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Historical Review of Nushagak River Chinook Salmon Management

Prepared by

Tom Brookover

Anchorage, AK
brookoverak@gmail.com

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and

Bristol Bay Science and Research Institute

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Introduction

In 1992, the Alaska Board of Fisheries (Board) adopted the Nushagak-Mulchatna King Salmon Management Plan (NMCSMP or the "Plan") to guide management of the subsistence, commercial and sport fisheries that harvest this important stock. Recent restrictions to the sport fishery due to low early season passage combined with sometimes intense fishing for sockeye in the Nushagak District led to calls to pair restrictions in the commercial and sport fishery (Proposals 41 and 42, Nov-Dec 2018 Board meeting). As part of its response, the Board established a working committee and tasked it to consider changes to the management plan.

The purpose of this chapter is to describe the management of Nushagak River Chinook salmon over the last several decades in context with the Plan. An overview of the history of the fisheries, evolution of their management, and associated issues and challenges are provided as a framework for common understanding and a basis for future management recommendations. Performance of the fisheries under the plan's direction since 1992 is discussed.

We partitioned historical Chinook Salmon management in the Nushagak into three eras:

- Pre-1992 (historical and pre-Chinook Salmon management plan)
- 1992 (development of the Chinook Salmon management plan)
- 1992 through 2019 (the management plan years)

This early draft of the report is intended to help inform members of the Board of Fisheries Committee established in December 2018 prior to discussions about possible changes to the Plan beginning in October 2019. This draft is open for comment by committee members and others. We expect the document to evolve and expand with input from the committee and the ADF&G area management staff. One area of interest to us is to hear from those on the Board committee who were part of developing the 1992 Plan so that we can better characterize the impetus for the Plan. Another is to identify any additional information needed to improve understanding of key dynamics taking place in the fisheries, stock assessment or management.

Pre-1992

The history of the Nushagak Chinook salmon fishery through the mid-1980s was well documented in a comprehensive report by Mike Nelson in 1987 (Nelson, 1987). The purpose of that report was to assist in creating a better understanding of the Chinook salmon management program and provide a basis for future recommendations regarding fishing regulations. This section summarizes Nelson's findings, which covered the period from 1884 through the mid-1980s. Nelson (1987) helped to set the stage for the

development of the Nushagak-Mulchatna King Salmon Management Plan in 1991. Issues identified by Nelson were addressed to varying degrees over the last four decades.

Nelson had worked as the Area Biologist overseeing management of the Nushagak commercial and subsistence fisheries from shortly after statehood until his retirement in 1987. At that time, the commercial fishery had "traditionally extracted a heavy toll from the total run, while freshwater sport fishing interests are growing rapidly." There was a growing concern that Nushagak Chinook salmon spawning escapements may be jeopardized and that the natural productivity could not be maintained. As greater fishing pressure was exerted on the stock, the fisheries were subjected to progressively more stringent regulations. Under this background, Nelson foresaw a clear need for "a careful, quantitative appraisal of the fishery impacts and of regulatory options" to maintain or increase productivity and address hardships among the various participants.

Key Management Issues

Nelson (1987) clearly recognized the value of Nushagak River Chinook salmon to the area's commercial, subsistence and sport fisheries, as well as the challenges presented by then-apparent very high exploitation rates and fishery practices. These included the potential for friction among the fisheries in the face of increasing demand as well as conservation-related concerns for the quantity and quality of escapement and resultant impacts to productivity of the stock. Several salient points discussed in the report and relevant to this review include:

- exploitation rates had exceeded 95% of early-run Chinook stocks and were expected to remain high without further restrictions,
- gill net mesh size and depth directly influenced exploitation rates and quantity and quality of escapement,
- fish holding within and above the district created difficulties in obtaining escapement throughout the run, and
- methods to assess inriver abundance/spawning escapement were under development

Harvests and Exploitation rates

The commercial fishery for salmon in Bristol Bay began in 1884. Sockeye salmon were, and remain, the targeted species and main emphasis for the Bristol Bay and Nushagak fishery. However, the commercial harvest of Chinook salmon in the Nushagak advanced rapidly once development began. Nelson chronicles the trends in commercial harvest from the fishery inception through 1986; annual harvests ranged from 1,635 (1935) to 195,287 (1982) Chinook salmon with the three largest harvests occurring in 1979, 1981 and 1982. By 1987, the Nushagak watershed produced the state's second largest stock-specific commercial Chinook salmon fishery, nearly matching those of the Yukon River.

He similarly discussed trends in the subsistence and sport fisheries, for which data existed over a much shorter time period. From 1963 through 1986, subsistence harvests averaged

7,200 and ranged from 2,900 (1964) to 12,600 (1986). Like the commercial fishery, the subsistence fishery accounted for its largest harvests in the early 1980s. Sport harvests were estimated 1997-1986. The largest sport harvest occurred in 1984 (2,382).

Using available catch and escapement data from 1966 through 1986, Nelson estimated the average Nushagak Chinook salmon total run at over 176,000. He noted an improvement in the adult production trend whereby then-recent runs (1978-1986) averaged 246,000 chinook salmon, nearly twice the size of runs averaged from 1966-1977 (125,000). Over the entire period, exploitation rates averaged 54 percent and ranged from 29 (1975) to 72 percent (1969).

Exploitation on the early component of the run appeared to be of specific concern; then-recent commercial and subsistence exploitation rates had exceeded 95% of early-run Chinook. Traditionally, the commercial Chinook fishery commenced in late May to early June. Approximately 85% of the annual harvest was taken in the month of June and the mid-point was June 18. Nelson describes a bimodal pattern of harvests taken 1973-1986, with the first peak occurring June 7-14 and the second, June 23-26. He ascribes the bimodal pattern to the established fishing schedule of 5 days per week prior June 16, when the fishery was closed unless opened for fishing by emergency order and notes that, as more pressure was exerted early in the run, fishery managers applied additional time and area closures. The effect of those actions became apparent in 1981, when high catch rates shifted from early in the season to later.

Gillnet mesh size and depth

Gillnets were (and remain) the only fishing gear allowed in the commercial fishery and were the only gear used, if not allowed, in the subsistence fishery. Drift gill net gear accounted for the majority of the total catch. As a result, and because of the characteristics of the gear related to fish size regardless of species, Nelson (1987) focused considerable discussion on the impacts gillnet mesh size and depth have on king salmon.

By 1987, much basic data on age, weight and length had been collected from the Nushagak Chinook salmon harvests and spawning escapement. According to Nelson (1987), a statistically adequate number of samples had been collected each year from the commercial fishery beginning 1966, and from subsistence harvests and spawning escapement beginning 1982. Some of the biological characteristics of Nushagak Chinook salmon included:

- Age class composition varies year to year, however the majority (80 percent) of return as 5- and 6-year old fish and over 96 percent return as age 5 through 7.
- Age class differences between males and females is striking; age 4 and 5 fish are predominantly males and in contrast, age 5 and 6 fish are predominately females.
- Based on data from the commercial fishery, there is considerable overlap of lengths between age classes. Females are generally longer than males of the same age class through age 6.
- Mean weight of females tends to be greater for a given age class compared to males.
- Age at sexual maturity varies between males and females.

- A weighted average (1982-1984) of catch and escapement indicated a higher proportion of males (53 percent) in the total runs.
- Based on fecundity data collected from the 1966 and 1968 Nushagak commercial catch (n=69), number per female averaged over 10,000 eggs. Nushagak River Chinook salmon appeared to have some of the highest fecundity rates found in Chinook salmon throughout the Pacific Coast.

At that time, the Nushagak Chinook gill net fishery showed considerable selectivity by age, size and sex. Historically, large mesh nets were used to target Chinook salmon while smaller mesh nets were used to target sockeye salmon. Gillnet specification varied from year to year but by the mid- 1970s, 8 to 8 ½ inch mesh was commonly used to target Chinook salmon (early in the season), while sockeye salmon were targeted using 5 1/8 to 5 ½ inch mesh gillnets (later in the season). Smaller mesh nets (5 3/8 inch) tended to selectively capture smaller Chinook salmon which are primarily males, while larger mesh nets (8¼ to 8½ inch) tended to select for larger salmon which are primarily females. Thus, early season (large) mesh accounted for a heavy preponderance of large females in the catch, while smaller mesh sockeye gear accounted for a higher proportion of younger age males. Some important additional points regarding mesh selectivity made by Nelson (1987) follow:

- The commercial fishery showed an overall higher percent of males and attributed that to a relatively greater abundance of early maturing smaller age 4 and 5 males.
- Mesh selectivity affected the age and sex composition of the escapement.
- A weighted average (1982-1984) of catch and escapement indicated a higher proportion of males in the Nushagak Chinook salmon catch and a higher proportion of females in the escapement.
- Since large mesh gill nets tend to harvest larger female Chinook salmon, mesh selectivity affected the average fecundity of the female spawning population. Chinook harvested with large mesh, i.e. 8 ½ inch, nets vs small mesh, i.e. 6 ½ inch, nets resulted in a two-fold difference in egg deposition on the spawning grounds.
- Large mesh gill net restrictions were implemented for the first time in 1985 and 1986 to reduce catch rates and were felt to be effective in allowing additional large Chinook salmon into the river to spawn.

While mesh size restrictions were historically implemented to manage sockeye salmon harvest, then-recent use of inseason restrictions on the use of large mesh showed promise in reducing exploitation of large fecund females.

Nelson stated that gillnet (mesh) depth was of equal importance to mesh size with respect to catch per unit of Chinook salmon. Chinook salmon appear to follow deeper water channels in the generally shallow water of the Nushagak District, where deeper nets are more effective.

Gillnet length and mesh size varied during the early years of the fishery until 1923 when the Bureau of Fisheries restricted both. At the time of the report, little information existed on

the depth of Chinook nets in existing literature, and the depth used appeared to closely follow a 28-mesh restriction enacted in 1925 for sockeye nets.

As interest in Chinook increased in the 1940's, some Nushagak fishermen began to experiment with deeper mesh nets for Chinook salmon. Reports from fisherman indicated higher success rates with deeper mesh nets through the mid-1950s and, as fishermen became more effective with deeper mesh nets, interest in the fishery accelerated.

By 1957, Federal fishery managers recognized the increased fishing effort required additional closed time for conservation purposes, and in 1958, weekly fishing time prior to June 22 was reduced by 36 hours and Chinook nets were limited to 28 meshes in depth. Nelson cited an experienced fisherman attesting to effectiveness of the depth restriction in reducing the increased exploitation on Chinook salmon, and stated that the depth restriction is considered to be an essential component of the regulatory management program for Nushagak Chinook salmon.

Migration behavior and timing

Nelson makes the point that, considering the rapid growth and "gross mismanagement" of the early Bristol Bay sockeye salmon fishery, Nushagak Chinook salmon were fortunate in that the run arrived before the sockeye fishery began in earnest. Thus, the advanced (earlier) run timing of Chinook salmon, along with the lower commercial interest in the smaller Chinook salmon run, helped the Chinook stock survive the development of the fishery.

Fishery managers began to use this difference in timing to manage for conservation of Chinook salmon in 1958, when weekly fishing time prior to June 22 was reduced by 36 hours. As more and effective effort began to target Chinook salmon, fishing time prior to June 16 was further reduced. For the 1987 season, ADF&G planned to prohibit fishing prior to June 1 and replace the 5-day fishing schedule then in place prior to June 16 with a 3-day schedule. At the time, fishing beginning June 16 was closed unless and until opened by emergency order. Future action including replacing the fishing schedule prior to June 16 with emergency order management would be considered depending on the success of the 1987 measures.

While the earlier run timing of Chinook salmon relative to sockeye salmon contributed greatly to Chinook salmon sustainability and provided a means to manage separately for Chinook salmon conservation, other migration tendencies of Chinook salmon posed management challenges. Nushagak Chinook salmon often mill and hold within the district, are believed by many fishermen to hold deep during calm weather and therefore unavailable to the fishery, and appear to move upriver and become available to the fishery under the influence of strong winds. For these reasons, the effectiveness of early season closures on reducing harvest rates was limited at times; early season closures coincided with a noticeable shift in high catch rates from early to later in the season in the early 1980s.

Run timing data was collected from four sources: commercial, subsistence and sport catch, and sonar-based enumeration. Over half (55 percent) of the commercial harvest was accumulated by June 16-20. Subsistence harvest in the Dillingham area peaked between June 20-30 (later upriver). Sport catches inriver peaked between June 26 and July 6. And available sonar data indicated 50% of the inriver run had passed the sonar site July 1-2. Nelson acknowledged the commercial fishery can influence the migration timing of the inriver run but pointed out that the data collectively indicated that the majority of Chinook salmon migrate into the lower river during late June to early July.

Inriver abundance and escapement assessment

Management of salmon fisheries in Alaska is based primarily on achieving escapement levels that support sustainable harvests. As Nelson stated: "the criterion of escapement has been the primary factor in determining fishing regulations in Alaska, from the passage of the White Act in 1924 to the present time." Yet, the magnitude (and quality) of spawning escapements has not always been estimated. Escapement data for Chinook salmon is relatively difficult to collect because spawning is generally concentrated in mainstem reaches of larger, turbid river systems.

Aerial surveys to locate Nushagak River Chinook salmon spawning areas and assess spawning magnitude began in 1956 and continued through publication of the report (and beyond). One of the objectives of the aerial survey assessments was to develop methods to expand aerial survey counts to total escapement estimates.

In 1979, a side scanning sonar project to enumerate adult sockeye salmon was initiated on the lower Nushagak River near Portage Creek. Nelson acknowledged the potential of the sonar project to estimate Chinook salmon escapement but continued aerial surveys during the subsequent years due to operational difficulties and sampling problems experienced by the sonar project. Some of the initial challenges of using sonar to estimate Chinook salmon passage included exceeding the density threshold of the Bendix units, limited sonar range/coverage of the migratory pathway of the larger Chinook salmon, and difficulties in apportioning sonar targets to specific species among the sockeye, chum, and Chinook salmon that comigrate by Portage Creek.

Annual monitoring of daily subsistence catches at Lewis Point on the lower Nushagak River was initiated in 1980 to provide daily estimates of Chinook salmon escapement in advance of estimates provided by the sonar project. Unlike the aerial survey assessments conducted on the spawning grounds, both the sonar and Lewis Point catch monitoring projects provided the added benefit of inseason "real-time" data on Chinook salmon inriver abundance in the Nushagak River. However, problems with the Lewis Point project also kept the emphasis on the aerial survey program as the primary means to estimate spawning escapement.

