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HISTORY AND MANAGEMENT

OF THE

NUSHAGAK CHINOOK SALMON FISHERY

By

Michael L. Nelson
Management Biologist

ALASKA DEPARTMENT OF FISH AND GAME
DIVISION OF COMMERCIAL FISHERIES
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PREFACE

The concept for the attached chinook salmon document was originally framed in 1968, and a rough draft of collected data was completed in 1969. Fishery statistics were updated frequently, and a complete reorganization of the data, and outline was prepared for the final draft in 1987.

This document emphasizes a descriptive account of the history and administration of the Nushagak chinook salmon fishery. Management objectives and procedures are outlined, and recommendations for future program direction are included. The basic objective in producing this document is to assist in creating a better understanding of the chinook salmon management program in Nushagak District.

This document is being placed into the Bristol Bay Data Report series, which has a limited distribution, as there is insufficient time to prepare this manuscript for the Department's Informational Leaflet series. Upon the retirement of this author in April of 1987, the report will undergo extensive editing for inclusion into the Informational Leaflet series, which has a wide distribution. In the meantime, the attached report represents the Bristol Bay staff's continuing, and most recent effort to describe fishery statistics and information useful for management of this important resource.

ABSTRACT

The chinook salmon (Oncorhynchus tshawytscha) resource of the Nushagak watershed in Bristol Bay is a valuable commercial, subsistence and recreational sport fishery. Chinook are caught by commercial and subsistence gill net fishermen in tidal waters, and by freshwater subsistence and sport fishermen as the fish enter the Nushagak River and make their way upstream to spawn. The commercial and subsistence gill net fisheries have been subject to progressively more stringent regulations as greater fishing pressure has been exerted on the resource. In an effort to provide for future recommendations regarding fishing regulations, present conservation measures and other pertinent historical information on the Nushagak chinook stocks were reviewed.

Salient points defined from this review were: (1) commercial development of the Nushagak chinook fishery accelerated rapidly, once exploitation of the area's sockeye salmon resource was begun; (2) drift gill nets became the primary commercial capture gear, and net mesh size and depth were found to directly influence exploitation rates and both quantity and quality of the escapement; (3) drift gill net gear accounts for the majority of the commercial chinook catch, and recent commercial and subsistence exploitation rates have been exceeding 95% of the early-run chinook stocks; (4) chinook catch per unit of effort is variable, with recent increases due to additional fishing effort and larger run size; (5) chinook run timing through the fishery was shown to be fairly regular with distinct peaks, but fish often hold within and above the fishing district, creating management related problems in obtaining escapement through time; (6) commercial chinook catches show a bimodal seasonal pattern, which was shown to be directly attributable to the established fishing schedule; (7) Nushagak chinook are intercepted by the Japanese high seas gill net fishery, and inshore returns may increase by 30,000 to 60,000 fish when the high seas fishery in the central Bering Sea is eliminated; (8) the subsistence gill net fishery is expected to continue at near record levels and effort, and the high chinook catch levels are expected to remain independent of stock abundance; (9) the sport recreational fishery is growing rapidly, and the potential exists for increased friction between the major user groups; (10) escapement studies on Nushagak chinook stocks show that the watershed escapement has averaged 82,000 fish, with a provisional escapement range of 50,000 to 100,000 chinook established, a value that has been met in most years; (11) an official optimum escapement goal will not be established until recent large chinook escapements are included into the data base, however, indicated returns through 1978 show an optimum value of 61,000 fish; (12) the chinook gill net fishery shows considerable selectivity by age, size and sex, and the majority (80%) of Nushagak chinook return as 5 and 6 year old fish, with the proportion of males to females increasing with the use of smaller mesh gear; (13) fecundity studies indicate that the Nushagak chinook stocks rate among the highest fecundities recorded on the Pacific Coast of North America; (14) mesh size regulations in the past have been related to sockeye salmon management, and not any biological considerations for chinook, and recent use of inseason mesh size restrictions shows promise in efforts to limit exploitation of large fecund females; (15) the total chinook return to Nushagak District was shown to average 125,000 fish from 1966 to 1977, and 246,000 from 1978 to 1986, while exploitation rates have ranged between 29% and 72%, averaging 54% from 1966 to 1986; and (16) the Nushagak management program is discussed and recommendations for future program studies are addressed through research and development of optimum escapement objectives, methods for accurately estimating escapement, and methods for achieving escapement objectives.

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INTRODUCTION AND BACKGROUND

Commercial exploitation of Nushagak Bay salmon was initiated in 1884, and development of fisheries within other major Bristol Bay watersheds following. By 1985, all of the major fishing areas of Bristol Bay were being exploited (Rich and Ball, 1928). The development of the fishing industry in Bristol Bay was directed at this region's vast sockeye salmon resource, and harvests of other species of salmon were either incidental to the sockeye fishery, or were precluded in the developmental phase of the fishery by restrictive regulations then in force, and lack of viable markets.

As the fishing industry developed, other species of salmon were targeted for exploitation. The chinook salmon (Oncorhynchus tshawytscha) resources of the Nushagak watershed now support a major commercial fishery, as well as growing sport and subsistence interests. However, as the Nushagak salmon fishery developed, annual harvest variations became more apparent. Overall production in this area was fairly stable until the early 1920's, when sockeye production began to decline. Chinook salmon production was also reduced, as the effort to reverse the downward trend of the sockeye fishery was implemented and economic factors adversely affected interest in chinook stocks.

To a large extent, the Nushagak chinook salmon fishery has developed on the back of the sockeye resource; however, the chinook resource is of major value to many user groups. Commercial gill net fishermen have traditionally extracted a heavy toll from the total run, while freshwater sport fishing interests are growing rapidly. The commercial and subsistence gill net fisheries have been subject to progressively more stringent regulations as greater fishing pressure is exerted on the resource. With these expanding pressures, there is growing concern that spawning escapements may be jeopardized, and that the natural productivity of the system cannot be maintained.

There is a clear need for a careful, quantitative appraisal of fishery impacts and of regulatory options that might be implemented to maintain or increase productivity, while at the same time minimizing or balancing hardships among resource users.

To provide a basis for future recommendations regarding fishing regulations, present conservation measures and other pertinent information on the Nushagak chinook salmon stocks and the fisheries which depend on them are reviewed in this report. Past management actions, as well as a historical review of the chinook fishery since 1893, are summarized to provide a basis of understanding for the management of this important resource.

NUSHAGAK BAY AND WATERSHED

PHYSICAL PROFILE

The Nushagak drainage, as defined in this report, is an area of approximately 14,000 square miles located in southwestern Alaska (Figure 1). The region's topography is extremely varied, extending from the coastal lowlands of Nushagak Bay on the Bering Sea to the Kilbuck and Ahklun Mountains, whose summits rise to an elevation of 2,000 to 5,000 feet. The Wood River-Tikchik Lakes system is composed of long, narrow glacial lakes separated by steep-walled mountains ranging in elevation from 3,000 to 5,000 feet. The lakes and rivers of this area drain into Nushagak Bay via the Wood, Nuyakuk and Nushagak Rivers. Two other trunk streams also drain into Nushagak Bay, the Snake and Igushik River systems. The Nushagak Hills and Taylor Mountains are low, rolling hills that form the northern border of the region. The Nushagak (locally referred to as Main River) and Mulchatna River basins are broad and relatively flat, containing many ponds and lakes that increase in number nearer the coast.

Nushagak Bay includes the inland waters between a line drawn offshore from the eastern side of Cape Constantine, near Protection Point, to Etolin Point on the eastern side of Nushagak Bay (Figure 1). Tides in the shallow bay are influenced by the strong Bering Sea currents, and a significant portion of the Bay's water is exchanged daily.

MORPHOMETRIC AND CLIMATOLOGICAL PARAMETERS

The morphometric parameters of some of the more important salmon-producing lakes are shown on Table 1. Seven major freshwater river systems are located within the watershed, including the Nushagak and Mulchatna, which are major contributors to the chinook salmon resource of this region (Table 1).

The Bristol Bay region is close to the Bering Sea and the North Pacific Ocean and this proximity has a moderating effect upon the climate. Unlike parts of interior Alaska, the Bristol Bay region is not subject to severe annual fluctuations in temperature. Snowfall is moderate, as is the annual precipitation. Summers are cool and include many cloudy days, especially along the coast. Freeze-up occurs any time after the first of October, generally in the first part of November. Many of the winter days are cloudy with a resultant warming of the region. Severe winter winds are frequent. Break-up generally occurs in May, and the larger rivers are ice free by early June.

Climatological records, as maintained in Dillingham, show a mean temperature ranging between 33.5 to 34.1 degrees F, with temperature extremes of 89 degrees F (high) and -54 degrees F (low). The average annual rain and snowfall amount to about 26 inches and 65 to 81 inches, respectively (Table 1). Winds are generally northerly from October to March and most frequently from the southerly directions during late spring, summer and early fall. Lakes throughout the Nushagak watershed can be expected to be frozen over between late November and early May. Nushagak Bay itself never freezes up but becomes impassible due to packed ice.

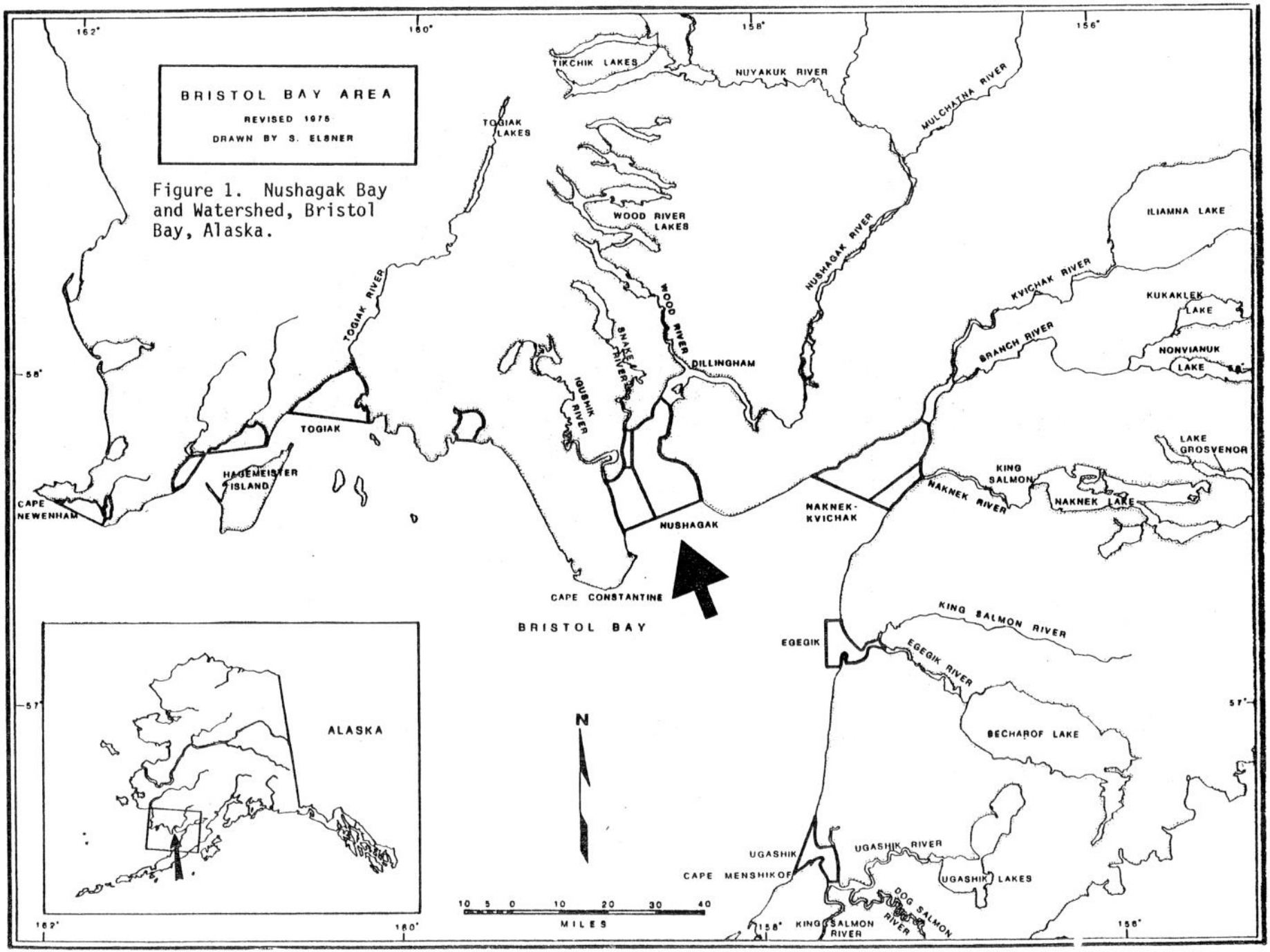

Figure 1. Nushagak Bay and Watershed, Bristol Bay, Alaska.

CHINOOK SALMON COMMERCIAL GILL NET FISHERY

In North America, chinook salmon (commonly called king salmon in Alaska) spawn in rivers and streams emptying into the Pacific Ocean from San Francisco Bay, California to the Wulik River in Kotzebue Sound of Alaska beyond the Bering Strait (Major, 1978).

In western Alaska, the chinook salmon resource is of significant importance to subsistence and local economies. Over 90% of the total western Alaska subsistence and commercial harvest of chinook is from the Nushagak, Kuskokwim and Yukon Rivers (Meacham, 1980).

The first significant reported commercial harvest of chinook salmon in Nushagak District was in 1893. Present day harvest rates (1960-86) show the Nushagak District commercial fishery accounting for 13% of Alaska's production of chinook, 29% of chinook production from western Alaska and 70% of Bristol Bay production (Tables 2 and 3). The Nushagak District watershed produces the state's second largest chinook salmon fishery that is stock-specific, nearly matching production from the Yukon River.

HISTORY OF FISHERY DEVELOPMENT

The commercial fishery for sockeye salmon in Bristol Bay began in 1884, after an initial exploratory salting effort was conducted in 1883 (Moser, 1902). Prior to this time, some salting (800 to 1,200 barrels) was done by fishermen operating a trap in Nushagak River. The first recorded salmon catch was in 1884, but it wasn't until 1893 that salmon catches were reported by species and number of fish (Rich and Ball, 1928). Although the target salmon specie and main emphasis for this fishery was sockeye salmon, the commercial harvest of chinook salmon accelerated rapidly once development began.

From the onset of the fishery in Bristol Bay until the mid-1940's, the only methods employed by the industry to process salmon were canning, cured salteries and minimal smoked product (Appendix Table 1). In 1946, the first recorded floating freezer began operating in Nushagak Bay, and in 1964 the first recorded fresh fly-out processor began operations. Canned chinook salmon amounted to over 79% of the commercial production through 1971. Emphasis on fresh and frozen production of chinook began to emerge between 1972 and 1976 when only 38% were canned and over 62% were either flown out fresh or frozen by floating and/or shore-based processors. From 1977 to the present, over 91% of chinook commercial production in Nushagak Bay are in the fresh/frozen category (Appendix Table 2).

The rapid growth of the salmon fishery in Bristol Bay went virtually unchecked (and uncontrolled) through the mid-1920's. The number of canneries increased until 25 were in operation in 1920, eight of which operated on Nushagak Bay (Appendix Table 1). Throughout the period from 1910 to 1920, numerous warnings by Federal fishery officials, of the apparent over-harvest of salmon stocks, were increasingly beginning to appear in print. Although most comments about this "resource crisis" were directed toward sockeye salmon, the overall potential adverse impact on all salmon stocks was apparent. Excerpts from a "Special

Investigation of the Salmon Fishery in Central and Western Alaska" highlight the early-year concerns over the long-term fate of this fishery (Gilbert and O'Malley, 1919):

> ----"these stocks have been drawn on heavily since the earliest days of the salmon industry in Alaska----the principal salmon districts in Western Alaska were already occupied----and have been assiduously fished for 30 years or more----the question of how well the salmon stocks have sustained the extractions of the commercial fisheries during this long-term of years is pertinent----the Bureau of Fisheries should at once proceed to gather----a well planned body of data----to protect and maintain the fisheries, for without this data we are groping in the dark----since the beginning of the Great War (World War I) unlimited demand for canned salmon and unheard of prices for all grades----we have seen an unexampled expansion of the business----the present administration of the fisheries appears based on the expectation that men will hold back their hands where a further profit can be made, but it is witless to expect them to do so----total exhaustion of the fisheries will occur, if not tomorrow, then the day after----not only are our fishery statutes now pitifully inadequate, but they are unusually and unnecessarily made difficult to enforce----fishing has always been freely permitted, practically without restrictions, in all these streams (Bristol Bay)----the amount of gear employed has more than doubled and the fishing grounds have been pushed farther and farther into the open bay----harvest levels have not been arrived at through any reasonable process----no precautions, whatever, were taken in the matter, everything was haphazard, in accordance with the customary policy----and all the fish which could be caught were taken without any heed to the future----it was known that it was impossible to catch them all, and it was vaguely hoped, if the matter was given thought at all that, whatever be done, enough would escape to keep the run going----fishing was conducted without limitations of any kind----the amount of gear was limited only by what could be profitably employed----fishing was permitted in all rivers as well as in the open bay----there was no closed season----"

With the foregoing litany of examples of gross mismanagement of this resource, it's remarkable that Bristol Bay production held up for as long as it did. Nushagak stocks of chinook salmon were also fortunate in that the majority of the incoming run arrived before the sockeye fishery began in earnest. This advanced run timing factor, as well as the smaller magnitude of chinook stocks, which attracted less interest than sockeye in Bristol Bay, helped the chinook salmon stocks survive the frenzy of the developmental period of this fishery.

HISTORICAL REVIEW OF FISHERY METHODS, REGULATIONS AND MANAGEMENT

The following section gives a general historical description of the Nushagak chinook salmon commercial fishery in terms of fishing methods and gear restrictions, area and boundary restrictions, past fishery regulations and management actions that have affected the development of the fishery.

Fishing Methods

Both gill nets and fish traps were used by the early operators to secure fish for canning and salting. The strong currents, narrow channels and soft muddy beaches favored gill netting over seining. Both fish traps and seining were prohibited by law in 1924 (Appendix Table 4). Use of fish traps peaked in 1906, when 14 traps were in operation in Nushagak District (Appendix Table 6). Fish traps were not effective on chinook salmon due to the salmon's mid-channel and early season migration tendencies. In 1906, Nushagak traps were installed "about June 20", when between 50% to 60% of the commercial chinook catch is already accounted for (Bureau of Fisheries, 1905-26).

Concern for escapement, and especially for diminished success of subsistence personal use fishermen, led to increased pressure to eliminate this form of capture gear. By the early 1920's, most traps had been phased out, and were no longer a major contributor to the commercial harvest. Fishing traps were initiated for two primary reasons: (1) to help augment pack guarantees when gill net fishermen were unsuccessful in providing the required number of salmon (primarily sockeye); and (2) to assist the fishery operators in acquiring legal ownership to large amounts of prime waterfront real estate. With land ownership firmly in place by the 1920's, and increasing pressure to close traps in Bristol Bay to protect escapement and subsistence use, the prohibition of traps, beginning in 1924, was effected without a great deal of adverse reaction (Bureau of Fisheries, 1905-26).

Fishing Gear

Gill nets went on to become the primary capture gear for all salmon species in Bristol Bay, after seines were prohibited in 1924, and trolling gear was finally prohibited in 1974 after numerous attempts to develop a troll fishery. Gill nets in Bristol Bay take two forms - stationary or anchored nets called "stake or set nets", and free floating nets called "drift nets".

Early records indicate that gill nets used on Nushagak Bay were of two sizes, one for chinook salmon and one for sockeye and coho salmon (Alexander, 1890). Chinook salmon nets were reported by Alexander in 1890 to be 100 fathoms long, 30 meshed deep and measured 9-1/2 inches stretch measure, while the smaller sockeye/coho nets were 75 fathoms long, 24 meshes deep and measured 6-1/2 inches stretch measure. In 1900 the following references to gear specifications were summarized from a report entitled "Salmon Investigations of the Steamer Albatross in the Summer of 1900" (Moser, 1902):

----"dimensions of the nets vary according to the depth of water and the individual ideas of the different cannery superintendents----for redfish (sockeye) the length varies from 75 to 80 fathoms, the depth from 20 to 26 meshes, and the mesh from 6-1/8 to 6-1/4 inches stretch measure---- for chinook salmon the length is from 120 to 125 fathoms, the depth 24 meshes, and the mesh 9-1/4 inches stretch measure----one company (Alaska Fishermen's Packing Company) used chinook nets that were 70 fathoms long, 22 meshes deep and were 10 inches stretch measure----(another) company used chinook nets in 1897 that were 100 fathoms in length, 20 meshes deep, and were 8-1/2 inches stretch measure----"

The length of gill net and mesh size varied from year to year according to the will of the cannery operators until 1923, when the Bureau of Fisheries enacted the first prohibitive restrictions on gill net length and mesh size (Appendix Table 4).

Gill net specifications for chinook salmon gear has evolved to the present time, where the "standard" gear favored by most fishermen is 150 fathoms in length, 28 meshes deep, and 8-1/4 to 8-1/2 inches stretch measure. Both maximum length and depth of mesh is regulated by law; however, maximum mesh size is the preference of individual fishermen. Minimum mesh size for chinook gear was set at 8-1/2 inch stretch measure in 1923, and remained in effect until 1960-61, when the minimum mesh size was reduced to the same minimums established for sockeye salmon nets, 5-1/2 and 5-3/8 inches, respectively (Appendix Table 5).

From 1968 through 1972, minimum mesh size varied from 5-3/8 to 7 inch stretch measure. Fishery managers were in favor of a smaller minimum mesh size to allow a higher harvest of excess male jack chinook salmon (age 4(2)), while individual fishermen and fishermen associations favored larger mesh, claiming there was "less drop-outs" in larger gear. Although many fishermen believe the "drop-out logic", this author, who has 25 years of experience with the Nushagak chinook salmon fishery, has yet to observe "significant" drop-out of chinook in small mesh gear. In all probability, the main factor prompting support of larger minimum mesh sizes, was to minimize the sockeye salmon catch during the early chinook season while sockeye price negotiations were taking place.

By the mid-1970's, fishing effort had begun to increase dramatically, and both fishing area and time were reduced to effect a lower exploitation rate on Nushagak chinook stocks. With reduced fishing area and time, the present 6-3/4 inch minimum mesh size effectively separates the two major gear sizes presently in use: chinook gear---from 8 to 8-1/2 inches, which maximizes the harvest of chinook, especially the older age groups, and minimizes the harvest of sockeye salmon; and sockeye gear---from 5-1/8 to 5-1/2 inches, which maximizes harvest of sockeye and smaller jack male chinook, while minimizing the catch per unit of effort (CPUE) of large chinook salmon.

In 1985 and again in 1986, field emergency order authority was used to modify the mesh size gear schedule. In both years the chinook salmon run exhibited a late run timing sequence, and appeared to be weak, or a combination of both factors. Subsequent fishing periods prohibited the use of large mesh chinook gear, thereby lessening the catch of larger chinook salmon.

Of equal importance to mesh size is the issue of mesh depth. Other than mesh size, perhaps no factor has had a greater effect on catch per unit of effort. Nushagak Bay is relatively shallow, and the chinook salmon milling and holding migratory characteristics can substantially effect catch rates, especially when weather and sea conditions are calm. Chinook often hold within the district during the early part of the season. The present 28 mesh deep restriction very effectively reduces the exploitation rate within the district. Very little information on depth of chinook nets is found in existing literature. Alexander (1890) references 30 mesh deep nets, while Moser (1902) speaks to nets of 22-25 meshes deep.

Apparently the depth of mesh for chinook gear closely followed the 28 mesh restriction for sockeye nets that was enacted in 1925. Throughout the 1930-40's, economic factors brought about a sharply curtailed fishing effort on Nushagak chinook, and there was little incentive to develop more effective fishing gear. With the end of World War II, and the advent of freezing operations in the Nushagak region in 1946, interest began to be directed toward more effective fishing gear to catch chinook.

In 1949 and 1950, several Nushagak fishermen experimented with deeper mesh nets by removing the lead line from one net and combining with another gill net to produce a 56 mesh deep net (Harvey Samuelsen, personal communication). Although overall success was limited, these modified nets, which were 9 to 9-1/2 inches stretch measure were more effective during calm weather than the standard depth nets.

By 1955-56, more Nushagak fishermen were experimenting with deeper mesh gear. In 1955, one fishermen group (fishing for the freezer ship "Reefer King") employed the use of deep mesh gear, which ranged from 36 to 50 meshes deep. The nine boats that used deep mesh gear for this group achieved the highest season catch per unit of effort (452 chinook per season) compared to the other five major operators, whose 196 fishermen achieved a season catch per unit of effort of 253 chinook (John "Jack" Lowman, personal communication). Beginning in 1955, commercial interest in chinook began to accelerate rapidly, as fishermen became more effective with deeper mesh nets (Appendix Table 7).

Chinook salmon migratory routine is apparently to follow the deeper water channels into the district, and the numerous sand/mud bars direct and divert chinook into the channels where deep mesh nets are more effective. In 1968, Jack Lowman, a long-time (1950-84) Nushaghak chinook fisherman, attributed the increased catches to the use of deep mesh nets (and increased effort), and felt that the 28 mesh restriction placed on chinook nets in 1958 was the primary regulation that slowed the rapid exploitation of Nushagak chinook.

By 1957 it was recognized by Federal fishery managers that "with the increased fishing effort a greater amount of closed time was necessary in order to maintain the chinook runs and to allow a portion of the run to escape to the spawning grounds" (Fish and Wildlife Services, 1931-59). In an effort to maintain the chinook runs, weekly fishing time prior to June 22, in 1958, was reduced by 36 hours and chinook nets were limited to 28 meshes in depth. The depth restriction initiated in 1958 is still in effect, and is considered to be an essential component of the regulatory management program for Nushagak chinook salmon.

Fishing Vessels

Fishing vessel use history in Bristol Bay and Nushagak District was wholly predicated upon the sockeye salmon fishery. The early gill net fishing boats were 25 foot Columbia River double-enders with a centerboard and spirit sail. These two-man boats were gradually improved in design, and in 1922 the first power boats were brought into Bristol Bay. Purse seine vessels were introduced that same year (1922) and they made excellent catches about 25 miles offshore from the Egegik District (Kallenberg, 1952).

Effective in 1924, both power boats and seiners were prohibited in Bristol Bay (Appendix Table 4). The less maneuverable and slower sailboat was less efficient at finding and catching fish; however, cannery operators were able to circumvent the power restriction by means of power scows (monkey boats) that towed sailboats to and from the fishing grounds (VanStone, 1967). In 1949, previous tradition was broken when two operators in the Naknek-Kvichak District, which was closed to fishing, towed their fishing boats down into the Egegik District and began receiving fish on their power scows (Fish and Wildlife Service, 1931-59). This episode rang the death-knell for sailboats in Bristol Bay, and in 1951, power boats were allowed into the fishery, along with a 32 foot maximum overall length which also became effective (Appendix Table 4).

Fishing Area and Seasons

Salmon management in Bristol Bay has been based on the premise that salmon homing to different river systems constitute individual production units or stocks. The individual fishing districts have been intentionally confined to areas as near as practical to the river mouths in order to minimize the interception of salmon destined for other, adjacent river systems. Specific river stock management is highly desirable and the physical geography of Bristol Bay is advantageous in this regard.

Prior to 1927, there were virtually no boundary restrictions for the Nushagak salmon fishery, and those regulations that were on the books were not enforced. The first effective (and enforceable) boundary restriction was the prohibition of fishing within the Wood and Nushagak Rivers in 1908 (Appendix Table 3). Prior to the Wood/Nushagak River closures, fishing within the rivers was common:

> ----"for many years after canning operations began, Nushagak River was regularly fished as far upstream as Angel Bay , 30 miles above the present limit stake----numbers of gill nets operated in lower reaches of the river, some to the full width of the river---- gill netters operated principally in the lower Bay in 1906, but some go as high up as Lewis Point on the Nushagak River and 10 miles up Wood River" (Bureau of Fisheries, 1905-26 and Batts and Fischler, 1967).

The complete history of fishing area and boundary locations is shown on Figure 2 and Appendix Table 3. Major boundary restrictions and relocations affecting management of Nushagak chinook salmon include:

1908 - fishing prohibited within Nushagak River, which is the primary chinook salmon producer in this region;
1927 - fishing prohibited within the inner bay, except for set net gear;
1928 - fishing was prohibited in outside waters of Nushagak Bay;
1951 - fishing with set net gear prohibited above the inner boundary established in 1927; and
1960 - fishing permitted south to the "chinook salmon line".

Traditionally, the Nushagak commercial chinook salmon fishery has commenced in late May to early June. Weekly fishing time allowed prior to the sockeye season, up through the mid-1970's was liberal, with fishing schedules generally showing a 5 day-per-week fishery and a 2 day weekend closure (Appendix Table 5). However, as more and effective effort began to target on the chinook fishery, the 5 day weekly schedule was modified to provide less fishing time. Present day regulations show a 5 day weekly schedule up to June 16, when the fishery is closed unless specifically opened for fishing by field emergency order announcement. In addition, since the late 1970's, additional closures have been necessary prior to June 16. With the continuing unabated commercial fishing pressure on Nushagak chinook stocks, plans in 1987 call for: (1) prohibiting commercial fishing prior to June 1; (2) prohibit fishing south of the existing "sockeye salmon boundary line" at any time; and (3) replacing the 5 day weekly schedule prior to June 16 with a 3 day fishing schedule. Depending upon the success of these measures, further steps to provide additional protection to chinook stocks, may include the complete elimination of the pre-set weekly fishing schedule, and replacement with a fishing schedule announced by field emergency announcement.

Effects of Past Management Actions

Prior to 1923, Bristol Bay fishery regulations were virtually non-existent. The only restrictive regulation that influenced harvest rates was the closure of Wood and Nushagak Rivers to commercial fishing in 1908. The first effective restrictive regulations began to appear in 1924: powerboats were banned, gill net mesh size, depth of nets and amount used were regulated, salmon traps and seines were prohibited, weekly closed periods were initiated, and restrictive boundary regulations followed beginning in 1927 (Appendix Tables 3, 4 and 5). The early Bristol Bay fishery prior to 1924 was essentially a quota fishery, and was limited only by the canning capacity of the industry.

During this developmental period, the Nushagak chinook salmon resource was exploited heavily, but due to earlier run timing and the fishing industry's emphasis on sockeye salmon, the chinook resource apparently remained in a healthy condition. From the late 1920's until the 1950's, economic conditions curtailed interest in the chinook salmon resource, and no regulatory actions were implemented that materially affected chinook stocks. Beginning in the 1950's, effort was again directed specifically toward Nushagak chinook salmon.

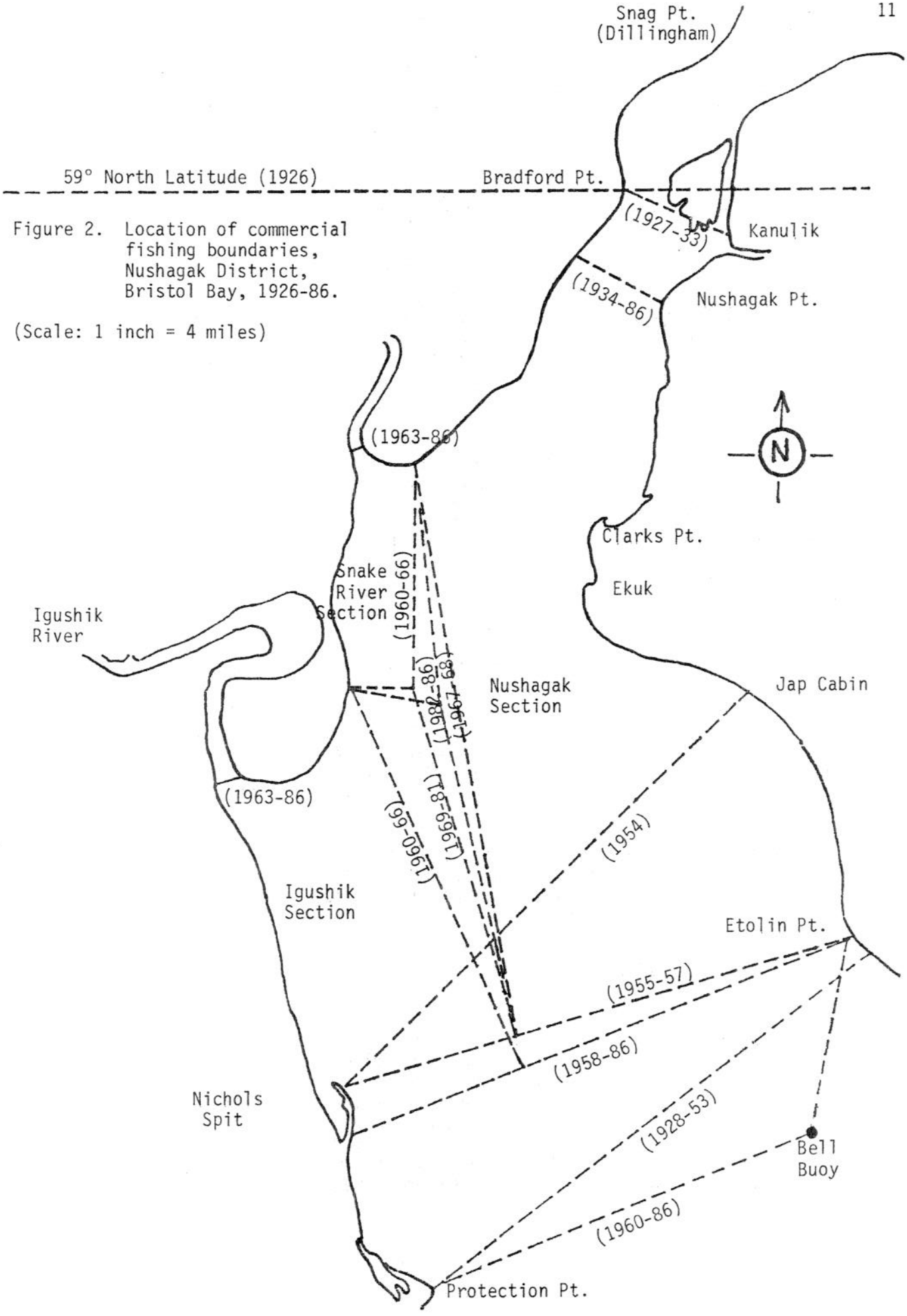

Figure 2. Location of commercial fishing boundaries, Nushagak District, Bristol Bay, 1926-86.

(Scale: 1 inch = 4 miles)

By the late 1950's increased efficiency through the use of deeper mesh gear, prompted the Federal fishery authorities to prohibit the use of gill nets deeper than 28 meshes (Appendix Table 4).

Gill net mesh size restrictions went through numerous changes between 1960 and 1972 that directly affected chinook exploitation:

1960 : minimum mesh size was reduced to 5 1/2 inch stretch measure (from 8 1/2 inch);
1961-67: minimum mesh size further reduced to 5 3/8 inch stretch measure;
1968-69: minimum mesh size increased to 7 inch stretch measure;
1970 : minimum mesh size returned to 5 3/8 inch stretch measure; and
1972 to present: minimum mesh size increased to 6 3/4 inch stretch measure (Appendix Tables 4 and 5).

The more significant of the gill net regulation changes was the limit on mesh depth. This single prohibition probably was chiefly responsible for slowing the rapid exploitation on Nushagak chinook. As commercial, subsistence and the relatively new sport fishing interests, continued to expand into the 1970's, exploitation was modified by additional time closures, and effective for the first time in 1985, inseason adjustment of gill net mesh size was accomplished to attempt to lower the catch per unit of effort on chinook.

COMMERCIAL CATCH

The available catch statistics for the early years between 1884 and 1892 of the salmon fishery in Bristol Bay are unsatisfactory in that they give records of the case pack only, without reference to species, so that estimates of the specie catch from case pack records are impossible to retrieve. Beginning in 1893, however, the annual reports of the special agents of the U.S. Treasury Department gave the number of fish caught in each district of Bristol Bay and, in 1904, the Bureau of Fisheries continued the collection of catch statistics in a fairly complete manner (Rich and Ball, 1928).

The Bureau of Fisheries (reorganized and renamed the Fish and Wildlife Service in 1940) maintained the catch statistics file in Bristol Bay until statehood, when the Alaska Department of Fish and Game (ADF&G) assumed the responsibility for fishery management in Bristol Bay.

Inshore Catch and Effort Trends

Nushagak chinook salmon catches exhibit strong annual variations (Figure 3). Part of this variability can be explained by differences in fishing effort, which reflect the economic conditions of the times. Viewed over ling time periods, however, annual catches can and do reflect changes in stock strength.

Since the beginning of the Bristol Bay fishery, Nushagak chinook salmon have contributed substantially to the overall production of Alaska chinook salmon, with the exception of a period of roughly 20 years extending from the early 1930's to

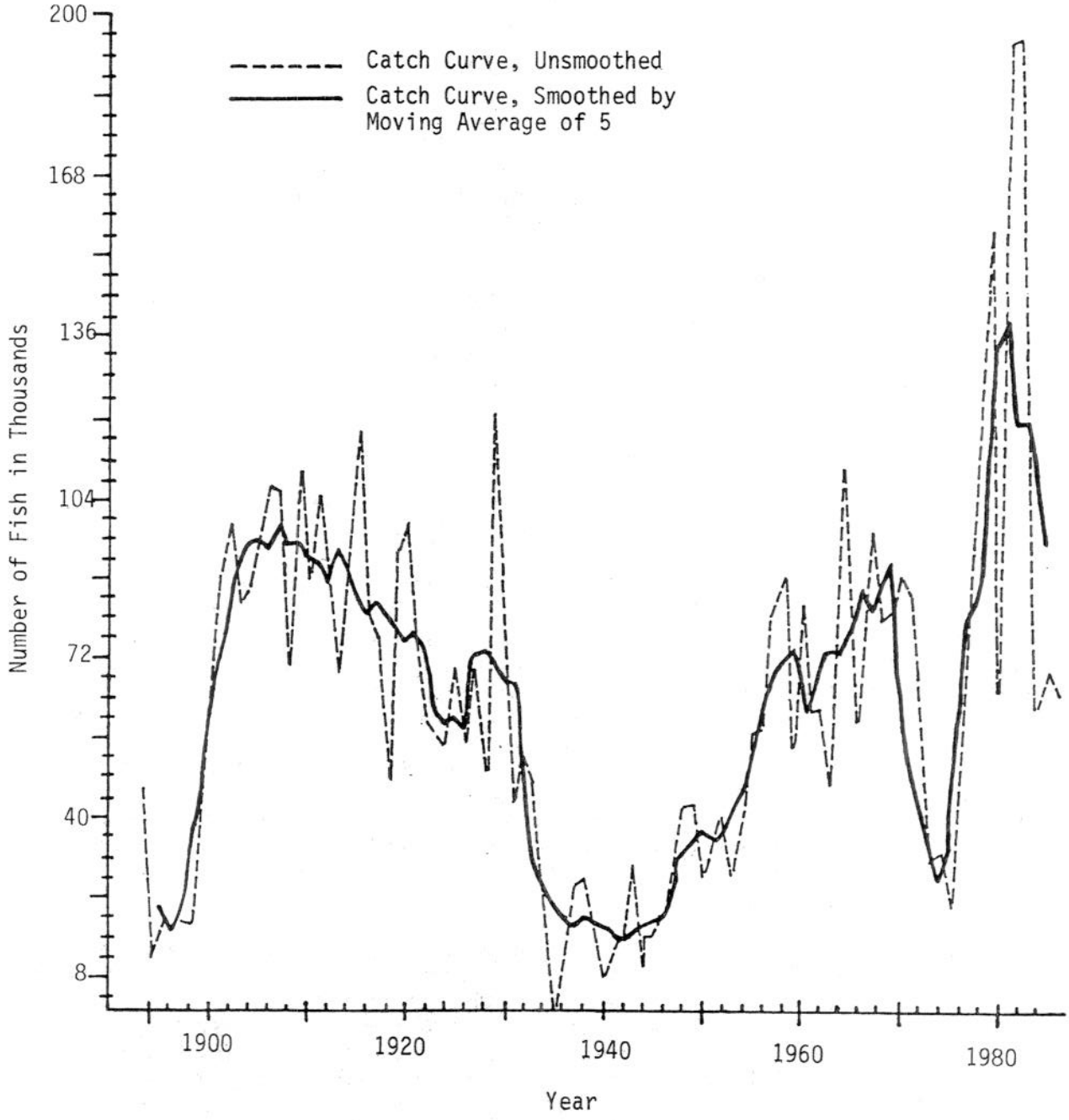

Figure 3. Commercial catch of chinook salmon in Nushagak District, Bristol Bay, 1893-1986.

the early 1950's. Economic conditions during this time brought about a reduction in the harvest of chinook to less than a third of the former yield, which had maintained an annual average of 78,000 fish for over 30 years. Packers rarely conducted fishing operations prior to the sockeye salmon season during this 20 year period, and the entire pack of chinook usually consisted of fish taken in 5-1/2 inch mesh gear incidental to the sockeye fishery. Since the early 1950's, effort was again directed specifically toward chinook salmon, and the catch rates began to increase.

