*Exxon Valdez* Oil Spill
Restoration Project Annual Report

# Kenai River Sockeye Salmon Restoration

Restoration Project 95255
Annual Report

This annual report has been prepared for peer review as part of the *Exxon Valdez* Oil Spill Trustee Council restoration program for the purpose of assessing project progress. Peer review comments have not been addressed in this annual report.

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**Study History:** This study was initiated as Restoration Project Number 59 "Assessment of Genetic Stock Structure of Salmonids." The project effort continued under Restoration Project Number 93012 "Genetic Stock Identification of Kenai River Sockeye Salmon." In FY94 the project was combined with Restoration Project Number 93015 into the genetics portion (95255-2) of Restoration Project Number 94255 "Kenai River Sockeye Salmon Restoration." In FY95 and FY96 the project continued under the same title as Restoration Projects Number 95255 and 96255, respectively. Final reports were submitted under the title Assessment of Genetic Stock Structure of Salmonids for Restoration Project Number 59 and under the title Genetic Diversity of Sockeye Salmon (*Oncorhynchus nerka*) of Cook Inlet, Alaska and its Application to Restoration of Injured Populations of the Kenai River for Restoration Projects Number 93012 and 94255.

**Abstract:** Genetic data from sockeye salmon (*Oncorhynchus nerka*) were collected from the Kenai River, a major salmon-producing system impacted by the *Exxon Valdez* Oil Spill, as well as all other significant spawning populations contributing to mixed-stock harvests in Cook Inlet, Alaska. A total of 68 allozyme loci were resolved from 37 populations. Allozyme data reveal a substantial amount of genetic diversity among populations. Mixed-stock analyses using maximum likelihood methods with 27 loci were evaluated to estimate the proportion of Kenai River populations in Cook Inlet driftnet fisheries. Simulations indicate that Kenai River populations can be identified in mixtures at a level of precision and accuracy useful for restoration and fishery management. Fishery samples were analyzed both inseason (within 48 h) and postseason. The contribution of Kenai River populations to the Cook Inlet fisheries varied from 16.3% to 90.9%. Samples from fish wheels from the Kenai, Kasilof, Yentna, and Susitna River systems were also analyzed. Microsatellite DNA data were also collected from four populations to assess the utility this technique to discriminate among populations. Results from this study are currently being used in the management and restoration of Kenai River sockeye salmon injured in the 1989 *Exxon Valdez* oil spill.

**Key Words:** Alaska, allozymes, *Exxon Valdez* oil spill, Cook Inlet, genetic diversity, *Oncorhynchus nerka*, sockeye salmon.

**Project Data:** *Description of Data* - The data collected during the course of this project were the relative frequencies of variation within three classes of genetic markers: 1) Allozyme - variant proteins formed by allelic forms of the same locus, 2) Mitochondrial DNA - genetic material found within the mitochondria with strict maternal inheritance and haploid nature, 3) Microsatellites - highly polymorphic variable number of tandem repeat nuclear DNA sequences that are distributed throughout the genome at intervals of approximately 10 kilobase pairs. *Format* - These data are stored in ASCII text format. *Custodian* - Contact Lisa W. Seeb at the Alaska Department of Fish and Game, Division of Commercial Fisheries

Management and Development, Genetics Laboratory, 333 Raspberry Rd., Anchorage, Alaska 99518. *Availability* - A complete set of the data are reported either in this report (allozyme and microsatellite) or in the final report for restoration projects 93012 and 94255 (mitochondrial DNA). Electronic copies of these data are available upon request.

**Citation:**

Seeb, L.W., C. Habicht, W.D. Templin, K.E. Tarbox, R.Z. Davis, L.K. Brannian, and J.E. Seeb. 1996. Kenai river sockeye salmon restoration, Restoration Project Annual Report (Restoration Project 95255), Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Anchorage, Alaska.

**LIST OF APPENDICES**

**Appendix I.**

Seeb, L. W., Habicht C., Templin, W. D., Tarbox, K. E., Davis, R. Z., Brannian, L. K., and Seeb, J. E.. 199x. Genetic diversity of sockeye salmon (*Oncorhynchus nerka)* of Cook Inlet, Alaska, and its application to restoration of populations affected by the *Exxon Valdez* Oil Spill. Can. J. Fish. Aquat. Sci. xx:xxx-xxx.

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To be submitted to Canadian Journal of Fisheries and Aquatic Sciences.

June 14, 1996
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# Genetic Diversity of Sockeye Salmon (*Oncorhynchus nerka*) of Cook Inlet, Alaska, and its Application to Restoration of Populations Affected by the *Exxon Valdez* Oil Spill

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**Abstract**

Genetic data from sockeye salmon (*Oncorhynchus nerka*) were collected from the Kenai River, a major salmon-producing system impacted by the *Exxon Valdez* Oil Spill, as well as all other significant spawning populations contributing to mixed-stock harvests in Cook Inlet, Alaska. A total of 68 allozyme loci were resolved from 47 putative populations. Allozyme data revealed a substantial amount of genetic diversity among populations. Mixed-stock analyses using maximum likelihood methods with 27 loci were evaluated to estimate the proportion of Kenai River populations in Cook Inlet fisheries. Simulations indicate that Kenai River populations can be identified in mixtures at a level of precision and accuracy useful for restoration and fishery management. Fishery samples were analyzed both inseason (within 48 h) and postseason. The contribution of Kenai River populations to the Cook Inlet fisheries varied from 16.3% to 90.9%. Samples from fish wheels from the Kenai, Kasilof, Yentna, and Susitna River systems were also analyzed. Results from this study are currently being used in the management and restoration of Kenai River sockeye salmon injured in the 1989 *Exxon Valdez* oil spill.

Key Words: *Oncorhynchus nerka*, sockeye salmon, Cook Inlet, Alaska, genetic diversity, allozymes, *Exxon Valdez* Oil Spill

The *T/V Exxon Valdez* hit Bligh Reef in Prince William Sound on March 24, 1989 spilling 11.2 million gallons of oil. In the ensuing days oil spread in a southwesterly direction through the Gulf of Alaska. Oil reached the Cook Inlet region, an area that supports large populations of Pacific salmon and extensive commercial fisheries. Fisheries on sockeye salmon *(Oncorhynchus nerka)* in Cook Inlet have been prosecuted since the late 1800's, and harvest levels have ranged from 95,000 to 9.5 million (Rigby et al. 1991; Ruesch and Fox 1994). Over the last 10 years the total value of the fishery has ranged from 12.3 to 111.1 million dollars, and sockeye salmon represented 80.4 to 96.0% of the total of all salmon species harvested (Ruesch and Fox 1994). However, in July of 1989, fishing time in the Cook Inlet area was greatly reduced due to the presence of oil from the *Exxon Valdez* spill.

As a direct result of the reduced exploitation, sockeye salmon spawning in the Kenai River system exceeded optimal escapement goals by three times. Extremely high escapements can produce enough fry to deplete invertebrate prey populations, causing high fry mortality, and can alter the species composition and productivity of prey populations for several years (Schmidt et al. 1995).

In anticipation of a potential decline in the fishery, efforts began in 1992 to refine stock identification and management techniques and to increase knowledge of the diversity and abundance of sockeye salmon in Cook Inlet. This information is essential to maintain the productivity of mixtures of stocks in mixed-stock harvests (Walters 1975; Kope 1992), while assisting managers to meet seasonal goals for individual stocks or stock-groups (Fried 1996) and to allow managers to assess the impacts of harvest regulations during the season (Mundy

1985; Mundy et al. 1993). By directing the commercial harvest managers could closely regulate the number of spawning adults in the Kenai River, one of the few ways to manage sockeye salmon fry production and restore the productivity of injured rearing areas.

Most of the sockeye salmon production in Upper Cook Inlet (UCI) comes from four major river systems. The largest sockeye salmon producer (2.8 million fish annually) is the Kenai River which drains 5,200 $km^2$ of the Kenai Peninsula on the east side of UCI (Fig. 1). Next are the Kasilof (1700 $km^2$) and Susitna River (49,000 $km^2$) systems which each produce approximately 700,000 sockeye salmon annually. The Kasilof River is on the Kenai Peninsula south of the Kenai River and the Susitna River empties into the north end of the Inlet. The fourth largest producer is the Crescent River drainage (200,000 fish) which covers 300 $km^2$ on the western side of the Inlet. The Kenai, Kasilof and Crescent River systems are characterized by large, central glacial lakes fed by numerous smaller tributaries. The Susitna River system has many smaller lakes each of which empties into the mainstem through smaller, separate streams. The Susitna River is also the only system in Cook Inlet where slough-spawning populations have been observed that have no obvious access to a nursery lake for early-life rearing. The remainder of the sockeye salmon production in UCI is composed of many minor stocks which contribute between 6% and 31% (15% on average) of the total inlet-wide escapement (Ruesch and Fox 1994).

Cook Inlet sockeye salmon have been the focus of a number of stock identification studies. Extensive efforts were made to delineate populations through scale pattern analyses (Marshall et al. 1987) and parasites (Waltemeyer et al. 1993). Neither technique proved adequate. Significant temporal and sexual variability within populations exists with scale pattern analyses (Waltemeyer et al. In press), and it is difficult to obtain stock-specific scales on an inseason basis. Additional stock identification techniques are warranted.

Genetic data have proven extremely effective for stock management in recent years (e. g. Seeb et al. 1986, 1990, chum salmon (*O. keta*); Shaklee and Phelps 1990, chum salmon; White and Shaklee 1991, pink salmon (*O. gorbuscha*) White 1996, pink salmon; Wood et al. 1989, 1994, sockeye salmon; Beacham et al. in press, sockeye salmon), and many genetic markers have been found which delineate groups of populations. These markers can also be used to discriminate populations in mixed-stock aggregations, and a considerable statistical framework (Mixed-Stock Analysis, MSA) based on maximum likelihood estimates (MLE) has been developed to identify individual stocks within mixtures (Fournier et al. 1984; Millar 1987, 1990; Pella and Milner 1987; Wood et al. 1987; Pella et al. 1996).

One of the earliest genetic studies of sockeye salmon focused on Cook Inlet, where Grant et al. (1980) found considerable heterogeneity among populations inhabiting the region. In evaluations of their resulting mixed-stock model, Grant et al. (1980) demonstrated a high degree of success using three allozyme loci to classify populations from the Kasilof River and Susitna River drainages, but incomplete baseline data was thought to confound the Kenai River classifications. Additional data from the Russian River, one of the Kenai River drainages, was presented by Wilmot and Burger (1985). They found significant differences between early and late runs from the Russian River. However, no comprehensive genetic survey of Cook Inlet has been undertaken since the 1970's (Grant et al. 1980). In this study, we present genetic data to delineate populations and evaluate the genetic model as a tool for stock identification and restoration of Kenai River sockeye salmon.

## Materials and Methods

Baseline samples for allozyme analysis were collected by personnel of Alaska Department of Fish and Game (ADF&G) from spawning populations of sockeye salmon using gillnets and beach seines. Target sample size for baseline collections was set at 100 to achieve acceptable precision around the allele frequency estimates (Allendorf and Phelps 1981; Waples 1990). Tissue samples from spawning populations were collected from all major sockeye salmon-producing systems of UCI. Approximately 7,000 individual sockeye salmon from spawning populations were sampled from 1992 to 1995 (Table 1; Fig. 1). Most spawning populations were sampled in at least two separate years and some sites were sampled twice within a year to check for run timing differences.

Mixed-stock collections originating from Cook Inlet fisheries (Central District; Fig. 1) were collected in a similar manner to that of spawning samples. Sockeye salmon from the drift gillnet fishery were sampled at processing plants as fishing vessels were offloaded. Attempts were made to randomize sampling, and multiple vessels were sampled. Collections were made during July in 1992-1995 (Table 1). In 1995, two collections were also taken from set gillnet sites fishing the eastern shore of the Central District. In addition, inriver collections were made at four mainstem fish wheel sites (Yentna River, river mile 4; Susitna River, river mile 80; Kasilof River, river mile 7; and Kenai River, river mile 19; Table 1; Fig. 1). Two mixture collections each year were processed within 48 h. Target mixed-stock sample sizes were set at 200 for inriver and 400 for fisheries samples (Wood 1989), although these were not always achieved.

Samples of muscle, liver, retinal fluid, and heart were dissected from freshly killed individuals. Individual sample numbers were assigned to uniquely identify all genetic tissues. Tissues were placed into cryovials, and the cryovials were stored in liquid nitrogen until transferred to -80°C storage where they remained until laboratory analysis.

A comprehensive examination for discriminating gene markers was conducted using allozyme electrophoresis. Allozyme techniques followed those of Aebersold et al. (1987); nomenclature rules followed the American Fisheries Society standard (Shaklee et al. 1990). A total of 68 allozyme loci were resolved (Table 2). A photographic record of each gel was made, and a collection of mobility standards for all scored alleles was constructed and used to verify alleles.

Of the 68 loci, 24 loci (*ADA-1**; *mAH-3**; *CK-A1**; *CK-C1**; *CK-C2**; *ESTD**; *FBALD-4**; *FH**; *βGALA**; *GAPDH-3**; *GAPDH-4**; *GAPDH-5**; *G3PDH-3**; *GR**; *LDH-A1**; *LDH-B1**; *LDH-C**; *sIDHP-2**; *αMAN**; *mMDH-1**; *mMDH-2**; *mMDH-3**; *sMEP-1**) were found to be invariant and were surveyed for only a single year from each site. Statistical analyses for all populations were based on the remaining set of 44 loci. A reduced set of 27 loci ( *mAAT-1**; *mAAT-2**; *mAH-1,2**; *mAH-4**; *sAH**; *ALAT**; *GAPDH-2**; *G3PDH-4**; *GPI-B1,2**; *GPI-A**; *sIDHP-1**; *LDH-B2**; *sMDH-A1,2**; *sMDH-B1,2**; *mMEP-1**; *PEPA**; *PEPB-1**; *PEPC**; *PEPLT**; *PGM-1**; *PGM-2**; *TPI-1,2**) was used in the majority of the admixture analyses. However, we were unable to resolve some loci (*mAAT-2; GPI-B1,2; G3PDH-4*) from all mixtures; in those cases estimates were based on all remaining loci. Loci in this set were chosen for their information content and ability to be adequately resolved from lesser quality tissues, a common occurrence in fishery samples.

Where possible, multiple collections at the same site were pooled for the analysis following the recommendation of Waples (1990) and White (1996). Genotypes were scored from enzyme phenotypes and then summarized into allele frequency estimates (Appendix A). Only homozygote alternate phenotypes could be scored for null allele variation at *PGM-1** (**100/null* scored as **100/*100*). Hardy-Weinberg expected frequencies were calculated for this locus and are listed in Appendix A. Expected frequencies were used for heterogeneity, gene diversity, and tree analyses, but phenotypic frequencies were used for the mixture analysis. Frequencies at isoloci (*sAAT-1,2*; mAH-1,2*; G3PDH-1,2*; sMDH-A1,2*; sMDH-B1,2*; GPI-B1,2*; TPI-1,2**) were calculated assuming the variation occurred with equal frequency at both loci. Tests for departure from Hardy-Weinberg equilibrium were made for each population at each single locus ($\alpha = 0.05$; adjusted for the number of tests; Lessios 1992) to test for random mating within each population. Isoloci were excluded from these tests.

Populations were grouped *a priori* into seven regions: Kenai River, Kasilof River, Susitna River, Yentna River, Northeast Cook Inlet, Knik Arm and West Cook Inlet. The first four regions encompass the entire watersheds of three of the four major river systems in Upper Cook Inlet. The vast Susitna River watershed, of which the Yentna River is a tributary, was divided into two separate regions to allow finer-scale resolution. Populations within each river system share common freshwater migration pathways. The last three regions are composed of the remaining Upper Cook Inlet river systems arranged into geographically proximal units. With a few exceptions, the populations within each of these three regions do not share freshwater migration pathways. The fourth major river system, Crescent River, is located in the West Cook Inlet region. One or more nursery or rearing lakes are located in each region.

Homogeneity of allelic frequencies among the various collections were tested using log-likelihood ratios (modified from Weir 1990) with $\alpha = 0.01$. This statistic is distributed approximately chi-squared with $(n - 1)(m - 1)$ degrees of freedom, where $n$ is the number of alleles and $m$ is number of populations in the test. The likelihood values can be summed over all loci to obtain a total value at each level of analysis. The total gene frequency dispersion at each locus was subdivided into within- and among-region components in a hierarchical fashion. Hierarchical levels were organized to test for homogeneity 1) among sites within nursery lakes, 2) among nursery lakes within regions, and 3) among river systems/regions. Rejection of the null hypothesis of homogeneity indicates presence of discrete spawning populations. This analysis is a conservative test because the degrees of freedom used reflect the entire pattern of diversity around Cook Inlet. In some situations we also performed pair-wise and region-wide analyses which resulted in fewer degrees of freedom and a finer scale analysis.

To further describe the subdivision of genetic diversity, a hierarchical gene diversity analysis (Nei 1973) was conducted to test for the distribution of variability among sites within nursery lakes, among nursery lakes within regions, and among regions. Isoloci and *PGM-1** (scored phenotypically) were excluded from the diversity analyses.

Genetic distance measures (Cavalli-Sforza and Edwards 1967), which summarize multi-locus data into a single number, were calculated between all pairs of spawning locations. These values were used to construct a neighbor-joining tree (N-J tree; Saitou and

Nei 1987) using PHYLIP (Version 3.5, Felsenstein 1993). This method allows for unequal rates of molecular change among branches. Allele frequency estimates, fit to expected genetic models, and genetic variability and distance measures were calculated using functions written in *S-Plus* (Mathsoft, Inc., Seattle, WA) .

Stock contributions to the mixture samples were estimated via maximum likelihood (MLE; Pella and Milner 1987) using a conjugate gradient searching algorithm with square root transformations (Pella et al. 1996). This algorithm provides good performance with large baselines and small stock differences (Pella et al. 1996). The precision (standard error) of the stock composition was estimated by an infinitesimal jackknife procedure (Millar 1987). Individuals missing data at two or more loci were deleted. Individual population estimates were first calculated, then summed into regional groupings (allocate-sum procedure, Wood et al. 1987). Simulated mixtures were used to evaluate the accuracy of the stock composition estimates reporting regions. These hypothetical mixtures (N = 400) were generated from the baseline allele frequencies assuming Hardy-Weinberg equilibrium. The precision (standard error) of the simulated mixtures was estimated by a parametric bootstrap (Efron and Tibshirani 1986), where the observed multilocus genotype frequencies were assumed to be distributed multinomial as were the allele frequencies in the baseline. One hundred bootstrap iterations were performed.

We conducted 100% simulations for the seven reporting regions (hypothetical mixtures composed entirely of stocks from the individual region). In order to maintain confidence in the estimates, fishery managers desired reporting regions that showed at least 90% allocation to the region of origin. Within regions the individual populations were constrained to contribute equally to the sample so that no allowances were made for differential abundances. We also performed simulations varying the contribution of the Kenai River; contributions varied from 0% to 100% in 10% increments.

**Results**

Heterogeneity Within Regions

*Kenai River*

Rearing of sockeye salmon occurs in Upper and Lower Russian Lakes, Kenai Lake, Skilak Lake, Hidden Lake, Tern Lake, and Trail Lake (Fig. 1). Spawning occurs in tributaries of these lakes as well as the mainstem Kenai River.

Divergence was detected within the Russian River. Spawning populations above and below Russian River Falls exhibited a distinct discontinuity in allele frequencies (Appendix A). Loci exhibiting the divergence between populations spawning above and below the falls included: *sAH*100* (above 0.26 - 0.29; below 0.96), *ALAT*100* (above 0.84 - 0.86; below 0.65), *LDH-B2*100* (above 0.50 - 0.71; below 0.92), and *PGM-1*100* (above 0.00 - 0.01; below 0.38). The population spawning below the falls more closely resembled populations inhabiting the mainstem Kenai River (Fig. 2). In addition, temporal differentiation was detected in pairwise comparisons between early- and late-run spawners above the falls ($G$=93.41, df = 12, $P < 0.001$) with significant heterogeneity at *LDH-B2*, mAAT-1*, mAAT-2**, and *mAH-1,2**.

Overall similarity among populations from the Kenai River drainage is apparent from the N-J tree (Fig. 2). Populations showing high levels of similarity and forming a single cluster included Skilak Lake Outlet, populations between Kenai and Skilak Lakes (sites 1-6), Ptarmigan Creek, Quartz Creek, and Russian River below-the-falls. Moose Creek joined a larger grouping which included populations from Susitna River drainages and West Cook Inlet. Other Kenai River populations appeared highly divergent. While the Russian River above-the-falls (both early and late) populations were the most divergent, Hidden Creek also appears to be highly distinct not only from the Russian River above-the-falls populations but also from the other Kenai River populations. Compared to mainstem Kenai River populations, Hidden Creek is characterized by higher frequencies of *mAAT-2*-73*; *ALAT*100*; and *PGM-2*100* (Appendix A). Moose Creek also is distinct within the drainage with high frequencies of *ALAT*91*.

*Kasilof River*

Populations returning to the Kasilof River drainage spawn in tributaries and along the shoreline of Tustumena Lake. Five tributaries (Bear, Moose, Glacier Flat, Nikolai, and Seepage Creeks; Fig. 1) were sampled. Lake spawners utilizing the beach were also sampled (Tustumena Lake sites 1 and 2). In comparisons among populations, Bear Creek, Moose Creek, and Seepage Creek, were statistically indistinguishable ($G=29.51$, $df= 32$, $P= 0.593$). Relative to other Cook Inlet sockeye salmon populations, the Kasilof River drainage populations were more similar and cluster together on the N-J tree (Fig. 2). Overall heterogeneity within the region when all Cook Inlet populations were considered was not significant (Table 3). As a group, Kasilof River drainage populations exhibited a high frequency of *ALAT*95* (frequencies range from 0.10 to 0.15) and consistent presence of rare alleles (*G3PDH-4*108; GPI-B1,2*132*).

*Susitna River Drainages*

The Susitna River is composed of the Yentna River and mainstem Susitna River drainages. Within each of these systems are many smaller lakes and tributaries that support sockeye salmon spawning and rearing. Chosen sampling sites were assumed to represent the largest spawning populations within the system although less is known about populations of the Susitna River than population from other drainages.

We found extensive divergence within the Susitna River system, both within and between the Yentna and Susitna Rivers (Table 3). Within the Yentna River drainage was a wide spectrum of loci at which one or more populations have exceptionally divergent allele frequencies (Table 3, Appendix A) . The most dramatic difference occurred at *PGM-2** where Shell and Trinity/Movie Lakes have frequencies of the **100* allele of 0.25 and 0.28 respectively, while Hewitt/Whiskey Lakes had a frequency of 0.63 and the remaining populations had frequencies greater than 0.80. Other loci that displayed a large amount of heterogeneity were: *PEPC*105* (generally < 0.01; Hewitt/Whiskey Lakes = 0.13; Shell Lake = 0.32), *PGM-1*100* (generally < 0.10; Judd Lake = 0.36), *PEPB-1*130* (generally = 0.00; Trinity/Movie Lakes = 0.15), *ALAT*100* (generally < 0.59; Trinity/Movie and Hewitt/Whiskey Lakes > 0.70), and *mAAT-1*100* (generally > 0.84; Judd Lake = 0.62).

Populations in the Susitna River mainstem also showed considerable heterogeneity at several loci (Table 3; Appendix A). At *PGM-1**, most of the populations had frequencies of the **100* allele between 0.19 and 0.40, but in Red Shirt Lake a frequency of 0.03 was estimated, and the **100* allele was absent in the Stephan Lake collections. Other alleles that displayed a large amount of heterogeneity were: *PEPC*105* (frequencies ranging from 0.003 to 0.17) and *sIDHP-1*94* (generally = 0.00; Stephan Lake = 0.13), and *mAAT-1*-83* (generally > 0.18; Birch Creek = 0.06; Red Shirt Lake = 0.00). The degree of differentiation was most easily seen in the N-J tree (Fig. 2) where Susitna River populations can be found on many different branches clustering with populations from other regions.

*Western Cook Inlet*

Populations assigned to the Western Cook Inlet region spawn in the river/lake systems that drain the west side of Cook Inlet from the mouth of the Susitna River south to the Crescent River. These are generally cold, high-energy streams fed by the glaciers and snowpack in the mountains that line the coast. An exception is the Packers Lake population which returns to Kalgin Island, a large island located in the middle of the Inlet west of the mouth of the Kasilof River. Unlike the Kenai River, Kasilof River and Susitna River populations, populations within a region do not generally share a common fresh-water migration pathway (Fig. 1).

As might be expected from the geography of the region, the Western Cook Inlet populations exhibited considerable regional heterogeneity (Table 3). A large part of the heterogeneity within the region can be attributed to a few loci within a few populations. The *ALAT*95* allele occurred much more frequently in McArthur River (frequency = 0.17) than in the remaining populations (frequency < 0.07). In this region, the *sMDH-B1,2*65* allele occurred only in Coal Creek and Packers Lake, while the **116* was a private allele for Packers Lake. The frequencies of the null allele for *PGM-1** ranged from 0.537 to 0.997, and the *PGM-2*136* allele frequencies ranged from 0.03 to 0.39 through all the populations in this region.

*Northeastern Cook Inlet*

Only two sites were sampled in the Northeastern Cook Inlet region: Daniels Lake and Bishop Creek. Both sites are in the Bishop Creek drainage located north of the mouth of the Kenai River on the Kenai Peninsula (Fig. 1). When sites were compared, heterogeneity was found at *ALAT**, *sAH**, *GPI-A**, and *mAAT-1** between Bishop Creek and Daniels Lake collections (Table 3). Their similarity to each other, though, was greater than their similarity to other populations as shown in the N-J tree (Fig. 2). Northeastern Cook Inlet populations were marked by a high frequency of *PEPLT*88* alleles, a low frequency of *PGM-2*100* alleles, and the lack of *LDH-B2** and *PEPC** variant alleles which were seen in every other region.

*Knik Arm*

Like the populations in Western Cook Inlet, the Knik Arm populations do not share a common freshwater migration path (Fig. 1). For this reason, sampling sites were chosen based on size of drainage and observed sockeye salmon escapement. The three populations of the region (Nancy Lake, Cottonwood Creek and Fish Creek) were significantly different (Table 3). Cottonwood Creek and Fish Creek clustered together in the N-J tree, but Nancy Lake was on a separate branch with populations from other regions.

Heterogeneity Among Regions

Observed and expected heterozygosities were calculated for all populations (Appendix A). Observed heterozygosities varied from a low of 0.021 in Chilligan River to a high of 0.056 in Stephan Lake. There was no regional trend in heterozygosity level in the populations sampled. All populations conformed to Hardy-Weinberg expectations.

A hierarchical gene diversity analysis was stratified by site, nursery lake, and region.

The greatest amount of variation (87.74%) occurred within sites (Table 4). Little variability was detected among sites within nursery lakes (0.38%). However, considerable heterogeneity (7.80%) existed among nursery lakes within regions with the remaining 4.08% of the variability allocated to the among-regions component.

Mixed-stock Analyses

The performance of the MSA model for Cook Inlet sockeye salmon was investigated through simulations. The Kenai River region, the group of greatest concern, showed 91% allocation in the simulation studies, above the 90% goal (Table 5). Northeastern Cook Inlet, Kasilof River and Knik Arm also were above or close to the goal (99%, 92% and 88% respectively). The Yentna River also was near the goal with an allocation of 88%, but the Susitna River misallocated to both the Yentna River and Western Cook Inlet resulting in a correct allocation of only 77%. When the Susitna and Yentna regions were combined, the allocation rose to 87%. Western Cook Inlet, a heterogenous grouping based on geographic proximity, performed at 86%, below the 90% objective.

A series of simulations was also conducted to test our ability to detect increasing Kenai River presence in the fishery. Simulations were designed so that the Kenai River contribution to the mixture sample varied from 0% to 100% in 10% increments. At low percentages the Kenai River contribution were slightly overestimated, while at higher percentages the contributions were underestimated (Fig. 3).

Maximum likelihood estimates were calculated for all samples collected from the Central District drift gillnet and Eastside set gillnet fisheries. These estimates were then summed by region for use in management (Table 6). In 1992, 1993 and 1994 few samples were taken and estimated contributions shed little light on the interactions of regions within the fishery (Fig. 4). In 1995, five samples were taken from that portion of the season coinciding with the expected presence of Kenai River sockeye salmon (Fig. 5). These samples show an increase (from 16.4% on July 3 to 86.0% on July 31) of Kenai River sockeye salmon in the drift gillnet fishery over the period examined. During this same period, the harvest of sockeye salmon peaked at 462,625 on July 17 (Table 7). At the peak of the harvest, Kenai River populations were estimated to comprise 42.6% of the catch which represented approximately 50% of the total harvest of Kenai River sockeye salmon for the month of July. While the proportion of Kenai River populations in the harvest continued to increase during late July, the total harvest of sockeye salmon in the fishery decreased (Table 7; Fig. 6). Sockeye salmon of Kenai River origin represented approximately one third of the total Cook Inlet harvest during the sampling period.

Maximum likelihood estimates were also calculated from samples originating from catches of inriver fish wheels (Table 8). Samples were collected from the Kenai, Kasilof, Susitna River mainstem, and Yentna River drainages (Table 1; Fig. 1). These inriver estimates assumed all contributing populations from a particular drainage were included in the baseline and that there was no straying into the river drainage. Estimates for the Kenai River samples ranged from 63% to 93% across all collections. The lowest value was for the July 10, 1994 collection, the earliest sample taken. A similar pattern was observed for the Susitna River mainstem (75% and 92%), Yentna River (81% to 98%) and Kasilof River (55% to 91%) where the low values were always obtained from the early samples. This may indicate that some early-run populations with unique genetic profiles have not been included in the baseline, or that early in the season fish may be entering non-natal systems prior to correctly homing to their natal stream ("nosing in").