Visual counts of salmon passing by points on the shoreline were conducted from counting towers beginning in 1953 to estimate sockeye escapement. Incidental tower counts were also collected routinely for Chinook salmon. Counting periods, designed to capture the

duration of the sockeye run, did not cover the duration of Chinook salmon run and Chinook salmon counts were of limited use as a result. One weir project – 1968 Stuyahok River weir - had been implemented in Bristol Bay to enumerate Chinook salmon.

Beginning in 1966, an expanded 'comprehensive' aerial survey program was used to expand counts of Chinook salmon to total inriver abundance. Expansion factors and methodology varied by year and had not been rigorously evaluated until 1982 after an extensive series of escapement data had been collected from numerous spawning streams within the Nushagak drainage. In that evaluation, selected portions of the Nushagak and Mulchatna main stems, for which counts had been collected for eight years, were correlated with total counts for years when they were available. The correlation, in turn, was then used to calculate total Chinook salmon escapement in the Nushagak drainage. Nelson provided the equation and estimated escapements since 1966 have averaged 82,000 and ranged from 25,000 (1972) to 162,000 (1983).

Management Program/Tools

Unlike the Bristol Bay sockeye fishery, the Nushagak Chinook salmon fishery received little directed effort at research and management until the 1950s. In the 1960s the management strategy was to limit harvest to a range of 60,000 to 80,000 fish with exceptions. As pressure on Chinook salmon increased in the 1970s, the need for more robust escapement data collection also increased. And as the sport fishery grew so did the need for information on sport fishing use. In addition to funding and staffing the Dillingham area office with biologists and technicians assigned to commercial and sport fish management and research in the Nushagak District, ADF&G conducted a suite of activities aimed at Chinook salmon at the time the report was written:

- Commercial and subsistence harvest monitoring – daily contact with processors enabled commercial catch estimates used to determine harvest rates. Project objectives included inseason estimates of catch and fishing effort for Chinook salmon by period, and inseason catch per unit effort.
- Commercial catch sampling – Chinook salmon from commercial harvests were measured for weight and length, sex determined, and scale removed for age determination. Project objectives were to provide age, weigh, length, and sex data for commercially harvested Chinook salmon.
- Sport fishery harvest monitoring
    - Creel surveys in the lower Nushagak River – anglers were interviewed to collect catch and harvest data, and sample harvested fish. Project objectives included estimates of angling effort, catch and harvest rates, and collection of biological and demographic data.
    - Statewide Harvest Survey – postal surveys were mailed to anglers that fished in Alaska to collect effort and harvest data. Results provide harvest estimates for the Nushagak Chinook salmon sport fishery.
- District test fishing – Fishing with gillnets took place within the Nushagak District to capture salmon. The primary objective was to monitor magnitude and entry pattern of

sockeye salmon in the district. A secondary objective was to provide indications of when Chinook salmon were present, holding, and moving upriver of the district.

- Lewis Point subsistence/test fishery – Lewis Point subsistence catches were monitored and sampled. Objectives were to estimate escapement into the river using subsistence catches, and sample catches for age, sex, and length data.
- Post-season aerial surveys – comprehensive surveys were flown to count spawning Chinook salmon. Primary objectives were to provide estimates of drainage-wide escapement and spawning distribution.
- Portage Creek Sonar – obtain daily salmon passage rates from two Bendix side-scanning sonar units in the lower river near Portage Creek, sample salmon for age, sex, and length data, and adjust sonar counts by species. Project objective was to estimate inseason escapement of salmon by species.

At the time Nelson (1987) was published, data collected from these projects were used for Chinook salmon inseason fishery management, post-season management assessment, and beginning in 1984, pre-season forecasts of projected run size.

Recommendations, Nelson 1987

Nelson identified four categories of needs that should be addressed: habitat protection, optimum escapement objectives, methods to accurately estimate escapement, and methods to achieve escapement objectives.

Habitat Protection

Nelson described the protection of freshwater spawning and rearing habitat a priority requirement to sustained and increased Chinook salmon production. Three habitat objectives were identified as referenced from the 1986 Comprehensive Salmon Plan:

- Maintain present quantity and quality of salmon habitat
- Enforce state water quality and anadromous stream protection regulations, and
- Develop land use plans for public lands adjoining salmon waters

"Optimum" Escapement Goal

Although provisional escapement objectives were in place, Nelson indicated a final goal should be developed and suggested delaying its development until after the 1990 run, when returns from the large escapements in 1981-1983 would be complete.

- Develop an optimum[1] escapement goal (after 1990 run)

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[1]Nelson is used the term *optimum* escapement goal in a similar sense to the way we currently use the biological escapement goal (BEG) based on the expected maximum sustainable yield (MSY). He did not use it to mean the same thing as today's Optimum Escapement Goal (OEG) in the State's escapement goal policy, which is set by the Board of Fisheries and takes into account biological and socio-economic factors to set the escapement goal target.

- Continued collection of age, sex, length and weight data needed for escapement goal development and run forecasting
- Conduct a mesh size study to determine the effects of mesh size on reproductive potential, and assess the use of regulatory mesh size restrictions as a Chinook salmon management tool
- Conduct a tagging study to assess movement and holding patterns in the fishery, district and lower river.

Estimation of Escapement

At the time of publication, Nelson (1987) envisioned substantial benefits to providing more accurate and timely information with which to estimate inseason escapement rates. Primary benefits included allowing for additional harvest during strong runs while providing additional protection to smaller runs.

- Improved subsistence monitoring, i.e. test fish project at Kanakanak Beach, to provide daily catch estimates and possibly additional data
- Continued development of the Portage Creek sonar to provide inseason and total estimates of escapement. Species apportionment was the primary challenge to reaching this objective. Successful development would allow the termination of the aerial survey program.

Achievement of Escapement

This goal was aimed at providing managers with effective methods to control fishing pressure and achieve escapement goals. It was predicated on defining optimum escapement objectives and developing methods to accurately estimate inseason escapement rates.

- Conduct the commercial fishery entirely under day-to-day (emergency order) management if planned regulatory changes in 1987 are not effective in reducing the exploitation rate to achieve better distribution of escapement through time.
- Restrict large mesh Chinook salmon gill net gear to reduce catch rates

Finally, Nelson noted positive attributes of the Nushagak Chinook salmon stocks compared to others in Alaska: the stock is generally in good condition; is concentrated in a large river system that can be managed independently; the fisheries on the stock are conducted in a terminal area where allocation considerations are modest and, Chinook are somewhat separated from other species by timing differences in most years. Ultimately, he noted: "*the success of management will depend on the effectiveness of stock assessment capabilities and maintenance of a management strategy that is responsive to stock abundance, while retaining an element of conservatism in response to uncertainty about stock productivity*."

Summary, Pre-1992

The period from the early1950s through 1987 was formative in the development of the Nushagak Chinook fisheries and their management. The period experienced a growing interest in Nushagak River Chinook salmon. After sustained commercial utilization (1955-1971), catches declined (1972-1975) but recovered, and then reached a historical peak over

the decade 1976-1986. Recovering salmon markets, advances in gear effectiveness at catching Chinook salmon, and the development of the Togiak herring fishery in April and May (which attracted fishermen who otherwise would have left their boats in storage) were all primary factors driving the renewed commercial interest in early season fishing effort. However, peak production enjoyed in the early 1980s resulted in a surge of interest and record harvests in the commercial fishery, and development of a growing sport fishery. Together, these dynamics presented concerns for adequate spawning escapement and potential for user conflicts.

Fishery managers responded to the increase in interest by enacting fishery restrictions to ensure sufficient numbers of Chinook salmon for spawning escapement. In 1958, Federal fishery managers had restricted weekly commercial fishing time and gillnet depth to boost the Chinook salmon escapement. Subsequent restrictions to fishing time, area and gear were implemented by state managers through the mid-1980s. In 1985 and 1986, large mesh gill nets were prohibited by emergency order. Plans for 1987 called for reducing area in the outer district, prohibiting fishing before June 1, and reducing the weekly fishing schedule prior to June 16 from five to three days. Notably, Nelson questioned whether the management approach to the 1987 season would be effective enough, and suggested that, if not, the next step should be to manage the Chinook commercial fishing season on a day-to-day emergency-order basis.

Fishery managers also responded to the increased interest in the fishery by adding stock assessment programs to ensure conservation of the Nushagak Chinook salmon stock. Aerial surveys to document Chinook salmon escapement began in 1956. In the 1960s, State managers expanded the aerial survey program to additional systems within the drainage and implemented a subsistence permit system in part to provide better accounting of subsistence fishing activity. In 1979, the side-scanning sonar project at Portage Creek was implemented to enumerate sockeye salmon with an interest in using that system to index or enumerate Chinook salmon. In the 1980s, creel surveys were initiated to estimate sport fishing effort and harvest.

Improved stock assessment allowed for additional tools to use in managing the Nushagak Chinook fishery. By 1987, fishery managers had compiled a time series of estimated harvests for each fishery component and escapement, which allowed for annual estimates of total run size. Age composition estimates obtained for each component allowed for the development of brood tables, which in turn provided information needed to develop a biological escapement goal and, beginning in 1984, an annual pre-season forecast of the Chinook run.

Despite the advances in stock assessment and increasingly conservative management of the fisheries, conservation issues remained to be addressed as of 1987. A formal escapement goal had yet to be developed. Accurate and timely (daily) inseason escapement estimates, needed to take advantage of harvestable surplus of large runs and conserve small runs, required continued research and development of the sonar program at Portage Creek. Species apportionment of fish counted by sonar, in particular continued as a major obstacle

to inseason assessment of Chinook Salmon. Finally, managers recognized that additional management measures may be needed should the restrictions envisioned for 1987 not be effective enough to control fishing pressure and achieve escapement objectives.

Development of the 1992 Nushagak-Mulchatna Chinook Salmon Management Plan

Post-Nelson, Pre-Plan, 1987-1991

While the period spanning the 1950s to the mid-1980s was formative in the development of the fisheries and their management, the following several years cemented the need for a structured management plan. A weak Chinook salmon run in 1986, coupled with a poor forecast for the 1987 run, indicated that the large runs experienced in the late 1970s and early 1980s were coming to an end (Minard et al., 1992). Indeed, runs observed from 1987 through 1990 declined from the very large runs observed from 1978 to 1983 to a level generally considered as 'depressed'.

By 1991, it had become fully evident that the large runs experienced in the early 1980s had produced poorly; spawning escapements from brood years 1981-1985 had produced only as many fish as had spawned in those years, or fewer. After a comprehensive review of production data, Minard et al. (1992) states that the decrease in production at higher escapement levels was the most notable trend in the spawner-return data for Nushagak drainage Chinook salmon. Normally, this would indicate density-dependent factors in the freshwater environment. However, in this case where the large escapements all occurred sequentially among brood years 1981-1985, it is difficult to determine whether the decrease in production was caused by the high levels of escapement or by some other factors that may have occurred during the life cycle of salmon produced in those years (e.g.., changes in ocean carrying capacity, high seas fisheries interceptions, freshwater habitat degradation, competition with other species in the fresh and/or marine environment).

The return to more typical (or depressed) run sizes in the mid-1980s prompted managers to implement additional conservation measures including emergency order management of the commercial fishery that Nelson had suggested, which ultimately led to closure of the directed commercial fishery for Chinook salmon. The 1987 commercial fishery opened normally but was closed by EO after approximately 5,000 Chinook salmon were caught with little indication of fish movement into the river. The commercial fishery was similarly closed by EO each of the three subsequent years, prompted by low pre-season forecasts and a likelihood of large incidental harvests of Chinook salmon in the sockeye fishery. An improved forecast in 1991 and indications of escapement in excess of the goal prompted a commercial period June 24. However, a boycott by commercial harvesters over salmon prices kept fishing effort low.

During this period, the Board of Fisheries also implemented several conservation measures.

- Prior to the 1988 season: the outer Chinook salmon boundary was eliminated by regulation; the commercial district was redefined to include only the sockeye salmon boundary as the southern-most district boundary line.
- the regulatory commercial fishing season was reduced from May 1 to June 1.
- sport fishing bag limits in the Nushagak drainage were reduced from 5 chinook salmon per day and in possession, of which only 2 may be over 28 inches, to 3 chinook salmon per day and in possession, of which only 2 may be over 28 inches.
- The following year (1989), the Board abolished the minimum mesh size requirement of 6 ¾ inch mesh in place in the commercial fishery prior to June 16.
- In 1990, the Board closed the Nushagak River drainage upstream from its confluence with the Iowithla River, including the Iowithla River, to the taking of king salmon from July 25 through December 31.

The poor runs experienced during this period underscored the need for a revised escapement goal as recommended by Nelson. By 1990 the returns from the large escapements experienced in the early 1980s had been observed, and seven years of additional spawner-return data had been added to the brood table. Other dynamics further heightened the need. Due to the poor production, the provisional escapement goal was not attained in 1986, 1988, and 1990. Additionally, commercial salmon fishery managers in Bristol Bay had traditionally accounted for returns as either commercial catch or escapement, the notion being inriver harvests were so small as be insignificant. With growth in the subsistence and sport fisheries, and the Department's mandate to manage for sustained yield, inriver harvests had to be explicitly accounted for in the escapement goal. This meant that the provisional 'escapement' goal of 75,000 was actually an inriver goal, and by managing for 75,000 fish at the Portage Creek sonar, the goal of attaining a spawning magnitude of 75,000 Chinook salmon would not be realized.

Nelson (1987) described concerns with the heavy toll extracted by the commercial fishery and the growing sport fishery, and identified the need for improved escapement monitoring, a formal escapement goal, and additional management measures for the Nushagak Chinook salmon fisheries in 1987. The poor performance of the large escapements during the early 1980s, the increasingly severe restrictions in the late 1980s resulting from the depressed runs, and the state of the provisional escapement goal all heightened concerns over conservation and exacerbated user conflicts that had begun to develop prior to 1987. During this period, they were raised to a level that received the attention of fishery participants, managers and regulators alike, and turned the heat up on the need to develop and implement a formal management plan. Because a plan would affect allocation among users, it had to be developed via the Board of Fisheries process.

Development of the 1992 Plan

In anticipation of the change in the BER and the subsequent need for management direction, the Nushagak Advisory Committee (NAC) submitted Proposal 157, and ADF&G submitted Proposal 158 in advance of the 1992 Bristol Bay Board meeting. Both proposals expressed concern over the poor recent runs and poor production trend as an impetus to developing a

plan. The NAC also specified high seas bycatch and interception as a concern but recognized that the issue was outside of the scope of the Board of Fisheries.