Commercial chinook salmon catch records for Nushagak show a six stage catch production pattern (Figure 3 and Appendix Table 7):

Period of:	Years Inclusive	Number	Average Catch
(1) Development	1893-1899	7	23,000
(2) Exploitation	1900-1934	35	78,000
(3) Economic Decline	1935-1954	20	24,000
(4) Sustained Utilization	1955-1971	17	74,000
(5) Recent Depletion	1972-1975	4	33,000
(6) Peak Production	1976-1986	11	110,000
Entire	1893-1986	94	63,000

After the period of initial development (1893-99), the fishery held up for some 35 years (1900-34) at a level which may be close to the maximum sustained yield (MSY). From 1935 to 1954, poor market conditions resulted in a drastic "economic" decline in catches. Beginning in 1955, and continuing through 1971, the market recovered and catches again rose to the same level as experienced in the early years. From 1972-75, there was another drastic decline, part of which which can be explained by the increased Japanese high seas fishery. Commercial catches recovered and peaked in the period from 1976-86, and have been 31% higher than the previous periods of sustained production. Bilateral negotiations with Japan, which resulted in significant reductions in the high seas harvest of western Alaska chinook salmon, exceptional escapements, and the good climactic/survival conditions, all appear to have been important to increased chinook catches and total returns since 1976.

Fishing effort trends are more difficult to follow due to the poor record - keeping practices in the early years. No records of the amount of gear used are available until 1904, and even then, the number of gill nets recorded in the statements submitted by the companies were a record of the total number of gill nets on hand for the season, rather then the number actually fished (Rich and Ball, 1928). Up through 1929, fishing effort was not defined by gear type nor by type of net (larger mesh chinook gear vs. smaller sockeye gear). Set net gear was not legally defined until 1927, although the literature suggests that this form of gear was in use prior to 1927 (Mathisen, 1971).

The reduction seen in total gear fished from 1904-29, in Nushagak District, is commensurate with the decline in sockeye salmon catches and the shift of fishing effort into other districts in Bristol Bay (Appendix Table 8). Beginning

in 1930, accurate estimates of both drift and set net gear registered to fish in the Nushagak fishery are available. From 1935-54, the previously discussed period of economic decline, drift net gear registration averaged 146 units per season. Average drift net registration in the fishery grew from 420 units in 1955-71 (period of sustained utilization) to 556 units in 1976-86 (the period of peak production (Figure 4).

Set net participation in the chinook salmon fishery has shown a relatively stable trend; however, this gear type ceased to be a major factor in 1951, when set nets were prohibited from fishing above the inner boundary line between Bradford and Nushagak Points (Appendix Table 3). In general, set nets have not been successful in the chinook fishery, where since 1951, 96% of all chinook have been taken with drift net gear (Appendix Table 9). The tendency for chinook to lead into the deeper water channels and avoid the set net beaches has led to a very low catch per unit of effort for most set nets. Prior to 1951, when set nets were allowed to fish in the inside waters area above the present inner boundary line, set gear accounted for over 28% of the total chinook catch (Appendix Table 9). Set nets in this "inner area" were so successful in catching chinook that had escaped the drift fishery, that they eventually were prohibited and the inner drift net boundary was adopted for set nets as well. After the boundary relocation in 1951, set net gear accounted for an average of only 3.5% of the total chinook harvest (Appendix Table 9).

The commercial chinook salmon drift net catch and catch per unit of effort has been variable, and comparison of catches and catch per unit of effort shows that recent increases in catch rates is due to increased effort, as well as increase in run size (Figure 5).

Inshore Seasonal Catch Distribution

The chinook salmon run to the Nushagak has a distinct and fairly regular run timing schedule. Historically, about 85% of the season commercial catch is taken in the month of June, while the mid-point (50%) of the commercial season is on June 18 (Figure 6). Average catches by time period for 1958-86 are shown below:

Average 1958-86

	Catch in Thousands		Percent	
Period	Period	Cumulative	Period	Cumulative
>6/18	10	10	12	12
6/ 9-15	22	32	27	39
6/16-22	20	52	24	63
6/23-29	17	69	21	84
6/30-7/6	7	76	8	92
7/ 7-13	4	80	5	97
7/14-20	2	82	2	99
7/21>	1	83	1	100
Total	83,000		100	

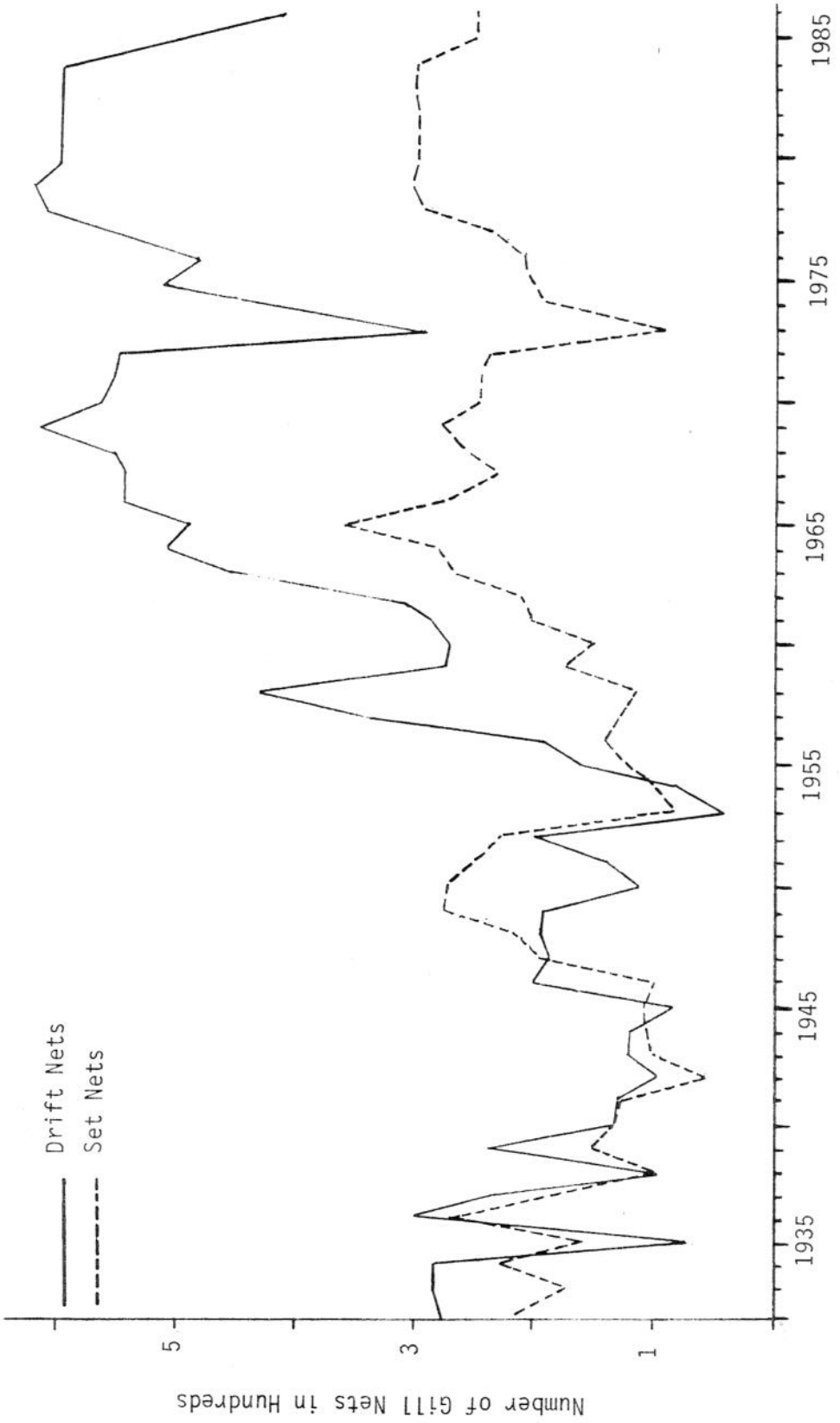

Figure 4. Number of commercial drift and set gill nets registered for Nushagak District, Bristol Bay, 1932-86.

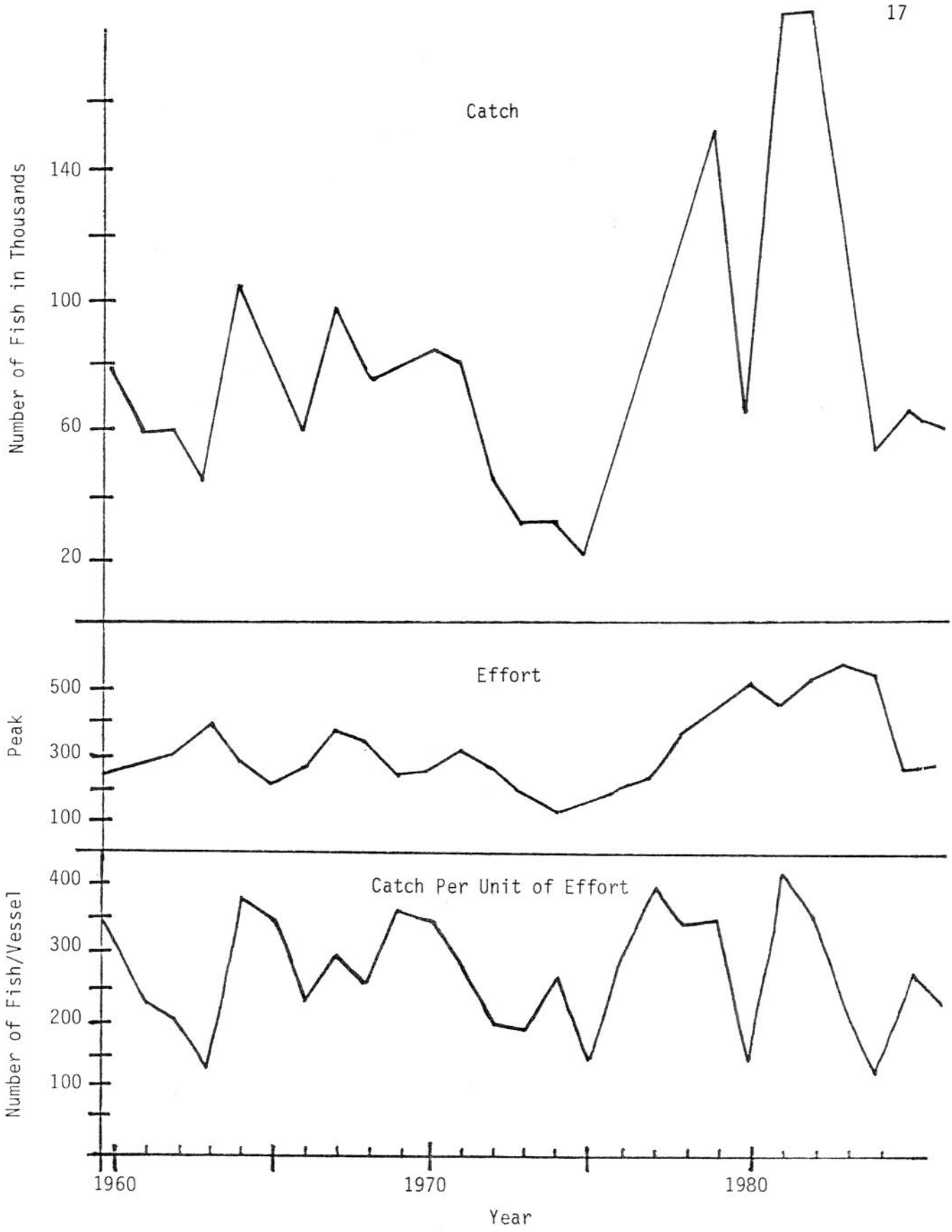

Figure 5. Commercial chinook salmon catch, season peak fishing effort and catch per unit of effort of drift net vessels in Nushagak District, Bristol Bay, 1960-86.

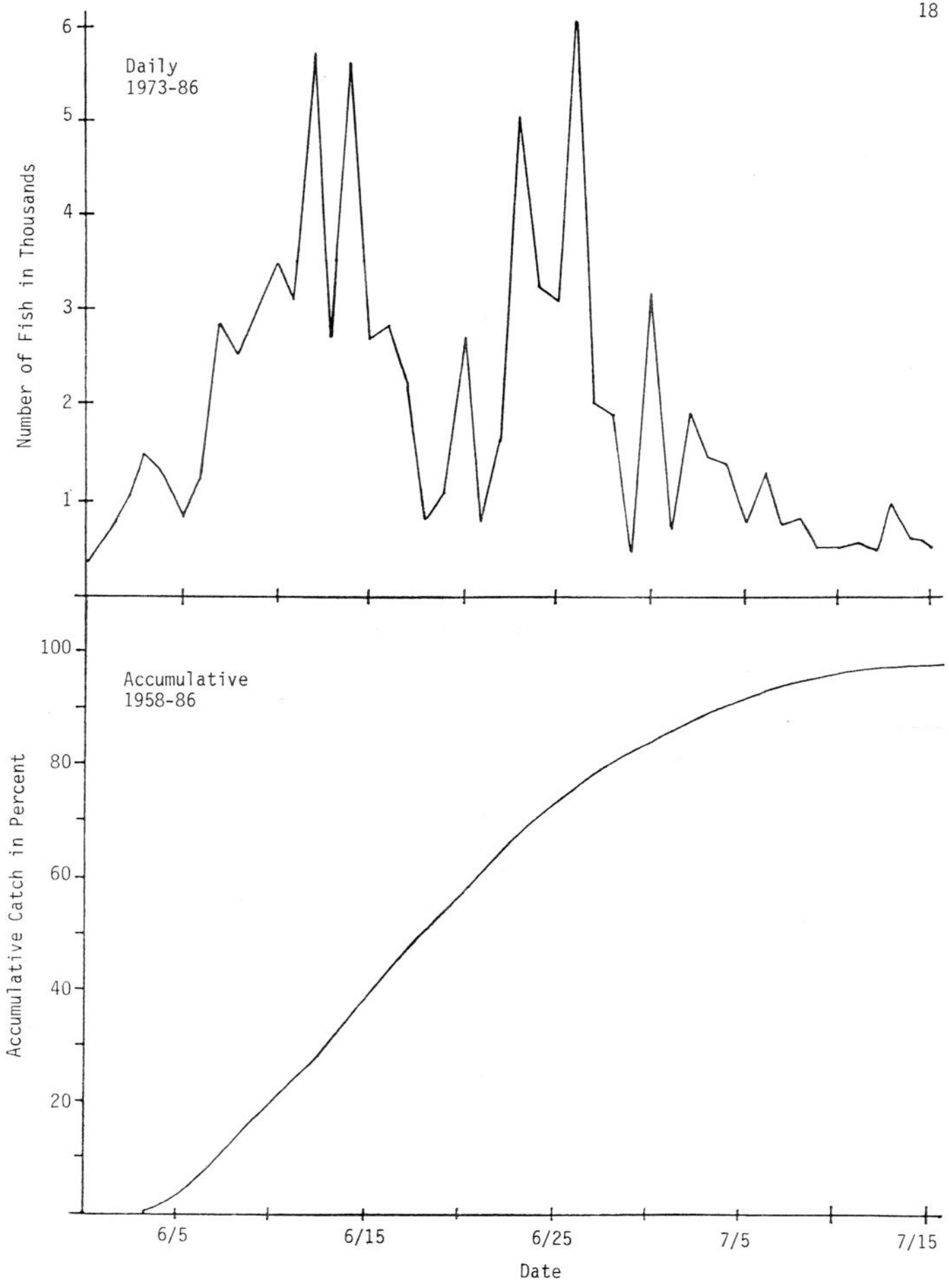

Figure 6. Average daily and accumulative commercial catch of chinook salmon in Nushagak District, Bristol Bay, 1958-86.

Daily Nushagak District commercial chinook salmon catches show a bimodal pattern for catches taken in 1973-86, with the first peak occurring on June 7-14 and the second on June 23-26 (Figure 6). The bimodality of chinook catches is directly influenced by the established fishing schedule. Prior to June 16, the fishery has seen a 5 day-per-week schedule in all but the most recent years. On the average, approximately 50% of the incoming run is accounted for by June 16-18, when the fishery is closed, unless opened, for fishing by emergency field order.

As referenced earlier, the migration tendencies of this race of chinook salmon has created untold management problems. It is common knowledge among all resource users (and fishery managers) that Nushagak chinook often mill and hold within the fishing district, as well as in both outside Bay waters, and in lower Nushagak River. Experienced fishery managers are aware that early season fishing period closures are often not entirely effective in providing increased escapement rates. References in the historical literature also allude to the holding tendencies of Nushagak chinook, and to the effects strong winds have on movement of fish:

> ----"in Nushagak it is claimed that south and southeast winds give the best results in the fishery (Moser, 1902), and----the old fisherman's belief is correct that the fish run deep during calm weather and it takes a good blow to make them available----weather is therefore something which must be considered when evaluating catch statistics for (inseason) immediate management purposes"----(Paddock, 1963).

Weekly chinook catches from 1973 to 1980 show the heavy exploitation rate the early season runs. As more fishing pressure was exerted, the managing agency (ADF&G) countered with additional area and time closures, and the shift in catch rates early in the season to higher late season rates is readily apparent beginning in 1981 (Figure 7).

Ocean Distribution and High Seas Catch

Available information on chinook salmon from the North Pacific Ocean is limited both quantitatively and qualitatively due to low abundance on the high seas, compared to the other target species of salmon, and the restricted coverage of the Japanese commercial and research fleets to that area west of 175 degrees W. longitude (Major, 1978).

The ocean distribution of chinook salmon has been documented with data provided by Japan's high seas research and commercial fishing fleets. The greatest concentration of chinook appears to be in the Bering Sea with secondary concentrations occurring south and southeast off the Kamchatka Peninsula, U.S.S.R. (Major, 1978) The vertical distribution of chinook salmon is less well known, but information from bottom trawl catches, where chinook are practically the only species of salmon caught, indicate that they occur at considerable depths.

Tagging operations further show that western Alaska chinook occur in the Bering Sea as far west as 172 degrees 12' E. longitude and in the North Pacific Ocean just south of Adak, where chinook from a wide coastal range, Yakutat to the Columbia River, are also found. There have been few recoveries in Asia of chinook salmon tagged on the high seas although indirect evidence from scale, maturity and distribution studies suggests that Asian chinook probably range as far south as about 40 degrees N. and as far east as about 180 degrees (Major, 1978).

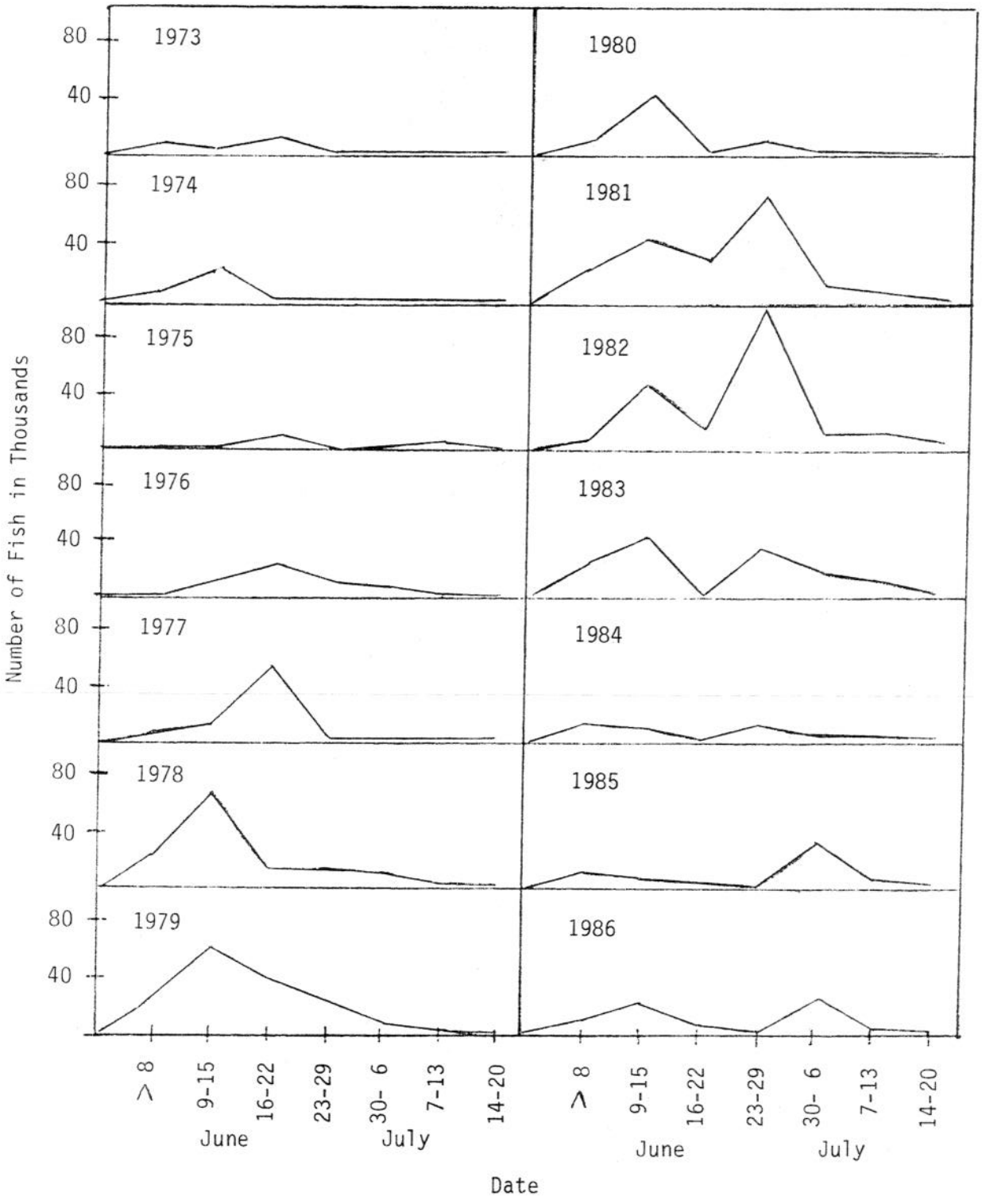

Figure 7. Weekly commercial catch of chinook salmon in Nushagak District, Bristol Bay, 1973-86.

Differences in the growth patterns of scales collected from Asian and western Alaskan chinook salmon have been used to classify immature chinook taken in the Japanese mothership fishery from 1961 to 1986 to area of origin (Table 5). Western Alaska-type chinook were found to increase in proportion from west to east within the mothership fishing area, particularly in the north central Bering Sea where catches of immatures are the greatest (Major, 1978). Recent evidence also demonstrates that western Alaska chinook stocks are subject to incidental harvest in both foreign and domestic trawl fisheries within the fisheries conservation zone. The impacts of increased allowances in incidental salmon catch by domestic joint-venture trawlers in the Shelikof Straits, Unimak Pass and Aleutian Islands groundfish fisheries may have an adverse effect on all chinook stocks originating from Alaskan waters.

In 1980, high seas exploitation of chinook salmon by the Japanese mothership fishing fleets saw record levels of interception, which resulted in this issue assuming major importance in bilateral negotiations between the United States and Japan. Japanese high seas catches of chinook salmon by the land-based and mothership fishing fleets are shown on Table 5. The level of interception of all species of salmon has been reduced since the mid-1970's by renegotiation of the INPFC treaty between the U.S. and Japan. However, of particular concern to inshore domestic fishery managers in 1980, was the drastic increase seen in the interception of chinook salmon by the high seas mothership fleet. From 1956-79, the average chinook harvest was 196,000 fish, but this interception rate increased over 3-1/2 fold in 1980 to 704,000 chinook, the highest since the inception of the mothership fishery in 1952 (Table 5). Over 59% of the total chinook harvest in 1980 (or 416,000) were estimated to be of western Alaska origin. In response to concerns by the U.S., Japan voluntarily agreed to limit chinook salmon harvests by the mothership fishery by agreeing to self-regulatory measures for a three year period (1981-83), which restricted the chinook harvest to 110,000 fish per year during this period.

While inshore chinook returns to Bristol Bay in 1982 were at record high levels, inshore returns to the Yukon and Kuskokwim Rivers and Norton Sound were relatively weaker than in the previous three years. Over 90% of the chinook salmon on the high seas in 1980 were immature 4-year olds, a large proportion of which should have matured and returned in 1982 as 6-year old fish. Using average maturity schedules and estimated natural mortality rates, it is possible that an additional 133,000 6-year old chinook salmon (over 3.0 million pounds) would have returned to western Alaska in 1982 had they not been harvested in 1980 as immature 4-year olds.

In 1983, the U.S. again requested the Government of Japan to voluntarily restrict the Japanese mothership fishery to open areas of the Bering Sea west of 180 degrees W. longitude after late June. In addition to "better verification" of high seas salmon catches, the Japanese Government agreed to a new, slightly reduced three year (1984-86) voluntary catch limit of 100,000 chinook salmon per year, with no more than 30,000 chinook from the central Bering Sea area.

As a result of the six years (1981-86) of voluntary restrictions, Japanese mothership average chinook catches were reduced to 82,000 fish for this period, 58% less than the previous long-term average of 196,000 (Figure 8 and Table 5).

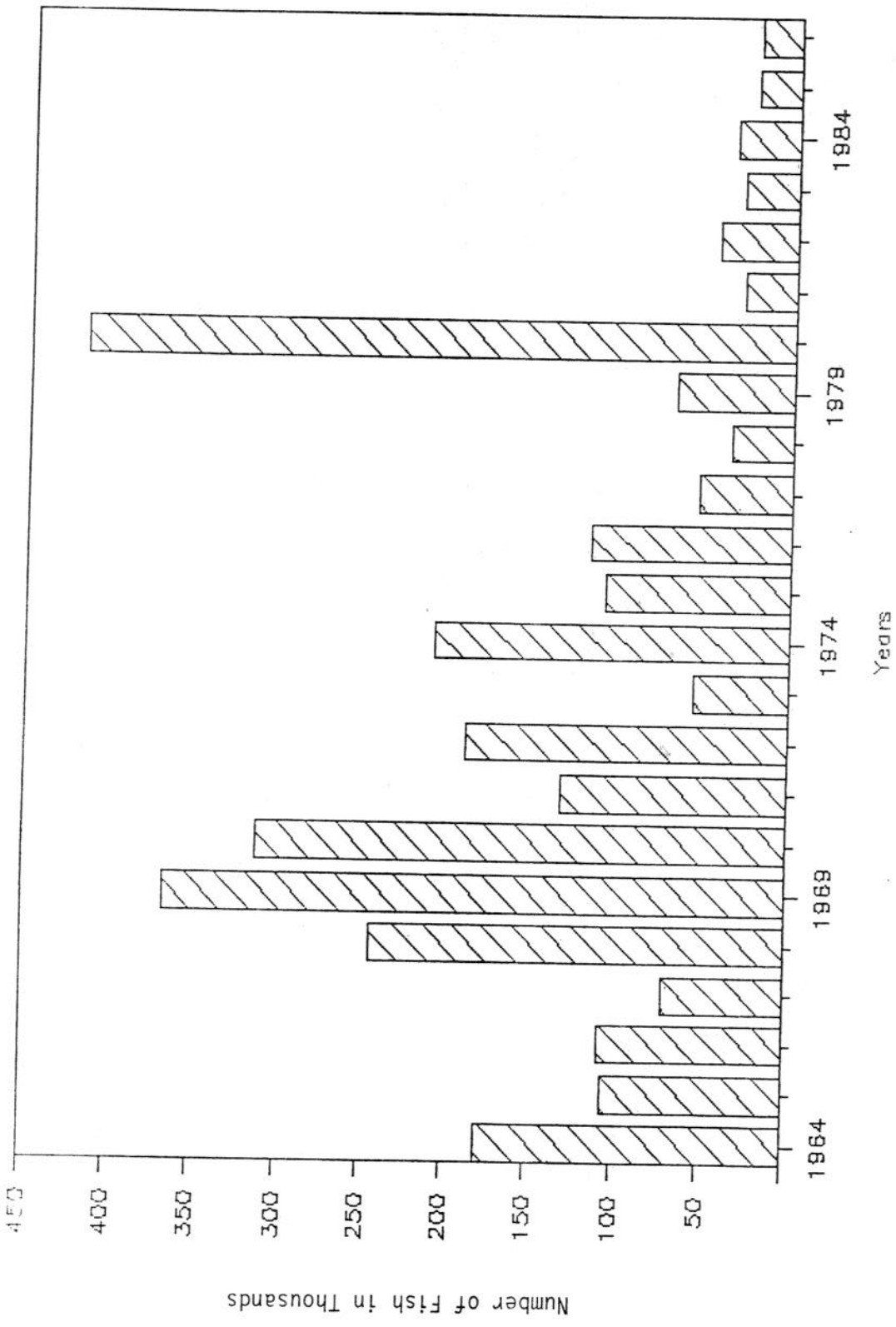

Figure 8. Japanese high seas interceptions of western Alaska chinook salmon by the mothership gill net fishery, 1964-86.

Primarily due to biological concerns for the chinook salmon resources of western Alaska, and the economic impact of this foreign fishery on western Alaska fishermen, emphasis began to shift from sockeye to chinook salmon after the huge high seas interception of chinook in 1980. Recent negotiations between the U.S. and Japan have resulted in reductions in both the mothership and land-based fisheries. Specific changes to these fisheries include a phaseout of fishing effort of the mothership gill net fleet in the central Bering Sea where the majority of chinook are caught, and the fishing effort within the U. S. 200 mile zone, will be capped at the average of recent years. The phaseout operation will commence in 1987, when the mothership fishery will be reduced by 25%, followed by elimination of fishing grounds eas of 180 degrees W. longitude in 1989, and complete elimination of the mothership fleet within the central Bering Sea after the 1993 fishing season. The land-based high seas fleet in 1986 saw a 45 mile shift (from 175 degrees E. to 174 degrees E.) of the fishing boundary away from Alaska toward Asia. Additionally, enforcement measures and research efforts were strengthened in the agreement between the two countries, and based upon future research results, further restrictive boundary closure lines may be negotiated for the land-based fishery.

When the phaseout agreement is fully implemented in 1994, total catches and interceptions of western Alaska chinook salmon are estimated to be reduced by 50%. When the loss of immature chinook from high seas gillnetting attributed to drop-outs are included, the benefit to the domestic inshore fishery may double.

Since 1961, the chinook of western Alaska origin have accounted for 62% of the total mothership catch (Table 5). Based strictly upon the proportion of chinook caught in western Alaska (Yukon, Kuskokwim, Bristol Bay and North Peninsula), the Nushagak District chinook salmon fishery may see increased annual returns of 30,000 to 60,000 chinook as a result of the high seas phaseout. At present day exvessel values, these additional mature full-sized chinook would contribute from $0.6 - $1.3 million to the commercial fishery alone, assuming all fish entered the commercial harvest.

Fishery Economics

The Nushagak chinook salmon fishery did not generate much in the way of revenue until frozen production obtained a solid foothold in the fishery. Records of prices paid to fishermen for chinook salmon, prior to initiation of frozen production in 1946, show a range of $.20 to $.99 paid per fish (Appendix Table 12).

Up through 1968, chinook were purchased on a per fish basis, and "company" fishermen, who were supplied boats, fishing nets and fuel by the processor, were paid less, usually about 62% of the independent price. Commencing in 1969, fish were purchased on a price per pound basis. Prices remained relatively stable until 1973, when fishermen were receiving an average of $4.16 for each chinook sold.

Commercial production of fresh and frozen chinook salmon began to accelerate rapidly beginning in 1972, and prices paid to fishermen reflected the increased market interest in chinook. Since 1977, 91% of all chinook production has entered the fresh and frozen markets, and prices paid have risen to an average of $19.25 per fish (Appendix Table 12).

Total exvessel commercial value of the chinook harvest is available since 1969, and has averaged $2.2 million paid to the fishermen from 1977-86, the period when both catches and prices rose dramatically (Appendix Table 12).

Currently, the Alaska Department of Fish and Game's management program is expending 3% annually (or $66,000) of the average exvessel value to manage the Nushagak chinook fishery. This level of funding is below that expended for sockeye (4%) and, as the commercial and sport fishing interests continue to expand, funding to support the management program should also be increased.

CHINOOK SALMON SUBSISTENCE AND SPORT FISHERY

This section will review the Nushagak chinook salmon subsistence (personal use) and the freshwater sport recreational fishery in terms of fishing regulations, harvest effort levels, and the future outlook for these resource user interests.

SUBSISTENCE FISHERY

The subsistence use of marine and freshwater fishery resources in Bristol Bay dates back as far as written literature is available. Despite the social and economic changes which have occurred in recent decades in Bristol Bay, fish continue to be an important food for most residents of the region. Large numbers of all five species of salmon, as well as some 20 other anadromous, freshwater, and marine fish species, are utilized for subsistence.

Sockeye salmon are harvested in the greatest numbers in Nushagak District, but chinook salmon are also important. Gillnetting is the primary method used for harvesting salmon. In areas where chinook are abundant, large numbers are taken for subsistence use. Chinook are highly prized for personal use because of their large size, excellent quality and early appearance in the season after a long winter without fresh salmon.

Regulations

Compared to commercial fishing regulations, relatively few restrictions have been imposed upon the subsistence fisheries in Bristol Bay. Subsistence regulations have evolved to meet administrative and enforcement needs in the larger communities, where commercial fishing activity and population are centered, and are largely intended to prevent waste and/or the sale of subsistence-caught fish.

Regulations pertaining to the subsistence fishery in Bristol Bay were initiated in 1924, when personal use fish could only be harvested by hand, rod, spear or gaff and could not be used for sale or barter, provided that taking fish for local food requirements or for use as dog feed was not prohibited in any way (Bureau of Fisheries, 1924-40). However, a literature review shows that salmon in Nushagak River were taken with gill nets as well as traps, which were constructed of split spruce strips, spears and dip nets (Bureau of Fisheries, 1905-26 and Van Stone, 1967).

Beginning in 1951, personal use fishing regulations in Bristol Bay required that subsistence fishermen give prior notice of the area to be fished, gear type, time of fishing and the approximate number of fish to be taken in any closed waters area. Personal use fishing was still legally limited only to hand rods, spears or gaffs, however, gill nets continued to be the primary capture gear (Fish and Wildlife Service, 1941-59).

In the period from 1952 through 1959, numerous changes in the subsistence (personal use) fishery regulations were enacted, and they are summarized below for Nushagak District (Fish and Wildlife Service, 1941-59):

1952 - previous 1951 notice requirements were dropped, and commercial salmon fishermen were prohibited from taking fish during any commercial season, except in compliance with commercial fishing regulations, or within 48 hours before or after any such season; snagging salmon was also prohibited in waters not open to commercial fishing;

1953 - "all" personal use fishermen now subject to commercial fishing regulations 48 hours prior to and after the sockeye salmon commercial season (June 25-August 3); fishing permitted at anyplace which is greater than 12 miles from the commercial district;

1954 - gill net fishing was prohibited during weekly closed periods and 48 hours before and after any commercial season (June 1 - August 31); personal use fishing, using hand rod, spear, gaff and trolling was permitted at all times, except in areas closed to all fishing; 12 mile rule from 1953 was modified to allow personal use set nets of no more than 15 fathoms to fish from the Pacific American Fisheries Co. dock at Dillingham to Bradford Point;

1955 - personal use gill nets were permitted each Wednesday (6 a.m. to 6 p.m.) throughout Nushagak District, and at any time 12 miles from the commercial district, and the special 15 fathom area in Dillingham was expanded to include beaches between Snag Point (at the mouth of Wood River) and Bradford Point, and nets in this area were also required to be registered;

1956-58 - similar to 1955 except that only set gill nets were allowed to fish in the Wednesday weekly 12 hour period; and

1959 - personal use fishing was prohibited from noon, June 20, until noon, July 27, except set nets were allowed in waters open to commercial fishing from 6 a.m. to 6 p.m. each Saturday; 12 mile rule and special Dillingham area 15 fathom set net area was retained.

After statehood, personal use (now called subsistence use) regulations went through another series of changes. The more important regulations affecting Nushagak District are summarized below in the year they became effective (ADFG, 1960-86a):

1960 - only Alaska residents may take salmon for subsistence purposes; set nets outside of commercial districts were limited to 50 fathoms; fishing was prohibited during closed periods within a commercial fishing district; within the open commercial district both drift and set net gear are legal;

1963 - subsistence permit system was initiated for some areas and the number of salmon taken for subsistence use may be limited; authority to restrict subsistence fishing by emergency field announcement was granted;

1965 - permit required for "all" subsistence fishing; waters within 300 feet of any stream mouth utilized by salmon were closed; no nets may obstruct more than 1/2 the width of any stream; nets must be separated by at least 300 feet;

1974 - from June 16 to July 17, fishing time was restricted to three 24 hour periods per week and set nets were limited to 10 fathoms in length between Bradford Point and Red Bluff in Wood River;

1975 - outside of the commercial district, and the special 10 fathom area, set net length was reduced to 25 fathoms; and

1977 - minimum distance between set nets reduced to 100 feet from Bradford Point to Red Bluff.

Of the foregoing regulations, the restrictive limit on fishing time and net length enacted in 1974 had the most impact on chinook salmon subsistence harvest rates. Prior to 1974, unrestricted fishing time, and the unpredictable migratory routine of Nushagak chinook, often resulted in large subsistence catches and waste of the resource. In recognition of this problem, local subsistence users and fishery managers jointly co-sponsored regulatory changes in 1974, which allowed only three 24 hour periods per week with 10 fathoms of gear between June 16 and July 17. Since over 75% of subsistence caught chinook are taken in this time period, the wastage problems encountered with unrestricted fishing time were virtually eliminated.

Catch and Effort Trends

Although considerable subsistence harvest has occurred throughout history in the Bristol Bay region, very little is known about the actual numbers of fish taken for subsistence purposes prior to 1963. Historically, large numbers of salmon were harvested in Bristol Bay for feeding dog teams. This practice was greatly reduced with the introduction of the snow machine, but is recently increasing with the renewed interest in dog racing and sport mushing. Records of the subsistence removal in Bristol Bay's major river systems have been kept by the Department since 1963 when a permit system was initiated. Much of the growth in the number of permits issued during these years reflects increasing compliance with the permitting and reporting requirements.

Subsistence catches of salmon in Nushagak District normally range between 50,000-80,000 fish, but have been increasing in recent years, primarily due to increased fishing effort. Local population increases, better catch reporting and the yearly influx of non-watershed participants have contributed to this increased harvest.

Since chinook salmon are the first species to arrive in the spring, there is considerable interest and fishing pressure on these stocks. Nushagak chinook salmon subsistence catches have averaged 7,200 fish for the past 24 years, but have seen a significant increase in harvest and fishing effort since 1970 (Figure 9 and Table 6):

Years (No.)	Average Fishing Effort	Average Catch	Average CPUE
1963-1969 (7)	112	4,600	41
1970-1979 (10)	261	6,400	25
1980-1986 (7)	408	11,100	27
Total (24)	260	7,200	28

Catch per unit of effort (CPUE) has remained stable in recent years due to the increase in total run size, and in spite of the significant growth of the number of resource users. Fishing effort has increased by 56% in 1980-86 over the previous 10 year period, while average catches have increased as well and the catch per individual user has remained largely stable (Table 6).

Chinook salmon begin to arrive in the Nushagak District and watershed as early as mid-May, and the subsistence community begins to gear up for the incoming run. In most years, the first subsistence catches occur in late May; however, records show catches occurring as early as May 14 (1984) at Dillingham subsistence beaches and May 19 (1970) and May 18 (1974) at the upriver subsistence village fishing sites at Ekwok and New Stuyahok, respectively. Most of the subsistence harvest of chinook takes place between June 15 and July 10, with catches in most years peaking between June 20-30 (Figure 10).

