A SUMMARY OF SALMON ENHANCEMENT AND RESTORATION IN THE KODIAK MANAGEMENT AREA THROUGH 2001: A REPORT TO THE ALASKA BOARD OF FISHERIES

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Regional Information Report[1] No. 4K01-65

Alaska Department of Fish and Game
Division of Commercial Fisheries
211 Mission Road
Kodiak, AK 99615

December 2001

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ACKNOWLEDGMENTS

Alaska Department of Fish and Game (ADF&G) staff, including many technicians and biologists have spent many hours working and compiling data for these projects. Nick Sagalkin, Rob Baer, and Jeff Wadle provided data and tables that are incorporated into this report. Kodiak Regional Aquaculture Association (KRAA) personnel, including Larry Malloy, Chris Clevenger, Drew Aro, and Gary Byrne also provided data on hatchery stocking. Patti Nelson provided direction for compiling this report and Rod Campbell, Jim McCullough, and Rob Baer provided editorial comments. Lucinda Neel provided formatting and publication expertise.

Funding for many of these projects was provided by the KRAA.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

LIST OF TABLES

LIST OF TABLES (Cont.)

LIST OF FIGURES

LIST OF FIGURES (Cont.)

LIST OF APPENDICES

ABSTRACT

This report summarizes enhancement and rehabilitation methods including stocking from Kitoi Bay and Pillar Creek Hatcheries, lake fertilization, the location and operation of barrier bypasses (fish passes), stream clearance activity, and fisheries in special and terminal harvest areas as well as in other traditional fishery areas. The results of enhancement and rehabilitation projects are described in terms of adult salmon runs, including harvests and escapements.

Stocking for enhancement included pink salmon (1971-2001), chum salmon (1982-1990, 1992-2001), coho salmon (1987, 1990, 1992-2001) and sockeye salmon (1989-1992, 1994-1998, 2000) juveniles, which were released directly from Kitoi Bay Hatchery (KBH) into Kitoi Bay. Additional releases for enhancement from KBH included late-run sockeye salmon into Little Kitoi Lake (1990, 1993-2001) and coho salmon into Little Kitoi (1984-1988, 1992-1993), Jennifer (1992-1993, 1995, 1997-2001), Ruth (1995, 1997-2000), Crescent (1988-1989, 1991-2001), and Katmai (1987-1988, 1992-2001) Lakes. Early-run sockeye salmon were stocked from Pillar Creek Hatchery (PCH) into Hidden (1992-2001), Little Waterfall (1992-2001), Big Waterfall (1992, 1999-2001) Crescent (1992-2001), Little Kitoi (1994-1997), and Sorg (1996) Lakes to produce enhanced runs. Late-run sockeye salmon were stocked from PCH into Spiridon (1991-2001; an experimental stocking from KBH occurred in 1990) and Ruth (1996-2000) Lakes for enhancement projects. The preceding lakes stocked were all barren systems prior to stocking. PCH also stocked Afognak (1992,1994, 1996-1998), Malina (1992-1999), and Laura (1994-1996, 1999) Lakes with sockeye salmon originating from each of these anadromous systems. The latter releases were implemented to rebuild depressed sockeye salmon runs.

Lake enrichment (fertilization) occurred at Afognak (1990-2000), Malina (1991-2001), Laura (1993-2001), Portage (1993-1997), Little Waterfall (1993-2001), and Little Kitoi (2000-2001) Lakes.

There are nine operational fish passes in the KMA, located at seven salmon systems. The Frazer River (Dog Salmon Creek) fish pass is on Kodiak Island, while the others, located at Little Kitoi Lake, Portage Creek, Laura Creek, Gretchen Creek, Little Waterfall Creek (three fish ladders), and Seal Bay Creek, are on Afognak Island.

Commercial harvests of enhanced fish averaged about 5.7 million pink salmon, 142 thousand chum salmon, 132 thousand coho salmon, and 336 thousand sockeye salmon annually from 1997-2001. These harvests composed 35% of the average total pink salmon (14.9 million), 15% of the average total chum salmon (800 thousand), 36% of the average total coho salmon (369 thousand), and 10% of the average total sockeye salmon (3.3 million) harvested in the KMA. The total enhanced salmon harvest averaged 6 million or 29% of the total (19.3 million) KMA salmon harvest from 1997-2001.

Restoration efforts at Afognak Lake resulted in a 20% increase in average sockeye salmon escapements and a 200% increase in average sockeye salmon harvests; however, the run has declined in 2000 and 2001. Malina Lake sockeye salmon restoration was successful in increasing average escapements by 100%, meeting escapement goals and allowing for a terminal harvest of about 10,000 adults in 2000 and 4,000 adults in 2001. Sockeye salmon runs to Portage and Pauls

Lakes increased as a result of restoration efforts, with average escapements at Portage increasing 37% and at Pauls increasing 147%. Average harvests in the Perenosa Bay area also increased from 747 to 3,635 fish. Coho salmon production at the Portage and Pauls systems also appeared to benefit from lake enrichment, with escapements increasing and average harvests in the Perenosa Bay area increasing 180%.

Sockeye salmon runs to Frazer Lake and pink salmon runs to Little Waterfall Creek continued to be sustainable due to fish ladder operation and maintenance. Harvests from 1996-2000 attributed to Frazer Lake production averaged 271 thousand sockeye salmon, which was about half of the average harvests when the run was composed of fish influenced by lake enrichment (1991-1995). Approximately 240 thousand Frazer Lake sockeye salmon were harvested in 2001. Little Waterfall pink salmon harvests have declined to less than 10 thousand fish in recent years from the peak catch of 382 thousand in 1995.

INTRODUCTION

Exploitation, Preservation, and Rebuilding of Kodiak Archipelago Salmon Stocks

Salmon have long been considered an important food source to the indigenous people and other inhabitants of the islands within the Kodiak archipelago (Schrof et al. 2000). Salmon have been commercially exploited in the Kodiak area for over 150 years, and local people believed it was important to conserve area salmon stocks to provide sustainable harvests (Roppel 1986). Commercial harvests of sockeye salmon *Oncorhynchus nerka* were documented, beginning in 1882. In 1974, a "limited entry system" was adopted by the State of Alaska to restrict participation into the commercial salmon fisheries (Brennan 1998, Wadle and Brennan 2001; Wadle 2001). In 2000, 608 commercial salmon permits consisting of 384 purse seine, 36 beach seine, and 188 set gillnet were available for use in the Kodiak Management Area (KMA; Wadle 2001).

Before Alaska became a state, the federal government was responsible for the management of Alaska's salmon resources (Schrof et al. 2000). Under federal control, Alaska's resources were heavily exploited as shown by the severe decline in salmon escapements and the huge volume of salmon harvested before Statehood in 1959 (1867-1950s) by the powerful canned salmon industry. In 1951, the territorial legislature created the Alaska Department of Fisheries (ADF) to preserve and rebuild the salmon runs (ADF 1951). As a way to rebuild depleted runs and protect healthy stocks, the ADF focused on the enhancement of the sockeye salmon fisheries (Appendix A). Various strategies including hatchery production, stocking of barren lakes, lake enrichment, and installation of steeppasses (fishways, fish ladders, or fish passes) to circumvent impassable falls were employed to increase sockeye salmon production and harvest opportunities in territorial days.

History of Sockeye Salmon Enhancement, Rehabilitation, and Research

Karluk Lake, located on the southwest side of Kodiak Island (Figure 1), was an important commercial salmon producer, during the late 1800s (Schrof et al. 2000). Sockeye salmon were heavily exploited at Karluk Lagoon during this period. According to Roppel (1982), cannery operators built the first hatchery in Alaska at the mouth of the Karluk River in 1896 (Appendix A). The hatchery was operated until 1917, but failed to produce substantial increases in sockeye salmon runs due to poor release strategies (Schmidt et al. 1998).

Afognak Lake, located on the southwest portion of Afognak Island, was the site of a large federal government sockeye salmon hatchery (White et al. 1990; Schrof et al. 2000; Figure 1; Appendix A). From 1908-1932, the hatchery released sockeye salmon fry into Afognak Lake and shipped eggs to other facilities in Alaska and other states. Over 50 million eggs were incubated at the hatchery during the peak years (1917-1922) of production. The facility closed after many years of marginal returns and amid controversy over hatchery production (Roppel 1982).

Physical barriers previously blocked fish migrations into the upper reaches of the Pauls Lake system which is composed of Pauls, Laura, and Gretchen Lakes, situated in the northeast corner of Perenosa Bay on Afognak Island (Schrof et al. 2000; Figure 1). Prior to an ADF salmon enhancement project in the early 1950s, sockeye salmon escapement into the Pauls Lake system

was limited to only a few hundred fish and spawning habitat in the upper drainage areas was inaccessible due to the barriers (ADF 1951; Honnold and Edmundson 1993; Appendix A). The installation of fishways in 1952, enabled returning adults access past the barriers. In addition, sockeye salmon eggs from Karluk and Portage Lakes (eyed-egg stage) were planted in Gretchen Creek from 1951-1955 to initiate adult returns to this Laura Lake tributary and to enhance overall sockeye salmon production. By the late 1950s, the sockeye salmon run was well established throughout the Pauls Lake drainage. In 1959, the Alaska Department of Fish and Game (ADF&G) installed a 9-meter Alaska steeppass (Ziemer 1962), replacing the original fishway in Gretchen Creek. In 1964, the ADF&G installed a 27-meter Alaska steeppass at the highest barrier at Laura Creek (Honnold and Edmundson 1993) to replace the original fishway. Modifications and improvements were continued at both sites in the 1970s and 1980s by adding more steeppasses, resting pools, and water diversion structures.

In 1951, the ADF introduced sockeye salmon into Frazer Lake, which is located on the southwestern end of Kodiak Island (ADF 1951; Blackett 1979; Blackett 1987; Kyle et al. 1988; Schrof et al. 2000; Sagalkin *in press*; Figure 1; Appendix A). A 10-m waterfall blocked anadromous fish migrations into Frazer Lake. To establish a self-sustaining run of sockeye salmon into Frazer Lake, sockeye salmon eggs were planted in tributary streams, and fry and adults were stocked into the lake from 1951-1971. The primary donor source for the sockeye salmon introductions into Frazer Lake was from Red Lake, with additional introductions from Karluk (1951-1954) and Becharof (on the Alaska Peninsula; 1969) Lakes. In 1962, an Alaska steeppass (Ziemer 1962) was constructed to allow salmon to navigate around the barrier. This ADF&G project proved successful in establishing the sockeye salmon run by the late 1970s, and adults from this run have been commercially harvested on an annual basis.

The Kitoi Bay Research Station (later known as the Kitoi Bay Hatchery) was constructed on the southeastern side of Afognak Island, in 1953 (Hall et al. 1998; Schrof et al. 2000; McCullough and Aro 2001; Figure 1; Appendix A). The hatchery facility was built to facilitate the research of techniques to successfully introduce sockeye salmon into lakes not utilized by anadromous fish (barren), and to evaluate environmental factors related to species competition, predation, and lake production (Meehan 1966). In 1955, the hatchery became operational and salmon research was initiated at Little Kitoi Lake to estimate the sockeye salmon smolt emigration (Figure 1). In 1956, Ruth Lake (a barren lake in the Kitoi Bay area) was studied to determine how predation by resident fish affects stocked sockeye salmon fry and how lake production responds to different stocking densities (Figure 1). In the early 1960s, steeppasses and concrete raceways were installed at the outlets of Little Kitoi and Ruth Lakes to provide simultaneous migration corridors for adults and smolts. The Ruth Lake steeppass was removed and stocking efforts discontinued after the study was completed.

In 1955, Bare Lake on Kodiak Island (drains into Ayakulik River; Figure 1) was the first lake in Alaska fertilized with a phosphate and sodium nitrate mixture (Roppel 1986; Honnold et al. 1996; Schrof et al. 2000; Honnold and Sagalkin *in press*; Appendix A). The intent of this project was to determine whether increasing nutrient levels in the lake could increase freshwater growth and survival of juvenile sockeye salmon, and subsequently increase adult production. The resultant fertilizer applications increased zooplankton abundance and produced a larger sized smolts (Nelson and Edmondson 1955). This project was a precursor to later lake enrichment programs such as Karluk Lake.

Karluk Lake sockeye salmon runs ranged, on average, from one million to two million fish from the 1920s through the 1940s, but declined substantially from the 1950s through the 1970s (Schrof et al. 2000). The ADF&G implemented a project from 1979-1986 on the Upper Thumb River (UTR) to rehabilitate a portion of the Karluk Lake early sockeye salmon run (White 1986; Figure 1; Appendix A). UTR sockeye salmon fry were "back-stocked" into the river after eggs and fry were cultured at the Kitoi Bay Hatchery on Afognak Island (1979-1981; Figure 1) and at a remote incubation facility located on the UTR (1982-1983). Eyed sockeye salmon eggs (Thumb River stock) were also planted in the gravel on the UTR (1980-1987). These fry and egg plants increased the UTR sockeye salmon escapement from less than 4,000 fish in 1980, to nearly 50,000 fish (historical levels) in 1988, which represented an increase in the UTR proportion of the total early-run sockeye salmon escapement into the Karluk River from about 5% to near 20% (White 1986).

Other Early Salmon Enhancement Projects

In the early 1970s, pink salmon *O. gorbuscha* enhancement began at Kitoi Bay Hatchery (Schrof et al. 2000; McCullough et al. 2000a; McCullough and Aro 2001). Fry releases were increased dramatically from thousands to hundreds of millions in the 1980s and 1990s (KRAA 1998a; Schrof et al. 2000; McCullough and Aro 2001). Kitoi Bay Hatchery also began a chum salmon *O. keta* enhancement project in the early 1980s with mixed results due to disease out beaks and insufficient brood fish (Hall et al. 1998); however, returns to the hatchery have improved in recent years. Pink salmon enhancement on Afognak Island also occurred at Seal Bay and Little Waterfall Creek in the late 1970s (McDaniel 1981; Honnold 1999; Figure 1). Fry plants from Kitoi Bay Hatchery, along with installation of a fish pass did not prove successful at Seal Bay Creek, likely due to poor imprinting to upstream habitat (McDaniel 1981; Honnold *in press*). However, the installation of three fish passes at Little Waterfall Creek allowed for colonization of a majority of previously unused spawning habitat (Honnold *in press*). By the early 1980s, pink salmon production increased sufficiently at Little Waterfall to allow for an annual harvest in Perenosa Bay. A fish pass was installed at Portage Creek on Afognak Island in the early 1970s to enhance pink salmon (Figure 1). The fish pass also increased sockeye and coho *O. kisutch* salmon production (White and Edmundson 1993).

Regional Salmon Production Planning

In accordance with Alaska Statutes 16.10.375-470, the Commissioner of the ADF&G has been responsible for the development of a comprehensive plan on salmon production in the KMA (KRPT 1987; 1992; Schrof et al. 2000). This responsibility was further delegated to the regional planning teams (RPT), consisting of representatives from the ADF&G and the regional aquaculture associations. The RPT's mission has been to plan for the long-term future of the salmon resources within the region by establishing priorities and examining the region's salmon production potential (KRPT 1992).

In 1983, the Commissioner of ADF&G (KRPT 1992) officially approved the Kodiak Regional Aquaculture Association (KRAA; Schrof et al. 2000). The purpose of the KRAA was to provide the public and user-groups assistance in the process of enhancing salmon production in the KMA in conjunction with the Kodiak Regional Planning Team (KRPT). In 1983, the results of a

questionnaire sent out to commercial, subsistence, and sport fishers concluded that the preferred salmon species to harvest in descending order were sockeye, pink, coho and chum salmon. Questionnaire results provided a mechanism for establishing production goals for the RPT.

In 1984, the Commissioner of the ADF&G approved Phase I of the Kodiak Regional Comprehensive Salmon Plan, 1982-2002 (KRPT 1992; Schrof et al. 2000). The Phase I plan was categorized into production and harvest goals, research and data gathering goals, and policy and management goals for 20 years from 1982-2002. In 1992, the KRPT scheduled an interim evaluation to assess the plan's progress. The KRPT's project planning was designed to achieve established goals and objectives, and benefit as many of the fishing user groups as possible. This was accomplished by assessing the needs expressed by the groups during the Phase I planning process.

As a result of the planning process, limnological and fishery research was initiated by the ADF&G at Karluk Lake to assess additional rehabilitation (egg planting at Upper Thumb was ongoing at the time) options for sockeye salmon (Schrof et al. 2000). In 1986 and continuing through 1994, KRAA, ADF&G, and the Kodiak Island Borough began a lake enrichment project at Karluk Lake (Koenings and Burkett 1987). Similarly, Frazer Lake was investigated from 1985-1987 to determine the appropriate strategy for rebuilding the sockeye salmon run and a lake enrichment program was conducted from 1988-1994 (Kyle et al. 1988; Sagalkin *in press*). Rebuilding the sockeye salmon run was necessary due to overescapement (escapement goals were established above sustainable production levels) into Frazer Lake.

As part of the Phase I planning (1990), the KRAA and the ADF&G constructed the Pillar Creek Hatchery (KRAA 1998b; Schrof et al. 2000; Figure 1). This new incubation facility, located on the Kodiak Island road system near the City of Kodiak, was designed for remote sockeye salmon stocking projects (Honnold et al. 1999; McCullough et al. 2000b; 2001). At the same time, the Kitoi Bay Hatchery was conducting fish culture research on the late-run Upper Station sockeye salmon stock (Hall et al. 1999; McCullough et al. 2000a; McCullough and Aro 2001). An age 0. component of this late-run stock was incubated and released into Big and Little Kitoi Bays. The intent of the saltwater release was to provide an on-site brood source for sockeye salmon stocking projects (primarily Spiridon Lake) in a relatively short time period (returns were expected in two to three years; Honnold 1997). Limnological and fishery investigations were also initiated during this period to determine the appropriate enhancement and/or rehabilitation strategy for depressed sockeye salmon stocks or the stocking potential of barren lakes (Honnold et al. 1996). In addition to sockeye salmon production projects, pink and chum salmon enhanced production continued, and a coho salmon stocking program was initiated at Kitoi Bay Hatchery.

By 1992, sockeye and pink salmon production was successful as reflected in the achievement of interim goals established in the KRPT plan (Schrof et al. 2000). The stocking and lake enrichment projects augmented the management strategy to achieve the goals. Wild stock coho and chum salmon production was at all time highs. Due to the early success of Phase I in the plan, the KRPT decided to reevaluate the initial goals and objectives through the Phase II planning process (KRPT 1992). The KRPT, again through the results of a questionnaire, established a new salmon species priority list (sockeye, coho, chum, pink, and chinook *O. tshawytscha*) and new salmon production goals and harvest objectives (outlined in Appendix B). Also, the KRPT received suggestions from fishers for potential projects to achieve these harvest

objectives. Sockeye salmon enhancement and rehabilitation efforts were directed at increasing the utilization of lake (fertilization and barren lake stockings) and stream (fish passes) habitat, and natural stock rebuilding (stocking).

Projects Developed to Achieve KRPT Comprehensive Plan Phase II Harvest Objectives

In the early 1990s, broodstock development was expanded at Little Kitoi Bay to include releases of late-run Upper Station sockeye salmon age 1. smolts as well as releases of presmolt into Little Kitoi Lake (Schrof et al 2000; McCullough et al. 2000a; McCullough and Aro 2001; Figure 2). In 1997, salt-water releases (age 0. and age 1.) were phased out due to poor adult sockeye salmon returns as well as return timing implications. The run timing (August) of returning adults to Little Kitoi Lake made it difficult to collect sockeye salmon broodstock during the pink salmon fishery at Kitoi Bay Hatchery (Hall et al. 1998). Similarly, using the Little Kitoi (originally Upper Station) broodstock for stocking Spiridon Lake would result in adult run timing that would increase promote the coincident harvest of wild Spiridon River pink salmon during the harvest of Spiridon Lake returns (Honnold 1997). Broodstock development for the Spiridon Lake enhancement project was continued from 1998-2001 with presmolt releases into Little Kitoi Lake using the Saltery Lake sockeye salmon stock, which should result in runs returning in July before the majority of pink salmon return. In addition, Little Kitoi Lake was fertilized in 2000 and 2001 to improve rearing conditions for the presmolts released in the lake (Figure 3). The first adult return large enough for broodstock collection is expected in 2002. The long-term goal of this project is to collect sockeye salmon eggs at Little Kitoi Lake and transfer the majority of the eggs to Pillar Creek Hatchery for incubation, rearing, and eventual release at Spiridon Lake (Figures 1 and 4).

A “put and take” sockeye salmon enhancement project was started at Jennifer Lakes near Kitoi Bay Hatchery in 1993 (Figures 1, 2, and 4; Honnold et al. 1998). This project was designed, through stocking (late-run Upper Station stock), to produce adult sockeye salmon for harvest in Duck, Izhut, and Kitoi Bays (Figure 2). Stocking was discontinued after 1997, when the Little Kitoi Lake broodstock was changed to Saltery Lake sockeye salmon, in order to phase out later returning adult sockeye salmon runs in the Kitoi Bay area.

A sockeye salmon stocking project was started in 1996 at Ruth Lake, located near Kitoi Bay Hatchery (Figures 1 and 2; Honnold et al. 1998). Saltery Lake juvenile salmon were stocked into the lake from 1996-2000 to provide for an adult harvest as described for Jennifer Lakes (Figure 2). This project was discontinued in 2001 due to a deterioration of the rearing quality (zooplankton) in the lake (McCullough et al. 2001).

In 1988, the ADF&G and KRAA initiated a two-year pre-project assessment to determine options for rehabilitation of the sockeye salmon run at Afognak Lake (Figure 1; White et al. 1990; Schrof et al. 2000). This assessment resulted in the lake being enriched annually, from 1990-2000 with nutrients (liquid fertilizer) to increase the lake’s forage base (zooplankton) for rearing juvenile sockeye salmon (Honnold and Sagalkin *in press*). In addition, Afognak Lake was stocked with native (Afognak Lake stock) sockeye salmon juveniles (back-stocked) as part of the rehabilitation program (1992, 1994, and 1996-1998; Honnold et al. 1999). Returns from these efforts, in excess of escapement goals, are harvested primarily in the Southeast Afognak Section of the Afognak District (Appendix C.1).

In 1990, pre-project limnological and fishery investigations were completed at Malina Lakes (Kyle and Honnold 1991; Schrof et al. 2000; Honnold and Sagalkin *in press*). The sockeye salmon run at Malina Lakes was determined to be depressed due to limitations in primary and secondary production in the lake. A project similar to the Afognak Lake nutrient enrichment project was initiated at Malina Lakes to rehabilitate the depressed sockeye salmon run (Figure 1). Lake fertilization (1991-2001) and stocking (1992-1999) were also employed at this system (Figure 3). After the escapement goal range (10,000-20,000) was exceeded for the first time in 1999, a terminal harvest area was established by Emergency Order (EO) adjacent to the mouth of Malina Creek to harvest excess returns in 2000 and 2001 (Wadle and Brennan 2001; Wadle 2001; Figure 5; Appendix C.2).

Also, in 1991, after extensive limnological and fishery investigations (Kyle et al. 1990), the Spiridon Lake sockeye salmon enhancement project began (Schrof et al. 2000; Figure 1). Spiridon Lake was devoid of anadromous fish prior to the stocking of juvenile sockeye salmon (Upper Station Lake broodstock from 1990-1994 and 1996-1997, and Saltery Lake broodstock in 1995, and from 1998-2001), because a series of barrier falls in the outlet stream blocked migrations into the lake (Honnold 1997; Figure 4). A pipeline for passing emigrating smolt past the falls (to avoid mortality) was constructed in 1991 and 1992. Since 1992, smolts have been guided into the pipeline by a weir and trapping system. The returning adults from this project are harvested in traditional Westside Kodiak fishing areas and Telrod Cove (also known as the Spiridon Lake Terminal Harvest Area; Figure 5; Appendices C.3 and D). Stocking occurs each year to continue this "put and take" enhancement project.