Finer scale estimation was also possible for some populations within some river drainages. A 100% simulation was conducted on the Russian River above-the-falls populations alone. The simulation result was 99.4%, S. D. 0.5%, indicating that the Russian River could be identified in mixtures of Cook Inlet populations with a high degree of accuracy and precision. Maximum likelihood estimates for the inriver mixtures from Kenai River were made to estimate the combined early- and late-runs of Russian River sockeye salmon above-the-falls (Fig. 7). Four estimates were possible in 1994; three in 1995. The results suggested a pulse of early-run fish, a lull, and then a large pulse of late-run fish.

## Discussion

The objective of this study was to improve stock assessment capabilities for sockeye salmon in an effort to protect and restore populations injured as a result of the oil spill. The allozyme data gave a detailed picture of the genetic diversity of Cook Inlet sockeye salmon, and the data representing 47 putative populations can be used not only to describe the diversity of the Inlet, but also to assess the contribution of injured populations to mixed-stock aggregations.

### Genetic Diversity of Cook Inlet Sockeye Salmon

This study represents the first comprehensive analysis of sockeye salmon from Cook Inlet since that of Grant et al. (1980). Grant et al. (1980) identified six informative of 26 total loci from 13 populations from Cook Inlet. They documented heterogeneity among both the Kenai and Susitna River drainages, while little heterogeneity was detected among Kasilof River populations. Wilmot and Burger (1985) surveyed Russian River populations and documented significant differences between the early- and late-run populations from the Russian River at *LDH-B2** and *sAH**. Our study confirms the previous observations of Grant et al. (1980) and Wilmot and Burger (1985) and greatly expands the database both in terms of loci and number of populations.

Sockeye salmon typically spawn in rivers or smaller creeks associated with nursery lakes, and it has been suggested that the nursery lake is the primary unit of genetic structuring (Utter et al. 1984; Wood et al. 1994). This may reflect the tendency of sockeye salmon to home with great fidelity to their natal streams, presumably to a greater extent than other Pacific salmon (Quinn 1985; Quinn et al. 1987). Juveniles will typically rear from one to two years in a nursery lake before undergoing smoltification and migrating to the sea.

The Kenai River drainage includes several nursery lakes. Early- and late-run Russian River populations are thought to rear in Upper and Lower Russian Lakes, "mainstem" spawning populations (Skilak Lake outlet, between Kenai and Skilak Lake, Russian River below-the-falls, Quartz Creek, and Ptarmigan Creek) are believed to rear in Kenai and Skilak Lakes, Moose Creek rear in Upper Trail Lake, Tern Lake rear in Tern Lake, and Hidden Creek juveniles rear in Hidden Lake. The genetic diversity among Kenai River populations is clearly far greater than previously documented. Two separate lineages corresponding to an early- and late-run occur above the falls in the Russian River. The falls serve as an effective isolating barrier with populations below the falls joining a large aggregation of mainstem populations that rear in Kenai and Skilak Lakes. A third highly divergent lineage is represented by the Hidden Creek population, and additional outliers with distinct genetic profiles occur in Moose Creek and Tern Lake.

In the Kasilof River region, sockeye salmon from four spawning tributaries as well as two beach spawning sites were surveyed from Tustumena Lake. Little heterogeneity among populations rearing in the lake was apparent (Table 3; Fig. 2). Burger et al. (1995) detected a distinct late run of river-spawners that appear near the end of September at the outlet of Tustumena Lake. These outlet-spawners have a distinct genetic profile based on both mitochondrial DNA and allozyme data, but a complete data set was not available for this study.

The high level of divergence of Susitna River and Western Cook Inlet populations was not unexpected, as Grant et al. (1980) also noted significant differences between Susitna River populations. Unlike the Kenai and Kasilof River drainages, there are no large nursery lakes that support multiple tributary-spawning populations. Rather, there are a number of isolated smaller lake systems and this isolation has likely led to the considerable divergence evident in both regions.

The data from the Kenai, Kasilof, and Susitna River drainages support a model of differentiation of populations based on natal spawning areas. In the gene diversity analysis, 7.8% of the variability existed among-nursery lakes within regions, while only 3.6% of the variability could be attributed to the among-region component. Wood et al. (1994) report similar results from a study of variation in 83 distinct spawning sites representing all major sockeye-producing river systems in Canada. They showed extensive differentiation among nursery lakes and attributed it to founder effects and isolation through strict homing behavior.

They found 7% of the variation to be attributable to differences among lakes within drainage with lesser amounts attributed to their "among drainages within systems" and "among river system" components.

Divergence within a nursery lake was seen in this study between the early- and late-run Russian River populations. Temporal and geographic divergence within lakes has been noted for other sockeye salmon populations. Wilmot and Burger (1985) report differences between early- and late-run sockeye salmon returning to Karluk Lake. Varnavskaya et al. (1994) studied the population structure within nine lake systems in North America and Russia and found differentiation among subpopulations exhibiting different run timing (earlier vs. later) or utilizing different spawning habitat (tributary vs. beach). They attribute the differentiation to precise homing to the natal streams, not just to the lake systems.

Mixed-stock Analyses

In addition to describing the genetic diversity present in Cook Inlet, a primary goal of this study was to evaluate and utilize the genetic data for MSA to aid in the management and restoration of injured Kenai River populations. A total of 27 of the 68 loci were used in the majority of the admixture analyses which represents a large increase over that available to Grant et al. (1980).

A basic requirement of using genetic data in mixed-stock analyses is that all major contributing populations are represented in the baseline. To a large extent, this assumption is met by the extensive genetic information collected by this study. However, unlike other species of Pacific salmon such as chinook salmon (*O. tschawytscha*, Utter et al. 1993), there is little relationship between genetic distance and geographic distance in sockeye salmon populations. Sockeye salmon populations inhabiting the same drainage may be more divergent than populations geographically quite separate. As a result, exhaustive baseline sampling is needed.

Simulation studies are a useful method to evaluate and refine the MSA model. We primarily used pure or 100% simulations. Bias in the estimated composition is expected to be greatest at the most extreme compositions (0 or 100%) given the constrained maximum likelihood techniques used (no estimates $< 0.00$ or $> 1.00$; Pella and Milner 1987). This pattern was evident in the simulations of increasing Kenai River contributions to the fishery (Fig. 3), but the bias was greater at high levels of Kenai River contributions than at low levels. The estimated Kenai River component was within one standard deviation of the true contribution over the range from 0% to 80%. A series of 100% simulations, thus, provides a rigorous test of the model.

Based on earlier work with sockeye salmon (Wood et al. 1989, 1994), we took a conservative approach by identifying regional reporting units and using the allocate-sum procedure to estimate regional contributions. Previous simulation studies on sockeye salmon have shown that estimates for individual populations may not be reliable (Wood et al. 1989). The performance of the Kenai River was of particular concern, but it did quite well with a 100% simulation estimate of 91.3% (S.D. 4.9%). Additional indicators of the accuracy of the method are the misallocations to a particular region. Misallocations to the Kenai River in 100% simulations of other regions were small, ranging from 0.3% from Northeastern Cook Inlet to Kenai River and 2.5% from the Kasilof to the Kenai River region. The Kasilof River, Northeastern Cook Inlet, and Knik Arm regions also performed well, and pooling the Yentna and Susitna River regions improved performance for the Susitna River populations. The poorest results were obtained for Western Cook Inlet, a very heterogeneous group of populations with genetic affinities to the Yentna and Susitna River populations.

The results for the maximum likelihood estimates of regional contribution to the commercial fishery over the four years varied not only through time, but also across years with the Kenai River estimate ranging from 16.4% to 90.9%. In 1995 the Kasilof River region was the largest contributor early in the season, but by mid-July the Kenai River became the dominant contributor. Yearly estimates will vary depending on the relative run strengths, location of sampling, and timing of sampling, but multi-year sampling, particularly with multiple samples within each year, may reveal consistent patterns.

The inriver mixed-stock estimates can be used to monitor individual populations within systems. For example, the Russian River and Hidden Creek populations of the Kenai River can be very accurately and precisely estimated and can potentially serve as indicator stocks for management purposes. The inriver samples can also provide an indication of the adequacy of the baseline. However, intrinsic in this application is the assumption that very little straying or "nosing in" occurs. Anecdotally, biologists have observed that some fish temporarily enter a non-natal stream prior to correctly homing. The model performs poorly early in the season and improves dramatically as the season progresses, which suggests that the baseline may be weighted towards populations with middle or late run timing. This is likely an acceptable bias as many of the early-timing populations may be very low in abundance. It also could indicate that entrance into a non-natal stream may be more prevalent early in the season.

The allozyme data reveal a substantial amount of genetic diversity among populations of Cook Inlet sockeye salmon. This diversity is distributed both within and among major drainages. In general, the data support a model of population structure based on the nursery lake, however we did detect significant divergence among both temporal and geographic components within nursery lakes. This diversity likely arises from isolation and genetic drift among nursery lakes combined with a tendency of sockeye salmon to home with great fidelity.

Application to Fishery Management

The commercial fishery management strategy in Upper Cook Inlet is to regulate the harvest of sockeye salmon by varying fishing time and area to meet a fixed range of escapement objectives. Season length is mid-June to mid-August with a peak fishery in mid-July. Typically, the fishery operates on Monday and Friday for 12 h. However, this time is adjusted by the ADF&G depending on run strength. Areas open to fishing can also be adjusted to affect exploitation rates. Evaluation of this strategy is done by estimating the number of adults reaching freshwater in the major river systems by sonar (Ruesch and Fox 1994)

Sockeye salmon move into the Central District from the south and tend to delay entering their natal streams. Residence times in the Central District for Kenai River sockeye salmon have a modal value of 11 days early in the season, rapidly declining to four days as the season progresses. The average residence time for Kasilof River populations is nine days at the beginning of the season and declines to five days at the end of the season. Susitna River populations, in contrast, hold for 19 days in the early portion of the season; the average time declines to seven days late in the season (Mundy et. al. 1993).

Approximately 600 drift gillnet vessels fish the offshore waters of the Central District in Upper Cook Inlet. Exploitation rates of the drift gillnet fleet averaged 41% (range 35-45%) for a single 12 h fishing period between 1979 and 1988. Rates have remained relatively stable to the present.

In contrast to the drift gillnet fishery, the set gillnet fishery in Upper Cook Inlet concentrates along the east side of Upper Cook Inlet. This fishery targets primarily Kasilof and Kenai River populations and consists of over 1200 35-fathom nets. Exploitation rates in a single 12 h period can be 70% of the fish available to the gear.

Variable residence times which concentrate fish, stock abundance, and high commercial exploitation rates, can combine to increase the probability of over-harvest in an uninformed mixed-stock fishery. It is, therefore, essential that stock identification in the harvest available for long term management of these fisheries so that weaker stocks can be identified and protected.

The results of the maximum likelihood estimates indicated that Kenai River populations can be identified in mixtures of Cook Inlet sockeye salmon with a level of precision, accuracy, and timeliness useful for fisheries management. The original intent of this study was to determine the Kenai River/non-Kenai River component of the harvest. To evaluate the model, though, populations were initially allocated to seven regions which were later reduced to six to improve model performance.

The maximum likelihood estimates were first incorporated into inseason fishery management in 1995; results were reported for Kenai River/non-Kenai River components only during the first year. In future years it is likely that four reporting groups, corresponding to current management regimes, will be used. These groups are: Kenai River, Kasilof River, Northern District (Susitna River, Yentna River, Northeastern Cook Inlet, Knik Arm, Coal Creek, Chilligan River, McArthur River), and a Western Cook Inlet component consisting of those populations spawning south of the Northern District boundary. Evaluation of these groups is being conducted.

Application of genetic data to stock identification in fishery management has several advantages over other methods including stability of allele frequencies over time, ability to process large amounts of samples rapidly, and reasonable costs (Shaklee and Phelps 1990). The accuracy and precision of the estimates can likely be further improved as additional genetic markers become available. The data collected in this study can be used throughout Cook Inlet and as well as within drainages to identify specific population components. These applications are currently underway in Cook Inlet to aid in the management and restoration of injured populations.

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Table 1. Sockeye salmon populations sampled for genetic studies. All populations originate from Upper Cook Inlet, 1992-1995.

| | Map # and Location | Sample Date | N |
|---|---|---|---|
| | **Kenai River Drainage** | | |
| 1 | Russian River (above falls, early) | 7/01/92 | 100 |
| | Russian River (above falls, late) | 8/06/92 | 100 |
| | | 7/26/93 | 100 |
| | Russian River (below falls, late) | 8/17/93 | 100 |
| 2 | Ptarmigan Creek | 8/31/92 | 100 |
| | | 8/05/93 | 98 |
| 3 | Tern Lake | 9/01/92 | 50 |
| | | 8/24/93 | 100 |
| 4 | Quartz Creek | 8/13/92 | 100 |
| | | 7/27/93 | 100 |
| 5 | Between Kenai/Skilak Lake | | |
| | River mile 69.8 (Site 6) | 8/18/92 | 100 |
| | | 8/13/93 | 99 |
| | | 8/27/93 | 100 |
| | River mile 79.8 (Site 1) | 8/11/94 | 50 |
| | | 8/22/94 | 50 |
| | River mile 76.6 (Site 2) | 8/12/94 | 50 |
| | | 8/23/94 | 50 |
| | River mile 70.5 (Site 3) | 8/12/94 | 100 |
| | | 8/23/94 | 50 |
| | River mile 72.5 (Site 4) | 8/23/94 | 50 |
| | River mile 65.3 (Site 5) | 9/09/94 | 100 |
| 6 | Hidden Creek | 8/03/92 | 100 |
| | | 8/04/93 | 100 |
| 7 | Skilak Lake outlet | | |
| | River mile 49.6 (north bank) | 8/19/92 | 100 |
| | River mile 47.6 (south bank) | 8/13/93 | 100 |
| | | 8/27/93 | 200 |
| | | 8/20/94 | 100 |
| | | 8/30/94 | 200 |
| | | 8/29/95 | 100 |

Table 1. Continued.

| | Map # and Location | Sample Date | N |
|---|---|---|---|
| 8 | Moose Creek | 7/27/93 | 100 |
| | | 7/13/94 | 100 |
| | **Susitna River (Yentna Drainages)** | | |
| 9 | Chelatna Lake | 8/20/92 | 100 |
| | | 8/02/93 | 100 |
| 10 | Yentna River West Fork (Unnamed slough) | 9/08/92 | 100 |
| | | 9/08/93 | 100 |
| 11 | Hewitt/Whiskey Lakes | 8/24/92 | 50 |
| | | 9/03/93 | |
| 12 | Shell Lake (Skwentna R.) | 8/26/92 | 100 |
| | | 9/01/93 | 100 |
| 13 | Trinity/Movie Lakes | 8/25/92 | 100 |
| | | 9/03/93 | 100 |
| 14 | Judd Lake (Talachulitna R.) | 8/24/92 | 100 |
| | | 8/24/93 | 100 |
| | **Susitna River (Mainstem Drainages)** | | |
| 15 | Byers Lake | 8/23/93 | 100 |
| 16 | Stephan Lake (Talkeetna R.) | 9/08/93 | 100 |
| | | 8/19/94 | 25 |
| 17 | Larson Lake (Talkeetna R.) | 8/20/92 | 100 |
| | | 8/31/93 | 100 |
| 18 | Birch Creek | 8/19/93 | 67 |
| 19 | Red Shirt Lake | 9/15/93 | 34 |
| 20 | Slough # 11 (Susitna R.) | 9/06/95 | 50 |
| | **Western Cook Inlet Drainages** | | |
| 21 | Coal Creek West Fork (Beluga R.) | 9/01/92 | 100 |
| | | 8/25/93 | 100 |
| 22 | Chilligan River (Chakachatna R.) | 9/08/92 | 100 |
| | | 9/13/94 | 50 |

Table 1. Continued.

| | Map # and Location | Sample Date | N |
|---|---|---|---|
| 23 | McArthur River (Chakachatna R.) | 8/18/93 | 100 |
| 24 | Wolverine Creek (Big R.) | 7/03/93 | 100 |
| 25 | Crescent Lake | | |
| | Site 1 (South Shore) | 8/14/94 | 50 |
| | | 8/23/95 | 50 |
| | Site 2 (near outlet) | 8/14/94 | 50 |
| | | 8/23/95 | 50 |
| | Site 3 | 8/23/95 | 50 |
| 26 | Packers Lake (Kalgin Island) | 7/16/92 | 100 |
| | | 7/26/93 | 100 |
| | **Kasilof River Drainage** | | |
| 27 | Bear Creek | 8/12/92 | 100 |
| | | 8/03/93 | 100 |
| 28 | Moose Creek | 8/10/92 | 100 |
| | | 8/03/93 | 100 |
| 29 | Glacier Flat Creek | 8/11/92 | 100 |
| | | 8/02/93 | 100 |
| | | 8/04/94 | 100 |
| 30 | Nikolai Creek | 7/29/92 | 100 |
| | | 7/27/93 | 100 |
| 31 | Tustumena Lake (lake spawners) | | |
| | Site 1 (between Glacier Flat and Crystal Ck) | 8/31/94 | 50 |
| | Site 2 (mouth of Crystal Creek) | 9/01/94 | 50 |
| 32 | Seepage Creek | 8/25/94 | 100 |
| | **Northeastern Cook Inlet Drainages** | | |
| 33 | Bishop Creek (Stream 602) | 8/23/93 | 100 |
| 34 | Daniels Lake (Bishop Ck. Drainage) | 9/02/92 | 100 |
| | | 8/20/93 | 100 |
| 35 | Nancy Lake (Little Susitna R.) | 8/26/93 | 100 |
| 36 | Cottonwood Lake (Knik Arm) | 8/18/93 | 100 |

Table 1. Continued.

| | Map # and Location | Sample Date | N |
|---|---|---|---|
| 37 | Fish Creek | 8/01/92 | 100 |
| | | 8/16/93 | 100 |
| | | 8/15/94 | 100 |
| | **Inriver Composite Samples** | | |
| | Kenai River (fish wheel site, river mile 19) | | |
| | 1992-1 | 7/13/92 | 200 |
| | 1994-1 | 7/08-7/14/94 | 88 |
| | 1994-2 | 7/17-7/18/94 | 200 |
| | 1994-3 | 7/31-8/01/94 | 200 |
| | 1994-4 | 8/09-8/11/94 | 200 |
| | 1995-1 | 7/19-7/21/95 | 300 |
| | 1995-2 | 7/26/95 | 300 |
| | 1995-3 | 8/02-8/05/95 | 300 |
| | Kasilof River (fish wheel site, river mile 7) | | |
| | 1992-1 | 7/02-7/03/92 | 200 |
| | 1992-2 | 7/22-7/23/92 | 200 |
| | 1994-1 | 7/08-7/10/94 | 200 |
| | 1994-2 | 7/17/94 | 200 |
| | 1994-3 | 8/01-8/03/94 | 98 |
| | Susitna River Mainstem (fish wheel, river mile 80) | 7/26/92 | 200 |
| | | 8/04/92 | 114 |
| | Yentna River (fish wheel site, river mile 4) | | |
| | 1992-1 | 7/16/92 | 200 |
| | 1992-2 | 7/24/92 | 200 |
| | 1994 | 7/25-26/94 | 200 |
| | **Commercial Fishery Sampling** | | |
| | Drift gillnet fishery 1992 | 7/13/92 | 200 |
| | | 7/20/92 | 200 |
| | Drift gillnet fishery 1993 | 7/12/93 | 400 |
| | | 7/16/93 | 283 |
| | Drift gillnet fishery 1994 | 7/08/94 | 350 |

Table 1. Continued.

| Map # and Location | Sample Date | N |
| --- | --- | --- |
| Drift gillnet fishery 1995 | 7/04/95 | 300 |
| | 7/10/95 | 399 |
| | 7/17/95 | 400 |
| | 7/24/95 | 400 |
| | 7/31/95 | 300 |
| Eastside set gillnet fishery 1995 | 7/07/95 | 400 |
| | 7/20/95 | 400 |

Table 2. Enzymes or proteins screened in Cook Inlet sockeye salmon. Enzyme nomenclature follows Shaklee et al. (1990), and locus abbreviations are given.

| Enzyme or Protein | Enzyme Number | Locus | Tissue | Buffer[1] |
|---|---|---|---|---|
| Aspartate aminotransferase | 2.6.1.1 | *sAAT-1,2** | Heart | ACE 7.2 |
| | | *sAAT-3** | Eye | TBCL |
| | | *mAAT-1** | Heart | ACE 7.2 |
| | | *mAAT-2** | Liver | ACE 7.0 |
| Adenosine deaminase | 3.5.4.4 | *ADA-1** | Muscle | KG |
| Aconitate hydratase | 4.2.1.3 | *mAH-1,2** | Heart | ACE 7.2 |
| | | *mAH-3** | Heart | ACE 7.2 |
| | | *mAH-4** | Heart | ACE 7.2 |
| | | *sAH** | Liver | ACE 7.0 |
| Alanine aminotransferase | 2.6.1.2 | *ALAT** | Muscle | KG |
| Creatine kinase | 2.7.3.2 | *CK-A1** | Muscle | TBCLE |
| | | *CK-A2** | Muscle | TBCLE |
| | | *CK-B** | Eye | ACE 7.0 |
| | | *CK-C1** | Eye | ACE 7.0 |
| | | *CK-C2** | Eye | ACE 7.0 |
| Esterase-D | 3.1.-.- | *ESTD** | Muscle | TBCLE |
| Fructose-biphosphate aldolase | 4.1.2.13 | *FBALD-4** | Eye | ACE 7.0 |
| Formalin dehydrogenase[2] (Hydroxyacylglutathione hydrolase) | 1.2.1.1 | *FDH ** (*HAGH**) | Liver | TBE |
| Fumarate hydratase | 4.2.1.2 | *FH** | Muscle | ACN 7.0 |
| β-N-Acetylgalactosaminidase | 3.2.1.53 | *βGALA** | Liver | ACE 7.0 |
| Glyceraldehyde-3-phosphate dehydrogenase | 1.2.1.12 | *GAPDH-2** | Heart | ACN 7.0 |
| | | *GAPDH-3** | Heart | ACN 7.0 |
| | | *GAPDH-4** | Eye | ACE 7.0 |

Table 2. Continued.

| Enzyme or Protein | Enzyme Number | Locus | Tissue | Buffer[1] |
|---|---|---|---|---|
| | | *GAPDH-5** | Eye | ACE 7.0 |
| Glycerol-3-phosphate dehydrogenase | 1.1.1.8 | *G3PDH-1,2** | Muscle | ACN 7.0 |
| | | *G3PDH-3** | Heart | ACN 7.0 |
| | | *G3PDH-4** | Heart | ACN 7.0 |
| Glucose-6-phosphate isomerase | 5.3.1.9 | *GPI-B1,2** | Muscle | TBCLE |
| | | *GPI-A** | Muscle | TBCLE |
| Glutathione reductase | 1.6.4.2 | *GR** | Eye | TBCL |
| Isocitrate dehydrogenase (NADP+) | 1.1.1.42 | *mIDHP-1** | Heart | ACN 7.0 |
| | | *mIDHP-2** | Heart | ACN 7.0 |
| | | *sIDHP-1** | Liver | ACE 7.0 |
| | | *sIDHP-2** | Liver | ACE 7.0 |
| L-Lactate dehydrogenase | 1.1.1.27 | *LDH-A1** | Muscle | ACN 7.0 |
| | | *LDH-A2** | Muscle | ACN 7.0 |
| | | *LDH-B1** | Muscle | TBCLE |
| | | *LDH-B2** | Liver | TBE |
| | | *LDH-C** | Eye | KG |
| αMannosidase | 3.2.1.24 | *αMAN** | Liver | TC4 |
| Malate dehydrogenase | 1.1.1.37 | *sMDH-A1,2** | Heart | ACN 7.0 |
| | | *sMDH-B1,2** | Heart | ACN 7.0 |
| | | *mMDH-1** | Heart | ACN 7.0 |
| | | *mMDH-2** | Muscle | ACN 7.0 |
| | | *mMDH-3** | Muscle | ACN 7.0 |
| Malic enzyme (NADP+) | 1.1.1.40 | *sMEP-1** | Liver | TC4 |
| | | *mMEP-1** | Muscle | ACN 7.0 |
| Mannose-6-phosphate isomerase | 5.3.1.8 | *MPI** | Liver | TBE |
| Dipeptidase | 3.4.-.- | *PEPA** | Muscle | TBCLE |

Table 2. Continued.

| Enzyme or Protein | Enzyme Number | Locus | Tissue | Buffer[1] |
|---|---|---|---|---|
| Tripeptide aminopeptidase | 3.4.-.- | *PEPB-1** | Heart | TBE |
| Peptidase-C | 3.4.-.- | *PEPC** | Eye | KG |
| Proline dipeptidase | 3.4.13.9 | *PEPD-1** | Heart | TBE |
| Peptidase-LT | 3.4.-.- | *PEPLT** | Muscle | TBCLE |
| Phosphogluconate dehydrogenase | 1.1.1.44 | *PGDH** | Liver | ACE 7.0 |
| Phosphoglucomutase | 5.4.2.2 | *PGM-1** | Heart | ACE 7.2 |
| | | *PGM-2** | Muscle | TBCLE |
| Superoxide dismutase | 1.15.1.1 | *sSOD-1** | Liver | TBE |
| Triose-phosphate isomerase | 5.3.1.1 | *TPI-1,2** | Eye | KG |
| | | *TPI-3** | Eye | KG |
| | | *TPI-4** | Eye | KG |

[1]Buffer system abbreviations and descriptions are : 1) **ACE 7.0** or **ACE 7.2**; N-(3-aminopropyl)-morpholine, citrate (pH 7.0 or 7.2) with EDTA (Clayton and Tretiak 1972); 2) **ACN 7.0**; N-(3-aminopropyl)-morpholine, citrate (pH 7.0) with NAD (Clayton and Tretiak 1972); 3) **KG**; Tris, glycine HCl (pH 8.5; tray concentration modified to 0.075 M Tris; Holmes and Masters 1970); 4) **TBCL**; Tris, borate, citrate, LiOH (pH 8.2; Ridgway et al. 1970); 5) **TBCLE**; Tris, borate, citrate, LiOH with EDTA (pH 8.2; Selander et al. 1971); 6) **TBE**; Tris, borate, EDTA (pH 8.7; Boyer et al. 1963); and 7) **TC4**; Tris citrate, NaOH (pH 5.9; Selander et al. 1971).

[2]*HAGH* (E.C. 3.1.2.6) and *FDH* (Formalin dehydrogenase, E.C. 1.2.1.1) appear to be the same locus.

