldsmith and others estimates

are not based on any actual surveys to calculate the contingent value specific to the resource at issue in Bristol Bay. Rather, they are based on inferences from other studies (benefits transfer method). Second, these other studies date from the 1980s and early 1990s and the implications of new literature and methods have not been examined. Additionally, the assumptions used to make the benefits transfer for the wildlife refuges may not be appropriate for the Bristol Bay study area. This is an area for future research.

The estimates in table 8 are for annual net economic values. Since these are values for renewable resource services that in principle should be available in perpetuity, it is of interest to also consider their present value (for example, total discounted value of their use into the foreseeable future). Recent literature (EPA 2000; Weitzman 2001) provides some guidance on the use of social discount rates for long-term (intergenerational) economic comparisons. Rates as low as 0.5 percent have been recommended by the EPA (2000). Weitzman, based on an extensive survey of members of the American Economic Association, suggests a declining rate schedule, which may be on the order of 4 percent (real) in the near term and declining to near zero in the long term. He suggests a constant rate of 1.75 percent as an equivalent to his rate schedule. Applying this parameter to the net economic values shown in table 8 implies a net present value of \$6.0 billion to \$10.2 billion for just the direct uses.

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References

- Adamowicz, W.; Asapu-Adjaye, J.; Boxall, P.; Phillips, W. 1991. Components of the economic value of wildlife: an Alberta case study. *The Canadian Field Naturalist*. 105(3): 423–429.
- Alaska Department of Fish and Game. 2005. Annual Management Report 2004 Bristol Bay Area. Report by the Divisions of Sport Fisheries and Commercial Fisheries. [Online]. 142 p. Available : <http://www.sf.adfg.state.ak.us/FedAidPDFs/Fmr05-41.pdf>. [August 15, 2006].
- Arrow, K.; Solow, R.; Portney, P.; Leamer, E.; Radner, R.; Schuman, H. 1993. Report of the NOAA Panel on Contingent Valuation. [Online]. 67 p. Available: <http://www.darrp.noaa.gov/library/pdf/cvblue.pdf>. [August 15, 2006].
- Carson, R.; Mitchell, R.; Hannemann, W.; Presser, S.; Ruud, P. 1992. A contingent valuation study of lost passive use values resulting from the Exxon Valdez oil spill. Report to the Attorney General of the State of Alaska. [Online]. Available: http://www.evostc.state.ak.us/Publications/Downloadables/Econ_Passive.pdf. [August 15, 2006].
- Duffield, J. 1997. Nonmarket valuation and the courts: the case of the Exxon Valdez. *Contemporary Economic Policy*. V. XV: 98–109.
- Duffield, J.; Merritt, P.; Neher, C. 2002. Valuation and policy in Alaskan sport fisheries. In: Pitcher, T.; Hollingworth, C., eds. *Recreational fisheries: ecological, economic and social evaluation*. Bangor, Wales, UK: Blackwell Science: 156–185.
- Environmental Protection Agency (EPA). 2000. Guidelines for preparing economic analyses. EPA 240-R-00-003. [Online]. Washington, DC: U.S. Environmental Protection Agency. 206 p. Available: <http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/Guidelines.html>. [August 15, 2006].
- Fall, J.; Holen, D.; Davis, B.; Krieg, T.; Koster, D. 2006. Subsistence harvests and uses of wild resources in Iliamna, Newhalen, Nondalton, Pedro Bay, and Pork Alsworth, Alaska. Technical Paper 302. Division of Subsistence, Alaska Department of Fish and Game. Juneau, Alaska. 351 p.