Additional barren lakes such as Hidden Lake (White 1992; Honnold 2001), Little Waterfall Lake (Edmundson et al. 1994), Big Waterfall Lake, and Crescent Lake (Honnold et al. 1999) were evaluated for enhancement potential in the early 1990s (Schrof et al. 2000; Figure 1). In 1992, sockeye salmon stocking projects using a "put and take" strategy were initiated at these lakes and Terminal Harvest Areas (THAs) were developed at Foul Bay (Hidden Lake), Waterfall Bay (Little Waterfall Lake), and Settler Cove (Crescent Lake) to provide for directed fisheries on these runs (Figures 4 and 5; Appendices C.4-C.6). The Waterfall Bay THA was expanded in 1999 to be more effective for harvesting sockeye salmon returning to Big Waterfall Bay. These lakes continue to be stocked annually with Afognak Lake stock juvenile sockeye salmon to continue enhanced adult harvests.

Limnological and fishery investigations at Laura (Pauls Lake system; Honnold and Edmundson 1993) and Portage (White and Edmundson 1993) Lakes resulted in sockeye salmon rehabilitation projects that began in 1993 (Schrof et al. 2000; Honnold and Sagalkin *in press*; Figure 1). Portage Lake was fertilized from 1993-1997 and Laura Lake was fertilized from 1993-2001 (Figure 3) and also stocked with sockeye salmon fry from 1994-1996 and in 1999. From 1993-2001, Little Waterfall Lake was fertilized to improve the survival of fry stocked for the "put and take" enhancement project (Figure 3; Edmundson et al 1994; Honnold and Sagalkin *in press*). Sockeye salmon returns in excess of the Pauls and Portage Lake systems' escapement goals are harvested primarily in the Perenosa Bay Section of the Afognak District (Figure 6; Appendix C.5).

Fish passes have been improved upon and are maintained annually to sustain sockeye salmon production at the Pauls Lake drainage, Frazer Lake (Dog Salmon River), Portage Lake, Little Kitoi Lake, and the Little Waterfall system (Schrof et al. 2000; Honnold *in press*; Sagalkin *in press*)

Figures 1, 2, and 6). The fish passes at Pauls, Portage, Little Kitoi and Little Waterfall have also helped increase and sustain coho salmon production to these systems. Coho salmon have also been stocked into several barren lakes in the Kitoi Bay area (1984-2001), at Katmai Lake near the village of Ouzinkie (1987-1988; 1992-2001), at Crescent (1988-1989; 1991-2001), and at Hidden Lake (1988-1991; Figures 1, 2, and 4). Coho salmon smolts have also been released annually since 1992 from Kitoi Bay Hatchery into Kitoi Bay. Little Kitoi Lake coho salmon was the initial broodstock used for these "put and take" enhancement projects. Returns to the hatchery have been sufficient since the mid-1990s for egg takes to occur at Big Kitoi Creek (McCullough et al 2000a; McCullough and Aro 2001). Commercial harvests of enhanced coho salmon returns occur in Duck, Izhut, and Kitoi Bays (Figure 2), while subsistence harvests occur near the Villages of Ouzinkie (Katmai Lake stocking) and Port Lions (Crescent Lake stocking; Figures 1 and 4; Appendix C.6).

Chum salmon enhancement at the Kitoi Bay Hatchery was started in 1982, and fry have been released annually into Big Kitoi Bay (except in 1991, when a virus outbreak occurred; KRAA 1998a; Schrof et al. 2000; McCullough and Aro 2001; Figure 4). Returning adult chum salmon are harvested in Duck, Izhut, and Kitoi Bays (Figure 2).

Pink salmon enhancement at Kitoi Bay Hatchery began in 1973, and fry have been released into Big Kitoi Bay each year since (KRAA 1998a; Schrof et al. 2000; McCullough and Aro 2001; Figure 4). Returning adults are harvested in Duck, Izhut, and Kitoi Bays (Figure 2). The original pink salmon enhancement projects at Little Waterfall (Honnold *in press*) and Portage Creeks, as described previously, have continued each year since their inception (Figure 6). Improvements to the fish passes have been made, resulting in increased pink salmon production. Pink salmon produced from these two systems are harvested in the Perenosa Bay Section of the Afognak District (Figure 6; Appendix C.5)

Evaluation and Monitoring

All salmon enhancement and rehabilitation projects are evaluated and monitored each year (ADF&G 2000; 2001; Figure 7). Limnological and fisheries information is collected at each system, including lake primary and secondary production data, juvenile rearing trend data, smolt emigration data, and adult run data. In addition, rearing hatchery fish are assessed for baseline data and, at Kitoi Bay Hatchery, juvenile sockeye salmon are marked to assess the success of different stocking strategies.

The purpose of this report is to summarize salmon stocking, lake enrichment, and other enhancement and rehabilitation methods used in the KMA and to present the results of projects in terms of adult salmon production through 2001.

Description of the Study Area

The study area is located within the KMA which comprises waters in the western Gulf of Alaska surrounding the Kodiak Archipelago and the Alaska Peninsula between Cape Douglas and Kilokak Rocks at Imuya Bay (Prokopowich 2000; Wadle and Brennan 2001; Wadle 2001). The archipelago is composed of Kodiak, Afognak, Shuyak, and many other smaller islands.

Salmon enhancement and rehabilitation investigations have encompassed an area from Red Fox Lake (58° 26' N lat., 152° 34' W long.,) on the northwestern end of Afognak Island to the Olga Lakes (commonly known as Upper Station Lakes) on the southwestern end of Kodiak Island (57° 04' N lat., 154° 15' W Long; Table 1; Figure 1). The morphology of most of the lakes in the area have been assessed in terms of surface area, mean depth, maximum depth, and volume. Other limnological characteristics such as euphotic zone depth and euphotic volume were also measured and can be referred to in Schrof et al. (2000).

Crescent and Spiridon Lakes are enhanced systems located on Kodiak Island where continual stocking of juvenile sockeye salmon is required to maintain supplemental returns (Table 1; Figures 1 and 4). Crescent Lake sockeye salmon (Afognak Lake brood source) return in late May through June. Returning adults are available for 100% harvest in the traditional commercial and subsistence fishing areas (Central Section of the Northwest Kodiak District). The Settler Cove Terminal Harvest Area (SCTHA) was created to allow for the harvest of adults that escaped traditional fisheries (Figure 5; Appendix C.6). The Spiridon Lake sockeye salmon project was originally established as a late-run stock (Olga Lake broodstock). Project goals were changed to a stock with an earlier run timing (Saltery Lake broodstock) in order to reduce the incidental harvest of Spiridon River wild pink and chum salmon stocks. Returning adults are harvested in the traditional fisheries (purse seine and gillnet) of the Northwest Kodiak District (Appendix D). The Spiridon Lake Terminal Harvest Area (SLTHA) was created to harvest excess fish that eluded the traditional fisheries (Figure 5; Appendix C.3).

Other lakes without anadromous salmon runs on Kodiak Island that were investigated for background limnology data include Dry Spruce, Goat, and Summit Lakes (Table 1; Figure 1).

Karluk, Frazer, and Bare Lakes are the only lakes on Kodiak Island that have had salmon rehabilitation programs, although many other lakes have been monitored for limnology and fishery data (Table 1; Figure 1). The lakes on the southwestern end of Kodiak Island are the most productive (sockeye salmon escapement and harvest) systems in the Kodiak archipelago. The largest sockeye salmon runs (>500,000 on average) in this area return to Karluk, Red, Frazer, and the Olga Lakes. Sockeye salmon escapement timing into these systems occurs from mid May to late September. Minor producing sockeye salmon systems in this area that have an early to mid summer run timing are Akalura, Little River, Uganik, Mush, (Northwest Kodiak District) and Horse Marine (Alitak Bay District) Lakes. Karluk, Akalura, and Olga (Upper Station) Lakes each contain an early and a late sockeye salmon component returning from May to mid-September (July 15 is the transition date for the two runs).

Buskin, Saltery, and Rose Tead Lakes are considered minor sockeye salmon systems and are located on the northeast end of Kodiak Island in proximity to the City of Kodiak (Table 1; Figure 1). The Buskin Lake sockeye escapement returns early, beginning in late May to the end of July. Saltery and Rose Tead Lake sockeye salmon return in late June through early August.

Other anadromous salmon systems on Kodiak Island proper that have been monitored include Barabara, Miam, and Sitkalidak Lakes (Table 1; Figure 1). Of these, Barabara Lake, located on the northern portion of the island has a sockeye salmon run that was considered depressed in the early 1990s, but may be rebounding as a result of a reduction in targeted subsistence fishing. Subsistence

fishing by Port Lions residents has been focused more on enhanced Crescent Lake sockeye salmon in recent years (L. Malloy, KRAA, Kodiak, personal communication).

Hidden, Jennifer, Little Kitoi, Little and Big Waterfall, and Ruth Lakes are enhanced systems located on Afognak Island where continual stocking of juvenile sockeye salmon is required to maintain returns (Table 1; Figures 1 and 4). Hidden and the Waterfall Lakes sockeye salmon (Afognak Lake brood source) return in late May through June. Adult sockeye salmon that return to Foul Bay (Hidden) and Waterfall Bay (Waterfall) THAs are all available for harvest (Figure 5; Appendices C.4 and C.5). The Little Kitoi Lake sockeye salmon project was originally established as a late-run (Upper Station stock) broodstock development program; however, project goals were changed to an earlier run timing. The earlier run timing of the Saltery Lake stock would reduce the incidental harvest during the directed pink salmon fishery at Kitoi Bay Hatchery (Honnold 1997; McCullough et al. 2000ab; 2001). In addition, early-run sockeye salmon (Afognak Lake stock) stocking into Little Kitoi Lake was discontinued when the late-run Upper Station stock was changed to the Saltery Lake stock. The stocking strategy was to only stock Saltery Lake sockeye salmon. Jennifer Lake was also stocked with a late-run Upper Station stock and stocking was discontinued when the late-run broodstock was changed. Ruth Lake was stocked with Saltery Lake sockeye salmon from 1996-2000, but stocking was discontinued in 2001 due to concerns that the lake's zooplankton would be over grazed. Currently, returning adults (from all three broodstocks stocked into Little Kitoi Lake and Bay, Jennifer, and Ruth Lakes) are harvested from mid-June through mid-September in the Izhut Bay, Duck Bay and Kitoi Bay statistical fishing areas (Figure 2). Once all the early-run Afognak Lake and late-run Upper Station fish that were stocked finish returning as adults, leaving only the Saltery Lake fish to return, the run will begin in late June and end by mid to late August. The Kitoi Bay Special Harvest Area (KBSHA) is a designated area for broodstock collection and/or for a cost recovery fishery, when either option is necessary (Figures 2 and 5).

Other lakes without anadromous salmon runs on Afognak Island that have been monitored for limnology data include Sorg, Big Kitoi, and Pillar Lakes (Table 1; Figure 1). Sorg Lake was stocked with sockeye salmon in 1996; however, stocking was discontinued because an artificial outlet was not constructed as planned to provide for smolt emigration (Clevenger et al. 1996; 1997).

Afognak Island anadromous sockeye salmon stocks (Afognak, Pauls/Laura, Portage, Thorsheim, Malina, Red Fox, and Little Afognak) enter their respective systems starting in late May with peak escapements occurring in June (Table 1; Figure 1). Afognak Lake and the Pauls Lake system were historically the largest sockeye salmon producers on Afognak Island. Both Afognak and Laura Lake were fertilized and stocked during the 1990s. Thorsheim and Red Fox Lakes, also located on Afognak Island, have minor sockeye salmon runs and productivity data are limited.

Coho, chum, and pink salmon enhancement projects occur at Kitoi Bay Hatchery and Kitoi area lakes (Figure 2). Coho salmon enhancement projects have been ongoing at Katmai Lake, near the Village of Ouzinkie, and Crescent Lake, near the Village of Port Lions (Figures 1 and 4). Pink salmon enhancement projects at Little Waterfall and Portage Creeks increased spawning habitat availability when the steeppasses became operational (Figures 1 and 6). Returning sockeye and chum salmon adults from projects in the Kitoi Bay area return in June and July, pink salmon return in July and August, and coho salmon return in August and September. Katmai and Crescent Lake coho salmon are primarily harvested in subsistence and sport fisheries near Ouzinkie and Port Lions

in August and September. Pink salmon returning to Little Waterfall and Portage are harvested in the Perenosa Bay Section in late July and August.

OBJECTIVES

The most recent (1999-2001) objectives for salmon enhancement and rehabilitation projects are described in the Pillar Creek Hatchery (Honnold et al. 1999; McCullough et al. 2000b; 2001) and Kitoi Bay Hatchery (Hall et al. 1999; McCullough et al. 2000a; McCullough and Aro 2001) Annual Management Plans (AMPs). Similarly, the evaluation and monitoring objectives (1999-2001) are outlined in individual operational plans by project (ADF&G 1999; 2000; 2001). Project and evaluation and monitoring objectives prior to 1999 are cited in Schrof et al. (2000).

METHODS

Hatchery Production

Kitoi Bay Hatchery (KBH)

KBH was utilized as a site specific production facility, focusing on an on-site egg take (Big Kitoi Creek-BKC and Little Kitoi Creek-LKC), incubation, and rearing (all life stages) strategy. (Hall et al. 1999; McCullough et al. 2000a; McCullough and Aro 2001). Pink and chum salmon were reared in saltwater net pens and released in Big Kitoi Bay (BKB), timing releases with area plankton blooms. Most coho salmon were reared in raceways (depending on release strategies) and short-term reared in net pens before release in BKB. Sockeye salmon smolts were also reared in raceways and short term reared in net pens before release into Little Kitoi Bay (LKB). A smaller portion of coho and sockeye salmon were reared in raceways at the hatchery and released into designated lakes in the Kitoi Bay area that do not have anadromous salmon runs (barren lakes).

Saltwater releases of pink salmon have ranged from 447,642 in 1974 to 169,552,112 in 1993 (Table 2; Figure 8A). Pink salmon fry releases averaged 138,893,598 from 1992-2001.

In 1982, 36,846 chum salmon fry were released in BKB for the first time and by 1988, over a million chum salmon fry were being released annually (Table 2; Figure 8B). Chum salmon stocking levels peaked in 1997 when 23,500,000 fry were released and averaged 15,373,905 juveniles from 1992-2001.

Coho salmon were first stocked as fingerlings into Little Kitoi Lake (LKL) in 1984 (Table 2; Figure 8C). In 1990, the first age 1. smolts (137,493) were released in BKB (9,600 age 0. presmolts were released in 1987) and over half a million smolts have been released in seven of the last ten years. The largest release was 1,098,338 smolts in 1999 and releases have averaged 642,573 coho salmon smolts from 1992-2001. Jennifer and Ruth Lakes, located in the Kitoi Bay area (Figure 2), were also stocked with coho salmon, beginning in 1992 and 1995, respectively.

Releases into Jennifer Lake have averaged 120,256 fingerlings and 19,520 in Ruth Lake from 1992-2001. Total coho salmon releases in the Kitoi Bay area have ranged from 0 in 1989 and 1991 to 1,269,338 in 1999, averaging 803,324 from 1992-2001.

Site specific sockeye salmon releases have occurred in LKB or LKL since 1989 (Table 2; Figure 8D). Stocking has varied from age 0. saltwater (0 check) releases, age 0. freshwater (presmolts), and age 1. (smolts) releases. The age 0. saltwater releases were phased out after 1994 (Honnold and Clevenger 1995) and the age 1. releases after 1998 (Hall et al. 1999) due to less than expected adult returns and straying concerns (a small saltwater release of age 0. fish occurred in 2000 due to transport tank malfunction). Age 0. freshwater releases continue today and have been successful in terms of adult production (Schrof et al. 2000; McCullough and Aro 2001). Sockeye salmon releases into LKL have averaged 193,899 presmolts from 1992-2001 (Table 2). From 1994-1997, a portion of the presmolt releases into LKL were from Pillar Creek Hatchery as part of an early-run (Afognak Lake stock) enhancement and broodstock development project. A portion of the saltwater and freshwater sockeye salmon releases into LKB and LKL were marked (fin-clipped) to assess survival and assist with identifying fish for run reconstructions. In addition, early-run fish from Pillar Creek Hatchery were stocked into Sorg Lake in 1996 and late-run fish were stocked into Jennifer Lake from 1994-1995 and in 1997. Releases of late-run sockeye salmon into Jennifer Lake were from KBH in 1993. From 1996-2000, late-run (Saltery Lake stock) sockeye salmon were stocked into Ruth Lake from Pillar Creek Hatchery. The average number of sockeye salmon stocked into Jennifer Lake was 120,800 fry from 1992-2001 (Table 2). Ruth Lake releases averaged 54,220 for the same period. Sockeye salmon releases for all sites combined in the Kitoi Bay area ranged from 143,725 juveniles in 1989 to 2,856,318 juveniles in 1994. The average number of sockeye salmon released from 1992-2001 was 1,027,051 juveniles.

Remote lake outstocking was also employed by KBH, which entailed incubation and rearing at the hatchery and then releasing juvenile salmon into lakes located in areas distant from the facility. This included coho salmon stocked from KBH into Katmai Lake (presmolts), beginning in 1987, and Crescent Lake (fingerlings), beginning in 1988 (Table 3; Figures 1 and 4; Appendix C.6). From 1992-2001, releases have averaged 14,967 presmolts at Katmai Lake and 145,402 fingerlings at Crescent Lake.

Pillar Creek Hatchery (PCH)

The Kodiak Island area remote lake outstocking program has been primarily associated with PCH (Honnold et al. 1999; McCullough et al. 2000b; 2001; Figure 1). PCH was constructed for the primary purpose of stocking juvenile sockeye salmon into barren lakes and to rehabilitate depressed anadromous sockeye salmon systems. In addition, a small number of coho and chinook salmon are reared at PCH to enhance sport fish opportunities along the Kodiak Island road system. Currently, sockeye salmon egg takes for barren lake stocking occur at Afognak and Saltery Lakes (Figure 1). Egg takes have also occurred at Upper Station Lakes (Olga Lakes). Juvenile sockeye salmon are incubated and reared at PCH to the fry, fingerling, and presmolt life stages, prior to release into the selected lakes.

PCH early-run sockeye salmon (Afognak Lake broodstock) releases from 1992-2001 averaged 347,955 into Hidden Lake, ranging from 98,650 presmolts in 1995 to 554,600 fry in 1993 (Table 4;

Figure 4 and 9A; Appendix C.4). During the same period, Little Waterfall Lake was stocked with an average of 255,400 sockeye salmon, with releases ranging from 82,300 presmolts in 1996 to 493,000 fry in 1992 (Table 4; Figure 4 and 9B; Appendix C.5). Big Waterfall Lake was stocked in 1992 with 96,000 fry, but was not stocked again until 1999, when just 42,000 presmolts were released (Table 4; Figure 4 and 9B; Appendix C.5). The largest release into Big Waterfall lake was 224,300 presmolts in 2001. Crescent Lake was stocked with an average of 334,440 sockeye salmon from 1992-2001, ranging from 90,200 presmolts in 1995 to 571,000 fry in 1998 (Table 3; Figure 4; Appendix C.6). Early-run sockeye salmon releases into Little Kitoi and Sorg Lakes were discontinued after 1997.

After an experimental stocking from KBH in 1990, Spiridon Lake was first stocked from PCH in 1991 (3,300,000) and average releases were 4,126,670 late-run (Upper Station and Saltery Lake stocks) sockeye salmon from 1992-2001 (Table 4; Figure 4 and 9C; Appendix C.3). The lowest stocking level was 1,700,600 fry in 2001 and the largest release was 6,700,000 fry in 1997. Ruth Lake (Saltery Lake stock) and Jennifer Lake (Upper Station Lake stock) were also stocked with sockeye salmon fry from PCH as previously mentioned.

Remote outstocking from PCH of juvenile sockeye salmon originating from their respective native stocks has occurred at three anadromous systems. Afognak Lake was stocked in 1992, 1994, and from 1996-1998, averaging 205,400 juveniles from 1992-2001 (Table 5; Figure 1; Appendix C.1 and C.2). The average for just the five stocking years is about 410,000 fish, which is about 5% of all rearing fish (natural recruitment plus stocked fish) in the lake for those years (Honnold and Sagalkin *in press*). Upper Malina Lake was stocked from 1992-1999 with an average of ~ 322,000 (257,670 from 1992-2001) sockeye salmon juveniles (Table 5; Figure 1; Appendix C.2). During the years stocked, hatchery fish, on average, composed about 27% of all rearing fish in Upper Malina Lake (Honnold and Sagalkin *in press*). Laura Lake was stocked with an average of 122,000 (48,700 from 1992-2001) juvenile sockeye salmon from 1994-1996 and in 1999 (Table 5; Figures 3 and 6; Appendix C.5). Stocked fish were about 9% of all rearing fish in the lake for these years (Honnold and Sagalkin *in press*).

Planning Annual Stocking Levels

The primary considerations in developing stocking recommendations are most importantly, the forage base status of each lake and, secondarily, the rearing limitations (i.e., lack of water, rearing units) at PCH and KBH (Schrof et al. 2000). Analyses of the bathymetry and two years of light penetration data determined the initial stocking capacity for each lake. These data were applied to a euphotic volume (EV) model as described by Koenings and Burkett (1987). Individual analyses resulted in a recommended range of fry released into a lake, which could produce either threshold (60 millimeter or 2 gram) or optimal (85 millimeter or 5 gram) size sockeye salmon smolts. The lower or optimum level was used as a guide for beginning stocking projects at each barren lake. Stocking levels for anadromous lakes that were considered rehabilitation candidates were adjusted based on fry recruitment from the parent year escapement.

In addition, previous stocking projects provided new insight to modify the EV model calculations used to adjust stocking capacities for some lakes. Consequently, for the last several years,

stocking levels have been dynamic, and adjusted in accordance with the zooplankton abundance and biomass trends at each lake. The anadromous systems (Afognak, Malina, and Laura Lakes) are evaluated for stocking levels in a similar manner to the barren lakes; however, escapement and lake enrichment are significant factors considered in planning. Lake enrichment has successfully increased the zooplankton abundance and biomass in these lakes and allows more flexibility in stocking. In 1994, a response to declines in the forage base at barren lakes resulted in the implementation of a presmolt rearing strategy at the hatcheries. This rearing strategy, in which sockeye salmon are reared at the hatchery until October and then released, was employed to reduce rearing time in the stocked lakes and to take advantage of the lower basal metabolism of juveniles in cooler water temperatures in order to lessen the impact on the zooplankton population. Preliminary data indicate that this strategy has worked. Most barren lakes (Hidden, Little and Big Waterfall, and Little Kitoi) are now stocked with presmolts. Hidden Lake was stocked for several years with both fry and presmolts; however, subsequent reductions in zooplankton indicated that presmolts may be the only option to continue production until the forage base rebounds (Honnold 2001). Anadromous lakes, however, appear more resilient, and rebound quicker when overgrazing of the zooplankton population occurs. Fertilization buffers anadromous lakes, allowing fry to be stocked at higher levels under the rehabilitation program.

The goal of the planning process is to incorporate what has been learned to maintain healthy lake rearing environments while continuing smolt and adult production at cost effective levels. The former ADF&G Limnology Section advised ADF&G Kodiak staff and KRAA staff on the appropriate stocking levels for each lake on an annual basis from 1993-1996. Typically, the zooplankton data analysis for a given year was complete by early winter and initial stocking recommendations were provided prior to drafting the AMPs. Recommendations from the limnology staff were utilized to adjust the next egg take/rearing cycle a year in advance. For example, 2001 zooplankton data would be used to recommend stocking for 2002. These recommendations were adjusted slightly to accommodate the rearing capacity and schedule of the hatcheries.

Since 1996, in-season analysis of zooplankton data collected at each lake stocked assisted with planning current year stocking adjustments (if needed) and also the following year's goals. The Soldotna limnology staff provided stocking recommendations the initial year of in-season analysis. Beginning in 1997, limnology support (other than providing raw data summaries) from Soldotna was discontinued, and Kodiak ADF&G staff developed the stocking recommendations (Honnold et al. 1999). Beginning in 2000, all limnology sample processing and data analyses were conducted by Kodiak ADF&G staff at a new laboratory located on Near Island near the City of Kodiak.