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 due to the irregular fishing schedule and the annual basic use level of subsistence users, which is independent of fish abundance.

SPORT FISHERY

The recreational freshwater sport fishery in Bristol Bay has become a major factor in this area's management plan for fishery resources. The uncrowded sport fishing areas of the early 1960's have given way to today's ever-increasing recreation-oriented population. New sport fisheries have been developed, and increasing pressure on fishery stocks has complicated maintenance of some stocks.

Freshwater sport fishing effort on Nushagak watershed chinook salmon has shown a phenomenal increase since professionally guided sport fishing operators discovered that the area's chinook runs could be successfully fished.

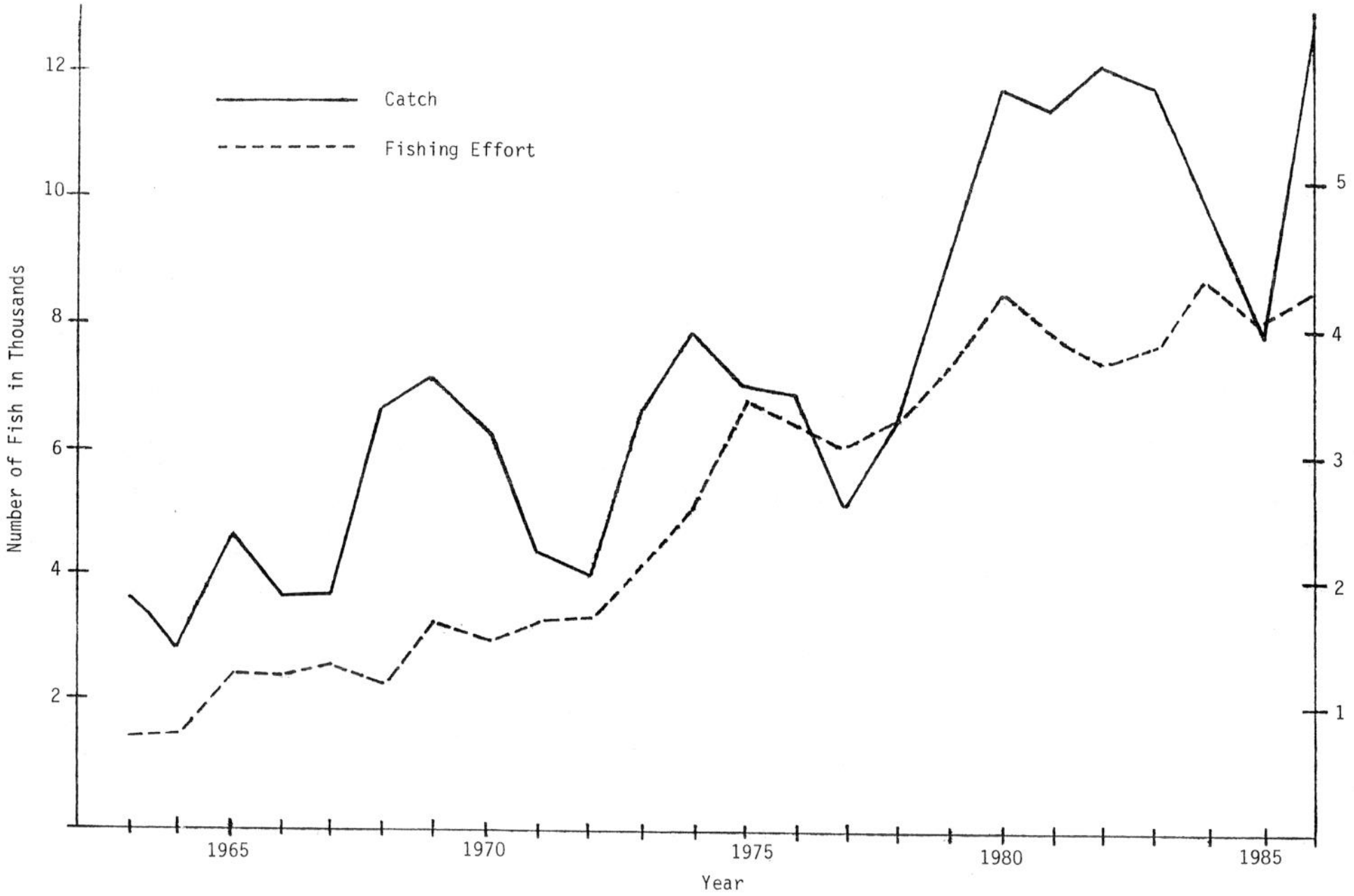

Figure 9. Subsistence catch of chinook salmon and fishing effort in Nushagak District, Bristol Bay, 1963-86.

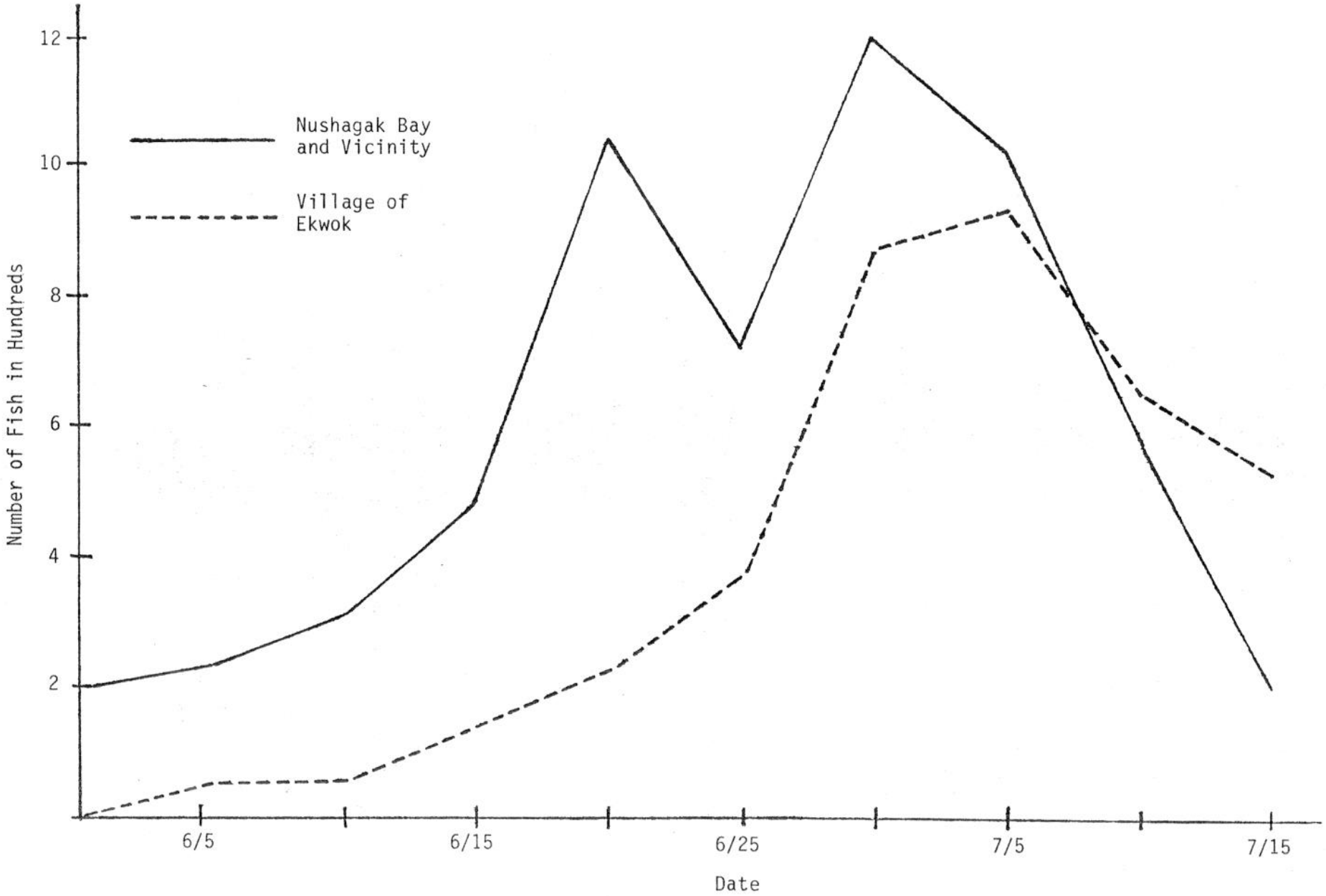

Figure 10. Subsistence catch of chinook salmon in Nushagak Bay and the village of Ekwok, Nushagak District, Bristol Bay, 1963-69.

"The first significant instance of chinook salmon sport utilization took place during 1963. John Pearson of the Wood River Wilderness Camps (now called Wood River Lodge) found angling success excellent at Portage Creek, about 30 miles from the mouth of the Nushagak River. Beyond this point the (river) gradient increases and the fish leave the tidal influence. Availability at this point is limited to a period extending approximately from June 15 to July 15, but it can be expected that this fishery will develop rapidly." (Paddock, 1964).

The easy accessibility afforded by small fixed-wing float equipped aircraft has also contributed to the rapid growth of the lower Nushagak River chinook salmon sport fishery. The chinook sport fishery has been carried out only in the upriver fresh to brackish water area because of the extreme turbidity in the lower reaches of Nushagak River and Bay. The sport fishery on this area's chinook resources can be categorized as follows: (1) it is (and has been) growing rapidly; (2) more effort is being directed at salmon resources, especially chinook and coho; (3) the recreational tourist industry is becoming a major economic force in Bristol Bay; and (4) as the harvest levels of sport caught chinook grow, the potential exists for increased friction between the major user groups (subsistence, commercial and recreational).

Regulations

Few regulations govern the chinook salmon freshwater sport fishery in Bristol Bay (ADFG, 1960-86a). Present freshwater sport fishing regulations on daily bag, possession and size limits for chinook salmon have been in effect since 1964 and they are extremely liberal:

1964-67 - 6 salmon daily, 12 in possession;
1968-71 - 10 salmon daily, 10 in possession, only 2 over 26 inches in length;
1972-75 - 5 salmon daily, 5 in possession, only 2 over 26 inches in length;
1976-79 - 5 salmon daily, 5 in possession, only 2 over 28 inches in length;
1980-87 - 5 salmon daily, 5 in possession, only 2 chinook salmon over 28 inches in length.

The present daily bag and possession limit of five chinook, only two of which may be over 28 inches in length, is much less restrictive than in other major chinook salmon producing regions of Alaska, where 1 to 2 chinook are allowed per day and in possession. Other general statewide regulations also apply to Nushagak District and include: a license is required; use of single line is required and various lures and hooks are restricted; live fish are prohibited for use as bait in freshwater; it is unlawful to intentionally snag fish in fresh water and other similar regulations. At present, there are no area or stream closures in the entire Nushagak drainage affecting the chinook salmon resource.

As sport and recreational fishing pressure continues to build on these stocks, additional restrictive regulatory measures may be in order. Although the sport fish harvest of Nushagak chinook is low in relation to the commercial and subsistence harvest, low chinook escapement obtained in 1986, demonstrates that spawning escapements may be jeopardized, and that the natural productivity of the system may be detrimentally impacted by increased sport fishing pressures

on the resource. Possible regulatory measures that might be implemented to maintain or increase productivity, while at the same time minimizing the effects of such restrictions, would be altered freshwater bag and size limits, area or season restrictions and a special punch-card reporting system to better document actual harvest rates.

Catch and Effort Trends

The freshwater sport fishery in the Nushagak drainage coincides with spawning migrations of chinook from about mid-June to as late as mid-August. Tidal chinook salmon sport fishing is generally concentrated on Nushagak River between Black Point and the village of Portage Creek. Fishing pressure is heaviest in the lower river, where the chinook are concentrated early in the season before they disperse to their spawning grounds in the upriver areas of the Nushagak-Mulchatna River drainage. The chinook salmon run usually enters the river from mid to late June, and typically migrates through the lower river during a two week period, with peak catch periods occurring from June 26 to July 6, and with 50% of the season's catch accounted for by July 2 (Figure 11).

Monitoring of chinook salmon sport fishing and effort trends in the Nushagak watershed was initiated in 1977, when a statewide random mail-out questionnaire was sent to Alaska sport fish license holders. Results of this survey showed a 4-fold increase in the chinook harvest from the lower Nushagak River from 1977 to 1986 (Table 7). Chinook harvest and fishing effort trends for both the Nushagak and Mulchatna River systems demonstrate the rapid escalation that this fishery has seen since the mid-1970's.

In addition to the statewide mail-out questionnaire, a creel census monitoring project was initiated on the lower Nushagak River between Black Point and Portage Creek in 1982 by the Alaska Department of Fish and Game, Division of Sport Fish. Results of this on-grounds monitoring activity, which has continued through 1986, with 1983 excepted, have documented sport fishing catch and effort directed toward chinook salmon (Brandt and Minard, 1985). The creel census activity has generated harvest estimates that compare favorably with those estimates of harvest documented by the statewide mail-out questionnaire. Creel census studies in 1982 and 1984-85 have shown that fishermen require approximately 2 hours of fishing time to land each chinook salmon; however, the catch per unit of effort (CPUE) in 1986 fell to 4 hours per chinook landed due to the smaller total run size and escapement that resulted.

Both subsistence and sport fishing activities are expected to continue to exert maximum pressure on the chinook resource. Since both fisheries extract fish from those chinook that have escaped the commercial fishery, the managing agency will need to refine inseason management to allow adequate chinook salmon escapement after both inriver user groups have extracted their toll. Regulatory changes for all three user groups may eventually be required to achieve optimum escapement requirements, and continued and increased funding of management related projects will be necessary.

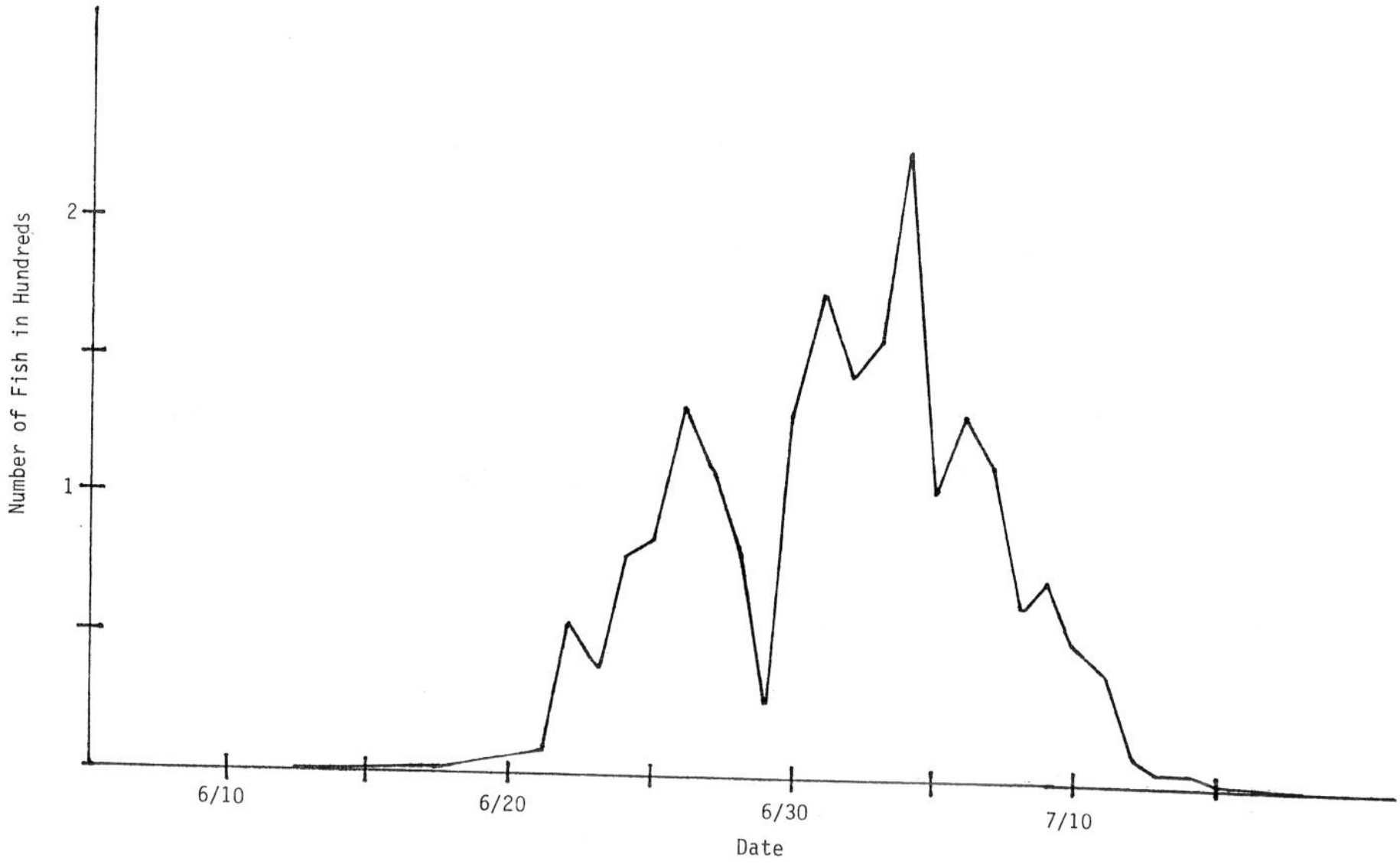

Figure 11. Average daily sport fish harvest of chinook salmon in the lower Nushagak River, Nushagak District, Bristol Bay, 1982 and 1984-85.

CHINOOK SALMON ESCAPEMENT AND SPAWNING DISTRIBUTION

Accurate determination of spawning escapement is vitally important to those responsible for regulation of the fisheries, to the fishing industry that harvests the salmon, and to the programs of research on salmon populations. No other single factor has influenced regulation of the salmon fisheries to the same extent as has magnitude of the spawning escapement. While decisions governing regulations have not always been based on sound knowledge of magnitude of escapement desired, or even upon accurate estimates of magnitude of escapement obtained, 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.

Chinook salmon spawn in approximately 380 streams on the Pacific coast of the United States; however, spawning is generally concentrated in the larger river systems. In Canada about 50% of the escapement is found in 14 streams (out of 260 total streams). Major river system producers in the United States are the Sacramento in California, Columbia in Oregon/Washington, and the Copper, Susitna, Nushagak, Kuskokwim and Yukon Rivers of Alaska.

Minimal data are available on escapement levels of chinook salmon in most western Alaska regions, because of the large size and turbid water conditions of the mainstem areas of the major chinook salmon river systems. Aerial surveys are frequently conducted on the more important spawning tributaries in western Alaska, and these surveys have provided relative indices of escapement to these rivers.

Enumeration of salmon stocks using aerial means has been a recognized method of recording salmon populations. The method and techniques used to survey salmon spawning grounds in Bristol Bay has sought to develop reliable annual estimates of the total spawning populations in the various river systems. The first recorded aerial stream survey in Alaska was conducted in 1930 by U. S. Bureau of Fisheries employees at Lake Clark in Bristol Bay. However, serious use of aircraft for surveys was not carried out until 1937-38, when the U. S. Bureau of Fisheries initiated a biological research program in Bristol Bay, and aerial survey methods and techniques were developed in the ensuing years (Nelson, 1986).

The majority of chinook salmon escapement studies in Bristol Bay have been centered in the Nushagak District where an extensive aerial survey data base has been developed. Aerial survey assessment to locate Nushagak chinook salmon spawning areas and to assess spawning populations began in 1956, and has been continued to the present time. Aerial surveys, coupled with ground surveys from rubber rafts, have attempted to obtain information which would allow the conversion of aerial counts into actual escapements, but these methods have had limited success (Table 8).

In 1979, a side scanning adult salmon sonar project was initiated on the lower Nushagak River, near the village of Portage Creek, which allowed another independent method of enumerating salmon escapement. Although the sonar counting system has the potential to allow accurate complete enumeration of all salmon species ascending the Nushagak River, start-up operational difficulties and sampling problems, have led to the continued use of the aerial survey data base to estimate the chinook salmon escapement to the Nushagak-Mulchatna watershed.

The balance of this section will review the timing and distribution of chinook salmon spawning escapement in Nushagak District, and will discuss methods used to derive index and total chinook escapement, as well as a discussion of provisional escapement requirements and potential optimum escapement goals.

MIGRATION TIMING

Timing of the seasonal chinook salmon run was documented from three sources:

(1) Subsistence Catches - catches from subsistence nets in the Dillingham area (upper Nushagak Bay) show chinook harvests peaking between June 20-30, with upriver village catches peaking several days later (Figure 10);

(2) Sport Fish Catches - chinook catches by the sport recreational fishery show a similar timing sequence with subsistence catches, peaking between June 26 and July 6; however, angling success is sometimes affected by high and turbid river flow;

(3) Sonar Enumeration - actual enumeration of chinook salmon as they pass the sonar enumeration site provides the best indications of timing into the Nushagak River system. Daily chinook salmon sonar enumeration rates were examined for seven years between 1979-86, and the sonar records show that peak daily chinook escapement rates occur between about June 23 to July 4, with 50% of the escapement accounted for by July 1-2 (Figure 12 and Appendix Table 13).

Migration timing results from the three sources listed are remarkably similar and, although timing can be modified by the large and efficient commercial gill net fishery, these data indicate that the majority of Nushagak River chinook salmon migrate into and through the lower Nushagak River during late June to early July. The chinook migration timing sequence shows conclusively that only 2% to 4% (or 2,000 to 4,000 fish) are accounted for through the upriver sonar site prior to June 16-20, when over 55% of the commercial gill net harvest is already accounted for (Figure 6 and Appendix Table 13).

ESCAPEMENT STUDIES

Chinook salmon escapement studies were initiated in 1956 by the Alaska Department of Fisheries through an aerial survey program to locate streams important to spawning chinook, and to develop methods whereby aerial index counts of fish could then be expanded to total escapement estimates. Inseason real-time escapement enumeration projects followed with initiation of the Nushagak River sonar and the Lewis Point escapement index project in 1979-80, respectively.

Test Fish Escapement Index

Chinook salmon daily subsistence catches have been monitored at the Lewis Point fish camp on the lower Nushagak River since 1980 (Figure 13). Daily chinook salmon escapement estimates are also generated from the sonar program at Portage Creek, 25

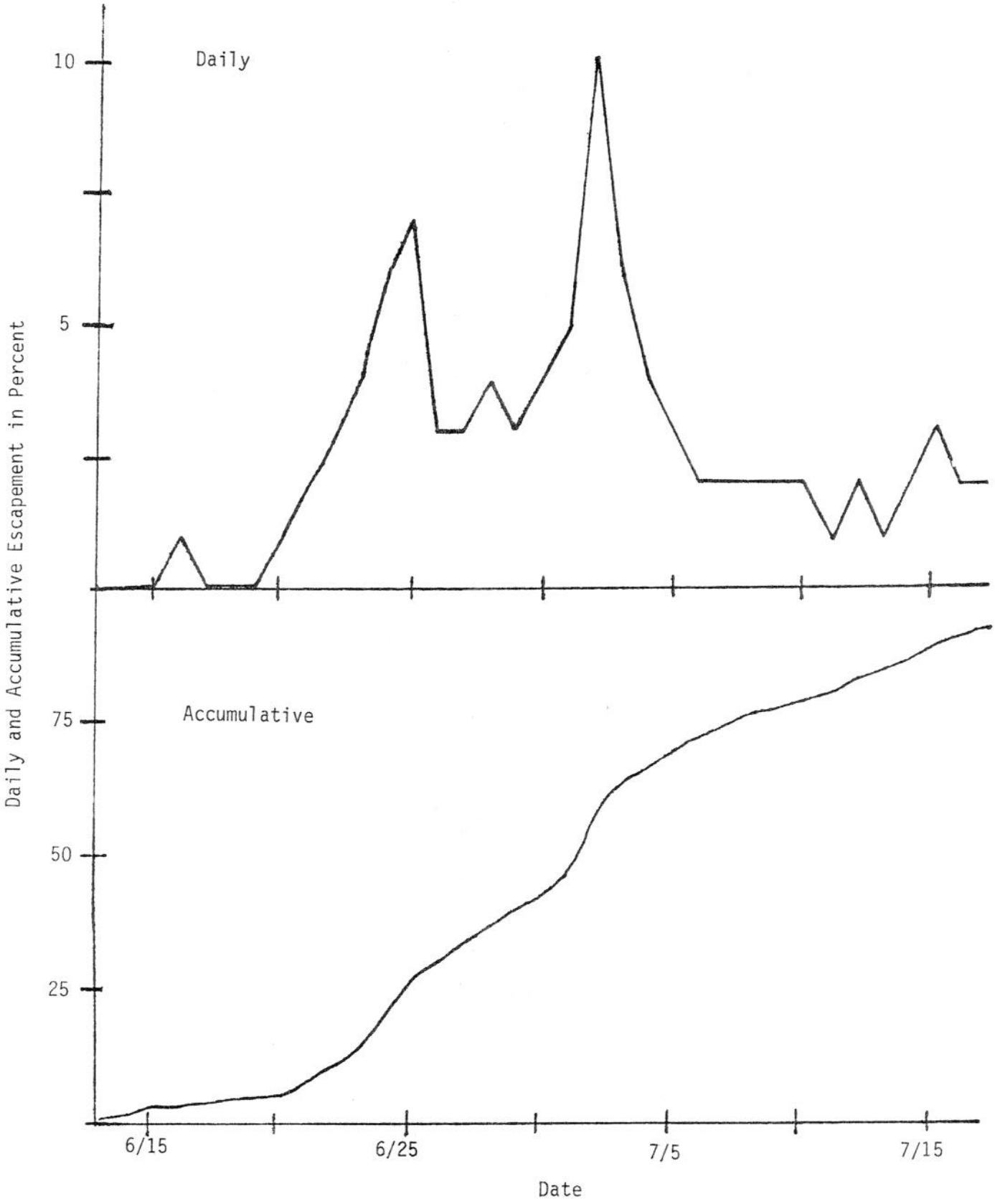

Figure 12. Average daily and accumulative chinook salmon sonar escapement rates, Nushagak River, Nushagak District, Bristol Bay, 1979-86.

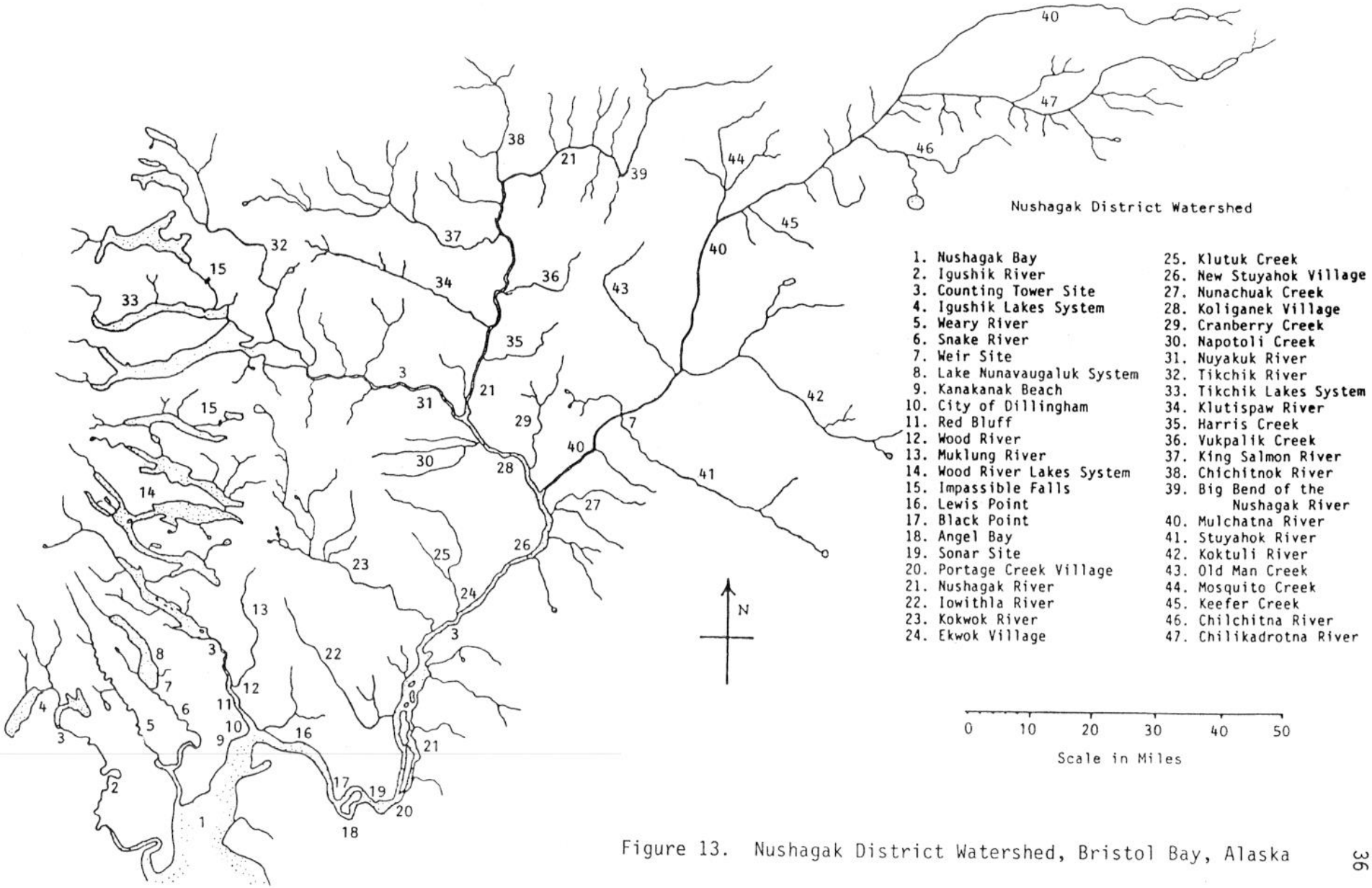

Figure 13. Nushagak District Watershed, Bristol Bay, Alaska

miles from the terminus of the commercial fishery; however, because of the significant delay between the commercial fishery and the sonar counters, as well as associated problems with species apportionment of sonar counts, the Lewis Point monitoring program attempts to provide estimates of chinook salmon escapement prior to the sonar enumeration efforts.

Success of the index test fish program has been variable. Substantial differences have occurred between test fish and sonar/aerial escapement estimates, but the Lewis Point monitoring program does accurately reflect daily trends in the chinook salmon escapement. These early indications of escapement at Lewis Point, coupled with similar data from the downriver subsistence chinook catches off Kanakanak Beach in the Dillingham area, provide the earliest indications of chinook escapement magnitude (Figure 14).

However, results from the Lewis Point escapement monitoring program are compromised because the subsistence gill nets do not consistently fish each day. It is often common practice for all nets to be pulled from the water, especially after prior heavy catches, which prohibits collection of consistent daily catch per unit of effort data. The upriver distant location and heavy, rough seas that often prevail in this area, preclude the development of a Department sponsored daily test fish program, which would require daily delivery of fish caught in the test nets. Similar data limitations prevail at Kanakanak Beach, where the restricted subsistence fishing schedule (three 24 hour periods per week) also precludes the collection of consistent data.

Hydroacoustic Sonar Escapement

The feasibility of using side scanning sonar to count adult salmon entering the Nushagak River was first investigated in 1979, when a single side scanning sonar unit was installed on the Nushagak River near Portage Creek (Figure 13). Continued research and development of sampling methods and equipment has led to the present sonar design. The original "Bendix Corporation" sonar units have been modified to include a 500 foot counting range without a substrate, increased sensitivity, a large fish discriminator, and a rock inhibitor were all incorporated into the original counters to improve salmon counting accuracy.

Initially in 1979-80, severe undercounting of the salmon escapement was encountered when sonar results were compared with post-season aerial survey and counting tower results (see below). The large sockeye and chum salmon escapements in 1979-80 were beyond the density threshold level of the sonar units, and undercounting was a daily occurrence. Additionally, chinook salmon do not follow the shoreline closely as do sockeye and chum salmon, and many chinook were offshore of the sonar's counting range. The offshore distribution patterns led to modifications that, in 1985, increased the effective counting range from 60 to 500 feet.

The improved sonar hardware, which is better suited to the physical characteristics of Nushagak River, and a revised sampling schedule to apportion daily sonar counts into species, has led to increased success in enumerating chinook salmon.

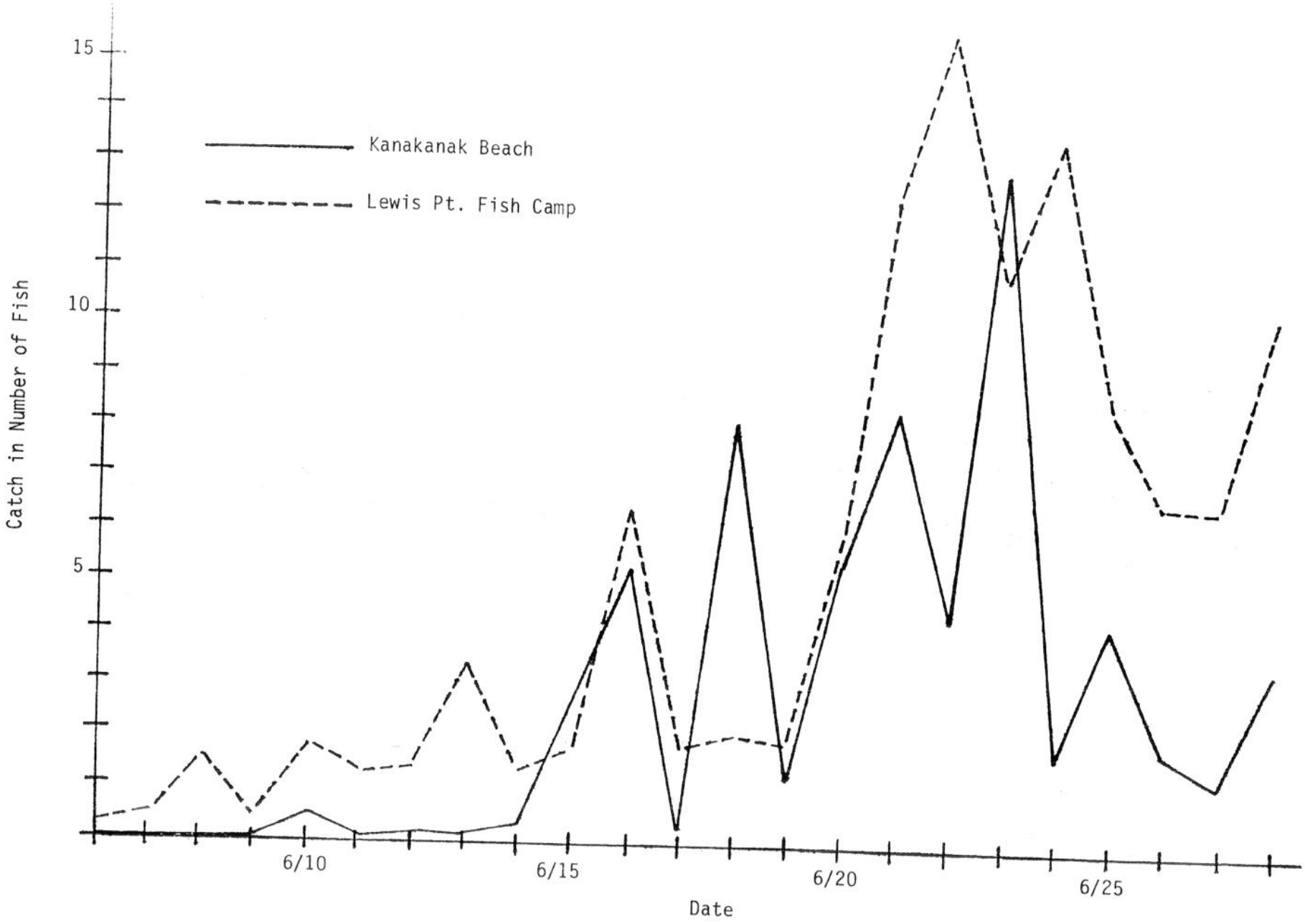

Figure 14. Average daily chinook salmon catch per unit of effort in subsistence gill nets at Kanakanak Beach and Lewis Point, Nushagak District, Bristol Bay, 1980-86.

However, the aerial survey program continues to be used to estimate the chinook escapement to the entire watershed. Sonar vs. Nushagak District aerial survey derived chinook escapements are shown below:

Year	Escapement		Proportion Sonar/Aerial (%)
	Sonar	Aerial	
1979	33,000	95,000	35
80	56,000	141,000	40
81	115,000	150,000	77
82	124,000	147,000	84
83	104,000	162,000	64
84	-	81,000	-
85	99,000	116,000	85
86	43,000	33,000	130

Assuming the aerial survey escapement estimates are an accurate representation of the actual chinook escapement, the proportion of sonar vs. aerial are fairly consistent for 1981-83 and 1985. In 1984, so few chinook salmon were caught in the daily sampling efforts, that apportionment of chinook was precluded, and in 1986 the sonar escapement exceeded the aerial survey estimate, perhaps because of poor aerial survey weather conditions encountered, or sonar daily apportionment problems. Apportionment by species of daily escapement continues to be a problem, especially so when high densities of sockeye and chum salmon tend to mask the number of migrating chinook. Despite the foregoing deficiencies of the sonar program, chinook salmon daily escapement rates have helped fishery managers develop inseason escapement estimates, which has led to more informed commercial fishing schedules.

Tower/Weir Escapement

Most Bristol Bay sockeye salmon populations escape the fisheries through a trunk river to which all of the spawning grounds are tributary. Visual count of the numbers of fish passing by vantage points on specially constructed towers that allow unobstructed passage of the fish upriver is the most common method employed in Bristol Bay to estimate the total escapement. This technique, developed and initiated in 1953 in the Wood River system, has permitted total sockeye escapement estimates to be made in many streams where it is not feasible to construct weirs or costly sonar operations. In conjunction with sockeye salmon counting tower operations, chinook salmon have been routinely enumerated for the duration of the tower operation. Tower derived chinook escapements should be considered as "index escapements", as most sockeye enumeration projects do not entirely cover the period when chinook are present. Nevertheless, tower counts do show the relative importance of chinook in the important sockeye salmon systems (Table 8). Wood, Igushik and Snake River systems contain few chinook salmon, but but the Nuyakuk River counting tower operation shows this river to be an important contributor to Nushagak chinook salmon production (Table 8).

Counting tower operations on Nushagak River, below the village of Ekwok, were conducted from 1966 through 1976, but were eventually terminated due to the inconsistent counting conditions at this site (Figure 13). Not only were river counting conditions poor, due to water clarity at the Ekwok tower site, but its up-river location to avoid multiple river channels, did not allow inseason use of the daily escapement estimates in a timely manner to adjust fishing schedules (Nelson, 1966-71).

Only one weir project has been employed in Bristol Bay to enumerate chinook salmon. In 1968, a wire/log weir was placed on the Stuyahok River, a major chinook salmon spawning stream of the Mulchatna River drainage (Figure 13). A total of 5,150 chinook salmon were counted through the Stuyahok River weir and subsequent aerial surveys of the river system provided an aerial estimate of 2,470 fish, or 48% of the known total chinook population (Table 14). Care must be used in applying this ratio to other streams because of differing physical and climatic conditions. However, the Stuyahok project does indicate in general terms what a comprehensive aerial survey under ideal conditions can account for in terms of total spawning populations.

Aerial Survey Escapement

Location of principal spawning areas, peak of spawning activities, and index counts of chinook salmon escapement in the Nushagak drainage was initiated in the mid-1950's by the Alaska Department of Fisheries (ADFG, 1957-59).

Since 1966, the expanded comprehensive aerial survey program has allowed a total estimate of the Nushagak watershed chinook salmon escapement to be made. Up through 1981, aerial counts of chinook were routinely expanded to provide total population estimates (Nelson, 1979). Expansion factors and methodology varied by year, but had yet to undergo a rigorous examination to determine if the methods and procedures in use were adequate to produce total district chinook escapement estimates. Factors used in expanding aerial counts included differential survey conditions, trends in distribution, expected proportions of fish actually seen from the air (derived from aerial surveillance of known numbers of sockeye salmon), and assumed levels of commercial exploitation (Nelson, 1979).