Table 3. Hierarchical log-likelihood heterogeneity analysis of Upper Cook Inlet sockeye salmon populations

| Populations | DF | *sAAT-1,2* | DF | *sAAT-3* | DF | *mAAT-1* | DF | *mAAT-2* | DF | *mAH-1,2* | DF | *mAH-4* | DF | *sAH* | DF | *ALAT* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Among regions | 12 | 31.12 ** | 6 | 9.52 | 6 | 491.83 ** | 6 | 407.18 ** | 6 | 185.77 ** | 6 | 11.77 | 18 | 906.30 ** | 18 | 826.66 ** |
| Within regions | 154 | 22.82 | 77 | 21.90 | 77 | 482.10 ** | 77 | 618.87 ** | 77 | 403.35 ** | 77 | 34.94 | 231 | 2023.23 ** | 231 | 1386.14 ** |
| Kenai River | 60 | 0.00 | 30 | 0.00 | 30 | 122.21 ** | 30 | 600.87 ** | 30 | 124.23 ** | 30 | 20.24 | 90 | 1973.01 ** | 90 | 589.49 ** |
| Among nursery lakes | 8 | 0.00 | 4 | 0.00 | 4 | 59.96 ** | 4 | 542.70 ** | 4 | 44.61 ** | 4 | 17.80 ** | 12 | 1915.00 ** | 12 | 445.60 ** |
| Within nursery lakes | 52 | 0.00 | 26 | 0.00 | 26 | 62.25 ** | 26 | 58.17 ** | 26 | 79.62 ** | 26 | 2.44 | 78 | 58.01 | 78 | 143.89 ** |
| Upper Russian Lake | 4 | 0.00 | 2 | 0.00 | 2 | 15.25 ** | 2 | 9.27 ** | 2 | 37.73 ** | 2 | 0.00 | 6 | 0.91 | 6 | 2.88 |
| Kenai / Skilak Lakes | 42 | 0.00 | 21 | 0.00 | 21 | 45.68 ** | 21 | 43.49 ** | 21 | 39.41 ** | 21 | 0.00 | 63 | 54.41 | 63 | 135.29 ** |
| Tern Lake | 2 | 0.00 | 1 | 0.00 | 1 | 0.55 | 1 | 3.27 | 1 | 2.35 | 1 | 2.44 | 3 | 2.20 | 3 | 0.35 |
| Hidden Lake | 2 | 0.00 | 1 | 0.00 | 1 | 0.41 | 1 | 0.25 | 1 | 0.02 | 1 | 0.00 | 3 | 0.00 | 3 | 3.05 |
| Trail Lake (Moose Ck.) | 2 | 0.00 | 1 | 0.00 | 1 | 0.36 | 1 | 1.89 | 1 | 0.11 | 1 | 0.00 | 3 | 0.49 | 3 | 2.32 |
| Yentna River | 22 | 0.00 | 11 | 6.18 | 11 | 151.45 ** | 11 | 0.00 | 11 | 34.80 ** | 11 | 14.70 | 33 | 6.82 | 33 | 208.02 ** |
| Among nursery lakes | 10 | 0.00 | 5 | 4.81 | 5 | 143.40 ** | 5 | 0.00 | 5 | 23.64 ** | 5 | 9.16 | 15 | 6.82 | 15 | 200.50 ** |
| Within nursery lakes | 12 | 0.00 | 6 | 1.37 | 6 | 8.05 | 6 | 0.00 | 6 | 11.16 | 6 | 5.54 | 18 | 0.00 | 18 | 7.52 |
| Chelatna Lake | 2 | 0.00 | 1 | 0.00 | 1 | 0.01 | 1 | 0.00 | 1 | 0.00 | 1 | 4.15 * | 3 | 0.00 | 3 | 1.68 |
| Yentna River, west fork | 2 | 0.00 | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 1 | 0.05 | 1 | 0.00 | 3 | 0.00 | 3 | 0.45 |
| Hewitt / Whiskey Lakes | 2 | 0.00 | 1 | 1.37 | 1 | 2.02 | 1 | 0.00 | 1 | 5.15 * | 1 | 0.00 | 3 | 0.00 | 3 | 0.75 |
| Shell Lake | 2 | 0.00 | 1 | 0.00 | 1 | 5.52 * | 1 | 0.00 | 1 | 0.21 | 1 | 0.00 | 3 | 0.00 | 3 | 1.03 |
| Trinity / Movie Lakes | 2 | 0.00 | 1 | 0.00 | 1 | 0.02 | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 3 | 0.00 | 3 | 1.42 |
| Judd Lake | 2 | 0.00 | 1 | 0.00 | 1 | 0.48 | 1 | 0.00 | 1 | 5.75 * | 1 | 1.39 | 3 | 0.00 | 3 | 2.19 |
| Susitna River | 14 | 22.82 | 7 | 0.00 | 7 | 83.22 ** | 7 | 0.00 | 7 | 35.98 ** | 7 | 0.00 | 21 | 14.07 | 21 | 118.37 ** |
| Among nursery lakes | 10 | 20.58 * | 5 | 0.00 | 5 | 80.53 ** | 5 | 0.00 | 5 | 29.75 ** | 5 | 0.00 | 15 | 12.27 | 15 | 111.90 ** |
| Within nursery lakes | 4 | 2.24 | 2 | 0.00 | 2 | 2.69 | 2 | 0.00 | 2 | 6.23 * | 2 | 0.00 | 6 | 1.80 | 6 | 6.47 |
| Stephan Lake | 2 | 2.24 | 1 | 0.00 | 1 | 0.40 | 1 | 0.00 | 1 | 2.24 | 1 | 0.00 | 3 | 1.80 | 3 | 4.85 |
| Larson Lake | 2 | 0.00 | 1 | 0.00 | 1 | 2.29 | 1 | 0.00 | 1 | 3.99 * | 1 | 0.00 | 3 | 0.00 | 3 | 1.62 |
| Western Cook Inlet | 24 | 0.00 | 12 | 10.97 | 12 | 46.58 ** | 12 | 11.01 | 12 | 155.46 ** | 12 | 0.00 | 36 | 9.88 | 36 | 370.57 ** |
| Among nursery lakes | 10 | 0.00 | 5 | 8.19 | 5 | 33.26 ** | 5 | 11.01 | 5 | 127.80 ** | 5 | 0.00 | 15 | 9.88 | 15 | 339.50 ** |
| Within nursery lakes | 14 | 0.00 | 7 | 2.78 | 7 | 13.32 | 7 | 0.00 | 7 | 27.66 ** | 7 | 0.00 | 21 | 0.00 | 21 | 31.07 |
| Crescent Lake | 10 | 0.00 | 5 | 0.00 | 5 | 11.96 * | 5 | 0.00 | 5 | 25.51 ** | 5 | 0.00 | 15 | 0.00 | 15 | 23.26 |
| Coal Creek | 2 | 0.00 | 1 | 2.78 | 1 | 0.39 | 1 | 0.00 | 1 | 1.92 | 1 | 0.00 | 3 | 0.00 | 3 | 7.26 |
| Chilligan River | 2 | 0.00 | 1 | 0.00 | 1 | 0.97 | 1 | 0.00 | 1 | 0.23 | 1 | 0.00 | 3 | 0.00 | 3 | 0.55 |
| Kasilof River | 22 | 0.00 | 11 | 4.75 | 11 | 14.61 | 11 | 4.82 | 11 | 15.74 | 11 | 0.00 | 33 | 8.20 | 33 | 18.27 |
| Northeast Cook Inlet | 4 | 0.00 | 2 | 0.00 | 2 | 47.09 ** | 2 | 2.17 | 2 | 4.39 | 2 | 0.00 | 6 | 11.25 | 6 | 37.87 ** |
| Among nursery lakes | 2 | 0.00 | 1 | 0.00 | 1 | 44.10 ** | 1 | 0.79 | 1 | 1.62 | 1 | 0.00 | 3 | 9.85 * | 3 | 33.85 ** |
| Within nursery lakes | 2 | 0.00 | 1 | 0.00 | 1 | 2.99 | 1 | 1.38 | 1 | 2.77 | 1 | 0.00 | 3 | 1.40 | 3 | 4.02 |
| Daniels Lake | 2 | 0.00 | 1 | 0.00 | 1 | 2.99 | 1 | 1.38 | 1 | 2.77 | 1 | 0.00 | 3 | 1.40 | 3 | 4.02 |
| Knik Arm | 8 | 0.00 | 4 | 0.00 | 4 | 16.94 ** | 4 | 0.00 | 4 | 32.75 ** | 4 | 0.00 | 12 | 0.00 | 12 | 43.55 ** |
| Among nursery lakes | 4 | 0.00 | 2 | 0.00 | 2 | 8.44 * | 2 | 0.00 | 2 | 28.52 ** | 2 | 0.00 | 6 | 0.00 | 6 | 32.60 ** |
| Within nursery lakes | 4 | 0.00 | 2 | 0.00 | 2 | 8.50 * | 2 | 0.00 | 2 | 4.23 | 2 | 0.00 | 6 | 0.00 | 6 | 10.95 |
| Fish Creek | 4 | 0.00 | 2 | 0.00 | 2 | 8.50 * | 2 | 0.00 | 2 | 4.23 | 2 | 0.00 | 6 | 0.00 | 6 | 10.95 |

Table 3. Continued

| Populations | DF | *CK-A2* | DF | *CK-B* | DF | *FDH* | DF | *GAPDH-2* | DF | *G3PDH-1,2* | DF | *G3PDH-4* | DF | *GPI-B1,2* | DF | *GPI-A* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Among regions | 6 | 11.21 | 6 | 9.14 | 6 | 3.84 | 12 | 70.65 ** | 18 | 22.11 | 6 | 78.98 ** | 12 | 372.77 ** | 12 | 50.23 ** |
| Within regions | 77 | 41.09 | 77 | 17.28 | 77 | 10.68 | 154 | 133.46 | 231 | 50.73 | 77 | 17.80 | 154 | 89.94 | 154 | 66.59 |
| Kenai River | 30 | 36.35 | 30 | 6.75 | 30 | 10.68 | 60 | 87.74 * | 90 | 44.42 | 30 | 0.00 | 60 | 33.80 | 60 | 48.86 |
| Among nursery lakes | 4 | 4.75 | 4 | 4.56 | 4 | 1.30 | 8 | 50.81 ** | 12 | 13.44 | 4 | 0.00 | 8 | 7.64 | 8 | 24.23 ** |
| Within nursery lakes | 26 | 31.60 | 26 | 2.19 | 26 | 9.38 | 52 | 36.93 | 78 | 30.98 | 26 | 0.00 | 52 | 26.16 | 52 | 24.63 |
| Upper Russian Lake | 2 | 0.00 | 2 | 2.19 | 2 | 0.00 | 4 | 2.21 | 6 | 0.00 | 2 | 0.00 | 4 | 0.00 | 4 | 0.00 |
| Kenai / Skilak Lakes | 21 | 31.60 | 21 | 0.00 | 21 | 9.38 | 42 | 33.37 | 63 | 30.17 | 21 | 0.00 | 42 | 24.42 | 42 | 24.43 |
| Tern Lake | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 3 | 0.81 | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 |
| Hidden Lake | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 1.35 | 3 | 0.00 | 1 | 0.00 | 2 | 0.34 | 2 | 0.20 |
| Trail Lake (Moose Ck.) | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 3 | 0.00 | 1 | 0.00 | 2 | 1.40 | 2 | 0.00 |
| Yentna River | 11 | 0.00 | 11 | 0.00 | 11 | 0.00 | 22 | 0.00 | 33 | 0.00 | 11 | 0.00 | 22 | 0.00 | 22 | 0.00 |
| Among nursery lakes | 5 | 0.00 | 5 | 0.00 | 5 | 0.00 | 10 | 0.00 | 15 | 0.00 | 5 | 0.00 | 10 | 0.00 | 10 | 0.00 |
| Within nursery lakes | 6 | 0.00 | 6 | 0.00 | 6 | 0.00 | 12 | 0.00 | 18 | 0.00 | 6 | 0.00 | 12 | 0.00 | 12 | 0.00 |
| Chelatna Lake | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 3 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 |
| Yentna River, west fork | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 3 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 |
| Hewitt / Whiskey Lakes | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 3 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 |
| Shell Lake | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 3 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 |
| Trinity / Movie Lakes | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 3 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 |
| Judd Lake | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 3 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 |
| Susitna River | 7 | 0.00 | 7 | 0.00 | 7 | 0.00 | 14 | 37.41 ** | 21 | 0.00 | 7 | 0.00 | 14 | 7.01 | 14 | 0.00 |
| Among nursery lakes | 5 | 0.00 | 5 | 0.00 | 5 | 0.00 | 10 | 37.24 ** | 15 | 0.00 | 5 | 0.00 | 10 | 5.62 | 10 | 0.00 |
| Within nursery lakes | 2 | 0.00 | 2 | 0.00 | 2 | 0.00 | 4 | 0.17 | 6 | 0.00 | 2 | 0.00 | 4 | 1.39 | 4 | 0.00 |
| Stephan Lake | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.17 | 3 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 |
| Larson Lake | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 3 | 0.00 | 1 | 0.00 | 2 | 1.39 | 2 | 0.00 |
| Western Cook Inlet | 12 | 0.00 | 12 | 0.00 | 12 | 0.00 | 24 | 3.53 | 36 | 6.31 | 12 | 0.00 | 24 | 4.96 | 24 | 0.00 |
| Among nursery lakes | 5 | 0.00 | 5 | 0.00 | 5 | 0.00 | 10 | 1.93 | 15 | 1.93 | 5 | 0.00 | 10 | 4.96 | 10 | 0.00 |
| Within nursery lakes | 7 | 0.00 | 7 | 0.00 | 7 | 0.00 | 14 | 1.60 | 21 | 4.38 | 7 | 0.00 | 14 | 0.00 | 14 | 0.00 |
| Crescent Lake | 5 | 0.00 | 5 | 0.00 | 5 | 0.00 | 10 | 1.60 | 15 | 4.38 | 5 | 0.00 | 10 | 0.00 | 10 | 0.00 |
| Coal Creek | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 3 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 |
| Chilligan River | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 3 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 |
| Kasilof River | 11 | 4.74 | 11 | 10.53 | 11 | 0.00 | 22 | 4.78 | 33 | 0.00 | 11 | 11.40 | 22 | 40.97 ** | 22 | 0.00 |
| Northeast Cook Inlet | 2 | 0.00 | 2 | 0.00 | 2 | 0.00 | 4 | 0.00 | 6 | 0.00 | 2 | 0.00 | 4 | 0.00 | 4 | 17.73 ** |
| Among nursery lakes | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 3 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 6.48 * |
| Within nursery lakes | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 3 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 11.25 ** |
| Daniels Lake | 1 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 3 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 11.25 ** |
| Knik Arm | 4 | 0.00 | 4 | 0.00 | 4 | 0.00 | 8 | 0.00 | 12 | 0.00 | 4 | 6.40 | 8 | 3.20 | 8 | 0.00 |
| Among nursery lakes | 2 | 0.00 | 2 | 0.00 | 2 | 0.00 | 4 | 0.00 | 6 | 0.00 | 2 | 2.06 | 4 | 1.01 | 4 | 0.00 |
| Within nursery lakes | 2 | 0.00 | 2 | 0.00 | 2 | 0.00 | 4 | 0.00 | 6 | 0.00 | 2 | 4.34 | 4 | 2.19 | 4 | 0.00 |
| Fish Creek | 2 | 0.00 | 2 | 0.00 | 2 | 0.00 | 4 | 0.00 | 6 | 0.00 | 2 | 4.34 | 4 | 2.19 | 4 | 0.00 |

Table 3. Continued

| Populations | DF | *mIDHP-1* | DF | *sIDHP-1* | DF | *sIDHP-2* | DF | *LDH-A2* | DF | *LDH-B2* | DF | *MDH-A1,2* | DF | *MDH-B1,2* | DF | *mMEP-1* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Among regions | 12 | 63.27 ** | 24 | 231.52 ** | 6 | 26.83 ** | 6 | 10.37 | 12 | 341.70 ** | 12 | 121.93 ** | 18 | 167.62 ** | 12 | 68.91 ** |
| Within regions | 154 | 42.37 | 308 | 220.76 | 77 | 71.82 | 77 | 37.03 | 154 | 710.17 ** | 154 | 141.90 | 231 | 216.73 | 154 | 74.54 |
| Kenai River | 60 | 5.36 | 120 | 80.32 | 30 | 71.82 ** | 30 | 6.84 | 60 | 373.01 ** | 60 | 107.13 ** | 90 | 32.23 | 60 | 5.31 |
| Among nursery lakes | 8 | 0.68 | 16 | 18.93 | 4 | 63.72 ** | 4 | 0.68 | 8 | 309.90 ** | 8 | 56.04 ** | 12 | 5.53 | 8 | 0.69 |
| Within nursery lakes | 52 | 4.68 | 104 | 61.39 | 26 | 8.10 | 26 | 6.16 | 52 | 63.11 | 52 | 51.09 | 78 | 26.70 | 52 | 4.62 |
| Upper Russian Lake | 4 | 0.00 | 8 | 0.00 | 2 | 0.00 | 2 | 0.00 | 4 | 26.14 ** | 4 | 0.00 | 6 | 1.62 | 4 | 0.00 |
| Kenai / Skilak Lakes | 42 | 4.68 | 84 | 58.62 | 21 | 6.07 | 21 | 6.16 | 42 | 35.70 | 42 | 51.09 | 63 | 25.08 | 42 | 4.62 |
| Tern Lake | 2 | 0.00 | 4 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.30 | 2 | 0.00 | 3 | 0.00 | 2 | 0.00 |
| Hidden Lake | 2 | 0.00 | 4 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.85 | 2 | 0.00 | 3 | 0.00 | 2 | 0.00 |
| Trail Lake (Moose Ck.) | 2 | 0.00 | 4 | 2.77 | 1 | 2.03 | 1 | 0.00 | 2 | 0.12 | 2 | 0.00 | 3 | 0.00 | 2 | 0.00 |
| Yentna River | 22 | 0.00 | 44 | 0.00 | 11 | 0.00 | 11 | 0.00 | 22 | 99.25 ** | 22 | 0.00 | 33 | 0.00 | 22 | 0.00 |
| Among nursery lakes | 10 | 0.00 | 20 | 0.00 | 5 | 0.00 | 5 | 0.00 | 10 | 88.95 ** | 10 | 0.00 | 15 | 0.00 | 10 | 0.00 |
| Within nursery lakes | 12 | 0.00 | 24 | 0.00 | 6 | 0.00 | 6 | 0.00 | 12 | 10.30 | 12 | 0.00 | 18 | 0.00 | 12 | 0.00 |
| Chelatna Lake | 2 | 0.00 | 4 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.38 | 2 | 0.00 | 3 | 0.00 | 2 | 0.00 |
| Yentna River, west fork | 2 | 0.00 | 4 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.68 | 2 | 0.00 | 3 | 0.00 | 2 | 0.00 |
| Hewitt / Whiskey Lakes | 2 | 0.00 | 4 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 2.83 | 2 | 0.00 | 3 | 0.00 | 2 | 0.00 |
| Shell Lake | 2 | 0.00 | 4 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 3 | 0.00 | 2 | 0.00 |
| Trinity / Movie Lakes | 2 | 0.00 | 4 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 4.93 | 2 | 0.00 | 3 | 0.00 | 2 | 0.00 |
| Judd Lake | 2 | 0.00 | 4 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 1.48 | 2 | 0.00 | 3 | 0.00 | 2 | 0.00 |
| Susitna River | 14 | 0.00 | 28 | 97.06 ** | 7 | 0.00 | 7 | 0.00 | 14 | 25.68 * | 14 | 0.00 | 21 | 0.00 | 14 | 0.00 |
| Among nursery lakes | 10 | 0.00 | 20 | 97.04 ** | 5 | 0.00 | 5 | 0.00 | 10 | 21.12 * | 10 | 0.00 | 15 | 0.00 | 10 | 0.00 |
| Within nursery lakes | 4 | 0.00 | 8 | 0.02 | 2 | 0.00 | 2 | 0.00 | 4 | 4.56 | 4 | 0.00 | 6 | 0.00 | 4 | 0.00 |
| Stephan Lake | 2 | 0.00 | 4 | 0.02 | 1 | 0.00 | 1 | 0.00 | 2 | 4.37 | 2 | 0.00 | 3 | 0.00 | 2 | 0.00 |
| Larson Lake | 2 | 0.00 | 4 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.19 | 2 | 0.00 | 3 | 0.00 | 2 | 0.00 |
| Western Cook Inlet | 24 | 11.04 | 48 | 21.16 | 12 | 0.00 | 12 | 25.41 * | 24 | 114.49 ** | 24 | 0.00 | 36 | 177.69 ** | 24 | 64.45 ** |
| Among nursery lakes | 10 | 8.28 | 20 | 16.77 | 5 | 0.00 | 5 | 16.52 ** | 10 | 94.76 ** | 10 | 0.00 | 15 | 176.70 ** | 10 | 55.63 ** |
| Within nursery lakes | 14 | 2.76 | 28 | 4.39 | 7 | 0.00 | 7 | 8.89 | 14 | 19.73 | 14 | 0.00 | 21 | 0.99 | 14 | 8.82 |
| Crescent Lake | 10 | 0.00 | 20 | 4.39 | 5 | 0.00 | 5 | 0.00 | 10 | 14.27 | 10 | 0.00 | 15 | 0.00 | 10 | 8.82 |
| Coal Creek | 2 | 2.76 | 4 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 3.00 | 2 | 0.00 | 3 | 0.99 | 2 | 0.00 |
| Chilligan River | 2 | 0.00 | 4 | 0.00 | 1 | 0.00 | 1 | 8.89 ** | 2 | 2.46 | 2 | 0.00 | 3 | 0.00 | 2 | 0.00 |
| Kasilof River | 22 | 25.97 | 44 | 9.17 | 11 | 0.00 | 11 | 4.78 | 22 | 11.91 | 22 | 12.15 | 33 | 6.81 | 22 | 4.78 |
| Northeast Cook Inlet | 4 | 0.00 | 8 | 0.00 | 2 | 0.00 | 2 | 0.00 | 4 | 0.00 | 4 | 0.00 | 6 | 0.00 | 4 | 0.00 |
| Among nursery lakes | 2 | 0.00 | 4 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 3 | 0.00 | 2 | 0.00 |
| Within nursery lakes | 2 | 0.00 | 4 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 3 | 0.00 | 2 | 0.00 |
| Daniels Lake | 2 | 0.00 | 4 | 0.00 | 1 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 3 | 0.00 | 2 | 0.00 |
| Knik Arm | 8 | 0.00 | 16 | 13.05 | 4 | 0.00 | 4 | 0.00 | 8 | 85.83 ** | 8 | 22.62 ** | 12 | 0.00 | 8 | 0.00 |
| Among nursery lakes | 4 | 0.00 | 8 | 12.47 | 2 | 0.00 | 2 | 0.00 | 4 | 74.76 ** | 4 | 7.16 | 6 | 0.00 | 4 | 0.00 |
| Within nursery lakes | 4 | 0.00 | 8 | 0.58 | 2 | 0.00 | 2 | 0.00 | 4 | 11.07 * | 4 | 15.46 ** | 6 | 0.00 | 4 | 0.00 |
| Fish Creek | 4 | 0.00 | 8 | 0.58 | 2 | 0.00 | 2 | 0.00 | 4 | 11.07 * | 4 | 15.46 ** | 6 | 0.00 | 4 | 0.00 |

Table 3. Continued

| Populations | DF | *MPI* | DF | *PEPA* | DF | *PEPB-1* | DF | *PEPC* | DF | *PEPD-1* | DF | *PEPLT* | DF | *PGDH* | DF | *PGM-1* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Among regions | 6 | 28.92 ** | 12 | 95.31 ** | 12 | 184.06 ** | 6 | 437.78 ** | 12 | 62.95 ** | 12 | 1061.90 ** | 6 | 7.49 | 12 | 515.14 ** |
| Within regions | 77 | 36.90 | 154 | 116.55 | 154 | 315.91 ** | 77 | 707.09 ** | 154 | 93.79 | 154 | 402.88 ** | 77 | 7.49 | 154 | 1522.25 ** |
| Kenai River | 30 | 36.90 | 60 | 100.65 ** | 60 | 99.73 ** | 30 | 53.90 ** | 60 | 63.37 | 60 | 252.75 ** | 30 | 0.00 | 60 | 663.67 ** |
| Among nursery lakes | 4 | 10.30 * | 8 | 36.56 ** | 8 | 56.10 ** | 4 | 9.65 * | 8 | 25.96 ** | 8 | 159.60 ** | 4 | 0.00 | 8 | 584.80 ** |
| Within nursery lakes | 26 | 26.60 | 52 | 64.09 | 52 | 43.63 | 26 | 44.25 * | 52 | 37.41 | 52 | 93.15 ** | 26 | 0.00 | 52 | 78.87 ** |
| Upper Russian Lake | 2 | 0.00 | 4 | 0.00 | 4 | 0.00 | 2 | 0.00 | 4 | 0.00 | 4 | 0.00 | 2 | 0.00 | 4 | 1.62 |
| Kenai / Skilak Lakes | 21 | 26.60 | 42 | 63.28 * | 42 | 41.39 | 21 | 37.82 * | 42 | 37.41 | 42 | 85.30 ** | 21 | 0.00 | 42 | 72.33 ** |
| Tern Lake | 1 | 0.00 | 2 | 0.81 | 2 | 0.92 | 1 | 2.19 | 2 | 0.00 | 2 | 5.80 | 1 | 0.00 | 2 | 1.92 |
| Hidden Lake | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.71 | 1 | 0.00 | 2 | 0.94 |
| Trail Lake (Moose Ck.) | 1 | 0.00 | 2 | 0.00 | 2 | 1.32 | 1 | 4.24 * | 2 | 0.00 | 2 | 1.34 | 1 | 0.00 | 2 | 2.06 |
| Yentna River | 11 | 0.00 | 22 | 0.00 | 22 | 216.18 ** | 11 | 398.64 ** | 22 | 9.60 | 22 | 35.85 * | 11 | 0.00 | 22 | 233.80 ** |
| Among nursery lakes | 5 | 0.00 | 10 | 0.00 | 10 | 215.70 ** | 5 | 385.50 ** | 10 | 6.82 | 10 | 33.38 ** | 5 | 0.00 | 10 | 228.90 ** |
| Within nursery lakes | 6 | 0.00 | 12 | 0.00 | 12 | 0.48 | 6 | 13.14 * | 12 | 2.78 | 12 | 2.47 | 6 | 0.00 | 12 | 4.90 |
| Chelatna Lake | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.66 |
| Yentna River, west fork | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 1 | 2.76 | 2 | 2.78 | 2 | 2.47 | 1 | 0.00 | 2 | 0.01 |
| Hewitt / Whiskey Lakes | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 1 | 0.48 | 2 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.90 |
| Shell Lake | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 2.85 |
| Trinity / Movie Lakes | 1 | 0.00 | 2 | 0.00 | 2 | 0.48 | 1 | 9.90 ** | 2 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.06 |
| Judd Lake | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.42 |
| Susitna River | 7 | 0.00 | 14 | 0.00 | 14 | 0.00 | 7 | 101.83 ** | 14 | 4.89 | 14 | 17.37 | 7 | 0.00 | 14 | 219.11 ** |
| Among nursery lakes | 5 | 0.00 | 10 | 0.00 | 10 | 0.00 | 5 | 100.40 ** | 10 | 4.89 | 10 | 17.37 | 5 | 0.00 | 10 | 213.50 ** |
| Within nursery lakes | 2 | 0.00 | 4 | 0.00 | 4 | 0.00 | 2 | 1.43 | 4 | 0.00 | 4 | 0.00 | 2 | 0.00 | 4 | 5.61 |
| Stephan Lake | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 1 | 0.05 | 2 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 |
| Larson Lake | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 1 | 1.38 | 2 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 5.61 |
| Western Cook Inlet | 12 | 0.00 | 24 | 4.94 | 24 | 0.00 | 12 | 91.84 ** | 24 | 4.93 | 24 | 4.90 | 12 | 7.49 | 24 | 350.53 ** |
| Among nursery lakes | 5 | 0.00 | 10 | 4.94 | 10 | 0.00 | 5 | 79.19 ** | 10 | 3.56 | 10 | 3.52 | 5 | 7.49 | 10 | 341.90 ** |
| Within nursery lakes | 7 | 0.00 | 14 | 0.00 | 14 | 0.00 | 7 | 12.65 | 14 | 1.37 | 14 | 1.38 | 7 | 0.00 | 14 | 8.63 |
| Crescent Lake | 5 | 0.00 | 10 | 0.00 | 10 | 0.00 | 5 | 6.04 | 10 | 0.00 | 10 | 0.00 | 5 | 0.00 | 10 | 1.45 |
| Coal Creek | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 1.37 | 2 | 1.38 | 1 | 0.00 | 2 | 3.49 |
| Chilligan River | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 1 | 6.61 * | 2 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 3.69 |
| Kasilof River | 11 | 0.00 | 22 | 10.96 | 22 | 0.00 | 11 | 41.75 ** | 22 | 7.80 | 22 | 0.00 | 11 | 0.00 | 22 | 11.60 |
| Northeast Cook Inlet | 2 | 0.00 | 4 | 0.00 | 4 | 0.00 | 2 | 0.00 | 4 | 0.00 | 4 | 2.34 | 2 | 0.00 | 4 | 0.99 |
| Among nursery lakes | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 2.29 | 1 | 0.00 | 2 | 0.13 |
| Within nursery lakes | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.05 | 1 | 0.00 | 2 | 0.86 |
| Daniels Lake | 1 | 0.00 | 2 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 2 | 0.05 | 1 | 0.00 | 2 | 0.86 |
| Knik Arm | 4 | 0.00 | 8 | 0.00 | 8 | 0.00 | 4 | 19.13 ** | 8 | 3.20 | 8 | 89.67 ** | 4 | 0.00 | 8 | 42.55 ** |
| Among nursery lakes | 2 | 0.00 | 4 | 0.00 | 4 | 0.00 | 2 | 13.02 ** | 4 | 1.02 | 4 | 89.21 ** | 2 | 0.00 | 4 | 40.58 ** |
| Within nursery lakes | 2 | 0.00 | 4 | 0.00 | 4 | 0.00 | 2 | 6.11 * | 4 | 2.18 | 4 | 0.46 | 2 | 0.00 | 4 | 1.97 |
| Fish Creek | 2 | 0.00 | 4 | 0.00 | 4 | 0.00 | 2 | 6.11 * | 4 | 2.18 | 4 | 0.46 | 2 | 0.00 | 4 | 1.97 |

Table 3. Continued

| Populations | DF | *PGM-2* | DF | *sSOD-1* | DF | *TPI-1,2* | DF | *TPI-3* | DF | *TPI-4* | DF | Overall |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Among regions | 12 | 904.25 ** | 6 | 3.74 | 12 | 30.02 ** | 6 | 63.45 ** | 12 | 11.42 | 384 | 8186.30 ** |
| Within regions | 154 | 1270.81 ** | 77 | 4.93 | 154 | 31.03 | 77 | 82.87 | 154 | 28.21 | 4928 | 12067.73 ** |
| Kenai River | 60 | 279.10 ** | 30 | 0.00 | 60 | 0.00 | 30 | 13.69 | 60 | 23.14 | 1920 | 6477.84 ** |
| Among nursery lakes | 8 | 223.70 ** | 4 | 0.00 | 8 | 0.00 | 4 | 2.05 | 8 | 17.16 * | 256 | 5120.00 ** |
| Within nursery lakes | 52 | 55.40 | 26 | 0.00 | 52 | 0.00 | 26 | 11.64 | 52 | 5.98 | 1664 | 1357.84 |
| Upper Russian Lake | 4 | 5.05 | 2 | 0.00 | 4 | 0.00 | 2 | 0.00 | 4 | 0.00 | 128 | 104.94 |
| Kenai / Skilak Lakes | 42 | 43.39 | 21 | 0.00 | 42 | 0.00 | 21 | 11.64 | 42 | 1.60 | 1344 | 1186.74 |
| Tern Lake | 2 | 0.91 | 1 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 1.60 | 64 | 26.47 |
| Hidden Lake | 2 | 4.18 | 1 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 64 | 13.10 |
| Trail Lake (Moose Ck.) | 2 | 1.87 | 1 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 2.78 | 64 | 26.59 |
| Yentna River | 22 | 714.02 ** | 11 | 0.00 | 22 | 0.00 | 11 | 0.00 | 22 | 0.00 | 704 | 2129.20 ** |
| Among nursery lakes | 10 | 705.70 ** | 5 | 0.00 | 10 | 0.00 | 5 | 0.00 | 10 | 0.00 | 320 | 2053.00 ** |
| Within nursery lakes | 12 | 8.32 | 6 | 0.00 | 12 | 0.00 | 6 | 0.00 | 12 | 0.00 | 384 | 76.20 |
| Chelatna Lake | 2 | 2.22 | 1 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 64 | 9.13 |
| Yentna River, west fork | 2 | 0.05 | 1 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 64 | 9.27 |
| Hewitt / Whiskey Lakes | 2 | 0.02 | 1 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 64 | 13.56 |
| Shell Lake | 2 | 0.85 | 1 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 64 | 10.48 |
| Trinity / Movie Lakes | 2 | 0.11 | 1 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 64 | 16.95 |
| Judd Lake | 2 | 5.07 | 1 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 64 | 16.81 |
| Susitna River | 14 | 26.99 * | 7 | 0.00 | 14 | 0.00 | 7 | 0.00 | 14 | 0.00 | 448 | 812.00 ** |
| Among nursery lakes | 10 | 26.77 ** | 5 | 0.00 | 10 | 0.00 | 5 | 0.00 | 10 | 0.00 | 320 | 779.10 ** |
| Within nursery lakes | 4 | 0.22 | 2 | 0.00 | 4 | 0.00 | 2 | 0.00 | 4 | 0.00 | 128 | 32.90 |
| Stephan Lake | 2 | 0.18 | 1 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 64 | 16.36 |
| Larson Lake | 2 | 0.04 | 1 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 64 | 16.54 |
| Western Cook Inlet | 24 | 191.20 ** | 12 | 4.93 | 24 | 26.26 | 12 | 60.92 ** | 24 | 5.07 | 768 | 1786.55 ** |
| Among nursery lakes | 10 | 181.20 ** | 5 | 4.93 | 10 | 24.92 ** | 5 | 42.79 ** | 10 | 3.61 | 320 | 1605.00 ** |
| Within nursery lakes | 14 | 10.00 | 7 | 0.00 | 14 | 1.34 | 7 | 18.13 * | 14 | 1.46 | 448 | 181.55 |
| Crescent Lake | 10 | 7.12 | 5 | 0.00 | 10 | 0.00 | 5 | 18.13 ** | 10 | 0.00 | 320 | 127.05 |
| Coal Creek | 2 | 2.48 | 1 | 0.00 | 2 | 1.34 | 1 | 0.00 | 2 | 1.46 | 64 | 30.68 |
| Chilligan River | 2 | 0.40 | 1 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 64 | 23.82 |
| Kasilof River | 22 | 10.60 | 11 | 0.00 | 22 | 4.77 | 11 | 8.26 | 22 | 0.00 | 704 | 310.36 |
| Northeast Cook Inlet | 4 | 4.65 | 2 | 0.00 | 4 | 0.00 | 2 | 0.00 | 4 | 0.00 | 128 | 128.54 |
| Among nursery lakes | 2 | 1.78 | 1 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 64 | 100.90 ** |
| Within nursery lakes | 2 | 2.87 | 1 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 64 | 27.64 |
| Daniels Lake | 2 | 2.87 | 1 | 0.00 | 2 | 0.00 | 1 | 0.00 | 2 | 0.00 | 64 | 27.64 |
| Knik Arm | 8 | 44.25 ** | 4 | 0.00 | 8 | 0.00 | 4 | 0.00 | 8 | 0.00 | 256 | 423.24 ** |
| Among nursery lakes | 4 | 34.19 ** | 2 | 0.00 | 4 | 0.00 | 2 | 0.00 | 4 | 0.00 | 128 | 345.10 ** |
| Within nursery lakes | 4 | 10.06 * | 2 | 0.00 | 4 | 0.00 | 2 | 0.00 | 4 | 0.00 | 128 | 78.14 |
| Fish Creek | 4 | 10.06 * | 2 | 0.00 | 4 | 0.00 | 2 | 0.00 | 4 | 0.00 | 128 | 78.14 |

* Test is significant at $\alpha$=0.05.
** Test is significant at $\alpha$=0.01.