In support of the planning efforts, ADF&G conducted a review of the then-present escapement goal (Minard et al. 1992). Estimates of number and age of Chinook salmon harvested in each fishery and for spawning escapement were available with limitations, and significant assumptions were made regarding the applicability of the data. Estimates of "biological escapement requirement" (BER), what we would call a Biological Escapement Goal (BEG) today, were derived using multiple methods, and ranged from 50,000 spawners (early-years Ricker model) to 65,000 (all-years Ricker model) Chinook salmon. ADF&G recommended a BER at the upper end of this range to be conservative because of uncertainty in the brood tables and the uncertainty over the cause of the poor returns from the 1980-1985 brood years.

Both the NAC and the Department proposed developing a plan that would distinguish inriver harvests from the BER, include management guidelines developed by the Board to share the burden of conservation and provide staff with management direction, and achieve the BER. The NAC proposal prescribed specific management measures for each fishery under various projected escapement levels. Both proposals recognized that: "without a well described management plan, continued exploitation by the user groups on an apparently declining stock could have a long-term negative affect on this important stock."

Prior to the January 1992 Board meeting, the Department and the NAC worked together on further developing the plan. By December 1991 the committee with the department's assistance had developed a draft plan (December 18, 1991) that contained much of the structure and content ultimately adopted by the Board in January 1992. The December 1991 draft plan included the BER of 65,000 spawners established by the department as a result of the recent escapement goal review. It included an inriver goal of 75,000 Chinook salmon to provide for the BER, and subsistence and sport harvest occurring upstream of the sonar. And it included management measures for the fisheries under three tiers based directly on projected inriver estimates at the sonar.

Using the NAC draft version of the plan as a template, the Board of Fisheries deliberated and modified it over the course of two days and approved the final plan January 8, 1992 (Appendix A). The plan directed the department to manage the commercial fishery to achieve an inriver goal of 75,000 chinook salmon upstream from the Portage sonar site. This inriver goal provided for a BER of 65,000 and harvests above the sonar in the subsistence and recreational fishery. It also set out a cap on the recreational harvest not to exceed 5,000 Chinook Salmon.

The Plan was structured under three tiers and associated triggers tied to the projected inriver run levels, much as it is remains today.

- At projected runs less than 40,000 chinook salmon, the sport and directed commercial fisheries were to be closed, the commercial fishery for sockeye was to

remain closed until 10% of the Wood River escapement goal is projected, and the subsistence fishery was to be restricted by time or area.

- At inriver runs projected between 40,000 and 75,000, the directed commercial fishery for Chinook Salmon was to be closed and gillnets with greater than 5 ½ inch mesh were to be prohibited. At inriver runs projected between 40,000 and 65,000, sport fishing was to be restricted.
- At projections above 75,000 the plan called for no restrictions on the commercial or subsistence fishery. However, at projections from 75,000 to 95,000 the sport fishery was to be managed such that harvests did not exceed 6,000 king salmon.

The third tier, in which inriver runs are projected to exceed the inriver goal, received considerable attention at the board meeting. The 'cap' on the sport fishery was one of the more controversial elements of the plan. Some considered capping the sport harvest when harvestable surplus was available as consistent with the purpose of harvesting Chinook salmon in the fisheries that historically harvest them. Others argued that capping sport harvest at or above optimum levels of yield was inconsistent with the sustained yield principle, particularly after other fisheries are afforded harvest under the same scenario.

Post-1992; Plan Changes, Fishery Trends, and Plan Performance

Over the 28 fishing seasons that have occurred since the Plan's adoption, changes have occurred in the Nushagak king salmon fisheries and the Plan. This section is intended to highlight some of the key dynamics associated with the Plan itself, and in the commercial, sport and subsistence fisheries.

Plan Modifications

The Plan has been modified seven times by the Board of Fisheries (Table 1). Its purpose and structure, with management actions directly based on inriver run projections to the sonar, has remained very similar to the original version. However, the management trigger levels (inriver projection levels of 40,000, 65,000, 75,000 and 95,000 king salmon) have changed twice.

The first, in 1997, was specific and effectively reduced the range in which sport fishery restrictions were to be issued from 40,000-65,000 to a range of 40,000-55,000. The 55,000-fish trigger was adopted partly based on analysis that showed little difference in expected productivity between the two levels. In addition, the 65,000-fish trigger had become quite disruptive to the sport fishery by precipitating frequent inseason restrictions prior to 1997.

The second, in 2012, changed the inriver and escapement goals and all management triggers contained in the Plan. The Board made these changes as requested in a proposal from the department to reflect a transition/conversion from Bendix to DIDSON sonar, which accounted for a higher proportion of king salmon migrating up the Nushagak River. The biological escapement goal was changed from 65,000 to a range of 55,000-120,000 king

salmon, the inriver goal was revised from 65,000 to 95,000 king salmon, and the various management triggers were changed as well.

Other changes to the Plan are discussed under the relevant fisheries below. The current Plan can be found in Appendix B.

Commercial Fishery

Regulation and Fishing Effort and Harvest

Directed commercial fishing on Chinook Salmon resumed under the NMCSMP in 1992 (Table 2). Decisions to open the fishery and set the opening durations were based largely on the pre-season forecast and inseason indicators of run strength, including commercial harvest performance, subsistence harvest rates, an inriver passage rates estimated at the Portage Creek sonar (Brookover et al., 1997; Morstad et al., 2010).

The approach to scheduling directed openings varied from 1992 to present. Initially, the number and duration of openings were limited. Openings were generally scheduled to follow inriver pulses of fish evidenced by spikes in subsistence catch rates and other indicators (Brookover et al., 1997). This ensured fish migrate iniver prior to exposure to the commercial fishery. From 1994 to 1996, the directed fishery was managed more aggressively to harvest available surplus by scheduling more openings during lulls in fish passage. However, due to escapement quality problems observed in 1995 and 1996, commercial fishing periods in 1997 were scheduled directly after pulses of fish were observed moving into the river again, to reduce selectivity for large fish. The board subsequently modified the Plan directing the department to schedule openings to provide pulses of fish into the river that haven't been subject to harvest with commercial gear. From 2003 through 2009, the management strategy included openings earlier in June, with more space between openings, when a surplus appeared to be available (Fair et al., 2004; Westing et al., 2005, Morstad et al., 2010). Opening early in June during the first third of the run was intended to allow for lower levels of harvest over a larger portion of the run, still provide for fish movement past the district, and provide improved market quality and value to fishermen but carried the potential of overharvesting the early part of the run. Beginning in 2010, stakeholder meetings were used to help establish directed fishery schedules prior to the season (Salomone et al., 2011).

From 1992 through 2010, the directed commercial fishery was opened every year except two (2000 and 2001; Figure 1). Commercial fishing opportunity, based on the number of openings and total duration during any given year, was highest during 1994, 1995, 1998, and 2005-2007. During the 1990s, 200 or more drift boats participated based on boat counts conducted during the open fishing periods, with the largest boat counts recorded in 1994 and 1995. As an indication of the popularity of the directed fishery, the peak daily commercial drift permit registration in 1994 and 1995 occurred on dates during the directed chinook fishery; in all other years the peak daily registration for the season occurred during the sockeye salmon fishery (Table 3). Number of drift deliveries peaked in 2005 and 2006. Based on these trends, fishing effort and potential harvest rates on

Nushagak River Chinook for the directed fishery appeared to peak in 1994-1995, and again in 2005-2006.

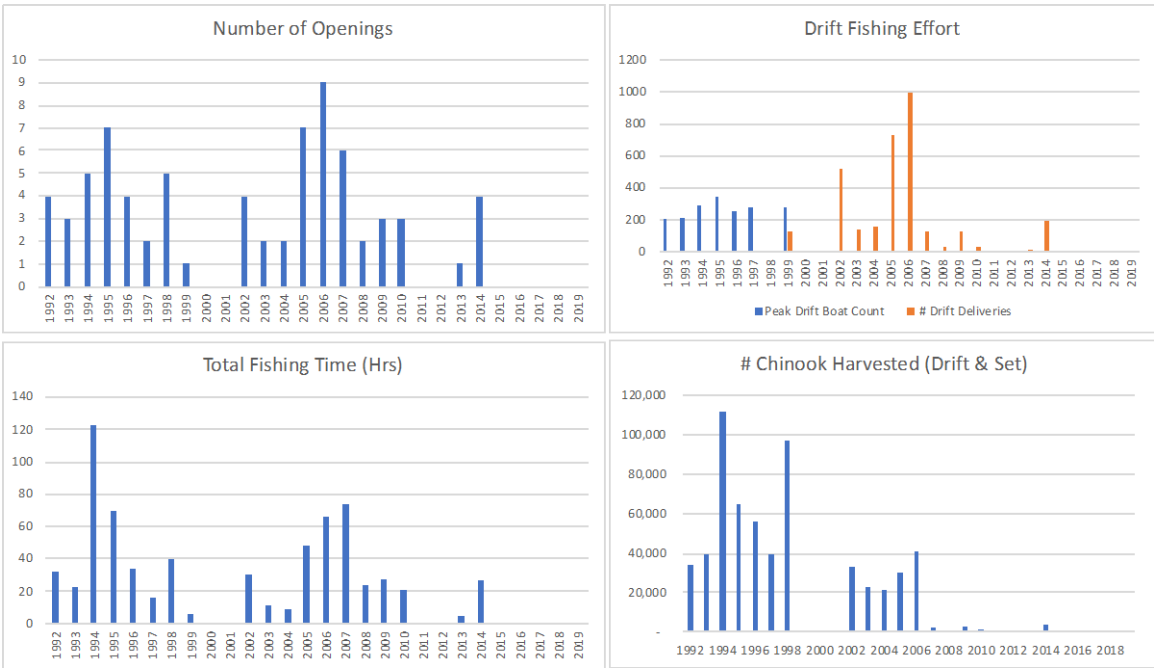

Figure 1. Trends in fishing opportunity, drift fishing effort, and chinook harvest in the directed commercial fishery.

Annual commercial harvests ranged from just over 11,000 (1999) to nearly 119,000 (1994) chinook salmon and exhibited a general declining trend (Figure 2). Directed fishery harvests 1992-1998 comprise a much greater proportion (77% average) of the seasonal harvest than any other period since except for 2002 (85%). From 2003-2006 the directed fishery comprised 43% - still much higher than the 5% average experienced 2007-2010. Across all years since 1992 during which a directed fishery occurred, chinook salmon harvests in the directed fishery comprised an average of 45% of the total season harvest.

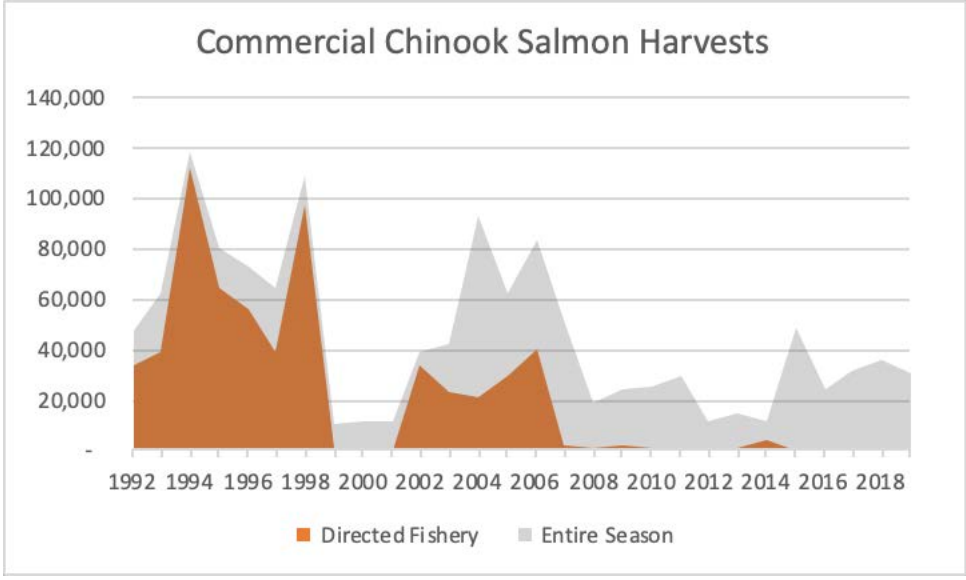

Figure 2. Commercial harvest of chinook salmon in the Nushagak District, 1992-2019.

The directed Chinook salmon commercial fishery waned considerably after the 2010 season. The Department ceased issuing a pre-season forecast for Chinook beginning 2011 (Jones et al., 2012). After experiencing a poor run in 2010 and lacking a reliable forecast, managers employed a conservative strategy for the next several years whereby fishing would be scheduled only if inseason escapement rates projected a harvestable surplus. The directed fishery was re-opened in 2013 and 2014 but participation and harvests were relatively low. Indications of a strong run exhibited early in the 2014 season were followed by very poor abundance in the second half and failed to indicate the weak run that ultimately resulted.

Strong sockeye salmon run forecasts for the Nushagak and Wood rivers increasingly factored into management of the Nushagak District beginning in 2015, whereby fishing for sockeye salmon was planned to begin earlier in June to control sockeye salmon escapement (Jones et al., 2016). The directed fishery has not been initiated since 2014 due to poor chinook runs experienced 2010-2014, lack of a pre-season forecast to guide any early season fishing, and the expected increased potential for incidental harvest of chinook during large sockeye runs.

Incidental harvests of Chinook salmon taken during the commercial fishery for sockeye comprised 55% of the total chinook salmon commercial fishery catch, on average, during years when the directed fishery was opened. During these years, incidental harvests ranged from 5,900 to 72,200 and averaged 22,700 chinook salmon (Figure 3). During years when the directed fishery was not opened, 11,000 to 49,000 chinook salmon (average 26,200) were harvested incidentally. From 1992 to 2002, the annual incidental Chinook catch averaged 13,800 and ranged from 5,900 to 25,300. Since 2003, the annual incidental harvest in the commercial sockeye fishery has averaged 30,200 and ranged from 7,500 to 49,300. The higher incidental Chinook Salmon catches in the latter period are likely due to

a combination of factors, including a shift from Chinook salmon that would have historically been caught in directed fishing effort to occurring in the sockeye fishery, generally larger sockeye returns resulting in earlier sockeye fishing and more intensive fishing, and in a few years, due to very early sockeye runs (e.g., 2003, 2013). Without a doubt, the large sockeye runs (~10 million+) since 2014 played a role in the location of the last five data points in Figure 3. Chinook run size is also a factor. However, care should be taken in characterizing apparent trends in the incidental catch of Chinook salmon and the total return given the uncertainty that exists in the escapement estimates, which are a very large component of the total run in low Chinook run years.