By 1982, an extensive series of escapement data had been collected from numerous spawning streams, and a complete examination led to an improved method to derive the district chinook escapement (Appendix Table 15). The mainstem Nushagak and Mulchatna Rivers comprise a significant proportion of the total chinook salmon spawning ground habitat within Nushagak District, and because water conditions very often preclude aerial surveys in these areas, there are only eight years since the survey program has been conducted that counts were obtained for these areas (Figure 13 and Table 11). For those years (1968, 1974, 1976-79 and 1983-84) selected portions (index areas) within the mainstems of Nushagak and Mulchatna Rivers produced aerial counts that were 15% and 11% of the total counts for all areas (Table 11).

Because aerial survey data is often incomplete for these two rivers, due to poor survey conditions, a method that would add the missing components and generate a total chinook escapement estimate was developed in 1982 using correlations for those years in which total counts were available (Bucher, 1983). Table 11 summarizes the eight years of comprehensive data which show a high positive correlation between the total peak aerial live counts (including Nuyakuk tower counts) and the total chinook population estimates for those years. The coefficient correlation was calculated to be .98, and the equation that was used to calculate the total chinook salmon escapement into the Nushagak drainage, using only index counts, is as follows:

$$Y = 4.27x + 11{,}440$$

Where Y = total population estimate of chinook salmon in the Nushagak and Mulchatna Rivers, including tributaries
x = total aerial counts for all index streams and areas

Since total chinook escapement estimates were first available in 1966, Nushagak District escapement has averaged 82,000 fish, with a range of 25,000 (1972) to 162,000 (1983)(Table 15).

SPAWNING GROUND DISTRIBUTION

Natural fluctuations in the relative abundance of various components of a stock, combined with selective effects of the fishery, often lead to poor distribution of the escapement on the spawning grounds. The total escapement may be adequate for a system, but if the distribution of the escapement does not conform to the relative spawning capacities of various spawning grounds, some grounds will be underutilized and others will be overutilized.

The initial chinook salmon aerial survey investigations in the Nushagak watershed revealed that significant contribution was also made by numerous smaller tributary streams throughout the entire region. Spawning ground aerial surveys were intensified in the mid-1960's, and of the 50 to 70 or so streams found to contain spawning chinook salmon, 27 of these spawning systems were designated as average, significant or primary spawning systems important to chinook salmon (Figure 13 and Table 9).

The streams listed on Table 9 as having been sampled for resident species have been found to be important spawning areas for chinook salmon. Streams shown by aerial surveys to be significant or primary contributors to the total chinook spawning population are the Muklung River, a tributary to the Wood River system, Iowithla, Klutispaw, King Salmon and Chichitnok Rivers, all tributary to the Nushagak River system, and the Stuyahok, Koktuli, and Chilikadrotna Rivers, and Old Man and Mosquito Creeks, which are tributary to the Mulchatna River system (Figure 13 and Table 10).

Of the dozens of freshwater tributaries to the Nushagak and Mulchatna River systems, the Koktuli, Stuyahok, King Salmon, Iowithla, Muklung and Klutispaw, all designated as "index streams", account for over 73% of the total observed district escapement (Table 11). In all probability, the mainstem Nushagak and Mulchatna Rivers are the number 1 and 2 chinook producers of the entire region. Chinook

utilize the Nushagak River extensively between the mouth of the Nuyakuk River to beyond Big Bend in the upper section of the river where over 85% of the entire river population spawns (Figure 13 and Table 12). In the Mulchatna River, heavy spawning (69% of the total) occurs from the mouth of the Koktuli River upstream to the mouth of the Chilchitna River (Figure 13 and Table 13).

Peak of spawning activity varies to some extent each year, but generally occurs between August 2-7, with chinook arriving in the upriver spawning tributaries by mid-July (Appendix Table 14). Although spawning activity peaks the first week of August, spawning continues at diminished rates until late August and early September (personal observations). Timing of aerial survey flights becomes critical, if aerial data is to be compared to ground counts to determine an expansion factor for estimating escapements in other streams. Generally, comparisons between ground and aerial survey methods have shown wide variability of success. Consecutive float surveys in 1962 on the King Salmon River demonstrated the rapidity with which the total count of chinook salmon may be expected to diminish following the peak of spawning (Table 14).

PROVISIONAL AND OPTIMUM ESCAPEMENT GOALS

Since the late 1970's, the Nushagak chinook salmon fishery has been managed to obtain an escapement of " at least 50,000 to 60,000 fish", and in 1984 an official provisional escapement range of 50 to 100,000 was established, with a point escapement objective of 75,000 (Fried, 1984).

Prior to the early 1970's, there were not enough escapement-return statistics to do a rigorous analysis of chinook salmon escapement requirements. Adequate age composition data were available for the commercial gill net harvest, but escapement samples were inadequate to document age structure. Commencing in 1981-82, an escapement sampling program was funded, and sampling showed that the age composition of both the catch and escapement were similar in most years (Appendix Tables 19 and 21). With this information in hand the inshore catch and escapement statistics were examined using a Ricker model of the relationship between spawning escapement and resulting returns.

Optimum escapement values were computed for the entire available complete data base (1966-78 brood years), and with forecasted 6, 7 and 8-year old chinook returns for the 1979-81 brood years:

Brood Years	Optimum Escapement	Maximum Sustained Yield	Escapement Range
1966-78	61,000	120,000	45,000 to 79,000
1966-79	62,000	121,000	46,000 to 81,000
1966-80	56,000	119,000	41,000 to 72,000
1966-81	56,000	119,000	42,000 to 73,000

The optimum chinook escapement for the years with complete returns (1966-78) show an optimum value of 61,000 fish, with a range of 45,000 to 79,000 (Figure 15). Forecast returns of 7 and 8-year old fish returning in 1979 and 1980, were included in the second and third optimum escapement calculations because these two large brood year escapements appear to be producing at a lower level (Table 16). If actual returns closely approximate those forecast, the indicated optimum escapement for the 1966-80 brood years would be 56,000 fish with a range of 41,000 to 72,000 (Figure 15).

Returns from recent large chinook escapements (1980-83), which averaged 150,000 fish, need to be included into the data base before an official optimum escapement goal is established. Preliminary indications (5-year return of 43,000 from the 1981 brood year and the 4-year return of 4,000 from the 1982 brood year) suggest that these two large brood year escapements may indeed produce at a much lower level of productivity (Table 16).

If lower returns do result from the 1980-83 brood year escapements, the indicated optimum range could very well fall within the 50,000 to 60,000 range previously established in the mid-1970's. In the meantime, the present provisional escapement objective of 75,000 chinook, which is slightly higher than the indicated optimum, should be maintained because the control over the commercial fishery is not precise, and some degree of underfishing is probably less costly in the long-term than overfishing the stocks. The Nushagak District chinook escapement has averaged 82,000 since total estimates were first available in 1966, a value that generally realized or exceeded the indicated optimum escapement range (Table 16).

An equally essential element of an escapement objective is the potential egg deposition they represent. The effects of commercial gill net mesh size on escapement sex ratios and the reproductive potential (egg deposition) has the potential to alter the long-term yield derived from the exploited stocks. The effects of mesh size will be discussed in the next section of this report.

CHINOOK SALMON BIOLOGY

Collection of basic age-weight-length data from Nushagak District chinook salmon and other life history information and research was initiated in 1956 by the Alaska Department of Fisheries (ADFG, 1957-59). However, statistically adequate sampling results were not forthcoming from the chinook salmon commercial catch until 1966, and from the escapement until 1982. All age, weight and length statistics for Nushagak chinook salmon are summarized in annual catch and escapement data compilation published reports for 1956-86 (Yuen and Nelson, 1984 and ADFG, 1978-86). Sampling procedures generally include measuring the length of the fish (mid-eye to fork of tail in millimeters) determining sex and removing a scale for aging purposes. Weights are regularly taken from Nushagak commercial catches, and samples from the chinook escapement frequently depend upon sampling of spawned carcasses with removal of scales or otoliths for aging purposes.

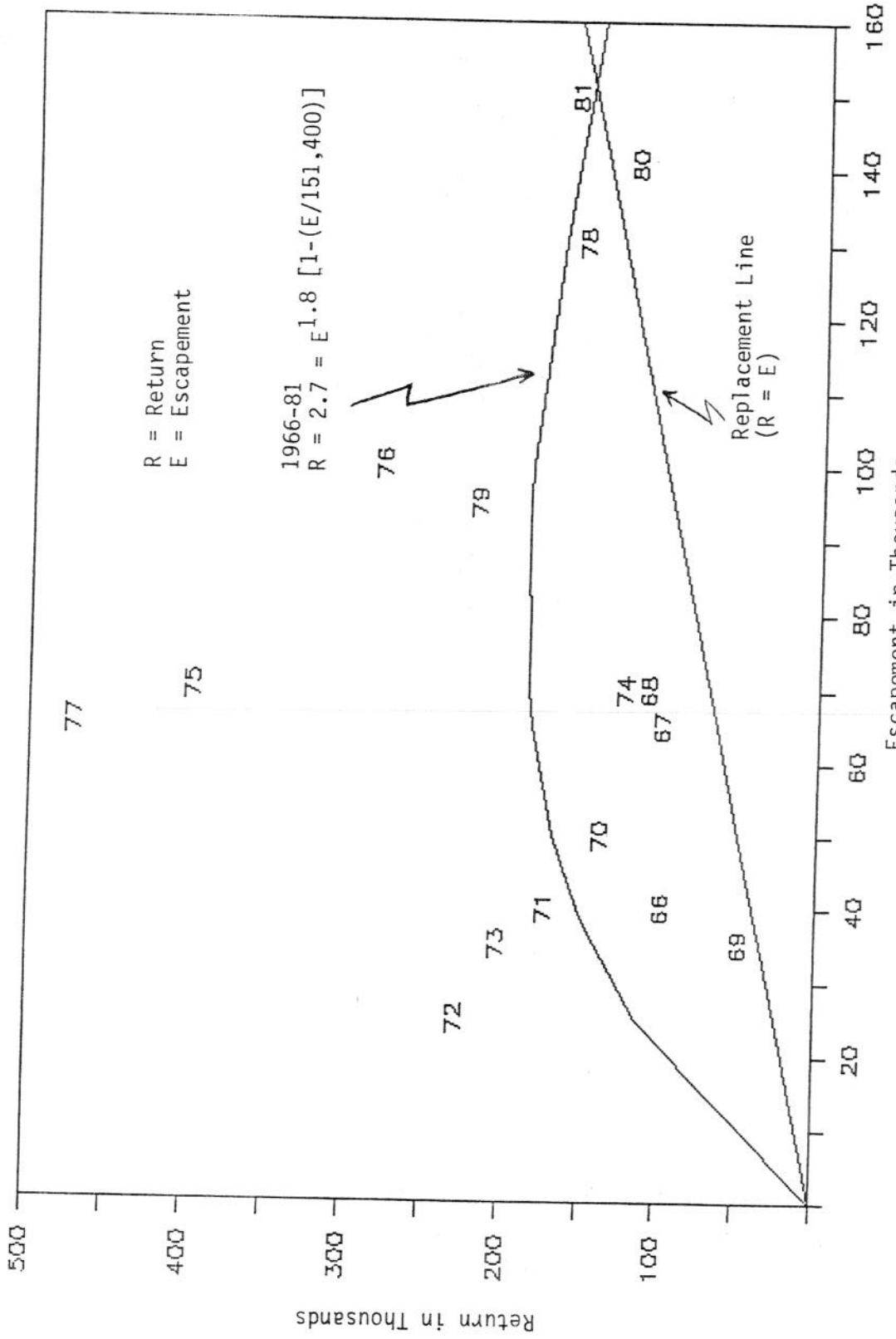

Figure 15. Escapement and return relationship of chinook salmon in Nushagak District, Bristol Bay, 1966-81.

AGE CLASS COMPOSITION

Scale samples from the commercial gill net chinook salmon fishery are available since 1956; however, the number of samples were relatively small in the early years (300 average), but since 1966 the annual sample size has averaged over 1,000 fish (Appendix Table 19). Sampling schedules now include a 500 fish sample from approximately three sampling periods, spread over the length of the fishery. Age designations used throughout this report are the European method superimposed over the Gilbert-Rich method.

Sample data from the subsistence gill net fishery and chinook salmon escapement are much less extensive. Increased sampling efforts on these two components began in 1982, and both data sets show a close similarity to age results from the commercial gill net fishery (Appendix Tables 20 and 21). Escapement samples taken in 1982-84 from 4 to 6 of the major chinook salmon producing river systems, demonstrated a relatively close age class similarity to samples from the commercial fishery in the same years:

		Percent By Age Class			
		1.2	1.3	1.4	1.5
		4(2)	5(2)	6(2)	7(2)
1982 -	Catch	8	43	38	4
	Escapement	7	44	44	2
1983 -	Catch	22	14	60	3
	Escapement	11	16	72	1
1984 -	Catch	7	51	34	8
	Escapement	7	43	38	11

Although there is some variation in age class composition from year to year, the majority (80%) of Nushagak chinook salmon return as 5 and 6-year old fish (Figure 16 and Table 16). Chinook salmon usually mature at greater age the further north they occur, and the span of dominant ages for chinook in Nushagak District of 4 to 7 years fits the northerly trend of increased age at maturity (Rogers, et al, 1983). Sampling of inshore returns have documented 16 individual chinook salmon age classes, but over 96% of the returns are composed of four age groups: 4(2), 5(2), 6(2) and 7(2) (Figure 16). Occasional 0 and 2 freshwater age classes appear in the inshore run, but virtually all Nushagak chinook spend only 1 winter in freshwater (Appendix Table 16).

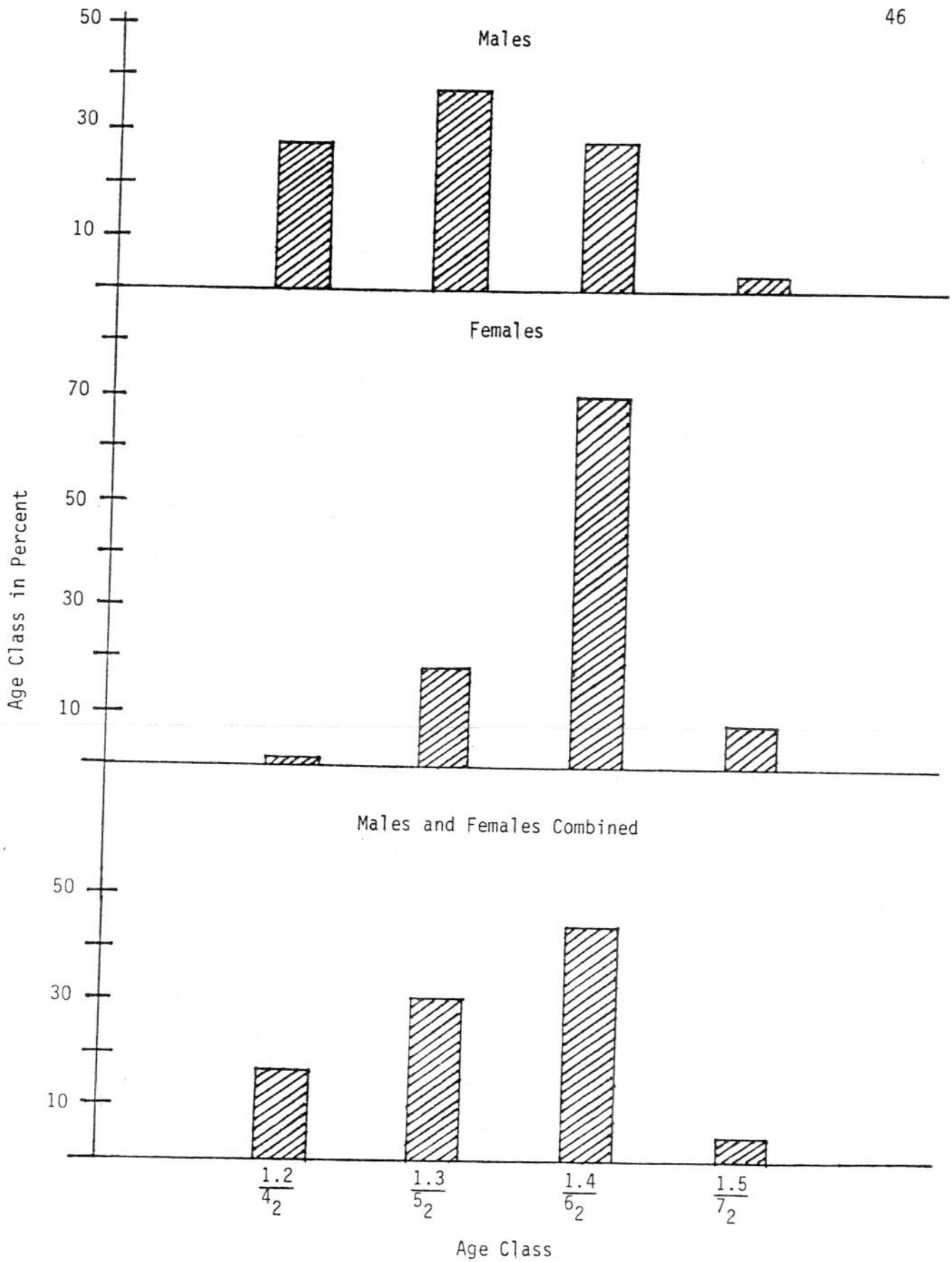

Figure 16. Age composition of male and female chinook salmon in the commercial catch, Nushagak District, Bristol Bay, 1956-86.

The age class differences between male and female chinook is striking, with the early-season large mesh chinook gill net gear accounting for a heavy preponderence of large females, while smaller mesh sockeye gear affects a high proportion of younger age males:

Average Percent by Age Class for 1956-86

	1.2	1.3	1.4	1.5
	4(2)	5(2)	6(2)	7(2)
Males -	27	39	28	2
Females-	1	18	69	8
Total	17	30	45	4

The Nushagak chinook fishery shows an overall higher percent of males in the commercial catch, which is due to a relatively greater abundance of early maturing smaller age 4 and 5-year males (Appendix Table 22). The larger age 6 and 7-year old age classes contain a significantly greater percentage of females.

SEX RATIO COMPOSITION

Although there are considerable variations in sex ratios from area to area and between years, there appears to be an overall higher percentage return of males during 1964-78, when the average percent of males in the harvest of western Alaska chinook was 51% and 52%, respectively, for the Yukon and Kuskokwim fishery, and 60% for the Nushagak fishery from 1956-86 (Meacham, 1980 and Appendix Table 22). A higher percentage of males was also found in all of the commercial fisheries with smaller mesh size gill net gear.

Since 1976, when smaller mesh gear has been allowed into the Nushagak fishery effective June 16, higher average harvests (20,000 fish) of excess male jack chinook salmon (age 4(2)) have resulted, compared to 4,000 age 4(2) chinook annually harvested prior to June 16 with the large mesh gear restriction (Appendix Table 16).

Unlike samples from the Yukon River chinook escapement in 1970-78, where males were in higher proportion than females, extensive sampling in Nushagak spawning tributaries in 1982-84 indicate an overall higher percentage of females in those areas sampled, although a weighted average of the catch and escapement continues to show an overall higher number of males:

		Sex Ratios in Percent		
		Males	Females	Sample Size
1982 -	Catch	55	45	1,027
	Escapement	51	49	1,491
1983 -	Catch	60	40	1,578
	Escapement	44	56	1,429
1984 -	Catch	67	33	503
	Escapement	44	56	1,408
Weighted Average	Catch	59	41	
	Escapement	47	53	
Total (1982-84)		53	47	

SIZE COMPOSITION

Length frequency distribution from the 1966-67 Nushagak commercial catches show that there is considerable overlap of lengths between various age classes, but that female chinook are generally longer than males of the same age up through 6 years of age (Figure 17). More recent length summaries from the Nushagak commercial fishery in 1967-80, confirm the continuing larger size for female chinook through age 6 (Rogers, et al, 1982).

	Length in Millimeters by Age Class 1/			
	1.2	1.3	1.4	1.5
	4(2)	5(2)	6(2)	7(2)
Males -	567	749	870	944
Females-	-	796	883	923

1/ Length measurement is mid-eye to tail fork.

Figure 18 shows the length frequency as a percentage distribution of the total number of fish measured by sex from all chinook sampled from the commercial fishery from 1956-67. Again this data shows the overall superior length of the females, except for older age groups (presumably 7 and 8-year old fish).

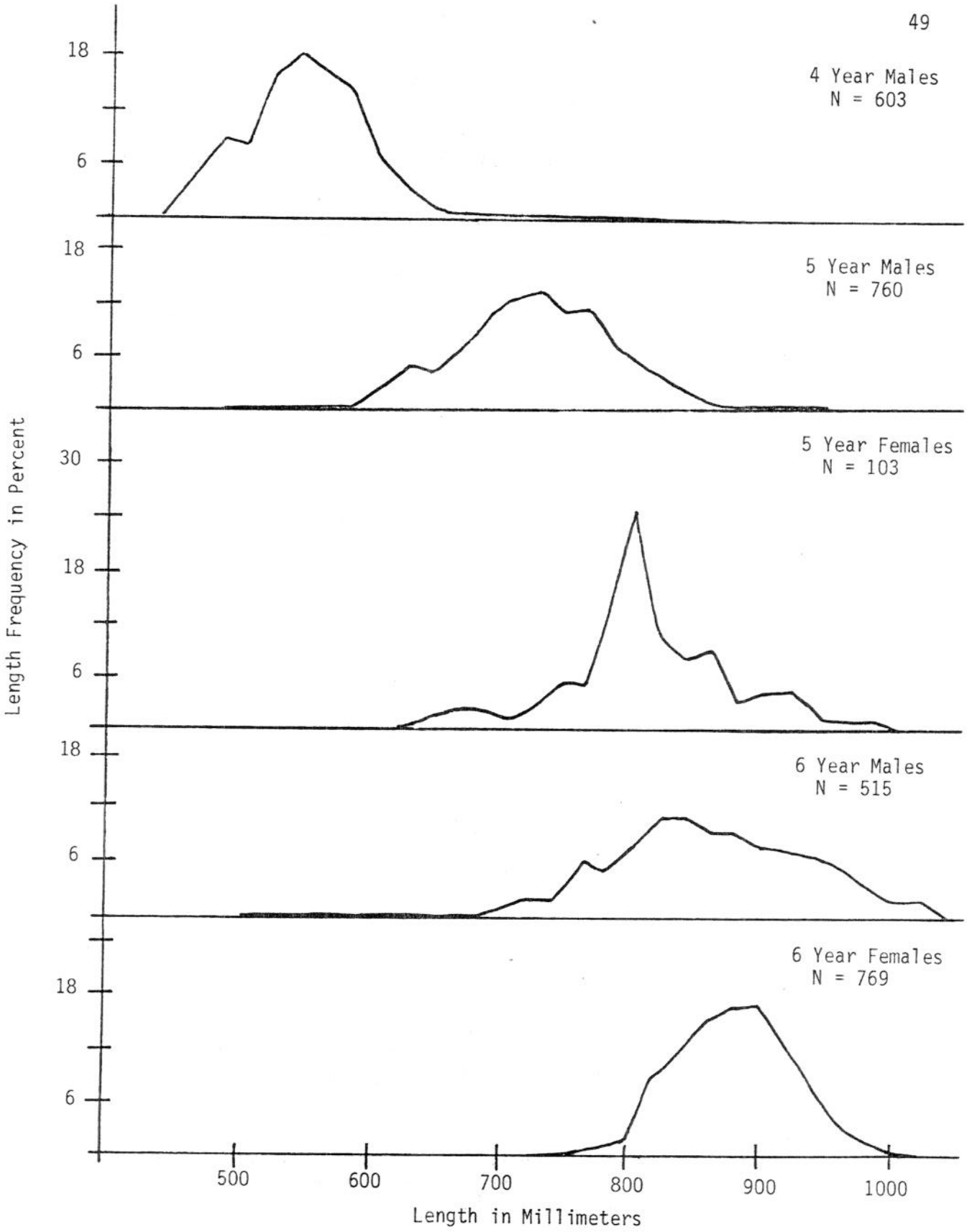

Figure 17. Length frequency distribution of male and female chinook salmon by age class from the commercial catch, Nushagak District, Bristol Bay, 1966-67.

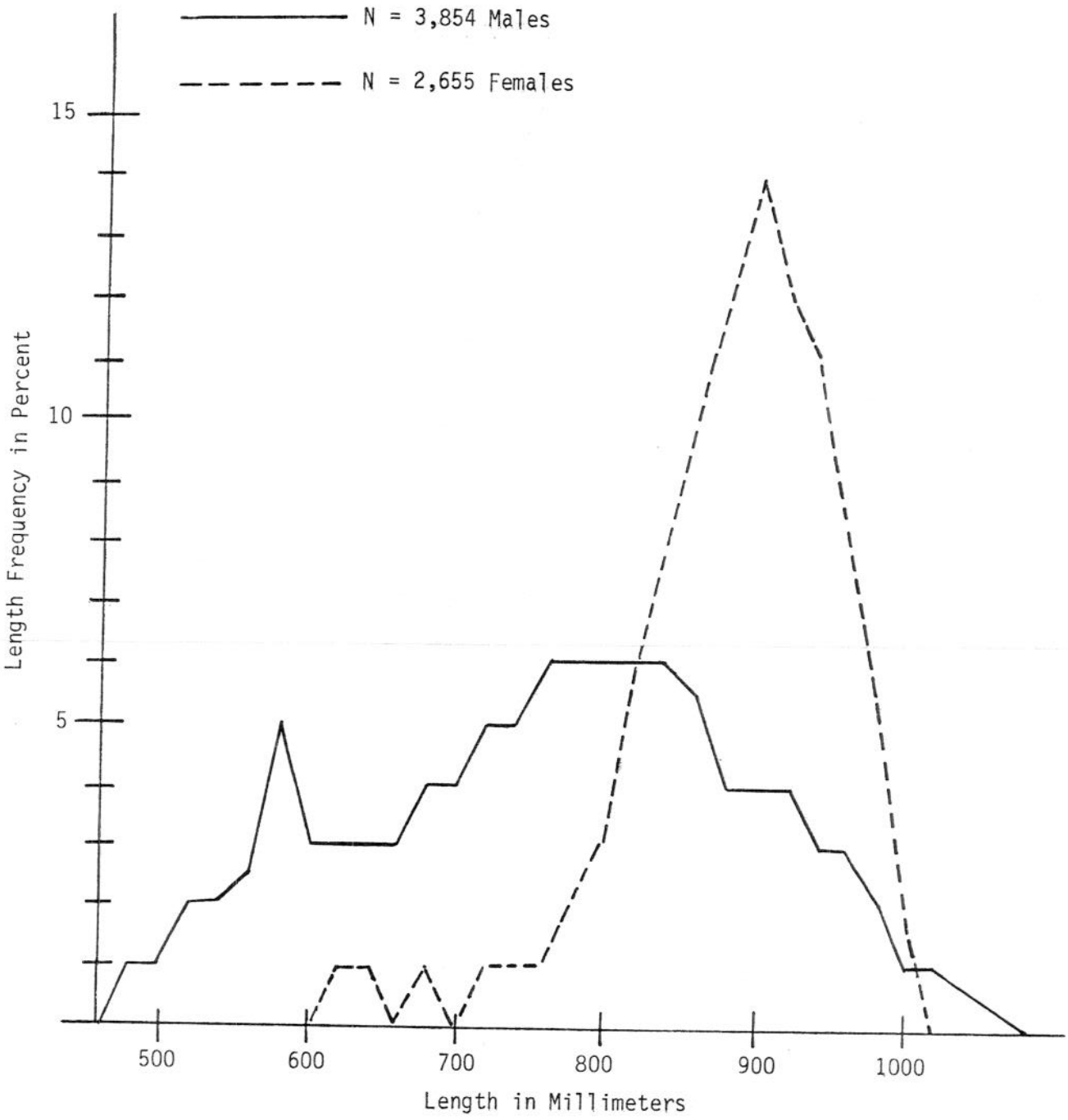

Figure 18. Length frequency distribution of male and female chinook salmon from the commercial catch, Nushagak District, Bristol Bay, 1956-67.

Chinook salmon weight samples have been taken regularly from the commercial catch, and a comparison of the mean weight values obtained are shown on Appendix Table 23. Male chinook salmon have averaged about 17 pounds in the commercial harvest, while females average approximately 25 pounds from data collected from 1964 through 1986.

Weight data by ocean age class and sex are also available, and the mean weight of females tends to be greater for a given age class than that for males of the same age class for the major ocean age groups: (Figure 19)

	Mean Weight in Pounds by Ocean Age						
	1	2	3	4	5	6	Total
Male	4.0	7.9	16.0	25.2	31.9	37.2	16.6
Female	-	7.0	19.7	26.0	29.5	-	24.8
Total	4.0	7.9	16.9	25.7	30.2	37.2	19.8

The length-weight relationship of 558 male and 401 female chinook salmon taken in the commercial gill net fishery in 1967 is shown on Figure 20.

FECUNDITY

In 1966 and 1968 a total of 69 fish were sampled from the Nushagak chinook commercial catch to determine fecundity, and in order to obtain a measure of potential productivity to relate escapement to future runs. The fecundity samples were selected at various length intervals between 730 to 1,060 mm to insure that all major age classes would be represented. Both actual tally count and a volumetric method were employed to enumerate the number of eggs from each female sampled.

The number of eggs per fish ranged from a minimum of 5,302 to a maximum of 16,049. The mean number of eggs by age group is shown below:

	Mean		
Age	Length 1/	Weight 2/	Fecundity
1.3/5(2)	777	18.2	8,358
1.4/6(2)	884	26.8	10,299
1.5/7(2)	974	33.3	12,214
Total	885	26.6	10,378

1/ Length in millimeters, mid-eye to tail fork.
2/ Weight in pounds.

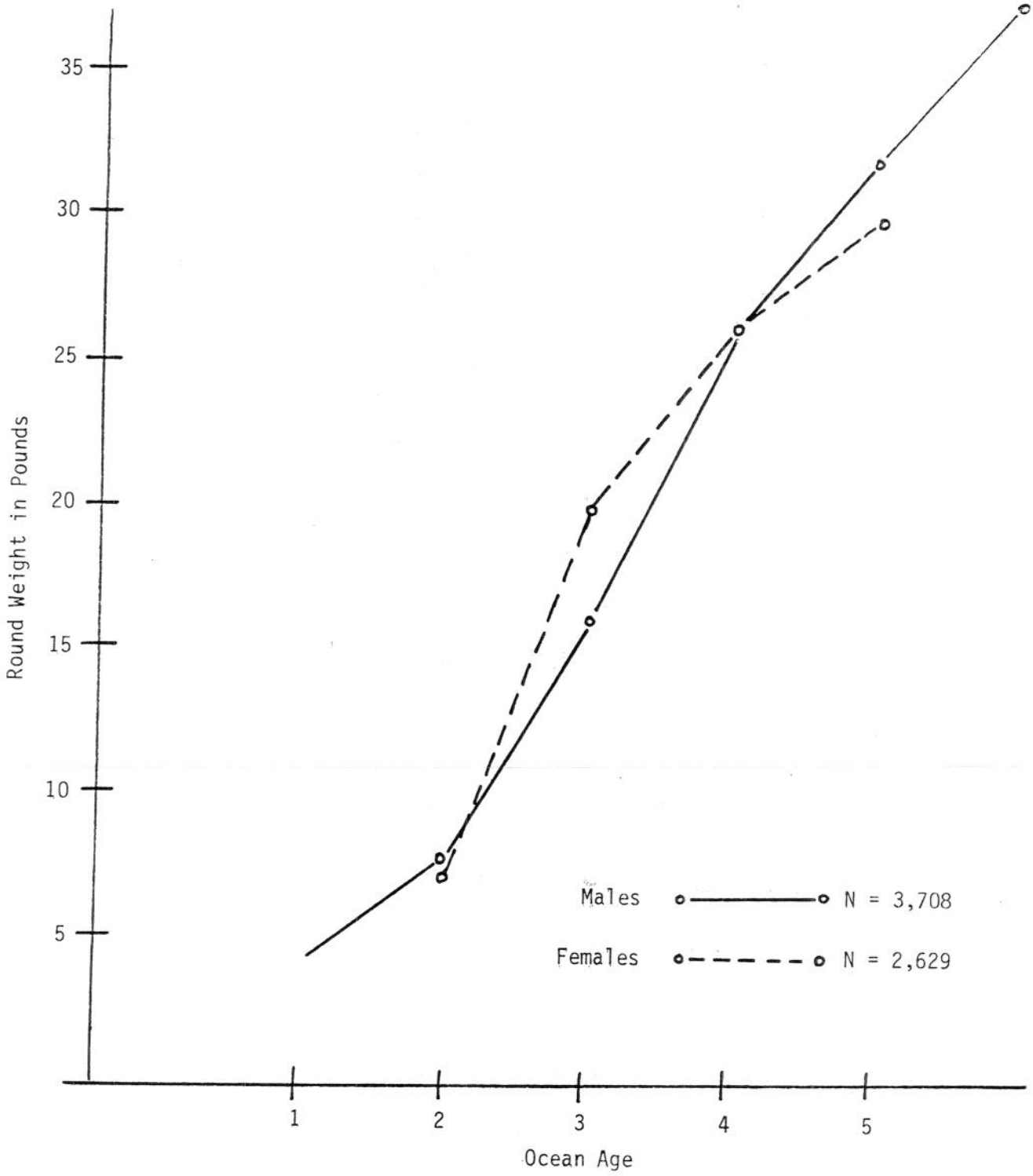

Figure 19. Mean round weight in pounds by ocean age of male and female chinook salmon in the commercial catch, Nushagak District, Bristol Bay, 1964-86.

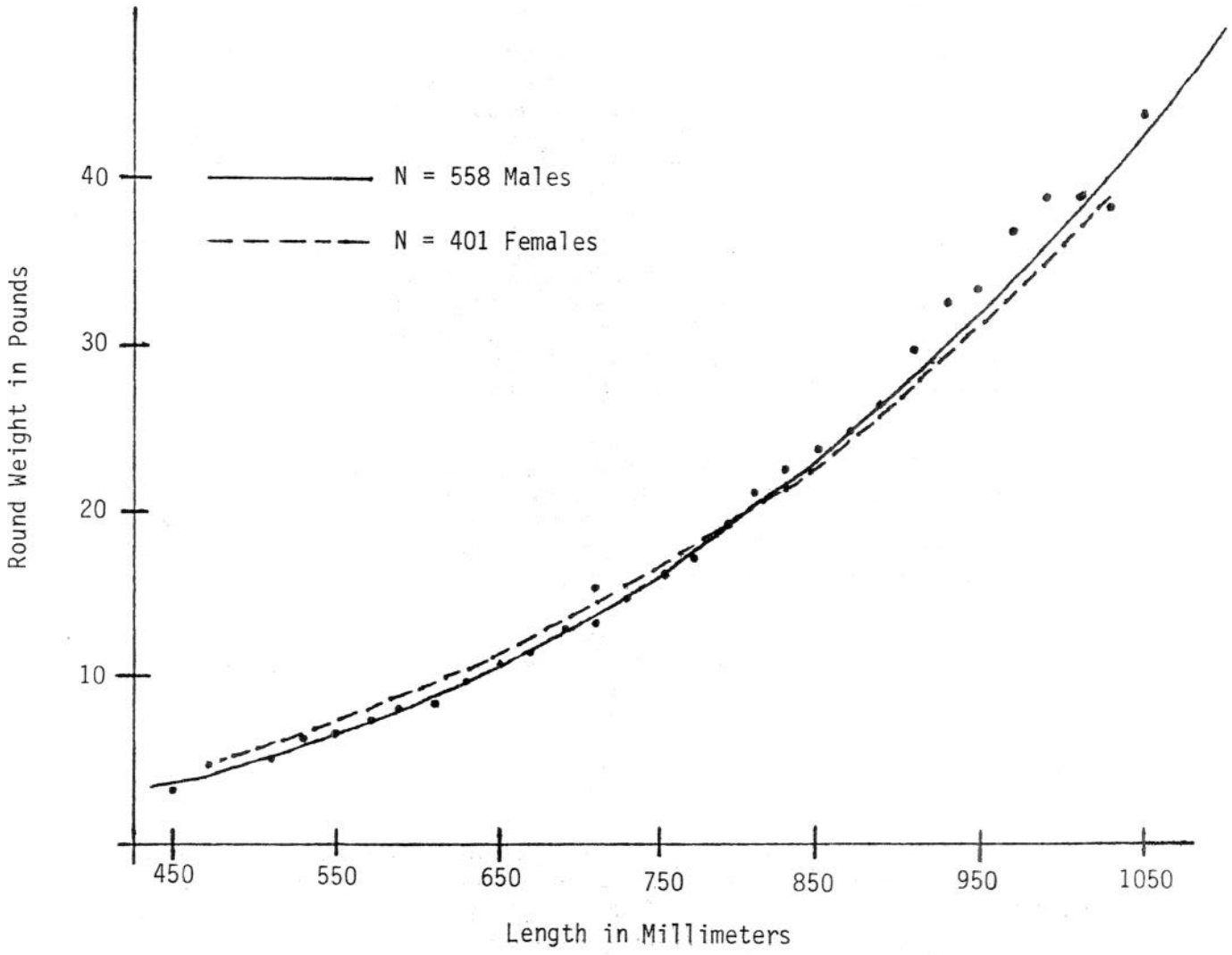

Figure 20. Length-weight relationship of male and female chinook salmon from the commercial catch, Nushagak District, Bristol Bay, 1967.

Chinook salmon from different areas have differing mean fecundities and it appears that the mean number of eggs in female chinook from Nushagak River are among the highest recorded on the Pacific Coast of North America (Appendix Table 25).

GILL NET MESH SIZE CONSIDERATIONS

In management of the salmon runs to the Columbia River, mesh sizes of gill nets used in the fishery are frequently regulated to permit the harvest of one species and reduce the catch of another. However, in Nushagak District, mesh sizes used in the past have been related to sockeye salmon management, and not for any biological considerations for chinook salmon.

Mesh size restrictions for the Nushagak chinook salmon commercial fishery have been in existence since 1923 (Appendix Table 5). Mesh size in gill nets primarily affects the size of fish captured, regardless of species. Since the age at sexual maturity varies both between and within chinook salmon populations, particularly between males and females, the actual sex ratio and age class composition of any chinook escapement can be significantly affected by the mesh size regulations pertaining to any gill net fishery that the chinook population passes through (ADFG, 1981).

For the first time in 1985 and again in 1986, large mesh chinook salmon gill net gear was restricted in Nushagak District to effect a lower catch per unit of effort on the chinook runs. Effectiveness of the inseason Nushagak mesh size adjustment was difficult to measure, but in 1985 it was intuitively felt to have allowed an additional 10,000 to 15,000 large chinook salmon to enter the escapement.

The balance of this section reviews the mesh size issue in regards to the effects on chinook size and age composition, sex ratios, reproductive potential and egg deposition.