Lake Enrichment

In 2001, lake enrichment programs were continued at Malina (upper lake was started in 1991 and the lower lake was started in 1996), Laura (started in 1993), Little Waterfall (started in 1993) and Little Kitoi Lakes (started in 2000), while fertilization was discontinued at Afognak Lake after 11 years (Table 6; Figure 3). Lake enrichment projects were previously completed at Karluk (1986-1990), Frazer (1988-1992), and Portage (1993-1997) Lakes (Table 6; Figure 1). The intent of the

lake enrichment projects were to increase zooplankton biomass, increase fry growth and survival, and increase adult returns (Honnold and Sagalkin *in press*).

Lakes were treated with nutrient additions composed of an aqueous nitrogen (N), white phosphorus (P), and potassium solution sprayed from a fixed wing aircraft (Kyle 1994; Koenings and Kyle 1997; Honnold and Sagalkin *in press*). The fertilizer type was dependent upon the phosphorus and nitrogen levels in each lake. Phosphorus was added in the form of inorganic phosphate and nitrogen as a mixture of ammonium, nitrate, and urea. The fertilizer N-to-P ratio approximated 20:1, which is the optimal ratio used for non blue-green algal production. Vollenweider (1976) based calculations on supplemental phosphorus levels on an annual mean loading rate of 90% according to equations. The fertilizer was applied to the lake surface on a weekly basis from June through August and was distributed to minimize rapid flushing of nutrients. Schrof et al. (2000) and Honnold and Sagalkin (*in press*) report specific application amounts by lake.

Barrier Bypasses – Increasing Available Habitat

Another method used to increase salmon production in the Kodiak Island archipelago has been the installation and operation of barrier bypasses (also referred to as fishways, steeppasses, fish passes, or fish ladders) to provide for access and use of previously unavailable spawning and rearing habitat (Honnold 1999; Schrof et al. 2000; Honnold *in press*). Currently, there are nine operational bypasses in the Kodiak Island archipelago: Dog Salmon Creek (Frazer River) fish pass is located on Kodiak Island and Little Kitoi Lake, Portage Creek, Laura Creek, Gretchen Creek, Little Waterfall Creek, and Seal Bay Creek fish passes are located on Afognak Island (Table 7; Figure 6). Detailed descriptions and specific operational procedures of each fish pass were reported by Schrof et al. (2000).

Spiridon Lake Smolt Bypass

A bypass system has been installed and operated at Telrod Creek (draining Spiridon Lake) to move sockeye salmon smolts downstream around injurious barrier falls, since 1992 (Honnold 1997; Schrof et al. 2000). Stocked fry utilize the nursery habitat in Spiridon Lake and migrate out as smolts via a pipeline around the falls to the marine environment. For a more detailed description of the design and materials used and other methods, refer to Honnold (1997) and ADF&G (2001).

Stream Clearance

The last method to provide for improved access to spawning and rearing habitat is stream clearance (Schrof et al. 2000). Jennifer, Ruth and Elk (Little Kitoi) Creeks in the Kitoi Bay area and Gretchen Creek in the Pauls Lake drainage have been examined periodically each year to ensure that no obstructions to smolts and adult (where applicable) passage exist (Figure 6). Schrof et al. (2000) and ADF&G (2001) reported specific stream clearance methods by system.

Harvest Opportunities for Enhanced Salmon

Salmon enhancement projects require methods for harvesting adult salmon returns in an orderly fashion and without adversely affecting wild stocks (McCullough et al. 2000ab; McCullough and Aro 2001). Harvest strategies for enhanced salmon returns include special openings in designated THAs and, if broodstock collection or cost recovery is required, in Special Harvest Areas (SHA). These harvest strategies are part of management plans for the KMA previously approved by the Alaska Board of Fisheries (BOF; Prokopowich 2000; Wadle and Brennan 2001; Wadle 2001). There is one SHA (Kitoi Bay SHA) and four THAs (Settler Cove THA, Foul Bay THA, Waterfall Bay THA, and Spiridon Lake THA) in the KMA that are part of BOF approved management plans (Table 8; Figure 5; Appendices C.3-C.6). In 2000, a new THA was established by EO at Malina Creek to harvest sockeye salmon returns in excess of escapement requirements (Table 8; Figure 5; Appendix C.2; Wadle and Brennan 2001). Specific descriptions of the SHA and THAs and the harvest strategies employed for each are described by Schrof et al. (2000), Wadle and Brennan (2001), and Wadle (2001).

Evaluation and Monitoring

All lakes were assessed for baseline limnology data for a minimum of two years prior to the initiation of salmon enhancement (stocking) and/or rehabilitation (stocking and/or fertilization) projects (Schrof et al. 2000). Once stocking and/or fertilization projects were initiated, monitoring annual limnological trends at each lake was continued throughout the program. Monitoring also occurred at lakes where sockeye salmon broodstocks were collected and at lakes where stocking and/or fertilization projects were complete (lakes are monitored for a minimum of two post-project years). In 2001, lakes assessed included Crescent, Frazer, Karluk, Saltery, and Spiridon on Kodiak Island and Afognak, Big Waterfall, Hidden, Jennifer, Little Kitoi, Little Waterfall, Laura, Malina (lower and upper), and Ruth Lakes on Afognak Island (Table 1; Figure 7).

Hydroacoustic surveys were conducted on many of the lakes to provide indices of juvenile rearing sockeye salmon populations (Schrof et al. 2000). Townetting was conducted in conjunction with hydroacoustic surveys to estimate the juvenile sockeye salmon populations. Currently, hydroacoustic surveys are conducted annually at Spiridon, Hidden, Little Kitoi, and Little Waterfall Lakes (Figure 7).

Also, smolt enumeration and sampling projects were conducted at many lakes. Sockeye salmon projects in 2001 occurred at Frazer, Malina, Little Kitoi, Spiridon, and Karluk Lakes (Figure 7). Sockeye and coho salmon smolt sampling also occurred at Afognak, Hidden, Laura, Little Waterfall, Portage, and Saltery Lakes in 2001. In addition, raceway-rearing smolts or presmolts were sampled from PCH and KBH prior to release for baseline age and size data.

Enhanced salmon runs were monitored at each respective stocking site for abundance and age class data (Figure 7; Schrof et al. 2000). Runs to THAs were monitored by tracking on-site catches and through the ADF&G database. The Spiridon Lake sockeye salmon runs were estimated from 1994-1997 as described by Nelson and Barrett (1994), Nelson and Swanton (1996; 1997), and Nelson (1999) when the run timing was similar to the late Upper Station run broodstock. The run timing changed in 1998 due to the use of the Saltery Lake broodstock for stocking, which precluded the

use of previous methods to estimate the Spiridon Lake sockeye salmon run (Nelson 1999). Thus, from 1998-2001, the run was estimated using the average proportion (~41%) of the previous years run caught in the Spiridon Lake THA. For example, if 10,000 sockeye salmon were harvested in the terminal harvest area, the run is calculated by dividing this catch by ~41% (average proportion harvested in the THA from 1994-1997), which would equate to a total run of about 24,400 fish. The harvests of Spiridon Lake fish in the Northwest Kodiak District were not estimated after 1997. The Kitoi Bay area salmon runs are tracked by monitoring catches and sampling in the Duck, Izhut, and Kitoi Bay Sections of the Afognak District.

Adult production from the rehabilitation projects was primarily assessed through monitoring of escapement and harvests trends (Figure 7; Schrof et al. 2000). Escapements were enumerated through weirs at each system (Afognak, Malina, and Pauls), except the Portage Creek system where escapements were enumerated through a weir for some years, but are primarily indexed through foot and aerial surveys. In addition, a weir was operated to enumerate sockeye salmon escapement in 1998 and 1999 at Thorsheim Creek and at Portage Creek in 2000 and 2001 as part of an evaluation of adult salmon straying associated with the barrier weir at Hidden Lake Creek and the barrier net at Little Waterfall Creek (Wadle and Honnold 2000). Harvests were primarily tracked through the ADF&G fish ticket database.

Saltery Lake and Afognak Lake sockeye salmon were monitored for escapement trends as related to broodstock collection (Figure 7; Schrof et al. 2000). In-season escapement estimates are used to determine if egg takes could occur and how many brood fish could be used (McCullough et al. 2000ab; 2001). Frazer Lake sockeye salmon escapements were also enumerated via the fish pass and Little Waterfall Creek pink salmon escapements were indexed by foot surveys.

Sockeye salmon catches and escapements were sampled for age, length, and sex (ALS) data. Sockeye salmon used for broodstock from Afognak, Malina, Laura (Pauls), Little Kitoi (previously), Upper Station (previously), and Saltery Lakes were sampled for freshwater age (collection of otoliths and scales), genetic baseline data (tissue samples), and disease incidence (ovarian fluid). Chum salmon broodstock at Kitoi Bay Hatchery were also sampled for ALS data.

Methods, specific operations, and results are described in detail for all evaluation and monitoring tasks in previous publications (ADF&G 1999; Brodie 1999; Sagalkin 1999; ADF&G 2000; Brodie 2000; Nelson and Foster 2000; Schrof et al. 2000; ADF&G 2001; Brodie 2001; Honnold 2001; Honnold and Sagalkin 2001; Honnold and Sagalkin *in press*; Sagalkin *in press*; Witteveen and Foster 2001). Adult production data are reported in the following sections of this report.

RESULTS

Enhanced Salmon Harvests

Kitoi Bay Area (Izhut, Duck, and Kitoi Bays)

Pink salmon commercial harvests in the Kitoi Bay area increased from 8,794 in 1974 to over 3.5 million in 1985 (Table 9; Figure 8A). By the 1990s, annual harvests were averaging almost 5

million pink salmon, ranged from 845,395 in 1992 to 13,126,761 pink salmon in 2001, and averaged 4,880,173 from 1992-2001. About 5.7 million pink salmon have been harvested annually in the past five years. Cost recovery harvests of pink salmon occurred from 1987-1989 in the Kitoi Bay Special Harvest Area. Approximately 166 thousand fish were caught in 1987, 298 thousand were caught in 1988, and 6.6 million were harvested in 1989 when the commercial fishery was closed due to the Exxon Valdez oil spill.

Chum salmon first returned to Kitoi Bay Hatchery in 1984 when 3,301 fish were harvested in the commercial fishery (Table 9; Figure 8B). Harvests from 1992-2001 ranged from 9,868 in 1992 to 303,783 in 2000, averaging 97,219 chum salmon. The most recent five-year (1997-2001) average harvest was 142,018 chum salmon.

Commercial harvests of coho salmon in the Kitoi Bay area began in 1986, when 3,477 were caught (Table 9; Figure 8C). From 1992-2001 the average harvest was 84,568 coho salmon and catches ranged from 32,517 in 1992 to 151,732 in 2001. The average harvest from 1997-2001 was 132,032 coho salmon.

Returns from sockeye salmon enhancement efforts in the Kitoi Bay area were first harvested in 1992 when 25,407 fish were caught (Table 9; Figure 8D). The average sockeye salmon harvest from 1992-2001 was 41,230 fish, ranging from 14,134 in 1994 to 75,506 in 1998. Harvests have averaged 57,646 sockeye salmon for the past five years.

Settler Cove THA (SCTHA)

Coho salmon were the first enhanced fish to return to SCTHA; however, few have been harvested commercially (Table 10). Coho salmon runs are primarily harvested by subsistence permit holders from the village of Port Lions. The average subsistence harvest was 797 coho salmon from 1990-2001, of which the best catches occurred prior to 1996. The 1997-2001 subsistence harvest of coho salmon has declined to an average of 262 fish.

Commercial and subsistence harvests of enhanced sockeye salmon in SCTHA began in 1995 (Table 10). Commercial harvests averaged 3,817 sockeye salmon from 1995-2001, ranging from 0 caught in 2000 to 13,278 caught in 1996. Subsistence harvests of sockeye salmon averaged 1,262 fish during the same period. The most recent five-year average commercial catch was 2,638 sockeye salmon or about twice the five-year average subsistence catch of 1,185 sockeye salmon.

Foul Bay THA (FBTHA)

The first and largest commercial harvest of enhanced sockeye salmon occurred in the FBTHA in 1995 when 44,479 fish were caught (Table 10; Figure 9A). The average catch from 1995-2001 was 28,340 sockeye salmon, and a low of 8,270 fish were harvested in 1998. Coho salmon were released in Hidden Lake in 1988, 1989, and 1991; however, the FBTHA was not established until 1995, which precludes reporting of specific coho salmon harvests. Theoretical returns, based on average survivals (McCullough and Aro 2001), should have resulted in harvestable runs of 6,000 to 10,000 coho salmon from 1990-1993.

Waterfall Bay THA (WBTHA)

Harvests of sockeye salmon in the WBTHA from 1995-2001 averaged 17,718 fish (Table 10; Figure 9B). Harvests ranged from 8,623 in 2000 to 36,496 sockeye salmon in 1996 and have averaged 14,585 fish from 1997-2001.

Spiridon Lake THA (SLTHA) and the Northwest Kodiak District

The first returns from Spiridon Lake sockeye salmon stocking were harvested in 1994 in the SLTHA and in traditional fisheries in the Northwest Kodiak District (Table 10; Figure 9C; Nelson and Barrett 1994; Honnold 1997). The estimated commercial harvest of Spiridon Lake sockeye salmon was 263,750 in 1994 (Nelson and Barrett 1994), 96,705 in 1995 (Nelson and Swanton 1996), 386,956 in 1996 (Nelson and Swanton 1997), and 145,246 fish in 1997 (Nelson 1999). From 1994-1997, approximately 41% of the harvest occurred in the Spiridon Lake THA (Nelson 1999). Harvests estimates ranged from 146,678 sockeye salmon in 2001 to 468,456 sockeye salmon in 1999, based on the average proportion of the catch in the SLTHA from 1994-1997. The estimated harvest of Spiridon Lake sockeye salmon averaged 235,751 from 1997-2001.

Summary of Enhanced Salmon Harvests from Barren Lake Stocking Projects

Excluding the Kitoi Bay area harvests, the enhanced harvests from barren lake stocking projects averaged 284,412 sockeye salmon from 1994-2001, of which 49,876 were early-run fish and 240,771 were late-run fish (Table 11). The lowest harvest of enhanced sockeye salmon was 156,045 fish in 1995 and the highest harvest was 518,876 in 1999. The average enhanced harvest was 277,917 sockeye salmon from 1997-2001. Enhanced coho salmon commercial harvests from barren lake stocking projects have been negligible.

Harvest Timing

Commercial harvests of salmon in Izhut, Duck, and Kitoi Bays typically occur from June through September (Figure 10A). Chum salmon are harvested primarily in June and July and peak harvests occur about 20 June. Sockeye salmon harvests occur from June through August, peaking between 25 July and 8 August. Harvests of pink salmon begin in mid to late July, peaking about 10 August, and end approximately 5 September. Coho salmon are first caught in the Kitoi Bay area in mid July, with harvests increasing in August, and ending in late September. The peak coho salmon harvest usually occurs by 30 August.

Commercial harvests of sockeye salmon in Waterfall and Foul Bay THAs from 1995-2001 occurred from 9 June (first commercial fishing opening) through early July (Figure 10B). Peak harvests occurred during the first week the fisheries were open and the majority of the fish were harvested by 25 June. Harvest timing in both of these THAs paralleled the escapement timing of the Afognak Lake stock, which was the broodstock used for stocking.

The timing of the sockeye salmon harvests in the Spiridon Lake THA also paralleled the escapement timing of the broodstocks used for stocking (Figure 10C). The 1994-1997 runs were a result of the stocking (1991-1994) of late-run Upper Station fry in Spiridon Lake and harvests

occurred primarily from late July through early September, peaking in mid August. Runs from 1998-2001 were composed of fish returning as a result of stocking of late-run Upper Station (1994, 1996-1997) and Saltery Lake (1995, 1998) fry. Beginning in 1998, harvest timing was earlier, starting in late June, and continuing into early September. There were two distinct peaks in the sockeye salmon harvests from 1998-1999, which paralleled the peak escapement timing of the two broodstocks (Honnold et al. 1999; McCullough et al. 2000b). Sockeye salmon harvests in the SLTHA are expected to occur from late June through mid August, peaking in mid July once runs are composed of only fish originating from the Saltery Lake broodstock (2003).

Enhanced Proportions of KMA Commercial Harvests

The enhanced proportion of the total KMA commercial pink salmon catch was less than 5% from 1972-1984, except in 1981 when the enhanced proportion was 9% (Table 12; Figure 11A). In 1985, of the total pink salmon harvested in the KMA, 49% were enhanced fish and in 2001, the enhanced proportion increased to 67% of the total pink salmon catch in the KMA. The pink salmon catch in the KMA from 1992-2001 was composed of 30% enhanced fish. The most recent five-year average (1997-2001) enhanced harvest was 35% of the total pink salmon harvest in the KMA.

Enhanced chum salmon catches were 1-3% of the total chum salmon catches in the KMA from 1984-1994, but have composed, on average, 10% of the total catches from 1992-2001 (Table 12; Figure 11B). The average KMA chum salmon catch from 1997-2001 was composed of 15% enhanced fish.

KMA coho salmon catches were composed of 5% or less enhanced fish until 1993, when the enhanced coho salmon contribution was 10% of the total KMA harvest (Table 12; Figure 11C). The enhanced proportion of the coho salmon catch continued to increase, averaging 25% of the KMA harvest from 1992-2001 and 36% from 1997-2001.

About 8-10% of the sockeye salmon catch in the KMA from 1992-2001 was composed of enhanced fish, with the enhanced proportion peaking at 13% in 1999 (Table 12; Figure 11D).

The harvest of enhanced salmon (all species excluding chinook salmon) was 57% of the total salmon catch in the KMA in 2001 and the average enhanced contribution to the total salmon catch was 29% from 1997-2001 (Table 12).

Restored Sockeye Salmon Production

Afognak Lake

Afognak Lake sockeye salmon runs comprised fish influenced by fertilization, beginning in 1993, and returns from stocking in 1995 (Table 13; Figure 12A; Honnold and Sagalkin *in press*). The average sockeye salmon escapement from 1984-1992 was 67,408 compared to 80,722 or about a 20% increase from 1993-2001. Harvests increased by over 200%, from an average of 9,290 from 1984-1992 to an average of 30,892 from 1993-2001. The total run (escapement and harvest) was over 200,000 sockeye salmon in 1996; however, the run declined substantially by 2000, and the

upper end of the escapement goal range (40,000-60,000) was not met for the first time in over ten years. The run declined further in 2001; the lower end of the escapement goal range was not met and no harvest occurred.

Malina Lake

The first sockeye salmon influenced by fertilization and produced from stocking returned to Malina Lake in 1994 (Table 13; Figure 12B; Honnold and Sagalkin *in press*). Average escapements from 1994-2001 increased by over 100% to 15,614 sockeye salmon compared to 6,910 sockeye salmon from 1985-1992. Escapements were within the 10,000-20,000 escapement goal range five of eight years from 1994-2001 and reached the upper range of the goal from 1999-2001. In 2000 and 2001 an average of 7,243 sockeye salmon were harvested in the Malina Creek THA.

Portage and Pauls Lakes

The 1996-2001 sockeye salmon runs to Portage and Pauls Lakes were composed of adults affected by fertilization (Table 13; Figure 12C and 12D; Honnold and Sagalkin *in press*). Juveniles stocked into Pauls Lake first returned as adults in 1997. The average sockeye salmon escapement from 1990-1995 at Portage Lake was 7,057 fish. The average escapement increased 37% from 1996-2001 to 9,684 fish. The average Pauls Lake sockeye salmon escapement increased 147% from 11,300 (1990-1995) to 27,904 (1996-2001) fish. Portage Lake escapements were within the escapement goal range (5,000-10,000) four of six years from 1996-2001 and exceeded the upper range of 10,000 three of six years; however, escapement in 2001 declined below the minimum goal. Pauls Lake escapements were within the escapement goal range (20,000-40,000) five of six years from 1996-2001, while not meeting the minimum goal the previous seven years. Perenosa Bay sockeye salmon harvests averaged 3,635 from 1996-2001 (fertilization/stocking) compared to 747 fish from 1990-1995 (pre-fertilization/stocking).

Coho Salmon Production from Portage and Pauls Lakes

Juvenile coho salmon reared in the Portage and Pauls Lake systems during the years that fertilizer was applied to the lakes as part of the sockeye salmon restoration program. Adult coho salmon that were potentially affected as juveniles by fertilization returned from 1996-2001 (Table 14; Figure 13). Escapement into the Portage Lake system from 1992-1995 averaged 17,160 coho salmon compared to 19,200 from 1996-2001 (Figure 13A). Pauls Lake coho salmon escapement averaged 8,503 fish from 1988-1995, increasing to an average of 14,700 or 73% higher from 1996-2001 (Figure 13B). Commercial harvests of coho salmon in the Perenosa Bay area increased about 180% on average from 4,377 to 12,297 during the same period (Figures 13A and 13B).

Production Trends of Salmon Runs Sustained by Fish Ladders

Frazer Lake Sockeye Salmon

The Frazer Lake sockeye salmon run averaged 555,866 adults from 1983-2001, of which 334,287 fish were harvested in the commercial fishery (Table 15; Figure 14). The 10-year average (1992-

2001) run was 565,147 sockeye salmon and 350,143 were harvested in the commercial fishery. The five-year average harvests increased from 72,300 sockeye salmon from 1981-1985 to 576,966 sockeye salmon from 1991-1995. The latter catches were those composed of fish that had reared during years of lake enrichment. The average catch from 1996-2000 was 271,359 sockeye salmon.

Little Waterfall Creek Pink Salmon

Pink salmon runs to Little Waterfall Creek were less than 10,000 fish prior to the installation of fish ladders in the late 1970s and early 1980s (Table 16; Honnold 1999; Honnold *in press*). Harvests were only about 1,000 pink salmon each year prior to fish pass installation. The average pink salmon run, after three fish passes were installed (1981-2001), was 113,457 fish, of which 44,786 were commercially harvested. Pink salmon harvests peaked at 382,131 in 1995 and have declined in recent years, primarily due to low fishing effort as observed in 1998 and 1999 when large escapements occurred.

SUMMARY

Salmon rehabilitation, enhancement, and research programs have been conducted in the KMA since the early 1900s. Sockeye salmon stocking projects were the first (1900s-1950s) of the early programs, followed by juvenile salmon introductions into barren lakes, fish ladder construction projects, juvenile sockeye salmon rearing investigations, and the initial lake fertilization project in Alaska. Later (1960s-1980s) programs included more extensive salmon introductions into barren lakes and associated fish ladder installations, and egg planting projects.

By the mid 1980s, regional salmon production planning in the KMA by the KRPT was underway and the KRAA was established. This resulted in the construction of Pillar Creek Hatchery, which was designed for remote lake stocking of sockeye salmon. Other projects that evolved from the salmon planning included the development of an on-site sockeye salmon broodstock at Kitoi Bay Hatchery, and pink, chum, and coho salmon stocking projects in the Kitoi Bay area.

Projects developed since 1991 include those in the Kitoi Bay area such as an expansion of the broodstock development at Kitoi Bay Hatchery to include sockeye salmon presmolt and smolt releases and a change from the late-run Upper Station to Saltery Lake broodstock. “Put and take” sockeye salmon projects were also started in the area at Jennifer and Ruth Lakes and in 2000 a lake fertilization project started at Little Kitoi Lake. Rehabilitation programs employing lake fertilization and stocking were initiated at Afognak Lake, the Malina Lakes, and at the Pauls Lake system to rebuild depressed sockeye salmon runs. Barren Spiridon, Hidden, Crescent, Little Waterfall, and Big Waterfall Lakes were stocked with sockeye salmon to enhance the KMA commercial harvests. Also during the 1990s, fish passes at the Pauls Lake drainage (sockeye, coho), Frazer Lake (sockeye and chinook), Portage Lake (sockeye, coho, and pink), Little Kitoi Lake (coho), and at the Little Waterfall system (pink and coho) were improved upon and maintained to sustain salmon production. Finally, chum, pink, and coho salmon enhancement at Kitoi Bay Hatchery was expanded during the 1990s.