Table 4. Gene diversity analysis of Cook Inlet sockeye salmon.

| | Absolute gene diversity | | Percent relative diversity | | | |
|---|---|---|---|---|---|---|
| Locus | Total | Within sites | Within sites | Among sites within nurseries | Among nuseries within regions | Among regions |
| *sAAT-3** | 0.0007 | 0.0007 | 99.57 | 0.01 | 0.35 | 0.07 |
| *mAAT-1** | 0.1706 | 0.1580 | 92.82 | 0.45 | 4.07 | 2.66 |
| *mAAT-2** | 0.0281 | 0.0238 | 84.75 | 0.75 | 11.66 | 2.83 |
| *mAH-4** | 0.0009 | 0.0008 | 99.23 | 0.00 | 0.70 | 0.07 |
| *sAH** | 0.0720 | 0.0299 | 41.55 | 0.14 | 51.09 | 7.22 |
| *ALAT** | 0.5315 | 0.4869 | 91.60 | 0.35 | 5.22 | 2.83 |
| *CK-A2** | 0.0008 | 0.0008 | 98.78 | 1.11 | 0.05 | 0.06 |
| *CK-B** | 0.0004 | 0.0004 | 99.40 | 0.51 | 0.03 | 0.06 |
| *FDH** | 0.0002 | 0.0002 | 99.79 | 0.18 | 0.01 | 0.02 |
| *GAPDH-* | 0.0049 | 0.0048 | 97.55 | 0.19 | 1.94 | 0.32 |
| *G3PDH-* | 0.0023 | 0.0023 | 98.95 | 0.46 | 0.01 | 0.57 |
| *GPI-A** | 0.0021 | 0.0021 | 98.48 | 0.42 | 0.69 | 0.41 |
| *mIDHP-* | 0.0018 | 0.0018 | 99.13 | 0.48 | 0.09 | 0.30 |
| *sIDHP-1** | 0.0112 | 0.0105 | 93.72 | 0.21 | 5.25 | 0.82 |
| *sIDHP-2** | 0.0015 | 0.0014 | 97.04 | 0.02 | 2.79 | 0.16 |
| *LDH-A2** | 0.0007 | 0.0007 | 98.97 | 0.05 | 0.89 | 0.10 |
| *LDH-B2** | 0.1755 | 0.1588 | 90.46 | 1.00 | 5.93 | 2.61 |
| *mMEP-1** | 0.0030 | 0.0029 | 96.38 | 0.39 | 2.58 | 0.66 |
| *MPI** | 0.0019 | 0.0019 | 99.18 | 0.47 | 0.15 | 0.20 |
| *PEPA** | 0.0061 | 0.0060 | 98.73 | 0.60 | 0.29 | 0.38 |
| *PEPB-1** | 0.0099 | 0.0089 | 89.49 | 0.16 | 9.00 | 1.35 |
| *PEPC** | 0.0588 | 0.0523 | 88.86 | 0.11 | 8.17 | 2.86 |
| *PEPD-1** | 0.0072 | 0.0070 | 98.49 | 0.54 | 0.47 | 0.49 |
| *PEPLT** | 0.0465 | 0.0398 | 85.62 | 0.09 | 2.48 | 11.81 |
| *PGDH** | 0.0002 | 0.0002 | 99.46 | 0.00 | 0.48 | 0.06 |
| *PGM-2** | 0.4033 | 0.3494 | 86.63 | 0.21 | 6.86 | 6.30 |
| *sSOD-1** | 0.0002 | 0.0002 | 99.51 | 0.00 | 0.44 | 0.05 |
| *TPI-3** | 0.0042 | 0.0041 | 97.07 | 1.19 | 1.20 | 0.54 |
| *TPI-4** | 0.0006 | 0.0006 | 99.49 | 0.00 | 0.47 | 0.04 |
| Overall | 1.5469 | 1.3573 | 87.74 | 0.38 | 7.80 | 4.08 |

Table 5. Results of simulated mixtures of Cook Inlet sockeye salmon from the adjusted 1995 baseline with 100 bootstrap resamplings and a simulated sample size of 400. Standard deviations are given in parentheses; row totals equal 1.000. Allocations to correct regions are in bold.

| Region | Regional Allocation | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Kenai | Kasilof | Yentna | Susitna | West Cook Inlet | NE Cook Inlet | Knik Arm | Unknown[1] |
| Kenai | **0.913** | 0.011 | 0.016 | 0.021 | 0.026 | 0.001 | 0.011 | 0.001 |
| | **(0.049)** | (0.018) | (0.021) | (0.028) | (0.029) | (0.003) | (0.022) | |
| Kasilof | 0.025 | **0.917** | 0.011 | 0.014 | 0.028 | 0.000 | 0.004 | 0.000 |
| | (0.024) | **(0.042)** | (0.017) | (0.020) | (0.032) | (0.000) | (0.008) | |
| Yentna | 0.007 | 0.002 | **0.883** | 0.060 | 0.027 | 0.002 | 0.019 | 0.001 |
| | (0.013) | (0.006) | **(0.065)** | (0.047) | (0.034) | (0.004) | (0.027) | |
| Susitna | 0.005 | 0.012 | 0.091 | **0.773** | 0.078 | 0.003 | 0.038 | 0.001 |
| | (0.011) | (0.024) | (0.063) | **(0.104)** | (0.069) | (0.005) | (0.048) | |
| Yentna/Susitna | 0.008 | 0.007 | | **0.874** | 0.072 | 0.001 | 0.037 | 0.000 |
| | (0.012) | (0.015) | | **(0.072)** | (0.066) | (0.003) | (0.049) | |
| West Cook Inlet | 0.021 | 0.013 | 0.027 | 0.053 | **0.857** | 0.000 | 0.029 | 0.000 |
| | (0.022) | (0.020) | (0.030) | (0.048) | **(0.066)** | (0.001) | (0.042) | |
| Northeastern Cook Inlet | 0.003 | 0.002 | 0.006 | 0.004 | 0.002 | **0.988** | 0.001 | 0.000 |
| | (0.004) | (0.007) | (0.002) | (0.006) | (0.006) | **(0.011)** | (0.003) | |
| Knik Arm | 0.009 | 0.003 | 0.021 | 0.046 | 0.037 | 0.003 | **0.881** | 0.000 |
| | (0.016) | (0.007) | (0.024) | (0.038) | (0.033) | (0.006) | **(0.059)** | |

[1] Genotypes in this category have a probability of less than $1.0\times10^{-10}$ of belonging to any population in the baseline.

Table 6. Results of Cook Inlet Central District drift and set-net fishery mixed-stock analysis, 1992-1995.

| Date | N | Kenai | | Kasilof | | Susitna/Yentna | | W. Cook Inlet | | NE. Cook Inlet | | Knik Arm | | Unknown[1] | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Estimate | SD | Estimate | SD | Estimate | SD | Estimate | SD | Estimate | SD | Estimate | SD | | |
| **1992**[2] | | | | | | | | | | | | | | | |
| July 13, 1992 | 150 | 0.8819 | 0.0772 | 0.0000 | 0.0000 | 0.0964 | 0.0654 | 0.0217 | 0.0460 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 |
| July 20, 1992 | 200 | 0.5643 | 0.0922 | 0.1038 | 0.0618 | 0.2093 | 0.0804 | 0.0691 | 0.0434 | 0.0115 | 0.0183 | 0.0419 | 0.0637 | 0.0000 | 1.0000 |
| **1993**[2] | | | | | | | | | | | | | | | |
| July 12, 1993 | 337 | 0.5185 | 0.0706 | 0.0344 | 0.0378 | 0.1461 | 0.0623 | 0.1438 | 0.0515 | 0.0000 | 0.0000 | 0.1394 | 0.0399 | 0.0178 | 0.9999 |
| July 16, 1993 | 278 | 0.8164 | 0.0835 | 0.0214 | 0.0551 | 0.0904 | 0.0600 | 0.0216 | 0.0189 | 0.0000 | 0.0000 | 0.0394 | 0.0354 | 0.0108 | 1.0000 |
| **1994** | | | | | | | | | | | | | | | |
| July 15, 1994 | 344 | 0.5304 | 0.0644 | 0.0480 | 0.0588 | 0.2112 | 0.0679 | 0.0794 | 0.0820 | 0.0093 | 0.0145 | 0.1216 | 0.0375 | 0.0000 | 0.9999 |
| **1995**[3] | | | | | | | | | | | | | | | |
| Drift gillnet Fishery | | | | | | | | | | | | | | | |
| July 3, 1995 | 298 | 0.1635 | 0.0523 | 0.4345 | 0.0755 | 0.1907 | 0.0791 | 0.0449 | 0.0422 | 0.0161 | 0.0139 | 0.1503 | 0.0417 | 0.0000 | 1.0000 |
| July 10, 1995 | 390 | 0.3216 | 0.0484 | 0.2113 | 0.0617 | 0.2927 | 0.0691 | 0.0688 | 0.0669 | 0.0000 | 0.0000 | 0.1055 | 0.0307 | 0.0000 | 1.0000 |
| July 17, 1995 | 394 | 0.4261 | 0.0537 | 0.2192 | 0.0611 | 0.0745 | 0.0488 | 0.1791 | 0.0629 | 0.0000 | 0.0000 | 0.1011 | 0.0270 | 0.0000 | 0.9999 |
| July 24, 1995 | 390 | 0.5521 | 0.0675 | 0.0454 | 0.0389 | 0.2987 | 0.0594 | 0.0390 | 0.0465 | 0.0000 | 0.0000 | 0.0623 | 0.0212 | 0.0026 | 1.0000 |
| July 31, 1995 | 298 | 0.8604 | 0.0612 | 0.0000 | 0.0000 | 0.0361 | 0.0397 | 0.0704 | 0.0636 | 0.0204 | 0.0117 | 0.0127 | 0.0241 | 0.0000 | 1.0001 |
| Set gillnet Fishery | | | | | | | | | | | | | | | |
| July 7, 1995 | 389 | 0.1629 | 0.0557 | 0.7766 | 0.0606 | 0.0459 | 0.0479 | 0.0032 | 0.0179 | 0.0115 | 0.0111 | 0.0000 | 0.0000 | 0.0000 | 1.0000 |
| July 20, 1995 | 297 | 0.9093 | 0.645 | 0.0164 | 0.0604 | 0.0341 | 0.0527 | 0.0330 | 0.0446 | 0.0000 | 0.0000 | 0.0072 | 0.0115 | 0.0000 | 1.0000 |

[1] Genotypes in this category have a probability of less than $1.0 \times 10^{-10}$ of belonging to any population in the baseline.

[2] *mAAT-2* and *G3PDH-4* were not used in mixed-stock analysis.

[3] *GPI-B1,2* was not used in mixed-stock analysis.

Table 7. Catch analysis for drift gillnet fisheries from Cook Inlet Central District that were sampled for sockeye salmon. Harvest, maximum likelihood estimates, catch estimates, and percent of Kenai River harvest are given.

| Date | Drift gillnet harvest | Relative Contribution Estimate | Relative Contribution SD | Catch Estimate | Catch SD | Percent of Kenai R. harvest |
|---|---|---|---|---|---|---|
| 3-Jul-95 | 48,490 | 0.1635 | 0.0523 | 7,928 | 2,536 | 2.1 |
| 10-Jul-95 | 225,621 | 0.3216 | 0.0484 | 72,560 | 10,920 | 18.1 |
| 17-Jul-95 | 462,625 | 0.4261 | 0.0537 | 197,125 | 24,843 | 49.3 |
| 24-Jul-95 | 133,462 | 0.5521 | 0.0675 | 73,684 | 9,009 | 18.4 |
| 31-Jul-95 | 56,522 | 0.8604 | 0.0612 | 48,632 | 3,459 | 12.2 |
| Total | 926,720 | | | 399,928 | | |

Table 8. Results of inriver mixed-stock analyses for Cook Inlet 1992-1995.

| | | Kenai | | Kasilof | | Susitna/Yentna | | W. Cook Inlet | | NE Cook Inlet | | Knik Arm | | Unknown[1] | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population | N | Estimate | SD | Estimate | SD | Estimate | SD | Estimate | SD | Estimate | SD | Estimate | SD | | |
| **Kenai River** | | | | | | | | | | | | | | | |
| July 13, 1992 | 199 | 0.8292 | 0.0602 | 0.0000 | 0.0000 | 0.0217 | 0.0357 | 0.1354 | 0.0518 | 0.0000 | 0.0000 | 0.0087 | 0.0121 | 0.0050 | 1.0000 |
| July 10, 1994 | 87 | 0.6325 | 0.2099 | 0.0489 | 0.1391 | 0.1661 | 0.1723 | 0.1525 | 0.1452 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 1.0000 |
| July 22, 1994 | 197 | 0.8406 | 0.0874 | 0.0896 | 0.0696 | 0.0646 | 0.0615 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0051 | 0.9999 |
| July 31, 1994 | 155 | 0.8339 | 0.0769 | 0.0000 | 0.0000 | 0.1567 | 0.0748 | 0.0000 | 0.0000 | 0.0077 | 0.0127 | 0.0016 | 0.0297 | 0.0000 | 0.9999 |
| August 9, 1994 | 192 | 0.9308 | 0.0672 | 0.0339 | 0.0543 | 0.0234 | 0.0516 | 0.0084 | 0.0107 | 0.0000 | 0.0000 | 0.0034 | 0.0145 | 0.0000 | 0.9999 |
| July 20, 1995 | 295 | 0.8885 | 0.0668 | 0.0000 | 0.0000 | 0.0493 | 0.0396 | 0.0622 | 0.0541 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 |
| July 26, 1995 | 298 | 0.9109 | 0.0494 | 0.0345 | 0.0222 | 0.0184 | 0.0402 | 0.0141 | 0.0170 | 0.0000 | 0.0000 | 0.0154 | 0.0168 | 0.0067 | 1.0000 |
| August 4, 1995 | 194 | 0.8632 | 0.0616 | 0.0000 | 0.0000 | 0.1357 | 0.0638 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0010 | 0.0156 | 0.0000 | 0.9999 |
| **Susitna River** | | | | | | | | | | | | | | | |
| Sunshine Sonar Site | | | | | | | | | | | | | | | |
| July 26, 1992 | 199 | 0.1282 | 0.0730 | 0.0000 | 0.0000 | 0.7500 | 0.1166 | 0.1168 | 0.1041 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0050 | 1.0000 |
| August 4, 1992 | 113 | 0.0355 | 0.0602 | 0.0000 | 0.0000 | 0.9226 | 0.0673 | 0.0101 | 0.0195 | 0.0000 | 0.0000 | 0.0052 | 0.0307 | 0.0265 | 0.9999 |
| **Yentna River** | | | | | | | | | | | | | | | |
| July 15, 1992 | 196 | 0.0759 | 0.0490 | 0.0000 | 0.0000 | 0.8104 | 0.0675 | 0.0000 | 0.0000 | 0.0235 | 0.0250 | 0.0749 | 0.0400 | 0.0153 | 1.0000 |
| July 24, 1992 | 200 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9591 | 0.0499 | 0.0216 | 0.0538 | 0.0027 | 0.0177 | 0.0116 | 0.0312 | 0.0050 | 1.0000 |
| July 25-26, 1994 | 199 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9819 | 0.0288 | 0.0005 | 0.0006 | 0.0000 | 0.0000 | 0.0176 | 0.0288 | 0.0000 | 1.0000 |
| **Kasilof River** | | | | | | | | | | | | | | | |
| July 2, 1992 | 196 | 0.0059 | 0.0091 | 0.9081 | 0.0717 | 0.0379 | 0.0427 | 0.0482 | 0.0631 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0001 |
| July 22, 1992 | 199 | 0.0000 | 0.0000 | 0.8485 | 0.065 | 0.0191 | 0.0220 | 0.1320 | 0.0629 | 0.0000 | 0.0000 | 0.0004 | 0.0057 | 0.0000 | 1.0000 |
| July 8-10, 1994 | 197 | 0.0913 | 0.0609 | 0.5484 | 0.1359 | 0.1013 | 0.0680 | 0.2589 | 0.1546 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9999 |
| July 17, 1994 | 180 | 0.0323 | 030556 | 0.8199 | 0.0822 | 0.1387 | 0.0937 | 0.0091 | 0.0277 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 |
| August 1-3, 1994 | 96 | 0.0471 | 0.0496 | 0.7999 | 0.1122 | 0.0823 | 0.0878 | 0.0000 | 0.0002 | 0.0000 | 0.0000 | 0.0707 | 0.0529 | 0.0000 | 1.0000 |

[1] Genotypes in this category have a probability of less than $1.0 \times 10^{-10}$ of belonging to any population in the baseline.

**List of Figures**

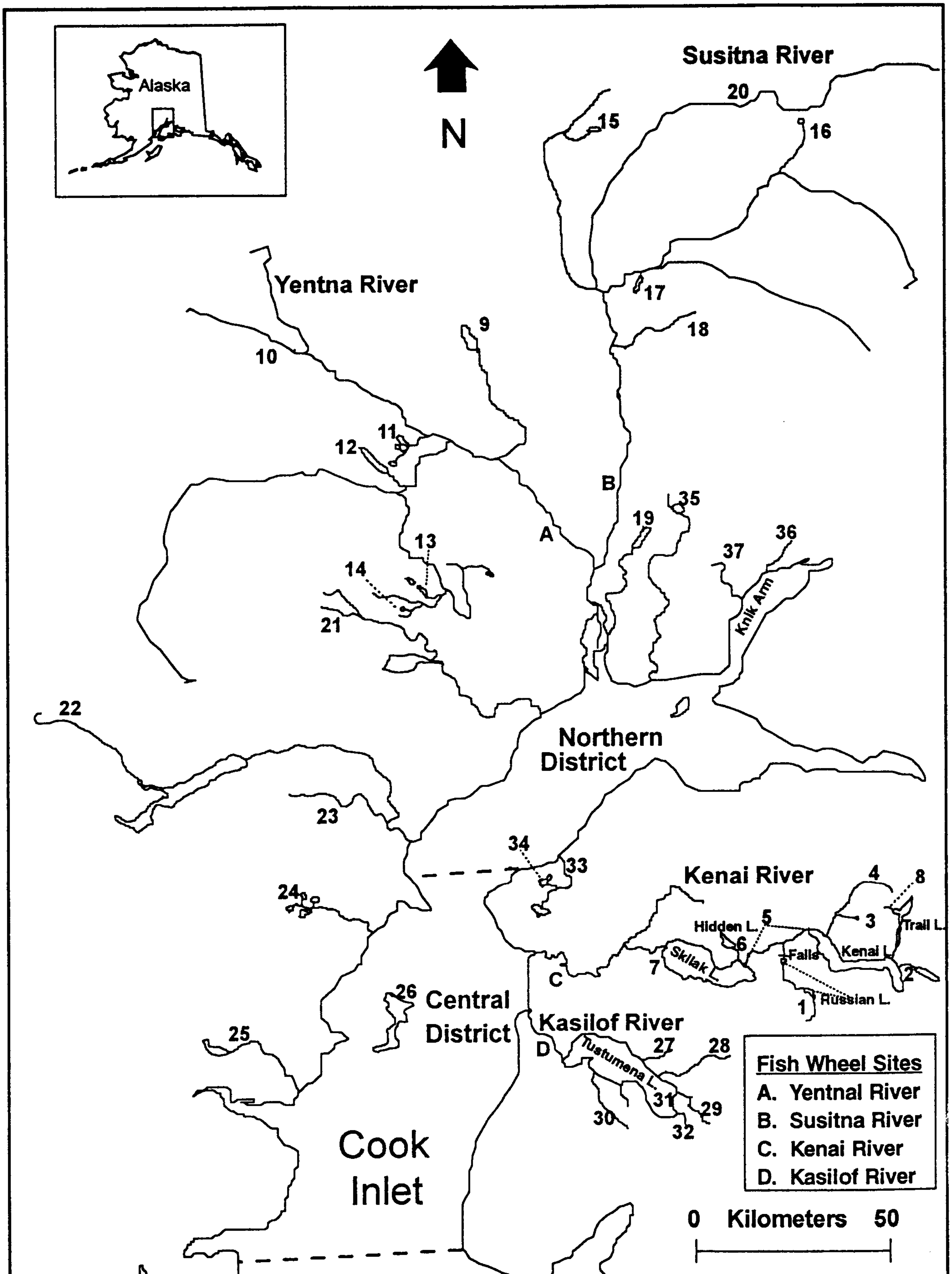


Figure 1. Sampling locations for sockeye salmon originating from Upper Cook Inlet, 1992-1995.

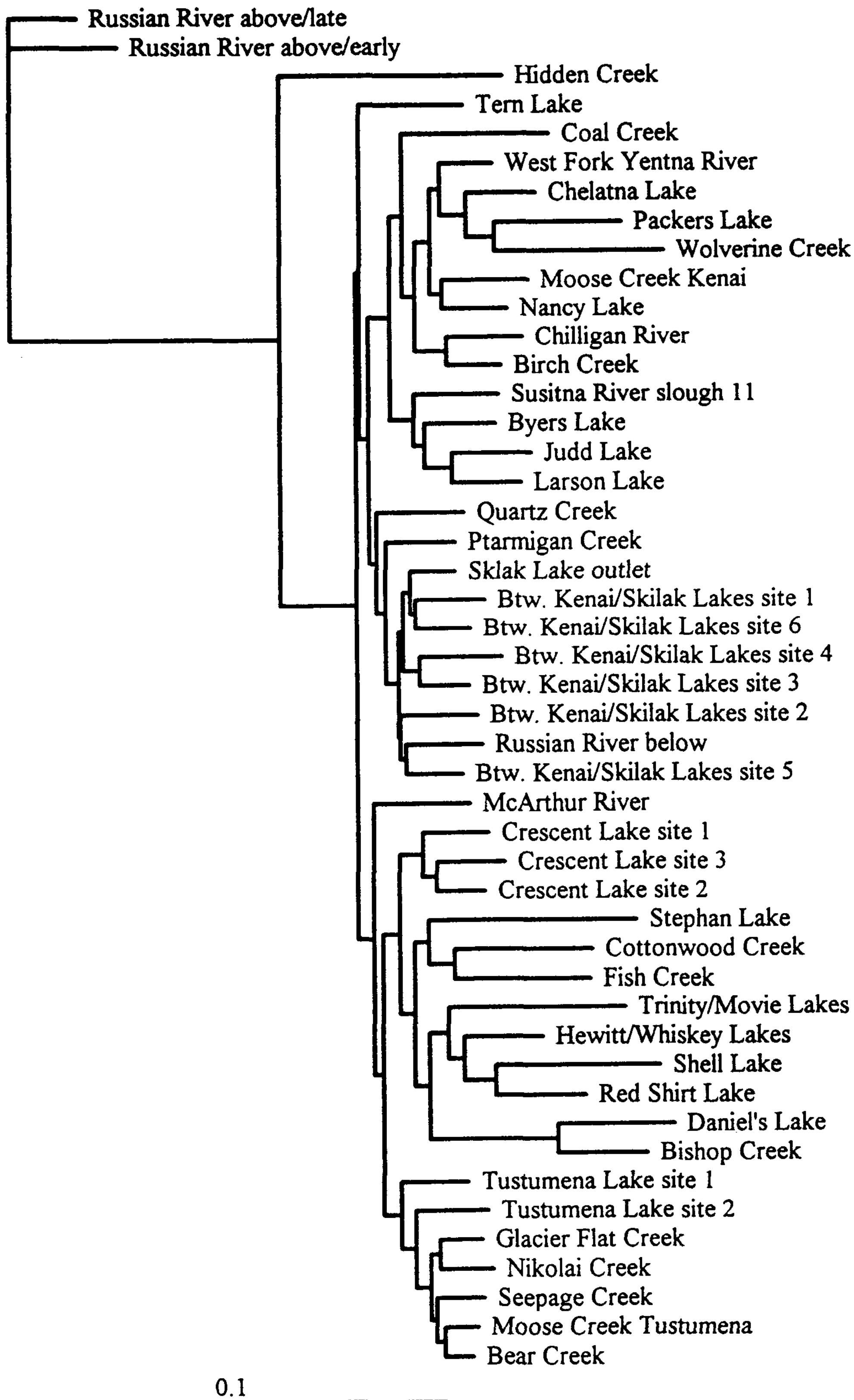


Figure 2. Neighboring-joining tree for Upper Cook Inlet sockeye salmon using Cavalli-Sforza and Edwards (1967) chord measure of genetic distance.

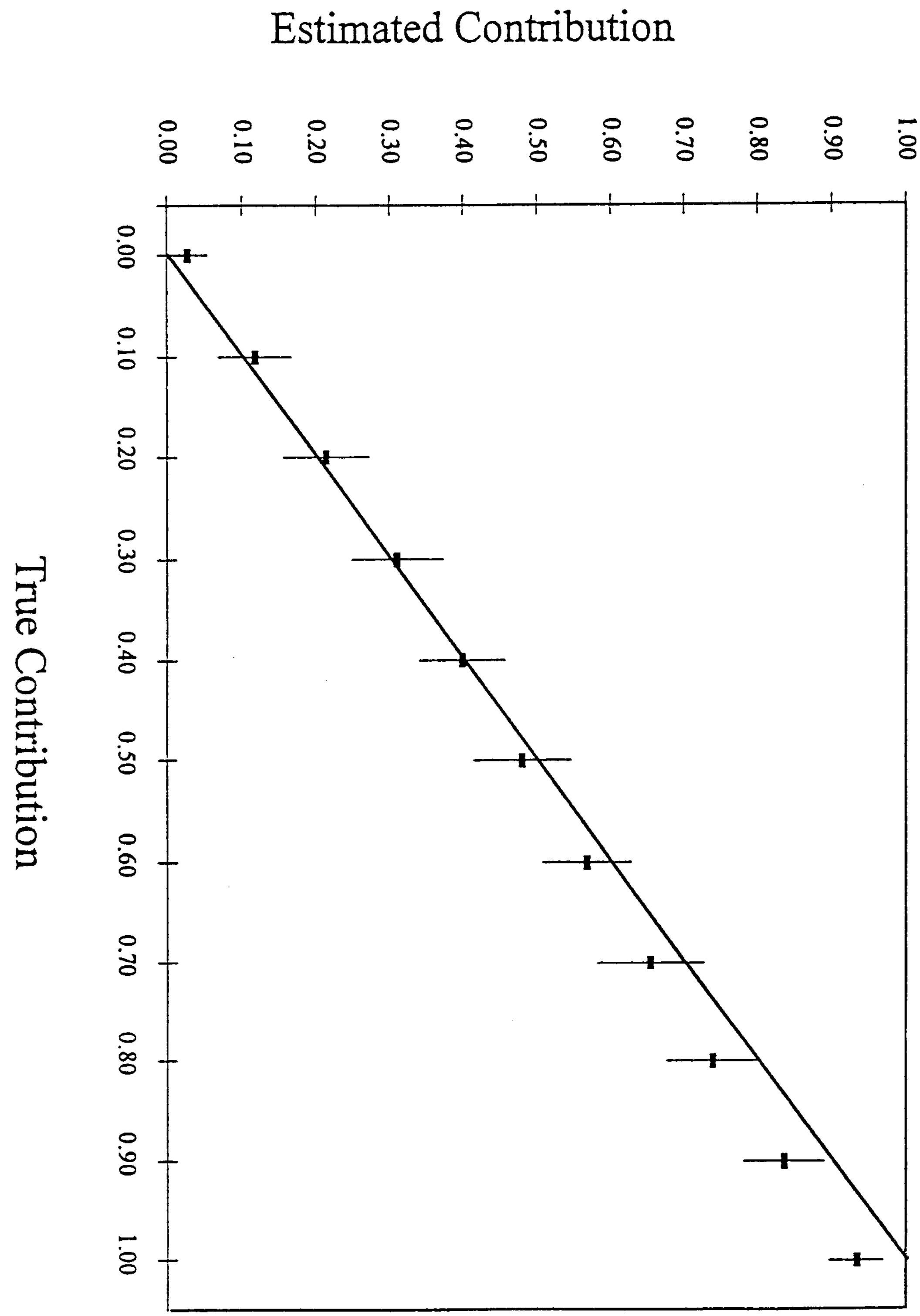


Figure 3. Estimated contributions to a simulated mixed-stock fishery in Cook Inlet with increasing contributions of Kenai River populations. The solid line represents the true contributions, and boxes are the estimated contributions with standard error lines included.