Effects on Size and Age Composition

As documented in this report, age at maturity for Nushagak chinook salmon stocks are variable, but that chinook maturing at an older marine age are, on the average, larger than those chinook maturing earlier. The selective action of gill nets also affects age composition of the resultant escapement. Length frequency distribution of chinook salmon in large vs. smaller mesh gill net gear is shown on Figure 21. The change in mesh size is usually accompanied by a change in the age composition of the catch, and particularly evident is the increase in the percentage of the smaller age 4(2) males. Also, with the change from large to small mesh gear, the mean lengths of the female remains similar or shows a slight decrease, while the mean lengths of the male chinook decreases significantly. Data of this type have led to a model which permit the estimation of the mean length of fish captured on the mesh size of the gill nets used. Data from chinook salmon taken in 5-3/8 to 8-1/2 inch mesh gill nets from the Yukon River and Nushagak District are summarized below:

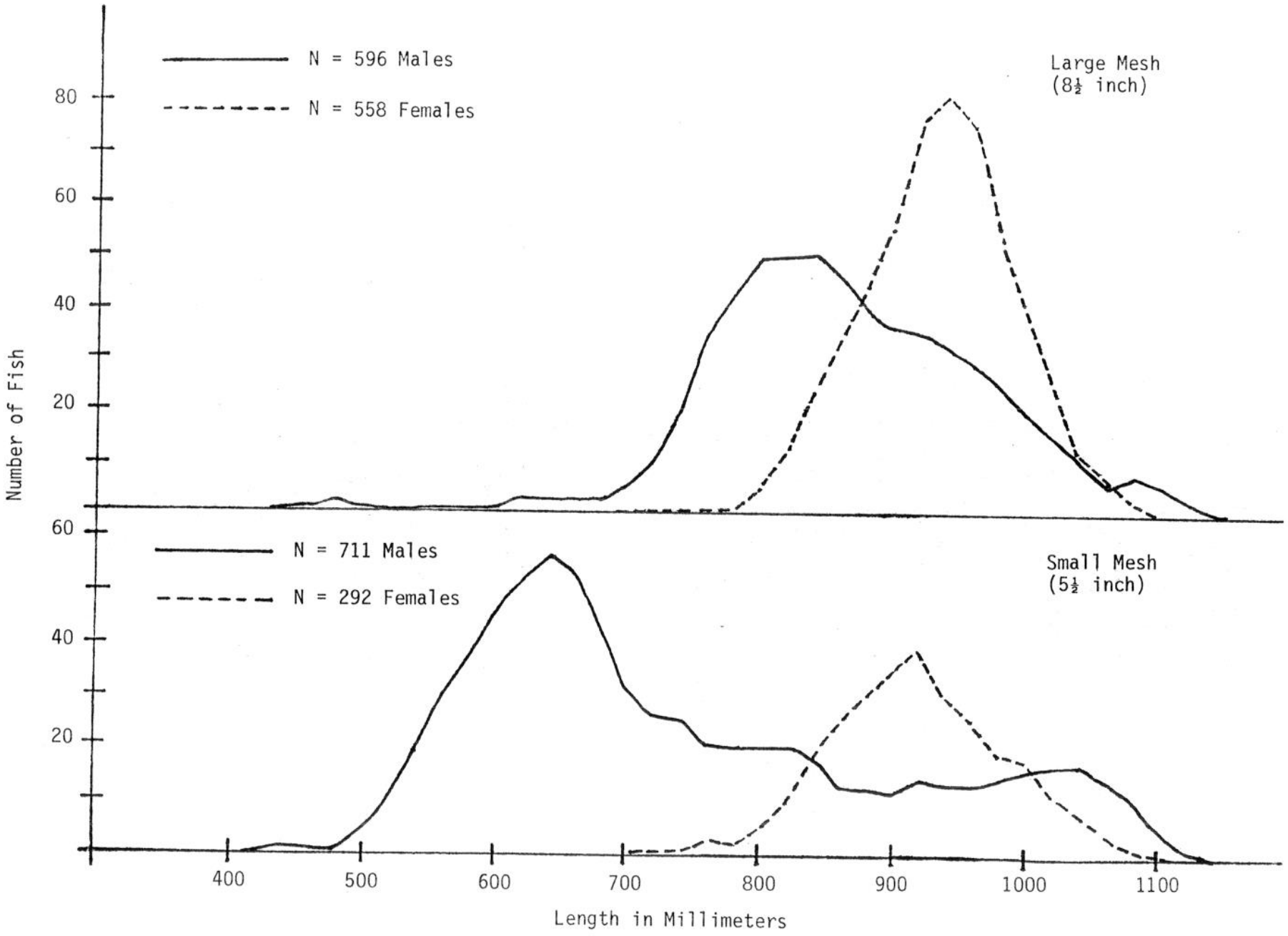

Figure 21. Length frequency distribution of male and female chinook salmon in the commercial catch from large and small mesh gill net gear, Nushagak District, Bristol Bay, 1956-59.

---"data is available from the Yukon River and from Nushagak District in Bristol Bay which will permit estimation of these parameters. Chinook salmon have been taken by the Yukon River test fish project using both 5-1/2 inch and 8-1/2 inch mesh gill nets. Yukon River data shows that a 6-inch mesh size may be expected to key upon relatively smaller chinook (roughly 10 pounds) while the 8-1/2 inch mesh definitely keys upon larger (roughly 20 pounds) chinook salmon"---

---"In Bristol Bay, Nushagak District commercial catches, taken in 5-3/8 inch and 8-1/2 inch gill nets, show a modal length of 693 mm (about 12.5 pounds) which will be most heavily selected for 6 inch mesh gear. As in the Yukon River fishery, the Nushagak selectivity data shows that the smaller 5-3/8 inch gear selects for a wider size range of fish than larger mesh. This difference principally manifests itself by selecting the 2-ocean fish (mostly males) more heavily in the smaller mesh gear"---

---"These two data sets provide independent estimates of the targeted size group harvested by 6-inch and 8-1/2 inch gill nets. Six inch mesh tends to select smaller chinook (average of 661 mm) than 8-1/2 inch mesh (average of 815 mm). Use of smaller mesh in Nushagak District would result in significant changes in the age and sex composition of the catch. Changes in sex composition aside, considering differences in fecundity between chinook salmon of different lengths indicates substantial differences in potential egg deposition between chinook which would theoretically be caught in 8-1/2 inch mesh gill net vs. 6-inch mesh gill net".---(Meacham, 1981).

Effects on Sex Ratio

It has long been recognized that the actual mesh size utilized by gill net fisheries affects the resultant sex ratio of chinook salmon populations on the spawning grounds. Age at maturity for chinook salmon is variable and is related to sex among other factors. On the average, male chinook salmon mature at a younger age and are therefore typically smaller than females. Smaller mesh gill nets (5-3/8 inch) tend to selectively capture smaller chinook salmon which are primarily males while larger mesh nets (8-1/4 to 8-1/2 inch) tend to select for larger salmon which are primarily females.

Selected studies in different areas show that in all cases, males outnumber females in catches made with small mesh gear:

River	Years	Mesh Size (inches)		Percent			
				Small Gear		Large Gear	
		Small	Large	Male	Female	Male	Female
Taku	1953	6	9	64	36	43	57
Stikine	1976	6-3/8	8-1/2	68	32	48	52
Yukon	1969-79	5-1/2	8-1/2	76	24	60	40
Nushagak	1956-86	5-3/8	8-1/2	68	32	56	44

(ADFG, 1981 and Appendix Table 22)

While these and other data exhibit significant variability in sex ratios of chinook salmon harvested with various mesh sizes, it is clear that small mesh gill nets target primarily on males while large mesh gill nets select predominantly females. Analysis of Yukon River data, for the period 1970-1978 indicated that the average sex ratio of the spawning population has been approximately 64% males vs. 36% females for those escapements sampled during carcass surveys (ADFG, 1981). This implies that a serious imbalance in sex ratio may have been occurring and that escapement levels observed probably bear little resemblance to actual seeding level in the various spawning grounds. On the other hand, extensive sampling of Nushagak River chinook escapement in 1982-84 shows an approximately equal balance between males and females, 53% vs. 47%, respectively.

Effects on Reproductive Potential and Egg Deposition

Since large mesh gill nets tend to harvest larger, female chinook salmon, such selectivity also affects the average fecundity of the female chinook spawning population. Numerous studies have shown that a positive relationship exists between length (and weight) per female and fecundity (number of eggs per female) (Appendix Table 25). Fecundity studies in 1966 and 1968 show that Nushagak chinook salmon have higher average fecundities with age: 5-year old females,8,400; 6-year old, 10,300; and 7-year old, 12,200 (Appendix Table 24).

Meacham, 1981 goes on to add that:

---"changes in sex composition aside, considering differences in fecundity between chinook salmon of different lengths indicates substantial differences in potential egg deposition between chinook which would theoretically be caught in 8-1/2 inch mesh gill nets vs. 6-inch mesh gill nets. In Nushagak District the theoretical chinook salmon catchability based on mesh size shows:

> 8-1/2 inch mesh-804 mm chinook with a 7,700 average fecundity; and
> 6-inch mesh-693 mm chinook with a 5,800 average fecundity".---

Using average fecundity data and the male to female ratios for Nushagak chinook harvested in large vs. small mesh gill nets, results in an estimated egg loss on the spawning grounds of approximately 339,000 eggs vs. 186,000 eggs per 100 chinook salmon harvested with large mesh vs. small mesh gill nets, respectively. This two-fold difference in potential egg deposition on the spawning grounds poses important questions regarding use of 8-1/2 inch mesh and its effect on the long-term sustained yield for the Nushagak chinook salmon fishery (ADFG, 1981).

Equally important would be a determination if large mesh gill nets can affect the genetic basis of the population, and if average size and hence productivity, can be decreased with continued use of large mesh nets. It is probable that the existing commercial fishing schedule is allowing a good mix of fish sizes, and thus the genetic question may not be of major importance.

CHINOOK SALMON FISHERY STOCK STATUS

Substantial quantitative data are available on Nushagak chinook salmon stocks. The status of this stock of is reviewed and summarized in this section from the collected data base in regards to catch and escapement trends, exploitation rates and the future outlook.

CATCH AND ESCAPEMENT TRENDS

Total inshore run catch and escapement statistics are available since 1966 for the Nushagak chinook salmon fishery. The current trend of total adult production shows a significant improvement beginning in 1978 compared to the period from 1966-77 (Figure 22). The total chinook return to Nushagak District has averaged 125,000 fish from 1966 through 1977, and more recently (1978-86) has averaged 246,000. Increased production since 1978 corresponds to warm weather and warm surface temperatures in the Bering Sea and northern Gulf of Alaska. The decline in air and water temperatures during the 1940's corresponds to the decline in the runs of many stocks of Alaskan salmon including the Nushagak stock of sockeye, and it may have affected chinook as well. The warm temperatures in the late 1950's coincided with a return to average or above average catches whereas the very cold years in the early 1970's coincided with very small runs of chinook in 1972 through 1975 (Table 15 and Appendix Table 7).

It has been generally felt that environmental conditions during the early marine life (smolt migration) are critical for total marine survival and that very cold winters may adversely affect freshwater survival. In addition to favorable environmental conditions, other factors which may have substantially increased chinook production in Nushagak District are (1) reduced fishing effort by the high seas Japanese gill net fishery on Bristol Bay chinook, and (2) the generally large, well distributed chinook escapement in the parent years from 1975 through 1979.

Chinook recreational sport fisheries are growing rapidly, but still remove only a small proportion of the total run, although increased levels of sport harvest trends since the early 1980's show the potential for future increased use by this interest group. Subsistence chinook harvest levels are expected to remain high, and will continue to be somewhat independent of stock abundance, while the commercial gill net fishery, which accounts for over 90% of the total chinook harvest exploitation, is expected to continue at harvest levels as experienced during the period of sustained utilization from 1955 through 1971.

The outlook for continued good chinook production is promising, although recent trends suggest reduced levels of productivity (Table 16). Recent evidence from scale pattern analysis demonstrates that all western Alaska chinook stocks are still subject to directed high seas foreign salmon fisheries, as well as increasing harvest from both foreign and domestic trawl fisheries within the fisheries conservation zone. The results of the recently concluded high seas fishery negotiations with Japan, may very well result in a substantial increase in chinook returns to western Alaska in the future.

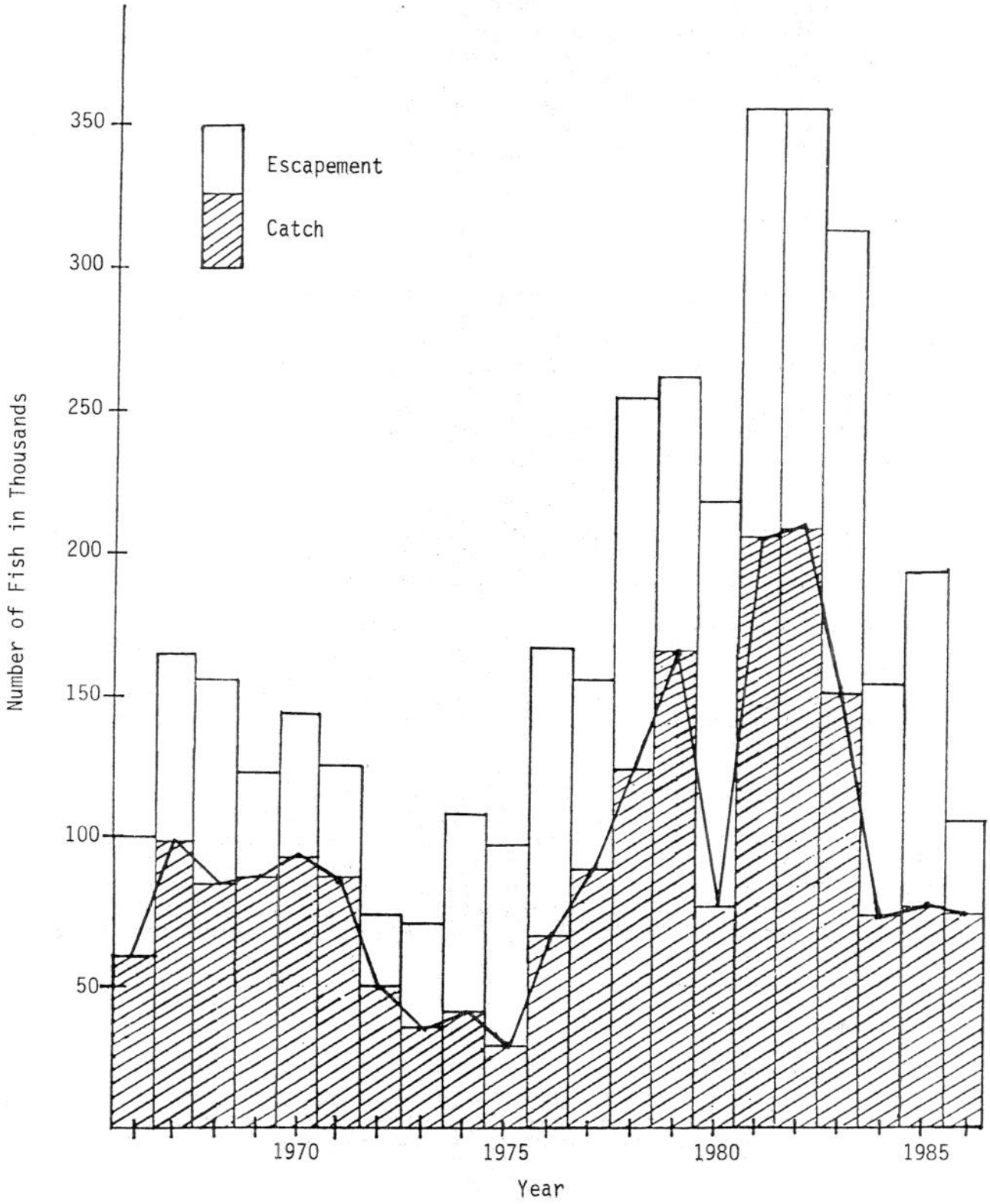

Figure 22. Total inshore return of chinook salmon, Nushagak District, Bristol Bay, 1966-86.

The chinook salmon escapement has averaged 82,000 fish since the first estimates were available in 1966, although the escapement of 33,000 obtained in 1986 was the lowest since 1972 (Table 15). Early season escapement of chinook has been minimal due to the heavy commercial exploitation on the early run stocks. It has yet to be shown if early run chinook that are destined for the various river tributaries, are separate entities or discrete populations distinguishable by different timing through the fishery. Sockeye salmon tagging studies in Bristol Bay show that this species is generally intermixed, and that no segregation of racial groups is evident. If the same holds true for Nushagak chinook salmon, it would be difficult to afford additional protection to chinook from any particular tributary race because of overlap in timing through the fishery.

EXPLOITATION RATES

The early-season exploitation rates from 1979-86 have averaged over 95% of the early Nushagak chinook run. These high exploitation rates are unacceptable and the heavy early-season commercial fishing pressure may be seriously affecting some of the early or distant chinook salmon spawning stocks. If the various chinook racial stocks are generally intermixed within the fishery, as are sockeye salmon, the heavy exploitation rates may have less effect upon the genetic integrity of the stocks. Regardless of this uncertainty, which can only be addressed through a tagging and recovery program, exploitation rates of any stock of fish which equals 95% is unacceptable. For the long-term health and viability of this chinook resource, it will be necessary to lower the commercial exploitation of these early-run fish, and attempt to spread the escapement out through time. The extent that this improved escapement distribution is effective may well seal the fate of how this chinook stock will fare in the future.

Levels of total seasonal exploitation for Nushagak District chinook salmon stocks have ranged from 29% to 72% and averaged 54% from 1966 through 1986 (Table 15). There have been no studies which would indicate an upper limit of exploitation for Nushagak chinook, however, escapements have generated an average of about three recruits per spawner, indicating that a harvest rate of up to 67% is sustainable (Table 16).

Through 1977 the chinook rate of return per spawner had averaged 3.88, but has fallen to approximately 1.44 from 1978-80 (with an estimated return of 7-year old fish from the 1980 brood year (Table 16). The cause of this apparent decline in reproductive potential is not known, but by inference the shift in chinook run strength and productivity may be associated with changes in gear selectivity, which in turn, affects the potential egg deposition. On the other hand, the high seas exploitation by gill nets, and the more recent trawl effort may also be a contributing factor.

INSHORE RUN FORECAST

The first chinook salmon forecast for the Nushagak District was produced in 1984, and was based upon spawner recruit and return of sibling age class information (Minard and Meacham, 1984-87). By 1987 three methods were being used to

forecast chinook returns of the four major age classes (4(2), 5(2), 6(2) and 7(2)) to Nushagak District:

1. Spawner Recruit Forecast: this method is based upon escapement-return curves derived for each of the four age classes;

2. Mean Percent: this method is based upon a single escapement-return relationship over all ages to estimate a total return; the estimated total is then broken out by age class by the mean percent contribution by age; and

3. Sibling Return: this method is based upon linear regressions of sibling returns for year t from observed returns in year t-1.

In addition, ranges are obtained for each forecast method, and selection of the actual forecast for each year is made based on evaluation of past forecast performance. The sibling return forecast method has produced the best results, while the escapement-return relationships do not appear sensitive to the large chinook escapements observed in the early 1980's (Table 18). The spawner-recruit and mean percent forecast methods have been much higher than actual returns in the past several years due to the large brood year escapements that are now producing the returns.

The performance for all forecast methods is shown on Table 18, while Figure 23 shows the success of the best forecast method (sibling model).

DISCUSSION

This section reviews the present chinook salmon management program for the Nushagak District, and concludes with recommendations for future studies and management steps to assist in the administration of the fishery.

NUSHAGAK MANAGEMENT PROGRAM

Management of the Nushagak District salmon resource is made more difficult by the multi-species aspect of this district's salmon runs. Nushagak District has accounted for over 70% of Bristol Bay's commercial production of chinook salmon, and is the only area with a major directed commercial effort aimed at chinook. Additionally, this district annually since 1967, produces large numbers of sockeye salmon (4.3 million, or 17% of total Bristol Bay production), chum salmon (740,000, or 51% of total), even-year pink salmon (3.0 million, or 86% of total) and coho salmon (311,000, or 51% of total).

The earlier run timing of Nushagak chinook from sockeye-chum stocks, generally allows the chinook resource to be managed separately from other salmon species entering the district. However, unusual run timing sequence can occur, and chinook often hold within the district and become inter-mixed with more abundant sockeye and chum salmon stocks.

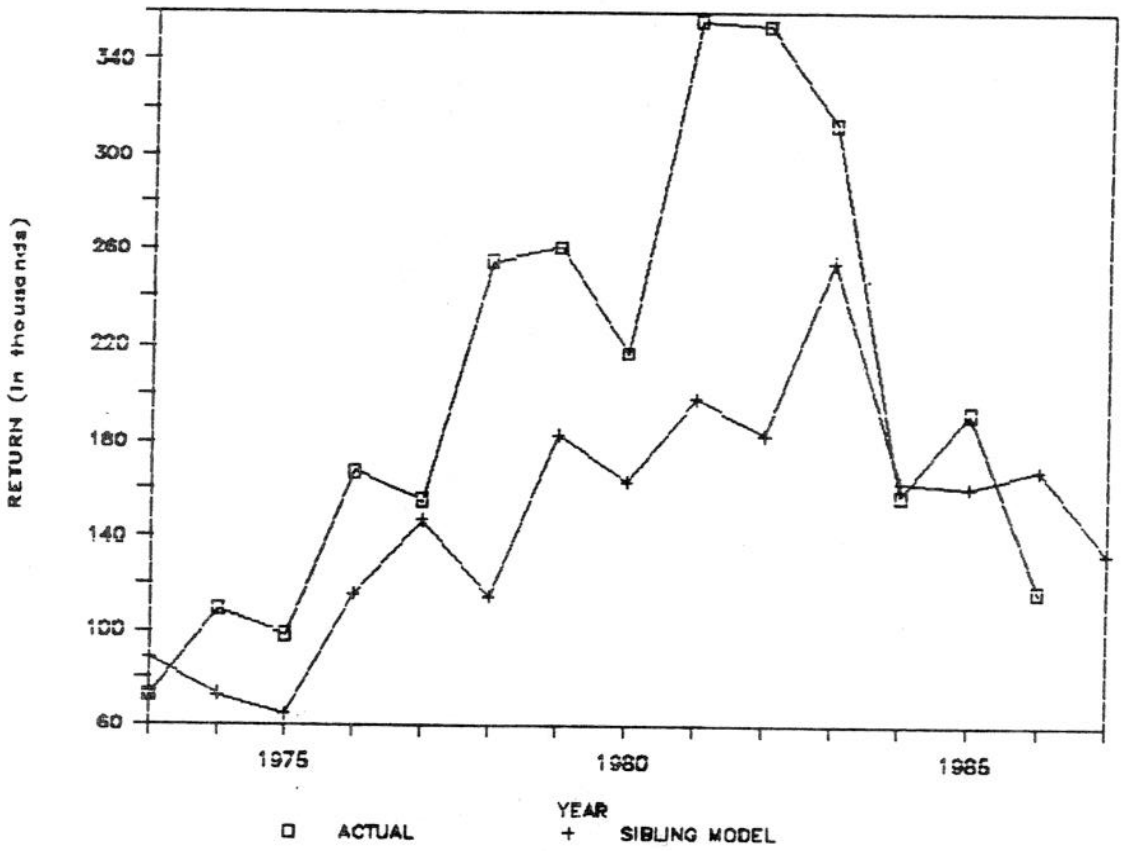

Figure 23. Performance of the sibling model forecast method compared to actual returns of chinook salmon, Nushagak District, Bristol Bay, 1973-86.

The Nushagak District chinook salmon management strategy in the 1960's was to limit the harvest to a range of 60,000 to 80,000 fish unless catch trends indicated that a significantly larger than average run was in progress. As fishery managers became more experienced, the local Dillingham subsistence fishery was found to be a reasonable indicator of general escapement trends. As chinook became more valuable in the mid-1970's, fishing effort began to increase dramatically. This increased fishing pressure was countered by additional inseason closures to obtain escapement needs. Since escapement assessment occurred well after the fishery, catch per unit of effort (CPUE) analysis was a basic management tool used in the management of the fishery. All would be well and good, except for the fact that very often early season closures to obtain chinook escapement are not successful. Area and time closures have become more frequent, especially so since the 1980's, with some success, but the increasing commercial fishing effort and efficiency has prompted a close self-examination of the current management program. Since the late 1970's - early 1980's, the high early season exploitation rates have precluded significant escapement, and escapement goals and requirements have been met utilizing the later portion of the run.

As commercial and recreational fishing pressure continued to build on the Nushagak chinook stocks, the need to develop and refine real-time inseason escapement enumeration techniques became apparent. To this end, the upriver Lewis Point subsistence index program and the Nushagak River sonar projects were developed in order to estimate daily escapement rates and trends. Fishery management decisions, whether or not to open or close the fishery, continue to depend upon the best estimate of the numbers of fish entering and leaving the fishery. Management of the chinook fishery is directed at achieving escapement goals, while at the same time maximizing harvest of the available surplus.

Conflicts between user groups have begun to develop in recent years, and they can be expected to continue and probably increase as the sport recreational fishery continues to grow. Because Bristol Bay has been a long established and highly productive sockeye salmon fishery for over 100 years, it has received more attention, funding and research than any salmon fishery in Alaska. Although even these efforts were limited for many years, the fact that many pioneering efforts were initiated in Bristol Bay established an invaluable data base and some important precedents in fisheries research and management. Unfortunately, the Nushagak chinook salmon fishery saw little effort directed at research and management until the mid to late 1950's, and it was not until 1982 that any significant effort was directed toward sport fish use patterns.

The Alaska Department of Fish and Game (ADF&G) presently has three permanent staff biologists assigned to commercial and sport fish chinook salmon management and research activities in the Nushagak District. There are from 10 to 12 seasonal positions hired each season to man the support projects, and funding for these projects amounts to about $66,000, which represents 3% of the average exvessel value of $2.2 million from 1977 to 1986.

The following summary is intended to present an overview of the scope and type of individual projects and activities presently being conducted in Nushagak District on an annual basis.

Program management provides personal services funding for a professional staff capable of assembling biological, social and economic data needed to implement a rational management plan for stock management. Also included are fixed supportive costs related to office and field program maintenance and administrative travel costs. Program management costs (exclusive of permanent staff) amount to $15,300 annually.

Commercial fishery monitoring provides personal services funding for the seasonal staff required to monitor the chinook fishery. Daily contact with processors concerning catch estimates provides needed information to determine harvest rates. Costs of these activities, along with the cost of subsistence fishery monitoring activities, are all included in this project. Project objectives are to provide inseason estimates of catch and fishing effort of chinook by period and inseason catch per unit of effort. Project costs amount to $5,300.

Chinook salmon are sampled from commercial catches made in the Nushagak District. Sampling includes measuring fish for length and weight, determining sex and removing a scale for aging purposes. Project objectives are to provide age, weight, length and sex data for commercially harvested chinook in order to monitor and assess the long-term effects of the commercial fishery. Catch sampling funding levels annually amount to $4,500.

Test fish escapement monitoring is conducted within the Nushagak District and waters adjacent to the fishery. The primary objective is to monitor the magnitude and entry pattern of sockeye salmon prior to, and immediately after the fish enter the district. However, district test fishing is also utilized to help define chinook escapement and when milling or holding fish begin movement out of the upper district and into the Nushagak River as escapement. Funding levels are minimal as program receipts make this project self-sustaining.

The inside river test fishing project monitors the catch of chinook salmon by the Lewis Point subsistence fishery. Objectives are to estimate escapement into the Nushagak River from subsistence catches, and to gather age, sex and length data, which is used for inseason management decisions and for postseason forecast purposes. Funding levels are set at about $7,500 annually.

Daily escapement estimates are obtained from two side-scanning sonar units that are installed in the lower portion of the Nushagak River near Portage Creek. Salmon migrating upstream are also sampled to obtain age, weight and sex data and to obtain species composition information. The sonar counts are adjusted for species composition, resulting in an estimate of the total salmon escapement by species. Project objective is to obtain accurate and timely (inseason) escapement estimates of salmon returning to the Nushagak River system to assist in providing data to establish commercial fishing schedules, and to evaluate long-term management strategy. Funding levels to support the chinook salmon sonar operation approximate $17,200.

Aerial surveys to estimate the escapement of chinook salmon to the entire Nushagak River drainage are conducted annually to provide escapement data needed to evaluate long-term management strategies. Project costs to estimate escapement to the entire drainage is $2,400 annually.

Forecast activities include assembling, reading and tabulating approximately 1,000 to 3,000 chinook salmon scales from the Nushagak catch and escapement. These data are used to allocate the Nushagak chinook catch into age class components, which are then assembled annually into brood year return tables, which provide a means to forecast the return of chinook to the Nushagak District one year in advance of the fishery. Funding levels to accomplish these activities amount to $3,000 annually.

Sport fish investigations include a roving creel census, which is conducted in the lower Nushagak River (Black Point to Portage Creek). Project objectives include estimates of angling effort, catch and harvest rates, and collection of biological and demographic data relative to the freshwater sport fishery. Data are used to assess sport fish impacts on the resource and track the growth and development of this rapidly expanding fishery. Additionally, a statewide postal survey is mailed to randomly selected anglers who sport fished in Alaska each year. Results of these surveys are summarized by river system and provide harvest estimates for the Nushagak chinook salmon sport fishery. These estimates provide an independent cross check of creel census data and a means to track long-term harvest trends. Funding levels associated with these census activities approximate $11,200.

RECOMMENDATIONS FOR FUTURE PROGRAM STUDIES

The basis of any recommendations for future chinook salmon program studies would consist of a continuation of habitat protection and regulatory and fishery management activities of the biological resource.

In addition to habitat protection, three primary management level needs that should be addressed through research and development are: (1) optimum escapement objectives, (2) methods for accurately estimating escapement, and (3) methods for achieving escapement objectives.

Habitat Protection

One of the primary explanations to sustained and increased chinook salmon production lies in protection of the freshwater spawning and rearing habitat. Salmon production in Bristol Bay is based upon a combination of factors, including water quality and quantity, and stream substrate, which collectively comprise salmon habitat. The highest priority should continue to be assigned to habitat protection activities in order to provide:

(a) "maintenance of the present quantity and quality of salmon habitat in Nushagak District as a prerequisite to maintaining salmon production and meeting harvest goals;

(b) enforcement of state water quality and anadromous stream protection regulations; and

(c) land use plans for public lands adjoining salmon waters to incorporate measures for maintenance of water quality, habitat, productivity and avoidance of conflicting uses" (ADFG, 1986b).

Optimum Escapement

Provisional chinook salmon escapement objectives are already in place, and are adequate until final optimum escapement goals can be established. Since preliminary indications suggest that the large brood year escapements in 1981-82 are producing at a much lower level of productivity, and the 1983 escapement was the largest on record, it is recommended that the final determination of the optimum chinook escapement level for the Nushagak watershed should be delayed until after the 1990 run, when virtually all recruits through the large escapements in 1981-83 will be accounted for (Table 16).

Continued emphasis should be placed upon maintaining a complete chinook catch and escapement data base. Collection of age-weight-length-sex ratio statistics is needed to properly manage the fishery and to produce spawner-recruit relationships, upon which optimum escapement values are established, and future runs are forecast.

A mesh size study to determine the effects of different gill net mesh sizes upon the reproductive potential of the resultant escapement would be beneficial. Fishery managers need to know if inseason adjustments of mesh size, as was established by emergency order in 1985-86, was successful as a management tool in securing additional escapement of larger, more fecund females.

A properly designed tagging and recovery study would help to determine if there is segregation by time through the fishery, as well as when chinook stocks hold within the fishery and lower river. In lieu of a extremely costly tagging and recovery program, sonic tagging and detection/recovery would shed information on upriver migration timing, and the holding tendency of Nushagak chinook, which contribute to over and under harvesting of the stock.

Estimation of Escapement

Accurate and timely inseason assessment of chinook escapement could provide substantial benefits by allowing higher fishery harvests of strong runs while providing more protection to weak returns, which would help to stabilize escapements at the most productive levels.

The Lewis Point chinook escapement monitoring program is compromised because the subsistence gill nets do not consistently fish each day. The data limitations that result from this inconsistent fishing schedule could be alleviated by es tablishment of a Department "contract" test fishing project on Kanakanak Beach in Dillingham. Daily chinook escapement rates and trends would be available immediately each day, and the "contract" nature of this type of project would require little local staff daily support time once the initial project fishing methods were developed. Additional positive factors for a project of this type would be its self-supporting structure under the test fish receipt program, and the project would be amenable to other associated studies, such as mesh size investigations.

Continued research and development of the hydroacoustic sonar counting system on Nushagak River is a high priority. This project has the potential to provide chinook escapement data for both inseason management purposes, as well as total watershed escapement, which would allow the aerial survey program to be terminated on all chinook spawning streams, with the possible exception of the Muklung River. Specie apportionment at the sonar site continues to be the major obstacle, especially when high daily rates of sockeye and chum salmon mask the number of migrating chinook.

Achievement of Escapement

Once chinook optimum escapement objectives are defined, and methods of accurately estimating inseason escapement rates and trends are developed, management personnel need to have in place methods whereby fishing pressure and efficiency can be controlled to achieve the escapement requirements.

Regulatory emergency order control, and regulation changes through the Board of Fisheries process, are important. If regulatory changes planned in 1987 for the commercial gill net fishery (restricted outer boundary, reduced season and weekly fishing schedules) are not effective in reducing the exploitation rate to achieve better distribution of escapement through time, the next regulatory step would be to conduct the commercial fishery entirely under day to day emergency order control, where fishing schedules would be set on a daily basis.

Continued restrictive use of large mesh chinook salmon gill net gear to effect a lower catch per unit of effort is recommended, especially when chinook hold within the fishing district, and the existence of sockeye and chum stocks require commercial harvest to test for run strength and/or to control early-season sockeye escapement rates.

The fishery should be managed from inseason indicated abundance as closely as possible to meet management objectives. Management considerations should include establishment of fishing periods of less duration than the "standard" length period (12 hours), and establishment of fishing schedules to take advantage of rough, windy weather conditions, which tend to move chinook salmon through the district.

Overall, Nushagak fishery managers are in an enviable position compared with managers of chinook salmon stocks in most of the other areas of Alaska. The stocks are apparently in good condition and production is concentrated in a major river system that can be managed independently. The fishery occurs in a terminal area where allocation considerations are minor, and chinook are largely separated from other target species by timing differences in most years. Ultimately, 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.

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There were six major sources for historical statistics on the chinook salmon fishery of the Nushagak District of Bristol Bay: (1) Alaska Fishery and Fur-Seal Industries, which had been published annually since 1905 through the mid-1950's, by the U. S. Bureau of Fisheries and the Fish and Wildlife Service respectively; (2) Statistical Review of the Alaska Salmon Fisheries-Part I. Bristol Bay and the Alaska Peninsula by Rich and Ball, which summarizes commercial catch statistics for Bristol Bay from 1893 through 1927; (3) Pacific Fishermen, an annual yearbook which contains statistical data compiled by the industry as well as summaries of some of the series compiled by the Federal Government. The yearbooks have been published yearly since 1902: (4) Bristol Bay Agent Reports, 1931-59, published for inter-departmental use on an annual basis by the U. S. Bureau of Fisheries, and Fish and Wildlife Service; and (5) Alaska Commercial Salmon Catch Statistics 1951-59 by Simpson, which lists the commercial salmon catch for Alaska by statistical area for 1951 through 1959; and (6) the source of all statistical data since 1960 was compiled from Alaska Department of Fish and Game records as maintained by the Division of Commercial Fisheries. The tables and appendix tables in this report were compiled from the publications listed in the Reference Sources section of this report and all references are numbered to correspond with document numbers in the reference section.

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TABLES

Table 1. Morphometry and climatological records of Nushagak drainage, Bristol Bay, Alaska.

Morphometry Data

Geographic Limits----------154 degrees and 159 degrees 20' long. by 58 degrees 40' and 60 degrees 40' lat.

Area (square miles)----------14,000 (approximate)

		Lakes	
		Number	Sq. Miles
Major Lake Areas----------	Igushik Lakes	2	29
	Lake Nunavaugaluk	1	34
	Wood River Lakes	5	164
	Tikchik Lakes	7	174

		Rivers	
		Length in Mi.	Flow in CFS
Major River Systems----------	Igushik River	78	373- 2,747
	Snake River	48	112- 2,109
	Wood River	21	1,100-14,440
	Nushagak River	264	
	Nuyakuk River	50	960-28,900
	Tikchik River	60	
	Mulchatna River	193	

CLIMATOLOGICAL DATA 1/

	Mean			
	1881-1933	1957-1985	High	Low
Precipitation (inches)	26.5	25.6 2/	37.5	13.8
Snowfall (inches)	65.4	79.2 3/	113.9	47.5
Temperature (F)	34.1	33.5	89	-54

1/ Recorded at Dillingham, Alaska.
2/ 1962-85.
3/ 1969-81.

(Sources: 1, 24, 36, 44 and 61)

Table 2. Comparison of the commercial catch of chinook salmon of Nushagak District with other regions of Alaska, 1960-86.

	Commercial Catch in Thousands of Fish									
		Western Alaska					Nushagak District			
								Percent Catch of		
Year	Alaska	Yukon	Kuskokwim	Bristol Bay	North Peninsula	Total 1/	Number	Bristol Bay	Western Ak.	Alaska
1960	547	68	6	112	10	196	81	72	41	15
61	504	120	24	89	6	243	61	69	25	12
62	461	95	21	84	6	213	61	73	29	13
63	501	117	19	62	4	208	46	74	22	9
64	639	94	21	140	4	261	109	78	42	17
65	581	118	24	113	6	263	86	76	33	15
66	540	93	26	77	9	207	58	75	28	11
67	611	129	30	117	6	284	96	82	34	16
68	611	107	43	104	5	260	78	75	30	13
69	639	91	65	125	5	288	81	65	28	13
1970	646	79	65	141	4	291	88	62	30	14
71	662	111	45	123	2	283	83	67	29	13
72	553	93	57	70	2	225	46	66	20	8
73	551	75	51	44	5	178	30	68	17	5
74	557	98	30	46	5	182	32	70	18	6
75	455	64	28	30	2	126	21	70	17	5
76	533	88	50	96	5	242	61	64	25	11
77	621	97	59	131	6	297	85	65	29	14
78	836	99	65	192	14	380	119	62	31	14
79	830	128	54	213	17	423	157	74	37	19
1980	676	154	49	96	17	322	65	68	20	10
81	823	158	79	237	19	501	193	81	39	23
82 2/	883	124	78	254	30	492	195	77	40	22
83 2/	830	107	81	199	30	427	137	69	32	17
84 2/	667	120	74	102	25	329	61	60	19	9
85 2/	722	144	74	121	23	381	68	56	18	9
86 2/	612	100	45	92	12	255	64	70	25	10
Average	633	106	47	119	10	287	84	70	29	13

1/ Includes commercial catches from Kotzebue, Norton Sound and the Aleutians management areas.
2/ Preliminary.

(Sources: 4, 10 and 34)

Table 3. Commercial catch of chinook salmon by district, Bristol Bay, 1960-86.

Year	Number of Fish					
	Naknek-Kvichak	Egegik	Ugashik	Nushagak	Togiak	Total
1960	17,778	2,991	2,209	81,416	7,309	111,703
61	10,206	3,266	3,483	60,953	10,748	88,656
62	8,816	2,070	2,929	61,283	8,949	84,047
63	4,713	2,355	3,030	45,979	6,192	62,269
64	12,902	3,618	3,694	108,606	10,716	139,536
65	9,793	2,313	4,042	85,910	10,909	112,967
66	5,456	1,949	1,916	58,184	9,967	77,472
67	3,705	2,285	1,582	96,240	13,381	117,193
68	6,398	3,472	2,153	78,201	13,499	103,723
69	19,016	2,801	2,107	80,803	20,181	124,908
1970	19,037	3,765	1,498	87,547	28,664	140,511
71	10,254	2,187	779	82,769	27,026	123,015
72	2,262	1,097	166	46,045	19,976	69,546
73	951	1,475	292	30,470	10,856	44,044
74	480	1,133	1,200	32,053	10,798	45,664
75	964	237	111	21,454	7,226	29,992
76	4,064	1,138	338	60,684	29,744	95,968
77	4,373	3,694	2,167	85,074	35,218	130,526
78	6,930	3,126	5,935	118,548	57,000	191,539
79	10,415	5,547	9,568	157,321	30,022	212,873
1980	7,517	5,610	4,900	64,958	12,543	95,528
81	11,048	5,468	3,416	193,461	23,911	237,304
82	12,425	4,834	7,170	195,287	33,786	253,502
83	8,955	4,758	9,276	137,123	38,497	198,609
84 1/	9,198	4,707	4,782	61,375	21,920	101,731
85 1/	5,891	3,844	6,509	67,616	37,355	121,215
86 1/	3,552	1,895	2,977	63,859	19,895	92,178
Average	8,041	3,024	3,268	83,823	20,604	118,760

1/ Preliminary.

(Sources: 1 and 4)

Table 4. Commercial drift net fishing effort and chinook salmon catch per unit of effort, Nushagak District, Bristol Bay, 1960-86.

Year	Drift Net Fishing Effort 1/			Drift Net Catch and Catch Per Unit of Effort 2/		
	Peak	Season	Landings	Catch	Per Vessel	Per Landing
1960	243		10,905	79,103	326	7.3
61	274 3/		8,004	59,006	215	7.4
62	304		11,856	59,858	197	5.0
63	381		7,331	43,771	115	6.0
64	273		13,346	103,856	380	7.9
65	226		5,546	81,915	362	14.8
66	267		11,298	56,002	210	5.0
67	327		8,178	93,608	286	11.4
68	323		18,076	77,369	240	4.3
69	228		7,022	79,429	348	11.3
1970	246		7,939	85,151	346	10.7
71	305		6,802	81,418	267	12.0
72	249		6,634	45,519	183	6.9
73	179		4,006	29,762	166	7.4
74	128		3,886	31,720	248	8.2
75	160	489	4,096	20,961	131 (42.9)	5.1
76	197	536	6,227	57,614	292 (107.5)	9.3
77	221	563	6,964	84,257	381 (149.7)	12.1
78	358	825	12,387	117,265	328 (142.1)	9.5
79	450	1,051	11,930	151,534	337 (144.2)	12.7
1980	507	1,176	14,593	63,255	125 (53.8)	4.3
81	451	1,000	17,620	183,275	406 (183.3)	10.4
82	539	1,165	17,924	184,852	343 (158.7)	10.3
83	571	1,029	12,983	122,925	215 (119.5)	9.5
84 4/	470	986	12,444	56,751	121 (57.6)	4.6
85 4/	287	685	3,558	53,234	185 (77.7)	15.0
86 4/	251	736	7,045	58,112	232 (79.0)	8.2

1/ Peak fishing effort is the maximum daily number of drift fishing vessels participating in the fishery between June 1-26; while season effort and landings, are the total number of vessels participating in the Nushagak fishery, and the total season number of landings made by these vessels, respectively.