Enhanced fish constituted 35% (5.7 million) of the average total pink salmon (14.9 million), 15% (142 thousand) of the average total chum salmon (800 thousand), 36% (132 thousand) of the average total coho salmon (369 thousand), and 10% (336 thousand) of the average total sockeye salmon (3.3 million) harvests in the KMA from 1997-2001. The total enhanced salmon harvest averaged 6 million or 29% of the total (19.3 million) KMA salmon harvest from 1997-2001.

Restoration efforts at Afognak Lake resulted in a 20% increase in average sockeye salmon escapements and a 200% increase in average sockeye salmon harvests; however, the run has declined in 2000 and 2001. Malina Lake sockeye salmon restoration was successful in increasing average escapements by 100%, meeting goals and allowing for a terminal harvest of about 10,000 adults in 2000 and 4,000 adults in 2001. Sockeye salmon runs to Portage and Pauls Lakes increased as a result of restoration efforts, with average escapements increasing 37% at Portage Lake and increasing 147% at Pauls Lake. Average harvests in the Perenosa Bay area also increased from 649 to 3,635 fish. Coho salmon production at the Portage and Pauls systems also appeared to benefit from lake enrichment, with escapements increasing and average harvests in the Perenosa Bay area increasing 180%.

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Table 1. Geographic location and morphometric parameters for Kodiak-Afognak Island area lakes investigated for enhancement and/or rehabilitation potential; bold indicates ongoing projects, including monitoring and research sites, 2001.

Lake	Latitude (N)	Longitude (W)	Surface Area (km^2)	Mean Depth (m)	Maximum Depth (m)	Volume ($x10^6$ m^3)
Kodiak Island						
Akalura	57° 11'	154° 12'	4.9	9.9	22.0	48.0
Barabara	57° 49'	152° 57'	1.4	3.1	11.6	4.4
Buskin	57° 46'	152° 32'	1.1	10.4	16.8	11.6
Crescent	**57° 85'**	**152° 88'**	**0.6**	**10.3**	**35.4**	**6.2**
Dry Spruce	57° 53'	152° 59'	0.6	8.0	26.0	4.9
Frazer	**57° 15'**	**154° 08'**	**16.6**	**33.2**	**58.9**	**551**
Goat	57° 27'	153° 01'	0.7	13.2	25.2	8.9
Horse Marine	57° 07'	153° 55'	0.9	12.2	28.7	11.0
Karluk	**57° 21'**	**154° 02'**	**39.4**	**48.6**	**126.0**	**1,920**
Little River	57° 75'	153° 65'	1.4	12.7	18.2	17.4
Miam	57° 30'	152° 35'	0.6	3.8	7.0	2.5
Mush	57° 41'	153° 27'	0.3	10.3	13.4	3.1
Olga - Upper	57° 04'	154° 14'	7.9	26.2	70.0	208
- Lower	57° 04'	154° 17'	na[a]	na[a]	2.0	na[a]
Red	57° 15'	154° 17'	8.4	24.7	45.0	208
Rose Tead	57° 29'	152° 28'	0.9	2.0	5.2	1.8
Saltery	**57° 32'**	**152° 45'**	**1.1**	**21.0**	**36.0**	**22.0**
Sitkalidak	57° 11'	153° 19'	na[a]	na[a]	na[a]	na[a]
Spiridon	**57° 43'**	**153° 41'**	**9.2**	**34.7**	**82.0**	**318**
Summit	57° 32'	152° 32'	0.3	6.0	13.4	1.6
Uganik	57° 39'	152° 20'	0.8	17.2	79.0	13.0
Uyak (Salmon)	57° 58'	153° 98'	0.4	6.6	11.0	2.8
Afognak Island						
Afognak	**58° 06'**	**152° 55'**	**5.3**	**8.6**	**23.0**	**46.0**
Big Waterfall	**58° 24'**	**152° 35'**	**0.3**	**5.8**	**15.0**	**1.6**
Big Kitoi	58° 11'	152° 23'	na[a]	na[a]	38.1	na[a]
Gretchen	**58° 23'**	**152° 18'**	**0.3**	**4.5**	**15.2**	**1.4**
Hidden	**58° 23'**	**152° 42'**	**1.9**	**10.8**	**42.0**	**20.6**

-Continued-

Table 1. (page 2 of 2)

Lake	Latitude (N)	Longitude (W)	Surface Area (km^2)	Mean Depth (m)	Maximum Depth (m)	Volume ($x10^6$ m^3)
Jennifer - Upper	**58° 11'**	**152° 17'**	**0.4**	**10.6**	**26.0**	**4.1**
- Lower	**58° 11'**	**152° 18'**	**0.2**	**9.8**	**26.0**	**1.7**
Little Kitoi	**58° 12'**	**152° 22'**	**0.4**	**11.1**	**24.4**	**4.8**
Little Afognak	58° 08'	152° 24'	1.4	5.8	28.0	8.1
Little Waterfall	**58° 22'**	**152° 33'**	**1.0**	**6.8**	**18.3**	**6.7**
Laura	**58° 21'**	**152° 18'**	**4.2**	**12.0**	**39.0**	**50.5**
Malina - Upper	**58° 09'**	**153° 05'**	**1.2**	**15.3**	**33.5**	**18.4**
- Lower	**58° 09'**	**153° 08'**	**0.7**	**6.9**	**15.0**	**4.6**
Pillar	58° 11'	152° 09'	0.4	4.8	27.0	2.1
Pauls	**58° 22'**	**152° 19'**	**0.6**	**11.4**	**21.3**	**6.9**
Portage	**58° 16'**	**152° 25'**	**1.7**	**7.6**	**22.8**	**13.0**
Red Fox	58° 26'	152° 34'	0.3	5.8	21.3	1.7
Ruth	**58° 12'**	**152° 18'**	**0.2**	**7.1**	**17.1**	**1.1**
Sorg	58° 08'	152° 20'	0.5	7.3	19.0	3.6
Thorsheim	58° 15'	152° 49'	0.5	5.1	12.4	2.5

[a] na indicates data are not available.

Table 2. Juvenile salmon releases in the Kitoi Bay area (lakes listed are barriered systems) for common property fishery enhancement, 1973-2001.

	Pink Salmon	Chum Salmon	Coho Salmon				
Year	Big Kitoi Bay	Big Kitoi Bay	Big Kitoi Bay	Little Kitoi Lake	Jennifer Lake	Ruth Lake	Total
1973	493,130	0	0	0	0	0	0
1974	447,642	0	0	0	0	0	0
1975	1,226,314	0	0	0	0	0	0
1976	2,486,410	0	0	0	0	0	0
1977	4,722,152	0	0	0	0	0	0
1978	17,255,424	0	0	0	0	0	0
1979	17,319,537	0	0	0	0	0	0
1980	22,458,947	0	0	0	0	0	0
1981	26,351,664	0	0	0	0	0	0
1982	47,828,701	36,846	0	0	0	0	0
1983	72,054,096	105,058	0	0	0	0	0
1984	87,065,569	630,422	0	127,700	0	0	127,700
1985	75,109,442	784,078	0	33,472	0	0	33,472
1986	97,773,052	414,233	0	53,360	0	0	53,360
1987	90,017,823	693,166	9,600	171,103	0	0	180,703
1988	94,172,516	4,737,587	0	43,807	0	0	43,807
1989	80,502,220	3,289,878	0	0	0	0	0
1990	84,907,550	1,502,501	137,493	0	0	0	137,493
1991	124,148,019	0	0	0	0	0	0
1992	147,145,130	22,214,472	60,755	70,605	162,387	0	293,747
1993	169,552,112	10,101,986	618,844	139,147	135,486	0	893,477
1994	163,192,575	6,507,497	97,973	0	0	0	97,973
1995	134,104,406	9,738,472	258,926	0	165,000	59,500	483,426
1996	144,045,245	20,139,843	894,486	0	0	0	894,486
1997	102,583,724	23,500,000	819,046	0	163,000	35,000	1,017,046
1998	128,101,460	12,310,015	769,000	0	165,000	35,000	969,000
1999	127,685,500	6,859,982	1,098,338	0	136,000	35,000	1,269,338
2000	137,702,154	22,334,640	871,448	0	155,688	30,695	1,057,831
2001	134,823,670	20,032,140	936,913	0	120,000	0	1,056,913
10-Yr. Avg.	138,893,598	15,373,905	642,573	20,975	120,256	19,520	803,324

-Continued-

Table 2. (page 2 of 2)

Year	Sockeye Salmon					
	Little Kitoi Bay	Little Kitoi Lake	Jennifer Lake	Ruth Lake	Sorg Lake	Total
1973	0	0	0	0	0	0
1974	0	0	0	0	0	0
1975	0	0	0	0	0	0
1976	0	0	0	0	0	0
1977	0	0	0	0	0	0
1978	0	0	0	0	0	0
1979	0	0	0	0	0	0
1980	0	0	0	0	0	0
1981	0	0	0	0	0	0
1982	0	0	0	0	0	0
1983	0	0	0	0	0	0
1984	0	0	0	0	0	0
1985	0	0	0	0	0	0
1986	0	0	0	0	0	0
1987	0	0	0	0	0	0
1988	0	0	0	0	0	0
1989	143,725	0	0	0	0	143,725
1990	1,312,728	578,932	0	0	0	1,891,660
1991	1,250,000	0	0	0	0	1,250,000
1992	1,645,000	0	0	0	0	1,645,000
1993	0	52,418	180,000	0	0	232,418
1994	2,292,210	194,108	370,000	0	0	2,856,318
1995	916,677	468,213	200,000	0	0	1,584,890
1996	573,242	206,337	0	150,000	146,000	1,075,579
1997	587,435	202,839	458,000	147,000	0	1,395,274
1998	397,000	99,085	0	100,000	0	596,085
1999	0	205,395	0	66,500	0	271,895
2000	23,756	228,502	0	78,700	0	330,958
2001	0	282,089	0	0	0	282,089
10-Yr. Avg.	643,532	193,899	120,800	54,220	14,600	1,027,051

Table 3. Juvenile salmon releases in the vicinity of Ouzinkie (Katmai) and Port Lions (Crescent) Villages (lakes listed are barriered systems) for subsistence and personal use fishery enhancement, 1987-2001.

	Coho Salmon		Sockeye Salmon
Year	Katmai Lake	Crescent Lake	Crescent Lake
1987	22,349	0	0
1988	20,000	241,373	0
1989	0	202,955	0
1990	0	0	0
1991	0	191,416	0
1992	14,973	69,100	399,000
1993	15,052	66,420	202,000
1994	13,178	163,680	314,000
1995	16,489	167,778	90,200
1996	15,246	163,200	427,000
1997	15,735	165,000	432,000
1998	14,000	163,000	571,000
1999	15,000	165,000	371,700
2000	15,000	165,837	206,000
2001	15,000	165,000	331,500
10-Yr. Avg.	14,967	145,402	334,440

Table 4. Juvenile sockeye salmon releases in areas (lakes listed are barriered systems) other than the Kitoi Bay area for common property fishery enhancement (Terminal Harvest Areas - THA - are in parentheses), 1990-2001.

	Early-Run Timing[a]			Late-Run Timing[b]
Year	Hidden Lake[c] (Foul Bay THA)	Little Waterfall Lake (Waterfall Bay THA)	Big Waterfall Lake (Waterfall Bay THA)	Spiridon Lake (Spiridon Lake THA)
1990	0	0	0	249,346
1991	0	0	0	3,300,000
1992	260,000	493,000	96,000	2,200,000
1993	554,600	205,000	0	4,246,000
1994	250,000	150,000	0	5,676,000
1995	98,650	197,800	0	4,599,000
1996	390,800	82,300	0	4,844,000
1997	455,200	246,800	0	6,700,000
1998	340,400	237,300	0	3,340,000
1999	310,000	273,000	42,000	3,564,000
2000	504,400	358,800	124,400	4,397,100
2001	315,500	310,000	224,300	1,700,600
10-Yr. Avg.	347,955	255,400	48,670	4,126,670

[a] Afognak Lake broodstock (peak return in June) used for all releases.

[b] Late-run Upper Station Lake broodstock (peak return in August) used for 1990-1994 and 1996-1997 releases; Saltery Lake broodstock (peak return in July) used for 1995, 1998-2001 releases.

[c] Coho salmon were released in Hidden Lake in 1988 (137,585), 1989 (239,817), and 1991 (250,889).

Table 5. Juvenile sockeye salmon releases[a] for common property fishery stock restoration (harvest areas are in parentheses), 1992-2001.

Year	Afognak Lake (Southeast Afognak[b])	Malina Lake (Southwest Afognak[c])	Laura Lake (Perenosa Bay[d])
1992	464,000	85,000	0
1993	0	318,000	0
1994	311,000	547,000	117,000
1995	0	53,500	16,000
1996	528,000	426,300	182,000
1997	328,300	390,400	0
1998	422,700	350,500	0
1999	0	406,000	172,000
2000	0	0	0
2001	0	0	0
10-Yr. Avg.	205,400	257,670	48,700

[a] System-specific early-run (June timing) broodstocks used for all releases.
[b] Statistical area 252-34.
[c] Statistical area 251-10.
[d] Statistical area 251-82 and 251-83.

Table 6. Kodiak area lake enrichment projects, 1984-2001.

Lake	Years			Status
	Pre-fertilization Investigtion	Fertilizer Application	Post-fertilization Monitoring	
Karluk	1984-1985	1986-1990	1991-2001	Continued monitoring
Frazer	1986-1987	1988-1992	1993-2001	Continued monitoring
Afognak	1988-1989	1990-2000	2001	Re-evaluate in 2002
Malina	1989-1990	1991-2001		Possibly discontinue in 2002 and begin monitoring
Laura	1991-1992	1993-2001		Possibly discontinue in 2003 and begin monitoring
Portage	1991-1992	1993-1997	1998-2000	Discontinued monitoring in 2001
Little Waterfall	1991-1992	1993-2001		Continue Application Until Lake Can Support Stocking
Little Kitoi	1990-1999	2000-2001		Continue Application Until Lake Can Support Stocking

Table 7. Barrier height, bypass length, bypass slope, bypass grade, and affected salmon species for operational barrier bypasses in the Kodiak Archipelago.

System	Geographic Location	Barrier Height (m)	Barrier Bypass			Affected Salmon Species
			Length (m)	Slope [a]	Grade (%)	
Frazer River	57°13' N, 154°04' W	10.0	60.0	6:1	22	Sockeye, Chinook, Pink, Chum
Gretchen Creek	58°23' N, 152°18' W	2.4	9.1	4:1	25	Coho and Sockeye
Laura Creek	58°21' N, 152°18' W	5.5	27.4 [b]	5:1	20	Coho and Sockeye
Little Kitoi Lake	58°12' N, 152°22' W	1.8	12.2	7:1	14	Pink, Coho, Sockeye
Little Waterfall Creek	58°22' N, 152°33' W	1.8	9.1	5:1	20	Pink and Coho
		2.4	12.2	5:1	20	Pink and Coho
		7.3	31.9 [b]	4.4:1	[c]	Pink and Coho
Portage Creek	58°16' N, 152°25' W	1.8	15.2	8:1	13	Pink, Coho, Sockeye
Seal Bay Creek	58°33' N, 152°22' W	2.0	9.1	4.6:1	16.5	Pink and Coho

[a] Length to height.
[b] Total length composed of three bypasses.
[c] Lower section originally 26%, upper section 28%; modified in 1995 so both sections are 17% and additional lower section added at 20% grade.

Table 8. Description and location of the terminal harvest and special harvest areas in the Kodiak Management Area, 2001.

Project Lake	Harvest Area		Boundaries
	Location	Designation[a]	
Big Kitoi Creek and Little Kitoi Lake	Kitoi Bay	Kitoi Bay SHA	all waters northwest of a line from the regulatory markers located at the entrance to Kitoi Bay commonly known as " The Jaws" to the terminus of Big and Little Kitoi Creeks (streams #252-323 and #252-324).
Crescent	Settler Cove	Settler Cove THA	all waters of Settler Cove west of 152° 50.80' W. Long.
Hidden	Foul Bay	Foul Bay THA	all waters of Foul Bay east of 152° 47.20' W. Long. to the terminus of Hidden Creek (stream #251-406).
Little Waterfall Big Waterfall	Waterfall Bay	Waterfall Bay THA	all waters seaward of the stream terminuses of Little Waterfall Creek (stream #251-822) and Big Waterfall Creek (stream #251-821) to a straight line extending northwesterly from 58°24.15' N. Lat., 152°28.23' W. Long. To 58°25.60'N.Lat., 152°30.80' W. Long.
Malina	Malina Cove	Malina Creek THA	all marine waters within 0.7 nautical miles of the stream terminus of Malina Creek (stream #251-105) located at 153° 12.95' W. Long., 58° 10.42' N. Lat.
Spiridon	Telrod Cove	Spiridon Lake THA	all waters of Telrod Cove north of a line extending from Stream Point 57° 39.00' N. Lat., 153° 38.50' W. Long. to 57° 38.80' N. Lat., 153° 37.60' W.Long.

[a] THA - Terminal Harvest Area; SHA - Special Harvest Area.

Table 9. Kitoi Bay area commercial salmon harvest, by species, 1974-2001. Harvests are a result of stocking projects at Big Kitoi Bay, Little Kitoi Bay, Little Kitoi Lake, Jennifer, and Ruth Lakes.

	Commercial Salmon Harvest [a,b]			
Year	Pink	Chum	Coho	Sockeye
1974	8,794			
1975	13,012			
1976	53,783			
1977	49,682			
1978	234,409			
1979	417,505			
1980	886,837			
1981	880,276			
1982	321,989			
1983	192,281			
1984	401,178	3,301		
1985	3,582,973	5,840		
1986	317,753	1,670	3,477	
1987	1,050,911	5,749	9,889	
1988	693,750	4,001	16,075	
1989	0	0	0	
1990	619,518	6,322	7,227	
1991	1,390,681	31,719	9,359	
1992	845,395	9,868	7,681	25,407
1993	12,076,738	11,886	32,517	31,221
1994	2,051,375	10,799	45,884	14,134
1995	4,519,885	215,351	42,235	31,326
1996	979,143	14,189	57,200	21,981
1997	1,213,615	11,029	110,344	50,115
1998	6,272,029	38,118	148,333	75,506
1999	4,057,093	140,896	116,513	63,342
2000	3,659,698	303,783	133,238	50,749
2001	13,126,761	216,266	151,732	48,516
1992-2001 avg.	4,880,173	97,219	84,568	41,230
1997-2001 avg.	5,665,839	142,018	132,032	57,646

[a] Cost recovery harvest occurred for pinks in 1987-1989 (165,773 - 1987; 298,439 - 1988; 6,641,889 - 1989).

[b] Total harvest from ADF&G Kodiak statistical areas 252-30 (Izhut Bay), 252-31 (Duck Bay), and 252-32 (Kitoi Bay) are considered an index of total harvest.

Table 10. Harvests of sockeye and coho salmon in terminal harvest areas (THA) and other statistical fishing areas as a result of barren lake stocking projectsa at Crescent, Hidden, Little Waterfall, Big Waterfall, and Spiridon Lakes, 1990-2001.

	Settler Cove THA				Foul Bay THA	Waterfall Bay THA
	Sockeye salmon		Coho salmon		Sockeye salmon	Sockeye salmon
Year	Commercial	Subsistence	Commercial	Subsistence	Commercial	Commercial
1990			0	1,158		
1991			0	1,505		
1992			0	1,391		
1993			0	1,313		
1994			1,100	897		
1995	253	1,263	79	1,184	44,479	14,608
1996	13,278	1,569	0	275	29,189	36,496
1997	6,356	1,659	0	372	18,751	27,868
1998	3,085	888	0	293	8,270	11,057
1999	25	905	30	129	41,042	9,353
2000	0	1,287	0	254	26,829	8,623
2001	3,722	no data	0	no data	29,822	16,023
Avg. 1990-2001	3,817	1,262	101	797	28,340	17,718
5-Yr. Ave.	2,638	1,185	6	262	24,943	14,585

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Table 10. (page 2 of 2)

	Spiridon Lake THA		Uganik Bay[b]		Uyak Bay[c]		Other[d]		Total[e]
	Sockeye salmon		Sockeye salmon		Sockeye salmon		Sockeye salmon		Sockeye salmon
Year	Commercial	(%)	Commercial	(%)	Commercial	(%)	Commercial	(%)	Commercial
1990									
1991									
1992									
1993									
1994	115,609	44%	68,325	26%	77,744	29%	2,072	1%	263,750
1995	31,692	33%	35,209	36%	29,804	31%	0	0%	96,705
1996	162,118	42%	153,292	40%	62,670	16%	8,876	2%	386,956
1997	64,483	44%	33,497	23%	43,918	30%	3,348	2%	145,246
1998	88,449	41%							217,191
1999	190,774	41%							468,456
2000	81,931	41%							201,186
2001	59,733	41%							146,678
Avg. 1990-2001	99,349		72,581		53,534		3,574		240,771
5-Yr. Avg.	97,074								235,751

[a] Settler Cove THA - Crescent Lake stocking; Foul Bay THA - Hidden Lake stocking; Waterfall Bay THA- Little and Big Waterfall Lakes stocking; Spiridon Lake THA, Uganik Bay, Uyak Bay, and Other - Spiridon Lake stocking.

[b] Statistical fishing areas 253-11-35

[c] Statistical fishing areas 254-10-40

[d] Inner and outer Karluk, and Halibut Bay statistical fish areas in 1994 and SW Afognak statistical fish area in 1996 and 1997.

[e] Total harvest attributed to the Spiridon Lake stocking project was estimated from 1998-2001 using the average proportion of the havest in the Spiridon Lake THA from 1994-1997.

Table 11. Coho and sockeye salmon commercial harvests as a result of barren lake stocking projects, 1994-2001.

	Total Enhanced Harvest from Barren Lake Stocking[a]			
Year	Coho	ER Sockeye	LR Sockeye	Total Sockeye
1994	1,100	0	263,750	263,750
1995	79	59,340	96,705	156,045
1996	0	78,963	386,956	465,919
1997	0	52,975	145,246	198,221
1998	0	22,412	217,191	239,603
1999	30	50,420	468,456	518,876
2000	0	35,452	201,186	236,638
2001	0	49,567	146,678	196,245
Avg. 1994-2001	151	49,876	240,771	284,412
5-Yr. Avg.	6	42,165	235,751	277,917

[a] ER (early run) stocking at Crescent, Hidden, Little and Big Waterfall Lakes. LR (late run) stocking at Spiridon Lake.

Table 12. Kodiak Management Area (KMA) total commercial salmon harvest and enhanced (E) portion of total commercial harvest, by species, 1971-2001.