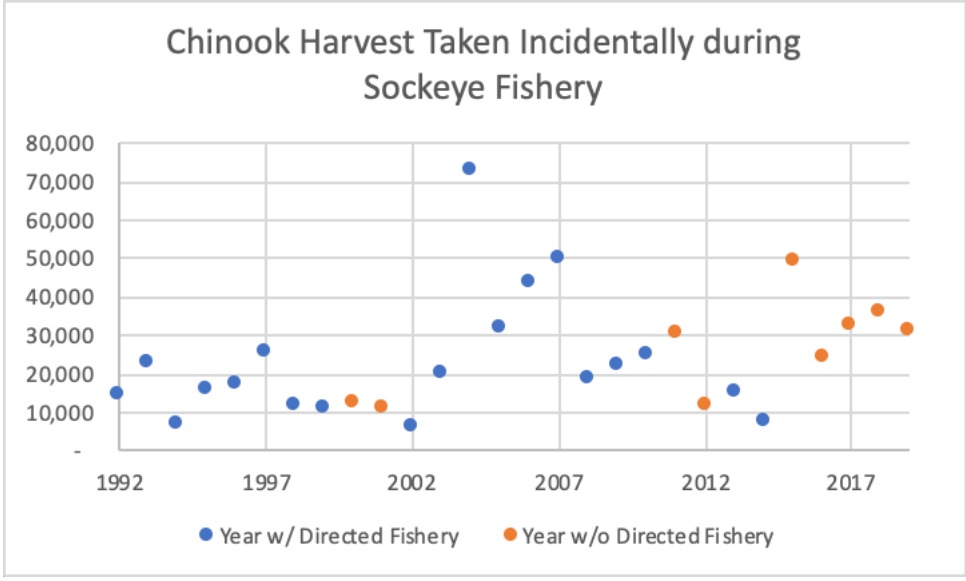

Figure 3. Number of Chinook salmon taken incidentally during the commercial sockeye season.

Since the NMCSP was adopted in 1992, sockeye runs to the Wood, Nushagak and Igushik Rivers have increased over time (Figure 4; Table 4). Average run sizes increased from 6.5 million sockeye salmon in the 1990s, to 9.4 million (2000-2010) to 12.4 million (2011-2019). Runs to the Nushagak district set all-time records in 2017 and 2018.

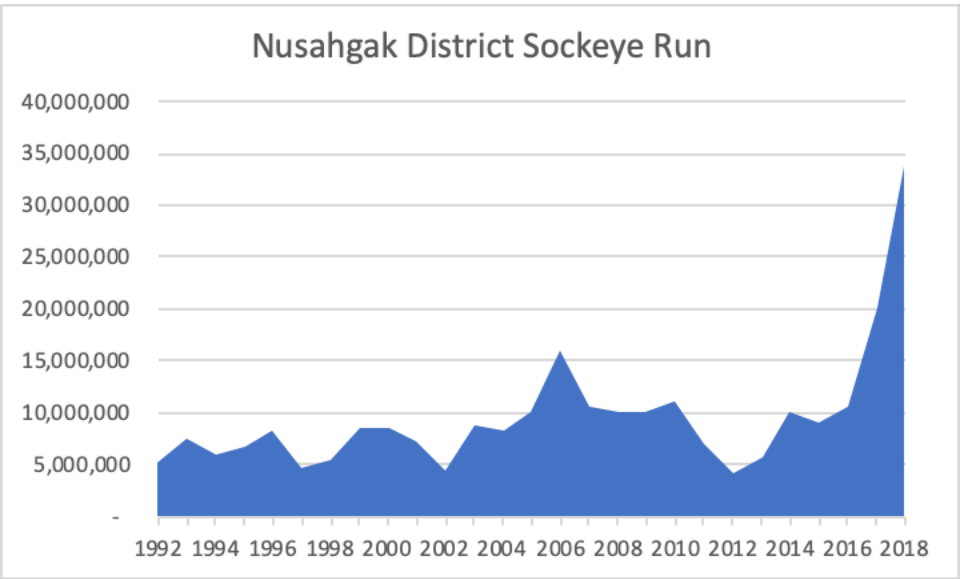

Figure 4. Annual Nushagak District sockeye salmon returns (district catch and escapement to three rivers), 1992-2019.

With both large sockeye runs and early sockeye runs, managers tend to open the commercial fishery earlier in June, and in the case of large runs, schedule fishing time more intensively through the season to control sockeye harvest and escapement (Jones et al., 2016). Figure 5 depicts dates on which the Nushagak District opened to commercial fishing for sockeye salmon with drift gillnets, dates on which fishing started and continued on an every-tide basis for the season, and dates on which fishing was extended until further notice. All three sets of dates, particularly season opening dates, exhibit a trend toward earlier starts to the sockeye fishery and intensive fishing regimes. This trend suggests a direct correlation to the increasing sockeye run size in the Nushagak District.

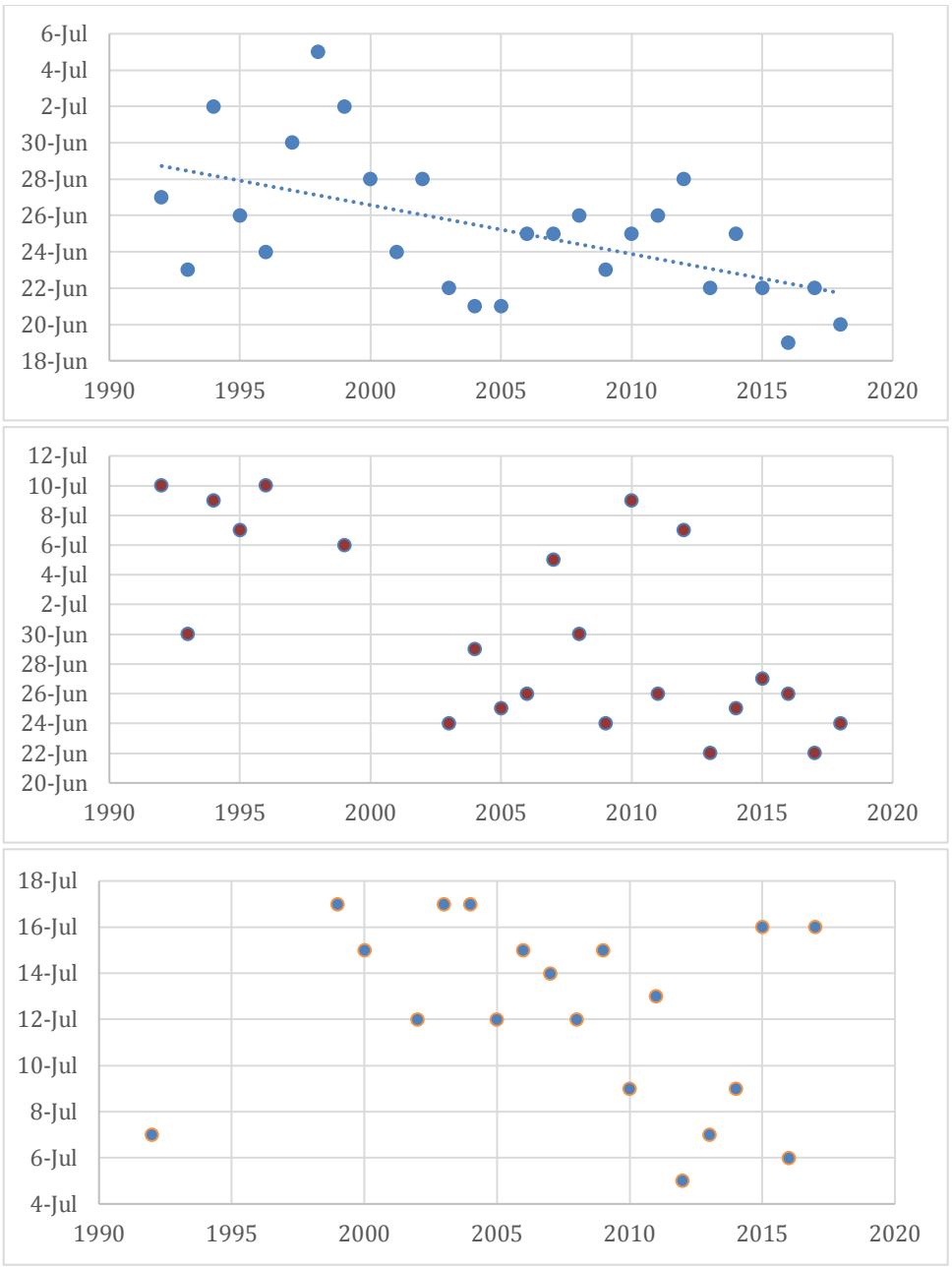

Figure 5. Key dates associated with the annual commercial drift net fishery for sockeye, including the season opening date (top), start date for fishing on an every-tide basis (middle), and dates on which fishing was extended until further notice.

Since the NMCSMP was adopted in 1992, commercial fishing effort appears to have increased based on permit registration statistics. Annual permit registration increased from the 1990s, when the average approximated 320 permits, to the 2000s and 2010s when the average approximated 415 permits (Table 3). Peak daily drift permit registrations showed a similar trend. Compounding this increase in effort, the peak registration date also appears

to have trended earlier over time (Figure 6), which is consistent with the increasing size of sockeye runs in recent years.

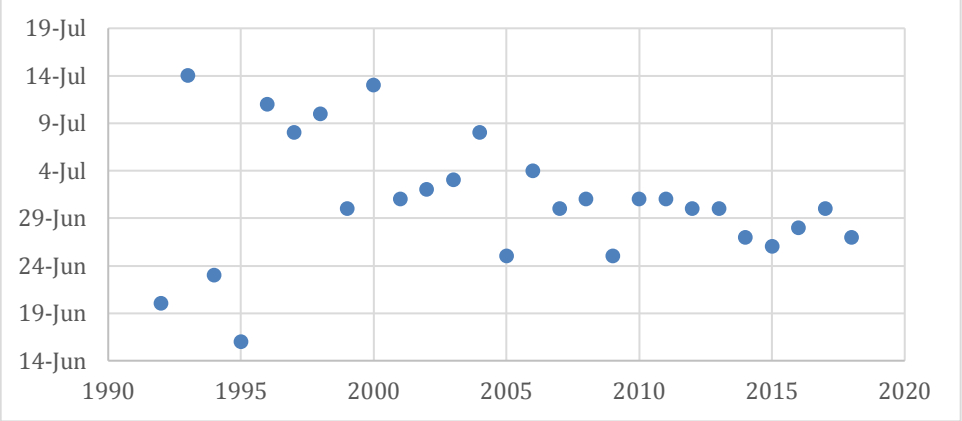

Figure 6. Peak daily drift gillnet registration dates.

Sport Fishery

Regulations

Sport fishing regulations pertaining to Nushagak River Chinook salmon – which consist of Bristol Bay-wide regulations, Nushagak River specific regulations, and NMCSMP provisions - have been modified eight times (Table 5). Regulations governing the sport fishery for Chinook salmon have generally become increasingly restrictive, conservative, and complex throughout the life of the Plan.

Most changes consisted of gear restrictions, season closures, bag limit reductions, imposition of annual limits and were adopted for a combination of conservation (e.g. spawning season closures) and/or social or allocative reasons (guideline harvest of 5,000 fish). One notable relaxation of restrictive regulations is the most recent change made December, 2018 that repealed Plan provisions directing the department to restrict the sport fishery under inriver run projection scenarios between 55,000-95,000 fish.

Emergency orders were issued during 10 seasons to restrict the sport fishery as directed by the Plan (Table 6). Bag limit reductions, followed by reductions in the annual limit, were the most common restrictions enacted. Fishing was restricted to catch-and-release during four years (1996, 1997, 2010, and 2019) and the season was closed to fishing for king salmon during two (1999 and 2010). During three of the years when the fishery was restricted (1999, 2011, and 2012), subsequent increases in the projected inriver run led managers to partially or completely ease restrictions.

Effort

Sport fishing effort for chinook salmon is concentrated in three areas: the lower Nushagak River near the village of Portage Creek, the middle section of the Nushagak River near the village of Ekwok, and the midsection of the Mulchatna River between the Stuyahok and Koktuli rivers (Dye and Borden, 2018). Between 1992 and 1997, effort in the Ekwok area was highly variable. Since about 1999, the lower river fishery has begun to expand steadily upriver to Ekwok and the 2 areas are merging into a single fishery.

Figure 7 and Table 7 depict sport fishing effort in the Nushagak drainage for all salmon and freshwater species. Effort in the Mulchatna appears to have declined considerably since the Plan was adopted, and Dye and Borden (2018) corroborate that angling for Chinook salmon in the middle section of the Mulchatna River seems to have diminished since bait was prohibited there in 1992. Drainage-wide, effort varied with no apparent trend through the mid-2000s, then began a steady decline over four years followed by a gradual increase. For the most recent 5 years depicted (2013-2017), effort appears to have stabilized at or slightly below levels experienced prior to the mid-2000s.