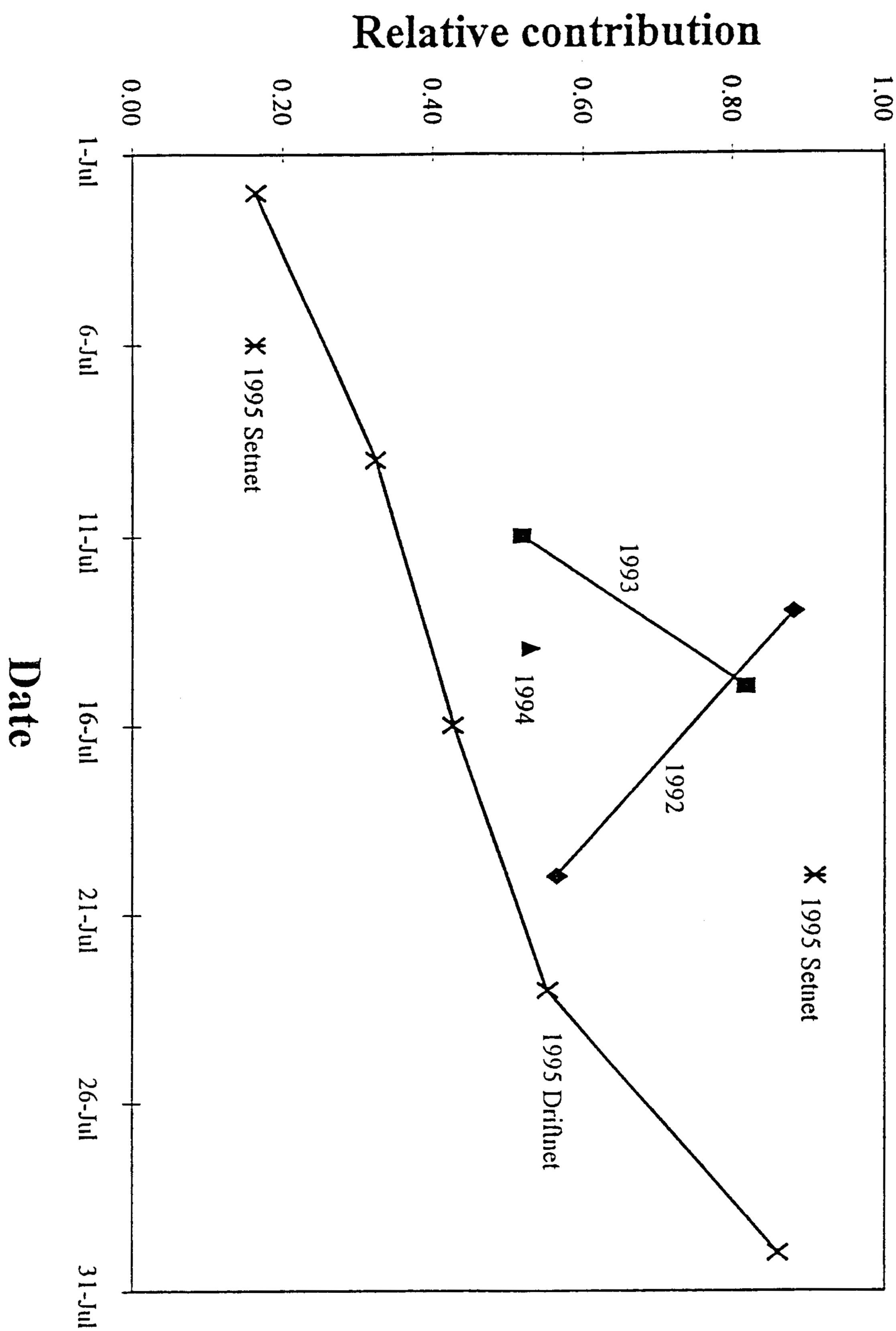


Figure 4. Relative contribution of Kenai River populations in the Cook Inlet Central District drift gillnet fisheries, 1992-1995, and the Eastside set gillnet fishery, 1995.

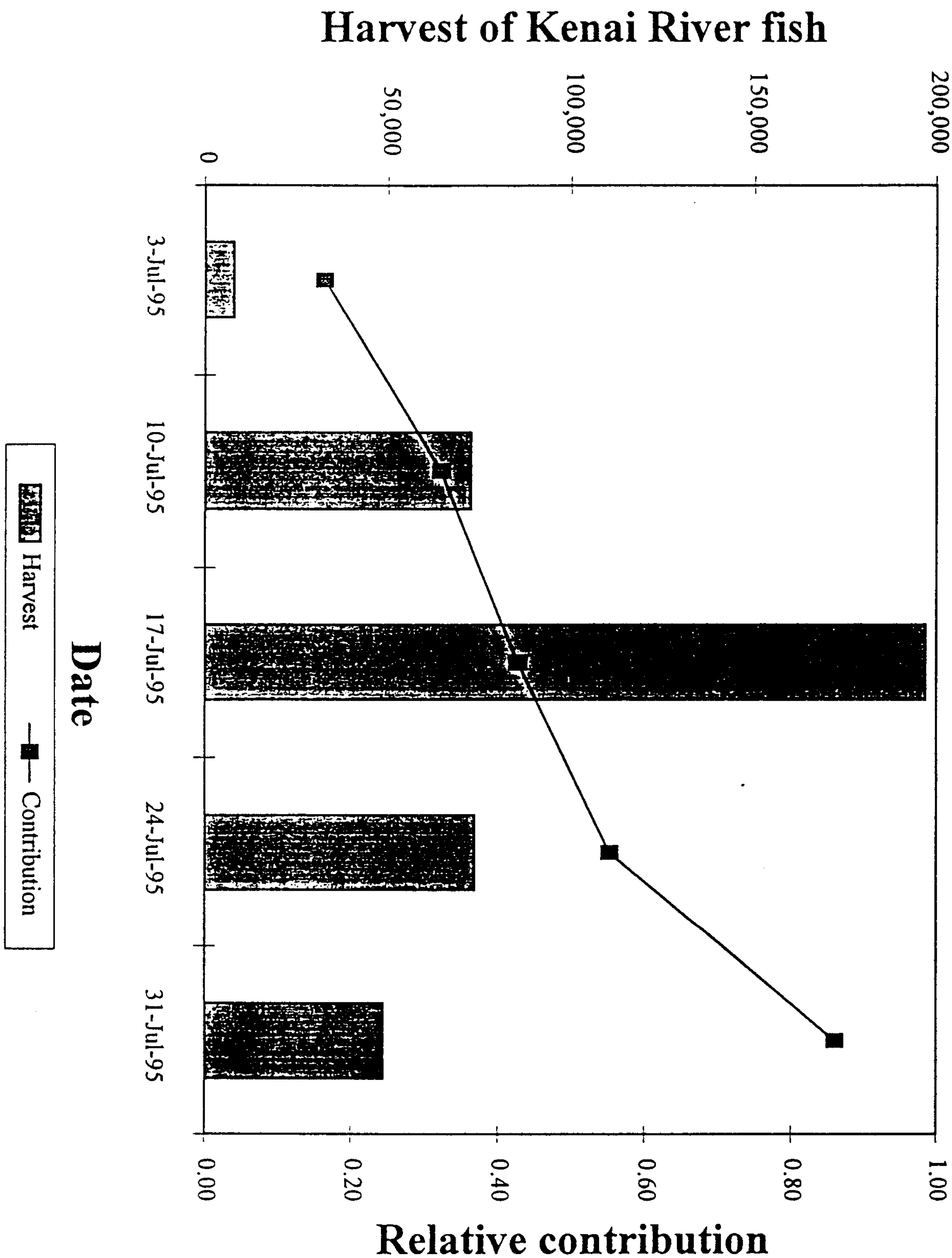


Figure 5. Relative contributions of sockeye salmon to the Cook Inlet Central District drift gillnet fisheries in 1995.

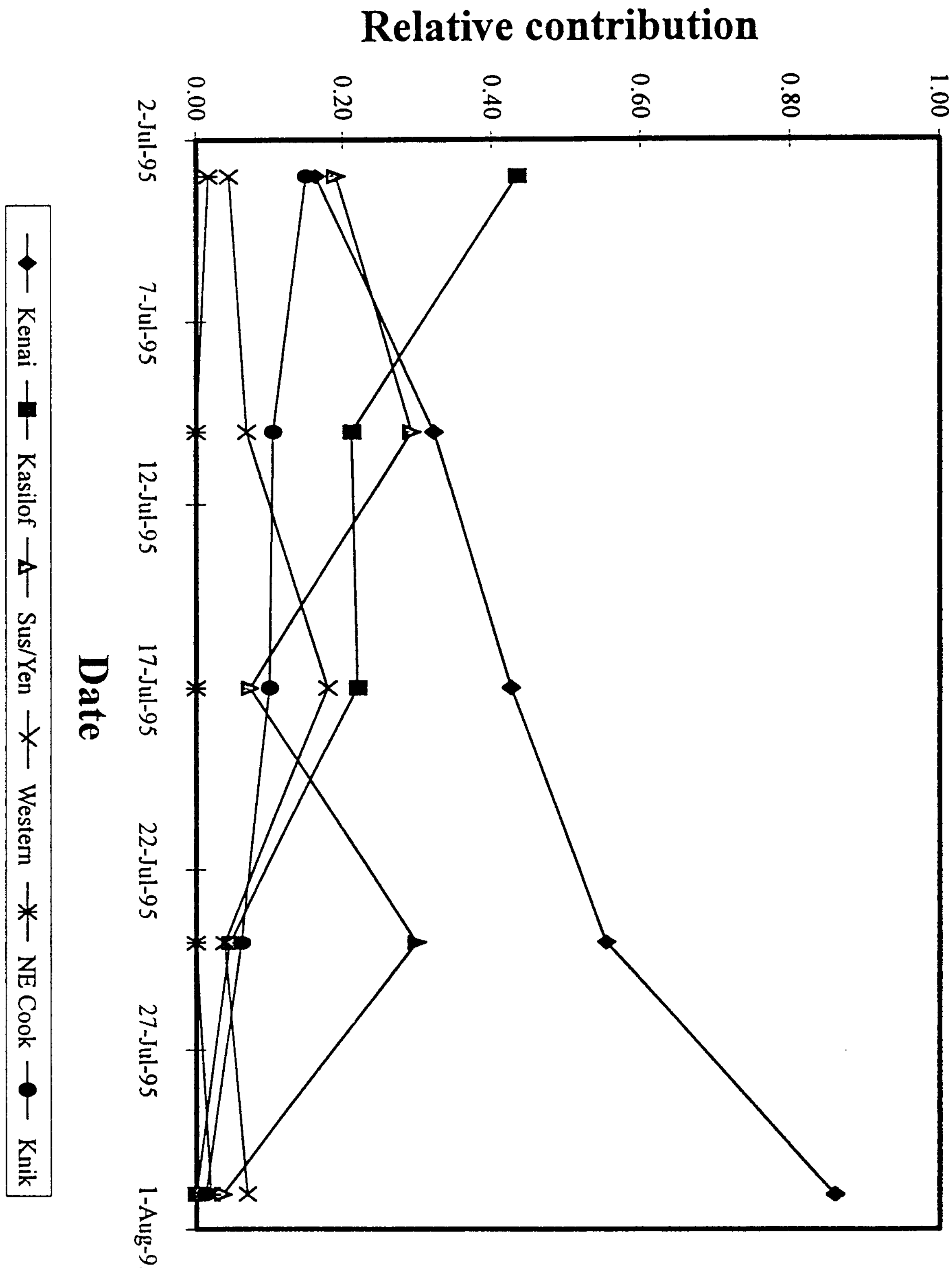


Figure 6. Estimated harvest and relative contribution of Kenai River sockeye salmon in the Cook Inlet Central District drift gillnet fisheries in 1995.

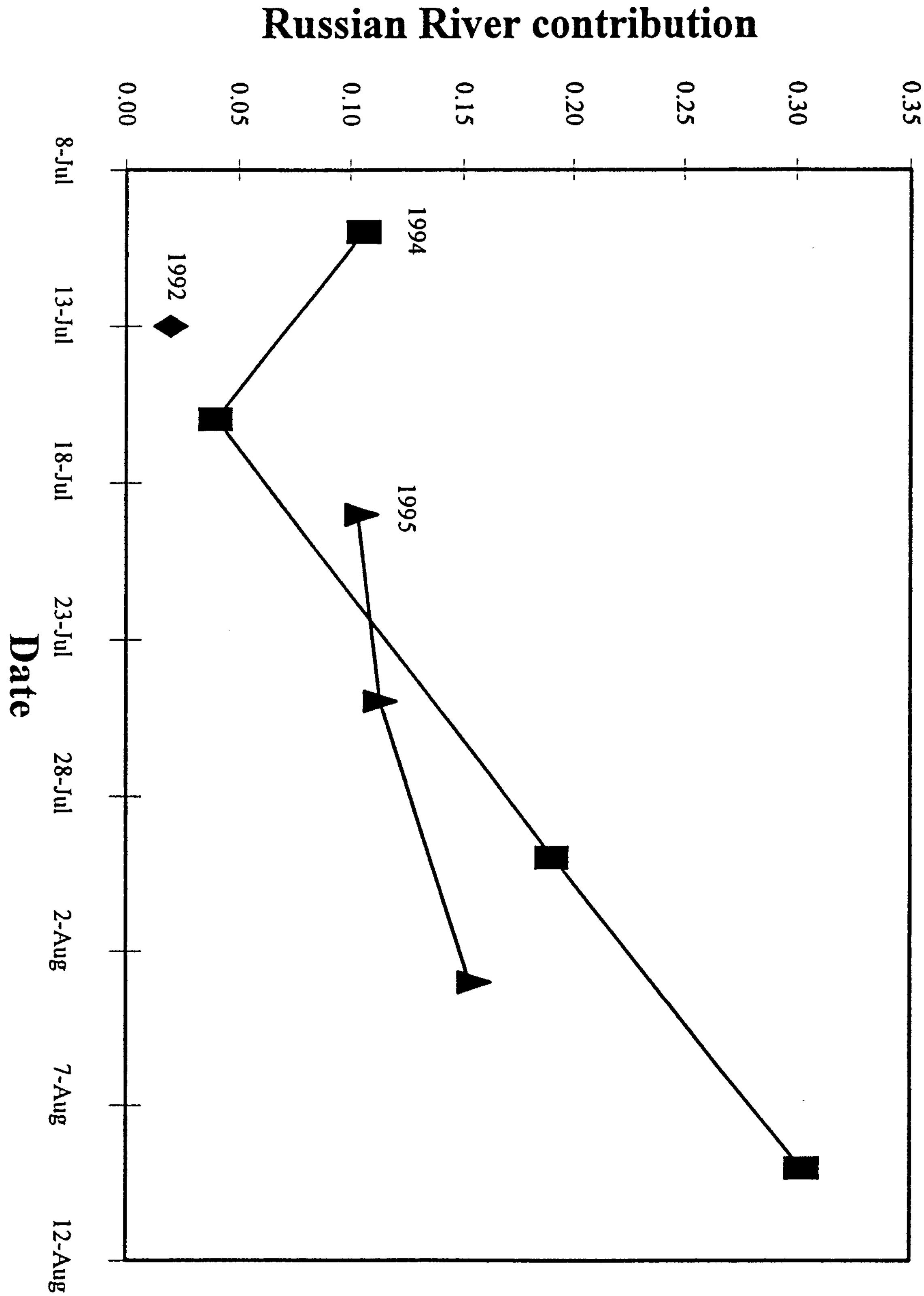


Figure 7. Relative contributions of Russian River populations to admixtures taken at the Kenai River fish wheel, 1992, 1994, and 1995.

**Appendix A.**

Estimated allele frequencies for Upper Cook Inlet sockeye salmon populations.

Appendix A. Estimated allele frequencies for Upper Cook Inlet sockeye salmon populations.

| | | *sAAT-1,2* | | | | *sAAT-3* | | | *mAAT-1* | | | *mAAT-2* | | | *mAH-1,2* | | | *mAH-4* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population | N | 100 | 77 | 122 | N | 100 | 117 | N | -100 | -83 | N | -100 | -73 | N | 100 | 75 | N | 100 | 114 |
| **Kenai River** | | | | | | | | | | | | | | | | | | | |
| Russian River above/early | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 0.805 | 0.195 | 98 | 0.918 | 0.082 | 100 | 0.958 | 0.043 | 100 | 1.000 | 0.000 |
| Russian River above/late | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 199 | 0.917 | 0.083 | 198 | 0.831 | 0.169 | 199 | 1.000 | 0.000 | 176 | 1.000 | 0.000 |
| Russian River below | 99 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 99 | 0.924 | 0.076 | 96 | 0.995 | 0.005 | 98 | 0.962 | 0.038 | 92 | 1.000 | 0.000 |
| Ptarmigan Creek | 198 | 1.000 | 0.000 | 0.000 | 192 | 1.000 | 0.000 | 198 | 0.960 | 0.040 | 182 | 1.000 | 0.000 | 198 | 0.932 | 0.068 | 197 | 1.000 | 0.000 |
| Tern Lake | 150 | 1.000 | 0.000 | 0.000 | 150 | 1.000 | 0.000 | 150 | 0.970 | 0.030 | 150 | 0.987 | 0.013 | 150 | 0.978 | 0.022 | 150 | 0.990 | 0.010 |
| Quartz Creek | 199 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 199 | 0.947 | 0.053 | 196 | 0.995 | 0.005 | 198 | 0.967 | 0.033 | 199 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 1 | 100 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 100 | 0.880 | 0.120 | 99 | 0.995 | 0.005 | 95 | 0.953 | 0.047 | 100 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 2 | 100 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 100 | 0.880 | 0.120 | 100 | 0.985 | 0.015 | 100 | 0.968 | 0.033 | 100 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 3 | 150 | 1.000 | 0.000 | 0.000 | 147 | 1.000 | 0.000 | 150 | 0.957 | 0.043 | 150 | 0.970 | 0.030 | 150 | 0.963 | 0.037 | 147 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 4 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 50 | 0.960 | 0.040 | 49 | 0.969 | 0.031 | 50 | 0.970 | 0.030 | 50 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 5 | 100 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 100 | 0.930 | 0.070 | 100 | 0.990 | 0.010 | 100 | 0.980 | 0.020 | 100 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 6 | 290 | 1.000 | 0.000 | 0.000 | 290 | 1.000 | 0.000 | 297 | 0.928 | 0.072 | 298 | 1.000 | 0.000 | 288 | 0.959 | 0.041 | 294 | 1.000 | 0.000 |
| Hidden Creek | 150 | 1.000 | 0.000 | 0.000 | 197 | 1.000 | 0.000 | 200 | 0.975 | 0.025 | 199 | 0.731 | 0.269 | 200 | 0.949 | 0.051 | 200 | 1.000 | 0.000 |
| Skilak Lake outlet | 796 | 1.000 | 0.000 | 0.000 | 788 | 1.000 | 0.000 | 795 | 0.906 | 0.094 | 795 | 0.996 | 0.004 | 796 | 0.968 | 0.032 | 798 | 1.000 | 0.000 |
| Moose Creek, Kenai | 199 | 1.000 | 0.000 | 0.000 | 197 | 1.000 | 0.000 | 199 | 0.970 | 0.030 | 198 | 0.987 | 0.013 | 180 | 0.935 | 0.065 | 198 | 1.000 | 0.000 |
| **Yentna River** | | | | | | | | | | | | | | | | | | | |
| Chelatna Lake | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 0.838 | 0.163 | 197 | 1.000 | 0.000 | 199 | 0.965 | 0.035 | 199 | 0.993 | 0.008 |
| West Fork Yentna River | 200 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 196 | 0.860 | 0.140 | 200 | 1.000 | 0.000 | 200 | 0.976 | 0.024 | 200 | 1.000 | 0.000 |
| Hewitt/Whiskey Lakes | 100 | 1.000 | 0.000 | 0.000 | 99 | 0.995 | 0.005 | 100 | 0.900 | 0.100 | 100 | 1.000 | 0.000 | 100 | 0.980 | 0.020 | 100 | 1.000 | 0.000 |
| Shell Lake | 198 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 198 | 0.904 | 0.096 | 200 | 1.000 | 0.000 | 193 | 0.970 | 0.030 | 199 | 1.000 | 0.000 |
| Trinity/Movie Lakes | 198 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 198 | 0.897 | 0.104 | 199 | 1.000 | 0.000 | 198 | 0.995 | 0.005 | 199 | 1.000 | 0.000 |
| Judd Lake | 200 | 1.000 | 0.000 | 0.000 | 198 | 1.000 | 0.000 | 199 | 0.618 | 0.382 | 200 | 1.000 | 0.000 | 199 | 0.971 | 0.029 | 199 | 0.998 | 0.003 |
| **Susitna River** | | | | | | | | | | | | | | | | | | | |
| Byers Lake | 100 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 97 | 0.742 | 0.258 | 96 | 1.000 | 0.000 | 97 | 0.946 | 0.054 | 98 | 1.000 | 0.000 |
| Stephan Lake | 125 | 0.990 | 0.010 | 0.000 | 123 | 1.000 | 0.000 | 125 | 0.812 | 0.188 | 125 | 1.000 | 0.000 | 125 | 0.990 | 0.010 | 125 | 1.000 | 0.000 |
| Larson Lake | 198 | 1.000 | 0.000 | 0.000 | 194 | 1.000 | 0.000 | 200 | 0.690 | 0.310 | 199 | 1.000 | 0.000 | 200 | 0.991 | 0.009 | 200 | 1.000 | 0.000 |
| Birch Creek | 50 | 1.000 | 0.000 | 0.000 | 66 | 1.000 | 0.000 | 67 | 0.940 | 0.060 | 67 | 1.000 | 0.000 | 67 | 0.985 | 0.015 | 67 | 1.000 | 0.000 |
| Red Shirt Lake | 34 | 0.993 | 0.000 | 0.007 | 34 | 1.000 | 0.000 | 34 | 1.000 | 0.000 | 34 | 1.000 | 0.000 | 34 | 0.956 | 0.044 | 34 | 1.000 | 0.000 |
| Susitna River slough 11 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 50 | 0.790 | 0.210 | 50 | 1.000 | 0.000 | 47 | 0.968 | 0.032 | 50 | 1.000 | 0.000 |
| **Western Cook Inlet** | | | | | | | | | | | | | | | | | | | |
| Coal Creek | 200 | 1.000 | 0.000 | 0.000 | 200 | 0.995 | 0.005 | 199 | 0.932 | 0.068 | 191 | 1.000 | 0.000 | 200 | 0.895 | 0.105 | 200 | 1.000 | 0.000 |
| Chilligan River | 150 | 1.000 | 0.000 | 0.000 | 146 | 1.000 | 0.000 | 150 | 0.973 | 0.027 | 150 | 1.000 | 0.000 | 149 | 0.997 | 0.003 | 150 | 1.000 | 0.000 |
| MacArthur River | 100 | 1.000 | 0.000 | 0.000 | 100 | 0.995 | 0.005 | 100 | 0.970 | 0.030 | 99 | 0.990 | 0.010 | 100 | 0.928 | 0.073 | 100 | 1.000 | 0.000 |
| Wolverine Creek | 97 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 92 | 0.886 | 0.114 | 99 | 0.995 | 0.005 | 64 | 0.867 | 0.133 | 91 | 1.000 | 0.000 |
| Crescent Lake site 1 | 99 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 99 | 0.975 | 0.025 | 99 | 1.000 | 0.000 | 82 | 0.973 | 0.027 | 99 | 1.000 | 0.000 |
| Crescent Lake site 2 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 0.945 | 0.055 | 100 | 1.000 | 0.000 | 92 | 0.984 | 0.016 | 98 | 1.000 | 0.000 |
| Crescent Lake site 3 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 48 | 0.938 | 0.063 | 50 | 1.000 | 0.000 | 44 | 1.000 | 0.000 | 47 | 1.000 | 0.000 |
| Packers Lake | 182 | 1.000 | 0.000 | 0.000 | 180 | 1.000 | 0.000 | 182 | 0.984 | 0.017 | 180 | 1.000 | 0.000 | 98 | 0.967 | 0.033 | 181 | 1.000 | 0.000 |
| **Kasilof River** | | | | | | | | | | | | | | | | | | | |
| Bear Creek | 119 | 1.000 | 0.000 | 0.000 | 166 | 1.000 | 0.000 | 200 | 0.903 | 0.098 | 199 | 1.000 | 0.000 | 199 | 0.962 | 0.038 | 199 | 1.000 | 0.000 |
| Moose Creek, Tustumena | 200 | 1.000 | 0.000 | 0.000 | 194 | 1.000 | 0.000 | 200 | 0.925 | 0.075 | 199 | 1.000 | 0.000 | 196 | 0.961 | 0.040 | 200 | 1.000 | 0.000 |
| Glacier Flat Creek | 220 | 1.000 | 0.000 | 0.000 | 294 | 0.998 | 0.002 | 299 | 0.896 | 0.104 | 298 | 0.998 | 0.002 | 299 | 0.966 | 0.034 | 300 | 1.000 | 0.000 |
| Nikolai Creek | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 0.863 | 0.138 | 200 | 1.000 | 0.000 | 186 | 0.948 | 0.052 | 200 | 1.000 | 0.000 |
| Tustumena Lake site 1 | 50 | 1.000 | 0.000 | 0.000 | 46 | 1.000 | 0.000 | 50 | 0.920 | 0.080 | 50 | 1.000 | 0.000 | 50 | 0.960 | 0.040 | 50 | 1.000 | 0.000 |
| Tustumena Lake site 2 | 50 | 1.000 | 0.000 | 0.000 | 45 | 1.000 | 0.000 | 50 | 0.900 | 0.100 | 50 | 1.000 | 0.000 | 50 | 0.990 | 0.010 | 50 | 1.000 | 0.000 |
| Seepage Creek | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 0.895 | 0.105 | 100 | 1.000 | 0.000 | 100 | 0.965 | 0.035 | 100 | 1.000 | 0.000 |
| **Northeastern Cook Inlet** | | | | | | | | | | | | | | | | | | | |
| Bishop Creek | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 97 | 0.840 | 0.160 | 98 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 |
| Daniels Lake | 199 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 199 | 0.985 | 0.015 | 200 | 0.998 | 0.003 | 200 | 0.998 | 0.003 | 200 | 1.000 | 0.000 |
| **Knik Arm** | | | | | | | | | | | | | | | | | | | |
| Nancy Lake | 100 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 100 | 0.970 | 0.030 | 99 | 1.000 | 0.000 | 99 | 0.965 | 0.035 | 100 | 1.000 | 0.000 |
| Cottonwood Creek | 95 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 98 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 |
| Fish Creek | 295 | 1.000 | 0.000 | 0.000 | 295 | 1.000 | 0.000 | 293 | 0.986 | 0.014 | 295 | 1.000 | 0.000 | 293 | 0.996 | 0.004 | 294 | 1.000 | 0.000 |