Year	Pink Salmon Harvest		
	Total KMA	E (Kitoi Bay Area)	E (%)
1971	4,332,994		
1972	2,485,802		
1973	518,692		
1974	2,646,087	8,794	0%
1975	2,942,801	13,012	0%
1976	11,077,992	53,783	0%
1977	6,252,405	49,682	1%
1978	15,004,083	234,409	2%
1979	11,287,592	417,505	4%
1980	17,290,615	886,837	5%
1981	10,336,829	880,276	9%
1982	8,076,203	321,989	4%
1983	4,603,371	192,281	4%
1984	10,844,293	401,178	4%
1985	7,334,815	3,582,973	49%
1986	11,807,727	317,753	3%
1987[a]	5,076,002	1,216,684	24%
1988[a]	14,409,291	992,189	7%
1989[a,b]	22,648,511	6,641,889	29%
1990	5,983,805	619,518	10%
1991	16,642,804	1,390,681	8%
1992	3,310,644	845,395	26%
1993	34,019,420	12,076,738	35%
1994	8,162,564	2,051,375	25%
1995	42,832,437	4,519,885	11%
1996	3,486,930	979,143	28%
1997	11,035,128	1,213,615	11%
1998	22,056,467	6,272,029	28%
1999	11,898,382	4,057,093	34%
2000	9,927,397	3,659,698	37%
2001	19,567,163	13,126,761	67%
Avg. 1992-2001	16,629,653	4,880,173	30%
Avg. 1997-2001	14,896,907	5,665,839	35%

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Table 12. (page 2 of 5)

Year	Chum Salmon Harvest		
	Total KMA	E (Kitoi Bay Area)	E (%)
1971	1,541,444		
1972	1,163,772		
1973	317,921		
1974	249,294		
1975	84,431		
1976	740,495		
1977	1,072,313		
1978	814,345		
1979	358,400		
1980	1,075,557		
1981	1,345,328		
1982	1,266,187		
1983	1,085,165		
1984	649,092	3,301	1%
1985	430,757	5,840	1%
1986	1,134,558	1,670	0%
1987	681,982	5,749	1%
1988	1,426,410	4,001	0%
1989[a]	835,734	0	0%
1990	577,740	6,322	1%
1991	1,029,070	31,719	3%
1992	679,559	9,868	1%
1993	588,331	11,886	2%
1994	738,856	10,799	1%
1995	1,522,705	215,351	14%
1996	543,751	14,189	3%
1997	520,329	11,029	2%
1998	316,080	38,118	12%
1999	913,867	140,896	15%
2000	1,194,448	303,783	25%
2001	1,053,730	216,266	21%
Avg. 1992-2001	807,166	97,219	10%
Avg. 1997-2001	799,691	142,018	15%

-Continued-

Table 12. (page 3 of 5)

Year	Coho Salmon Harvest		
	Total KMA	E (Kitoi Bay Area)	E (%)
1971	22,844		
1972	16,588		
1973	3,573		
1974	13,631		
1975	23,659		
1976	23,714		
1977	27,920		
1978	48,795		
1979	140,629		
1980	139,154		
1981	121,544		
1982	343,531		
1983	157,612		
1984	229,524		
1985	284,166		
1986	168,773	3,477	2%
1987	192,540	9,889	5%
1988	303,298	16,075	5%
1989[a]	141,433	0	0%
1990	293,699	7,227	2%
1991	324,860	9,359	3%
1992	280,085	7,681	3%
1993	313,387	32,517	10%
1994[c]	296,305	46,984	16%
1995	307,729	42,235	14%
1996	201,836	57,200	28%
1997	380,925	110,344	29%
1998	425,023	148,333	35%
1999	296,979	116,513	39%
2000	333,002	133,238	40%
2001	407,978	151,732	37%
Avg. 1992-2001	324,325	84,678	25%
Avg. 1997-2001	368,781	132,032	36%

-Continued-

Table 12. (page 4 of 5)

Year	Sockeye Salmon Harvest				
	Total KMA	E (Kitoi Bay Area)	E-Other	E-Total	E (%)
1971	478,479				
1972	222,800				
1973	167,341				
1974	418,761				
1975	136,418				
1976	641,484				
1977	623,468				
1978	1,071,782				
1979	631,735				
1980	651,394				
1981	1,288,980				
1982	1,204,793				
1983	1,231,989				
1984	1,950,439				
1985	1,843,185				
1986	3,188,269				
1987	1,792,819				
1988	2,698,637				
1989[a]	2,628,565				
1990	5,248,339				
1991	5,704,041				
1992	4,167,877	25,407		25,407	1%
1993	4,377,688	31,221		31,221	1%
1994	2,878,023	14,134	263,750	277,884	10%
1995	4,485,321	31,326	156,045	187,371	4%
1996	4,970,390	21,981	465,919	487,900	10%
1997	2,505,660	50,115	198,221	248,336	10%
1998	3,623,094	75,506	239,603	315,109	9%
1999	4,652,961	63,342	518,876	582,218	13%
2000	2,906,391	50,749	236,638	287,387	10%
2001	2,659,267	48,516	196,245	244,761	9%
Avg. 1992-2001	3,722,667	41,230	284,412	268,759	8%
Avg. 1997-2001	3,269,475	57,646	277,917	335,562	10%

-Continued-

Table 12. (page 5 of 5)

Year	All Species Combined Salmon Harvest		
	Total KMA	E	E (%)
1971	6,375,761	0	0%
1972	3,888,962	0	0%
1973	1,007,527	0	0%
1974	3,327,773	8,794	0%
1975	3,187,309	13,012	0%
1976	12,483,685	53,783	0%
1977	7,976,106	49,682	1%
1978	16,939,005	234,409	1%
1979	12,418,356	417,505	3%
1980	19,156,720	886,837	5%
1981	13,092,681	880,276	7%
1982	10,890,714	321,989	3%
1983	7,078,137	192,281	3%
1984	13,673,348	404,479	3%
1985	9,892,923	3,588,813	36%
1986	16,299,327	322,900	2%
1987	7,743,343	1,232,322	16%
1988	18,837,636	1,012,265	5%
1989 [a]	26,254,243	6,641,889	25%
1990	12,103,583	633,067	5%
1991	23,700,775	1,431,759	6%
1992	8,438,165	888,351	11%
1993	39,298,826	12,152,362	31%
1994	12,075,748	2,123,292	18%
1995	49,148,192	4,808,797	10%
1996	9,202,907	1,072,513	12%
1997	14,442,042	1,385,103	10%
1998	26,420,664	6,533,986	25%
1999	17,762,189	4,377,844	25%
2000	14,361,238	4,147,468	29%
2001	23,688,138	13,543,275	57%
Avg. 1992-2001	21,483,811	5,103,299	23%
Avg. 1997-2001	19,334,854	5,997,535	29%

[a] Include cost recovery harvests at Kitoi Bay Hatchery.

[b] Fisheries were severely limited due to the M/V Exxon Valdez oil spill; the 1989 catch data presented are the projected catch had there been no fishery restrictions (Barrett et al. 1990) .

[c] Enhanced coho salmon harvest includes 1,100 caught in the Settler Cove THA.

Table 13. Sockeye salmon escapements and associated statistical fishing section harvests for Kodiak Area anadromous (non-barren) lakes stocked and/or fertilized, 1978-2001 (shaded area indicates that a portion of returns were produced from stocking and a portion of returns were affected by fertilization).

	Afognak Lake		Malina Lake		Portage Lake	Pauls Lake	Perenosa Bay
Year	Escapement	Harvest[a]	Escapement[b]	Harvest[c]	Escapement[b]	Escapement	Harvest[d]
1978	52,701	3,414			*3,200*	20,043	6,200
1979	82,703	2,146	*40,000*		*15,400*	8,415	12,520
1980	93,861	28	*27,800*		*4,200*	50,993	714
1981	57,267	16,990	*1,800*		*11,822*	21,806	30,015
1982	123,055	21,622	*14,000*		*17,926*	18,574	22,898
1983	40,049	4,349	*6,800*		*3,600*	20,625	5,186
1984	94,463	6,130	*6,200*		*3,000*	32,659	5,965
1985	53,563	1,980	*3,200*		*6,400*	14,941	2,095
1986	48,328	2,585	*8,000*			5,402	3,329
1987	25,994	1,323	*8,000*		*1,000*	13,122	476
1988	39,012	14				22,794	1,388
1989	88,825	0	*4,900*		*850*	12,605	0
1990	90,666	22,149	*7,600*		3,670	14,510	435
1991	88,557	47,237	*7,700*		5,466	3,237	35
1992	77,260	2,196	7,610		6,045	8,033	4
1993	71,460	1,848	8,273		5,363	12,442	82
1994	80,570	17,362	9,042		*6,800*	16,100	139
1995	100,131	67,665	10,803		*15,000*	13,480	3,789
1996	101,718	106,141	8,030		*16,800*	41,145	4,985
1997	132,050	10,409	9,455		*14,600*	31,456	37
1998	66,869	26,060	14,917		*4,200*	15,343	78
1999	95,361	34,420	29,171		*5,900*	28,884	16,292
2000	54,064	14,124	21,006	10,485	13,456	27,373	393
2001	24,271	0	22,490	4,001	3,147	23,221	26
Avg. pre-fert/stock[e]	67,408	9,290	6,910		7,057	11,300	747
Avg. fert/stock	80,722	30,892	15,614	7,243	9,684	27,904	3,635

[a] Statistical fishing section 252-34 (Afognak Bay).

[b] Italicized indicate peak live counts from aerial or foot survey estimates - doubled to estimate total escapement Barrett et al. (1990); remaining data from weir counts.

[c] An unknown number of Malina Lake sockeye salmon were likely harvested in statistical fishing sections 251-10-30 for all years; harvests in 2000- 2001were from designated Terminal Harvest Area within statistical fishing section 251-10.

[d] Combined harvests from statistical fishing sections 252-82-83 (Perenosa Bay); specific harvests of Portage and Pauls Lake sockeye salmon are unknown.

[e] Number of years used for pre-fert/stock average were equal to number of years used for fert/stock average.

Table 14. Coho salmon escapements for Portage and Pauls Lake systems and coho salmon harvests in the Perenosa Bay Section, 1981-2001 (shaded area indicates returns likely influenced by fertilization).

	Portage Lake		Pauls Lake	Perenosa Bay
Year	Peak Count[a]	Escapement[b]	Escapement[c]	Harvest[d]
1981	849	2,038		7,762
1982	439	1,054		37,843
1983	1,000	2,400		7,104
1984	1,500	3,600	4,274	13,008
1985	3,400	8,160	9,535	20,262
1986	200	480	9,403	2,200
1987			4,767	4,201
1988			5,563	20,865
1989	7,000	16,800	7,919	0
1990	4,277	10,265	3,668	4,282
1991	400	960		251
1992	2,800	6,720		336
1993	2,500	6,000	10,664	466
1994	8,000	19,200	12,538	2,516
1995	15,300	36,720	10,663	6,299
1996			15,491	1,608
1997	11,000	26,400	8,280	23,051
1998	7,000	16,800	15,514	12,528
1999			11,206	2,752
2000	10,000	24,000	12,676	12,302
2001	4,000	9,600	25,032	21,518
Avg. pre-fert.[e]	7,150	17,160	8,503	4,377
Avg. fert.	8,000	19,200	14,700	12,297

[a] From aerial or foot survey estimates.

[b] Peak count mulitiplied by 2.4 (Minard 1986; Honnold 1999; Honnold in press).

[c] Weir counts.

[d] Combined harvests from statistical fishing sections 252-82-83 (Perenosa Bay); specific harvests of Portage and Pauls Lake coho salmon are unknown.

[e] Number of years used for pre-fert average were equal to number of years used for fert average.

Table 15. Frazer Lake sockeye salmon, escapement, catch, run, and exploitation rate, 1971-2001.

Year	Escapement			Catch [c]	5 Yr Ave	Run	Exploitation Rate (%)
	DS Weir [a]	Fish Ladder	River [b]				
1971		55,366		10,549		65,915	16
1972		66,419		2,761		69,180	4
1973		56,255		1,210		57,465	2
1974		82,609		2,765		85,374	3
1975		64,199		3,300	4,117	67,499	5
1976		119,321		8,770		128,091	7
1977		139,548		1,366		140,914	1
1978		141,981		30,336		172,317	18
1979		126,742		26,805		153,547	17
1980		405,535		55,173	24,490	460,708	12
1981		377,716		110,210		487,926	23
1982		430,423		76,232		506,655	15
1983	166,655	158,340	8,315	29,668		196,323	15
1984[d]	48,844	53,524	-4,680	13,853		62,697	22
1985	506,336	485,835	20,501	131,535	72,300	637,871	21
1986	136,553	126,529	10,024	41,652		178,205	23
1987	48,956	40,544	8,412	8,626		57,582	15
1988 [e]	248,055	246,704	1,351	210,406		458,461	46
1989	362,007	360,373	1,634	708,864		1,070,871	66
1990	254,540	226,707	27,833	725,293	338,968	979,833	74
1991	288,013	190,358	97,655	980,132		1,268,145	77
1992	206,406	185,825	20,581	212,367		418,773	51

-Continued-

Table 15. (page 2 of 2)

Year	Escapement			Catch [c]	5 Yr Ave	Run	Exploitation Rate (%)
	DS Weir [a]	Fish Ladder	River [b]				
1993	198,412	178,391	20,021	552,993		751,405	74
1994	240,913	206,071	34,842	409,132		650,045	63
1995	222,170	196,323	25,847	730,207	576,966	952,377	77
1996	208,638	198,695	9,943	492,275		700,913	70
1997	268,328	205,264	63,064	148,091		416,419	36
1998	245,409	233,755	11,654	360,949		606,358	60
1999	222,964	216,565	6,399	134,115		357,079	38
2000	173,340	158,044	15,296	221,365	271,359	394,705	56
2001	163,455	154,349	9,106	239,936		403,391	59
Average 1983-2001	221,579	201,168	20,410	334,287		555,866	50
10 yr. Average	215,004	193,328	21,675	350,143		565,147	58

[a] Prior to 1983 the Dog Salmon weir was not in operation.
[b] Dog Salmon weir count minus Frazer fish ladder count.
[c] Although Frazer Lake sockeye catch occurred prior to 1983, numbers are unreliable.
[d] In 1984, the Dog Salmon weir count was inaccurate due to high water; Alitak catch based upon Frazer count.
[e] Estimated escapement, weir was inoperable for part of season actual count was 241,970 sockeye.

Table 16. Little Waterfall Creek mean (1968-1980) and annual (1981-2001) pink salmon escapement, harvest, and total run.

Year [a]	Escapement	Harvest	Total Run
Mean 1968-1980:	6,824	1,022	7,846
Mean 1968-1980 (Odd Year):	6,745	766	7,511
Mean 1968-1980 (Even Year):	6,870	1,168	8,038
1981	61,247	58,284	119,531
1982	47,829	53,862	101,691
1983	21,560	4,220	25,780
1984	40,016	6,832	46,848
1985	119,211	48,751	167,962
1986	50,884	38,387	89,271
1987	29,093	15,718	44,811
1988	27,550	112,010	139,560
1989	147,016	0	147,016
1990	47,000	48,978	95,978
1991	115,000	7,619	122,619
1992	43,000	1,109	44,109
1993	166,391	126,832	293,223
1994	50,937	13,328	64,265
1995	100,223	382,131	482,354
1996	13,624	194	13,818
1997	24,339	2,302	26,641
1998	151,655	2,668	154,323
1999	115,322	9,180	124,502
2000	36,006	4,937	40,943
2001	34,184	3,171	37,355
Mean (1981-2001):	68,671	44,786	113,457
Mean (Odd Year):	84,871	59,837	144,708
Mean (Even Year):	50,850	28,231	79,081

[a] First two barriers bypassed with fish passes in 1979; third bypassed in 1980 (improvements made in 1995).

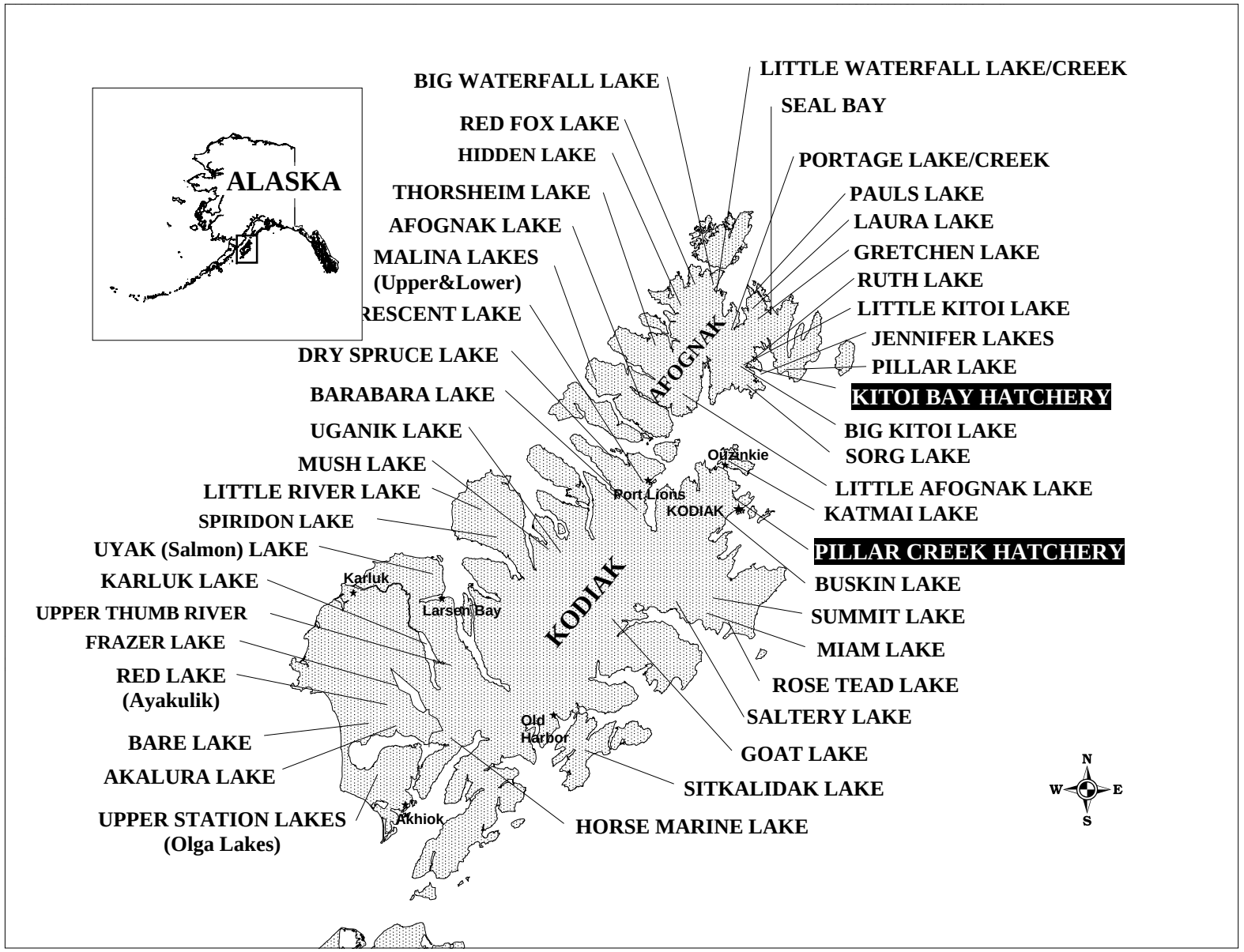


Figure 1. Locations of salmon investigations on Kodiak and Afognak Islands, 1951 - 2001.

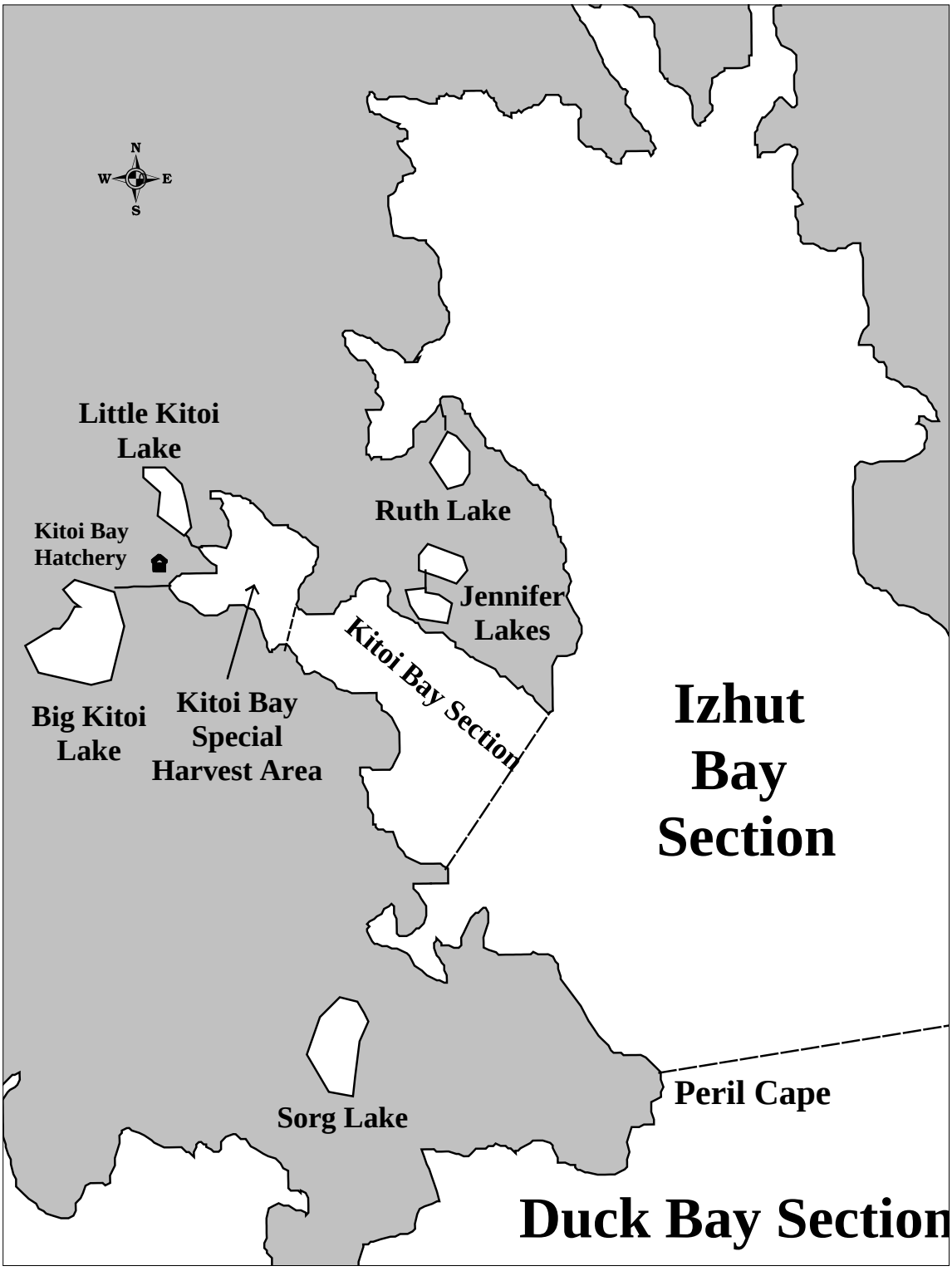


Figure 2. Izhut (252-30), Duck (252-31) and Kitoi (252-32) Bay Sections of the Afognak commercial fishing district.

Figure 3. Location of lake enrichment systems on Afognak Island, 2001.

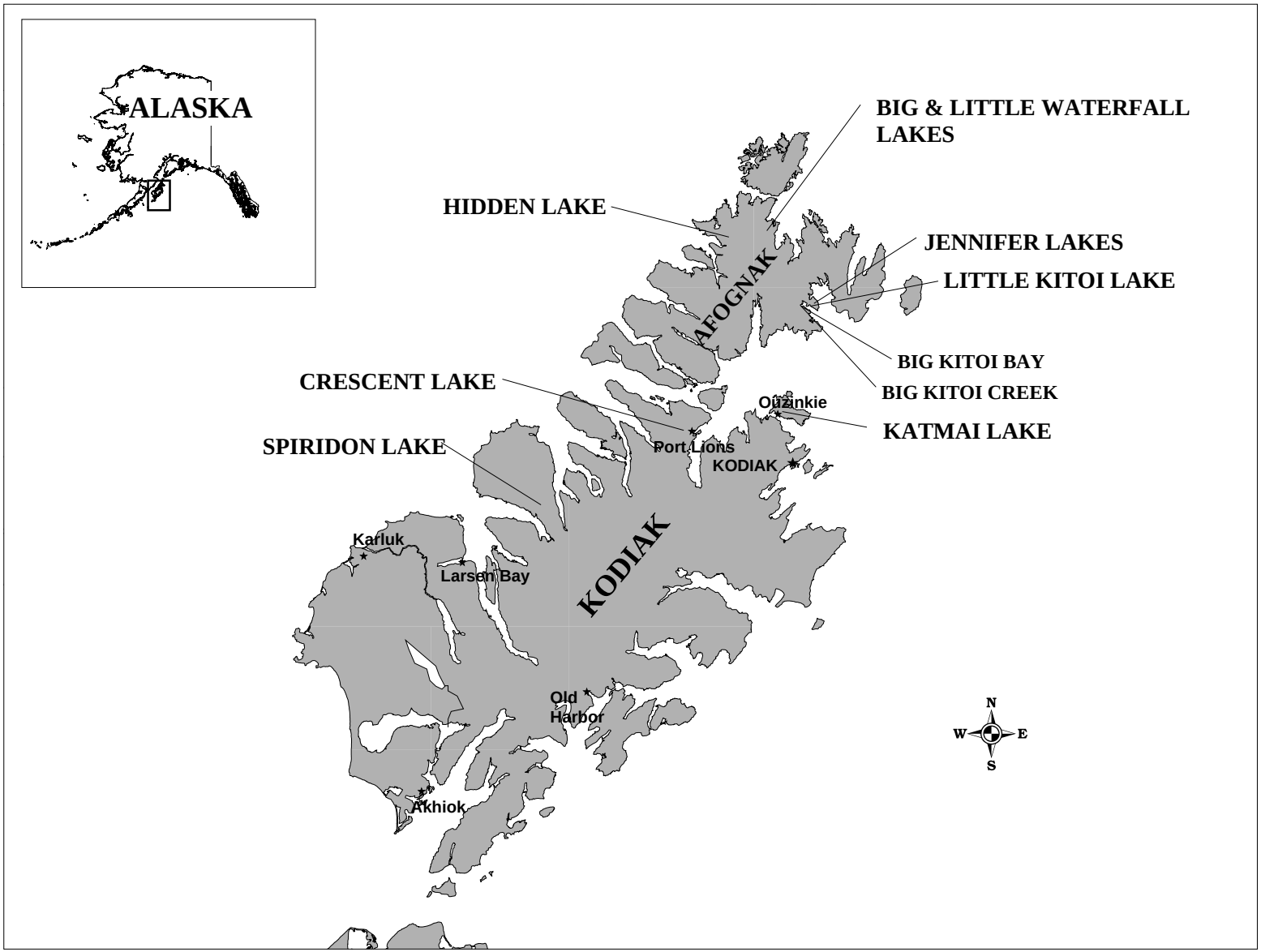


Figure 4. Salmon stocking locations on Kodiak and Afognak Islands, 2001.