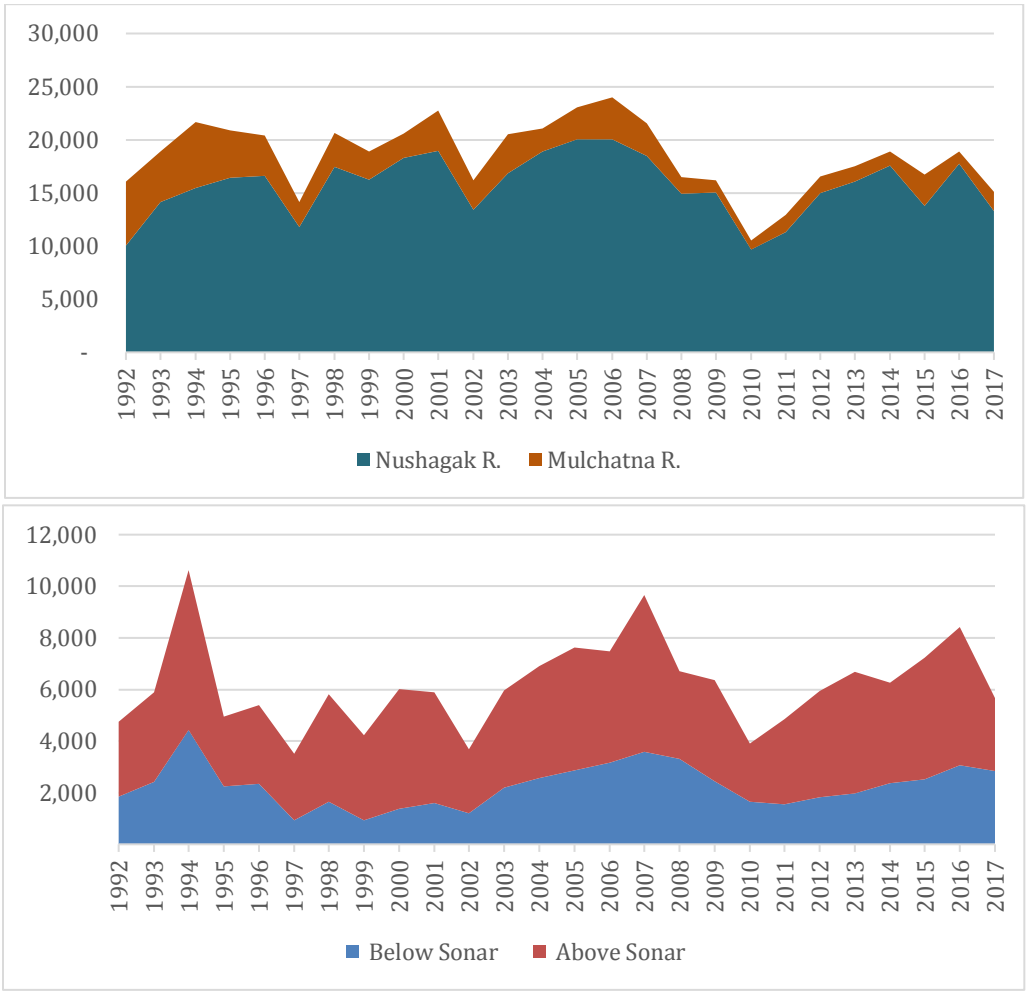

Figure 7. Sport fishing effort (top; angler days) on the Nushagak and Mulchatna Rivers, and Chinook salmon harvest (bottom).

Based on freshwater logbook data from the period 2006-2016, 46 to 65 (average 53) guide businesses and 155-250 (average 211) guides have operated on the Nushagak River (all species) (Figure 8; Table 8). During any given year, the guide industry served approximately 1,400 to 3,100 clients (average 2,500), many of whom fished for Chinook salmon. Business and guide activity were at their highest early during this period. Similar to the trend observed above for angling effort, the number of guides and businesses declined through about 2010-2012 and then increased to a level slightly lower than that observed in 2006-2007. Guided effort (client days) and Chinook harvest followed a very similar trend. Reasons for the decline in participation between 2005-2010 are varied. However, national economic downturns experienced during that time likely played a primary role in the dynamics observed in guided fishing activity.

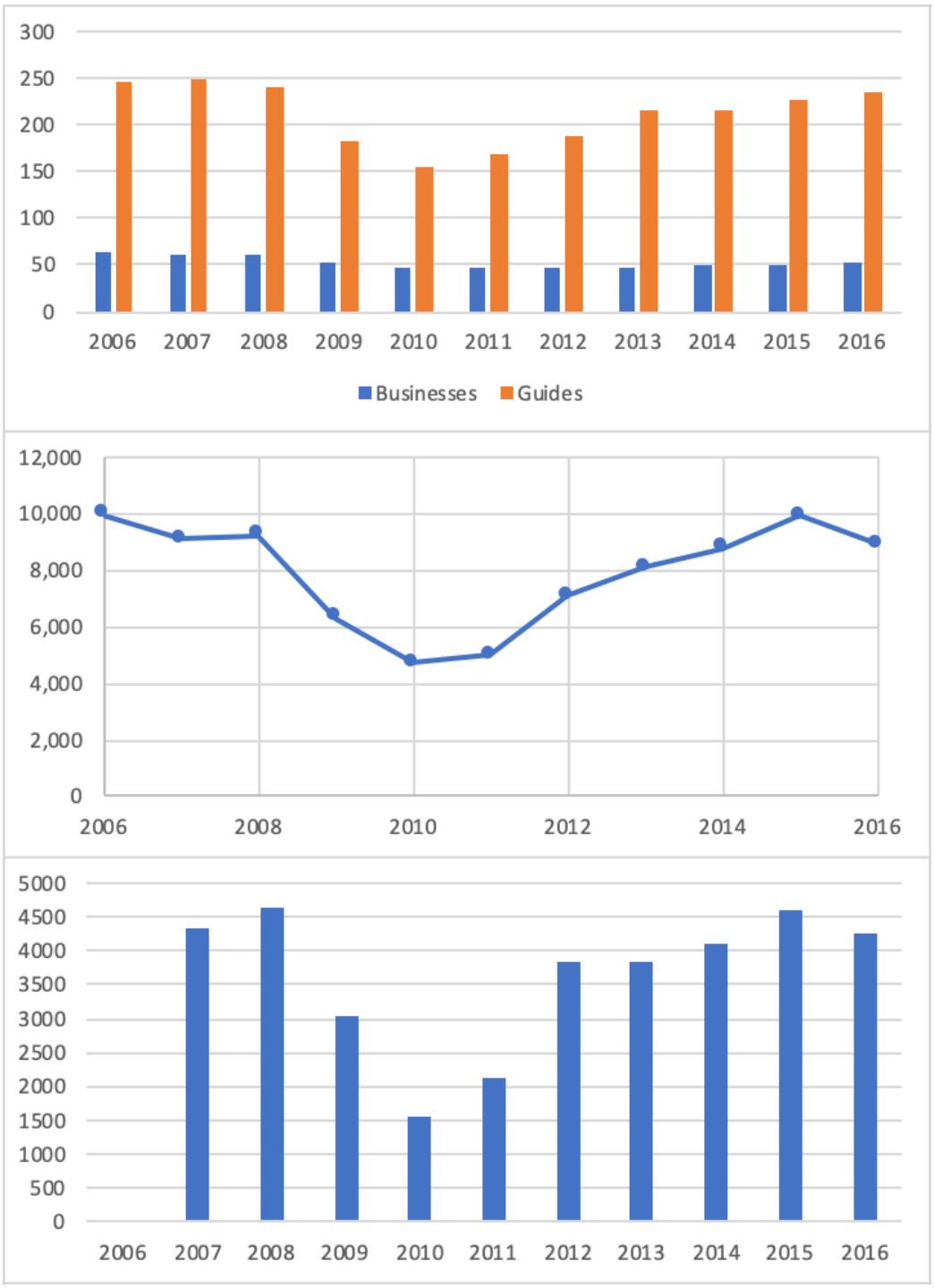

Figure 8. Number of sport fishing businesses and guides (top), client days (middle) and Chinook salmon harvest by clients (bottom) as estimated by the ADF&G Freshwater Logbook program for the Nushagak River, 2006-2016.

Harvests

Sport harvests of chinook ranged from approximately 3,500 (1997) to 10,600 (1994) and averaged 6,170 Chinook salmon (Figure 8; Table 7). Approximately one-third (36%) of the harvest occurs below the sonar.

Subsistence Fishery

Regulations, Effort, and Harvest

Nelson (1987) noted that, compared to commercial fishing regulations, few restrictions had been imposed on the subsistence fisheries in Bristol Bay. Of the restrictions that had been enacted prior to the mid-1980s, Nelson noted that the 1974 limit on fishing time (3 days/week) and net length (10 fathoms) on the Dillingham beaches from June 16 to July 17 had the most impact on chinook salmon harvest rates. Relatively few regulatory changes to the Nushagak subsistence fishery have been enacted since the adoption of the NMCSMP, with two notable exceptions. In 2018, the Board repealed the limits to subsistence fishing periods (i.e. weekly 3-day schedule) and allowed subsistence fishing with dip nets near Dillingham.

Participation in the subsistence fishery, based on the number of permits issued, appears to have been relatively stable and increasing since adoption of the NMCSMP (Halas and Neufeld, 2018). Comparing average figures for 1992-1996 against those for 2013-2017 indicates the number of subsistence permits issued increased by nearly 20% (Figure 9, Table 9). Between the same two time periods, the number of Chinook salmon harvested per permit decreased by about 25%, which caused annual harvests to decline by 13%.

These trends in the subsistence fishery are similar to those observed by Nelson over 30 years ago. He stated then: “Since subsistence fishing is considered a priority use of the resource in Alaska, subsistence use can be expected to continue at near record levels of effort. Harvest levels are expected to remain high, and will continue to be somewhat independent of stock abundance…” It is likely the same outlook holds true today.

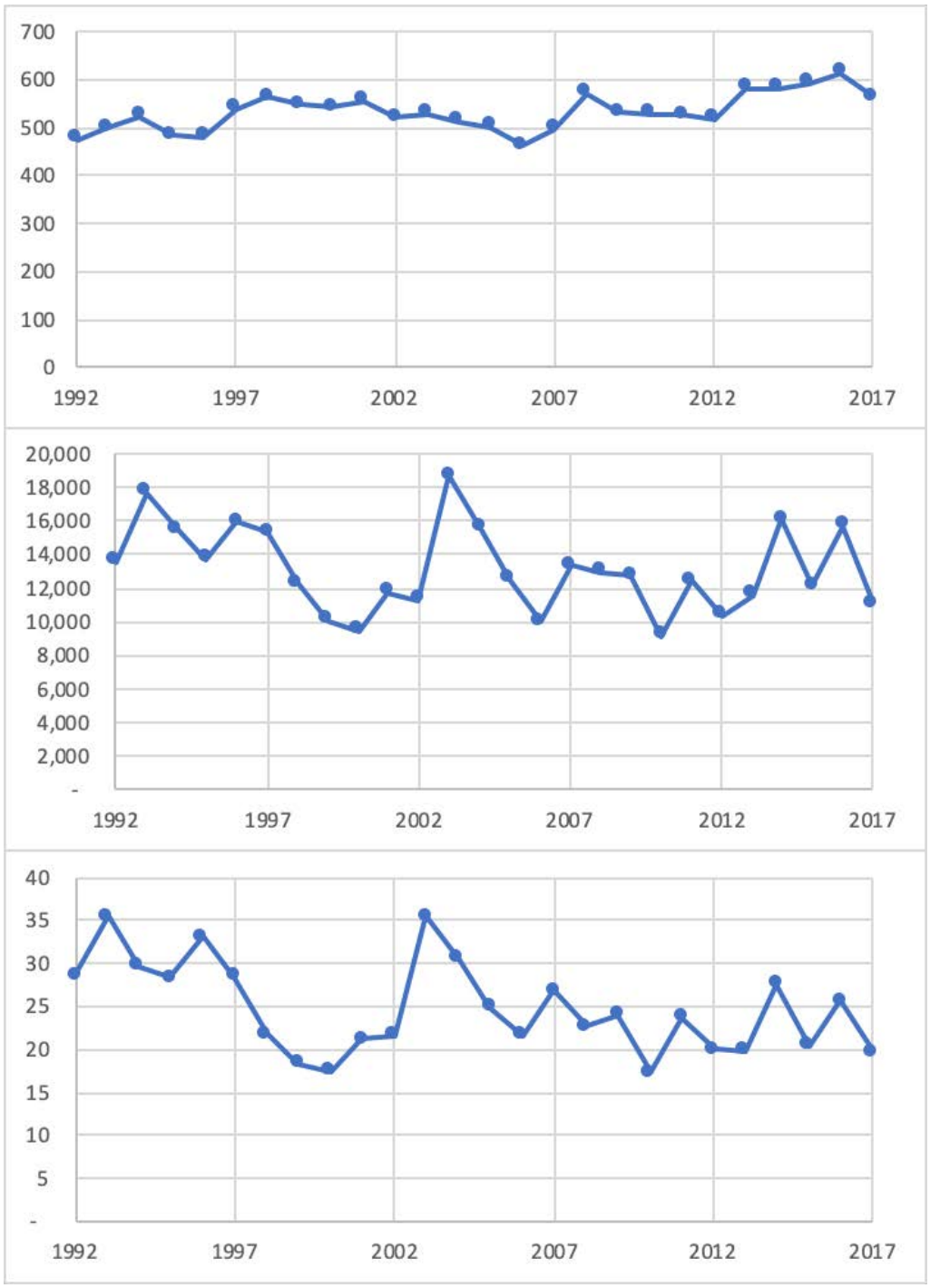

Figure 9. Number of subsistence fishing permits issued (top), estimated Chinook salmon harvest (middle), and harvest per permit (bottom) in Nushagak District.

Plan Performance

This section will discuss how the fisheries have performed with respect to management objectives within the NMCSMP.

Changes in Escapement Assessment Tool

Before going further, some discussion is needed regarding the inriver assessment of Chinook salmon because two objectives (inriver run goal and biological escapement goal) rely directly on it and significant uncertainties surround the sonar project and its results.

In 1997, aerial surveys of Chinook salmon spawners raised concern over the accuracy of the sonar counts (Brookover et al., 1997). A distribution study on coho salmon that year coupled with low water conditions indicated that a substantial number of chinook migrated offshore of the effective reach of the sonar and, as a result, the department committed to assessing offshore distribution of salmon as an integral component of the project in the future.

Beginning 2002, the department began using dual frequency identification sonar (DIDSON) concurrently with the Bendix acoustic system then in use (Buck et al., 2012). DIDSON is a type of imaging sonar that generally superior to the 1960s technology used for the Bendix equipment[2]. Comparisons over the next few years found that the DIDSON detected a higher number of fish than the Bendix system, particularly in the more distant-from-shore areas that had been ensonified. In 2005, after a few partial-year, partial-river-segment comparisons of counts from each sonar the Department transitioned to using the DIDSON technology to measure the inriver salmon runs at Portage Creek, and discontinued use of the aging and increasingly difficult-to-service Bendix equipment. Conversion factors for chinook salmon and other species were subsequently calculated from the relationship between DIDSON and Bendix passage, and applied to historical Bendix passage estimates. The revised estimates were then used to produce revised total run and brood tables for Nushagak salmon composed of DIDSON or equivalent estimates. More recently, it has become clear that the Bendix-DIDSON conversion ratios that were developed in 2005 are problematic, and this affects the utility of the historical escapement estimates before and after the change in equipment (ADF&G Nushagak escapement goal memo, July 11, 2019).