| Population | N | *sAH* 100 | 117 | 83 | 75 | N | *ALAT* 100 | 91 | 108 | 95 | N | *CK-A2* 100 | 125 | N | *CK-B* 100 | 102 | N | *FDH* 100 | 128 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Kenai River** | | | | | | | | | | | | | | | | | | | |
| Russian River above/early | 100 | 0.260 | 0.740 | 0.000 | 0.000 | 100 | 0.855 | 0.140 | 0.000 | 0.005 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 79 | 1.000 | 0.000 |
| Russian River above/late | 199 | 0.294 | 0.706 | 0.000 | 0.000 | 200 | 0.835 | 0.155 | 0.000 | 0.010 | 197 | 1.000 | 0.000 | 200 | 0.998 | 0.003 | 176 | 1.000 | 0.000 |
| Russian River below | 99 | 0.955 | 0.046 | 0.000 | 0.000 | 100 | 0.650 | 0.260 | 0.000 | 0.090 | 99 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 96 | 1.000 | 0.000 |
| Ptarmigan Creek | 198 | 0.990 | 0.010 | 0.000 | 0.000 | 197 | 0.622 | 0.338 | 0.000 | 0.041 | 197 | 1.000 | 0.000 | 198 | 1.000 | 0.000 | 196 | 0.997 | 0.003 |
| Tern Lake | 150 | 0.997 | 0.003 | 0.000 | 0.000 | 148 | 0.686 | 0.291 | 0.000 | 0.024 | 148 | 1.000 | 0.000 | 150 | 1.000 | 0.000 | 148 | 1.000 | 0.000 |
| Quartz Creek | 200 | 0.995 | 0.005 | 0.000 | 0.000 | 199 | 0.485 | 0.475 | 0.000 | 0.040 | 199 | 0.985 | 0.015 | 200 | 1.000 | 0.000 | 198 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 1 | 100 | 0.960 | 0.030 | 0.010 | 0.000 | 98 | 0.694 | 0.270 | 0.000 | 0.036 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 2 | 100 | 0.975 | 0.025 | 0.000 | 0.000 | 98 | 0.653 | 0.311 | 0.000 | 0.036 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 3 | 150 | 0.980 | 0.017 | 0.000 | 0.003 | 148 | 0.639 | 0.304 | 0.000 | 0.057 | 148 | 1.000 | 0.000 | 150 | 1.000 | 0.000 | 148 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 4 | 50 | 1.000 | 0.000 | 0.000 | 0.000 | 50 | 0.630 | 0.290 | 0.010 | 0.070 | 50 | 1.000 | 0.000 | 48 | 1.000 | 0.000 | 50 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 5 | 100 | 0.980 | 0.020 | 0.000 | 0.000 | 100 | 0.690 | 0.275 | 0.000 | 0.035 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 6 | 297 | 0.973 | 0.025 | 0.002 | 0.000 | 296 | 0.647 | 0.284 | 0.005 | 0.064 | 297 | 0.998 | 0.002 | 295 | 1.000 | 0.000 | 296 | 0.998 | 0.002 |
| Hidden Creek | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 200 | 0.810 | 0.073 | 0.000 | 0.118 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 199 | 1.000 | 0.000 |
| Skilak Lake outlet | 793 | 0.981 | 0.018 | 0.001 | 0.000 | 786 | 0.694 | 0.246 | 0.001 | 0.059 | 795 | 1.000 | 0.000 | 800 | 1.000 | 0.000 | 797 | 1.000 | 0.000 |
| Moose Creek, Kenai | 199 | 0.980 | 0.020 | 0.000 | 0.000 | 197 | 0.383 | 0.614 | 0.000 | 0.003 | 198 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 199 | 1.000 | 0.000 |
| **Yentna River** | | | | | | | | | | | | | | | | | | | |
| Chelatna Lake | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 198 | 0.462 | 0.535 | 0.000 | 0.003 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 |
| West Fork Yentna River | 200 | 0.995 | 0.005 | 0.000 | 0.000 | 199 | 0.543 | 0.450 | 0.000 | 0.008 | 197 | 1.000 | 0.000 | 199 | 1.000 | 0.000 | 200 | 1.000 | 0.000 |
| Hewitt/Whiskey Lakes | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 99 | 0.727 | 0.273 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 99 | 1.000 | 0.000 | 100 | 1.000 | 0.000 |
| Shell Lake | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 200 | 0.435 | 0.540 | 0.000 | 0.025 | 200 | 1.000 | 0.000 | 199 | 1.000 | 0.000 | 193 | 1.000 | 0.000 |
| Trinity/Movie Lakes | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 199 | 0.771 | 0.226 | 0.000 | 0.003 | 180 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 |
| Judd Lake | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 198 | 0.586 | 0.346 | 0.000 | 0.068 | 180 | 1.000 | 0.000 | 199 | 1.000 | 0.000 | 200 | 1.000 | 0.000 |
| **Susitna River** | | | | | | | | | | | | | | | | | | | |
| Byers Lake | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 100 | 0.680 | 0.225 | 0.000 | 0.095 | 98 | 1.000 | 0.000 | 99 | 1.000 | 0.000 | 100 | 1.000 | 0.000 |
| Stephan Lake | 125 | 0.984 | 0.016 | 0.000 | 0.000 | 125 | 0.552 | 0.316 | 0.000 | 0.132 | 124 | 1.000 | 0.000 | 125 | 1.000 | 0.000 | 125 | 1.000 | 0.000 |
| Larson Lake | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 199 | 0.726 | 0.256 | 0.003 | 0.015 | 179 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 198 | 1.000 | 0.000 |
| Birch Creek | 67 | 1.000 | 0.000 | 0.000 | 0.000 | 63 | 0.571 | 0.429 | 0.000 | 0.000 | 67 | 1.000 | 0.000 | 65 | 1.000 | 0.000 | 66 | 1.000 | 0.000 |
| Red Shirt Lake | 34 | 1.000 | 0.000 | 0.000 | 0.000 | 34 | 0.441 | 0.544 | 0.000 | 0.015 | 34 | 1.000 | 0.000 | 34 | 1.000 | 0.000 | 34 | 1.000 | 0.000 |
| Susitna River slough 11 | 50 | 1.000 | 0.000 | 0.000 | 0.000 | 50 | 0.440 | 0.490 | 0.000 | 0.070 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 |
| **Western Cook Inlet** | | | | | | | | | | | | | | | | | | | |
| Coal Creek | 198 | 1.000 | 0.000 | 0.000 | 0.000 | 200 | 0.375 | 0.603 | 0.000 | 0.023 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 196 | 1.000 | 0.000 |
| Chilligan River | 150 | 1.000 | 0.000 | 0.000 | 0.000 | 150 | 0.570 | 0.430 | 0.000 | 0.000 | 149 | 1.000 | 0.000 | 150 | 1.000 | 0.000 | 150 | 1.000 | 0.000 |
| MacArthur River | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 98 | 0.607 | 0.225 | 0.000 | 0.168 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 |
| Wolverine Creek | 98 | 0.990 | 0.010 | 0.000 | 0.000 | 97 | 0.113 | 0.887 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 97 | 1.000 | 0.000 |
| Crescent Lake site 1 | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 100 | 0.540 | 0.390 | 0.000 | 0.070 | 100 | 1.000 | 0.000 | 98 | 1.000 | 0.000 | 100 | 1.000 | 0.000 |
| Crescent Lake site 2 | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 100 | 0.530 | 0.445 | 0.000 | 0.025 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 |
| Crescent Lake site 3 | 50 | 1.000 | 0.000 | 0.000 | 0.000 | 50 | 0.520 | 0.460 | 0.000 | 0.020 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 |
| Packers Lake | 181 | 0.997 | 0.003 | 0.000 | 0.000 | 182 | 0.338 | 0.659 | 0.000 | 0.003 | 183 | 1.000 | 0.000 | 182 | 1.000 | 0.000 | 176 | 1.000 | 0.000 |
| **Kasilof River** | | | | | | | | | | | | | | | | | | | |
| Bear Creek | 199 | 1.000 | 0.000 | 0.000 | 0.000 | 199 | 0.548 | 0.342 | 0.000 | 0.111 | 199 | 1.000 | 0.000 | 199 | 1.000 | 0.000 | 200 | 1.000 | 0.000 |
| Moose Creek, Tustumena | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 200 | 0.578 | 0.323 | 0.000 | 0.100 | 196 | 1.000 | 0.000 | 199 | 1.000 | 0.000 | 192 | 1.000 | 0.000 |
| Glacier Flat Creek | 298 | 0.998 | 0.002 | 0.000 | 0.000 | 298 | 0.549 | 0.309 | 0.000 | 0.143 | 294 | 0.998 | 0.002 | 300 | 1.000 | 0.000 | 300 | 1.000 | 0.000 |
| Nikolai Creek | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 199 | 0.558 | 0.307 | 0.000 | 0.136 | 180 | 1.000 | 0.000 | 200 | 0.993 | 0.008 | 199 | 1.000 | 0.000 |
| Tustumena Lake site 1 | 50 | 0.990 | 0.010 | 0.000 | 0.000 | 50 | 0.510 | 0.340 | 0.000 | 0.150 | 50 | 1.000 | 0.000 | 44 | 1.000 | 0.000 | 50 | 1.000 | 0.000 |
| Tustumena Lake site 2 | 50 | 1.000 | 0.000 | 0.000 | 0.000 | 50 | 0.540 | 0.310 | 0.000 | 0.150 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 |
| Seepage Creek | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 100 | 0.515 | 0.350 | 0.000 | 0.135 | 100 | 1.000 | 0.000 | 97 | 1.000 | 0.000 | 98 | 1.000 | 0.000 |
| **Northeastern Cook Inlet** | | | | | | | | | | | | | | | | | | | |
| Bishop Creek | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 100 | 0.330 | 0.620 | 0.000 | 0.050 | 98 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 |
| Daniels Lake | 200 | 0.970 | 0.030 | 0.000 | 0.000 | 200 | 0.470 | 0.385 | 0.000 | 0.145 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 |
| **Knik Arm** | | | | | | | | | | | | | | | | | | | |
| Nancy Lake | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 100 | 0.460 | 0.540 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 |
| Cottonwood Creek | 99 | 1.000 | 0.000 | 0.000 | 0.000 | 100 | 0.570 | 0.430 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 96 | 1.000 | 0.000 |
| Fish Creek | 294 | 1.000 | 0.000 | 0.000 | 0.000 | 300 | 0.647 | 0.340 | 0.000 | 0.013 | 298 | 1.000 | 0.000 | 300 | 1.000 | 0.000 | 236 | 1.000 | 0.000 |

Appendix A. Continued

| Population | N | *GAPDH-2* | | | N | *G3PDH-1,2* | | | | N | *G3PDH-4* | | N | *GPI-B1,2* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 100 | 50 | 208 | | -100 | -150 | -175 | 0 | | 100 | 108 | | 100 | 132 | 143 |
| **Kenai River** | | | | | | | | | | | | | | | | |
| Russian River above/early | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 |
| Russian River above/late | 198 | 0.998 | 0.003 | 0.000 | 196 | 1.000 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 |
| Russian River below | 99 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 |
| Ptarmigan Creek | 197 | 1.000 | 0.000 | 0.000 | 198 | 1.000 | 0.000 | 0.000 | 0.000 | 198 | 1.000 | 0.000 | 197 | 1.000 | 0.000 | 0.000 |
| Tern Lake | 150 | 1.000 | 0.000 | 0.000 | 150 | 0.998 | 0.000 | 0.002 | 0.000 | 148 | 1.000 | 0.000 | 148 | 1.000 | 0.000 | 0.000 |
| Quartz Creek | 195 | 1.000 | 0.000 | 0.000 | 198 | 1.000 | 0.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 199 | 0.994 | 0.006 | 0.000 |
| Btwn Ken/Ski Lks site 1 | 100 | 0.990 | 0.010 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 |
| Btwn Ken/Ski Lks site 2 | 100 | 1.000 | 0.000 | 0.000 | 100 | 0.998 | 0.003 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 |
| Btwn Ken/Ski Lks site 3 | 150 | 0.993 | 0.007 | 0.000 | 150 | 0.998 | 0.002 | 0.000 | 0.000 | 150 | 1.000 | 0.000 | 150 | 1.000 | 0.000 | 0.000 |
| Btwn Ken/Ski Lks site 4 | 50 | 0.990 | 0.010 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 |
| Btwn Ken/Ski Lks site 5 | 100 | 1.000 | 0.000 | 0.000 | 100 | 0.998 | 0.003 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 |
| Btwn Ken/Ski Lks site 6 | 294 | 0.990 | 0.010 | 0.000 | 296 | 0.996 | 0.003 | 0.000 | 0.002 | 274 | 1.000 | 0.000 | 296 | 1.000 | 0.000 | 0.000 |
| Hidden Creek | 200 | 0.983 | 0.000 | 0.018 | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 0.996 | 0.004 | 0.000 |
| Skilak Lake outlet | 796 | 0.991 | 0.009 | 0.000 | 796 | 0.999 | 0.001 | 0.000 | 0.000 | 779 | 1.000 | 0.000 | 798 | 1.000 | 0.000 | 0.000 |
| Moose Creek, Kenai | 198 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 198 | 0.999 | 0.001 | 0.000 |
| **Yentna River** | | | | | | | | | | | | | | | | |
| Chelatna Lake | 196 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 |
| West Fork Yentna River | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 196 | 1.000 | 0.000 | 0.000 |
| Hewitt/Whiskey Lakes | 100 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 |
| Shell Lake | 199 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 |
| Trinity/Movie Lakes | 198 | 1.000 | 0.000 | 0.000 | 120 | 1.000 | 0.000 | 0.000 | 0.000 | 198 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 |
| Judd Lake | 200 | 1.000 | 0.000 | 0.000 | 120 | 1.000 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 |
| **Susitna River** | | | | | | | | | | | | | | | | |
| Byers Lake | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 0.998 | 0.000 | 0.003 |
| Stephan Lake | 124 | 0.952 | 0.048 | 0.000 | 125 | 1.000 | 0.000 | 0.000 | 0.000 | 124 | 1.000 | 0.000 | 125 | 1.000 | 0.000 | 0.000 |
| Larson Lake | 200 | 1.000 | 0.000 | 0.000 | 96 | 1.000 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 199 | 0.999 | 0.001 | 0.000 |
| Birch Creek | 67 | 1.000 | 0.000 | 0.000 | 67 | 1.000 | 0.000 | 0.000 | 0.000 | 67 | 1.000 | 0.000 | 67 | 1.000 | 0.000 | 0.000 |
| Red Shirt Lake | 33 | 1.000 | 0.000 | 0.000 | 34 | 1.000 | 0.000 | 0.000 | 0.000 | 34 | 1.000 | 0.000 | 34 | 1.000 | 0.000 | 0.000 |
| Susitna River slough 11 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 |
| **Western Cook Inlet** | | | | | | | | | | | | | | | | |
| Coal Creek | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 |
| Chilligan River | 150 | 1.000 | 0.000 | 0.000 | 150 | 1.000 | 0.000 | 0.000 | 0.000 | 150 | 1.000 | 0.000 | 150 | 1.000 | 0.000 | 0.000 |
| MacArthur River | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 |
| Wolverine Creek | 95 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 99 | 0.998 | 0.003 | 0.000 |
| Crescent Lake site 1 | 99 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 |
| Crescent Lake site 2 | 96 | 1.000 | 0.000 | 0.000 | 100 | 0.998 | 0.000 | 0.000 | 0.003 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 |
| Crescent Lake site 3 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 |
| Packers Lake | 183 | 1.000 | 0.000 | 0.000 | 183 | 1.000 | 0.000 | 0.000 | 0.000 | 179 | 1.000 | 0.000 | 183 | 1.000 | 0.000 | 0.000 |
| **Kasilof River** | | | | | | | | | | | | | | | | |
| Bear Creek | 198 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 0.000 | 200 | 0.993 | 0.008 | 200 | 0.971 | 0.029 | 0.000 |
| Moose Creek, Tustumena | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 200 | 0.995 | 0.005 | 200 | 0.963 | 0.038 | 0.000 |
| Glacier Flat Creek | 295 | 0.998 | 0.002 | 0.000 | 299 | 1.000 | 0.000 | 0.000 | 0.000 | 299 | 0.982 | 0.018 | 299 | 0.986 | 0.014 | 0.000 |
| Nikolai Creek | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 200 | 0.990 | 0.010 | 200 | 0.969 | 0.031 | 0.000 |
| Tustumena Lake site 1 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 0.000 | 50 | 0.990 | 0.010 | 50 | 1.000 | 0.000 | 0.000 |
| Tustumena Lake site 2 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 0.000 | 49 | 1.000 | 0.000 | 50 | 0.985 | 0.015 | 0.000 |
| Seepage Creek | 100 | 1.000 | 0.000 | 0.000 | 98 | 1.000 | 0.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 0.965 | 0.035 | 0.000 |
| **Northeastern Cook Inlet** | | | | | | | | | | | | | | | | |
| Bishop Creek | 99 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 |
| Daniels Lake | 199 | 1.000 | 0.000 | 0.000 | 198 | 1.000 | 0.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 |
| **Knik Arm** | | | | | | | | | | | | | | | | |
| Nancy Lake | 99 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 98 | 1.000 | 0.000 | 0.000 |
| Cottonwood Creek | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 |
| Fish Creek | 294 | 1.000 | 0.000 | 0.000 | 296 | 1.000 | 0.000 | 0.000 | 0.000 | 295 | 0.997 | 0.003 | 300 | 0.999 | 0.001 | 0.000 |

Appendix A. Continued

| | | *GPI-A* | | | | *mIDHP-1* | | | | *sIDHP-1* | | | | | | *sIDHP-2* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population | N | 100 | 94 | 107 | N | 100 | 33 | 77 | N | 100 | 72 | 84 | 61 | 94 | N | 100 | 92 |
| **Kenai River** | | | | | | | | | | | | | | | | | |
| Russian River above/early | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 |
| Russian River above/late | 200 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 |
| Russian River below | 99 | 0.985 | 0.015 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 98 | 0.985 | 0.005 | 0.005 | 0.005 | 0.000 | 99 | 1.000 | 0.000 |
| Ptarmigan Creek | 197 | 1.000 | 0.000 | 0.000 | 198 | 1.000 | 0.000 | 0.000 | 198 | 0.985 | 0.005 | 0.010 | 0.000 | 0.000 | 198 | 1.000 | 0.000 |
| Tern Lake | 148 | 1.000 | 0.000 | 0.000 | 150 | 1.000 | 0.000 | 0.000 | 150 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 150 | 1.000 | 0.000 |
| Quartz Creek | 198 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 200 | 0.995 | 0.003 | 0.000 | 0.003 | 0.000 | 200 | 0.998 | 0.003 |
| Btwn Ken/Ski Lks site 1 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 2 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 0.980 | 0.000 | 0.020 | 0.000 | 0.000 | 99 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 3 | 150 | 1.000 | 0.000 | 0.000 | 149 | 1.000 | 0.000 | 0.000 | 150 | 0.993 | 0.000 | 0.007 | 0.000 | 0.000 | 149 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 4 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 5 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 98 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 6 | 296 | 0.998 | 0.000 | 0.002 | 294 | 1.000 | 0.000 | 0.000 | 297 | 0.995 | 0.002 | 0.003 | 0.000 | 0.000 | 297 | 1.000 | 0.000 |
| Hidden Creek | 200 | 0.988 | 0.000 | 0.013 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 |
| Skilak Lake outlet | 798 | 1.000 | 0.000 | 0.000 | 798 | 0.999 | 0.001 | 0.000 | 796 | 0.992 | 0.003 | 0.003 | 0.002 | 0.001 | 796 | 1.000 | 0.000 |
| Moose Creek, Kenai | 198 | 1.000 | 0.000 | 0.000 | 198 | 1.000 | 0.000 | 0.000 | 200 | 0.995 | 0.003 | 0.003 | 0.000 | 0.000 | 200 | 0.968 | 0.033 |
| **Yentna River** | | | | | | | | | | | | | | | | | |
| Chelatna Lake | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 |
| West Fork Yentna River | 196 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 |
| Hewitt/Whiskey Lakes | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 |
| Shell Lake | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 |
| Trinity/Movie Lakes | 200 | 1.000 | 0.000 | 0.000 | 196 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 |
| Judd Lake | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 |
| **Susitna River** | | | | | | | | | | | | | | | | | |
| Byers Lake | 98 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 |
| Stephan Lake | 125 | 1.000 | 0.000 | 0.000 | 124 | 1.000 | 0.000 | 0.000 | 119 | 0.874 | 0.000 | 0.000 | 0.000 | 0.126 | 124 | 1.000 | 0.000 |
| Larson Lake | 199 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 |
| Birch Creek | 67 | 1.000 | 0.000 | 0.000 | 67 | 1.000 | 0.000 | 0.000 | 67 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 67 | 1.000 | 0.000 |
| Red Shirt Lake | 34 | 1.000 | 0.000 | 0.000 | 34 | 1.000 | 0.000 | 0.000 | 34 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 34 | 1.000 | 0.000 |
| Susitna River slough 11 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 |
| **Western Cook Inlet** | | | | | | | | | | | | | | | | | |
| Coal Creek | 200 | 1.000 | 0.000 | 0.000 | 199 | 0.995 | 0.005 | 0.000 | 197 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 197 | 1.000 | 0.000 |
| Chilligan River | 150 | 1.000 | 0.000 | 0.000 | 150 | 1.000 | 0.000 | 0.000 | 150 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 150 | 1.000 | 0.000 |
| MacArthur River | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 0.985 | 0.000 | 0.000 | 0.000 | 0.015 | 100 | 1.000 | 0.000 |
| Wolverine Creek | 99 | 1.000 | 0.000 | 0.000 | 97 | 0.995 | 0.005 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 |
| Crescent Lake site 1 | 100 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 99 | 0.995 | 0.000 | 0.000 | 0.005 | 0.000 | 99 | 1.000 | 0.000 |
| Crescent Lake site 2 | 99 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 |
| Crescent Lake site 3 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 |
| Packers Lake | 183 | 1.000 | 0.000 | 0.000 | 182 | 1.000 | 0.000 | 0.000 | 182 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 180 | 1.000 | 0.000 |
| **Kasilof River** | | | | | | | | | | | | | | | | | |
| Bear Creek | 200 | 1.000 | 0.000 | 0.000 | 198 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 |
| Moose Creek, Tustumena | 200 | 1.000 | 0.000 | 0.000 | 200 | 0.995 | 0.000 | 0.005 | 200 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 |
| Glacier Flat Creek | 299 | 1.000 | 0.000 | 0.000 | 300 | 0.985 | 0.000 | 0.015 | 297 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 267 | 1.000 | 0.000 |
| Nikolai Creek | 200 | 1.000 | 0.000 | 0.000 | 199 | 0.998 | 0.000 | 0.003 | 200 | 0.998 | 0.003 | 0.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 |
| Tustumena Lake site 1 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 0.990 | 0.010 | 0.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 |
| Tustumena Lake site 2 | 50 | 1.000 | 0.000 | 0.000 | 46 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 |
| Seepage Creek | 100 | 1.000 | 0.000 | 0.000 | 100 | 0.990 | 0.000 | 0.010 | 100 | 0.995 | 0.005 | 0.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 |
| **Northeastern Cook Inlet** | | | | | | | | | | | | | | | | | |
| Bishop Creek | 99 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 |
| Daniels Lake | 200 | 0.980 | 0.000 | 0.020 | 199 | 1.000 | 0.000 | 0.000 | 198 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 |
| **Knik Arm** | | | | | | | | | | | | | | | | | |
| Nancy Lake | 98 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 |
| Cottonwood Creek | 100 | 1.000 | 0.000 | 0.000 | 97 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 |
| Fish Creek | 300 | 1.000 | 0.000 | 0.000 | 294 | 1.000 | 0.000 | 0.000 | 295 | 0.980 | 0.020 | 0.000 | 0.000 | 0.000 | 299 | 1.000 | 0.000 |

Appendix A. Continued

| Population | N | *LDH-A2* 100 | 150 | N | *LDH-B2* 100 | 110 | 85 | N | *sMDH-A1,2* 100 | 64 | 147 | N | *sMDH-B1,2* 100 | 65 | 120 | 116 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Kenai River** | | | | | | | | | | | | | | | | |
| Russian River above/early | 100 | 1.000 | 0.000 | 99 | 0.495 | 0.505 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 |
| Russian River above/late | 196 | 1.000 | 0.000 | 197 | 0.706 | 0.294 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 0.998 | 0.003 | 0.000 | 0.000 |
| Russian River below | 99 | 1.000 | 0.000 | 99 | 0.924 | 0.076 | 0.000 | 100 | 0.990 | 0.003 | 0.008 | 99 | 1.000 | 0.000 | 0.000 | 0.000 |
| Ptarmigan Creek | 198 | 1.000 | 0.000 | 198 | 0.889 | 0.111 | 0.000 | 198 | 0.992 | 0.000 | 0.008 | 198 | 1.000 | 0.000 | 0.000 | 0.000 |
| Tern Lake | 148 | 1.000 | 0.000 | 150 | 0.833 | 0.167 | 0.000 | 150 | 1.000 | 0.000 | 0.000 | 150 | 1.000 | 0.000 | 0.000 | 0.000 |
| Quartz Creek | 199 | 1.000 | 0.000 | 200 | 0.888 | 0.113 | 0.000 | 200 | 0.980 | 0.000 | 0.020 | 199 | 1.000 | 0.000 | 0.000 | 0.000 |
| Btwn Ken/Ski Lks site 1 | 100 | 1.000 | 0.000 | 100 | 0.840 | 0.160 | 0.000 | 100 | 0.998 | 0.000 | 0.003 | 100 | 1.000 | 0.000 | 0.000 | 0.000 |
| Btwn Ken/Ski Lks site 2 | 100 | 1.000 | 0.000 | 100 | 0.880 | 0.120 | 0.000 | 100 | 0.993 | 0.003 | 0.005 | 100 | 1.000 | 0.000 | 0.000 | 0.000 |
| Btwn Ken/Ski Lks site 3 | 150 | 1.000 | 0.000 | 150 | 0.900 | 0.100 | 0.000 | 150 | 0.985 | 0.000 | 0.015 | 150 | 1.000 | 0.000 | 0.000 | 0.000 |
| Btwn Ken/Ski Lks site 4 | 50 | 1.000 | 0.000 | 50 | 0.870 | 0.130 | 0.000 | 50 | 0.980 | 0.000 | 0.020 | 50 | 1.000 | 0.000 | 0.000 | 0.000 |
| Btwn Ken/Ski Lks site 5 | 100 | 1.000 | 0.000 | 100 | 0.945 | 0.055 | 0.000 | 100 | 0.995 | 0.000 | 0.005 | 100 | 1.000 | 0.000 | 0.000 | 0.000 |
| Btwn Ken/Ski Lks site 6 | 292 | 0.998 | 0.002 | 294 | 0.884 | 0.116 | 0.000 | 299 | 0.990 | 0.001 | 0.009 | 297 | 1.000 | 0.000 | 0.000 | 0.000 |
| Hidden Creek | 200 | 1.000 | 0.000 | 200 | 0.973 | 0.028 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 |
| Skilak Lake outlet | 791 | 1.000 | 0.000 | 799 | 0.921 | 0.080 | 0.000 | 800 | 0.992 | 0.000 | 0.008 | 793 | 0.998 | 0.002 | 0.001 | 0.000 |
| Moose Creek, Kenai | 199 | 1.000 | 0.000 | 200 | 0.910 | 0.090 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 0.000 |
| **Yentna River** | | | | | | | | | | | | | | | | |
| Chelatna Lake | 200 | 1.000 | 0.000 | 200 | 0.938 | 0.063 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 |
| West Fork Yentna River | 197 | 1.000 | 0.000 | 200 | 0.898 | 0.103 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 |
| Hewitt/Whiskey Lakes | 99 | 1.000 | 0.000 | 99 | 0.990 | 0.010 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 |
| Shell Lake | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 |
| Trinity/Movie Lakes | 199 | 1.000 | 0.000 | 200 | 0.933 | 0.068 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 197 | 1.000 | 0.000 | 0.000 | 0.000 |
| Judd Lake | 197 | 1.000 | 0.000 | 200 | 0.893 | 0.105 | 0.003 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 |
| **Susitna River** | | | | | | | | | | | | | | | | |
| Byers Lake | 95 | 1.000 | 0.000 | 100 | 0.960 | 0.040 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 |
| Stephan Lake | 124 | 1.000 | 0.000 | 125 | 0.916 | 0.084 | 0.000 | 125 | 1.000 | 0.000 | 0.000 | 121 | 1.000 | 0.000 | 0.000 | 0.000 |
| Larson Lake | 196 | 1.000 | 0.000 | 199 | 0.950 | 0.050 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 |
| Birch Creek | 63 | 1.000 | 0.000 | 67 | 0.993 | 0.008 | 0.000 | 67 | 1.000 | 0.000 | 0.000 | 67 | 1.000 | 0.000 | 0.000 | 0.000 |
| Red Shirt Lake | 33 | 1.000 | 0.000 | 34 | 1.000 | 0.000 | 0.000 | 34 | 1.000 | 0.000 | 0.000 | 34 | 1.000 | 0.000 | 0.000 | 0.000 |
| Susitna River slough 11 | 50 | 1.000 | 0.000 | 50 | 0.930 | 0.070 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 0.000 |
| **Western Cook Inlet** | | | | | | | | | | | | | | | | |
| Coal Creek | 200 | 1.000 | 0.000 | 200 | 0.978 | 0.023 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 0.953 | 0.048 | 0.000 | 0.000 |
| Chilligan River | 150 | 0.987 | 0.013 | 150 | 0.970 | 0.030 | 0.000 | 150 | 1.000 | 0.000 | 0.000 | 150 | 1.000 | 0.000 | 0.000 | 0.000 |
| MacArthur River | 97 | 1.000 | 0.000 | 100 | 0.860 | 0.140 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 |
| Wolverine Creek | 99 | 1.000 | 0.000 | 100 | 0.980 | 0.020 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 |
| Crescent Lake site 1 | 100 | 1.000 | 0.000 | 100 | 0.890 | 0.110 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 |
| Crescent Lake site 2 | 100 | 1.000 | 0.000 | 100 | 0.955 | 0.045 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 |
| Crescent Lake site 3 | 49 | 1.000 | 0.000 | 50 | 0.880 | 0.120 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 0.000 |
| Packers Lake | 181 | 1.000 | 0.000 | 182 | 1.000 | 0.000 | 0.000 | 183 | 1.000 | 0.000 | 0.000 | 183 | 0.980 | 0.003 | 0.000 | 0.018 |
| **Kasilof River** | | | | | | | | | | | | | | | | |
| Bear Creek | 200 | 1.000 | 0.000 | 200 | 0.870 | 0.130 | 0.000 | 200 | 0.999 | 0.000 | 0.001 | 199 | 1.000 | 0.000 | 0.000 | 0.000 |
| Moose Creek, Tustumena | 197 | 1.000 | 0.000 | 200 | 0.870 | 0.130 | 0.000 | 200 | 0.998 | 0.000 | 0.003 | 200 | 1.000 | 0.000 | 0.000 | 0.000 |
| Glacier Flat Creek | 299 | 1.000 | 0.000 | 300 | 0.873 | 0.127 | 0.000 | 300 | 0.998 | 0.000 | 0.002 | 300 | 0.998 | 0.002 | 0.000 | 0.000 |
| Nikolai Creek | 200 | 0.998 | 0.003 | 200 | 0.883 | 0.118 | 0.000 | 200 | 0.994 | 0.000 | 0.006 | 200 | 1.000 | 0.000 | 0.000 | 0.000 |
| Tustumena Lake site 1 | 50 | 1.000 | 0.000 | 50 | 0.850 | 0.150 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 0.000 |
| Tustumena Lake site 2 | 50 | 1.000 | 0.000 | 50 | 0.960 | 0.040 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 0.000 |
| Seepage Creek | 100 | 1.000 | 0.000 | 100 | 0.875 | 0.125 | 0.000 | 100 | 0.998 | 0.000 | 0.003 | 100 | 1.000 | 0.000 | 0.000 | 0.000 |
| **Northeastern Cook Inlet** | | | | | | | | | | | | | | | | |
| Bishop Creek | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 |
| Daniels Lake | 197 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.000 |
| **Knik Arm** | | | | | | | | | | | | | | | | |
| Nancy Lake | 100 | 1.000 | 0.000 | 100 | 0.950 | 0.050 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.000 |
| Cottonwood Creek | 99 | 1.000 | 0.000 | 100 | 0.650 | 0.350 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 98 | 1.000 | 0.000 | 0.000 | 0.000 |
| Fish Creek | 297 | 1.000 | 0.000 | 300 | 0.883 | 0.117 | 0.000 | 300 | 0.994 | 0.000 | 0.006 | 299 | 1.000 | 0.000 | 0.000 | 0.000 |