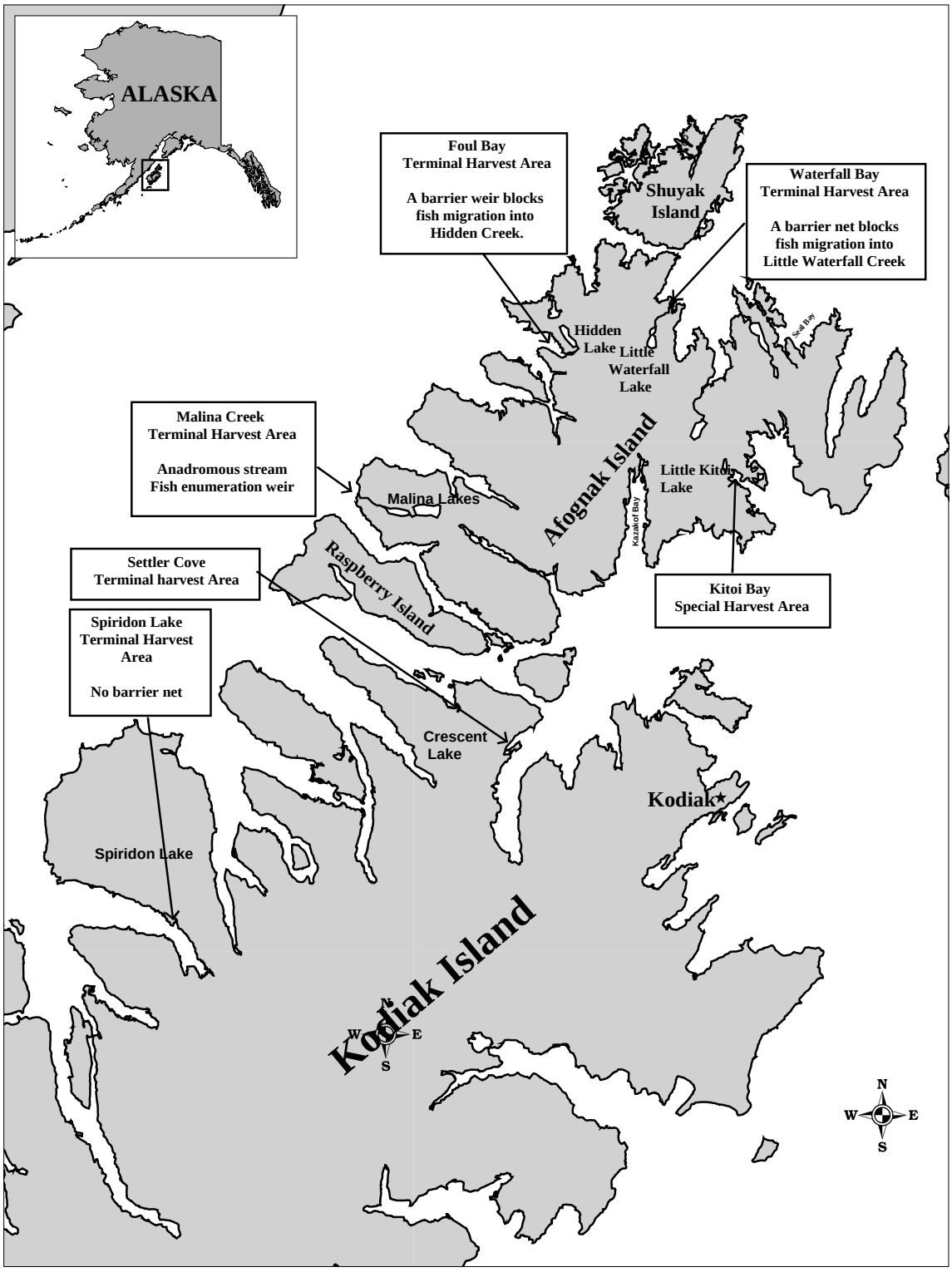


Figure 5. Locations of terminal and special harvest areas with associated barrier weirs/nets at these systems, 2001.

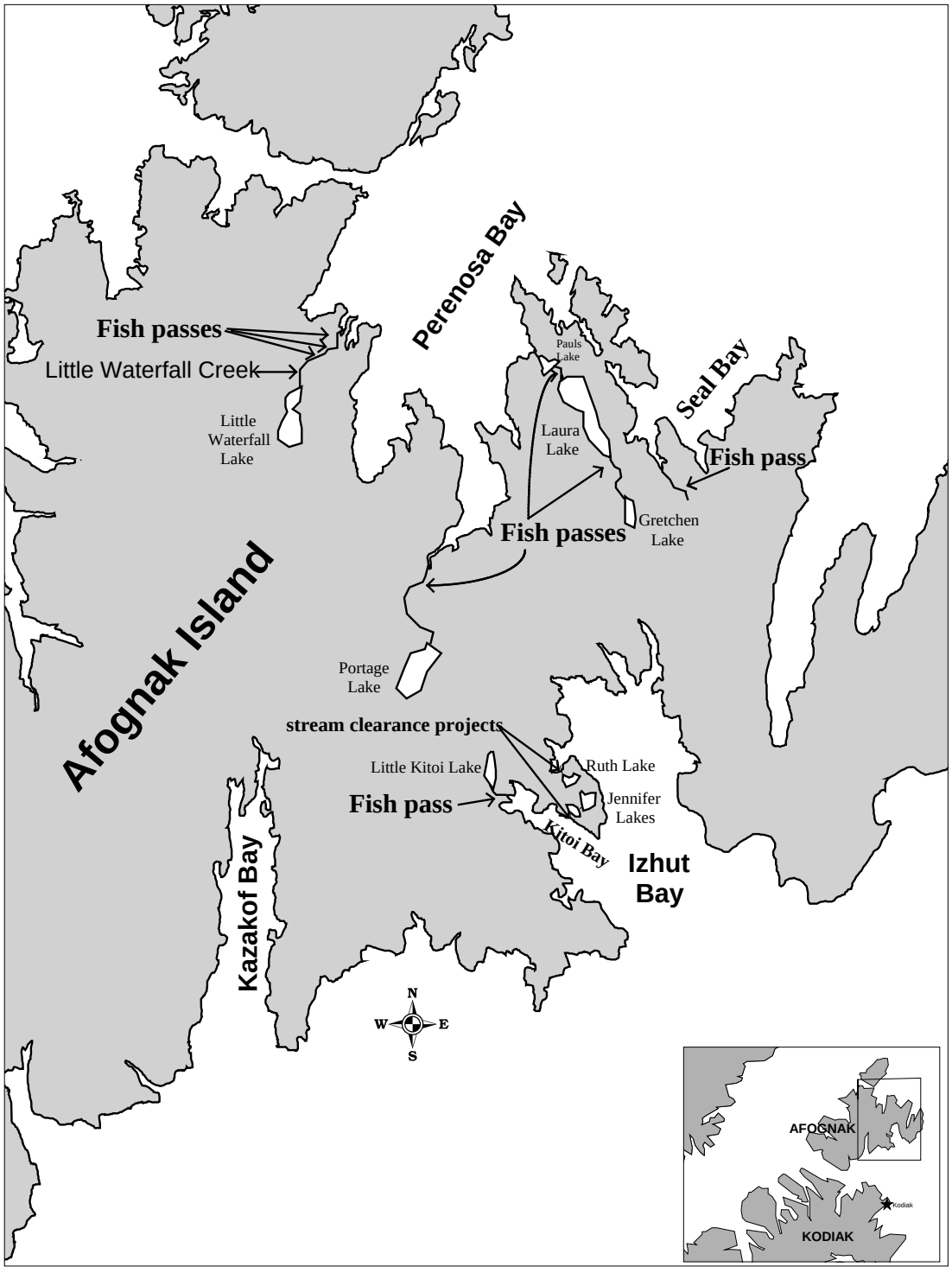


Figure 6. Location of fish passes (barrier bypasses) and stream clearance operations at salmon systems on Afognak Island, 2001.

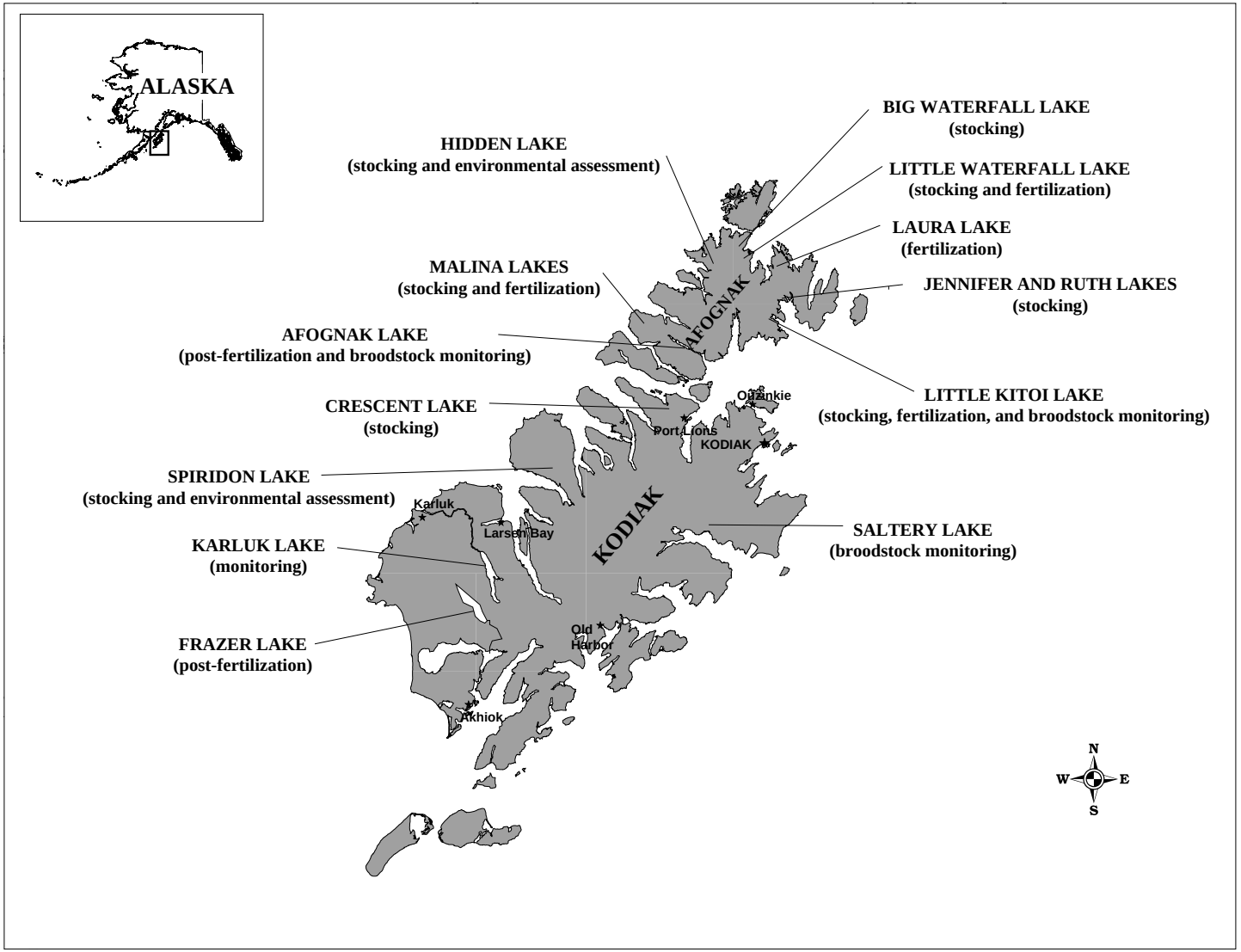


Figure 7. Locations of sockeye salmon evaluation and monitoring programs on Kodiak and Afognak Islands, 2001.

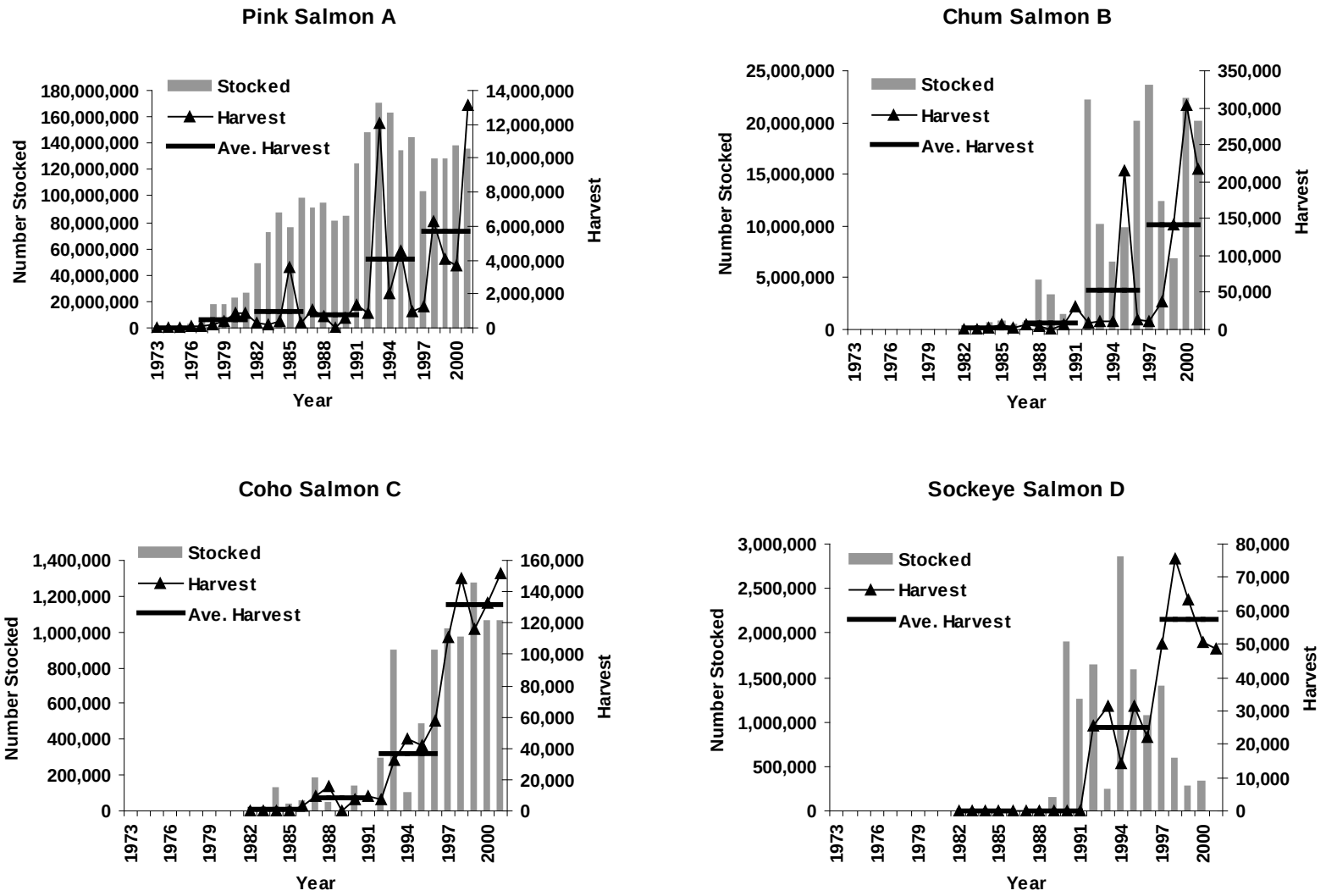


Figure 8. Number of juvenile salmon stocked, number of adult salmon harvested, and five year average harvest in the Kitoi Bay area, by species, 1973-2001. Note: the majority adults return after stocking as follows: pink salmon (A) - 1 year, chum salmon (B) - 3 years, coho salmon (C) - 1 year, sockeye salmon (D) - 3-4 years.

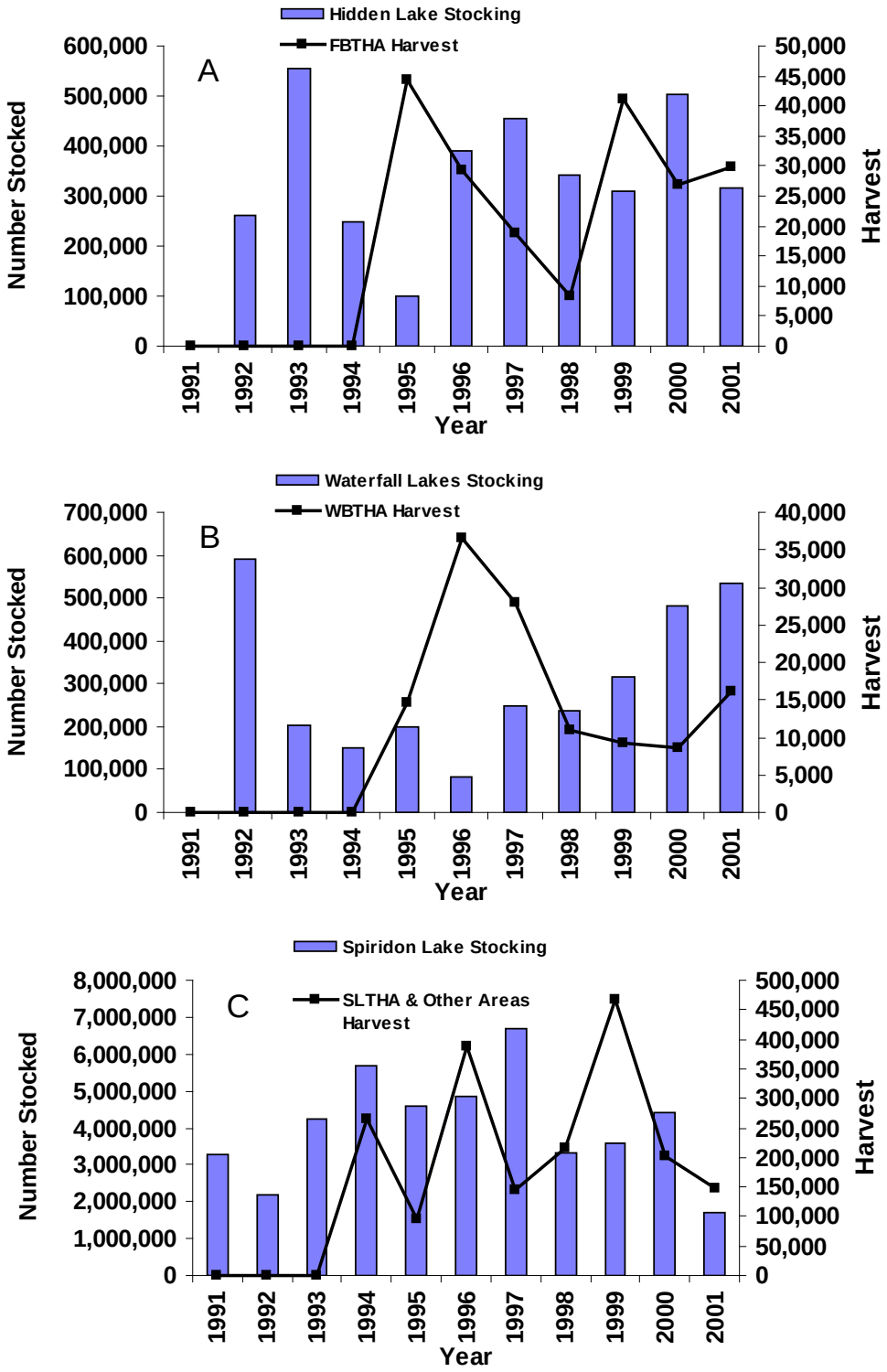


Figure 9. Juvenile sockeye salmon stocking levels in barren Hidden (A), Little and Big Waterfall (B), and Spiridon (C) Lakes and resultant commercial harvests, 1991-2001. Note: adults typically return 3-4 years after stocking.

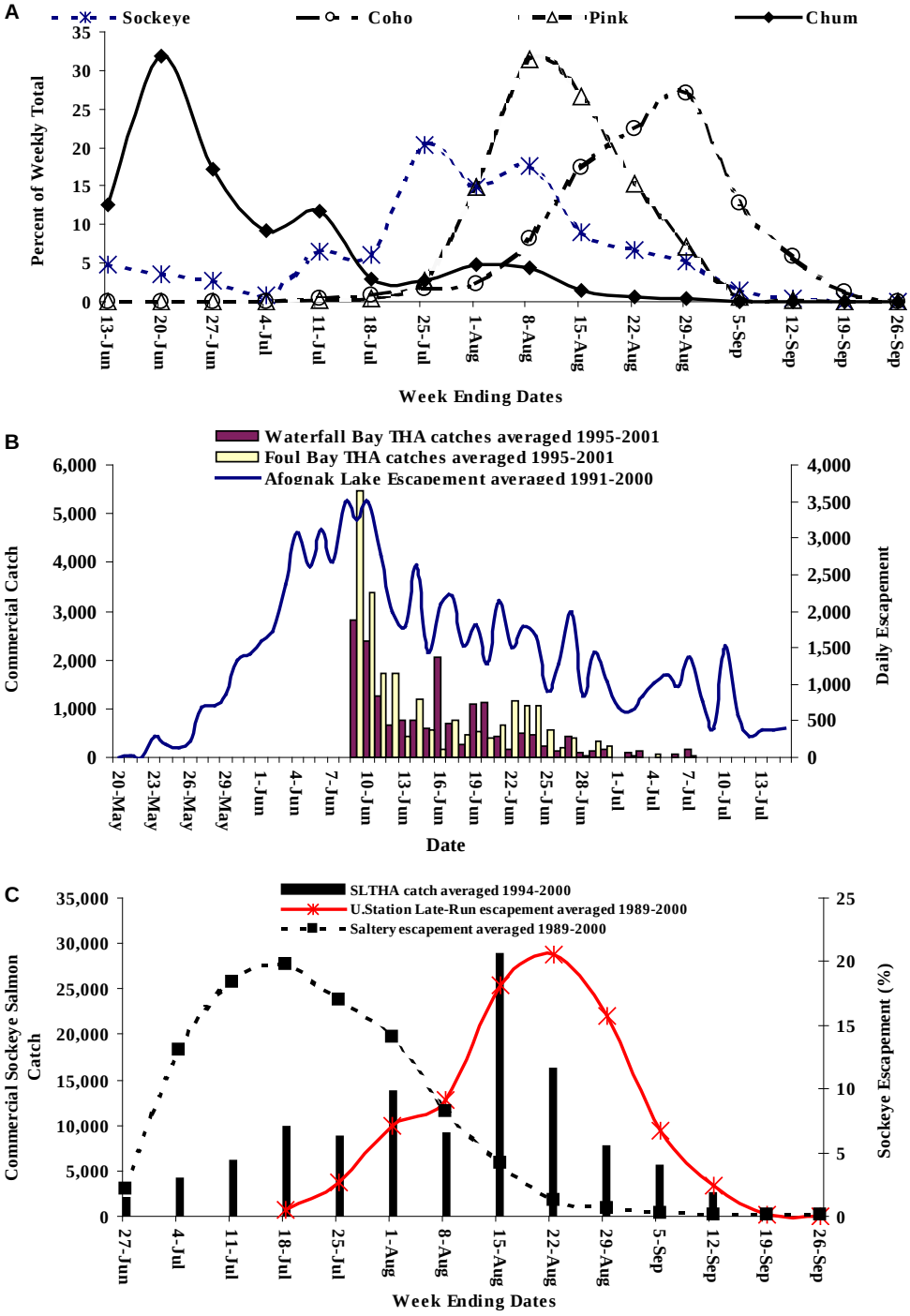


Figure 10. Average salmon harvest timing in the Izhut, Duck, and Kitoi Bay Sections combined, 1990-2000 (A), sockeye salmon harvest timing in the WBTHA and the FBTHA compared to the escapement timing of the Afognak Lake brood source (B), and sockeye salmon harvest timing in the SLHA compared to the escapement timing of the Upper Station and Saltery Lakes brood sources (C).