- Goldsmith, O.; Hill, A.; Hull, T.; Markowski, M.; Unsworth, R. 1998. Economic assessment of Bristol Bay area national wildlife refuges: Alaska Peninsula/Becherof, Izembek, Togiak. Report of the U.S. Department of Interior, Fish and Wildlife Service. [Online]. 8 p. Available: <http://www.iser.uaa.alaska.edu/publications/repsum/bbrefuges.pdf>. [August 15, 2006].
- Hoehn, J.; Randall, A. 1989. Too many proposals pass the benefit cost test. *American Economic Review*. 79: 544–551.
- Knapp, G. 2004. Projections of future Bristol Bay salmon prices. [Online]. Report prepared for the Commercial Fisheries Entry Commission. 171 p. Available: http://www.iser.uaa.alaska.edu/iser/people/knapp/Knapp_BB_Price_Projections_October_2004.pdf. [August 15, 2006].
- Krutilla, J. 1967. Conservation reconsidered. *American Economic Review*. 57(4): 777–786.
- McCollum, D.; Miller, S. 1994. Alaska hunters: their hunting trip characteristics and economics. On file with the Alaska Department of Fish and Game, Division of Wildlife Conservation, Information Management Program, Anchorage, AK. 476 p.
- National Research Council. 2005. Valuing ecosystem services: toward better environmental decision making. Washington, DC: National Academy Press. 278 p.
- Randall, A.; Stoll, J. 1983. Existence value in a total valuation framework. In: Rowe, R.; Chestnut, L., eds. *Managing air quality and scenic resources at national parks and wilderness areas*. Boulder, CO: Westview Press: 265–274.
- Romberg, W. 1999. Market segmentation, preferences and management attitudes of Alaska nonresident anglers. Blacksburg, VA: Virginia Polytechnic Institute and State University. 226 p. Thesis. [Online]. Available: http://scholar.lib.vt.edu/theses/available/etd-121799-032703/unrestricted/Romberg_ETD.PDF. [August 9, 2006].
- U.S. Bureau of the Census. 2006. [Online]. Available: <http://quickfacts.census.gov/> [August 9, 2006].
- Walsh, R.; Loomis, J.; Gillman, R. 1984. Valuing option, existence, and bequest demands for wilderness. *Land Economics*. 60(1): 14–29.
- Walsh, R.; Bjonback, R.; Rosenthal, D.; Aiken, R. 1985. Public benefits of programs to protect endangered wildlife in Colorado. In: *Proceedings, symposium on issues and technology in the management of impacted western wildlife; 1985 February 4–5; Glenwood Springs, CO*. Boulder, CO: Thorne Ecological Institute: 65–71.
- Ward, K.; Duffield, J. 1992. *Natural resource damages: law and economics*. New York: John Wiley and Sons, Inc. 694 p.
- Weisbrod, B. 1964. Collective consumption services of individual consumption goods. *Quarterly Journal of Economics*. 78(3): 471–477.
- Weitzman, M. L. 2001. Gamma discounting. *American Economic Review*. 91(1): 260–271.
- Wolfe, R.; Ellanna, L., comps. 1983. Resource use and socioeconomic systems: case studies of fishing and hunting in Alaskan communities. Technical Paper 61. Juneau: Alaska Department of Fish and Game, Division of Subsistence. 316 p. [Online]. Available: <http://www.subsistence.adfg.state.ak.us/TechPap/tp061.pdf>. [August 15, 2006].
- Wolfe, Robert J.; Gross, Joseph J.; Langdon, Steven J.; Wright, John M.; Sherron, George K.; Ellanna, Linda J. 1984. Subsistence-based economies in coastal communities of southwest Alaska. Technical Paper 89. Juneau: Alaska Department of Fish and Game, Division of Subsistence. 643 p. [Online]. Available: <http://www.subsistence.adfg.state.ak.us/TechPap/tp089.pdf>. [August 15, 2006].
- Wright, J.; Morris, J.; Schroeder, R. 1985. Bristol Bay regional subsistence profile. Technical Paper 114. Juneau: Alaska Department of Fish and Game, Division of Subsistence. 116 p. [Online]. Available: <http://www.subsistence.adfg.state.ak.us/TechPap/tp114.pdf>. [August 15, 2006].