2/ Catch per unit of effort (CPUE) for fishing vessels was based on peak daily fishing effort, as well as on the total number of vessels participating in the Nushagak fishery (1975-86, shown in parenthesis).

3/ Based on pre-post 1961 effort levels.

4/ Preliminary.

(Sources: 1 and 4)

Table 5. Japanese high seas land based and mothership gill net commercial catch of chinook salmon of Western Alaska origin, 1956-86.

	Catch in Thousands of Fish			
	Fleet		Mothership Catch of Western Alaska Origin	
Year	Land Based	Mother-ship	Number	Percent
1956	18	137		
57	33	31		
58	45	46		
59	42	68		
1960	113	180		
61	79	31	14	45
62	124	122	30	25
63	102	87	41	47
64	195	410	179	44
65	93	185	106	57
66	112	208	108	52
67	110	128	71	55
68	88	362	244	67
69	83	554	367	66
1970	101	437	312	71
71	134	206	132	64
72	103	261	189	72
73	162	119	56	47
74	186	361	208	58
75	135	162	108	67
76	201	283	117	41
77	146	93	55	59
78	210	105	36	34
79	161	126	69	55
1980	160	704	416	59
81	190	88	30	34
82	165	107	45	42
83	178	87	31	36
84	92	82	36	44
85	100	66	25	38
86 1/	76	60	24	40
Average	121	190	117	62

1/ Preliminary.

(Source: 6)

Table 6. Subsistence chinook salmon catch and fishing effort in Nushagak District compared to other districts in Bristol Bay, 1963-86. 1/

Year	Nushagak Fishing Effort 2/	Number of Fish by District					
		Nushagak	Naknek-Kvichak	Egegik	Ugashik	Togiak	Total
1963	71	3,600	500		+		4,100
64	74	2,900	500				3,400
65	121	4,600	500			100	5,200
66	110	3,700	600				4,300
67	128	3,700	500		+		4,200
68	115	6,600	500		+		7,100
69	162	7,100	400				7,500
1970	147	6,300	300		+		6,600
71	164	4,400	200				4,600
72	168	4,000	400		100		4,500
73	216	6,600	600		+		7,200
74	261	7,900	1,000	+	100	1,200	10,200
75	340	7,100	700	+	+	800	8,600
76	317	6,900	900		100	500	8,400
77	306	5,200	1,300	+	100	400	7,000
78	331	6,600	1,200		100	300	8,200
79	364	8,900	1,200		+	200	10,300
1980	425	11,800	1,500		+	900	14,200
81	395	11,500	1,000	+	+	400	12,900
82	376	12,100	1,100	+	+	400	13,600
83	389	11,800	1,000	+	+	700	13,500
84	438	9,800	900	+	+	600	11,300
85	406	7,900	1,200	+	+	600	9,700
86	424	12,600	1,300	100	100	700	14,800
Average	260	7,200	800	+	+	600	8,600

1/ Catches rounded to nearest 100 fish; + sign indicates less than 50 fish.
2/ Number of fishing permits issued.

(Sources: 1 and 47)

Table 7. Harvest and catch per unit of effort of chinook salmon by sport fishermen, Nushagak and Mulchatna Rivers, Nushagak District, Bristol Bay, 1977-86. 1/

	In Number of Fish by River System				
	Nushagak River		Mulchatna River	Others 2/	
Year	Harvest	CPUE 3/	Harvest	Harvest	Total Harvest
1977	402		521	0	923
78	151		291	0	442
79	312		342	0	654
1980	611		146	0	757
81	929		291	0	1,220
82	1,436	.45	388	0	1,824
83	1,615		388	0	2,003
84	1,534	.53	786	62	2,382
85	1,517	.40	292	43	1,852
86 4/	1,780	.26	-	-	-
Average	1,029		383	53	1,340

1/ Harvest estimates for 1977-85 is derived from a random statewide mail-out questionnaire sent to Alaska sport fish license holders.
2/ Includes the Wood, Nuyakuk and Tikchik River systems.
3/ Catch per unit of effort (CPUE) is expressed in fish caught per hour, and is derived from on-grounds creel census surveys.
4/ Preliminary harvest and CPUE from creel census survey.

(Sources: 11, 17, 38 and 42)

Table 8. Counting tower, weir and sonar derived escapements of chinook salmon by river system, Nushagak District, Bristol Bay, 1961-86.

	Number of Fish by River System 1/					
Year	Wood 2/	Igushik 2/	Snake 3/	Nuyakuk 2/	Nushagak 4/	Stuyahok 5/
1961	0	18	0			
62	0	0	60	774		
63	0	0	108	60		
64	0	0	0	288		
65	0	18		108		
66	6	72		834	8,966	
67	24	30		514	5,166	
68	24	40		1,824	14,628	5,150
69	24	6		390	6,576	
1970	0	0		1,080	1,518	
71	6	0		300		
72	18	0		594		
73	72	0	9	588	11,364	
74	138	42	14	1,590	6,564	
75	78	24	2	1,686		
76	18	216		2,490	4,962	
77	0	18		996		
78	0	18		258		
79	30	0		504	32,801	
1980	30	174		3,814	55,957	
81	0	12		5,460	115,105	
82	162	0		6,198	124,939	
83	216	84		2,958	103,765	
84	516	78		3,246		
85	114	132		2,616	99,037	
86	108	36		622	43,434	
Average	61	39	28	1,592	82,148 6/	5,150

1/ All specie counts were initiated in the mid-1960's; however, all tower counts should be considered as "index" escapement counts.
2/ Tower count.
3/ Tower counts 1961-64 and weir counts 1973-75.
4/ Tower counts 1966-70, 1973-74, and 1976; sonar counts 1979-83 and 1985-86.
5/ Weir count.
6/ Average of sonar estimates 1979-86.

(Sources: 1, 33, and 45)

Table 9. List of some streams utilized by spawning chinook salmon of the Nushagak District drainage, Bristol Bay.

Area and Stream	Importance as Spawning Area 1/		
	Average	Significant	Primary
NUSHAGAK BAY			
Igushik River	X		
Snake River:	X		
Weary River	X		
Wood River:	X		
Muklung River		X	
NUSHAGAK RIVER DRAINAGE			
Nushagak River			X
Iowithla River		X	
Kokwok River	X		
Klutuk Creek	X		
Nunachuak Creek	X		
Cranberry Creek	X		
Napotoli Creek	X		
Nuyakuk River	X		
Tikchik River	X		
Harris Creek	X		
Klutispaw River		X	
Vukpalik Creek	X		
King Salmon River			X
Chichitnok River		X	
MULCHATNA RIVER DRAINAGE			
Mulchatna River			X
Stuyahok River			X
Old Man Creek	X		
Koktuli River			X
Mosquito Creek		X	
Keefer Creek	X		
Chilchitna River	X		
Chilikadrotna River		X	

1/ Spawning streams are categorized as:
Average - average of less than 500 fish observed on aerial surveys;
Significant - average of 500 to 1,500 fish observed on aerial surveys, and
Primary - average of 1,500 or more fish observed on aerial surveys.

(Sources: 1 and 7)

Table 10. Comparison of peak aerial survey escapement estimates of live chinook salmon for selected time periods, Nushagak District, Bristol Bay, 1956-86.

Stream	1956-67 No. Ob.	1956-67 Average	1968-73 No. Ob.	1968-73 Average	1974-86 No. Ob.	1974-86 Average
NUSHAGAK BAY DRAINAGE						
Igushik River			4	70	8	130
Snake River:	2	20	4	100	9	70
Weary River	2	80	3	110	3	20
Wood River:			2	30	9	40
Muklung River	7	350	5	460	13	1,140
Streams	1	20	3	20	12	10
NUSHAGAK BAY DRAINAGE SUB-TOTALS 1/		330		570		1,320
NUSHAGAK RIVER DRAINAGE						
Nushagak River: (TOTALS)	2	(4,150)	3	(1,280)	12	(7,760)
Portage Cr. to Ekwok					6	300
Ekwok to Mulchatna R.					7	270
Mulch. R. to Nuyakuk R.			2	190	10	590
Nuy. R. to Klutispaw R.	1	400	1	220	12	850
Klutis. R. to King Sal. R.	1	1,100	2	530	12	2,150
King Sal. R. to Chich. R.	1	400	3	200	12	1,070
Chichitnok R. to Big Bend			2	720	11	1,950
Big Bend on North			1	160	10	1,330
Iowithla River	6	120	5	540	12	1,450
Kokwok River	4	+	3	90	12	230
Klutuk Creek			3	100	9	480
Nunachuak Creek	1	100	1	0		
Cranberry Creek	1	0	1	0		
Napotoli Creek	1	+	2	10		
Nuyakuk River			5	190	5	530
Tikchik River					3	40
Harris Creek			1	0		
Klutispaw River	4	220	5	280	13	1,070
Vukpalik Creek			1	50		
King Salmon River	8	380	5	1,020	13	3,450
Chichitnok River	3	310	4	120	12	800
NUSHAGAK DRAINAGE SUB-TOTALS 1/		1,400		2,520		14,520
MULCHATNA RIVER DRAINAGE						
Mulchatna River: (TOTALS)	2	(1,160)	2	(860)	7	(4,910)
Nush. R. to Stuyahok R.			1	190	7	490
Stuy. R. to Koktuli R.			1	250	7	290
Koktuli R. to Mosquito Cr.	1	410	1	510	7	2,290
Mos. Cr. to Chil. R.			1	490	6	1,160
Chilchitna R. to Chilik. R.	1	300	1	150	6	190
Chilikadrotna R. to Turq. Lk.			1	120	7	330
Stuyahok River	4	1,200	5	1,480	13	3,400
Old Man Creek	2	30	2	10	2	60
Koktuli River	4	1,930	5	1,940	13	5,830
Mosquito Creek			2	230	9	1,210
Keefer Creek			1	100		
Chilchitna River	1	0	1	120	4	400
Chilikadrotna River	1	300	2	210	7	570
MULCHATNA DRAINAGE SUB-TOTALS 1/		3,040		3,990		13,150
NUSHAGAK/MULCHATNA TOTALS 1/		2,890		6,410		28,990

1/ Average chinook salmon aerial escapement estimates for all years.

(Sources: 1 and 7)

Table 11. Peak aerial escapement estimates of live chinook salmon on the spawning grounds in selected index streams and portions of the main Nushagak and Mulchatna Rivers, Nushagak District, Bristol Bay, 1967-86. 1/

Year	Muklung	Iowithla	Klutispaw	King Salmon	Stuyahok	Koktuli	Nushagak River 2/	Mulchatna River 3/	Total
1967	350	200	-	-	2,500	3,300	-	-	6,350
68*	750	850	310	1,000	2,470	4,220	970	510	11,080
69	520	580	90	670	1,220	1,600	(910)	(680)	(6,270)
70	590	700	320	1,060	1,900	1,500	(1,180)	(880)	(8,130)
71	280	390	-	-	-	-	-	-	670
1972	150	170	280	900	610	1,450	(690)	(510)	(4,760)
73	-	-	380	1,470	1,220	950	-	-	4,020
74*	1,010	860	440	2,000	2,300	3,920	2,340	2,160	15,030
75	660	1,040	670	2,900	2,530	4,080	(2,320)	(1,710)	(15,910)
76*	850	1,110	1,180	3,510	3,750	6,710	1,760	2,580	21,440
1977*	940	840	650	1,420	2,700	4,630	820	1,980	13,980
78*	1,170	1,700	1,940	4,450	4,400	6,730	5,850	2,280	28,520
79*	950	1,350	1,040	2,150	3,570	6,260	2,880	1,730	19,930
80	1,620	(2,310)	970	4,500	7,200	10,620	(5,300)	(3,920)	(36,420)
81	2,260	2,630	1,650	2,950	5,980	9,960	(4,960)	(3,670)	(34,060)
1982	790	2,520	350	8,390	3,640	6,780	(4,380)	(3,240)	(30,090)
83*	1,830	2,430	2,090	5,990	2,910	8,060	6,330	4,260	33,900
84*	1,300	1,080	770	1,780	2,010	2,860	2,800	1,060	13,660
85	1,250	1,610	1,950	4,460	2,690	4,940	(3,420)	(2,390)	(22,710)
86	230	270	170	380	520	290	(380)	(260)	(2,500)
Average	920	1,190	850	2,780	2,850	4,680	2,780	1,940	16,470
Percent of Total 4/	5.58	6.49	5.34	14.16	15.30	27.54	15.08	10.51	100.00

1/ Numbers in parentheses are proportional estimates based on the mean percentage of fish counted in those areas when aerial coverage was complete (eight years noted with an asterisk).
2/ Includes that section of Nushagak River between Nuyakuk River and King Salmon River.
3/ Includes that section of Mulchatna River between Koktuli River and Mosquito Creek.
4/ Includes only those years noted with an asterisk.

(Source: 7)

Table 12. Peak aerial survey escapement estimates of live chinook salmon by index area in Nushagak River, Nushagak District, Bristol Bay, 1964-85.

Year	Date	Number of Chinook by Index Area 1/								Total
		1	2	3	4	5	6	7	8	
1964	8/ 2	-	-	-	400	1,100	400	(-1,700-)		3,600
68	8/ 5	-	-	320	220	750	310	710	160	2,470
69	8/ 8	-	-	60	-	-	100	-	-	160
1972	8/ 4	-	-	-	-	300	180	730	-	1,210
74	8/ 1-3	-	-	1,000	720	1,620	380	1,220	330	5,270
75	8/ 2	30 2/	30 2/	120 2/	250	1,010	730	1,480	720	4,370
76	8/ 2-3	120 2/	310	630	760	1,000	620	2,480	1,050	6,970
77	7/31-8/1	-	60 2/	90 2/	220	600	1,060	1,470	800	4,300
78	8/ 1-3	160 2/	490 2/	750 2/	2,000	3,850	2,140	2,710	1,190	13,290
79	7/31-8/3	0 2/	0 2/	450	600	2,280	1,600	2,310	930	8,170
1980	8/ 8	-	-	50 2/	280	1,450	300	-	-	2,080
81	8/ 5	-	-	-	1,680	4,370	1,560	1,310	-	8,920
82	8/ 3	-	-	720	680	2,370	1,020	590	2,940	8,320
83	8/ 1-3	840	580	1,540	1,810	4,520	1,630	4,240	1,540	16,700
84	8/ 5-9	670	400	520	820	1,980	1,510	2,130	1,010	9,040
85	7/31	-	-	-	420	760	240	1,520	2,740	5,680
Average		300	270	520	780	1,860	860	1,760	1,220	7,570
Percent		4	4	7	10	25	11	23	16	100

1/ Index area: 1 - Portage Creek to Ekwok;
2 - Ekwok to Mulchatna River;
3 - Mulchatna River to Nuyakuk River;
4 - Nuyakuk River to Klutispaw River;
5 - Klutispaw River to King Salmon River;
6 - King Salmon River to Chichitnok River;
7 - Chichitnok River to Big Bend; and
8 - Big Bend on North.

2/ Aerial survey coverage not complete.

(Sources: 1 and 7)

Table 13. Peak aerial survey escapement estimates of live chinook salmon by index area in Mulchatna River, Nushagak District, Bristol Bay, 1959-84.

Year	Date	Number of Chinook by Index Area 1/						Total
		1	2	3	4	5	6	
1959	7/30	-	-	410	-	-	-	410
1964	8/14	-	-	(-1,600-)		300	-	1,900
68	8/ 6-7	190	250	510	490	150	120 2/	1,710
1974	8/ 2	870	540	2,160	1,590	90	80 2/	5,330
76	8/ 2-4	690	200	2,580	840	520	200	5,030
77	7/31	150	90	1,980	250	0	270	2,740
78	8/ 2	590	350	2,280	2,120	420	470	6,230
79	8/ 1-2	60 2/	80 2/	1,730	790	0 2/	0 2/	2,660
1983	8/ 1-2	420	390	4,260	(-2,450-)		1,190	8,710
84	8/ 7-8	620	400	1,060	1,350	130	110 2/	3,670
Average		450	290	1,890	1,060	230	350	4,270
Percent		11	7	44	25	5	8	100

1/ Index areas: 1 - Nushagak River to Stuyahok River;
2 - Stuyahok River to Koktuli River;
3 - Koktuli River to Mosquito Creek;
4 - Mosquito Creek to Chilchitna River;
5 - Chilchitna River to Chilikadrotna River; and
6 - Chilikadrotna River to Turquoise Lake.

2/ Aerial survey coverage not complete.

(Source: 7)

Table 14. Comparison between ground and aerial survey methods of determining escapement of live chinook salmon, by river system, Nushagak District, Bristol Bay, 1958-79. 1/

River System	Year	Survey Date and Number of Live Fish: Ground Date	Ground Number	Aerial Date	Aerial Number	Percent Aerial Est. of Ground Est.
Iowithla	1958	8/5-10	531	8/15	13 2/	2.4
	59	8/7-13	748	8/10	228	30.5
Nuyakuk	1972	8/ 4	432	8/ 4	70	16.2
	73	7/30	588	8/ 8	140	23.8
	74	8/ 1	1,338	8/ 1	750	56.1
	75	7/27	1,686	8/ 3	540	32.0
	76	8/ 3	2,490	8/ 3	1,100	44.2
	77	8/ 1	888	8/ 1	20	2.3
	79	7/18	504	8/ 3	240	47.6
King Salmon	1957	8/7-9	287	7/29	125 2/	43.6
	58	8/19-20 3/4/	3	8/14	0 4/	-
	59	8/2-5	3,122	7/30	737	23.6
	1960	8/6-8	169 3/	7/28	137	81.1
	62	8/3-7	514 3/	8/ 1	471	91.6
		8/10-12	224			
	63	8/4-6	493	8/ 5	48 3/	9.7
	64	8/12-14	254 4/	8/ 2	700	-
	65	8/6-8	264 3/	7/30	850	-
Stuyahok	1963	8/6-8	422 3/	8/ 5	227	53.8
	64	8/5-8	1,661	8/ 5	1,410	84.9
	68	7/25	4,531	7/25	2,700	59.6
		8/ 4	5,130	8/ 4	2,470	48.1
Koktuli	1959	8/15-22	118 4/	8/10	431	-

1/ Methods of determining escapement include:
Ground Counts - float individual river systems in rubber rafts; except Nuyakuk River, which are tower counts, and Stuyahok River in 1968, which is a weir count.

Aerial Counts - aircraft; using established procedures.

2/ Entire river not surveyed.
3/ Poor survey conditions.
4/ Survey past peak of spawning.

(Sources: 1, 7 and 45)

Table 15. Inshore catch, escapement and total run of chinook salmon in Nushagak District, Bristol Bay, 1960-86. 1/

Year	Number of Fish						
	Catch						
	Commercial	Subsistence	Sport 2/	Total	Escapement 3/	Total Run	Exploitation Rate
1960	81,416	-	-	81,416	-	-	-
61	60,953	-	-	60,953	-	-	-
62	61,283	-	-	61,283	-	-	-
63	45,979	3,600	-	49,579	-	-	-
64	108,606	2,900	-	111,506	-	-	-
65	85,910	4,600	-	90,510	-	-	-
66	58,184	3,700	-	61,884	40,000 a/	101,884	0.61
67	96,240	3,700	-	99,940	65,000 b/	164,940	0.61
68	78,201	6,600	-	84,801	70,000	154,801	0.55
69	80,803	7,100	-	87,903	35,000	122,903	0.72
1970	87,547	6,300	-	93,847	50,000	143,847	0.65
71	82,769	4,400	-	87,169	40,000 4/	127,169	0.69
72	46,045	4,000	-	50,045	25,000	75,045	0.67
73	30,470	6,600	-	37,070	35,000	72,070	0.51
74	32,053	7,900	-	39,953	70,000	109,953	0.36
75	21,454	7,100	-	28,554	70,000	98,554	0.29
76	60,684	6,900	-	67,584	100,000	167,584	0.40
77	85,074	5,200	923	91,197	65,000	156,197	0.58
78	118,548	6,600	442	125,590	130,000	255,590	0.49
79	157,321	8,900	654	166,875	95,000	261,875	0.64
1980	64,958	11,800	757	77,515	141,000	218,515	0.35
81	193,461	11,500	1,220	206,181	150,000	356,181	0.58
82	195,287	12,100	1,824	209,211	147,000	356,211	0.59
83	137,123	11,800	2,003	150,926	161,730	312,656	0.48
84	61,375 5/	9,800	2,382	73,557	80,940	154,497	0.48
85	67,616 5/	7,900	1,852	77,368	115,720	193,088	0.40
86	63,859 5/	12,600	1,780	75,339	32,774	108,113	0.70
Average	83,823	7,233	1,384	90,658	81,865	176,746	0.54

1/ Escapement estimates are based on data collected on comprehensive aerial surveys of the spawning grounds; these escapement estimates supersede previously reported escapements, and are rounded to the nearest thousand fish.

2/ Sport fish catches include only fish caught in the Nushagak and Mulchatna River systems, except 1986 which includes only Nushagak River catch. Data unavailable prior to 1977.

3/ Comprehensive aerial coverage was begun in 1968; escapements prior to 1968 were derived from:
   a/ tower enumeration data from Nushagak River, and estimate of total escapement accounted for by tower enumeration;
   b/ tower enumeration data, minimal aerial survey coverage, and general run strength indicators (commercial and subsistence catches).

4/ Aerial escapement precluded by adverse weather; however, the escapement was estimated from average mean exploitation rates from 1966-70 and 1972-76.

5/ Preliminary.

(Sources: 1, 4, 7 and 11)

Table 16. Escapement and inshore return of chinook salmon by brood year, Nushagak District, Bristol Bay, 1966-86. 1/

Brood Year	Escapement	Return by Year 3	4	5	6	7	8	Total	Return Per Spawner 2/
1966	40	+	21	32	39	5	1	99	2.48
67	65		10	18	47	25	+	100	1.54
68	70		14	19	68	9		110	1.57
69	35	+	1	15	30	3		49	1.40
1970	50		1	57	75	5	1	139	2.77
71	40		2	57	96	20		174	4.35
72	25		33	53	128	15		229	9.15
73	35		2	82	106	13		203	5.79
74	70		24	44	51	5		125	1.78
75	70	1	95	146	140	17		399	5.70
76	100	2	8	112	152	7	+	280	2.80
77	65		96	155	207	15	+	473	7.27
78	130	2	27	47	56	22	+	154	1.18
79	95	3	49	70	86	12		(220)	(2.32)
1980	141	+	11	48	51			(110)	(0.78)
81	150	1	33	43				(77)	(0.52)
82	147	1	4					(5)	(0.04)
83	162	+							
84	81								
85	116								
86	33								
Average 3/	61	+	26	64	92	12	+	195	3.19
Percent 3/		0.2	13.3	33.0	47.1	6.3	0.1	100.0	

1/ All escapements and returns are rounded to the nearest thousand fish, and due to rounding the total returns may not equal the sum of the brood year returns by year.

2/ Returns in parenthesis are incomplete.

3/ Averages and percentages computed from returns in 1966-78.

(Sources: 1, 4, 7 and 41)

Table 17. Egg fecundity by age of female chinook salmon from the commercial catch, Nushagak District, Bristol Bay, 1966 and 1968.

Age 1/	Sample Size	Mean 2/ Length	Mean 2/ Weight	Egg Fecundity Mean	Egg Fecundity Range
			1966		
1.3/5(2)	5	784	18.5	8,578	8,222- 9,270
1.4/6(2)	22	881	27.0	10,379	6,362-16,049
1.5/7(2)	4	972	31.3	11,559	7,666-15,321
Mean	31	877	26.2	10,241	6,362-16,049
			1968		
1.3/5(2)	5	769	17.9	8,138	5,302- 9,916
1.4/6(2)	24	887	26.6	10,225	7,383-14,668
1.5/7(2)	9	974	34.4	12,506	10,915-14,607
Mean	38	892	26.9	10,491	5,302-14,668
			Combined		
1.3/5(2)	10	777	18.2	8,358	5,302- 9,916
1.4/6(2)	46	884	26.8	10,299	6,362-16,049
1.5/7(2)	13	974	33.3	12,214	7,666-15,321
Mean	69	885	26.6	10,378	5,302-16,049

1/ Age designations are the European/Gilbert-Rich methods.
2/ Length measurements in mm (mid-eye to fork of tail), and weights are in pounds to the nearest tenth.

(Source: 1)

Table 18. Forecast and inshore chinook salmon return, Nushagak District, Bristol Bay, 1973-86.

Year	Number of Fish in Thousands: Forecast 1/ Spawner Recruit	Mean Percent	Sibling Return	Inshore Return 2/	Percent Deviation from Forecast 3/: Spawner Recruit	Mean Percent	Sibling Return
1973	321	176	89	72	+346	+144	+ 24
74	256	146	73	110	+133	+ 33	- 34
75	271	115	64	99	+174	- 16	- 35
76	251	117	116	168	+ 49	- 30	- 31
77	204	96	147	156	+ 31	- 38	- 6
78	262	95	115	256	+ 2	- 63	- 55
79	329	134	183	262	+ 26	- 49	- 30
1980	329	186	163	219	+ 50	- 15	- 26
81	323	201	198	356	- 9	- 44	- 44
82	355	224	183	356	0	- 37	- 49
83	328	227	255	313	+ 5	- 27	- 19
84	307	329	163	154 4/	+ 99	+114	+ 6
85	290	415	161	193 4/	+ 50	+115	- 17
86	358	522	168	108 4/	+231	+383	+ 56
Absolute Mean Percent Forecast Deviation: 5/					48	6	26

1/ Forecast methods are:
   a. Spawner Recruit - this method is based upon escapement/return (E/R) curves for each of the four major age classes;
   b. Mean Percent - the E/R relationship of all age classes combined, and forecast by age class is derived by applying the mean percent contribution by age to the total forecast; and
   c. Sibling Return - based on linear regressions of sibling returns for year K from observed returns in year K-1.

2/ Inshore commercial, subsistence and sport catch plus escapement.

3/ Percent deviation = $\frac{\text{Forecast minus (-) Inshore Return}}{\text{Inshore Return}} \times 100$

4/ Preliminary.

5/ Absolute deviation without regard to sign.

(Sources: 1, 4, 7, 11 and 41)

APPENDIX TABLES

Appendix . Number of commercial [illegible] processors and buyers operating in the Nushagak District, Bristol Bay, 1884-1986. 1/

Year	Processing Method: Canned, Shore Based	Canned, Floater	Fresh	Frozen	Cured 2/
1884	1				
85	1				
86	3				1
87	3				1
88	4				1
89	4				1
1890	4				1
91	4				1
92	2				1
93	3				1
94	3				1
95	3				1
96	3				1
97	3				1
98	3				1
99	5				1
1900	5				1
01	8				1
02	8				1
03	10				1
04	10				1
05	8				1
06	9				1
07	8				1
08	9				1
09	9				1
1910	9				1
11	9				1
12	9				1
13	9				1
14	8				2
15	8				2
16	8				3
17	8				3
18	8				1
19	8				2
1920	8				2
21	6				2
22	8				2
23	8				3
24	8				2
25	8				2
26	7				2
27	8				1
28	8				2
29	8				2
1930	7	1 3/			1
31	7	1			1
32	5	1			1
33	5	1			2
34	5	1			1
35	3	1			1
36	6	1			1
37	5	1			1

Year	Processing Method: Canned, Shore Based	Canned, Floater	Fresh	Frozen	Cured 2/
1938	2				1
39	5				1
1940	3				3
41	3				
42	3				
43	3				
44	3				
45	3				4
46	5			1 4/	8
47	4			1	3
48	4	1		2	4
49	4	3		2	5
1950	2	3		2	8
51	2	2		4	7
52	3	1			3
53	1	1		1	5
54	1	1		3	6
55	2			7	3
56	3			3	1
57	3			4	2
58	2			1	2
59	3			3	3
1960	3			1	1
61	3			2	2
62	3			2	2
63	3			3	2
64	2		1 5/		
65	2				
66	2		2		1
67	3		1	2	1
68	3		2	3	1
69	3		4	2	4
1970	3		2	5	2
71	3		2	3	
72	3		1	3	
73	2		1	3	
74	3		2	1	
75	3		4	2	
76	3		3	3	
77	3		5	5	
78	3		6	10	
79	3		8	16	2
1980	3		7	21	3
81	3		15	19	2
82	3		15	28	3
83	3		11	21	1
84	3		10	18	2
85	3		8	15	1
86			5	22	1

1/ Indicates operators with either a physical plant or processing facility or those operators from other areas buying fish and/or providing tender and support service for fishermen in districts away from the facility.
2/ Includes hand pack canneries, hard and mild-cured salteries and smoked product.
3/ First recorded floating cannery.
4/ First recorded floating freezer.
5/ First recorded fresh fly-out processor.

(Sources: 1, 3, 19, 21, 43, 52 and 60)

Appendix Table 2. Commercial production and disposition of chinook salmon, in numbers of fish, Nushagak District, Bristol Bay, 1946-86.

Year	Number and Percent by Type of Processing						
	Canned	(%)	Fresh Frozen 1/	(%)	Others 2/	(%)	Total
1946	15,890	(88)	-		2,230	(12)	18,120
47	19,702	(67)	7,474	(25)	2,364	(8)	29,540
48	30,668	(76)	9,549	(24)	-		40,217
49	15,391	(37)	20,532	(49)	5,685	(14)	41,608
1950	10,651	(38)	11,106	(40)	5,931	(22)	27,688
51	11,856	(35)	20,954	(61)	1,416	(4)	34,226
52	39,837	(100)	-		11	(+)	39,848
53	26,259	(95)	187	(1)	1,025	(4)	27,502
54	29,142	(76)	8,691	(23)	212	(1)	38,045
55	36,930	(65)	19,158	(34)	375	(1)	56,463
56	33,031	(58)	24,395	(42)	15	(+)	57,441
57	53,701	(68)	25,418	(32)	3	(+)	79,122
58	82,893	(95)	4,179	(5)	173	(+)	87,245
59	49,695	(92)	3,596	(6)	1,008	(2)	54,299
1960	78,879	(97)	2,362	(3)	175	(+)	81,416
61	51,012	(84)	9,731	(16)	210	(+)	60,953
62	58,001	(95)	3,282	(5)	-		61,283
63	37,246	(81)	7,316	(16)	1,417	(3)	45,979
64	108,216	(100)	390	(+)	-		108,606
65	85,910	(100)	-		-		85,910
66	57,571	(99)	608	(1)	5	(+)	58,184
67	76,587	(80)	19,643	(20)	10	(+)	96,240
68	61,440	(79)	13,120	(17)	3,641	(4)	78,201
69	51,962	(64)	18,455	(23)	10,386	(13)	80,803
1970	53,729	(61)	33,818	(39)	3	(+)	87,547
71	54,441	(66)	28,328	(34)	-		82,769
72	21,457	(47)	24,588	(53)	-		46,045
73	2,041	(7)	28,429	(93)	-		30,470
74	15,546	(49)	16,507	(51)	-		32,053
75	8,989	(42)	12,465	(58)	-		21,454
76	23,727	(39)	36,957	(61)	-		60,684
77	7,912	(9)	77,162	(91)	-		85,074
78	17,782	(15)	100,766	(85)	-		118,548
79	10,541	(7)	146,151	(93)	629	(+)	157,321
1980	2,468	(4)	61,255	(94)	1,235	(2)	64,958
81	15,477	(8)	176,823	(91)	1,161	(1)	193,461
82	2,734	(1)	190,014	(98)	2,539	(1)	195,287
83	16,866	(12)	118,749	(87)	1,508	(1)	137,123
84	3,621	(5)	57,386	(94)	368	(1)	61,375 3/
85	9,331	(14)	57,541	(85)	744	(1)	67,616 3/
86	2,874	(5)	60,985	(95)	-		63,859 3/

1/ Frozen fish production commenced in 1947.
2/ Primarily salted, some smoked.
3/ Preliminary.

(Sources: 1, 4 and 21)

Appendix Table 3. History of the commercial fishing boundary locations of Nushagak District, Bristol Bay, 1896-1986.

Year (Inclusive)	Nushagak District Boundary Locations	
	Inside Waters	Outside Waters
1896-99	Fishing with gill nets prohibited above tide water in streams less than 500 ft. in width.	
1900-19	Fishing with nets prohibited within 100 yards of stream mouths.	
1908-19	Prohibits commercial fishing in Wood River and the area within 500 yards of its mouth, and in Nushagak River proper.	
1920-62	Prohibits fishing within 500 yds. of the terminus of all salmon streams.	
1926	Fishing prohibited north of 59 degrees north latitude.	
1927-33	Fishing prohibited north of a line from Bradford Pt. through the southern end of Williams (Grassy) Island to the opposite shore south of Kanulik village, except that set nets will be permitted north of 59 degrees north latitude to markers at Snag Pt. (Dillingham).	
1928-53		Fishing permitted within a line from Protection Pt. to Etolin Point.
1934-40 and 1942-50	Fishing prohibited north of a line from a marker 2 statute miles below Bradford Pt. to a marker on the opposite shore at Nushagak Pt.; provided that set nets will be permitted north to Snag Pt. on the west shore and to the old village (Kanulik) on the east shore.	
1941	Closed set net fishing north of inside boundary on east shore near Kanulik; balance of inside boundaries remained unchanged from that in 1934-40.	

(continued)

Appendix Table 3. (continued)

Year (Inclusive)	Nushagak District Boundary Locations	
	Inside Waters	Outside Waters
1951-86	Closed all gill net fishing north of inside boundary line from a marker 2 statute miles below Bradford Pt. to a marker on the opposite shore at Nushagak Point.	
1954		Fishing permitted within a line from "Jap cabin" at approximately 158 degrees 25' west long. and the upper end of Nichols Spit.
1955-57		Fishing permitted within a line from Etolin Pt. to the upper end of Nichols Spit.
1958-86		Fishing permitted within a line from the white Coast and Geodetic Survey markers near Nichols Hills and Etolin Point.
1960-86		Fishing permitted (from mid-May to the emergency order period) within a line from Protection Pt. to the bell buoy off Etolin Pt., thence to the white Coast and Geodetic Survey marker near Etolin Pt. (i.e.: known as the "King Salmon Line"). 1/
1960-66		Igushik and Snake River sections established within Nushagak district.
1961-68		Snake River section closed to commercial fishing; provided that prior to the emergency order period fishing is allowed.
1969-86		Snake River section remains closed to commercial fishing, but fishing both prior to and after the emergency order period is allowed.

(continued)

Appendix Table 3. (continued)

Year (Inclusive)	Nushagak District Boundary Locations	
	Inshore Waters	Outside Waters
1963-86	Established inside boundaries on Igushik and Snake River sections.	
1967-68		Igushik and Snake River sections enlarged. Igushik River section closed to commercial fishing in 1967 during the emergency order period.
1969-81		Igushik and Snake River sections were modified, reducing the size of both sections.
1975		Nushagak section established within Nushagak district.
1982-86		Igushik and Snake River sections again modified to take advantage of LORAN C points; both sections were slightly enlarged.

1/ Fishing permitted south to the "king salmon line" varies each season; area opens between May 15-17 and closes between June 16-27.

(Sources: 5, 20, 22, 49 and 55).

Appendix Table 4. History of significant commercial gear specifications and vessel regulations affecting the chinook salmon fishery of Nushagak District, Bristol Bay, 1923-86. 1/

Year		Regulation
1923	(1)	Drift gill nets were the only legal salmon gear, and they were limited to 200 fathoms in length.
	(2)	Minimum mesh size for chinook and sockeye salmon was adopted, 8-1/2 inch stretch measure for chinook and 5-1/2 inch for sockeye.
1924	(1)	Salmon traps, beach seines and purse seines were prohibited.
	(2)	Minimum mesh size for sockeye salmon was increased to 5-3/4 inch stretch measure.
	(3)	Motor propelled fishing boats were prohibited.
1925	(1)	Sockeye salmon gill nets were limited to 28 meshes in depth.
1926	(1)	Minimum mesh size for sockeye salmon was reduced to 5-1/2 inch stretch measure.
	(2)	The use of other forms of fishing gear was prohibited.
1927	(1)	Set gill net gear was made legal, and limited to 75 fathoms in length.
1928	(1)	Drift gill nets were reduced to 150 fathoms in length.
1932	(1)	Set gill nets were reduced to 50 fathoms in length.
1937	(1)	A minimum distance of 450 feet between set gill nets was established.
	(2)	Drift gill nets were further reduced to 100 fathoms in length.
1938	(1)	Drift gill nets were returned to 150 fathom minimum length per net.
1951	(1)	The use of motor propelled fishing boats was made legal.
	(2)	A maximum overall length on fishing boats was set at 32 feet.
1956	(1)	Trolling gear was made legal for salmon.
1958	(1)	Chinook salmon gill nets were limited to 28 meshes in depth.
1960	(1)	Minimum mesh size was reduced to 5-1/2 inch stretch measure for the entire season.

(continued)

Appendix Table 4. (continued)

Year		Regulation
1961	(1)	Minimum mesh size was further reduced to 5-3/8 inch stretch measure for the entire season.
1968	(1)	Minimum mesh size for chinook salmon prior to June 21 was established at 7 inch stretch measure.
	(2)	Drift and set gill nets were reduced to 75 and 25 fathoms, respectively, by sliding gear scale regulations.
1969	(1)	Drift gill nets were reduced to 125 fathoms by sliding gear scale regulations.
1970	(1)	Sliding gear scale regulations were repealed, and drift and set gill nets were returned to 150 and 50 fathom limits, respectively.
	(2)	Minimum mesh size for chinook salmon was reduced to 5-3/8 inch stretch measure.
1972	(1)	Minimum mesh size for chinook salmon was increased prior to June 21 to 6-3/4 inch stretch measure.
1973	(1)	Effective June 16 drift and set gill nets were again reduced to 75 and 25 fathoms, respectively, by sliding gear scale regulations.
1974	(1)	Trolling gear used for salmon fishing was prohibited.
1976	(1)	Sliding gear scale was again repealed, and drift and set gill nets were returned to 150 and 50 fathom limits, respectively.
1985	(1)	Minimum mesh size for sockeye salmon was eliminated.
1986	(1)	Inseason authority to adjust mesh size by emergency field order was granted.

1/ Regulations are shown in the first year in which they apply, and are in effect until superseded by subsequent regulations.

(Sources: 5, 20 and 22)

Appendix Table 5. History of the chinook salmon commercial fishing season dates, weekly closed periods, and drift gill net gear specifications, Nushagak District, Bristol Bay, 1923-86.

I. COMMERCIAL CHINOOK SALMON FISHING SEASON DATES BY YEAR: 1/

Time Period		Season Dates		
			Mesh Size Required 2/	
Years	Number	Open to Fishing	Mean	Range
1923-49	27	-	June 25	June 22-26
1950-59	10	June 1	June 25	June 20-25
1960-67	8	-	June 24	June 20-27
1968-75	8	-	June 21	June 15-23
1976-86	11	May 1	June 16	June 16

II. AVERAGE WEEKLY CLOSED PERIODS BY YEAR: 3/

Time Period		Average Weekly Closed Period in Hours
Years	Number	
1924-29	6	36
1930-39	10	60
1940-49	10	61
1950-59	10	43
1960-86	27	48

III. DRIFT GILL NET GEAR SPECIFICATIONS BY YEAR:

Time Period		Drift Gill Net Gear Specifications				
			Depth in Meshes 4/		Minimum Mesh Size in Inches 5/	
Years	Number	Length in Fathoms	Chinook	Sockeye	Chinook	Sockeye
1923	1	200	-	-	8-1/2	5-1/2
1924	1	200	-	-	8-1/2	5-3/4
1925	1	200	-	28	8-1/2	5-3/4
1926-27	2	200	-	28	8-1/2	5-1/2
1928-36	9	150	-	28	8-1/2	5-1/2
1937	1	100	-	28	8-1/2	5-1/2
1938-57	20	150	-	28	8-1/2	5-1/2
1958-59	2	150	28	28	8-1/2	5-1/2
1960	1	150	28	28	5-1/2	5-1/2
1961-67	7	150	28	28	5-3/8	5-3/8
1968	1	75	28	28	7	5-3/8
1969	1	150	28	28	7	5-3/8
1970-71	2	150	28	28	5-3/8	5-3/8
1972	1	150	28	28	6-3/4	5-3/8
1973-75	3	150 6/	28	28	6-3/4	5-3/8
1976-84	9	150	28	28	6-3/4	5-3/8
1985-86	2	150	28	28	6-3/4	7/

1/ Except for two periods (1950-59 and 1976-86), there was no restriction on the opening date for chinook season; however, in most years commercial fishing effort directed at chinook salmon commences the last week in May to the first week in June.