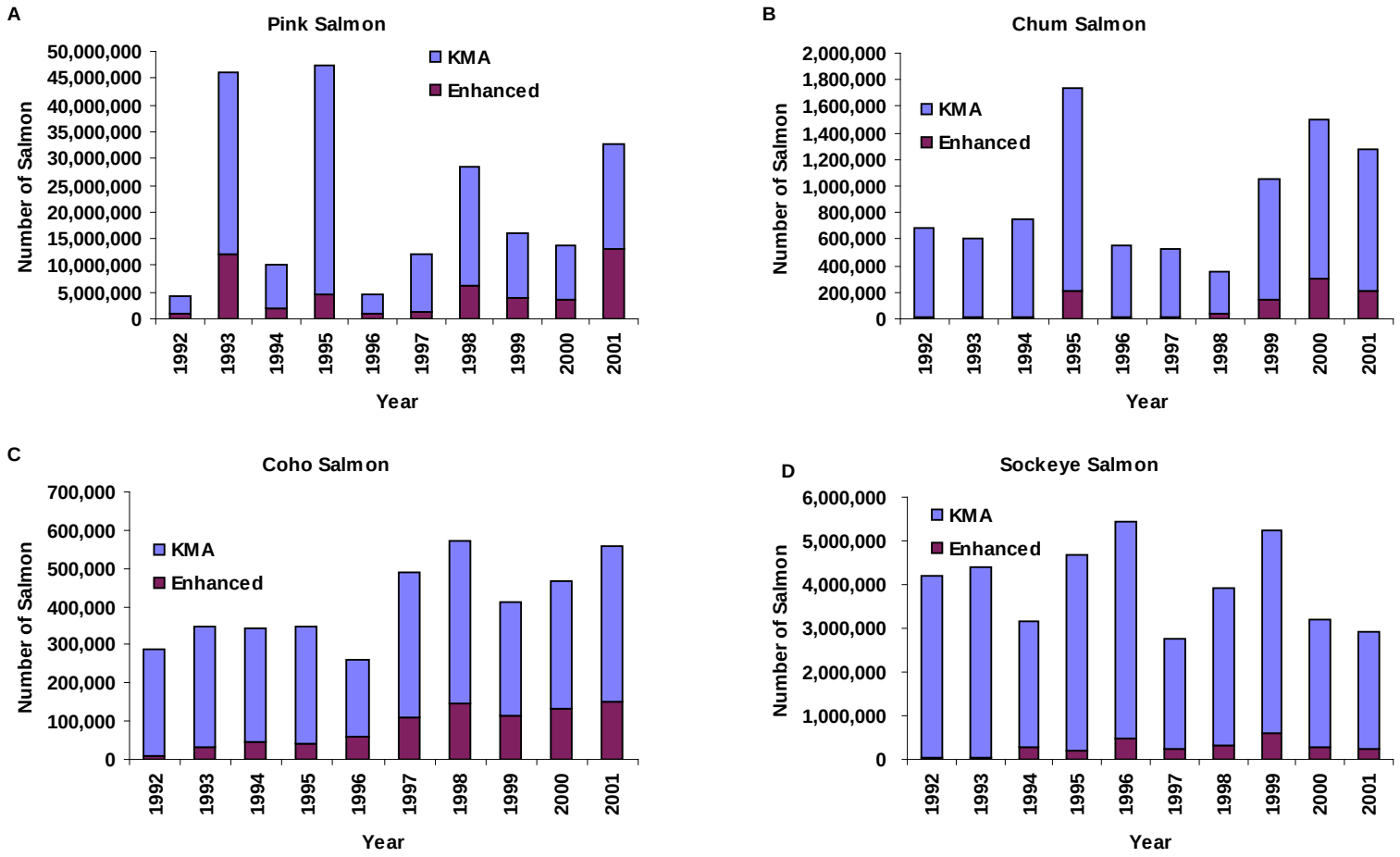


Figure 11. Enhanced harvest compared to total Kodiak Management Area harvest of pink (A), chum (B), coho (C), and sockeye (D) salmon, 1992-2001.

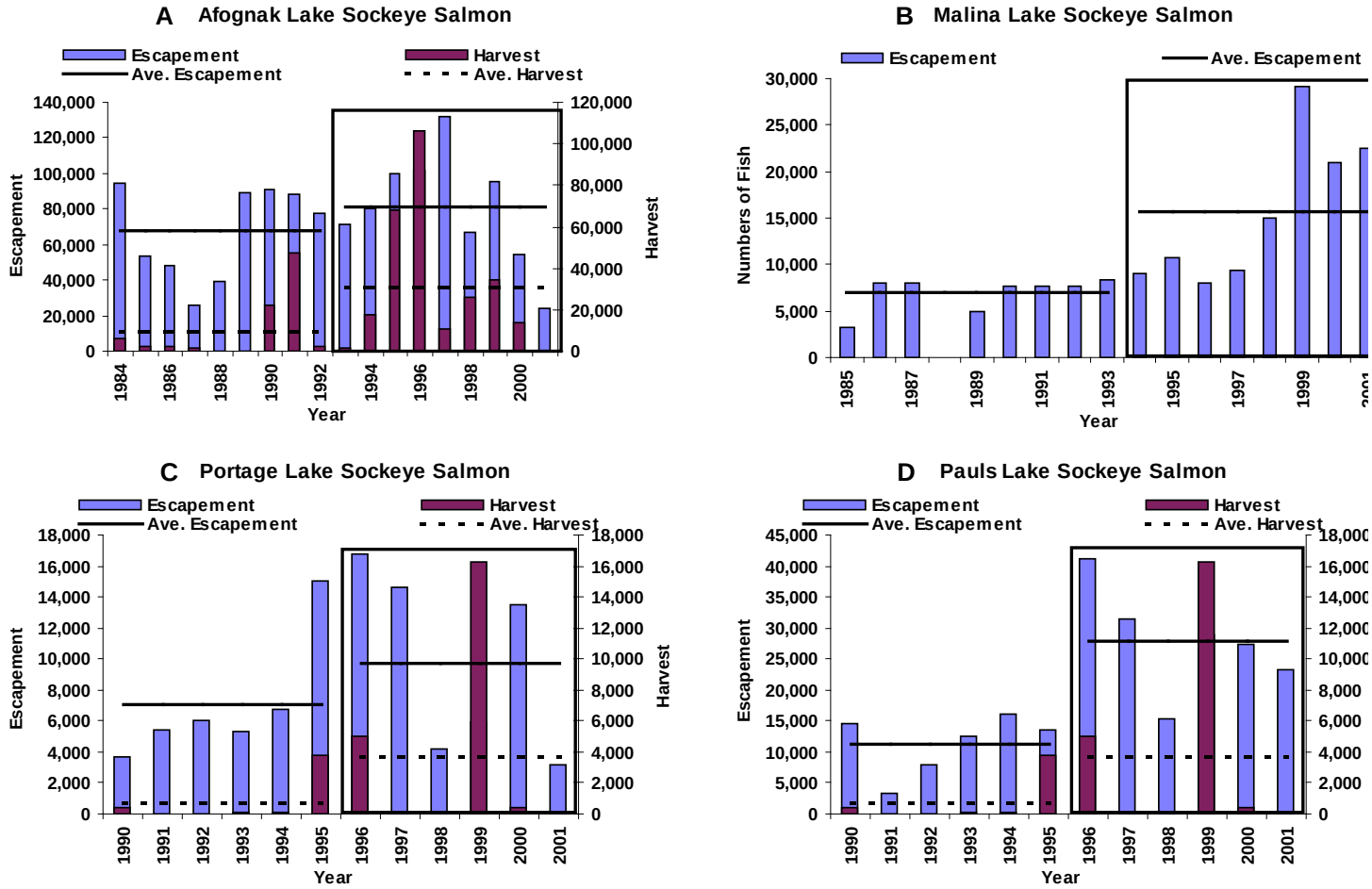


Figure 12. Sockeye salmon escapements and associated fishing section harvests (except for Malina Lake), including averages, for years when returns were (boxed area) and were not composed of fish affected by fertilization for Afognak (A), Malina (B), Portage (C), and Pauls (D) Lake systems. Note: the same harvest data (Perenosa sections 251-82-83) were applied to the Portage and Pauls figures.

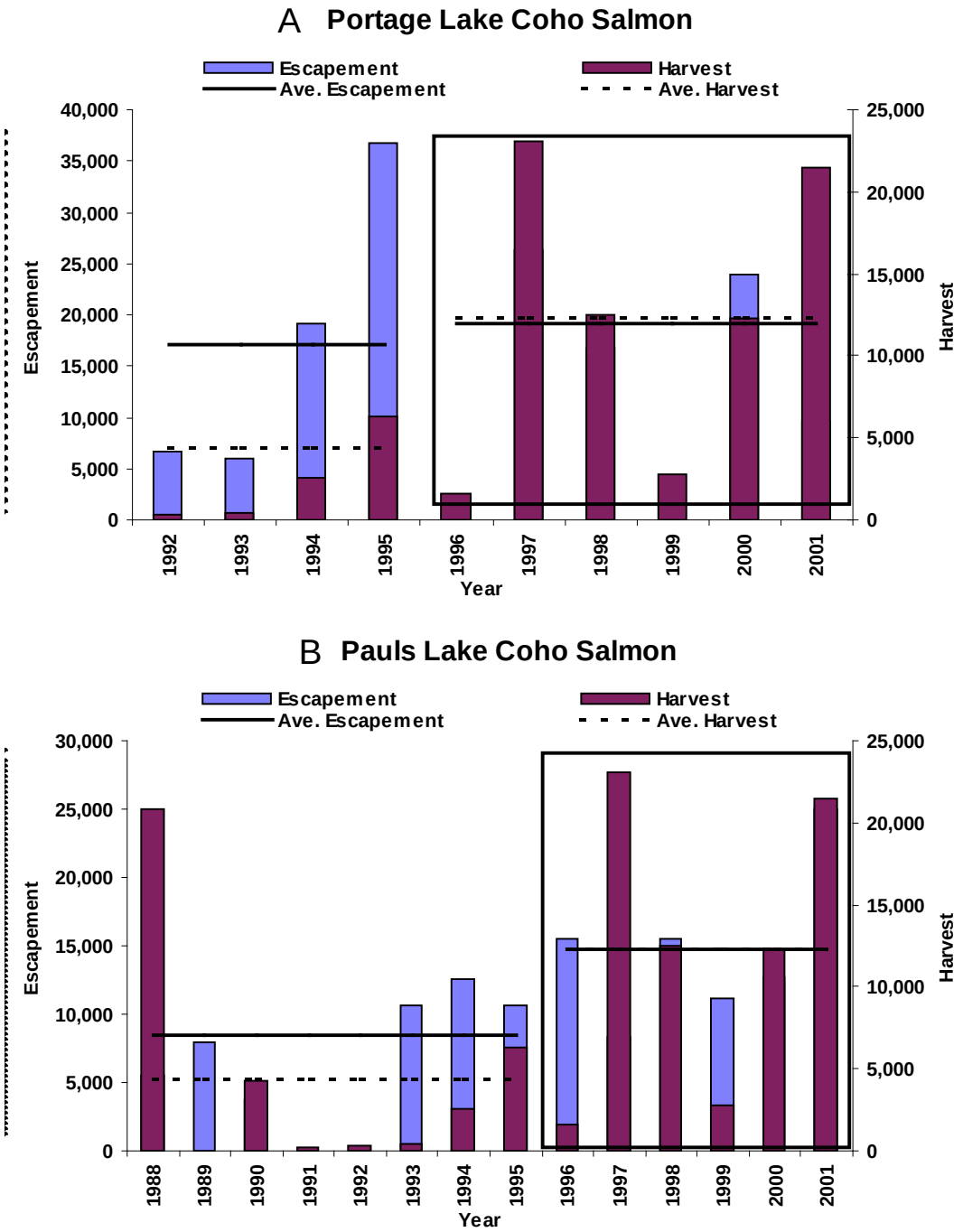


Figure 13. Coho salmon escapements and associated fishing section harvests, including averages, for years when returns were (boxed area) and were not composed of fish affected by fertilization for Portage (A) and Pauls (B) Lake systems. Note: the same harvest data (Perenosa sections 251-82-83) were applied to the figures.

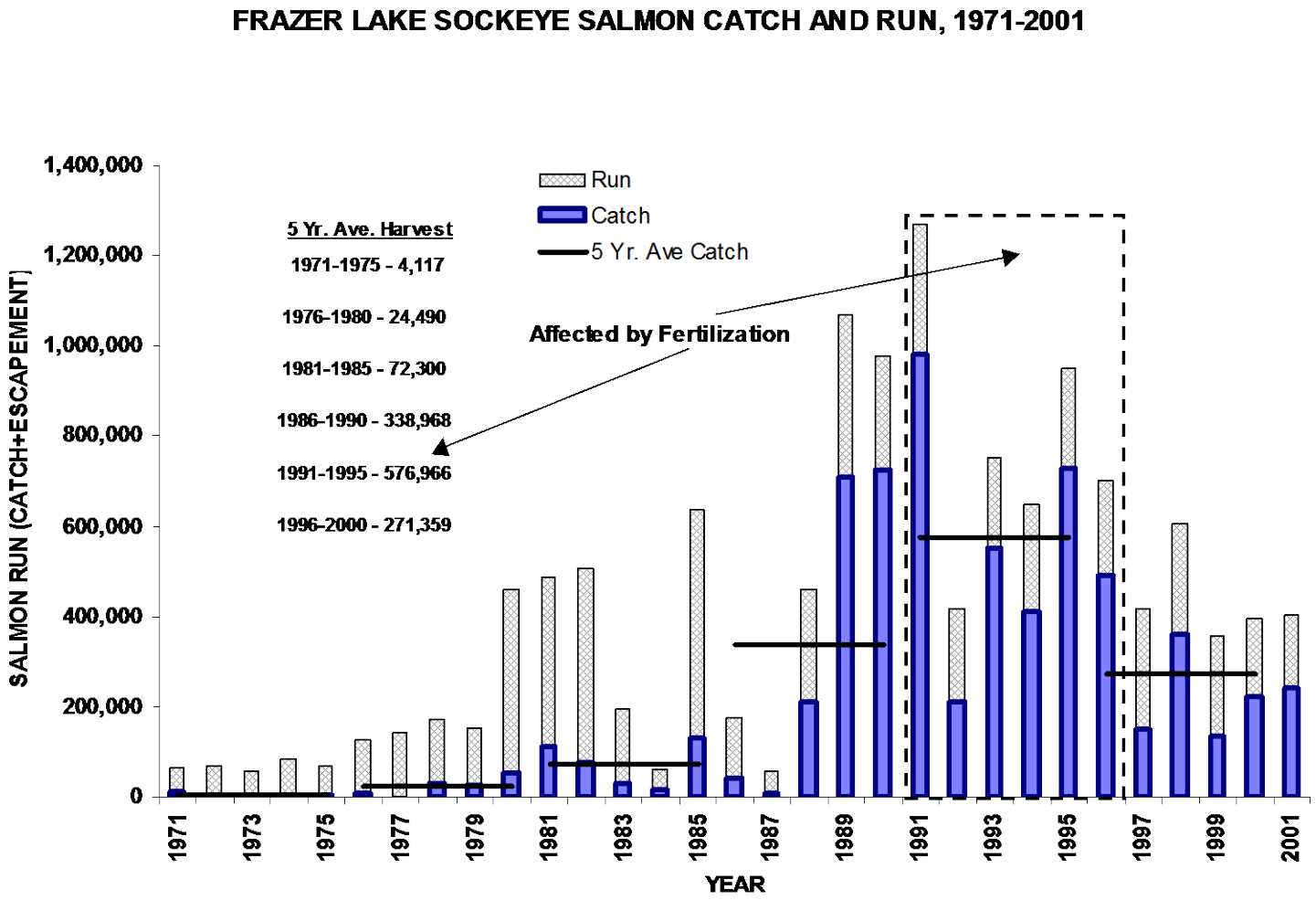


Figure 14. Frazer Lake sockeye salmon run, catch, and five year average catch. Note: returns affected by fertilization are noted in the dashed box.

APPENDIX

Appendix A. Chronology of Kodiak Island sockeye salmon enhancement (E) and restoration (R) projects, 1891-2001.

Project	Years[a]	Funding Source
Karluk Voluntary Hatchery (E)	1891, 1896-1917	Cannery Operators
Afognak Lake Federal Hatchery (E)	1908-1932	Bureau of Fisheries
Pauls Lake System Egg Plants and Fishway Development (E)	1951-1955	Alaska Territorial Department of Fisheries (ATDF)
Frazer Lake Egg Plants, Fry Stocking, Adult Transplants, and Fish Ladder (E)	1951-1971	ATDF; Alaska Department of Fish and Game (ADF&G)
Kitoi Bay Research Station/Hatchery[b]	1953-1972	ATDF; ADF&G
Bare Lake Enrichment[b]	1955	USF&WS
Karluk Lake Streamside Incubation/ U.Thumb River Egg Plants (R)	1979-1986	ADF&G
Kodiak Regional Aquaculture Association (KRAA; E&R)	1983-present	Fishery Enhancement Tax
Karluk Lake Enrichment (R)	1986-1990	KRAA; Kodiak Island Borough (KIB)
Frazer Lake Enrichment (R)	1988-1992	KRAA; KIB
Little Kitoi Lake Broodstock Development (E)	1988-2001[c]	KRAA
Afognak Lake Enrichment/Stocking (R&E)[b]	1990-2000	KRAA
Kodiak and Afognak Island Lakes Feasibility Investigations (E&R)	1990-1992	KRAA

-Continued-

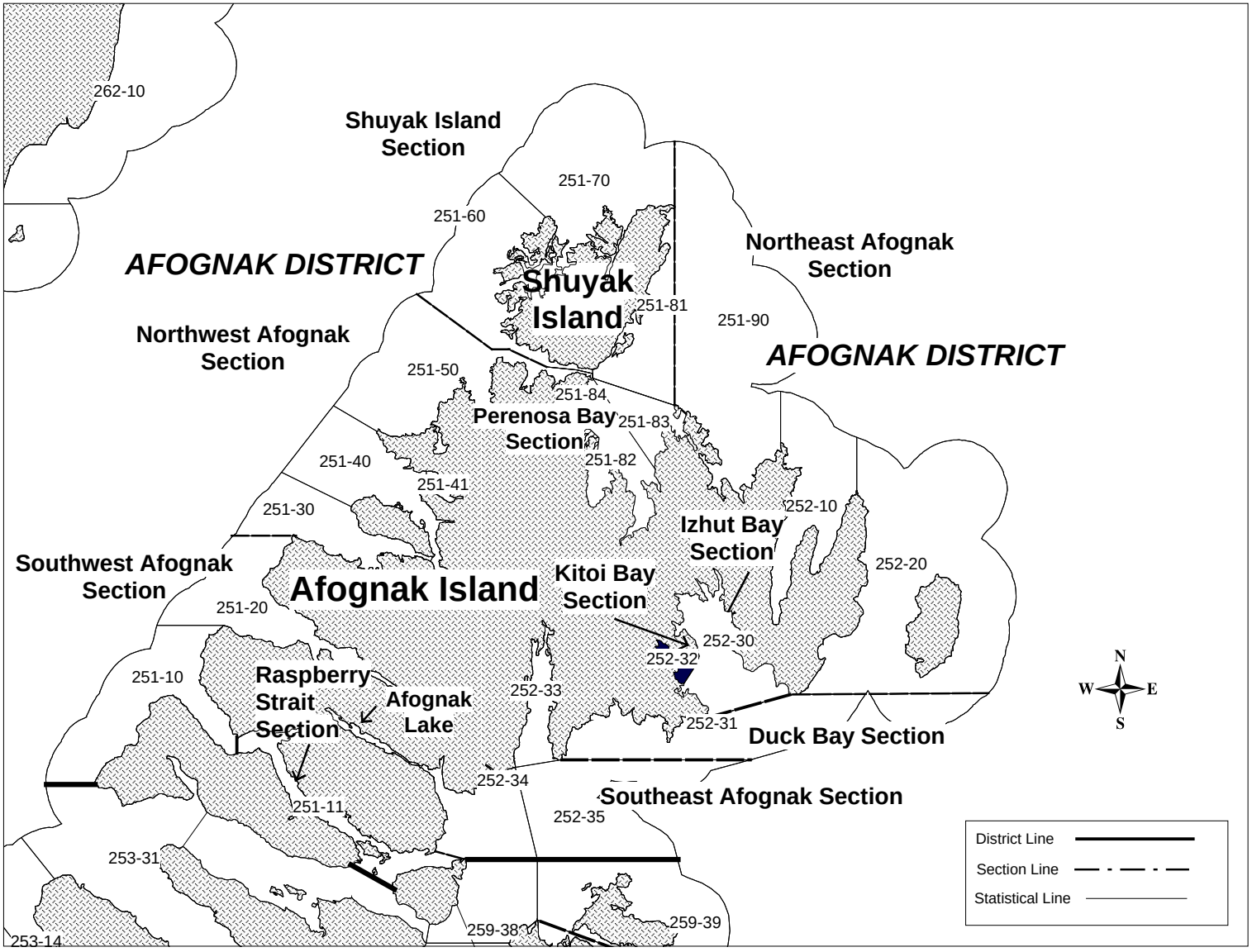
Appendix A. (page 2 of 2)

Project	Years[a]	Funding Source
Spiridon Lake Stocking (E)	1990-2001[c]	ADF&G; KRAA
Malina Lakes Enrichment/Stocking (R)	1991-2001[c]	ADF&G; KRAA
Little Waterfall Lake Stocking/Enrichment (E)	1992-2001[c]	KRAA
Hidden Lake Stocking (E)	1992-2001[c]	KRAA
Crescent Lake Stocking (E)	1992-2001[c]	KRAA
Portage Lake Enrichment (R)	1993-1997	KRAA
Jennifer Lakes Stocking (E)	1993-1997	KRAA
Laura Lake Enrichment/Stocking (R)	1993-2001[c]	KRAA
Ruth Lake Stocking (E)	1996-2000	KRAA
Big Waterfall Lake Stocking (E)	1999-2001[c]	KRAA
Little Kitoi Enrichment (E)[d]	2000-2001[c]	