Erickson et al. (2018) summed up uncertainties associated with the current sonar program in a report to the Board in December 2018. A 2011–2014 acoustic tagging study estimated that the sonar beam covered less than a third of the Nushagak River channel. “Preliminary results from the 2011–2014 acoustic tagging study estimated the proportion of Chinook salmon traveling outside the sonar beam range was 47–65% with a mean of 57%. Similarly, a 2014–2016 mark–recapture study estimated the abundance of adult Chinook salmon in

[2] In addition, the Bendix equipment was becoming more and more difficult to service and maintain. Al Menin, who invented the Bendix sonar, continued to service the Bendix equipment up until just prior to his death in 2005.

the Nushagak River independently from the sonar estimate. Both studies indicated that a substantial number of Chinook salmon are not enumerated by the existing sonar assessment and that the current sonar assessment is an index of abundance. At this time, ADF&G has not quantified the consistency of the sonar index."

This assessment of Plan performance takes the current inriver abundance estimates, and resulting spawning escapement and total run estimates, at face value (Table 10). This is problematic in that inriver abundance estimates prior to 2013 were revised by Buck et al. (2012). As a result, management performance in achieving an inriver or escapement goal, for example, can not readily be assessed, at least using the revised estimates, for years prior to 2013. The 1997 season provides a good example of the challenges. In 1997, spawning escapement estimated by aerial surveys (82,000) was twice the sonar count, indicating a problem with the sonar. The revised inriver run estimate presented in Buck et al. (2012) is 170,610. Using the original sonar count, the inriver goal of 75,000 at the time was not met. Using the aerial survey count, the inriver goal was met. And using the current estimate the inriver goal was far exceeded.

Figure 10 and Table 10 depict the Nushagak River Chinook salmon total run (and harvest) estimates. Since the Plan was adopted, runs have generally declined and recent runs (2013-2017) have averaged about 149,000 fish. Harvest among all fisheries has generally followed the same trend.

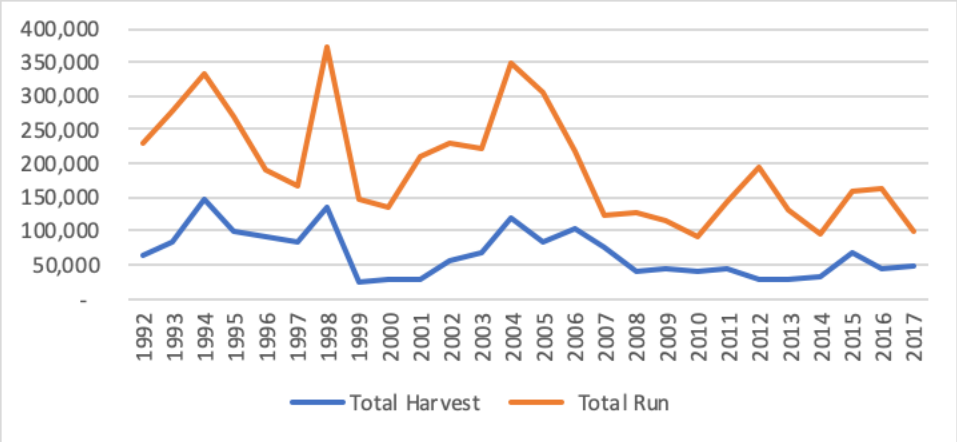

Figure 10. Nushagak Chinook salmon total run and harvest, all fisheries combined, 1992-2017.

Plan Objectives:

The department shall manage the commercial and sport fisheries in the Nushagak District to achieve an inriver goal of 95,000 king salmon present in the Nushagak River upstream from the department sonar counter.

Inriver run performance can be assessed by a simple comparison of the estimated inriver run with the inriver run goal. The combination of changes to the inriver run goal and, as stated above, the Bendix-DIDSON conversion makes assessment difficult for years prior to 2013. For this reason, only 2013 through the current is assessed. Since 2013, the estimated inriver run exceeded the inriver run goal four times but fell short three (Figure 11; 2014, 2017 and 2019). In 2014 and 2017, the total run size only slightly exceeded the inriver goal.

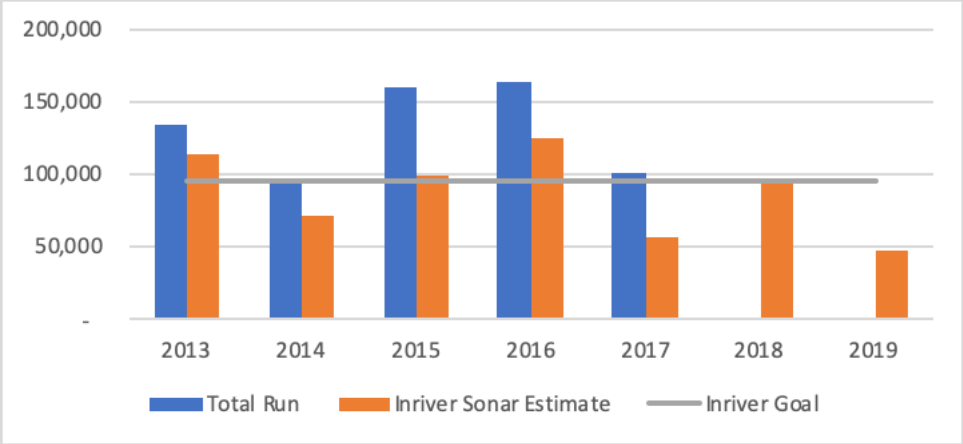

Figure 11. Inriver run estimates compared to the inriver run goal, 2013-2019.

Provide for a biological escapement goal of 55,000 - 120,000 fish.

Since 2013, estimated spawning escapement fell within the goal in all but two years (2017 and 2019). Aerial surveys conducted in 2017 indicated that actual spawning escapement was likely greater than estimated by the sonar. From a biological standpoint, the Plan appears to be working generally well in ensuring spawning goals are achieved. However, should future runs continue near current levels, achieving inriver goals may pose a continued challenge.

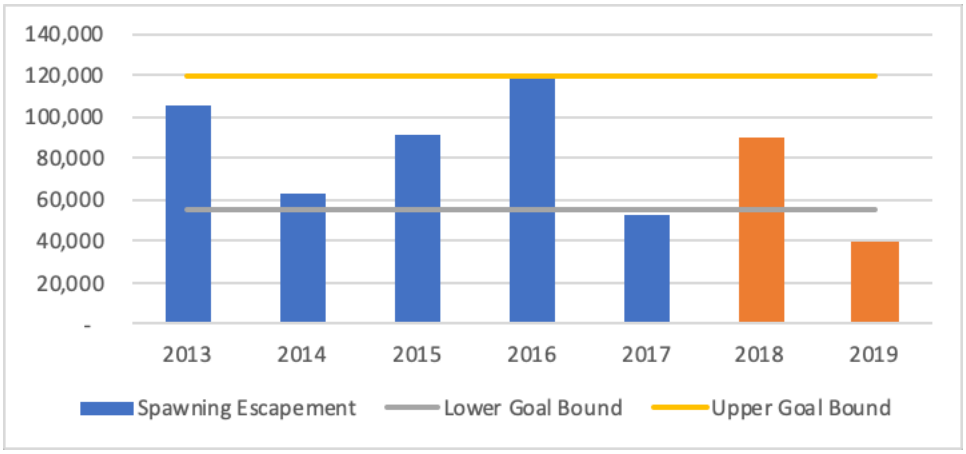

Figure 12. Spawning escapement estimates compared to the escapement goal (55,000-120,000), 2013-2019. Orange bars depict "preliminary" escapement estimates derived for

this report using the inriver sonar estimates less average (2013-2017) upriver subsistence and sport harvests to envision approximately where the final estimate might fall.

Provide for reasonable opportunity for subsistence harvest of king salmon; and a king salmon sport fishery guideline harvest level of 5,000 fish, 20 inches or greater in length.

Chinook salmon harvests have declined in the commercial fishery and have remained relatively stable in subsistence and sport fisheries (Figure 13; Table 10).

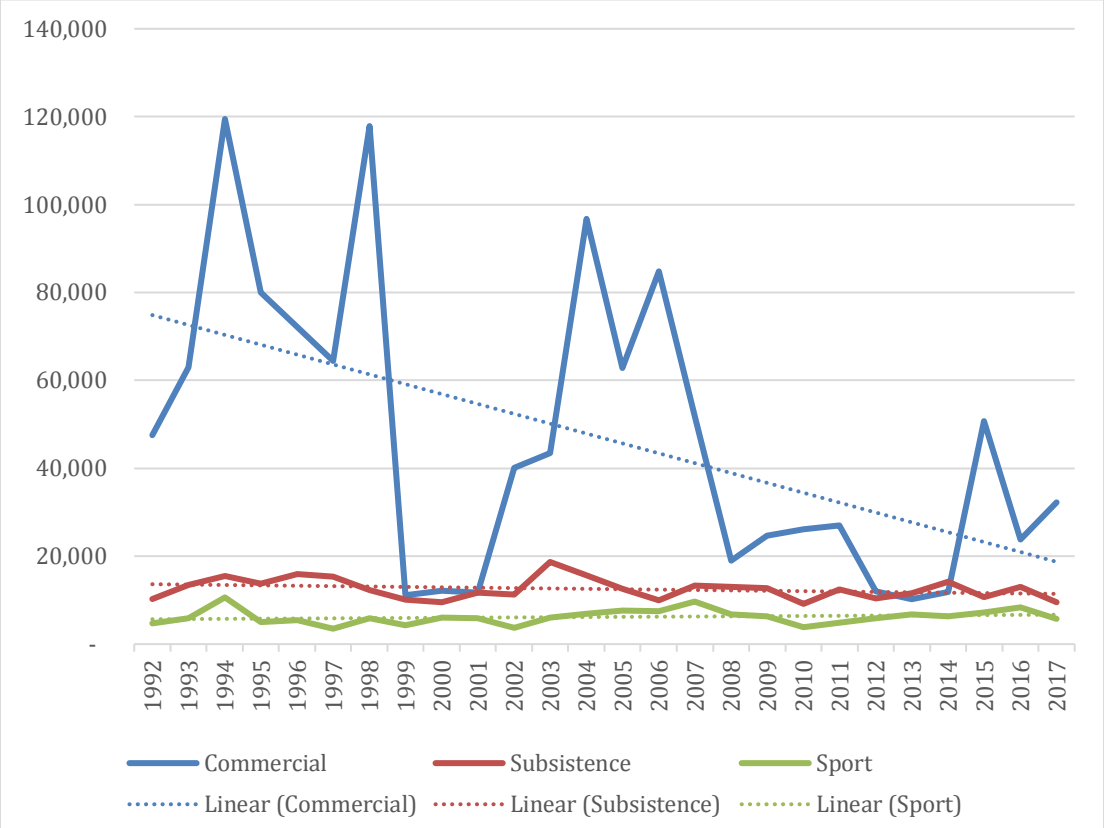

Figure 13. Trends in harvests of Nushagak River Chinook salmon among the commercial, subsistence and sport fisheries, 1992-2017.

The sport fishery guideline harvest level applies when projected inriver runs do not exceed 95,000 king salmon. Since 2013, inriver run estimates fell at or below the inriver run goal in 3 years: 2014, 2017 and 2019. Sport harvest estimates are not available for 2019. Harvests in 2014 (6,250 king salmon) and 2017 (5,671 king salmon) exceeded the guideline harvest level.

Maintain a natural representation of age classes in the escapement.

The Plan's objective to maintain a natural representation of age classes in the escapement has not been addressed in this analysis. Nor has the objective of providing reasonable

opportunity for subsistence harvest of king salmon. Addressing the first was beyond the time available to prepare this draft report. The second was beyond the scope. Both, however, are core Plan objectives and should be assessed.

Management Challenges

Many of the recommendations Nelson made in 1987 have been partially or fully carried out. A biological escapement goal was developed in 1992 and subsequently refined in 2012. Development of the Portage Creek sonar has continued through conversion to DIDSON technology, which expanded the portion of the river width ensonified, and the commercial fishery is managed as recommended – by emergency order and using mesh size restrictions to reduce catch rates and achieve a better distribution of escapement through time.

A number of the challenges Nelson identified in 1987 – inriver run abundance assessment, overlap between king salmon and sockeye salmon run timing, and size selectivity - remain today. More recently, several new dynamics have emerged creating new types of challenges.

Difference between sockeye and Chinook salmon run magnitude.

Fluctuations in the magnitude of Chinook and sockeye runs don't necessarily pose management challenges. Large runs of both species, for example, can accommodate liberal fishing opportunity among fisheries without necessarily causing management issues for one species or the other. Similarly, restrictions in the various fisheries can adequately protect poor runs of both species without grossly precluding opportunity on one species. Recently, however, large record-setting sockeye runs to the Wood and Nushagak Rivers have combined with relatively poor Chinook runs, exacerbating the ratio between the species and highlighting the challenge inherent to the overlap in run timing. This recent pattern has, on occasion, challenged managers' ability to both deliver Chinook salmon to the inriver fisheries and escapement (i.e. achieve the inriver goal) and to harvest available sockeye salmon surplus to sockeye salmon escapement goals. As a result, sport fishing restrictions were needed and, in two recent years, the Nushagak Chinook salmon escapement goal was not achieved.

Accuracy and Precision of Inriver Run and Escapement Estimates

Despite improvements to the sonar program since 1992, substantial uncertainties associated with the inriver run and spawning escapement estimates remain. Based on recent tagging studies, a large fraction of the Chinook run still passes the sonar site beyond the reach of the sonar beams. Whether the fraction missed by the sonar is consistent among and within years remains to be determined. Uncertainties surrounding inriver run estimates are great enough that fishery restrictions predicated on the sonar were later found to be unnecessary based on post-season aerial survey counts in at least three years (1997, 1999, 2017), and are suspected in other years.

Plan Specificity

The combination of the two challenges above, in turn, pressured area fishery managers to adhere to the Plan's specific multi-tiered triggers, while trying to reconcile the limits of the sonar-based estimates that drove the decision rules. Low water conditions thought to at least partially cause low sonar estimates in the past, coupled with reported inriver catch rates cast doubt on sonar estimates in some recent years. Yet managers were held accountable to specific management actions prescribed solely on inseason sonar estimates. As stated above, some of the management restrictions recently implemented were later determined to be unnecessary when it was discovered that the actual spawning escapement was greater than estimated at the sonar. Restrictions to the sport fishery on Chinook due to low early season passage, combined with sometimes intense sockeye fishing continued and led to calls to pair restrictions in the commercial and sport fishery (Proposals 41 and 42, Nov-Dec 2018 Board meeting).

Plan provisions that prescribed restrictions to the sport fishery in mid-range inriver run scenarios were eliminated in the November-December Board meeting, leaving a simpler Plan and allowing ADF&G to consider sonar data along with other inseason information in managing fisheries to ensure the escapement goal is met. However, the fundamental challenges associated with the multi-species and multi-stock commercial, sport and subsistence fisheries in the Nushagak area remain. Counting salmon in the Nushagak River is more difficult than once thought. The Chinook and sockeye salmon stocks have similar run timing and differ in productivity (and hence sustainable exploitation rates), but the recent large sockeye runs have added a new dimension. These basic dynamics combine to add complexity and challenges to regulating harvests in a common commercial fishery and implementing conservation measures where and when warranted.