2/ Minimum stretch measure chinook salmon mesh size restriction as shown in category III below.

3/ Prior to 1924 the entire Bering Sea area, which included Bristol Bay, was excluded from weekend closures in effect for some other areas of Alaska.

4/ Prior to 1958 there were no restrictions on depth of nets for larger mesh chinook salmon gear, while depth mesh restrictions for sockeye were initiated in 1925.

5/ Minimum mesh size restrictions for chinook and sockeye salmon seasons.

6/ Prior to 9 a.m., June 16 (1973 and 1975) and June 23 (1974) allowable drift net gear was limited to 150 fathoms, and after this date allowable gear was limited by sliding gear scale regulations.

7/ The minimum mesh size requirement for sockeye gill net gear was eliminated.

(Sources: 5, 20, 22 and 55)

Appendix Table 6. Number of commercial fish traps operated in Nushagak District, Bristol Bay, 1904-23.

Year	Number of Commercial Fish Traps 1/			
	Wood River	Igushik River	Nushagak Bay	Total
1904				10
05	4		5	9
06	7		7	14
07	6		6	12
08 2/			11	11
09			10	10
1910		2	8	10
11		2	8	10
12				8
13				8
14				8
15				8
16				8
17				7
18				7
19				7
1920				3
21				0
22				3
23 3/				0

1/ Fish trap breakdown by area in 1904 and 1912-23 is unavailable.
2/ Wood and Nushagak Rivers closed hereafter to commercial fishing.
3/ Fishing with traps prohibited after 1923.

(Sources: 19, 29 and 55)

Appendix Table 7. Commercial catch of chinook salmon, in numbers of fish, Nushagak District, Bristol Bay, 1893-1986.

Year	Catch	Year	Catch	Year	Catch
1893	44,000	1925	68,596	1957	79,122
94	10,500	26	54,856	58	87,245
95	18,473	27	68,044	59	54,299
96	14,777	28	51,076		
97	18,134	29	127,613	1960	81,416
98	16,736			61	60,953
99	37,011	1930	88,032	62	61,283
		31	44,863	63	45,979
1900	55,146	32	57,721	64	108,606
01	86,431	33	45,559	65	85,910
02	98,216	34	36,875	66	58,184
03	81,640	35	1,635	67	96,240
04	85,787	36	13,425	68	78,201
05	96,929	37	24,263	69	80,803
06	105,058	38	29,731		
07	104,157	39	17,260	1970	87,547
08	69,175			71	82,769
09	108,311	1940	6,899	72	46,045
		41	23,609	73	30,470
1910	86,433	42	14,575	74	32,053
11	103,806	43	29,590	75	21,454
12	87,489	44	8,170	76	60,684
13	67,656	45	15,618	77	85,074
14	88,693	46	18,120	78	118,548
15	116,387	47	29,540	79	157,321
16	81,921	48	40,217		
17	74,316	49	41,608	1980	64,958
18	46,386			81	193,461
19	93,778	1950	27,688	82	195,287
		51	34,226	83	137,123
1920	97,937	52	39,848	84	61,375 1/
21	71,048	53	27,502	85	67,616 1/
22	60,924	54	38,045	86	63,859 1/
23	56,397	55	56,463		
24	53,532	56	57,441		

1/ Preliminary.

(Sources: 1, 4, 21, 46, 52, 55 and 59)

Appendix Table 8. Number of registered commercial fishing gill nets, Nushagak District, Bristol Bay, 1904-86. 1/

Number of Drift and Set Gill Nets by Year								
Year	Drift	Set	Year	Drift	Set	Year	Drift	Set
1904	760		1932	276	208	1960	275	169
05	496		33	280	167	61	286	199
06	518		34	279	221	62	319	210
07	421		35	65	154	63	488	283
08	495		36	298	263	64	505	281
09	394		37	236	173	65	486	357
			38	99	96	66	542	277
1910	431		39	235	144	67	542	230
11	492					68	554	257
12	758		1940	129	128	69	615	275
13	871		41	125	116			
14	977		42	96	53	1970	569	246
15	1,163		43	119	98	71	559	243
16	1,078		44	118	103	72	548	238
17	1,263		45	82	103	73 2/	290	93
18	1,224		46	198	97	74	432	187
19	1,096		47	182	189	75	513	205
			48	194	216	76	479	206
1920	1,172		49	189	272	77	547	234
21	1,057					78 3/	609	292
22	952		1950	108	270	79	617	305
23	760		51	138	242			
24	405		52	197	223	1980	596	278
25	625		53	40	81	81	595	279
26	450		54	78	99	82	595	279
27	444		55	160	121	83	594	280
28	206		56	195	139	84	593	281
29	246		57	337	125	85	485	247
			58	431	113	86	404	253
1930	256	91	59	275	175			
31	147	no record						

1/ The number of gill nets by gear type is:
- 1904-29 - not defined by gear type;
- 1930-59 - compiled from cannery and miscellaneous operators lists of boat and set net fishermen;
- 1960-73 - based on preseason gear registration which does not incorporate inseason district transfers;
- 1974-84 - based on preseason registration of Limited Entry gill net permits, and does not incorporate inseason district transfers;
- 1985-86 - based on inseason daily drift entry permit peak registration, which incorporates district transfers. Set net registration continues to be based on preseason entry permit registration and actual fishing effort.

2/ A sliding gear scale was in effect in 1973, and gear effort levels were greatly exaggerated (drift-1,204, set-388); therefore, fishing effort was based on actual gear fished at the peak of the fishery.

3/ From 1978-84 entry permit preseason registration was computed using preseason processor fishing effort information and Nushagak District fishing effort averages from prior years.

(Sources: 1, 4, 21 and 55)

Appendix Table 9. Commercial catch of chinook salmon by type of gear, in numbers of fish, Nushagak District, Bristol Bay, 1945-86. 1/

Year	Catch by Type of Gear				
	Drift Net	Percent	Set Net	Percent	Total
1945	10,068	64.5	5,550	35.5	15,618
46	13,460	74.3	4,660	25.7	18,120
47	22,972	77.8	6,568	22.2	29,540
48	25,247	62.8	14,970	37.2	40,217
49	31,414	75.5	10,194	24.5	41,608
1950	20,570	74.3	7,118	25.7	27,688
51	32,726	95.6	1,500	4.4	34,226
52	38,278	96.1	1,570	3.9	39,848
53	25,145	91.4	2,357	8.6	27,502
54	36,744	96.6	1,301	3.4	38,045
55	55,139	97.7	1,324	2.3	56,463
56	56,251	97.9	1,190	2.1	57,441
57	78,458	99.2	664	0.8	79,122
58	86,564	99.2	681	0.8	87,245
59	52,712	97.1	1,587	2.9	54,299
1960	79,103	97.2	2,313	2.8	81,416
61	59,006	96.8	1,947	3.2	60,953
62	59,858	97.7	1,425	2.3	61,283
63	43,771	95.2	2,208	4.8	45,979
64	103,856	95.6	4,750	4.4	108,606
65	81,915	95.3	3,995	4.7	85,910
66	56,002	96.2	2,182	3.8	58,184
67	93,608	97.3	2,632	2.7	96,240
68	77,369	98.9	832	1.1	78,201
69	79,429	98.3	1,374	1.7	80,803
1970	85,151	97.3	2,396	2.7	87,547
71	81,418	98.4	1,351	1.6	82,769
72	45,519	98.9	526	1.1	46,045
73	29,762	97.7	708	2.3	30,470
74	31,720	99.0	333	1.0	32,053
75	20,961	97.7	493	2.3	21,454
76	57,614	94.9	3,070	5.1	60,684
77	84,257	99.0	817	1.0	85,074
78	117,265	98.9	1,283	1.1	118,548
79	151,534	96.3	5,787	3.7	157,321
1980	63,255	97.4	1,703	2.6	64,958
81	183,275	94.7	10,186	5.3	193,461
82	184,852	94.7	10,435	5.3	195,287
83	122,925	89.6	14,198	10.4	137,123
84	56,751	92.5	4,624	7.5	61,375 1/
85	53,234	78.7	14,382	21.3	67,616 1/
86	58,112	91.0	5,747	9.0	63,859 1/

1/ Preliminary.

(Sources: 1, 4, 21 and 59)

Appendix Table 10. Commercial catch of chinook salmon by week, in thousands of fish, Nushagak District, Bristol Bay, 1958-86. 1/

	1958		1959		1960		1961		1962	
Period	Per.	Acc.	Per.	Acc.	Per.	Acc.	Per.	Acc.	Per.	Acc.
>6/8	18	18	5	5	1	1	16	16	11	11
6/ 9-15	26	44	9	14	11	12	26	42	15	26
6/16-22	26	70	27	41	30	42	13	55	21	47
6/23-29	7	77	1 2/	42	27	69	4	59	10	57
6/30-7/6	8	85	7	49	3	72	1	60	3	60
7/ 7-13	1	86	2	51	4	76	+	60	1	61
7/14-20	+	86	2	53	3	79	+	60	1	62
7/21>	1	87	1	54	2	81	+	60	+	62
Total 3/	87,245		54,299		81,416		60,953		61,283	

	1963		1964		1965		1966		1967	
Period	Per.	Acc.	Per.	Acc.	Per.	Acc.	Per.	Acc.	Per.	Acc.
>6/8	2	2	2	2	7	7	1 2/	1	12	12
6/ 9-15	5	7	29	31	12	19	26	27	23	35
6/16-22	35	42	42	73	38	57	27	54	31	66
6/23-29	+ 2/	42	18	91	23	80	2	56	27	93
6/30-7/6	1	43	11	102	4	84	1	57	1	94
7/ 7-13	2	45	3	105	1	85	1	58	+	94
7/14-20	1	46	4	109	1	86	1	59	2	96
7/21>	+	46	1	110	+	86	+	59	+	96
Total 3/	45,979		108,606		85,910		58,184		96,240	

	1968		1969		1970		1971		1972	
Period	Per.	Acc.	Per.	Acc.	Per.	Acc.	Per.	Acc.	Per.	Acc.
>6/8	12	12	18	18	5	5	+	+	2	2
6/ 9-15	25	37	15	33	21	26	1	1	10	12
6/16-22	25	62	23	56	25	51	20	21	4	16
6/23-29	10	72	3 2/	59	17	68	44	65	23	39
6/30-7/6	2	74	11	70	14	82	5	70	1	40
7/ 7-13	2	76	10	80	4	86	10	80	5	45
7/14-20	1	77	1	81	1	87	2	82	1	46
7/21>	+	77	1	82	1	88	1	83	+	46
Total 3/	78,201		80,803		87,547		82,769		46,045	

(continued)

Appendix Table 10. (continued)

	1973		1974		1975		1976		1977	
Period	Per.	Acc.	Per.	Acc.	Per.	Acc.	Per.	Acc.	Per.	Acc.
>6/8	9	9	4	4	1	1	1	1	8	8
6/ 9-15	4	13	21	25	2	3	11	12	15	23
6/16-22	13	26	+	25	10	13	23	35	56	79
6/23-29	2	28	0	25	+	13	11	46	2	81
6/30-7/6	+	28	3	28	+	13	6	52	3	84
7/ 7-13	0	28	2	30	4	17	2	54	+	84
7/14-20	2	30	+	30	3	20	6	60	1	85
7/21>	+	30	+	30	1	21	1	61	+	85
Total 3/	30,470		32,053		21,454		60,684		85,074	

	1978		1979		1980		1981		1982	
Period	Per.	Acc.	Per.	Acc.	Per.	Acc.	Per.	Acc.	Per.	Acc.
>6/8	25	25	25	25	11	11	23	23	6	6
6/ 9-15	66	91	59	84	40	51	43	66	43	49
6/16-22	8	99	38	122	0 2/	51	28	94	16	65
6/23-29	8	107	25	147	9	60	75	169	97	161
6/30-7/6	7	114	6	153	1	61	13	182	12	173
7/ 7-13	1	115	2	155	2	63	7	189	14	187
7/14-20	3	118	1	156	1	64	3	192	7	194
7/21>	+	118	1	157	1	65	2	194	1	195
Total 3/	118,548		157,321		64,958		193,461		195,287	

									Average 1958-86			
	1983		1984 4/		1985 4/		1986 4/		Catch		Percent	
Period	Per.	Acc.	Per.	Acc.	Per.	Acc.	Per.	Acc.	Per.	Acc.	Per.	Acc.
>6/8	24	24	17	17	10	10	8	8	10	10	12	12
6/ 9-15	41	65	13	30	6	16	21	29	22	32	27	39
6/16-22	0	65	0	30	5	21	6	36	20	52	24	63
6/23-29	37	102	17	47	0	21	0	36	17	69	21	84
6/30-7/6	18	120	4	51	35	56	23	60	7	76	8	92
7/ 7-13	13	133	4	55	8	64	2	62	4	80	5	97
7/14-20	3	136	4	59	3	67	1	63	2	82	2	99
7/21>	1	137	2	61	1	68	1	64	1	83	1	100
Total 3/	137,123		61,375		67,616		63,859		83,000		100	

1/ There is some overlap of period dates between years; these catches are prorated between periods when necessary.
2/ Catches affected by fishermen-processor price dispute.
3/ Due to rounding, the totals may not equal the sum of the period catches.
4/ Preliminary.

(Sources: 1, 4 and 21)

Appendix Table 11. Commercial catch of chinook salmon accounted for by date, Nushagak District, Bristol Bay, 1958-86.

Year	Percent of Total Catch Accounted for By Date									Peak Day
	10	20	30	40	50	60	70	80	90	
1958 1/	6/ 4	6/ 8	6/10	6/12	6/15	6/17	6/20	6/23	7/ 1	6/16
59 1/	6/ 8	6/12	6/15	6/17	6/18	6/20	6/21	6/30	7/ 6	6/18
1960	6/ 9	6/14	6/15	6/16	6/18	6/21	6/22	6/24	7/ 4	6/16
61	6/ 7	6/ 9	6/12	6/13	6/14	6/15	6/19	6/21	6/24	6/15
62	6/ 8	6/11	6/12	6/14	6/19	6/21	6/22	6/25	6/26	6/22
63 1/	6/12	6/16	6/16	6/17	6/18	6/19	6/20	6/21	6/22	6/19
64	6/ 9	6/11	6/15	6/17	6/18	6/19	6/24	6/26	7/ 3	6/19
65	6/ 7	6/10	6/16	6/17	6/17	6/17	6/21	6/22	6/25	6/17
66	6/13	6/14	6/15	6/16	6/20	6/22	6/25	6/26	6/26	6/26
67	6/ 8	6/12	6/14	6/19	6/20	6/21	6/23	6/25	6/29	6/21
68	6/ 5	6/10	6/11	6/13	6/17	6/20	6/21	6/24	6/30	6/11
69	6/ 4	6/ 6	6/11	6/14	6/16	6/17	6/27	7/ 3	7/ 9	6/17
1970	6/ 9	6/11	6/13	6/17	6/18	6/22	6/26	6/28	7/ 2	6/18
71	6/15	6/18	6/26	6/26	6/26	6/29	6/30	7/ 2	7/ 8	6/26
72	6/15	6/16	6/20	6/22	6/23	6/23	6/27	6/29	7/ 9	6/23
73	6/ 8	6/ 9	6/ 9	6/13	6/19	6/20	6/20	6/20	6/27	6/20
74	6/ 8	6/11	6/13	6/14	6/14	6/14	6/14	6/15	7/ 5	6/14
75	6/12	6/16	6/16	6/17	6/17	6/21	7/10	7/11	7/15	6/17
76	6/10	6/16	6/18	6/18	6/18	6/22	6/28	7/ 2	7/14	6/18
77	6/ 7	6/ 8	6/14	6/15	6/16	6/16	6/16	6/17	6/23	6/16
78	6/ 6	6/ 9	6/13	6/13	6/14	6/14	6/19	6/24	7/ 3	6/14
79	6/ 4	6/11	6/12	6/13	6/14	6/19	6/20	6/23	6/27	6/20
1980	6/ 6	6/ 9	6/10	6/10	6/10	6/11	6/12	6/23	6/23	6/10
81	6/ 3	6/ 9	6/10	6/17	6/22	6/23	6/24	6/26	7/ 2	6/23
82	6/11	6/14	6/16	6/24	6/24	6/26	6/26	6/28	7/ 7	6/26
83	6/ 7	6/ 9	6/13	6/14	6/25	6/26	6/26	7/ 3	7/ 7	6/26
84 2/	6/ 5	6/ 7	6/ 9	6/12	6/12	6/25	6/25	6/27	7/11	6/25
85 2/	6/ 7	6/14	6/20	6/30	6/30	6/30	7/ 2	7/ 4	7/ 6	6/30
86 2/	6/ 6	6/12	6/12	6/12	6/19	6/19	6/30	6/30	7/ 3	6/12
Mean	6/ 7	6/10	6/13	6/15	6/18	6/21	6/24	6/28	7/ 4	6/18

1/ Estimated from weekly accumulative catch reports.
2/ Preliminary.

(Sources: 1, 4 and 21)

Appendix Table 12. Prices paid to fishermen for commercially caught chinook salmon, Nushagak District, Bristol Bay, 1933-86. 1/

	Average Price Paid Per Fish in Dollars 2/					
	Independent Fishermen			Company Fishermen 3/		
Year	Small	Medium	Large	Small	Medium	Large
1933-34				.20		.40
35				.25		.50
36				.27		.54
1937-40				.31		.62
41				.33		.66
42 4/				-		-
43				.45		.90
1944-45				.46		.91
46				.50		.99
47				.55		1.10
1948-50				.75		1.50
51			4.00	1.00		2.00
1952-54 5/			3.38	1.10		2.20
55 5/	1.67		3.34	1.10		2.20
56	1.68		3.38	1.12		2.23
57	1.70		3.40	1.13		2.25
58	1.75		3.49	1.21		2.41
59	1.75		3.50	1.21		2.41
1960		1.75	3.50	---- 1.27 6/ ----		2.53
61	1.00	1.84	3.68	---- 1.33 6/ ----		2.66
1962-65	1.00	1.87	3.75	---- 1.35 6/ ----		2.70
1966	1.00	1.94	3.87	.64	1.20	2.40
1967-68	1.03	1.94	3.87	.69	1.39	2.78

(continued)

Appendix Table 12. (continued)

Year	Average Value in Dollars: Price Per Pound 2/ Canned	Price Per Pound 2/ Fresh/Frozen	Price Per Fish	Total Exvessel Value
1969	.11		2.39	193,000
1970	.11		2.29	200,000
1971	----	.12 7/ ----	2.99	247,000
72	----	.13 7/ ----	2.59	119,000
73	----	.18 7/ ----	4.16	127,000
74	----	.24 7/ ----	6.22	199,000
75	.35	.40	8.54	183,000
76	.41	.46	10.09	612,000
77	.45	.65	15.40	1,310,000
78	.50	.70	15.86	1,880,000
79	.52	1.00	18.11	2,849,000
1980	.80	1.00	20.31	1,319,000
81	----	1.23 7/ ----	21.53	4,165,000
82	----	1.26 7/ ----	25.64	5,007,000
83	----	.71 7/ ----	14.91	2,045,000
84	----	1.07 7/ ----	22.16	1,360,000 8/
85	----	1.05 7/ ----	17.77	1,202,000 8/
86	----	1.04 7/ ----	20.76	1,326,000 8/

1/ Prior to 1960 chinook were classified as either large (15 lbs. or over) or small (15 lbs. or under); beginning 1960 chinook were classed as small (under 8 lbs.), medium (8 to 15 lbs.) and large (over 15 lbs.)
2/ Prices paid were based on fish size through 1968, and effective in 1969 were based on a per pound basis.
3/ Prior to 1952 all fishermen were classified as company fishermen.
4/ Price data not available.
5/ Company and sailboat and set net fishermen received $1.11 for small chinook, and $2.22 for large chinook.
6/ Both small and medium chinook were grouped together under one class.
7/ Average price per pound derived from processor records and is weighted by the catch of each processor against the total catch.
8/ Preliminary.

(Sources: 1 and 21)

Appendix Table 13. Daily chinook salmon escapement sonar counts, in numbers of fish, Nushagak River, Bristol Bay, 1979-86. 1/

Date	1979		1980		1981		1982		1983		1985		1986		Average 1979-86 Escapement		Average 1979-86 Percent	
	Daily	Accum.	Daily	Accum.	Daily	Accum.	Daily	Accum.	Daily	Accum.	Daily	Accum.	Daily	Accum.	Daily	Accum.	Daily	Accum.
6/ 6																		
7													1	1	+	+	+	+
8													9	10	1	1	+	+
9													6	16	1	2	+	+
10													11	27	2	4	+	+
													51	78	7	11	+	+
11									118	118	46	46	41	118	29	40	+	+
12					1,128	1,128			156	274	9	55	82	201	196	236	+	+
13					2,124	3,252			212	486	112	168	318	519	395	631	+	1
14					1,951	5,203	281	281	131	618	148	316	297	816	401	1,032	+	1
15					1,500	6,703	589	870	204	822	33	348	101	916	347	1,379	+	2
16					2,660	9,363	557	1,427	139	960	24	373	148	1,064	504	1,883	1	2
17					909	10,272	1,432	2,859	132	1,092	14	387	43	1,107	361	2,244	+	3
18					584	10,856	1,583	4,442	143	1,235	20	406	72	1,179	343	2,587	+	3
19					568	11,424	1,123	5,565	136	1,371	371	778	424	1,603	375	2,962	+	4
20					14	11,438	790	6,355	368	1,739	2,671	3,449	789	2,392	662	3,624	1	4
21					56	11,494	7,836	14,191	570	2,309	3,886	7,334	525	2,917	1,839	5,463	2	7
22			3,975	3,975	2,056	13,550	5,746	19,937	3,180	5,489	1,775	9,090	521	3,438	2,462	7,925	3	10
23			5,377	9,352	3,556	17,106	6,791	26,728	1,553	7,042	3,557	12,647	188	3,627	3,003	10,928	4	13
24	73	73	1,463	10,815	7,500	24,606	17,239	43,967	5,124	12,166	888	13,535	274	3,901	4,652	15,580	6	19
25	17,614	17,687	2,040	12,855	11,472	36,078	4,179	48,146	2,715	14,881	380	13,915	516	4,417	5,559	21,139	7	26
26	713	18,400	3,707	16,562	7,049	43,127	2,612	50,758	4,388	19,269	645	14,560	643	5,060	2,822	23,961	3	29
27		18,400	4,623	21,185	5,592	48,719	1,567	52,325	4,828	24,097	1,761	16,321	999	6,059	2,767	26,728	3	33
28		18,400	3,661	24,846	1,625	50,344	1,567	53,892	11,618	35,715	1,716	18,037	748	6,807	2,991	29,719	4	36
29		18,400	1,524	26,370	3,140	53,484	3,134	57,027	5,649	41,364	604	18,641	405	7,212	2,065	31,784	3	39
30		18,400	1,553	27,923	3,909	57,393	5,224	62,251	8,468	49,832	907	19,548	443	7,656	2,929	34,713	4	42
7/ 1	4,906	23,306	1,875	29,798	2,432	59,825	5,746	67,997	5,742	55,574	9,184	28,731	128	7,783	4,288	39,001	5	47
2	1,898	25,204	4,688	34,486	21,917	81,742	5,746	73,744	5,556	61,130	15,016	43,747	181	7,964	7,857	46,858	10	57
3		25,204	2,702	37,188	14,789	96,531	5,224	78,968	2,880	64,009	6,527	50,274	187	8,152	4,616	51,474	6	63
4		25,204		37,188	10,517	107,048	1,045	80,012	4,866	68,875	4,291	54,565	82	8,234	2,972	54,446	4	66
5	64	25,268	2,850	40,038		107,048	4,179	84,192	4,876	73,751	4,074	58,639	782	9,016	2,404	56,850	3	69
6	294	25,562		40,038		107,048	4,179	88,371	1,769	75,520	5,850	64,489	1,249	10,265	1,906	58,756	2	72
7		25,562	2,052	42,090		107,048	3,657	92,028	1,342	76,862	4,023	68,512	2,256	12,521	1,904	60,660	2	74
8		25,562	602	42,692	1,028	108,076	1,567	93,595	1,482	78,344	3,217	71,728	1,990	14,511	1,412	62,072	2	76
9		25,562	285	42,977	1,720	109,796	2,090	95,684	1,168	79,512	2,752	74,480	2,192	16,703	1,458	63,530	2	77
10	503	26,065		42,977		109,796	3,134	98,819	981	80,493	2,886	77,366	1,843	18,546	1,335	64,865	2	79

(continued)

Appendix Table 13. (continued)

	1979		1980		1981		1982		1983		1985		1986		Average 1979-86 Escapement		Average 1979-86 Percent	
	Daily	Accum.	Daily	Accum.	Daily	Accum.	Daily	Accum.	Daily	Accum.	Daily	Accum.	Daily	Accum.	Daily	Accum.	Daily	Accum.
7/11		26,065	1,284	44,261		109,796	1,567	100,386	2,351	82,843	2,192	79,558	1,111	19,657	1,215	66,080	1	80
12		26,065	917	45,178	2,049	111,845	2,612	102,998	2,347	85,191	1,222	80,780	3,891	23,549	1,863	67,943	2	83
13	705	26,770		45,178	1,103	112,948	2,090	105,088	1,794	86,985	829	81,609	1,247	24,795	1,110	69,053	1	84
14		26,770	1,108	46,286	959	113,907	2,090	107,177	2,345	89,330	1,880	83,489	1,447	26,242	1,404	70,457	2	86
15		26,770	624	46,910	934	114,841	4,702	111,879	2,440	91,770	4,016	87,505	3,045	29,287	2,252	72,709	3	89
16	2,809	29,579	662	47,572	264	115,105	1,567	113,446	755	92,524	2,000	89,505	1,166	30,453	1,318	74,027	2	90
17	927	30,506	2,689	50,261			2,090	115,536	387	92,911	1,718	91,223	3,097	33,550	1,558	75,585	2	92
18	683	31,189	5,101	55,362			2,090	117,625	435	93,346	1,631	92,854	1,146	34,696	1,584	77,169	2	94
19	1,612	32,801	595	55,957			522	118,148	422	93,768	2,389	95,244	1,176	35,872	959	78,128	1	95
20							1,045	119,192	456	94,223	951	96,195	936	36,808	484	78,612	1	96
21							522	119,715	361	94,585	493	96,688	738	37,546	302	78,914	+	96
22							1,567	121,282	373	94,958	477	97,165	398	37,945	402	79,316	+	97
23							522	121,804	435	95,393	371	97,535	288	38,232	231	79,547	+	97
24							1,045	122,849	458	95,850	119	97,654	808	39,040	347	79,894	+	97
25								122,849	566	96,416	522	98,177	463	39,503	222	80,116	+	97
26							2,090	124,939	597	97,013	319	98,495	618	40,121	518	80,634	1	98
27									592	97,605	234	98,730	1,168	41,289	285	80,919	+	98
28									633	98,238	104	98,833	120	41,409	122	81,041	+	98
29									644	98,882	29	98,863		41,409	96	81,137	+	98
30									413	99,295	17	98,879	182	41,591	87	81,224	+	98
31									957	100,253	27	98,906	60	41,651	149	81,373	+	99
8/ 1									660	100,913	26	98,933	50	41,701	105	81,478	+	99
2									790	101,703	18	98,951		41,701	115	81,593	+	99
3									734	102,438	24	98,975		41,701	108	81,701	+	99
4									658	103,096	62	99,037	787	42,488	215	81,916	+	99
5									55	103,151			381	42,870	62	81,978	+	99
6									89	103,240			204	43,074	42	82,020	+	99
7									83	103,323			87	43,161	24	82,044	+	99
8									211	103,533			72	43,233	40	82,084	+	99
9									232	103,765			65	43,299	43	82,127	+	99
10													135	43,434	19	82,146	+	100
Total		32,801		55,957		115,105		124,939		103,765		99,037		43,434		82,146		100

1/ The sum of the daily escapements may not equal the accumulative escapement due to rounding. No estimate of chinook escapement was made in 1984.

(Sources: 1 and 33)

Appendix Table 14. Daily chinook salmon escapement weir counts, Stuyahok River, Nushagak District, Bristol Bay, 1968.

Date	Escapement Counts		Percent of Total	
	Daily	Accumulative	Daily	Accumulative
6/29	0	0	0.00	0.00
30	1	1	0.02	0.02
7/ 1	0	1	0.00	0.02
2	15	16	0.29	0.31
3	12	28	0.23	0.54
4	3	31	0.06	0.60
5	0	31	0.00	0.60
6	15	46	0.29	0.89
7	6	52	0.12	1.01
8	4	56	0.08	1.09
9	576	632	11.19	12.28
10	663	1,295	12.88	25.16
11	44	1,339	0.85	26.01
12	39	1,378	0.76	26.77
13	122	1,500	2.37	29.14
14	168	1,668	3.26	32.40
15	446	2,114	8.66	41.06
16	157	2,271	3.05	44.11
17	268	2,539	5.20	49.31
18	438	2,977	8.50	57.81
19	664	3,641	12.90	70.71
20	102	3,743	1.98	72.69
21	166	3,909	3.22	75.91
22	300	4,209	5.84	81.75
23	63	4,272	1.22	82.97
24	234	4,506	4.54	87.51
25	25	4,531	0.48	87.99
26	192	4,723	3.73	91.72
27	94	4,817	1.83	93.55
28	70	4,887	1.36	94.91
29	47	4,934	0.91	95.82
30	45	4,979	0.87	96.69
31	45	5,024	0.87	97.56
8/ 1	31	5,055	0.60	98.16
2	29	5,084	0.56	98.72
3	33	5,117	0.64	99.36
4	13	5,130	0.25	99.61
5	5	5,135	0.10	99.71
6	11	5,146	0.21	99.92
7	4	5,150	0.08	100.00
Total	5,150	5,150	100.00	100.00

(Source: 45)

Appendix Table 15. Peak aerial survey escapement estimates by date of live chinook salmon in streams and tributaries of Nushagak District, Bristol Bay, 1956-86. 1/

Stream	1956 Date	1956 No. Est.	1957 Date	1957 No. Est.	1958 Date	1958 No. Est.	1959 Date	1959 No. Est.
NUSHAGAK BAY DRAINAGE								
Igushik River								
Snake River:								
Weary River								
Wood River:								
Muklung River	8/ 6	150	8/16	25 2/	8/15	27 2/	8/10	299
Streams 3/								
NUSHAGAK BAY DRAINAGE SUB-TOTALS		150		25		27		299
NUSHAGAK RIVER DRAINAGE								
Nushagak River: (TOTALS)								
Portage Cr. to Ekwok								
Ekwok to Mulchatna R.								
Mulch. R. to Nuyakuk R.								
Nuy. R. to Klutispaw R.								
Klutis. R. to King Sal. R.								
King Sal. R. to Chich. R.								
Chichitnok R. to Big Bend								
Big Bend on North								
Iowithla River	8/ 6	101	7/29	50 2/	8/15	13 2/	8/10	228
Kokwok River	8/ 6	+	8/16	2 2/				
Klutuk River								
Nunachuak Creek								
Cranberry Creek							7/28	0
Napotoli Creek							7/28	+
Nuyakuk River								
Tikchik River								
Harris Creek								
Klutispaw River							7/30	518 2/
Vukpalik Creek								
King Salmon River			7/29	125 2/	8/14	0 2/	7/30	737
Chichitnok River							8/10	16
NUSHAGAK DRAINAGE SUB-TOTALS		101		177		13		1,499
MULCHATNA RIVER DRAINAGE								
Mulchatna River: (TOTALS)								(414)
Nush. R. to Stuyahok R.								
Stuy. R. to Koktuli R.								
Koktuli R. to Mosquito Cr.							7/30	414
Mosq. Cr. to Chil. R.								
Chilchitna R. to Chilik. R.								
Chilikadrotna R. to Turq. Lk.								
Stuyahok River							7/28	655 2/
Old Man Creek							7/30	51
Koktuli River							8/10	431
Mosquito Creek								
Keefer Creek								
Chilchitna River								
Chilikadrotna River								
MULCHATNA DRAINAGE SUB-TOTALS		-		-		-		1,551
NUSHAGAK/MULCHATNA TOTALS		251		202		40		3,349

(continued)

Appendix Table 15. (continued)

Stream	1960 Date	1960 No. Est.	1962 Date	1962 No. Est.	1963 Date	1963 No. Est.	1964 Date	1964 No. Est.
NUSHAGAK BAY DRAINAGE								
Igushik River								
Snake River:								
Weary River							7/27	115 2/
Wood River:								
Muklung River							7/31	1,000
Streams 3/								
NUSHAGAK BAY DRAINAGE SUB-TOTALS		-		-		-		1,115
NUSHAGAK RIVER DRAINAGE								
Nushagak River: (TOTALS)								(3,600) 2/
Portage Cr. to Ekwok								
Ekwok to Mulchatna R.								
Mulch. R. to Nuyakuk R.								
Nuy. R. to Klutispaw R.							8/ 2	400
Klutis. R. to King Sal. R.							8/ 2	1,100
King Sal. R. to Chich. R.							8/ 2	400
Chichitnok R. to Big Bend							>8/ 2	1,700
Big Bend on North								
Iowithla River							8/15	100
Kokwok River							8/15	0
Klutuk Creek								
Nunachuak Creek							8/14	100
Cranberry Creek								
Napotoli Creek								
Nuyakuk River								
Tikchik River								
Harris Creek								
Klutispaw River	7/28	158	8/ 1	79				
Vukpalik Creek								
King Salmon River	7/28	137	8/ 1	471	8/ 5	48	8/ 2	700
Chichitnok River							8/ 2	400
NUSHAGAK DRAINAGE SUB-TOTALS		295		550		48		4,900
MULCHATNA RIVER DRAINAGE								
Mulchatna River: (TOTALS)								(1,900) 2/
Nush. R. to Stuyahok R.								
Stuy. R. to Koktuli R.								
Koktuli R. to Mosquito Cr.								
Mosq. Cr. to Chil. R.							8/14	1,600
Chilchitna R. to Chilik. R.							8/14	300
Chilikadrotna R. to Turq. Lk.								
Stuyahok River					8/ 5	227	8/ 5	1,410
Old Man Creek							8/ 5	0
Koktuli River	7/28	704					8/14	3,300
Mosquito Creek								
Keefer Creek								
Chilchitna River							8/14	0
Chilikadrotna River							8/14	300
MULCHATNA DRAINAGE SUB-TOTALS		704		-		227		6,910
NUSHAGAK/MULCHATNA TOTALS		999		550		275		12,925

(continued)

Appendix Table 15. (continued)

Stream	1965 Date	1965 No. Est.	1966 Date	1966 No. Est.	1967 Date	1967 No. Est.	1968 Date	1968 No. Est.
NUSHAGAK BAY DRAINAGE								
Igushik River							7/ 8	100
Snake River:			8/ 6	25	8/ 8	20		
Weary River					8/ 8	50 2/		
Wood River:								
Muklung River	7/30	570			8/10	350 2/	8/ 4	750
Streams 3/					8/ 3	22		
NUSHAGAK BAY DRAINAGE SUB-TOTALS		570		25		442		850
NUSHAGAK RIVER DRAINAGE								
Nushagak River: (TOTALS)		(4,700) 2/						(2,470) 2/
Portage Cr. to Ekwok								
Ekwok to Mulchatna R.								
Mulch. R. to Nuyakuk R.							8/ 5	320
Nuy. R. to Klutispaw R.							8/ 5	220
Klu. R. to K. Sal. R.	7/27	4,700 2/					8/ 5	750
King Sal. R. to Chich. R.							8/ 5	310
Chichitnok R. to Big Bend							8/ 5	710
Big Bend on North							8/ 5	160
Iowithla River					8/10	200	8/ 4	850
Kokwok River	7/30	0						
Klutuk Creek							8/ 6	130
Nunachuak Creek							8/ 6	0
Cranberry Creek							8/ 6	0
Napotoli Creek							8/ 7	0
Nuyakuk River							8/ 5	430
Tikchik River								
Harris Creek							8/ 5	0
Klutispaw River	7/30	140					8/ 5	310
Vukpalik Creek							8/ 5	50
King Salmon River	7/30	850					8/ 5	1,000
Chichitnok River	7/30	500					8/ 5	160
NUSHAGAK DRAINAGE SUB-TOTALS		6,190		-		200		5,400
MULCHATNA RIVER DRAINAGE								
Mulchatna River: (TOTALS)								(1,710)
Nush. R. to Stuyahok R.							8/ 6	190
Stuy. R. to Koktuli R.							8/ 6	250
Koktuli R. to Mosquito Cr.							8/ 6	510
Mosq. Cr. to Chil. R.							8/ 7	490
Chilchitna R. to Chilik. R.							8/ 7	150
Chilikadrotna R. to Turq. Lk.							8/ 7	120 2/
Stuyahok River					8/ 3	2,500	8/ 4	2,470
Old Man Creek							8/ 6	10
Koktuli River					8/ 3	3,300	8/ 6	4,220
Mosquito Creek							8/ 6	340
Keefer Creek							8/ 7	100
Chilchitna River							8/ 7	120
Chilikadrotna River							8/ 7	410
MULCHATNA DRAINAGE SUB-TOTALS		-		-		5,800		9,380
NUSHAGAK/MULCHATNA TOTALS		6,760		25		6,442		15,630

(continued)

Appendix Table 15. (continued)

Stream	1969 Date	1969 No. Est.	1970 Date	1970 No. Est.	1971 Date	1971 No. Est.	1972 Date	1972 No. Est.
NUSHAGAK BAY DRAINAGE								
Igushik River			8/ 5	100	8/ 3	40		
Snake River:	8/ 6	60	8/ 5	150	8/ 3	60		
Weary River			8/ 5	230	8/ 3	60		
Wood River:			8/22	50	9/ 1	0		
Muklung River	8/ 2	520	8/ 5	590	8/ 3	280	8/ 3	150
Streams 3/	8/6-16	64	8/22	0	8/13	0		
NUSHAGAK BAY DRAINAGE SUB-TOTALS		644		1,120		440		150
NUSHAGAK RIVER DRAINAGE								
Nushagak River: (TOTALS)	8/ 8	(160) 2/						(1,210) 2/
Portage Cr. to Ekwok								
Ekwok to Mulchatna R.								
Mulch. R. to Nuyakuk R.	8/ 8	60						
Nuy. R. to Klutispaw R.								
Klutis. R. to King Sal. R.							8/ 4	300
K. Sal. R. to Chich. R.	8/ 8	100					8/ 4	180
Chichitnok R. to Big Bend							8/ 4	730
Big Bend on North								
Iowithla River	8/ 2	580	8/ 5	700	8/ 3	390	8/ 3	170
Kokwok River	8/ 7	90	8/ 5	110	8/ 3	80		
Klutuk Creek	8/ 7	50 2/	8/ 5	130				
Nunachuak Creek								
Cranberry Creek								
Napotoli Creek	8/ 8	20 2/						
Nuyakuk River	8/ 8	70	8/ 7	240			8/ 4	70
Tikchik River								
Harris Creek								
Klutispaw River	8/ 8	90	8/ 7	320			8/ 4	280
Vukpalik Creek								
King Salmon River	8/ 8	670	8/ 7	1,060			8/ 4	900
Chichitnok River	8/ 8	100					8/ 4	100
NUSHAGAK DRAINAGE SUB-TOTALS		1,830		2,560		470		2,730
MULCHATNA RIVER DRAINAGE								
Mulchatna River: (TOTALS)							8/ 4	(0) 2/
Nush. R. to Stuyahok R.								
Stuy. R. to Koktuli R.								
Koktuli R. to Mosquito Cr.								
Mosq. Cr. to Chil. R.								
Chilchitna R. to Chilik R.								
Chilik. R. to Turq. Lk.								
Stuyahok River	8/ 7	1,220	8/ 7	1,900			8/ 4	610
Old Man Creek	8/ 7	0 2/						
Koktuli River	8/ 7	1,600	8/ 7	1,500			8/ 4	1,450
Mosquito Cr.	8/ 7	110 2/						
Keefer Creek								
Chilchitna River								
Chilikadrotna River							8/ 4	0 2/
MULCHATNA DRAINAGE SUB-TOTALS		2,930		3,400		-		2,060
NUSHAGAK/MULCHATNA TOTALS		5,404		7,080		910		4,940