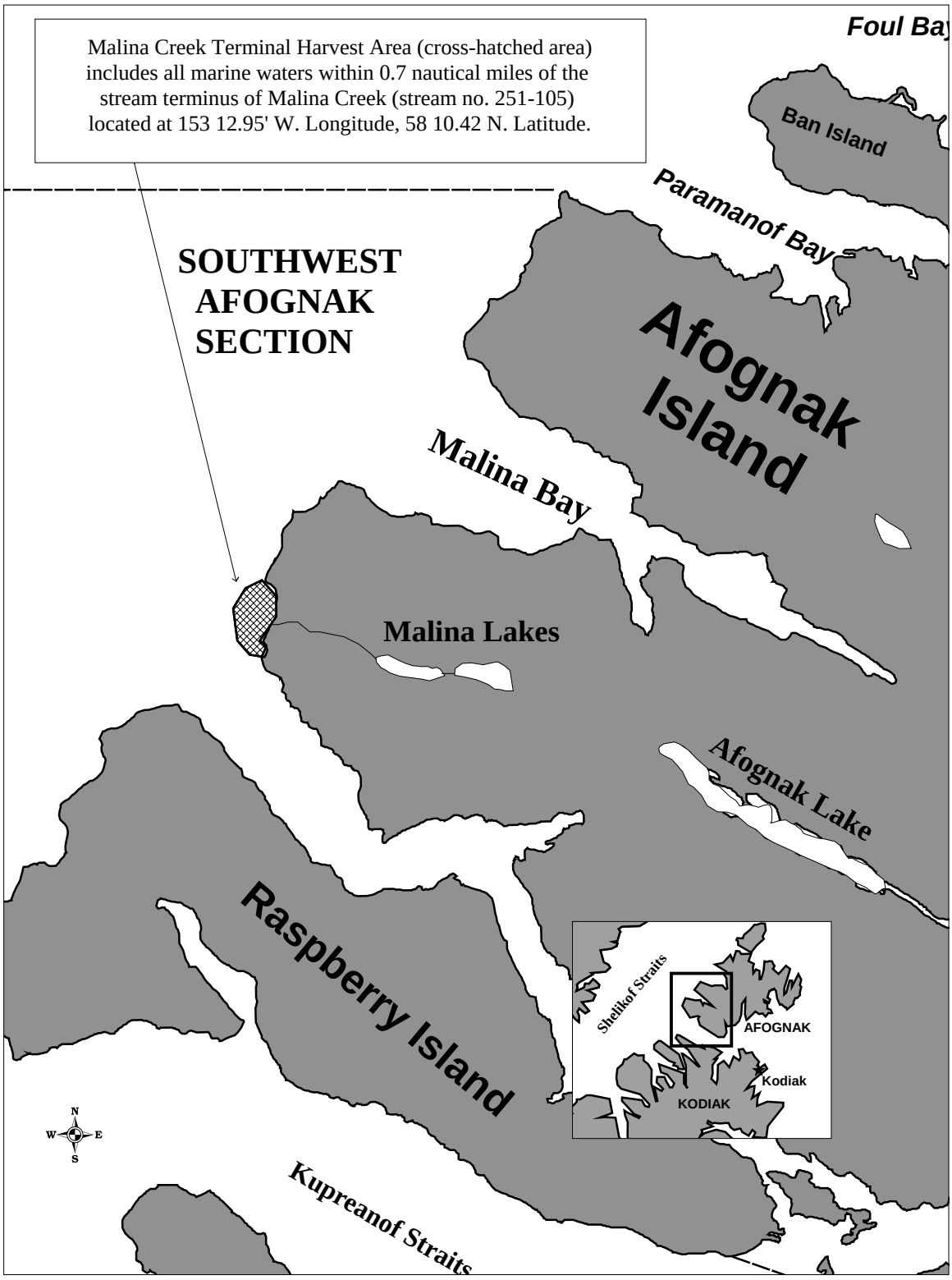
[a] Does not include pre or post stocking and enrichment evaluation years.
[b] Research projects evaluating enhancement or rehabilitation techniques.
[c] Plan to continue in 2002.
[d] Part of broodstock development project.

Appendix B. Kodiak Comprehensive Salmon Plan 1982-2002, Phase II harvest objectives (natural, supplemental, and total), by species.

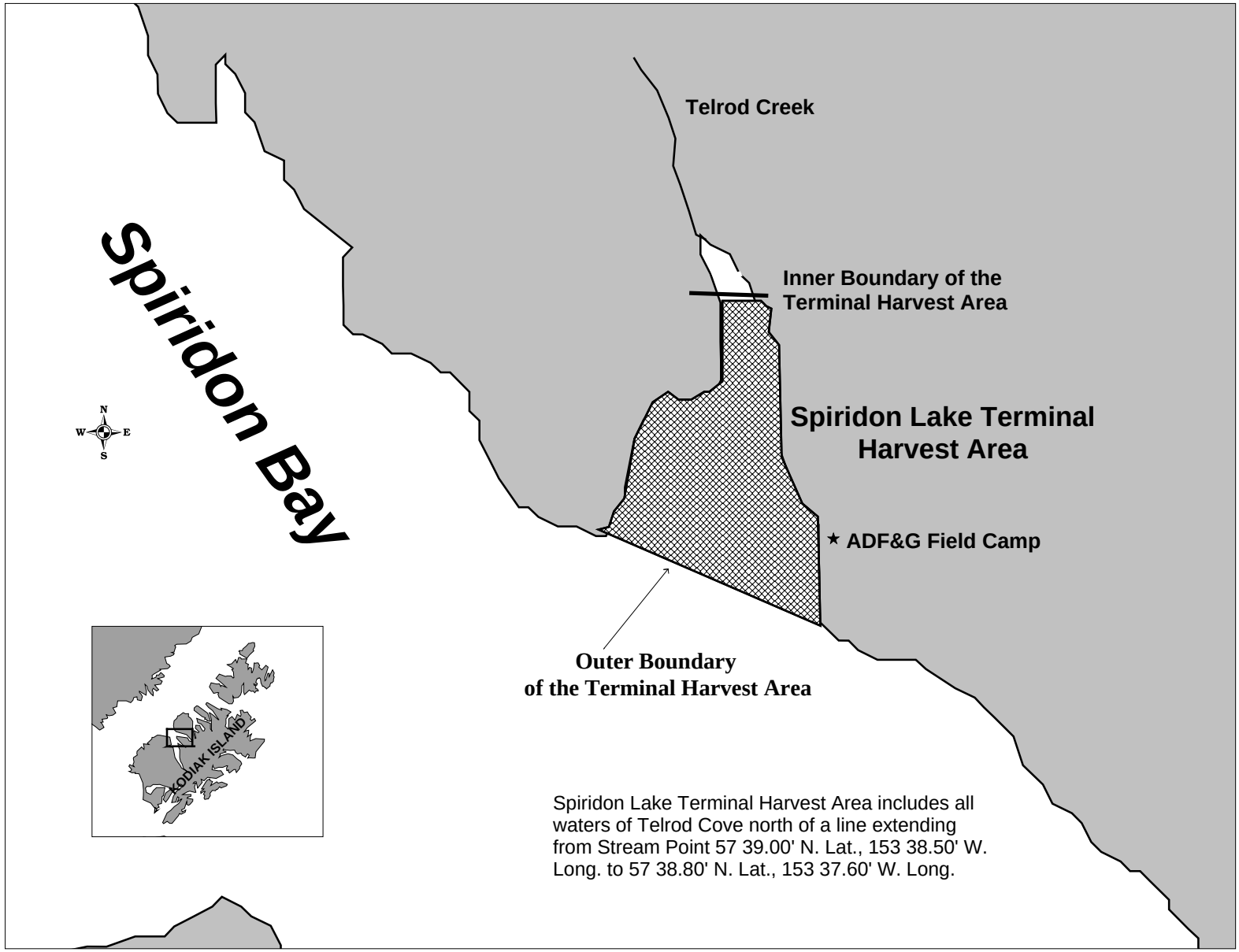
Species	Harvest Objective			Harvest Gap
	Natural (wild runs)	Supplemental (enhanced runs)	Total	
Pink				
odd year	7,500,000	11,500,000	19,000,000	-
even year	12,000,000	11,500,000	23,500,000	500,000
Sockeye	2,700,000	1,700,000	4,400,000	1,700,000
Chum	900,000	1,100,000	2,000,000	1,100,000
Coho	161,000	382,000	543,000	382,000
Chinook	12,000	3,000	15,000	3,000
Total Harvest:				
odd year	11,273,000	14,685,000	25,958,000	3,185,000
even year	15,773,000	14,685,000	30,458,000	3,685,000



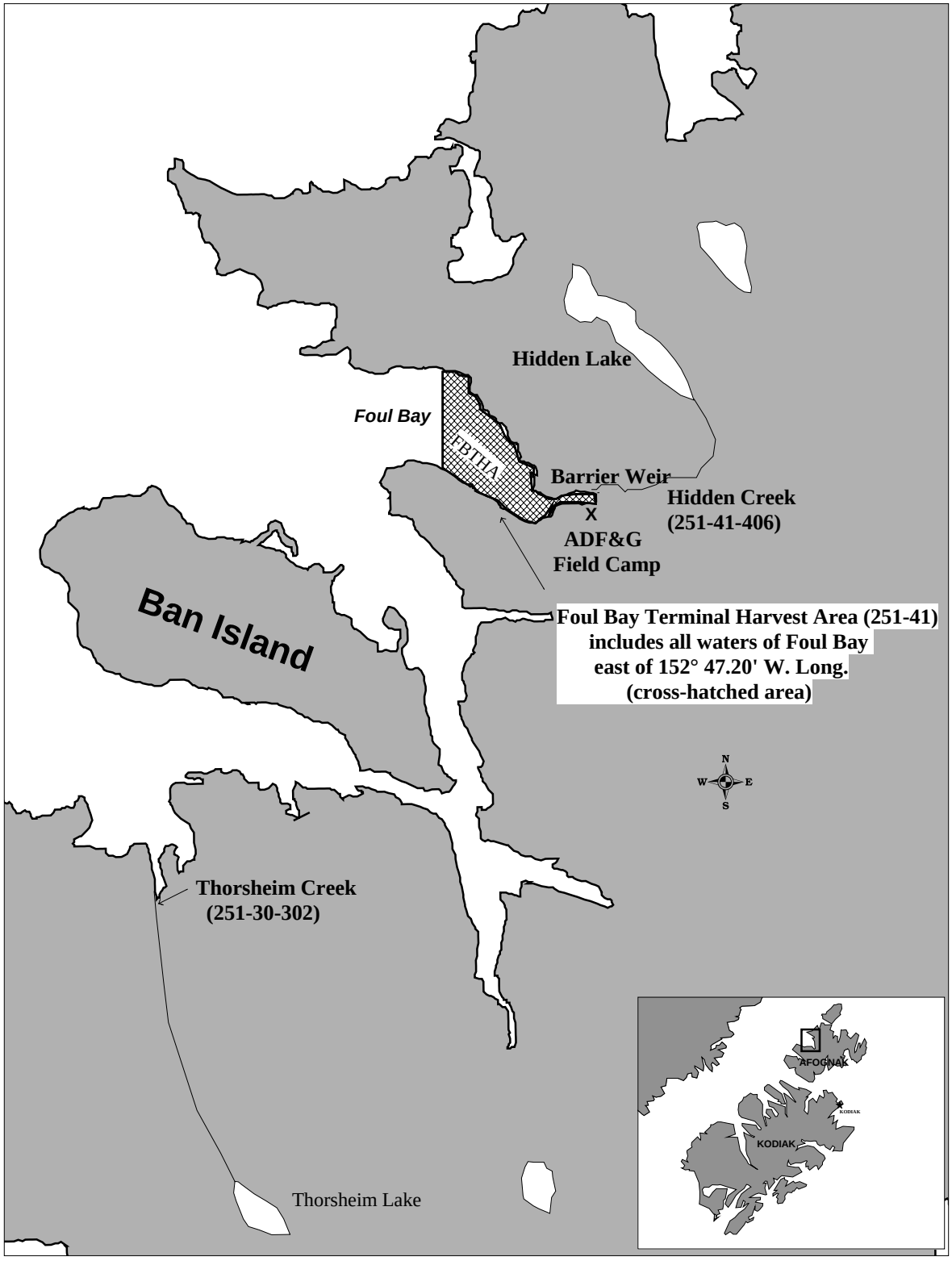
Appendix C.1. Afognak District of the Kodiak Management Area, 2001.



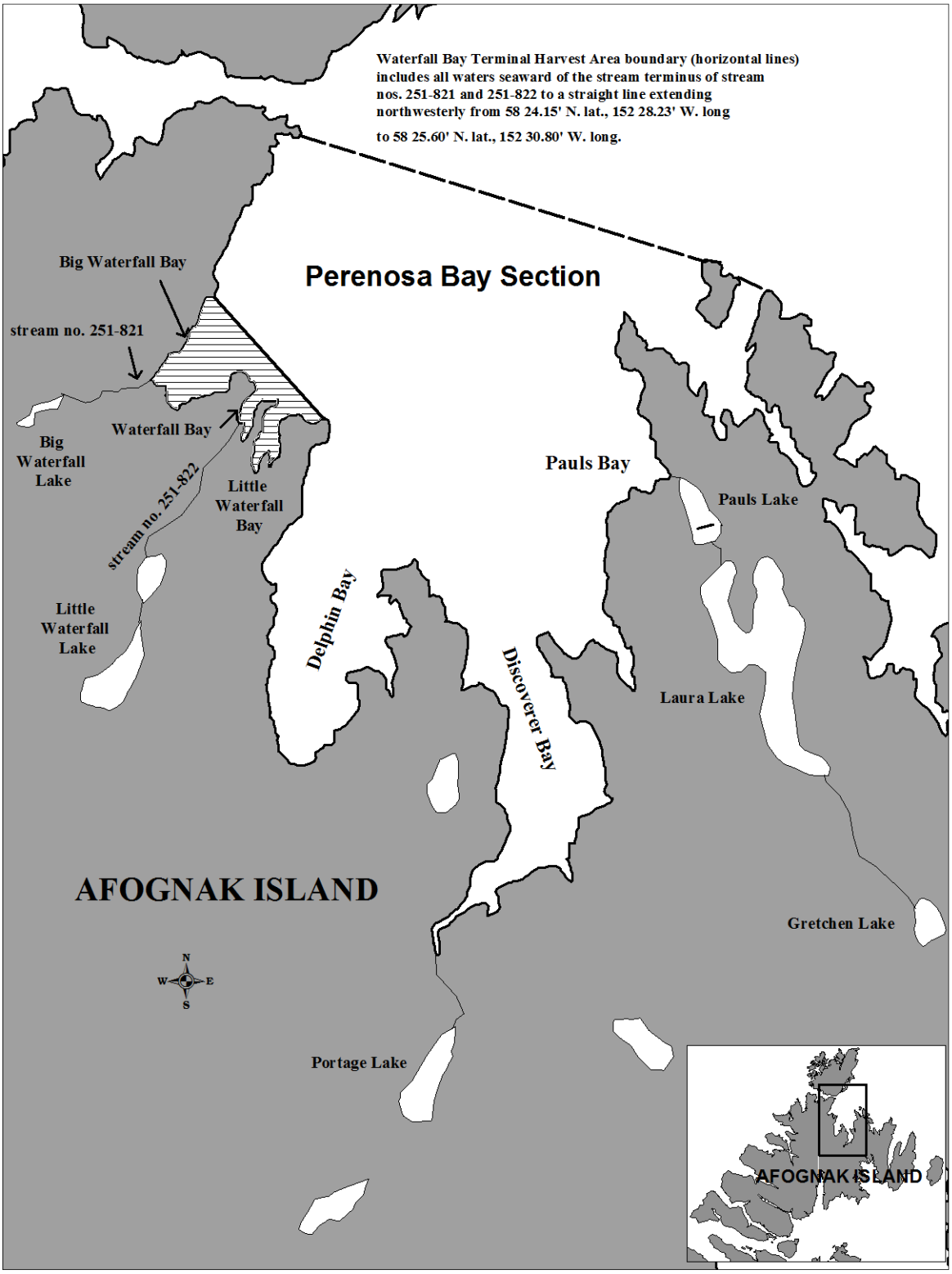
Appendix C.2. Location of the Malina Creek Terminal Harvest Area (MCTHA) on Afognak Island.



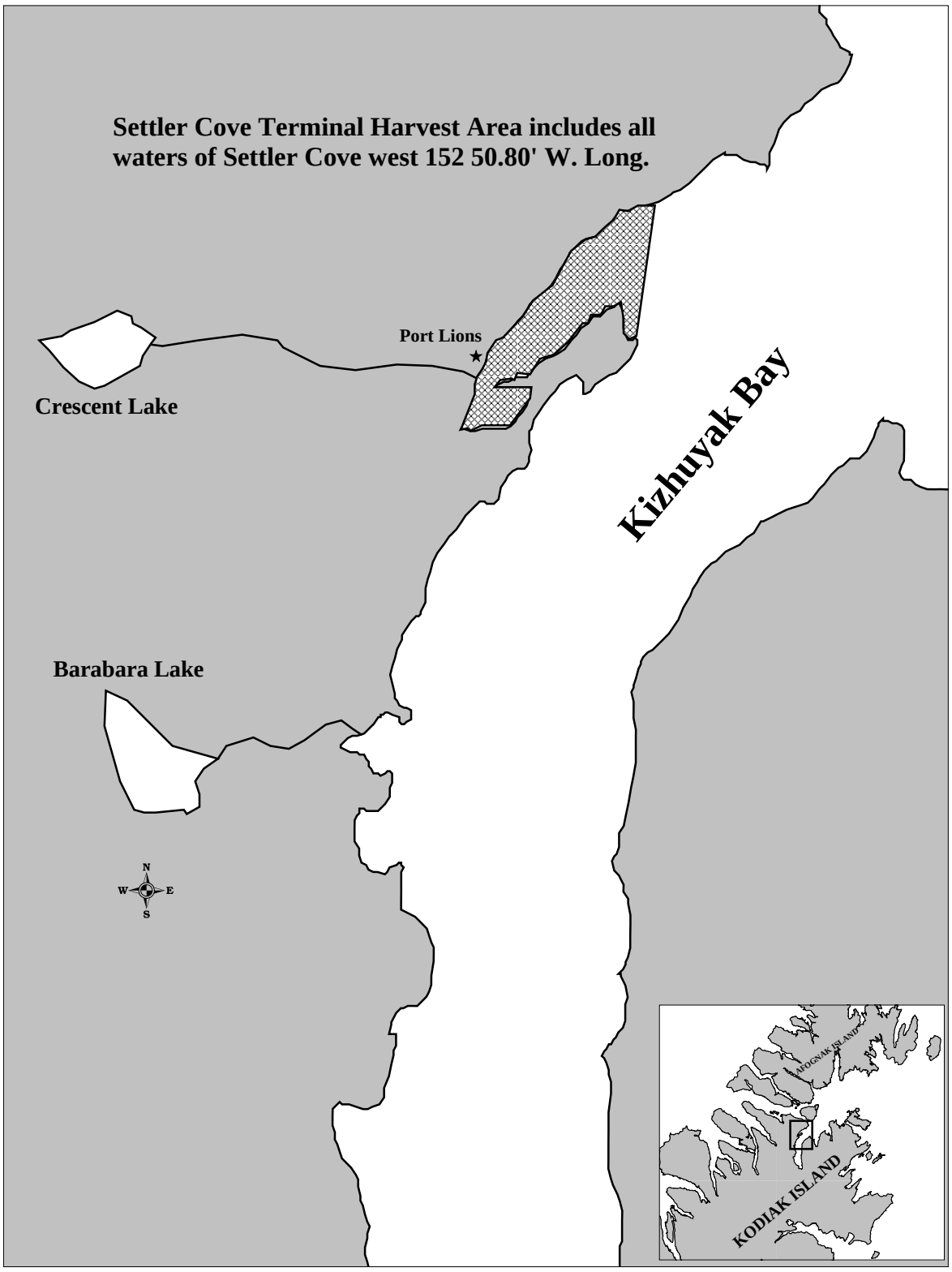
Appendix C.3. Spiridon Lake Terminal Harvest Area (SLTHA; Telrod Cove) boundaries and ADF&G camp location in Telrod Cove.



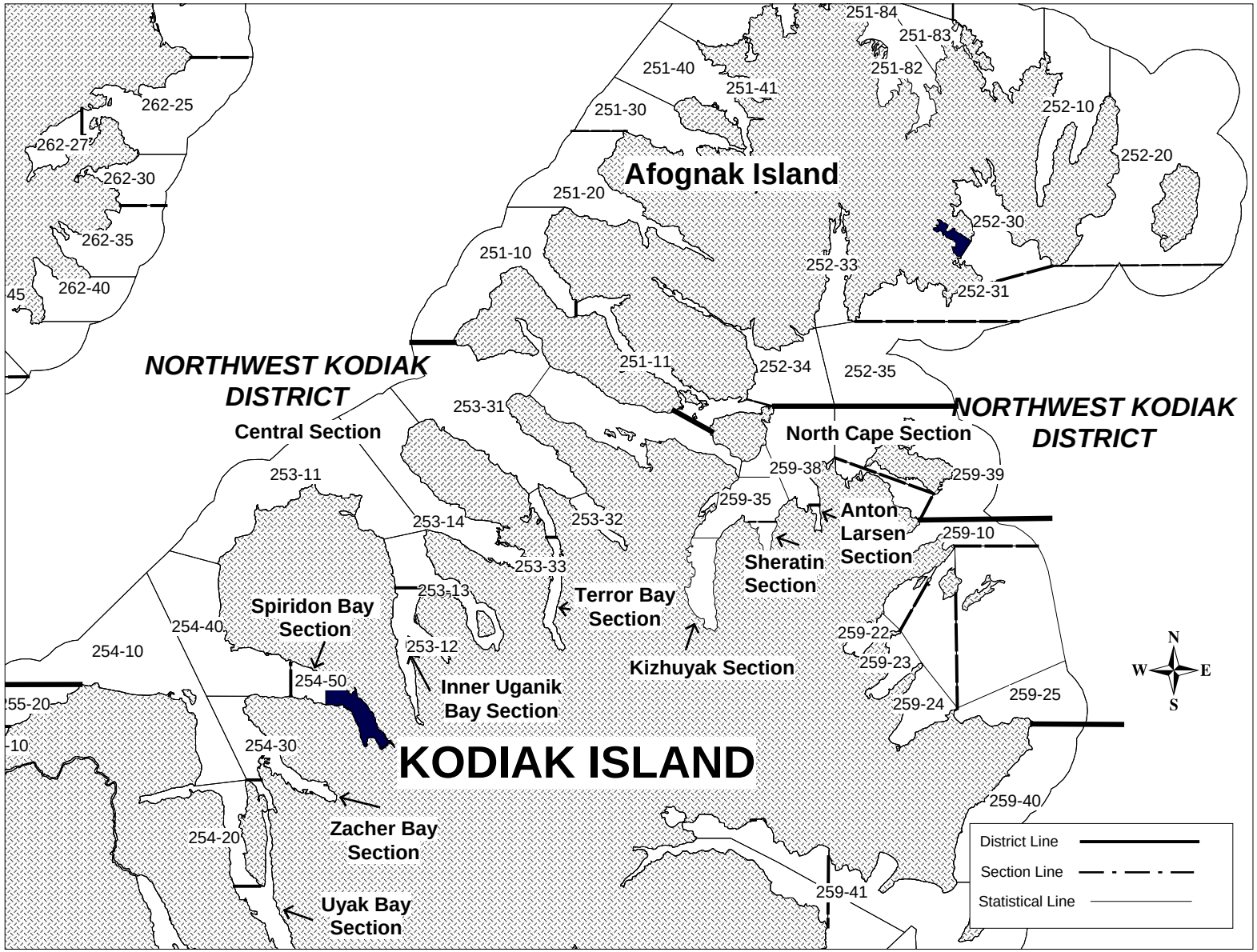
Appendix C.4. Location of the Foul Bay Terminal Harvest Area (FBTHA), ADF&G field camp, and the barrier weir at Hidden Creek.



Appendix C.5. Waterfall Bay (Little and Big Waterfall Lakes) Terminal Harvest Area (WBTHA) and rehabilitation project sites in Perenosa Bay.



Appendix C.6. Settler Cove (Crescent Lake) Terminal Harvest Area (SCTHA) boundaries.



Appendix D. Northwest Kodiak District of the Kodiak Management Area, 2001.