Appendix A. Continued

| Population | N | *mMEP-1* | | | N | *MPI* | | N | *PEPA* | | | N | *PEPB-1* | | | N | *PEPC* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 100 | 80 | 58 | | 100 | 105 | | 100 | 106 | 92 | | 100 | 130 | 163 | | 100 | 105 |
| **Kenai River** | | | | | | | | | | | | | | | | | | |
| Russian River above/early | 92 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 |
| Russian River above/late | 198 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 |
| Russian River below | 99 | 1.000 | 0.000 | 0.000 | 100 | 0.995 | 0.005 | 100 | 1.000 | 0.000 | 0.000 | 100 | 0.995 | 0.005 | 0.000 | 100 | 1.000 | 0.000 |
| Ptarmigan Creek | 198 | 1.000 | 0.000 | 0.000 | 198 | 0.998 | 0.003 | 198 | 0.995 | 0.005 | 0.000 | 198 | 0.985 | 0.015 | 0.000 | 198 | 0.998 | 0.003 |
| Tern Lake | 150 | 1.000 | 0.000 | 0.000 | 150 | 1.000 | 0.000 | 150 | 0.997 | 0.003 | 0.000 | 149 | 0.956 | 0.044 | 0.000 | 149 | 0.997 | 0.003 |
| Quartz Creek | 198 | 1.000 | 0.000 | 0.000 | 199 | 0.995 | 0.005 | 200 | 0.983 | 0.005 | 0.013 | 195 | 0.985 | 0.015 | 0.000 | 200 | 0.998 | 0.003 |
| Btwn Ken/Ski Lks site 1 | 100 | 1.000 | 0.000 | 0.000 | 100 | 0.990 | 0.010 | 100 | 0.990 | 0.000 | 0.010 | 100 | 1.000 | 0.000 | 0.000 | 100 | 0.990 | 0.010 |
| Btwn Ken/Ski Lks site 2 | 100 | 1.000 | 0.000 | 0.000 | 100 | 0.985 | 0.015 | 100 | 0.995 | 0.005 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 100 | 0.995 | 0.005 |
| Btwn Ken/Ski Lks site 3 | 150 | 1.000 | 0.000 | 0.000 | 150 | 0.997 | 0.003 | 150 | 0.967 | 0.010 | 0.023 | 150 | 1.000 | 0.000 | 0.000 | 150 | 0.990 | 0.010 |
| Btwn Ken/Ski Lks site 4 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 50 | 0.980 | 0.000 | 0.020 | 49 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 5 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 0.995 | 0.000 | 0.005 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 |
| Btwn Ken/Ski Lks site 6 | 283 | 1.000 | 0.000 | 0.000 | 296 | 1.000 | 0.000 | 297 | 0.987 | 0.002 | 0.012 | 295 | 1.000 | 0.000 | 0.000 | 295 | 0.998 | 0.002 |
| Hidden Creek | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 |
| Skilak Lake outlet | 741 | 0.999 | 0.000 | 0.001 | 787 | 0.997 | 0.003 | 800 | 0.986 | 0.002 | 0.012 | 796 | 1.000 | 0.000 | 0.000 | 794 | 0.993 | 0.007 |
| Moose Creek, Kenai | 199 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 194 | 0.997 | 0.000 | 0.003 | 198 | 0.992 | 0.008 |
| **Yentna River** | | | | | | | | | | | | | | | | | | |
| Chelatna Lake | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 197 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 |
| West Fork Yentna River | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 197 | 1.000 | 0.000 | 0.000 | 199 | 0.995 | 0.005 |
| Hewitt/Whiskey Lakes | 99 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 99 | 0.874 | 0.126 |
| Shell Lake | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 186 | 0.686 | 0.315 |
| Trinity/Movie Lakes | 198 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 200 | 0.848 | 0.153 | 0.000 | 197 | 0.982 | 0.018 |
| Judd Lake | 199 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 |
| **Susitna River** | | | | | | | | | | | | | | | | | | |
| Byers Lake | 94 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 98 | 0.995 | 0.005 |
| Stephan Lake | 123 | 1.000 | 0.000 | 0.000 | 124 | 1.000 | 0.000 | 125 | 1.000 | 0.000 | 0.000 | 123 | 1.000 | 0.000 | 0.000 | 124 | 0.831 | 0.169 |
| Larson Lake | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 196 | 1.000 | 0.000 | 0.000 | 200 | 0.998 | 0.003 |
| Birch Creek | 67 | 1.000 | 0.000 | 0.000 | 67 | 1.000 | 0.000 | 67 | 1.000 | 0.000 | 0.000 | 67 | 1.000 | 0.000 | 0.000 | 67 | 0.970 | 0.030 |
| Red Shirt Lake | 33 | 1.000 | 0.000 | 0.000 | 34 | 1.000 | 0.000 | 34 | 1.000 | 0.000 | 0.000 | 34 | 1.000 | 0.000 | 0.000 | 34 | 0.897 | 0.103 |
| Susitna River slough 11 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 49 | 1.000 | 0.000 | 0.000 | 50 | 0.980 | 0.020 |
| **Western Cook Inlet** | | | | | | | | | | | | | | | | | | |
| Coal Creek | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 |
| Chilligan River | 148 | 1.000 | 0.000 | 0.000 | 150 | 1.000 | 0.000 | 150 | 1.000 | 0.000 | 0.000 | 149 | 1.000 | 0.000 | 0.000 | 149 | 0.990 | 0.010 |
| MacArthur River | 97 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 98 | 0.954 | 0.046 |
| Wolverine Creek | 99 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 0.995 | 0.005 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 |
| Crescent Lake site 1 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 99 | 0.944 | 0.056 |
| Crescent Lake site 2 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 97 | 1.000 | 0.000 | 0.000 | 100 | 0.920 | 0.080 |
| Crescent Lake site 3 | 50 | 0.980 | 0.020 | 0.000 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 0.940 | 0.060 |
| Packers Lake | 179 | 0.953 | 0.048 | 0.000 | 182 | 1.000 | 0.000 | 182 | 1.000 | 0.000 | 0.000 | 182 | 1.000 | 0.000 | 0.000 | 181 | 1.000 | 0.000 |
| **Kasilof River** | | | | | | | | | | | | | | | | | | |
| Bear Creek | 200 | 0.998 | 0.003 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 200 | 0.995 | 0.005 |
| Moose Creek, Tustumena | 199 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 197 | 1.000 | 0.000 | 0.000 | 194 | 1.000 | 0.000 | 0.000 | 198 | 1.000 | 0.000 |
| Glacier Flat Creek | 300 | 1.000 | 0.000 | 0.000 | 298 | 1.000 | 0.000 | 298 | 1.000 | 0.000 | 0.000 | 299 | 1.000 | 0.000 | 0.000 | 300 | 0.970 | 0.030 |
| Nikolai Creek | 198 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 0.998 | 0.000 | 0.003 | 200 | 1.000 | 0.000 | 0.000 | 200 | 0.968 | 0.033 |
| Tustumena Lake site 1 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 |
| Tustumena Lake site 2 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 50 | 0.990 | 0.010 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 49 | 0.990 | 0.010 |
| Seepage Creek | 100 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 91 | 0.989 | 0.011 |
| **Northeastern Cook Inlet** | | | | | | | | | | | | | | | | | | |
| Bishop Creek | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 |
| Daniels Lake | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 196 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 |
| **Knik Arm** | | | | | | | | | | | | | | | | | | |
| Nancy Lake | 99 | 1.000 | 0.000 | 0.000 | 98 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 99 | 0.970 | 0.030 |
| Cottonwood Creek | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 97 | 0.887 | 0.113 |
| Fish Creek | 292 | 1.000 | 0.000 | 0.000 | 300 | 1.000 | 0.000 | 300 | 1.000 | 0.000 | 0.000 | 297 | 1.000 | 0.000 | 0.000 | 299 | 0.901 | 0.099 |

Appendix A. Continued

| Population | N | PEPD-1 | | | N | PEPLT | | | N | PGDH | | N | PGM-1 | | | N | PGM-2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 100 | 113 | 94 | | 100 | 88 | 114 | | 100 | 90 | | 100 | null | -180 | | 100 | 136 | 57 |
| **Kenai River** | | | | | | | | | | | | | | | | | | | |
| Russian River above/early | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 0.000 | 1.000 | 0.000 | 100 | 0.895 | 0.105 | 0.000 |
| Russian River above/late | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 0.005 | 0.995 | 0.000 | 200 | 0.875 | 0.125 | 0.000 |
| Russian River below | 99 | 0.975 | 0.025 | 0.000 | 100 | 0.985 | 0.005 | 0.010 | 99 | 1.000 | 0.000 | 99 | 0.379 | 0.611 | 0.010 | 100 | 0.800 | 0.200 | 0.000 |
| Ptarmigan Creek | 198 | 0.985 | 0.015 | 0.000 | 198 | 0.985 | 0.003 | 0.013 | 198 | 1.000 | 0.000 | 198 | 0.323 | 0.677 | 0.000 | 198 | 0.864 | 0.136 | 0.000 |
| Tern Lake | 147 | 1.000 | 0.000 | 0.000 | 149 | 0.977 | 0.024 | 0.000 | 150 | 1.000 | 0.000 | 150 | 0.222 | 0.778 | 0.000 | 150 | 0.663 | 0.337 | 0.000 |
| Quartz Creek | 199 | 1.000 | 0.000 | 0.000 | 196 | 0.972 | 0.015 | 0.013 | 200 | 1.000 | 0.000 | 199 | 0.277 | 0.724 | 0.000 | 199 | 0.814 | 0.186 | 0.000 |
| Btwn Ken/Ski Lks site 1 | 100 | 0.985 | 0.015 | 0.000 | 100 | 0.960 | 0.015 | 0.025 | 100 | 1.000 | 0.000 | 100 | 0.252 | 0.748 | 0.000 | 100 | 0.780 | 0.220 | 0.000 |
| Btwn Ken/Ski Lks site 2 | 100 | 0.980 | 0.020 | 0.000 | 100 | 0.980 | 0.020 | 0.000 | 100 | 1.000 | 0.000 | 100 | 0.344 | 0.656 | 0.000 | 100 | 0.775 | 0.225 | 0.000 |
| Btwn Ken/Ski Lks site 3 | 150 | 0.990 | 0.010 | 0.000 | 150 | 0.987 | 0.003 | 0.010 | 150 | 1.000 | 0.000 | 150 | 0.330 | 0.663 | 0.007 | 150 | 0.790 | 0.210 | 0.000 |
| Btwn Ken/Ski Lks site 4 | 50 | 0.970 | 0.030 | 0.000 | 50 | 0.990 | 0.010 | 0.000 | 50 | 1.000 | 0.000 | 50 | 0.297 | 0.693 | 0.010 | 50 | 0.770 | 0.230 | 0.000 |
| Btwn Ken/Ski Lks site 5 | 100 | 0.980 | 0.020 | 0.000 | 100 | 0.980 | 0.005 | 0.015 | 100 | 1.000 | 0.000 | 100 | 0.368 | 0.633 | 0.000 | 100 | 0.795 | 0.205 | 0.000 |
| Btwn Ken/Ski Lks site 6 | 296 | 0.998 | 0.002 | 0.000 | 297 | 0.968 | 0.010 | 0.022 | 297 | 1.000 | 0.000 | 297 | 0.307 | 0.693 | 0.000 | 297 | 0.801 | 0.199 | 0.000 |
| Hidden Creek | 199 | 1.000 | 0.000 | 0.000 | 200 | 0.903 | 0.098 | 0.000 | 200 | 1.000 | 0.000 | 198 | 0.057 | 0.943 | 0.000 | 200 | 0.993 | 0.008 | 0.000 |
| Skilak Lake outlet | 793 | 0.994 | 0.006 | 0.000 | 795 | 0.993 | 0.003 | 0.004 | 800 | 1.000 | 0.000 | 800 | 0.329 | 0.672 | 0.000 | 800 | 0.754 | 0.246 | 0.000 |
| Moose Creek, Kenai | 199 | 1.000 | 0.000 | 0.000 | 194 | 0.997 | 0.003 | 0.000 | 200 | 1.000 | 0.000 | 198 | 0.113 | 0.887 | 0.000 | 200 | 0.740 | 0.260 | 0.000 |
| **Yentna River** | | | | | | | | | | | | | | | | | | | |
| Chelatna Lake | 200 | 1.000 | 0.000 | 0.000 | 195 | 0.995 | 0.005 | 0.000 | 200 | 1.000 | 0.000 | 200 | 0.038 | 0.962 | 0.000 | 200 | 0.868 | 0.130 | 0.003 |
| West Fork Yentna River | 200 | 0.995 | 0.005 | 0.000 | 199 | 0.972 | 0.028 | 0.000 | 200 | 1.000 | 0.000 | 200 | 0.071 | 0.929 | 0.000 | 197 | 0.805 | 0.195 | 0.000 |
| Hewitt/Whiskey Lakes | 100 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 99 | 0.068 | 0.932 | 0.000 | 100 | 0.625 | 0.375 | 0.000 |
| Shell Lake | 200 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 0.098 | 0.902 | 0.000 | 200 | 0.250 | 0.750 | 0.000 |
| Trinity/Movie Lakes | 200 | 1.000 | 0.000 | 0.000 | 198 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 0.049 | 0.951 | 0.000 | 200 | 0.283 | 0.718 | 0.000 |
| Judd Lake | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 0.360 | 0.640 | 0.000 | 200 | 0.850 | 0.150 | 0.000 |
| **Susitna River** | | | | | | | | | | | | | | | | | | | |
| Byers Lake | 99 | 1.000 | 0.000 | 0.000 | 100 | 0.980 | 0.020 | 0.000 | 99 | 1.000 | 0.000 | 100 | 0.188 | 0.812 | 0.000 | 100 | 0.815 | 0.185 | 0.000 |
| Stephan Lake | 125 | 1.000 | 0.000 | 0.000 | 120 | 1.000 | 0.000 | 0.000 | 125 | 1.000 | 0.000 | 125 | 0.000 | 1.000 | 0.000 | 125 | 0.736 | 0.264 | 0.000 |
| Larson Lake | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 0.395 | 0.606 | 0.000 | 200 | 0.680 | 0.320 | 0.000 |
| Birch Creek | 67 | 1.000 | 0.000 | 0.000 | 67 | 0.993 | 0.008 | 0.000 | 67 | 1.000 | 0.000 | 66 | 0.282 | 0.718 | 0.000 | 67 | 0.813 | 0.187 | 0.000 |
| Red Shirt Lake | 33 | 1.000 | 0.000 | 0.000 | 34 | 1.000 | 0.000 | 0.000 | 34 | 1.000 | 0.000 | 34 | 0.030 | 0.970 | 0.000 | 34 | 0.588 | 0.412 | 0.000 |
| Susitna River slough 11 | 50 | 0.990 | 0.000 | 0.010 | 50 | 0.970 | 0.030 | 0.000 | 47 | 1.000 | 0.000 | 50 | 0.152 | 0.849 | 0.000 | 50 | 0.800 | 0.200 | 0.000 |
| **Western Cook Inlet** | | | | | | | | | | | | | | | | | | | |
| Coal Creek | 199 | 0.998 | 0.000 | 0.003 | 200 | 0.998 | 0.003 | 0.000 | 200 | 1.000 | 0.000 | 200 | 0.464 | 0.537 | 0.000 | 200 | 0.858 | 0.143 | 0.000 |
| Chilligan River | 150 | 1.000 | 0.000 | 0.000 | 145 | 1.000 | 0.000 | 0.000 | 150 | 1.000 | 0.000 | 150 | 0.201 | 0.799 | 0.000 | 150 | 0.927 | 0.073 | 0.000 |
| MacArthur River | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 0.213 | 0.787 | 0.000 | 100 | 0.780 | 0.220 | 0.000 |
| Wolverine Creek | 100 | 1.000 | 0.000 | 0.000 | 98 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 0.062 | 0.938 | 0.000 | 100 | 0.970 | 0.030 | 0.000 |
| Crescent Lake site 1 | 100 | 1.000 | 0.000 | 0.000 | 92 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 99 | 0.130 | 0.870 | 0.000 | 100 | 0.725 | 0.275 | 0.000 |
| Crescent Lake site 2 | 99 | 1.000 | 0.000 | 0.000 | 97 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 0.152 | 0.849 | 0.000 | 100 | 0.620 | 0.380 | 0.000 |
| Crescent Lake site 3 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 50 | 0.163 | 0.837 | 0.000 | 50 | 0.610 | 0.390 | 0.000 |
| Packers Lake | 183 | 1.000 | 0.000 | 0.000 | 182 | 1.000 | 0.000 | 0.000 | 182 | 0.995 | 0.006 | 183 | 0.003 | 0.997 | 0.000 | 182 | 0.756 | 0.245 | 0.000 |
| **Kasilof River** | | | | | | | | | | | | | | | | | | | |
| Bear Creek | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 0.120 | 0.880 | 0.000 | 200 | 0.668 | 0.333 | 0.000 |
| Moose Creek, Tustumena | 200 | 1.000 | 0.000 | 0.000 | 198 | 1.000 | 0.000 | 0.000 | 198 | 1.000 | 0.000 | 200 | 0.117 | 0.883 | 0.000 | 200 | 0.695 | 0.305 | 0.000 |
| Glacier Flat Creek | 300 | 0.998 | 0.002 | 0.000 | 299 | 1.000 | 0.000 | 0.000 | 300 | 1.000 | 0.000 | 300 | 0.117 | 0.883 | 0.000 | 300 | 0.678 | 0.322 | 0.000 |
| Nikolai Creek | 200 | 0.995 | 0.005 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 0.089 | 0.911 | 0.000 | 200 | 0.688 | 0.313 | 0.000 |
| Tustumena Lake site 1 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 50 | 0.152 | 0.849 | 0.000 | 50 | 0.670 | 0.330 | 0.000 |
| Tustumena Lake site 2 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 50 | 0.117 | 0.883 | 0.000 | 50 | 0.620 | 0.380 | 0.000 |
| Seepage Creek | 99 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 0.106 | 0.894 | 0.000 | 100 | 0.660 | 0.340 | 0.000 |
| **Northeastern Cook Inlet** | | | | | | | | | | | | | | | | | | | |
| Bishop Creek | 99 | 1.000 | 0.000 | 0.000 | 99 | 0.768 | 0.232 | 0.000 | 100 | 1.000 | 0.000 | 100 | 0.200 | 0.800 | 0.000 | 100 | 0.320 | 0.680 | 0.000 |
| Daniels Lake | 199 | 1.000 | 0.000 | 0.000 | 198 | 0.710 | 0.290 | 0.000 | 200 | 1.000 | 0.000 | 200 | 0.213 | 0.787 | 0.000 | 200 | 0.268 | 0.733 | 0.000 |
| **Knik Arm** | | | | | | | | | | | | | | | | | | | |
| Nancy Lake | 100 | 1.000 | 0.000 | 0.000 | 100 | 0.985 | 0.015 | 0.000 | 100 | 1.000 | 0.000 | 100 | 0.123 | 0.878 | 0.000 | 100 | 0.770 | 0.230 | 0.000 |
| Cottonwood Creek | 99 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 0.057 | 0.943 | 0.000 | 100 | 0.750 | 0.250 | 0.000 |
| Fish Creek | 298 | 0.998 | 0.000 | 0.002 | 300 | 0.837 | 0.163 | 0.000 | 300 | 1.000 | 0.000 | 293 | 0.012 | 0.988 | 0.000 | 300 | 0.583 | 0.417 | 0.000 |

Appendix A. Continued

| | | *sSOD-1* | | | *TPI-1,2* | | | | *TPI-3* | | | *TPI-4* | | | Heterozygosity | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population | N | 100 | 48 | N | -100 | -173 | -82 | N | 100 | 98 | N | 100 | 106 | 97 | Observed | Expected |
| **Kenai River** | | | | | | | | | | | | | | | | |
| Russian River above/early | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.0505 | 0.0528 |
| Russian River above/late | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.0460 | 0.0482 |
| Russian River below | 93 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.0429 | 0.0419 |
| Ptarmigan Creek | 198 | 1.000 | 0.000 | 198 | 1.000 | 0.000 | 0.000 | 197 | 1.000 | 0.000 | 198 | 1.000 | 0.000 | 0.000 | 0.0407 | 0.0393 |
| Tern Lake | 150 | 1.000 | 0.000 | 150 | 1.000 | 0.000 | 0.000 | 150 | 1.000 | 0.000 | 149 | 0.993 | 0.000 | 0.007 | 0.0408 | 0.0410 |
| Quartz Creek | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 0.998 | 0.003 | 200 | 1.000 | 0.000 | 0.000 | 0.0423 | 0.0425 |
| Btwn Ken/Ski Lks site 1 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.0481 | 0.0469 |
| Btwn Ken/Ski Lks site 2 | 100 | 1.000 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 99 | 0.995 | 0.005 | 99 | 1.000 | 0.000 | 0.000 | 0.0434 | 0.0452 |
| Btwn Ken/Ski Lks site 3 | 150 | 1.000 | 0.000 | 150 | 1.000 | 0.000 | 0.000 | 150 | 1.000 | 0.000 | 150 | 1.000 | 0.000 | 0.000 | 0.0409 | 0.0423 |
| Btwn Ken/Ski Lks site 4 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 0.0411 | 0.0426 |
| Btwn Ken/Ski Lks site 5 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.0327 | 0.0343 |
| Btwn Ken/Ski Lks site 6 | 297 | 1.000 | 0.000 | 296 | 1.000 | 0.000 | 0.000 | 296 | 1.000 | 0.000 | 296 | 1.000 | 0.000 | 0.000 | 0.0441 | 0.0421 |
| Hidden Creek | 199 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.0345 | 0.0346 |
| Skilak Lake outlet | 800 | 1.000 | 0.000 | 800 | 1.000 | 0.000 | 0.000 | 793 | 0.999 | 0.001 | 798 | 1.000 | 0.000 | 0.000 | 0.0401 | 0.0398 |
| Moose Creek, Kenai | 199 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 0.995 | 0.000 | 0.005 | 0.0412 | 0.0406 |
| **Yentna River** | | | | | | | | | | | | | | | | |
| Chelatna Lake | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 197 | 1.000 | 0.000 | 193 | 1.000 | 0.000 | 0.000 | 0.0324 | 0.0347 |
| West Fork Yentna River | 200 | 1.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 198 | 1.000 | 0.000 | 0.000 | 0.0382 | 0.0385 |
| Hewitt/Whiskey Lakes | 100 | 1.000 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 0.0372 | 0.0374 |
| Shell Lake | 200 | 1.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 0.0417 | 0.0436 |
| Trinity/Movie Lakes | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 198 | 1.000 | 0.000 | 0.000 | 0.0382 | 0.0375 |
| Judd Lake | 200 | 1.000 | 0.000 | 157 | 1.000 | 0.000 | 0.000 | 197 | 1.000 | 0.000 | 197 | 1.000 | 0.000 | 0.000 | 0.0435 | 0.0424 |
| **Susitna River** | | | | | | | | | | | | | | | | |
| Byers Lake | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.0408 | 0.0407 |
| Stephan Lake | 124 | 1.000 | 0.000 | 124 | 1.000 | 0.000 | 0.000 | 125 | 1.000 | 0.000 | 125 | 1.000 | 0.000 | 0.000 | 0.0555 | 0.0568 |
| Larson Lake | 198 | 1.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 0.0435 | 0.0382 |
| Birch Creek | 67 | 1.000 | 0.000 | 67 | 1.000 | 0.000 | 0.000 | 67 | 1.000 | 0.000 | 67 | 1.000 | 0.000 | 0.000 | 0.0260 | 0.0286 |
| Red Shirt Lake | 34 | 1.000 | 0.000 | 34 | 1.000 | 0.000 | 0.000 | 34 | 1.000 | 0.000 | 34 | 1.000 | 0.000 | 0.000 | 0.0382 | 0.0376 |
| Susitna River slough 11 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 0.0451 | 0.0432 |
| **Western Cook Inlet** | | | | | | | | | | | | | | | | |
| Coal Creek | 198 | 1.000 | 0.000 | 200 | 0.991 | 0.000 | 0.009 | 200 | 1.000 | 0.000 | 193 | 0.997 | 0.003 | 0.000 | 0.0427 | 0.0410 |
| Chilligan River | 148 | 1.000 | 0.000 | 150 | 1.000 | 0.000 | 0.000 | 150 | 1.000 | 0.000 | 150 | 1.000 | 0.000 | 0.000 | 0.0211 | 0.0219 |
| MacArthur River | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.0452 | 0.0435 |
| Wolverine Creek | 100 | 0.995 | 0.005 | 100 | 1.000 | 0.000 | 0.000 | 99 | 1.000 | 0.000 | 99 | 1.000 | 0.000 | 0.000 | 0.0294 | 0.0273 |
| Crescent Lake site 1 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 0.950 | 0.050 | 100 | 1.000 | 0.000 | 0.000 | 0.0401 | 0.0408 |
| Crescent Lake site 2 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 0.995 | 0.005 | 100 | 1.000 | 0.000 | 0.000 | 0.0391 | 0.0384 |
| Crescent Lake site 3 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 0.980 | 0.020 | 50 | 1.000 | 0.000 | 0.000 | 0.0391 | 0.0413 |
| Packers Lake | 180 | 1.000 | 0.000 | 182 | 1.000 | 0.000 | 0.000 | 182 | 1.000 | 0.000 | 182 | 1.000 | 0.000 | 0.000 | 0.0304 | 0.0299 |
| **Kasilof River** | | | | | | | | | | | | | | | | |
| Bear Creek | 199 | 1.000 | 0.000 | 200 | 0.999 | 0.001 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.0452 | 0.0463 |
| Moose Creek, Tustumena | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.0433 | 0.0451 |
| Glacier Flat Creek | 250 | 1.000 | 0.000 | 295 | 1.000 | 0.000 | 0.000 | 300 | 1.000 | 0.000 | 300 | 1.000 | 0.000 | 0.000 | 0.0466 | 0.0478 |
| Nikolai Creek | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 200 | 1.000 | 0.000 | 200 | 1.000 | 0.000 | 0.000 | 0.0530 | 0.0518 |
| Tustumena Lake site 1 | 50 | 1.000 | 0.000 | 49 | 1.000 | 0.000 | 0.000 | 49 | 1.000 | 0.000 | 49 | 1.000 | 0.000 | 0.000 | 0.0422 | 0.0452 |
| Tustumena Lake site 2 | 50 | 1.000 | 0.000 | 50 | 1.000 | 0.000 | 0.000 | 50 | 0.990 | 0.010 | 50 | 1.000 | 0.000 | 0.000 | 0.0378 | 0.0403 |
| Seepage Creek | 100 | 1.000 | 0.000 | 98 | 1.000 | 0.000 | 0.000 | 97 | 0.995 | 0.005 | 98 | 1.000 | 0.000 | 0.000 | 0.0460 | 0.0485 |
| **Northeastern Cook Inlet** | | | | | | | | | | | | | | | | |
| Bishop Creek | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.0395 | 0.0425 |
| Daniels Lake | 200 | 1.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 199 | 1.000 | 0.000 | 199 | 1.000 | 0.000 | 0.000 | 0.0427 | 0.0421 |
| **Knik Arm** | | | | | | | | | | | | | | | | |
| Nancy Lake | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.0355 | 0.0333 |
| Cottonwood Creek | 100 | 1.000 | 0.000 | 98 | 1.000 | 0.000 | 0.000 | 100 | 1.000 | 0.000 | 100 | 1.000 | 0.000 | 0.000 | 0.0439 | 0.0413 |
| Fish Creek | 294 | 1.000 | 0.000 | 298 | 1.000 | 0.000 | 0.000 | 297 | 1.000 | 0.000 | 298 | 1.000 | 0.000 | 0.000 | 0.0464 | 0.0464 |

**Appendix II.**

Final Report of Contract

Bentzen, P., and Olsen, J. 1996. Microsatellite variation in Cook Inlet sockeye salmon.

Draft. This unpublished data is not cited without permission of the authors.

# Microsatellite Variation in Cook Inlet Sockeye Salmon

Final Report

prepared for

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## Introduction

The objective of this project was to use a new class of genetic marker, microsatellites, to examine genetic population structure in Cook Inlet sockeye salmon (*Oncorhynchus nerka*). Microsatellites are a class of variable number of tandem repeat (VNTR) nuclear DNA sequences that are ubiquitous in eukaryotes and are distributed throughout the genome at intervals of approximately 10 kilobase pairs (Wright 1992). Microsatellites tend to be highly polymorphic with a potential for high resolution of intra-specific population structure in salmonids (Wright and Bentzen 1994). The application of microsatellites to studying population structure of Cook Inlet sockeye salmon is intended to augment the extensive allozyme data base collected by Alaska Department of Fish and Game (ADF&G) genetics personnel.

Because the use of microsatellites in salmonid population studies is limited our project involved two phases. First, 15 microsatellite primer pairs developed from various species of salmonid were screened in sockeye salmon to assess quality of the amplified polymerase chain reaction (PCR) product, optimize PCR conditions, and assess each microsatellites potential for assessing genetic population structure. In phase two, four candidate primer pairs were chosen from among the 15 and used to survey four Cook Inlet populations from three river drainages. These populations include the Russian River (late) and Skilak Lake outlet (Kenai River drainage), Moose Creek (Kasilof River drainage) and the Yentna River (Susitna River drainage) (Figure 1).

## Methods

Phase One:

*Microsatellite Screening*:

DNA from liver tissue provided by the ADFG&G genetics lab was extracted from four sockeye using the phenol/chloroform method (Hoelzel and Green 1994). Sequences for 15 microsatellite primers were obtained from the literature and/or via communication and permission from other labs (Table 1). Microsatellite primers were synthesized at the Marine Molecular Biotechnology Lab (MMBL) on a Beckman Oligo $1000_{TM}$ DNA synthesizer.