Despite these challenges, the fisheries and stocks in the Nushagak are generally healthy and support vibrant fisheries. To address these challenges, the Board-appointed working committee is scheduled to meet prior to the October 2019 Work Session to receive an update from ADF&G on the escapement goal for Nushagak Chinook salmon, and begin discussing possible changes to the NMKSMP for consideration at the March, 2020 Statewide Board meeting. This report is the first of several to aid the deliberations of the Board committee. We welcome and expect input from the committee and ADF&G staff on this initial draft of the report.

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Appendix A. 1992 Version, Nushagak-Mulchatna Chinook Salmon Management Plan.

5 AAC 06.361. NUSHAGAK-MULCHATNA CHINOOK SALMON MANAGEMENT PLAN. (a) The purpose of this management plan is to ensure adequate spawning escapement of chinook salmon into the Nushagak-Mulchatna river systems. It is the intent of the Board of Fisheries that Nushagak-Mulchatna chinook salmon be harvested in the fisheries that have historically harvested them. The plan in this section provides management guidelines to the department in an effort to preclude allocation conflicts between the various users of this resource. The department shall manage Nushagak-Mulchatna chinook salmon stocks in a conservative manner consistent with sustained yield principles and the subsistence priority.

(b) The department shall manage the commercial fishery in the Nushagak District to achieve an inriver goal of 75,000 chinook salmon present in the Nushagak River upstream from the department sonar. The inriver goal provides for:

(1) a biological escapement requirement of 65,000 fish;

(2) reasonable opportunity for subsistence harvest, and;

(3) a chinook salmon sport fishery harvest of not more than 5,000 fish.

(c) If the total inriver chinook salmon return in the Nushagak River is projected between 75,000 and 95,000 fish, the inriver chinook salmon sport fishery harvest shall not exceed 6,000 fish.

(d) If the total inriver chinook salmon return in the Nushagak River is projected to be between 40,000 and 74,999 fish, the department shall;

(1) by emergency order, close the directed chinook salmon commercial fishery in the Nushagak District; during a closure under this paragraph, the use of a commercial gillnets with webbing larger than 5 1/2 inches, is prohibited; and

(2) if the projected inriver return of chinook salmon in the Nushagak River is less than 65,000 fish, restrict the chinook salmon sport fishery in the Nushagak River by establishing periods by emergency order during which, at the departments discretion, one or more of the following is in effect;

(A) bag and possession limits are reduced to one (1) fish;

(B) the use of bait is prohibited;

(C) time or area for fishing is reduced;

(D) the chinook salmon sport fishery is closed.

(e) If the total inriver chinook salmon return in the Nushagak River is projected to be less than 40,000, the department shall;

(1) close the sockeye salmon commercial fishery in the Nushagak District until the projected sockeye salmon escapement into the Wood River exceeds 100,000 fish;

(2) close the sport fishery in the Nushagak River to the taking of chinook salmon; and

(3) by emergency order, establish periods during which time or area is reduced for the inriver chinook salmon subsistence fishery in the Nushagak River.

Appendix B. 2019 version, Nushagak-Mulchatna King Salmon Management Plan.

5 AAC 06.361. Nushagak-Mulchatna King Salmon Management Plan (a) The purpose of this management plan is to ensure biological spawning escapement requirements of king salmon into the Nushagak-Mulchatna river systems. It is the intent of the Alaska Board of Fisheries (board) that Nushagak-Mulchatna king salmon be harvested in the fisheries that have historically harvested them. This management plan provides guidelines to the department in an effort to preclude allocation conflicts between the various users of this resource. The department shall manage Nushagak-Mulchatna king salmon stocks in a conservative manner consistent with sustained yield principles and the subsistence priority.

(b) The department shall manage the commercial and sport fisheries in the Nushagak District as follows:

(1) to achieve an inriver goal of 95,000 king salmon present in the Nushagak River upstream from the department sonar counter; the inriver goal provides for

(A) a biological escapement goal of 55,000 - 120,000 fish;

(B) reasonable opportunity for subsistence harvest of king salmon; and

(C) a king salmon sport fishery guideline harvest level of 5,000 fish, 20 inches or greater in length;

(2) in order to maintain a natural representation of age classes in the escapement, the department shall attempt to schedule commercial openings to provide pulses of fish into the river that have not been subject to harvest by commercial gear;

(3) the department may close the commercial drift or set gillnet fishery if the harvest in the directed commercial king salmon fishery for either gear group is more than two sockeye salmon for every one king salmon.

(c) If the total inriver king salmon return in the Nushagak River is projected to exceed 95,000 fish, the guideline harvest level described in (b)(1)(C) of this section does not apply. (d) If the spawning escapement of king salmon in the Nushagak River is projected to be more than 55,000 fish and the projected inriver return is less than 95,000 fish, the commissioner

(1) shall close, by emergency order, the directed king salmon commercial fishery in the Nushagak District; during a closure under this paragraph, the use of a commercial gillnet with webbing larger than five and one-half inches in another commercial salmon fishery is prohibited;

(2) repealed 5/31/2019;

(3) repealed 5/31/2019;

(e) If the spawning escapement of king salmon in the Nushagak River is projected to be less than 55,000 fish, the commissioner

(1) shall close, by emergency order, the sockeye salmon commercial fishery in the Nushagak District until the projected sockeye salmon escapement into the Wood River exceeds 100,000 fish;

(2) shall close, by emergency order, the sport fishery in the Nushagak River to the taking of salmon and prohibit the use of bait for fishing for all species of fish until the end of the king salmon season specified in 5 AAC 67.020 and 5 AAC 67.022(g); and

(3) shall establish, by emergency order, fishing periods during which the time or area is reduced for the inriver king salmon subsistence fishery in the Nushagak River.

(f) Notwithstanding 5 AAC 06.200, in a directed king salmon commercial fishery, the southern boundary of the Nushagak District is a line from an ADF&G regulatory marker located at Etolin Point at 58° 39.37' N. lat., 158° 19.31' W. long., to 58° 33.92' N. lat., 158° 24.94' W. long. to Protection Point at 58° 29.27' N. lat., 158° 41.78' W. long.

(g) During a directed king salmon commercial fishery in the Nushagak District, drift gillnet and set gillnet fishing periods will be of equal length, but do not have to be open concurrently.

Appendix C. Tables.

Table 1. A chronology of regulatory modifications to the Nushagak-Mulchatna River King Salmon Management Plan.

Year	Modification
1992	Nushagak and Mulchatna King Salmon Management Plan (5 AAC 06.361; Appendix A) is adopted.
1994	Set the sport harvest allocation of 5,000 as a guideline harvest rather than a cap.
1997	Modified the plan directing the department to attempt to schedule commercial openings to provide pulses of chinook salmon into the river that have not been exposed to commercial gear. Established an escapement projection of 55,000 king salmon below which inseason restrictions in the sport fishery must be imposed.
2001	Allowed a catch-and-release fishery when the final inriver abundance is projected to be below 55,000 fish but above 40,000 fish. When the king salmon sport fishery is restricted to catch-and-release or is closed for conservation, the use of bait must be prohibited.
2003	Modified provision (d) directing the department to reduce the sport fishing bag limit to 1 per day and in possession, any size, if the projected inrver return falls between 55,000 and 75,000 king salmon. Added provision allowing the department to close the commercial drift or set gillnet fishery if the harvest in the directed commercial fishery for either gear group is more than two sockeye salmon for every one king salmon.
2006	Provision added to require, during a directed commercial opening, drift and set gillnet fishing periods to be of equal length, but do not have to be open concurrently.
2012	Modified the biological escapement requirement, inriver goal, and management triggers to reflect changes in inriver sonar operations (Bendix to DIDSON conversion).
2018	Repealed provisions (d)(2) and (3) directing the department to restrict the sport fishery if the projected inriver return falls between 55,000 and 95,000 king salmon.

Table 2.-Fishery statistics for Nushagak District commercial fishing periods targeting king salmon (directed king salmon openings), 1992-2019. All data are preliminary, as reported in annual management reports.

	Number	Opening	Peak Drift	# of Deliveries		# Chinook Harvested (Drift & Set)		
Year	of Openings	Duration (Hrs)	Boat Count	Drift	Set	Directed Fishery	Entire Season	Source
1992	4	32	200			33,905	47,897	*ADF&G (1993)*
1993	3	23	211			39,536	62,294	*ADF&G (1994)*
1994	5	122.5	290			111,886	118,643	*Browning and Miller (1995)*
1995	7	70	347			64,745	80,180	*ADF&G (1996)*
1996	4	34	252			56,256	73,365	*ADF&G (1997)*
1997	2	16	278			39,003	64,294	*ADF&G (1998)*
1998	5	40	-			97,169	108,486	*ADF&G (1999)*
1999	1	6	279	125	23	563	11,008	*Morstad (2000)*
2000	-	-		-	-	-	12,055	*ADF&G (2001)*
2001	-	-		-	-	-	11,050	*Fair (2002)*
2002	4	30	-	519	594	33,447	39,382	*Weiland et al. (2003)*
2003	2	11	-	140	48	23,008	42,615	*Fair et al. (2004)*
2004	2	9	-	153	58	21,233	93,414	*Westing et al. (2005)*
2005	7	48	-	731	100	30,003	61,854	*Westing et al. (2006)*
2006	9	66 [a]	-	1,000	194	40,503	83,679	*Salomone et al. (2007)*
2007	6	74	-	125	2	2,049	51,350	*Sands et al. (2008)*
2008	2	24	-	26	-	496	18,634	*Jones et al. (2009)*
2009	3	27	-	122	156	2,575	24,058	*Morstad et al. (2010)*
2010	3	21	-	33	35	1,143	25,580	*Salomone et al. (2011)*
2011	-	-		-	-	-	29,811	*Jones et al. (2012)*
2012	-	-		-	-	-	11,501	*Jones et al. (2013)*
2013	1	5		8	9	518	15,175	*Jones et al. (2014)*
2014	4	26 [b]		197	49	3,985	11,448	*Elison et al. (2015)*
2015	-	-		-	-	-	48,968	*Jones et al. (2016)*
2016	-	-		-	-	-	23,783	*Salomone et al. (2017)*
2017	-	-		-	-	-	32,194	*Elison et al. (2017)*
2018	-	-		-	-	-	35,938	*Salomone et al. (2019)*
2019	-	-		-	-	-	30,579	

[a] drift and setnet openings managed separately; drift and setnet hours totaled 66 and 108.

[b] drift and setnet openings managed separately; drift and setnet hours totaled 26 and 8.

Table 3. Annual drift gill net permit registration statistics, Nushagak District commercial fishery, 1992-2019. For data sources, see Table 2.

	Average Daily Registration		Peak Daily Registration		
	Total Permits[a]	Dual Permits	Total Permits[a]	Dual Permits	Peak Date
1992	317		360		20-Jun
1993	250		326		14-Jul
1994	269		304		23-Jun
1995	225		374		16-Jun
1996	357		465		11-Jul
1997	386		499		8-Jul
1998	404		526		10-Jul
1999	358		383		30-Jun
2000	402		598		13-Jul
2001	467		705		1-Jul
2002	279		465		2-Jul
2003	407		512		3-Jul
2004	362		399		8-Jul
2005	527		678		25-Jun
2006	564		687		4-Jul
2007	475		741		30-Jun
2008	354		470		1-Jul
2009	342		431		25-Jun
2010	405		453		1-Jul
2011	424		508		1-Jul
2012	282		395		30-Jun
2013	313	49	372	60	30-Jun
2014	389	65	590	119	27-Jun
2015	332	53	474	84	26-Jun
2016	364	167	518	244	28-Jun
2017	403	167	636	244	30-Jun
2018	803	412	1053	548	27-Jun
2019					

[a] Total permit sum includes dual boat registrations.

Table 4. Start dates for initial fishing periods, intensive fishing periods, and continuous fishing periods in the commercial fishery for sockeye salmon, and total sockeye run, Nushagak District, 1992-2019. All data are preliminary, as reported in annual management reports (See Table 2).

	Start Date[a]		Intensive Fishing[b] Start Date		Continuous Fishing[c] Start Date		Sockeye Salmon Total Run	
Year	Drift	Setnet	Drift	Setnet	Drift	Setnet	Pre-season Forecast	Actual
1992	27-Jun	27-Jun	10-Jul	10-Jul			4,600,000	5,187,351
1993	23-Jun	23-Jun	30-Jun	30-Jun	7-Jul	7-Jul	5,100,000	7,624,224
1994	2-Jul	2-Jul	9-Jul	9-Jul			5,300,000	5,881,064
1995	26-Jun	26-Jun	7-Jul	7-Jul			5,300,000	6,704,568
1996	24-Jun	24-Jun	10-Jul	10-Jul			5,800,000	8,303,614
1997	30-Jun	30-Jun					5,700,000	4,639,699
1998	5-Jul	5-Jul					5,300,000	5,402,866
1999	2-Jul	2-Jul	6-Jul	6-Jul			4,900,000	8,533,542
2000	28-Jun	28-Jun		12-Jul	17-Jul	14-Jul	5,490,000	8,484,050
2001	24-Jun	24-Jun		2-Jul	15-Jul	10-Jul	7,800,000	7,289,194
2002	28-Jun	27-Jun		29-Jun[d]			5,200,000	4,538,394
2003	22-Jun	23-Jun	24-Jun	24-Jun	12-Jul	29-Jun	6,700,000	8,907,474
2004	21-Jun	20-Jun	29-Jun	24-Jun[e]	17-Jul	1-Jul	7,300,000	8,232,466
2005	21-Jun	21-Jun	25-Jun	26-Jun[e]	17-Jul	30-Jun	7,400,000	10,090,869
2006	25-Jun	25-Jun	26-Jun	26-Jun	12-Jul	27-Jun	7,500,000	15,923,444
2007	25-Jun	24-Jun	5-Jul	25-Jun	15-Jul	6-Jul	8,900,000	10,604,183
2008	26-Jun	26-Jun	30-Jun	27-Jun	14-Jul	2-Jul	1,041,000	10,160,079
2009	23-Jun	22-Jun	24-Jun	23-Jun[f]	12-Jul	3-Jul	8,930,000	9,988,322
2010	25-Jun	25-Jun	9-Jul	8-Jul	15-Jul	12-Jul	10,600,000	11,100,363
2011	26-Jun	25-Jun	26-Jun	25-Jun[e]	9-Jul	2-Jul	9,500,000	6,922,015
2012	28-Jun	26-Jun	7-Jul	11-Jul	13-Jul	13-Jul	6,800,000	4,098,632
2013	22-Jun	21-Jun	22-Jun	21-Jun	5-Jul	25-Jun	5,100,000	5,648,859
2014	25-Jun	24-Jun	25-Jun	25-Jun	7-Jul	30-Jun	8,900,000	10,171,331
2015	22-Jun	21-Jun	27-Jun	27-Jun	9-Jul	3-Jul	8,100,000	8,987,563
2016	19-Jun	19-Jun	26-Jun	26-Jun	16-Jul	9-Jul	10,300,000	10,569,247
2017	22-Jun	21-Jun	22-Jun	22-Jun	6-Jul	26-Jun	8,300,000	20,027,749
2018	20-Jun	19-Jun	24-Jun	19-Jun	16-Jul	13-Jul	21,200,000	33,755,636
2019								

[a] Dates represent the day on which the Nushagak Section opened to commercial fishing for sockeye salmon. From 1992-1998, the entire district including Niushagak Section was opened to both gear types. Beginning in 1998, openings were established for each gear type and section independently.

[b] Dates represent the day on which fishing began to occur on an every-tide basis, regardless of number of hours fished per tide.

[c] Dates represent the day on which fishing was extended 'until further notice' by EO.

[d] After July 5, all fishing occurred in the WRSHA; the district did not re-open.

[e] A 1-tide break in fishing occurred for the drift fleet (July 5, 2004; June 30, 2005; July 1, 2001).

[f] Two breaks in fishing occurred for the drift fleet (June 27 and July 8, 2009).

Table 5. A chronology of significant sport fishing regulation changes for the Nushagak and Mulchatna rivers.

Effective year	Bay-Wide Sport	Nushagak-Mulchatna Sport	Nushagak-Mulchatna King Salmon Plan
1990		Season established from January 1 to July 25 upstream of and including the Iowithla River.	
1992		Gear restricted to single-hook artificial lures for the portion of the Mulchatna River between the Koktuli and Stuyahok rivers.	
1992			Nushagak and Mulchatna King Salmon Management Plan (5 AAC 06.361) is adopted. Sport harvest capped at 5,000 fish; escapement projection of 65,000 established as trigger for inseason restrictions in the sport fishery.
1994			Sport allocation set as aguideline harvest rather than a cap.
1997	Bay-wide annual harvest limit of 5 king salmon was adopted. Guides prohibited from retaining any species of fish while guiding.	Bag and possession limit reduced to 2 king salmon per day, only 1 over 28 inches. Annual harvest limit of 4 king salmon adopted for the entire Nushagak–Mulchatna drainage. Kokwok River and Nushagak River upstream from its confluence with Harris Creek closed to fishing for king salmon. July 31 spawning season closure adopted for Nushagak River drainage downstream of Iowithla River outlet.	Escapement projection of 55,000 king salmon established as trigger below which inseason restrictions in the sport fishery must be imposed.
2001	Anglers prohibited from removing king salmon from the water if the fish were to be released. Bag and possession limit for king salmon under 20 inches of 10 per day is adopted bay-wide except Nushagak drainage.		Allow a catch-and-release fishery when the final inriver abundance is projected to be below 55,000 fish but above 40,000 fish. Stipulates that when the king salmon sport fishery is restricted to catch-and-release or is closed for conservation, the use of bait must be prohibited.
2003		Bag and possession limit for king salmon under 20 inches of 5 per day is implemented on the Nushagak drainage. King salmon under 20 inches do not count toward the annual limit of 4 and are in addition to the bag limit for king salmon 20 inches or longer.	If inriver projections fall below 75,000, a bag limit of 1 per day, 1 in possession, no size limit, is implemented.
2012		From May 1 to July 31 only 1 single-hook or single-hook lure may be used and the use of bait is allowed UNTIL an angler harvests a daily bag limit of king salmon 20 inches or greater in length, then that angler can only fish with 1 UNBAITED, single-hook or single-hook lure for the remainder of that day.	Plan amended to reflect counts from the new dual frequency identification sonar counter.
2018			Repealed provisions (d)(2) and (3) directing the department to restrict the sport fishery if the projected inriver return falls between 55,000 and 95,000 king salmon.

Table 6. Emergency orders issued for the sport and subsistence fisheries under direction of the Nushagak-Mulchatna King Salmon Management Plan.

Year	Effective Date	Sport	Subsistence
1992			
1993			
1994			
1995			
1996	Preseason	Preseason: Bag and possession limit reduced from 3, 2 over 28 inches, to one of any size.	
	9-Jul	Catch and release only for king salmon.	
1997	Preseason	Bag and possession limit reduced from 3, 2 over 28 inches, to one of any size.	
	30-Jun	Catch and release only for king salmon.	
1998			
1999	30-Jun	Seasonal limit reduced from 4 to 2 fish.	
	2-Jul	Fishing for king salmon closed.	
	6-Jul	Season re-opened with seasonal limit of 2 fish.	
	2-Jul		Fishing in the Nushagak River drainage reduced to 3 days per week until August 1.
2000			
2001			
2002			
2003			
2004			
2005			
2006			
2007	7-Jul	Bag and possession limit reduced from 2, 1 over 28 inches, to one of any size.	
2008			
2009			
2010	27-Jun	Bag and possession limit reduced from 2, 1 over 28 inches, to one of any size.	
	30-Jun	Retention and use of bait prohibited.	
	5-Jul	Fishing for king salmon closed, bait prohibited.	
	6-Jul		Fishing in the Nushagak River drainage reduced to 3 days per week until August 1.
2011	24-Jun	Bag and possession limit reduced from 2, 1 over 28 inches, to one of any size. Annual limit reduced from 4 to 2 fish.	
	13-Jul	Annual limit restored to 4 fish.	
2012	28-Jun	Bag and possession limit reduced from 2, 1 over 28 inches, to one of any size. Annual limit reduced from 4 to 2 fish.	
	3-Jul	Annual limit restored to 4 fish.	
	7-Jul	Bag and possession limit restored to 2, 1 over 28 inches.	
2013			
2014	7-Jul	Bag and possession limit reduced from 2, 1 over 28 inches, to one of any size.	
2015			
2016			
2017	23-Jun	Bag and possession limit reduced from 2, 1 over 28 inches, to one of any size. Annual limit reduced from 4 to 2 fish.	
2018			
2019	3-Jul	Bag and possession limit reduced from 2, 1 over 28 inches, to one of any size. Annual limit reduced from 4 to 2 fish.	
	10-Jul	Retention and use of bait prohibited.	

Table 7. ADF&G Alaska Sport Fishing Survey summary of angler effort and harvest in the Nushagak drainage, 2006 - 2016.

	Angler Days[a]			Harvest[b]		
Year	Nushagak R.	Mulchatna R.	Total	Below Sonar	Above Sonar	Total
1992	10,031	6,028	16,059	1,844	2,911	4,755
1993	14,168	4,729	18,897	2,408	3,492	5,899
1994	15,460	6,230	21,690	4,436	6,191	10,626
1995	16,410	4,484	20,894	2,238	2,713	4,951
1996	16,584	3,806	20,390	2,346	3,045	5,390
1997	11,789	2,362	14,151	931	2,567	3,497
1998	17,480	3,142	20,622	1,640	4,188	5,827
1999	16,259	2,642	18,901	934	3,304	4,237
2000	18,285	2,306	20,591	1,389	4,628	6,016
2001	18,951	3,787	22,738	1,600	4,299	5,899
2002	13,396	2,807	16,203	1,193	2,500	3,693
2003	16,834	3,706	20,540	2,203	3,752	5,955
2004	18,869	2,218	21,087	2,567	4,339	6,906
2005	20,050	3,017	23,067	2,863	4,774	7,637
2006	20,045	3,947	23,992	3,166	4,307	7,473
2007	18,457	3,084	21,541	3,581	6,088	9,669
2008	14,936	1,553	16,489	3,305	3,395	6,700
2009	15,051	1,156	16,207	2,451	3,903	6,354
2010	9,668	879	10,547	1,659	2,248	3,907
2011	11,329	1,600	12,929	1,542	3,302	4,844
2012	14,973	1,573	16,546	1,833	4,098	5,931
2013	16,082	1,415	17,497	1,971	4,714	6,685
2014	17,576	1,338	18,914	2,369	3,891	6,260
2015	13,766	2,949	16,715	2,514	4,720	7,234
2016	17,737	1,169	18,906	3,053	5,358	8,411
2017	13,299	1,806	15,105	2,834	2,837	5,671
2018						
2019						

[a] Alaska Sport Fishing Survey database [Internet]; 1996-2017, Howe et al.(1996); 1995; Howe et al.(1995); 1994, Mills (1994); 1993, Mills (1993); 1992.

[b] Dye and Borden, 2018.

Table 8. ADF&G Freshwater logbook summary of guided sport fishing in the Nushagak drainage, 2006 - 2016.

Year	Businesses	Guides	Trips	Clients[a]	Client Days	Crew Days[b]	Harvest[c]
2006	65	247	3,422	2,971	9,960	395	
2007	62	250	3,147	2,891	9,111	124	4,324
2008	60	240	3,140	2,836	9,259	143	4,621
2009	52	183	2,163	1,931	6,309	124	3,030
2010	47	155	1,697	1,401	4,715	136	1,567
2011	47	168	1,864	1,895	4,970	74	2,140
2012	46	189	2,504	2,299	7,105	102	3,827
2013	47	217	2,932	2,553	8,096	174	3,823
2014	51	215	3,066	2,883	8,760	181	4,095
2015	50	227	3,492	3,091	9,903	193	4,613
2016	53	234	3,186	2,770	8,934	159	4,273

[a] Clients excludes youth anglers and anglers without a sport fishing license written. Crew is also excluded, since they aren't clients.

[b] Crew days are the number of days crew fished and excludes client days.

[c] Source: Dye and Borden (2018)

Table 9. Nushagak River drainage subsistence fishery parameter estimates, 1992-2017.[a]

Year	Subsitence Permits Issued	King Salmon Harvest	Harvest/ Permit
1992	476	13,588	29
1993	500	17,709	35
1994	523	15,490	30
1995	484	13,701	28
1996	481	15,941	33
1997	538	15,318	28
1998	562	12,258	22
1999	548	10,057	18
2000	541	9,470	18
2001	554	11,760	21
2002	520	11,281	22
2003	527	18,686	35
2004	511	15,610	31
2005	502	12,529	25
2006	461	9,971	22
2007	496	13,330	27
2008	571	12,960	23
2009	530	12,737	24
2010	528	9,150	17
2011	525	12,461	24
2012	517	10,350	20
2013	582	11,567	20
2014	581	16,049	28
2015	591	12,117	21
2016	613	15,735	26
2017	562	11,060	20
Mean 92-96	493	15,286	31
Mean 13-17	586	13,306	23

[a] Source: Halas and Neufeld (2018)

Table 10.–Chinook salmon commercial, subsistence, sport harvest, and escapement for the Nushagak River drainage, 1989–2019.[a]

		Harvests Below Sonar				Harvests Above Sonar		
Year	Total Run	Commercial	Subsistence	Sport	Inriver Sonar estimate	Subsistence	Sport	Spawning Escapement
1992	229,469	47,563	7,688	1,844	172,374	2,499	2,911	166,964
1993	279,443	62,976	10,552	2,408	203,508	2,919	3,492	197,097
1994	332,388	119,480	8,829	4,436	199,643	6,661	6,191	186,792
1995	268,137	79,943	7,810	2,238	178,146	5,891	2,713	169,542
1996	192,011	72,123	9,086	2,346	108,456	6,855	3,045	98,557
1997	165,205	64,390	8,731	931	170,610	6,587	2,567	82,000 [b]
1998	370,908	117,820	6,987	1,640	244,461	5,271	4,188	235,003
1999	147,530	11,178	5,732	934	129,686	4,325	3,304	122,058
2000	136,194	12,120	5,398	1,389	117,288	4,072	4,628	108,588
2001	212,037	11,746	6,703	1,600	191,988	5,057	4,299	182,632
2002	228,969	40,039	6,430	1,193	181,307	4,851	2,500	173,956
2003	222,846	43,485	10,651	2,203	166,507	8,035	3,752	154,720
2004	350,407	96,759	8,898	2,567	242,183	6,712	4,339	231,132
2005	306,892	62,764	7,142	2,863	234,123	5,387	4,774	223,962
2006	218,413	84,881	5,683	3,166	124,683	4,288	4,307	116,088
2007	123,469	51,831	7,598	3,581	60,459	5,732	6,088	48,639
2008	126,990	18,968	7,387	3,305	97,330	5,573	3,395	88,362
2009	115,884	24,693	7,260	2,451	81,480	5,477	3,903	72,100
2010	93,116	26,056	5,216	1,659	60,185	3,935	2,248	54,003
2011	143,850	26,927	7,103	1,542	108,278	5,358	3,302	99,618
2012	195,581	11,952	7,711	1,833	174,085	2,639	4,098	167,348
2013	133,246	10,213	6,613	1,971	113,709	4,989	4,714	104,746
2014	95,091	11,862	10,378	2,369	70,482	3,790	3,891	62,801
2015	159,695	50,675	8,487	2,514	98,019	2,209	4,720	91,090
2016	163,268	23,783	11,064	3,053	125,368	1,933	5,358	118,077
2017	99,648	32,194	7,659	2,834	56,961	1,826	2,837	52,298
2018		35,243			97,239			
2019		20,783			46,763			
Average								
1992-1996	260,289	76,417	8,793	2,654	172,425	4,965	3,670	163,790
2013-2017	149,376	25,745	8,840	2,548	92,908	2,949	4,304	85,802
1992-2017	196,565	46,785	7,800	2,264	142,743	4,726	3,906	131,084
Percent								
1992-1996		79%	9%	3%		5%	4%	
2013-2017		58%	20%	6%		7%	10%	
1992-2017		71%	12%	3%		7%	6%	

[a] Source: 1992-2018; Dye and Borden (2018) with the following exceptions: inriver sonar estimates for 2007, 2008, 2010, and 2011 are from Buck et al. (2012) and for 2012 are from Salomone et al. (2019), corresponding spawning escapement and total run estimates reflect the exceptions, 2019; September 17, 2019 ADF&G News Release.

[b] Spawning escapement estimated from inriver sonar abundace less upriver harvest for all years except 1997. 1997 estimate