The initial PCR parameters were based on general guidelines from the literature and past experience with salmonid microsatellite primers at the MMBL and other labs (Table 1). Each PCR was carried out in a 10µl volume consisting of 10 mM Tris-HCL (pH 8.3), 50 mM KCL, 1.5mM $MgCl_2$, 0.8 mM dNTP's, 0.4 units Taq polymerase, 0.3 µM primer, 50 ng DNA template and $H_2O$. Results of each PCR were assessed by visualizing the PCR product following its electrophoresis in an 0.8% agarose or 6% non-denaturing polyacrylamide gel. For each microsatellite primer pair a quality grade of 1-5 was assigned following a modified protocol of Pepin et al. 1995. A grade of 1 represented strong amplification with one or two bands and no smearing. A grade of 5 indicated no amplification. Following the quality assessment, further PCRs were carried out under more stringent conditions (e.g. increased annealing temperature and/or decreased $MgCl_2$ concentration) for those microsatellite primers receiving a grade of 3 or below. To simplify the final screening a standard PCR profile (PCR profile A) was used: (94° (2min) + 7(94° (1min) + XX° (30sec) + 72° (15sec)) + 18(94° (30sec) + XX° (30sec) + 72° (15sec))). Ultimately, those primers receiving a grade below 3 were excluded from the battery of primers recommended for use in phase two. Four microsatellite primers were chosen from among the 15 tested for use on Cook Inlet sockeye.

*Multiplex PCR:*

Prior to initiating the population survey in phase two, an attempt was made to co-amplify the four loci in a single PCR. Co-amplification or "multiplexing" allows rapid detection of microsatellite variation and reduces processing cost (O'Reilly et al., in press; Urquhart et al. 1995). We employed the Perkin Elmer-Applied Biosystems Inc. (ABI) four color labeling system to label the forward primer for each microsatellite locus (Perkin Elmer 1995). One of three different color labels was assigned to each microsatellite locus based on expected allelic range. With this system up to three loci with overlapping alleles may be multiplexed using the ABI GeneScan color detection system. A fourth color was reserved for the internal lane (sizing) standard. All fluorescently tagged primers were synthesized at the MMBL as described above. Because the optimal annealing temperature differed for the four primer sets (Table 1), the multiplex was tested at 52°, 54° and 56° using first two, then three and four of the primer sets in the same PCR. PCR primer concentrations were adjusted following each test to achieve similar product quantity as judged by peak height for each microsatellite allele on the Genotyper electropherogram. The four individuals used in the initial screening were genotyped using the multiplex system and alleles were scored for each microsatellite locus to assure co-amplification did not alter fragment length.

Phase Two:

*Population Survey:*

Samples of liver tissue from 50 individuals from each of the four populations was provided by the ADF&G genetics lab. Genomic DNA for PCR was extracted using a rapid, simplified cell lysis protocol modified from Hoelzel and Green, 1994. Approximately 10 mg of tissue from each sample was placed in a cell lysis buffer consisting of 10 mM TrisHCL pH 8.3, 50 mM KCL, and 0.5% TWEEN 20. One μl of proteanase K (10mg/ml) was added to each sample before incubation at 37° for approximately 12 hours. The samples were then heated to 95° for 15 minutes, centrifuged for 5 minutes at 14,000 RPM and frozen at -20° until needed for PCR.

Using the multiplex system, 200 individuals were genotyped for the microsatellite loci identified in phase 1. Following PCR, the amplified products were electrophoresed on a de-naturing polyacrylamide gel and detected using an ABI 373A$_{TM}$ automated sequencer. The GeneScan software uses the internal lane standard and color code to determine length (in base pairs) of each microsatellite allele. Final analysis and synthesis of the GeneScan data was performed with the Genotyper software provided by ABI.

*Statistical Analysis:*

Two methods were used to evaluate within and between population genetic variation using the microsatellite allele frequency data. First, a test for Hardy-Weinberg equilibrium (HWE) and population differentiation was performed using GENEPOP ver. 1.1 (Raymond and Rousset 1994). GENEPOP utilizes recently developed algorithms that provide estimates of significance levels for Fisher exact tests of HWE and contingency chi-square analysis of independence between populations and the allelic composition. The exact test has been suggested for VNTR data because many loci have 10 or more alleles and some genotype frequencies are very low or zero. These algorithms were developed to utilize exact tests when allele numbers per locus are large (>4) and computation time would otherwise be prohibitive. Second, estimates of genetic differentiation among populations as indicated by the fixation index, $F_{ST}$, were made using GENEPOP which computes F-statistics according to Weir and Cockerham (1984).

Two estimates of genetic relatedness were made using PHYLIP ver. 3.5c (Felsenstein 1993). First, GENEDIST was used to compute Nei's genetic distance using the allele frequency data. The distance data was then used to construct phylogenies by applying both UPGMA and neighbor joining methods in NEIGHBOR. Second, a maximum likelihood algorithm (CONTML) was used to analyze the microsatellite data and group the four populations according to similarity of allele frequencies.

## Results and Discussion

*Microsatellite Screening and Multiplex PCR:*

The results of the phase one screening are shown in Table 1. For each microsatellite primer pair Table 1 summarizes the optimum PCR condition, quality of the PCR product, approximate product size (in base pairs), primer sequence, source of the sequence (lab and/or author) and source species. Based on the quality criteria described above, ten of fifteen microsatellite primer pairs were considered for the population study and four were chosen from among the group of ten. These included Oneμ1, Oneμ11, Oneμ14 and Ssa293 (Scribner 1996; P. Bentzen pers. Comm.). Table 1 shows the fluorescent amidite label used for each of the four primer sets and their corresponding color display. The four primer pairs co-amplified using an annealing temperature of 52° for PCR profile A. Primer concentrations for PCR were adjusted to achieve similar band intensity as follows: Oneμ1(Hex)(0.07μm), Oneμ11(Tet)(0.07μm), Oneμ14(Hex)(0.15μm), Ssa293(Tet)(0.10μm).

*Ssa293:*

At this point it is worth noting the exceptionally low observed heterozygosity ($H_o$) at the Ssa 293 locus (Table 2). In fact some samples failed to amplify. This is likely the result of mutation at one or more alleles in the DNA sequence complementary to the microsatellite primer. These "null" alleles have been described previously for human microsatellites (Callen et al. 1993) and are more likely a concern when transferring primers between species (Forbes et al. 1995). Verification of the "null" allele(s) by adjusting priming sites and sequencing has not been done. To complete the population survey all 200 fish were screened for a fifth microsatellite locus, Oneμ2. The Ssa293 data was not included in subsequent statistical analyses.

*Allelic Variation at each Microsatellite Locus:*

Table 2 summarizes the microsatellite variability by locus and population. With the exception of Oneμ1 in the Russian River, all loci were polymorphic in all populations. The range of variation was considerable as indicated by heterozygosity and allele number. Excluding Ssa293, observed heterozygosity ranged from 0.20 to 0.90. The mean heterozygosity for all loci was approximately 0.50 for Moose Creek, Skilak Lake and Yentna River. The Russian River exhibited the lowest degree of variability with a mean heterozygosity of 0.32. The test for Hardy-Weinberg equilibrium revealed no significant differences between observed versus expected heterozygosities within each population at each locus (Table 2). Numbers of alleles per locus ranged from 2-10.

Allele frequencies differed among all populations and ranged from 1-100% (Figure 2). No clear pattern was evident in the shapes of the allele distributions across populations. For each locus the same allele was most frequent in all populations: Oneμ1(114bp), Oneμ2(270bp), Oneμ11(150bp), Oneμ14(150bp). At three of the four loci at least one population unique allele was present. Notably, the 129 and 137 bp alleles at Oneu14 in Moose Creek and Russian River sockeye respectively had frequencies of 11% and 8%. Additional screening would be needed to determine if these alleles are present in other populations.

Significant differences in allele frequencies ($p<0.0001$, $SE<0.0001$) were shown for all populations using the Markov chain algorithm to estimate the probability of independence from an exact Fisher test on multiple RxC contingency tables (Table 3). Further, a pairwise comparison of all populations using the same algorithm showed significant differences ($p<0.05$) in allele frequencies at most loci (Table 3). The exceptions were: Moose Creek and Skilak Lake at Oneμ1 and Oneμ2; Moose Creek and Russian River at Oneμ11; Russian river and Skilak Lake at Oneμ11. Finally, an estimate of $F_{ST}$ for each locus revealed moderate genetic differentiation (Table 4). Values ranged from 0.042-0.100. For all loci, combined $F_{ST}$ was estimated to be 0.071 with a bootstrap confidence interval of 0.049-0.092 (95% CI).

*Genetic Relationships Among Populations:*

Estimated genetic relatedness among the four sockeye populations is depicted in three phenograms in Figure 3. The three methods gave very similar results placing Moose Creek and Skilak Lake outlet populations closest and approximately the same distance from the Russian River and Yentna River populations. The two clustering methods using Nei's distance placed the Moose Creek and Skilak Lake populations closest to the Russian River population while the maximum likelihood method placed them closest to Yentna River.

Interestingly, the pairwise comparison of allele frequencies and cluster analysis suggest the Skilak Lake and Moose Creek populations are most genetically similar and the Russian River population is significantly different from both and equally close to the Yentna River population (Susitna River drainage). This seems counter to geographic considerations which would suggest Skilak Lake and Russian River, because they share the same watershed, would show the greatest genetic affinity. Two possible explanations for this apparent contradiction are offered. First, due the glacial history of this region these populations are evolutionarily young. Colonization events have occurred most likely within the last 2000 years (Burger et al. submitted). The genetic relationships evident here, while based on only four microsatellite loci, may be the result of founding effects and chance genetic convergence through drift. Genetic bottlenecking due to recent colonization may explain the non-uniform allele distribution at each locus and the presence of alleles in one population which are lacking in the other two (e.g. the 129 bp and 137 bp alleles at Oneμ14). A second explanation is that the four microsatellite loci used in this study do not reflect the overall genetic relationships among these four populations. Short of screening additional loci, evidence for or against this explanation will rest with how well our data accords with others who have screened the same populations with different markers.

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Table 1: Sockeye salmon (*Oncorhynchus nerka*) microsatellite screening log

| Primer | Primer Sequence | Source | Size Range of product | Anneal (oC) | MgCl2 mM | Primer (uM) | PCR Profile | Product Qual 1\ | Amidite Label | Color Display | Source Species |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fgt1F | 5'-AGA-TTT-ACC-CAG-CCA-GGT-AG | Sakamoto et al. 1993 | 190-200 | 56 | 1.5 | 0.3 | A | 1 | | | Oncorhynchus |
| Fgt1R | 5'-CAT-AGT-CTG-AAC-AGG-GAC-AG | | | | | | | | | | mykiss |
| Omy77F | 5'-CGT-TCT-CTA-CTG-AGT-CAT | Bentzen, (pers. com.) | N/A | 51 | 1.5 | 0.3 | A | 5 | | | Oncorhynchus |
| Omy77R | 5'-GGG-TCT-TTA-AGG-CTT-CAC-TGC-A | | | | | | | | | | mykiss |
| [redacted] | | | | | | | | | | | |
| Ots6F | 5'-TCT-CTT-CCA-GCA-CCA-CAC-A | Hedgecock, in press | N/A | 60 | 1.5 | 0.3 | A | 5 | | | Oncorhynchus |
| Ots6R | 5'-AGA-CAG-TTT-TTC-CAC-ATC-C | | | | | | | | | | tshawytscha |
| PuPuPyF | 5' -ATG-CAG-CGG-ATG-TAG-GGG-GA | Bentzen, (pers. com.) | N/A | 52 | 1.5 | 0.3 | A | 5 | | | Oncorhynchus |
| PuPuPyR | 5'-TTA-AGT-GAA-AAG-ACG-TAA-GTC | | | | | | | | | | mykiss |
| Ssa4F | 5'-ATT-AGG-CAG-CAG-CAG-GCT-GC | McConnell et al. 1995 | 120 | 57 | 1.5 | 0.3 | A | 2 | | | Salmo |
| Ssa4R | 5'-TGT-TCA-CTC-ACT-GAC-ACG-CG | | | | | | | | | | salar |
| Ssa85F | 5'-AGG-TGG-GTC-CTC-CAA-GCT-AC | O'Reilly et al. in press | 140 | 58 | 1.5 | 0.3 | A | 2 | | | Salmo |
| Ssa85R | 5'-ACC-CGC-TCC-TCA-CTT-AAT-C | | | | | | | | | | salar |
| Ssa171F | 5'-TTA-TTA-TCC-AAA-GGG-GTC-AAA-A | O'Reilly et al. in press | N/A | 58 | 1.5 | 0.3 | A | 5 | | | Salmo |
| Ssa171R | 5'-GAG-GTC-GCT-GGG-GTT-TAC-TAT | | | | | | | | | | salar |
| Ssa202F | 5'-CTT-GGA-ATA-TCT-AGA-ATA-TGG-C | O'Reilly et al. in press | N/A | 58 | 1.5 | 0.3 | A | 5 | | | Salmo |
| Ssa202R | 5'-TTC-ATG-TGT-TAA-TGT-TGC-GTG | | | | | | | | | | salar |
| [redacted] | | | | | | | | | | | |
| Str60F | 5'-CGG-TGT-GCT-TGT-CAG-GTT-TC | Estoup et al. 1993 | 120 | 57 | 1.5 | 0.3 | A | 1 | | | Salmo |
| Str60R | 5'-GTC-AAG-TCA-GCA-AGC-CTC-AC | | | | | | | | | | trutta |
| Str73F | 5'-CCT-GGA-GAT-CCT-CCA-GCA-GGA | Estoup et al. 1993 | 130 | 58 | 1.5 | 0.3 | A | 2 | | | Salmo |
| Str73R | 5'-CTA-TTC-TGC-TTG-TAA-CTA-GAC-CTA | | | | | | | | | | trutta |

Product Quality (After Pepin et al. 1995):

1 - strong amplification with one or two bands and no smearing.

2 - weak to moderate amplification with one or two bands and/or some smearing.

3 - multiple bands and no smearing.

4 - multiple bands and smearing.

5- no amplification at all.

PCR profile A:

1X- 94°(120s)

7X- (94°(60s)+XX°(30s)+72°(15s))

18X- (94°(30s)+XX°(30s)+72°(15s))

4°(Hold)

Table 2. Allele number (A), observed heterozygosity ($H_O$), and expected heterozygosity ($H_E$) at four microsatellite loci in Cook Inlet sockeye salmon. (P) is the statistical P-value (probability that $H_O$ and $H_E$ are statistically similiar). S.E. is the standard error of (P) 1\.

| | Moose Creek | | | | | | Russian River | | | | | | Skilak Lake | | | | | | Yentna River | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Locus 2\ | n | A | $H_O$ | $H_E$ | (P) | S.E. | n | A | $H_O$ | $H_E$ | (P) | S.E. | n | A | $H_O$ | $H_E$ | (P) | S.E. | n | A | $H_O$ | $H_E$ | (P) | S.E. |
| Oneu1 | 50 | 2 | 0.20 | 0.18 | 1.00 | | 50 | 1 | 0.00 | 0.00 | * | * | 50 | 3 | 0.24 | 0.22 | 1.00 | | 50 | 3 | 0.38 | 0.40 | 0.79 | |
| Oneu2 | 50 | 10 | 0.76 | 0.80 | 0.15 | 0.01 | 50 | 6 | 0.38 | 0.40 | 0.53 | 0.01 | 48 | 9 | 0.90 | 0.83 | 0.59 | 0.01 | 50 | 7 | 0.68 | 0.72 | 0.70 | 0.01 |
| Oneu11 | 50 | 3 | 0.46 | 0.43 | 0.35 | | 50 | 3 | 0.36 | 0.45 | 0.08 | | 50 | 4 | 0.42 | 0.42 | 0.74 | | 50 | 3 | 0.58 | 0.65 | 0.15 | |
| Oneu14 | 50 | 8 | 0.64 | 0.67 | 0.72 | 0.01 | 50 | 5 | 0.52 | 0.51 | 0.48 | 0.01 | 50 | 8 | 0.54 | 0.55 | 0.17 | 0.01 | 50 | 5 | 0.38 | 0.38 | 0.35 | 0.01 |
| Ssa293 | 43 | 4 | 0.28 | 0.70 | 0.00 | | 41 | 5 | 0.10 | 0.57 | 0.00 | 0.00 | 40 | 9 | 0.25 | 0.76 | 0.00 | 0.00 | 41 | 8 | 0.34 | 0.59 | 0.00 | 0.00 |
| Avg./Pop | | 5.8 | 0.52 | 0.52 | | | | 3.8 | 0.32 | 0.34 | | | | 6.0 | 0.52 | 0.51 | | | | 4.5 | 0.51 | 0.54 | | |

1\ Standard error values are provided for those loci in which the Markov-chain method was used to estimate P.
2\ Average/population data does not include Ssa293.

Table 3. Results of the pairwise test of independence between populations and allelic composition. The P-value is the probability that two populations have similar allele frequencies. S.E. is the standard error of the P-value estimate

| Population | Oneu1 | | Oneu2 | | One11 | | Oneu14 | |
|---|---|---|---|---|---|---|---|---|
| | P-value | S.E. | P-value | S.E. | P-value | S.E. | P-value | S.E. |
| Moose Ck x Russian R | 0.0008 | 0.0006 | 0.0000 | 0.0000 | 0.5669 | 0.0141 | 0.0000 | 0.0000 |
| Moose Ck x Skilak L | 0.3503 | 0.0094 | 0.0534 | 0.0077 | 0.0035 | 0.0012 | 0.0025 | 0.0014 |
| Moose Ck x Yentna R | 0.0041 | 0.0022 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Russian R x Skilak L | 0.0006 | 0.0004 | 0.0000 | 0.0000 | 0.0875 | 0.0068 | 0.0000 | 0.0000 |
| Russian R x Yentna R | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0002 | 0.0000 | 0.0000 |
| Skilak L x Yentna R | 0.0009 | 0.0007 | 0.0010 | 0.0008 | 0.0000 | 0.0000 | 0.0227 | 0.0000 |
| All Populations | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

Table 4. $F_{ST}$ according to Weir and Cockerham (1984)

| Locus | $F_{ST}$ |
|---|---|
| Oneu1 | 0.100 |
| Oneu2 | 0.085 |
| Oneu11 | 0.068 |
| Oneu14 | 0.042 |
| All Loci | 0.071 |
| 95% CI | 0.049-0.092 |

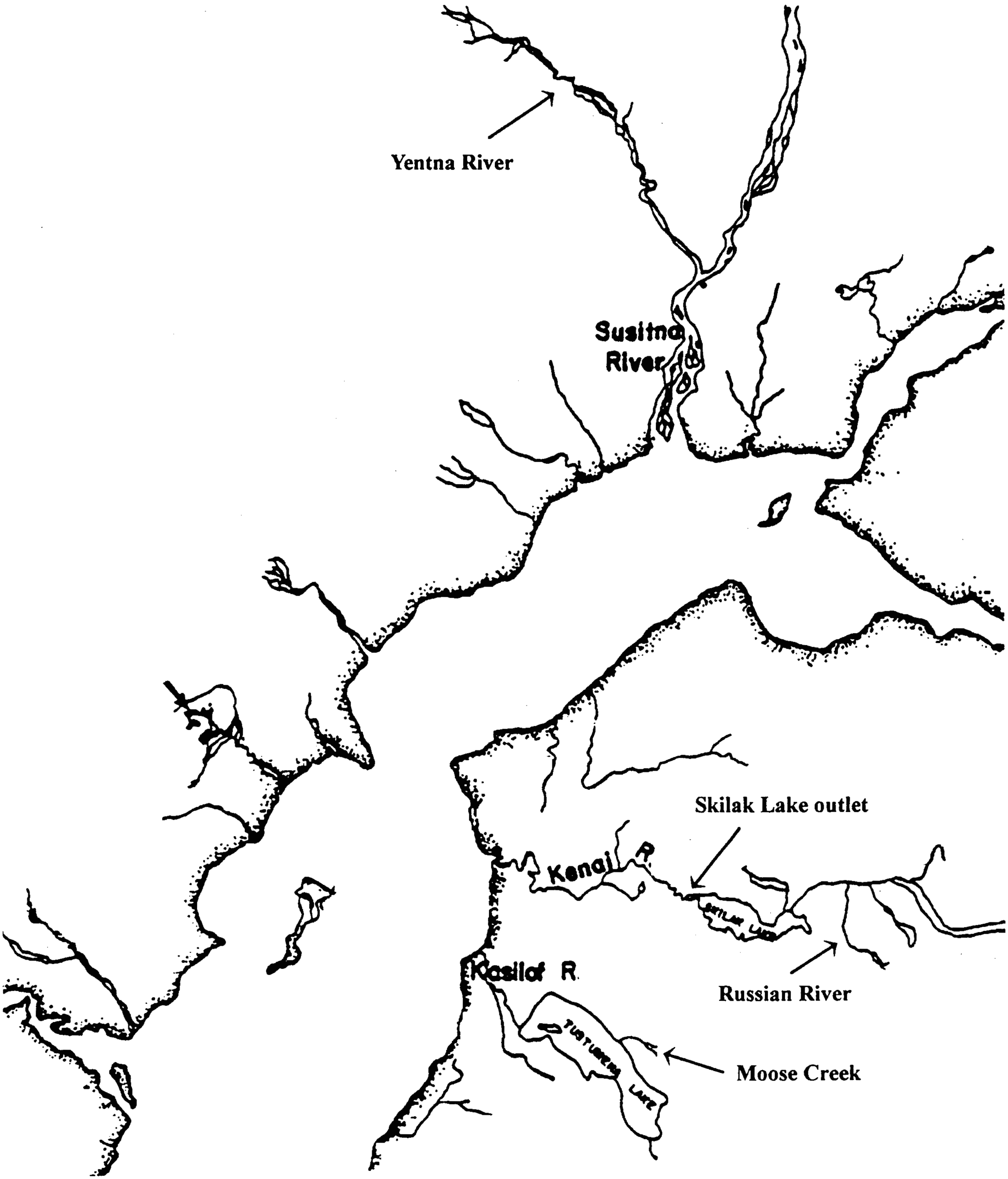


**Figure 1. Map of Cook Inlet showing Moose Creek, Skilak Lake, Russian River, and Yentna River.**

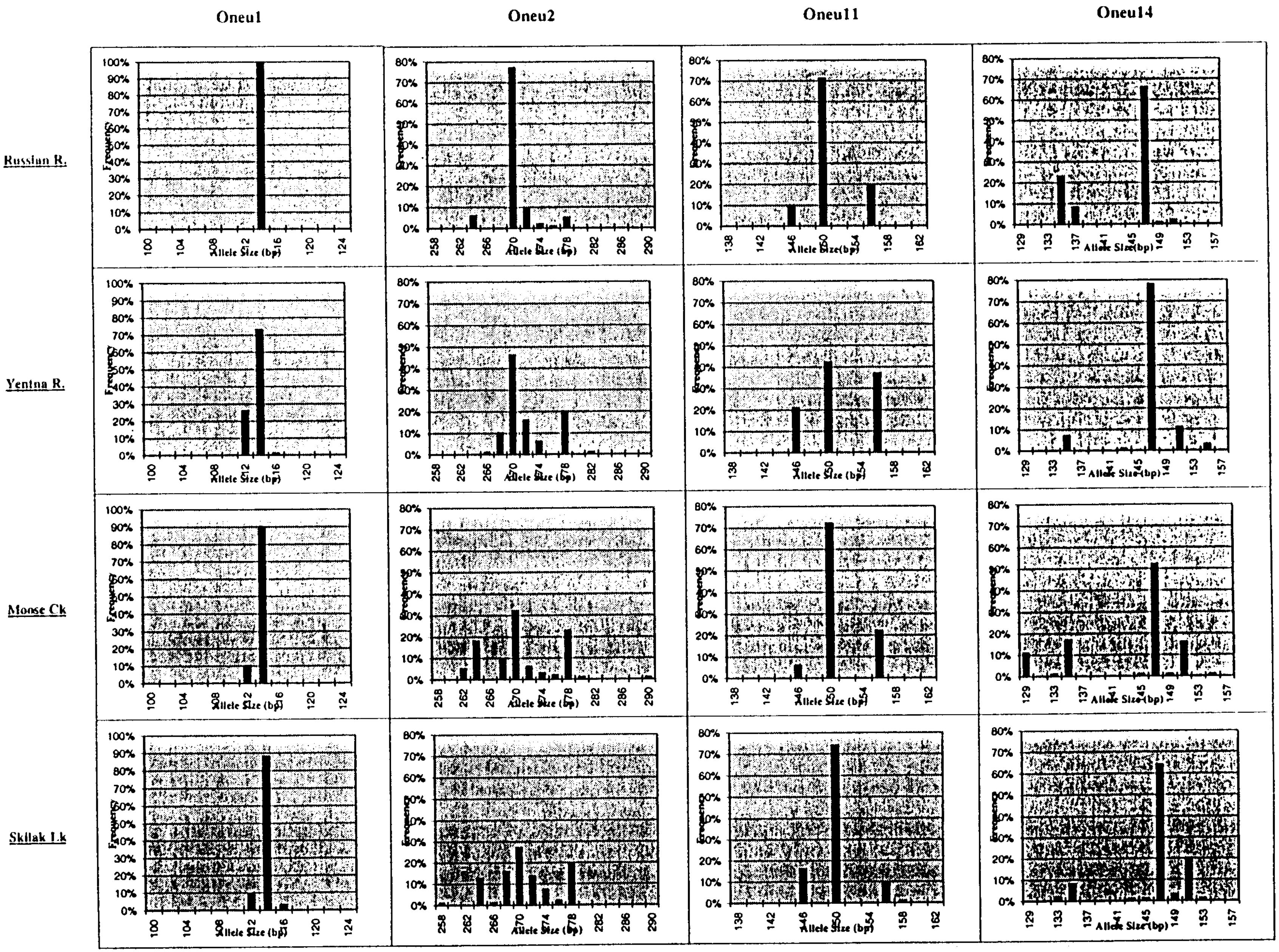


*Figure 2*. Allele frequency distributions for four microsatellite loci in four populations of Cook Inlet sockeye salmon.

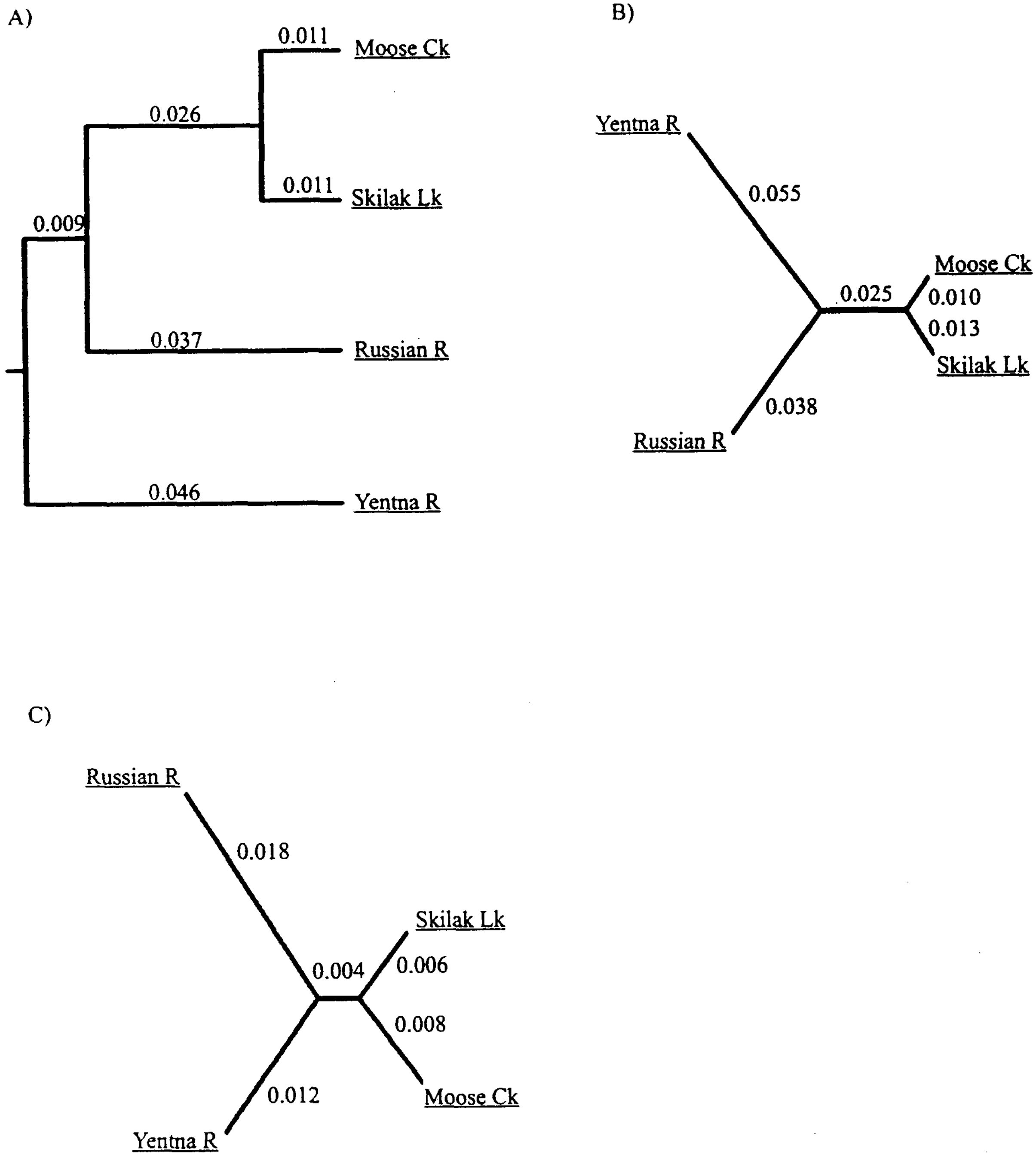


*Figure 3*. Genetic relatedness among four populations of Cook Inlet sockeye salmon calculated from allele frequencies at four microsatellite loci. A) Cluster analysis (UPGMA) of Nei's genetic distance. B) Cluster analysis (Neighbor-Joining) of Nei's genetic distance. C) Maximum likelyhood analysis of allele frequencies. Numbers at branches indicate relative genetic distance.