(continued)

Appendix Table 15. (continued)

Stream	1973 Date	1973 No. Est.	1974 Date	1974 No. Est.	1975 Date	1975 No. Est.	1976 Date	1976 No. Est.
NUSHAGAK BAY DRAINAGE								
Igushik River	8/ 3	40	8/ 1	100	8/ 5	70	7/30	170
Snake River:	8/ 3	110	8/ 1	130	8/ 5	10	8/10	40
Weary River	8/ 3	50	8/ 1	40	8/ 5	0		
Wood River:					8/ 5	10	8/10	60
Muklung River			8/ 1	1,010	8/ 3	660	8/ 5	850
Streams 3/			8/5-17	20	8/18	6	8/10	10
NUSHAGAK BAY DRAINAGE SUB-TOTALS		200		1,300		756		1,130
NUSHAGAK RIVER DRAINAGE								
Nushagak River: (TOTALS)				(5,270) 2/		(4,370) 2/		(6,970) 2/
Portage Cr. to Ekwok					8/ 2	30 2/	8/ 3	120 2/
Ekwok to Mulchatna R.					8/ 2	30 2/	8/ 2	310
Mul. R. to Nuyakuk R.			8/ 1	1,000	8/ 2	120 2/	8/ 2	630
Nuy. R. to Klutispaw R.			8/ 3	720	8/ 2	250	8/ 3	760
Klutis. R. to King Sal. R.			8/ 3	1,620	8/ 2	1,010	8/ 3	1,000
K. Sal. R. to Chich. R.			8/ 3	380	8/ 2	730	8/ 3	620
Chichitnok R. to Big Bend			8/ 3	1,220	8/ 2	1,480	8/ 3	2,480
Big Bend on North			8/ 3	330	8/ 2	720	8/ 3	1,050
Iowithla River			8/ 1	860	8/ 3	1,040	8/ 5	1,110
Kokwok River			8/ 3	60	8/ 3	270	8/ 4	560
Klutuk Creek			8/ 3	160	8/ 3	300	8/ 4	500
Nunachuak Creek								
Cranberry Creek								
Napotoli Creek								
Nuyakuk River	8/ 8	140	8/ 1	750	8/ 3	540	8/ 3	1,100
Tikchik River			8/ 3	50	8/11	0	8/10	80
Harris Creek								
Klutispaw River	8/ 8	380	8/ 3	440	8/ 3	670	8/ 3	1,180
Vukpalik Creek								
King Salmon River	8/ 8	1,470	8/ 3	2,000	8/ 3	2,900	8/ 3	3,510
Chichitnok River	8/ 8	110	8/ 3	350	8/ 2	710	8/ 3	500 2/
NUSHAGAK DRAINAGE SUB-TOTALS		2,100		9,940		10,800		15,510
MULCHATNA RIVER DRAINAGE								
Mulchatna River: (TOTALS)				(5,330) 2/				(5,030)
Nush. R. to Stuyahok R.			8/ 2	870			8/ 2	690
Stuy. R. to Koktuli R.			8/ 2	540			8/ 2	200
Koktuli R. to Mosquito Cr.			8/ 2	2,160			8/ 4	2,580
Mosq. Cr. to Chil. R.			8/ 2	1,590			8/ 2	840
Chilchitna R. to Chilik. R.			8/ 2	90			8/ 4	520
Chilikadronta R. to Turq. Lk.			8/ 2	80 2/			8/ 4	200
Stuyahok River	8/ 8	1,220	8/ 2	2,300	8/ 2	2,530	8/ 2	3,750
Old Man Creek			8/ 2	40			8/ 4	80
Koktuli River	8/ 8	950	8/ 2	3,920	8/ 2	4,080	8/ 2	6,710
Mosquito Creek			8/ 2	710	8/ 2	150	8/ 4	1,110
Keefer Creek							8/ 4	430
Chilchitna River							8/ 2	780
Chilikadrotna River			8/ 2	450				
MULCHATNA DRAINAGE SUB-TOTALS		2,170		12,750		6,760		17,890
NUSHAGAK/MULCHATNA TOTALS		4,470		23,990		18,316		34,530

(continued)

Appendix Table 15. (continued)

Stream	1977 Date	1977 No. Est.	1978 Date	1978 No. Est.	1979 Date	1979 No. Est.	1980 Date	1980 No. Est.
NUSHAGAK BAY DRAINAGE								
Igushik River	8/ 4	50	7/31	110	7/31	100		
Snake River:	8/ 4	20	7/31	140	7/31	20		
Weary River	8/ 4	20						
Wood River:	8/ 4	10	8/ 7	30	7/31	20		
Muklung River	8/ 1	940	8/ 3	1,170	7/31	950	8/ 8	1,620
Streams 3/	8/19	0	8/ 7	0	8/21	0	8/12	4
NUSHAGAK BAY DRAINAGE SUB-TOTALS		1,040		1,450		1,090		1,624
NUSHAGAK RIVER DRAINAGE								
Nushagak River: (TOTALS)		(4,300) 2/		(13,290) 2/		(8,170) 2/		(2,080) 2/
Portage Cr. to Ekwok			8/ 3	160 2/	7/31	0 2/		
Ekwok to Mulchatna R.	7/31	60 2/	8/ 3	490 2/	8/ 1	0 2/		
Mul. R. to Nuyakuk R.	8/ 1	90 2/	8/ 3	750 2/	8/ 2	450	8/ 8	50 2/
Nuy. R. to Klutispaw R.	8/ 1	220	8/ 1	2,000	8/ 1	600	8/ 8	280
Klutis. R. to K. Sal. R.	8/ 1	600	8/ 1	3,850	8/ 1	2,280	8/ 8	1,450
K. Sal. R. to Chich. R.	8/ 1	1,060	8/ 1	2,140	8/ 3	1,600	8/ 8	300
Chichit. R. to Big Bend	8/ 1	1,470	8/ 1	2,710	8/ 3	2,310		
Big Bend on North	8/ 1	800	8/ 1	1,190	8/ 3	930		
Iowithla River	8/ 1	840	8/ 3	1,700	7/31	1,350		
Kokwok River	8/ 1	310	8/ 3	520	8/ 3	170	8/ 8	70
Klutuk Creek	8/ 1	260	8/ 3	460	7/31	360		
Nunachuak Creek								
Cranberry Creek								
Napotoli Creek								
Nuyakuk River	8/ 1	20 2/			8/ 3	240		
Tikchik River								
Harris Creek								
Klutispaw River	8/ 1	650	8/ 1	1,940	8/ 2	1,040	8/ 8	970
Vukpalik Creek								
King Salmon River	8/ 1	1,420	8/ 1	4,450	8/ 1	2,150	8/ 4	4,500
Chichitnok River	8/ 1	780	8/ 1	1,220	8/ 3	980	8/ 8	100 2/
NUSHAGAK DRAINAGE SUB-TOTALS		8,580		23,580		14,460		7,720
MULCHATNA RIVER DRAINAGE								
Mulchatna River: (TOTALS)		(2,740)		(6,230)		(2,660) 2/		
Nush. R. to Stuyahok R.	7/31	150	8/ 2	590	8/ 1	60 2/		
Stuy. R. to Koktuli R.	7/31	90	8/ 2	350	8/ 1	80 2/		
Kok. R. to Mosquito Cr.	7/31	1,980	8/ 2	2,280	8/ 2	1,730		
Mosq. Cr. to Chil. R.	7/31	250	8/ 2	2,120	8/ 2	790		
Chil. R. to Chilik. R.	7/31	0	8/ 2	420	8/ 2	0 2/		
Chilik. R. to Turq. Lk.	7/31	270	8/ 2	470	8/ 2	0 2/		
Stuyahok River	7/31	2,700	8/ 2	4,400	8/ 1	3,570	8/ 4	7,200
Old Man Creek								
Koktuli River	7/31	4,630	8/ 2	6,730	8/ 1	6,260	8/ 4	10,620
Mosquito Creek	7/31	570	8/ 2	1,130	8/ 2	930		
Keefer Creek								
Chilchitna River			8/ 2	310				
Chilikadrotna River	7/31	430	8/ 2	570	8/ 2	290		
MULCHATNA DRAINAGE SUB-TOTALS		11,070		19,370		13,710		17,820
NUSHAGAK/MULCHATNA TOTALS		20,690		44,400		29,260		27,164

(continued)

Appendix Table 15. (continued)

Stream	1981 Date	1981 No. Est.	1982 Date	1982 No. Est.	1983 Date	1983 No. Est.	1984 Date	1984 No. Est.
NUSHAGAK BAY DRAINAGE								
Igushik River							7/30	230
Snake River:							7/30	220
Weary River								
Wood River:	8/ 6	40			8/22	100	8/ 9	90
Muklung River	8/ 5	2,260	8/ 2	790	8/ 4	1,830	8/ 3	1,300
Streams 3/	8/ 6	4	8/ 9	10	8/ 5	10	8/ 9	70
NUSHAGAK BAY DRAINAGE SUB-TOTALS		2,304		800		1,940		1,910
NUSHAGAK RIVER DRAINAGE								
Nushagak River: (TOTALS)		(8,920) 2/		(8,320) 2/		(16,700)		(9,040)
Portage Cr. to Ekwok					8/ 1	840	8/ 9	670
Ekwok to Mulchatna R.					8/ 1	580	8/ 7	400
Mul. R. to Nuyakuk R.			8/ 3	720	8/ 3	1,540	8/ 7	520
Nuy. R. to Klutis. R.	8/ 5	1,680	8/ 3	680	8/ 3	1,810	8/ 5	820
Klut. R. to K. Sal. R.	8/ 5	4,370	8/ 3	2,370	8/ 3	4,520	8/ 5	1,980
K. Sal. R. to Chich. R.	8/ 5	1,560	8/ 3	1,020	8/ 3	1,630	8/ 5	1,510
Chich. R. to Big Bend	8/ 5	1,310	8/ 3	590	8/ 3	4,240	8/ 5	2,130
Big Bend on North			8/ 3	2,940	8/ 3	1,540	8/ 5	1,010
Iowithla River	8/ 5	2,630	8/ 4	2,520	8/ 4	2,430	8/ 3	1,080
Kokwok River	8/ 6	130	8/ 2	90	8/ 4	350	8/ 3	110
Klutuk Creek	8/ 5	460	8/ 4	1,480			8/ 3	330
Nunachuak Creek								
Cranberry Creek								
Napotoli Creek								
Nuyakuk River								
Tikchik River								
Harris Creek								
Klutispaw River	8/ 5	1,650	8/ 2	350	8/ 3	2,090	8/ 5	770
Vukpalik Creek								
King Salmon River	8/ 5	2,950	8/ 2	8,390	8/ 3	5,990	8/ 5	1,780
Chichitnok River	8/ 5	730	8/ 3	1,110	8/ 3	1,210	8/ 5	870
NUSHAGAK DRAINAGE SUB-TOTALS		17,470		22,260		28,770		13,980
MULCHATNA RIVER DRAINAGE								
Mulchatna River: (TOTALS)						(8,710)		(3,670) 2/
Nush. R. to Stuyahok R.					8/ 1	420	8/ 7	620
Stuy. R. to Koktuli R.					8/ 1	390	8/ 7	400
Koktuli R. to Mosq. Cr.					8/ 1	4,260	8/ 7	1,060
Mosq. Cr. to Chil. R.					8/ 2	2,450	8/ 8	1,350
Chilchitna R. to Chilik. R.							8/ 8	130
Chilikadrotna R. to Turq. Lk.					8/ 2	1,190	8/ 8	110 2/
Stuyahok River	8/ 4	5,980	8/ 2	3,640	8/ 1	2,910	8/ 7	2,010
Old Man Creek								
Koktuli River	8/ 4	9,960	8/ 2	6,780	8/ 1	8,060	8/ 7	2,860
Mosquito Creek	8/ 4	2,840			8/ 2	2,770	8/ 8	640
Keefer Creek								
Chilchitna River	8/ 4	790					8/ 8	60 2/
Chilikadrotna River					8/ 2	860	8/ 8	640
MULCHATNA DRAINAGE SUB-TOTALS		19,570		10,420		23,310		9,880
NUSHAGAK/MULCHATNA TOTALS		39,344		33,480		54,020		25,770

(continued)

Appendix Table 15. (continued)

Stream	1985 Date	1985 No. Est.	1986 Date	1986 No. Est.	Mean 1956-86 No. Observ.	Mean 1956-86 Average
NUSHAGAK BAY DRAINAGE						
Igushik River	8/ 1	200			12	110
Snake River:	8/ 1	10	8/12	40	15	70
Weary River					7	80
Wood River:	8/ 6	20			10	40
Muklung River	7/30	1,250	8/12	230	23	850
Streams 3/	8/ 6	20			11	20
NUSHAGAK BAY DRAINAGE SUB-TOTALS		1,500		270		860 4/
NUSHAGAK RIVER DRAINAGE						
Nushagak River: (TOTALS)		(5,680) 2/			(16)	(6,570)
Portage Cr. to Ekwok					5	360
Ekwok to Mulchatna R.					6	310
Mul. R. to Nuyakuk R.					12	520
Nuy. R. to Klutispaw R.	7/31	420			14	780
Klutis. R. to K. Sal. R.	7/31	760			15	1,870
K. Sal. R. to Chich. R.	7/31	240			15	910
Chich. R. to Big Bend	7/31	1,520			14	1,760
Big Bend on North	7/31	2,740			11	1,220
Iowithla River	7/30	1,610	8/12	270	20	1,030
Kokwok River	7/30	60			15	200
Klutuk Creek					12	390
Nunachuak Creek					1	100
Cranberry Creek					1	0
Napotoli Creek					1	0
Nuyakuk River					10	360
Tikchik River					2	70
Harris Creek					1	0
Klutispaw River	7/30	1,950	8/11	170	21	760
Vukpalik Creek					1	50
King Salmon River	7/30	4,460	8/11	380	21	2,470
Chichitnok River	7/31	1,140			17	620
NUSHAGAK DRAINAGE SUB-TOTALS		14,900		820		7,510 4/
MULCHATNA RIVER DRAINAGE						
Mulchatna River: (TOTALS)					(9)	(4,220)
Nush. R. to Stuyahok R.					8	450
Stuy. R. to Koktuli R.					8	290
Koktuli R. to Mosquito Cr.					9	1,890
Mosq. Cr. to Chil. R.					7	1,060
Chilchitna R. to Chilik. R.					5	260
Chilikadrotna R. to Turq. Lk.					7	350
Stuyahok River	7/31	2,690	8/11	520	22	2,560
Old Man Creek					4	50
Koktuli River	7/31	4,940	8/11	290	21	4,410
Mosquito Creek					11	1,030
Keefer Creek					1	100
Chilchitna River					5	340
Chilikadrotna River					9	530
MULCHATNA DRAINAGE SUB-TOTALS		7,630		810		8,960 4/
NUSHAGAK/MULCHATNA TOTALS		24,030		1,900		17,330 4/

1/ Aerial survey escapement estimates are categorized as indices of the total escapement; as a rule of thumb, multiplying the aerial index escapement estimate by a factor of 3.0 will give a close approximation of the total escapement for each stream.
2/ Aerial survey coverage not complete.
3/ Includes Ice and Sunshine Creeks, and Peace and Wind Rivers.
4/ Average king salmon aerial escapement estimates for all years.

(Sources: 1 and 7)

Appendix Table 16. Inshore return of chinook salmon by age class, in numbers of fish, Nushagak District, Bristol Bay, 1966-86. 1/

	Number of Fish by Age Class 2/																
	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	0.5	1.4	2.3	0.6	1.5	2.4	1.6	2.5	
Year 3/	3(1)	3(2)	4(1)	4(2)	4(3)	5(1)	5(2)	5(3)	6(1)	6(2)	6(3)	7(1)	7(2)	7(3)	8(2)	8(3)	Total
1966 C	0	0	171	9559	0	0	19278	0	0	27899	0	0	1047	230	0	0	58184
E	0	0	116	6572	0	0	13252	0	0	19180	0	0	720	160	0	0	40000
S	0	0	11	608	0	0	1226	0	0	1774	0	0	66	15	0	0	3700
T	0	0	298	16739	0	0	33756	0	0	48853	0	0	1833	405	0	0	101884
1967 C	0	0	1247	20821	0	2058	25485	0	194	41169	261	0	4735	231	39	0	96240
E	0	0	845	14060	0	1391	17212	0	130	27807	175	0	3198	156	26	0	65000
S	0	0	48	800	0	79	980	0	7	1583	10	0	182	9	2	0	3700
T	0	0	2140	35681	0	3528	43677	0	331	70559	446	0	8115	396	67	0	164940
1968 C	0	386	970	4681	0	1568	24498	0	310	38521	87	0	6944	187	49	0	78201
E	0	343	868	4193	0	1407	21931	0	280	34482	77	0	6216	168	35	0	70000
S	0	32	82	395	0	133	2068	0	27	3251	7	0	586	16	3	0	6600
T	0	761	1920	9269	0	3108	48497	0	617	76254	171	0	13746	371	87	0	154801
1969 C	99	41	603	9362	0	1623	20754	0	79	42853	66	63	4586	674	0	0	80803
E	42	17	263	4057	0	703	8988	0	35	18561	28	28	1988	290	0	0	35000
S	8	4	53	823	0	143	1823	0	7	3765	6	6	403	59	0	0	7100
T	149	62	919	14242	0	2469	31565	0	121	65179	100	97	6977	1023	0	0	122903
1970 C	0	0	4507	8507	0	1015	50859	0	152	20169	190	0	2014	69	65	0	87547
E	0	0	2575	4860	0	580	29045	0	85	11520	110	0	1150	40	35	0	50000
S	0	0	324	612	0	73	3660	0	11	1452	14	0	145	5	4	0	6300
T	0	0	7406	13979	0	1668	83564	0	248	33141	314	0	3309	114	104	0	143847
1971 C	0	0	185	6376	0	3039	17868	0	0	54527	0	0	570	166	0	38	82769
E	0	0	88	3080	0	1468	8636	0	0	26352	0	0	276	80	0	20	40000
S	0	0	10	339	0	161	950	0	0	2899	0	0	30	9	0	2	4400
T	0	0	283	9795	0	4668	27454	0	0	83778	0	0	876	255	0	60	127169

(continued)

Appendix Table 16. (continued)

	Number of Fish by Age Class 2/																
	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	0.5	1.4	2.3	0.6	1.5	2.4	1.6	2.5	
Year 3/	3(1)	3(2)	4(1)	4(2)	4(3)	5(1)	5(2)	5(3)	6(1)	6(2)	6(3)	7(1)	7(2)	7(3)	8(2)	8(3)	Total
1972 C	141	0	513	8273	0	966	10033	47	0	23657	80	0	2135	161	39	0	46045
E	77	0	277	4493	0	525	5448	25	0	12845	43	0	1160	87	20	0	25000
S	12	0	44	719	0	84	872	4	0	2055	7	0	186	14	3	0	4000
T	230	0	834	13485	0	1575	16353	76	0	38557	130	0	3481	262	62	0	75045
1973 C	0	0	163	407	0	160	7733	0	80	19475	160	0	2132	160	0	0	30470
E	0	0	186	469	0	182	8883	0	91	22372	185	0	2450	182	0	0	35000
S	0	0	35	89	0	34	1675	0	17	4219	35	0	462	34	0	0	6600
T	0	0	384	965	0	376	18291	0	188	46066	380	0	5044	376	0	0	72070
1974 C	0	0	0	403	0	0	4233	0	0	19755	0	0	7157	101	303	101	32053
E	0	0	0	882	0	0	9247	0	0	43141	0	0	15631	217	665	217	70000
S	0	0	0	100	0	0	1044	0	0	4869	0	0	1764	24	75	24	7900
T	0	0	0	1385	0	0	14524	0	0	67765	0	0	24552	342	1043	342	109953
1975 C	0	0	0	529	0	0	12343	0	0	6407	176	0	1822	118	59	0	21454
E	0	0	0	1729	0	0	40271	0	0	20902	574	0	5943	385	196	0	70000
S	0	0	0	175	0	0	4085	0	0	2120	58	0	603	39	20	0	7100
T	0	0	0	2433	0	0	56699	0	0	29429	808	0	8368	542	275	0	98554
1976 C	0	0	52	12044	0	143	20189	180	0	26620	479	0	880	97	0	0	60684
E	0	0	80	19850	0	230	33270	300	0	43870	790	0	1450	160	0	0	100000
S	0	0	5	1370	0	16	2296	21	0	3027	54	0	100	11	0	0	6900
T	0	0	137	33264	0	389	55755	501	0	73517	1323	0	2430	268	0	0	167584
1977 C	0	0	0	1202	0	373	28483	0	0	51649	691	0	2200	476	0	0	85074
E	0	0	0	916	0	286	21762	0	0	39462	526	0	1684	364	0	0	65000
S	0	0	0	73	0	23	1741	0	0	3157	42	0	135	29	0	0	5200
T	0	0	0	2191	0	682	51986	0	0	94268	1259	0	4019	869	0	0	155274

(continued)

Appendix Table 16. (continued)

Year 3/		Number of Fish by Age Class 2/															
		0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	0.5	1.4	2.3	0.6	1.5	2.4	1.6	2.5	
		3(1)	3(2)	4(1)	4(2)	4(3)	5(1)	5(2)	5(3)	6(1)	6(2)	6(3)	7(1)	7(2)	7(3)	8(2)	8(3)	Total
1978	C	0	272	198	11045	0	0	38094	0	0	58159	1321	0	5829	3235	0	395	118548
	E	0	299	221	12116	0	0	41769	0	0	63778	1443	0	6396	3549	0	429	130000
	S	0	15	11	615	0	0	2121	0	0	3238	73	0	325	180	0	22	6600
	T	0	586	430	23776	0	0	81984	0	0	125175	2837	0	12550	6964	0	846	255148
1979	C	0	949	0	57388	0	0	25262	1308	0	63547	0	0	4369	4498	0	0	157321
	E	0	570	0	34656	0	0	15257	788	0	38371	0	0	2641	2717	0	0	95000
	S	0	53	0	3247	0	0	1429	74	0	3595	0	0	247	255	0	0	8900
	T	0	1572	0	95291	0	0	41948	2170	0	105513	0	0	7257	7470	0	0	261221
1980	C	0	0	0	2270	0	0	43558	0	0	15239	0	0	3891	0	0	0	64958
	E	0	0	0	4920	0	0	94555	0	0	33079	0	0	8446	0	0	0	141000
	S	0	0	0	412	0	0	7913	0	0	2768	0	0	707	0	0	0	11800
	T	0	0	0	7602	0	0	146026	0	0	51086	0	0	13044	0	0	0	217758
1981	C	0	0	0	57226	0	0	59226	792	0	71130	1771	0	1231	2085	0	0	193461
	E	0	1724	0	35345	0	0	48276	0	0	61207	1724	0	862	862	0	0	150000
	S	0	0	0	3402	0	0	3520	47	0	4228	105	0	74	124	0	0	11500
	T	0	1724	0	95973	0	0	111022	839	0	136565	3600	0	2167	3071	0	0	354961
1982	C	0	1141	0	17304	0	0	82337	2281	0	73589	7796	0	7226	3613	0	0	195287
	E	0	1972	0	9662	0	0	64085	986	0	64280	296	0	2465	3254	0	0	147000
	S	0	0	0	484	0	0	5082	121	0	5324	605	0	242	242	0	0	12100
	T	0	3113	0	27450	0	0	151504	3388	0	143193	8697	0	9933	7109	0	0	354387
1983	C	0	205	0	30770	0	0	18747	402	0	82552	117	0	3692	638	0	0	137123
	E	0	0	0	16977	0	0	25691	0	0	116459	113	0	2037	453	0	0	161730
	S	0	0	0	1420	0	0	2017	0	0	7991	0	0	298	74	0	0	11800
	T	0	205	0	49167	0	0	46455	402	0	207002	230	0	6027	1165	0	0	310653

(continued)

Appendix Table 16. (continued)

		Number of Fish by Age Class 2/															
		0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	0.5	1.4	2.3	0.6	1.5	2.4	1.6	2.5	
Year 3/		3(1)	3(2)	4(1)	4(2)	4(3)	5(1)	5(2)	5(3)	6(1)	6(2)	6(3)	7(1)	7(2)	7(3)	8(2)	8(3)	Total
1984 4/	C	0	196	0	4020	0	0	31179	0	0	20904	0	0	5076	0	0	0	61375
	E	0	688	0	5925	0	0	34667	0	0	30927	0	0	8620	0	113	0	80940
	S	0	60	0	1129	0	0	4008	0	0	3712	0	0	891	0	0	0	9800
	T	0	944	0	11074	0	0	69854	0	0	55543	0	0	14587	0	113	0	152115
1985 4/	C	0	433	0	24923	34	0	13760	0	0	22077	0	0	6315	0	74	0	67616
	E	0	1041	0	7788	0	0	32170	0	0	60707	0	0	14014	0	0	0	115720
	S	0	0	0	727	0	0	1975	0	0	3713	0	0	1485	0	0	0	7900
	T	0	1474	0	33438	34	0	47905	0	0	86497	0	0	21814	0	74	0	191236
1986 4/	C	0	64	0	1990	0	58	24469	115	0	30134	231	0	6368	372	0	58	63859
	E	0	33	0	1023	0	29	12559	59	0	15466	118	0	3268	190	0	29	32774
	S	0	0	38	819	0	0	5569	0	0	4599	189	0	1046	264	38	38	12600
	T	0	97	38	3832	0	87	42597	174	0	50199	538	0	10682	826	38	125	109233

1/ Inadequate escapement samples were obtained in 1966-80 and 1986, and the escapement for this period was apportioned by age class with commercial catch age composition data; similarly, the subsistence catch was apportioned using commercial catch age compositions for all years except 1982-86, when subsistence catches were adequately sampled.

2/ Age determinations are the European/Gilbert-Rich methods.

3/ Inshore return by year included the commercial catch (C), escapement (E), subsistence catch (S) and total run (T). Chinook caught on sport gear were not included.

4/ Preliminary.

(Sources: 8 and 63)

Appendix Table 17. Age composition of male chinook salmon in the commercial catch, Nushagak District, Bristol Bay, 1956-86. 1/

Year	Sample Size	Percent by Age Class 2/ 1.2 4(2)	1.3 5(2)	1.4 6(2)	1.5 7(2)	Total
1956	194	45.36	36.08	12.88	0.52	94.84
57	245	17.76	40.97	28.30	0.93	87.96
58	359	15.11	40.58	36.00	2.72	94.41
59	179	8.98	47.85	33.33	6.53	96.69
1960	177	7.35	63.27	22.60	0.56	93.78
61	158	20.89	38.61	34.81	0	94.31
62	142	13.38	23.94	55.64	4.23	97.19
63	31	67.74	16.13	16.13	0	100.00
64	160	66.25	20.00	10.62	2.50	99.37
65	155	24.98	39.60	28.76	4.22	97.56
66	469	24.70	44.77	29.10	0.76	99.33
67	1,419	33.09	35.77	25.61	1.97	96.44
68	972	10.52	48.10	33.12	3.85	95.59
69	815	24.56	36.51	33.37	2.78	97.22
1970	1,219	16.46	65.07	11.35	0.98	93.86
71	640	16.36	35.88	44.33	0.35	96.92
72	545	31.74	26.42	34.77	2.77	95.70
73	222	2.53	32.29	58.87	4.30	97.99
74	134	2.98	25.37	60.44	8.96	97.75
75	162	3.09	69.74	20.37	5.56	98.76
76	424	33.37	33.67	29.95	1.11	98.10
77	415	2.35	44.39	49.45	1.17	97.36
78	401	13.83	46.73	33.25	3.10	96.91
79	582	50.86	18.33	26.50	0.88	96.57
1980	340	6.18	80.29	12.35	1.18	100.00
81	829	40.94	33.76	22.18	0.42	97.30
82	564	11.23	50.82	27.58	2.20	91.83
83	1,003	37.02	19.48	40.69	1.97	99.16
84 3/	307	9.52	62.51	22.25	5.24	99.52
85 3/	771	51.14	24.37	18.23	5.15	98.89
86 3/	580	5.28	52.66	34.69	6.00	98.63
Average	471	27.38	38.57	28.41	2.21	96.57

1/ Age composition weighted by the commercial catch in 1957-59, 1961, 1965-86 and unweighted in all other years. Only major age classes included.
2/ Age designations are the European/Gilbert-Rich methods.
3/ Preliminary.

(Sources: 8 and 63)

Appendix Table 18. Age composition of female chinook salmon in the commercial catch, Nushagak District, Bristol Bay, 1956-86. 1/

Year	Sample Size	Percent by Age Class 2/ 1.2 4(2)	1.3 5(2)	1.4 6(2)	1.5 7(2)	Total
1956	88	0	25.00	60.23	1.14	86.37
57	154	0	13.64	69.94	9.23	92.81
58	327	0	9.01	77.66	6.64	93.31
59	127	0	13.78	73.65	7.03	94.46
1960	172	0.58	20.35	65.70	3.49	90.12
61	153	0	7.84	81.70	1.96	91.50
62	134	0	5.22	81.34	10.45	97.01
63	15	0	6.67	59.99	33.34	100.00
64	49	0	12.25	81.63	4.08	97.96
65	90	0	16.37	74.00	8.91	99.28
66	245	0	10.00	85.41	3.87	99.28
67	712	0	8.94	75.20	10.50	94.64
68	721	0	9.17	70.57	15.52	95.26
69	878	0	16.01	70.59	8.26	94.86
1970	798	0	48.04	39.88	4.20	92.12
71	758	0	8.87	85.05	0.99	94.91
72	434	1.04	16.10	71.80	6.93	95.87
73	190	0	17.64	69.56	10.02	97.22
74	184	0	4.35	62.50	32.07	98.92
75	203	1.97	47.79	37.44	10.84	98.04
76	428	2.70	32.76	61.52	1.88	98.86
77	365	0.29	20.45	74.16	4.28	99.18
78	264	2.68	10.66	72.32	7.60	93.26
79	228	0.83	10.42	74.83	7.47	93.55
1980	261	0	49.81	37.93	12.26	100.00
81	368	2.19	23.02	71.94	1.17	98.32
82	463	5.26	33.66	50.01	5.49	94.42
83	575	0.27	4.83	89.88	3.79	98.77
84 3/	196	0.65	27.44	57.60	14.31	100.00
85 3/	448	6.53	11.79	63.29	18.22	99.83
86 3/	467	0.43	20.49	62.73	14.91	98.56
Average	339	1.08	18.23	68.80	7.65	95.76

1/ Age composition weighted by the commercial catch in 1957-59, 1961, 1965-86 and unweighted in all other years. Only major age classes included.
2/ Age designations are the European/Gilbert-Rich methods.
3/ Preliminary.

(Sources: 8 and 63)

Appendix Table 19. Age composition of chinook salmon in the commercial catch, both sexes combined, Nushagak District, Bristol Bay, 1956-86. 1/

Year	Sample Size	Percent by Age Class 2/ 1.2 4(2)	1.3 5(2)	1.4 6(2)	1.5 7(2)	Total
1956	282	31.21	32.62	27.66	0.71	92.20
57	399	10.72	30.13	44.81	4.22	89.88
58	686	8.03	25.78	55.53	4.56	93.90
59	306	5.11	33.18	50.70	6.74	95.73
1960	349	4.01	42.12	43.84	2.01	91.98
61	311	10.61	23.47	57.88	0.96	92.92
62	276	6.88	14.85	68.12	7.25	97.10
63	46	45.65	13.05	30.43	10.87	100.00
64	209	50.72	18.18	27.27	2.87	99.04
65	245	16.29	31.51	44.50	5.85	98.15
66	714	16.43	33.13	47.95	1.80	99.31
67	2,131	21.63	26.48	42.78	4.92	95.81
68	1,693	5.99	31.33	49.26	8.88	95.46
69	1,693	11.59	25.68	53.03	5.68	95.98
1970	2,017	9.72	58.09	23.04	2.30	93.15
71	1,398	7.70	21.59	65.88	0.69	95.86
72	979	17.97	21.79	51.38	4.64	95.78
73	412	1.34	25.38	63.92	7.00	97.64
74	318	1.26	13.21	61.63	22.33	98.43
75	365	2.47	57.53	29.86	8.49	98.35
76	852	19.85	33.27	43.87	1.45	98.44
77	780	1.41	33.48	60.71	2.59	98.19
78	665	9.32	32.13	49.06	4.92	95.43
79	810	36.48	16.06	40.39	2.78	95.71
1980	601	3.49	67.06	23.46	5.99	100.00
81	1,197	29.58	30.61	36.77	0.64	97.60
82	1,027	8.53	43.06	37.72	3.69	93.00
83	1,578	22.44	13.67	60.20	2.69	99.00
84 3/	503	6.55	50.80	34.06	8.27	99.68
85 3/	1,219	36.86	20.35	32.65	9.34	99.20
86 3/	1,047	3.12	38.32	47.19	9.97	98.60
Average	810	16.87	30.44	44.54	4.38	96.23

1/ Age composition weighted by the commercial catch in 1957-59, 1961, 1965-86 and unweighted in all other years. Only major age classes included.
2/ Age designations are the European/Gilbert-Rich methods.
3/ Preliminary.

(Sources: 8 and 63)

Appendix Table 20. Age composition of chinook salmon in the subsistence catch both sexes combined, Lewis Point, Nushagak District, Bristol Bay, 1982-86. 1/

Year	Sample Size	Percent by Age Class 1.2 4(2)	1.3 5(2)	1.4 6(2)	1.5 7(2)	Total
1982	98	4.00	42.00	44.00	2.00	92.00
83	316	12.03	17.09	67.72	2.53	99.37
84	330	11.52	40.90	37.88	9.09	99.39
85	196	9.20	25.00	47.00	18.80	100.00
86 2/	338	6.50	44.20	36.50	8.30	95.50

1/ Only major age classes included.
2/ Preliminary.

(Source: 40)

Appendix Table 21. Age composition of chinook salmon in the escapement, both sexes combined, Nushagak District, Bristol Bay, 1957-86. 1/

Year	River	Sample Size	Percent by Age Class 1.2 4(2)	1.3 5(2)	1.4 6(2)	1.5 7(2)	Total
1957	2/	51	35.40	43.20	19.50	0	98.10
59	3/	89	22.40	37.20	28.30	4.40	92.30
1961	4/	57	0	52.80	43.80	1.70	98.30
62	King Salmon	32	12.50	18.70	59.40	6.20	96.80
64	5/	46	30.60	28.10	37.10	2.10	97.90
65	King Salmon	9	11.10	33.40	55.50	0	100.00
68	Stuyahok	23	8.70	34.78	13.04	0	56.52 6/
1981	Nushagak	45	8.89	53.33	37.78	0	100.00
	Mulchatna	14	21.43	35.71	35.72	7.14	100.00
	Stuyahok	88	21.59	28.41	46.59	3.41	100.00
	Koktuli	63	26.98	33.33	36.51	3.18	100.00
	Total	210	23.56	32.18	40.80	0.58	97.12
1982	Nushagak	699	9.60	48.60	37.30	1.10	96.60
	King Salmon	316	2.80	48.70	41.90	1.50	94.90
	Stuyahok	189	6.30	39.00	45.50	4.10	94.90
	Koktuli	287	3.10	29.90	61.10	1.20	95.30
	Total	1,491	6.57	43.60	43.73	1.68	95.58
1983	Nushagak	511	13.70	18.20	67.90	0.20	100.00
	Mulchatna	61	3.30	19.70	67.20	8.20	98.40
	King Salmon	339	8.60	14.10	76.10	1.20	100.00
	Stuyahok	198	7.60	7.60	81.80	2.50	99.50
	Koktuli	320	10.60	18.50	69.10	0.90	99.10
	Total	1,429	10.50	15.89	72.01	1.26	99.66

(continued)

Appendix Table 21. (continued)

Year	River	Sample Size	Percent by Age Class 1.2 4(2)	1.3 5(2)	1.4 6(2)	1.5 7(2)	Total
1984 7/	Nushagak	434	13.36	47.46	34.34	3.46	98.62
	Mulchatna	255	3.53	39.22	41.95	14.51	99.21
	King Salmon	49	8.16	34.70	44.89	12.25	100.00
	Muklung	139	9.36	40.28	43.18	5.74	98.56
	Stuyahok	218	3.22	44.94	34.41	17.43	100.00
	Koktuli	313	3.83	40.26	39.94	14.70	98.73
	Total	1,408	7.32	42.83	38.21	10.65	99.01
1985 7/	Nushagak	138	8.70	33.33	45.66	11.59	99.28
	Stuyahok	50	4.01	17.99	65.99	10.00	97.99
	Koktuli	35	2.85	20.00	60.02	17.13	100.00
	Total	223	6.73	27.80	52.46	12.11	99.10
1986 7/	Nushagak	24	0	25.00	75.00	0	100.00
	King Salmon	19	0	52.94	41.18	5.88	100.00
	Stuyahok	12	0	50.00	50.00	0	100.00
	Total	55	0	40.42	57.45	2.13	100.00

1/ Four (4) major age classes included, which account for over 97% of the total escapement age classifications.
2/ Nushagak and King Salmon Rivers.
3/ King Salmon and Koktuli Rivers.
4/ Iowithla and King Salmon Rivers.
5/ King Salmon and Stuyahok Rivers.
6/ Age 3(2) (1.1) was 43.48%.
7/ Preliminary.

(Sources: 8, 39 and 63)

Appendix Table 22. Sex composition of chinook salmon in the commercial catch, by gear type, Nushagak District, Bristol Bay, 1956-86.

Year	Chinook Gear			Sockeye Gear			Combined		
	Sample Size	Percent		Sample Size	Percent		Sample Size	Percent	
		Male	Female		Male	Female		Male	Female
1956 1/	-	-	-	282	68.79	31.21	-	-	-
57	219	53.10	46.90	180	71.95	28.05	399	60.36	39.64
58	565	50.65	49.35	121	63.30	36.70	686	53.12	46.88
59	169	55.10	44.90	137	62.90	37.10	306	56.93	43.07
1960 1/	349	50.72	49.28	-	-	-	-	-	-
61 1/	311	50.80	49.20	-	-	-	-	-	-
62 1/	276	51.45	48.55	-	-	-	-	-	-
63 1/	-	-	-	46	67.39	32.61	-	-	-
64 1/	209	76.55	23.45	-	-	-	-	-	-
65	214	62.25	37.75	31	70.97	29.03	245	65.21	34.79
66	361	66.80	33.20	353	66.29	33.71	714	66.52	33.48
67	849	55.58	44.42	1,282	71.01	28.99	2,131	65.38	34.62
68	1,106	60.63	39.37	587	51.40	48.60	1,693	56.90	43.10
69	1,016	47.44	52.56	677	46.70	53.30	1,693	47.17	52.83
1970	1,606	61.28	38.72	411	54.30	45.70	2,017	59.03	40.97
71 1/	-	-	-	-	-	-	1,398	47.09	52.91
72	641	47.81	52.19	338	68.80	31.20	979	55.14	44.86
73	317	49.84	50.16	95	67.38	32.62	412	52.82	47.18
74 1/	318	42.14	57.86	-	-	-	-	-	-
75 1/	365	44.38	55.62	-	-	-	-	-	-
76	712	45.35	54.65	140	70.71	29.29	852	55.91	44.09
77 1/	404	55.69	44.31	-	-	-	780	54.42	45.58
78	457	57.11	42.89	208	67.31	32.69	665	59.54	40.46
79	417	56.12	43.88	393	88.55	11.45	810	71.26	28.74
1980 1/	601	56.57	43.43	-	-	-	-	-	-
81	462	60.82	39.18	735	75.76	24.24	1,197	70.68	29.32
82	453	55.41	44.59	574	54.53	45.47	1,027	54.79	45.21
83	559	44.90	55.10	1,019	74.30	25.70	1,578	60.33	39.67
84 2/	462	59.96	40.04	41	73.17	26.83	503	66.59	33.41
85 2/	578	47.75	52.25	641	77.22	22.78	1,219	67.99	32.01
86 2/	564	55.85	44.15	483	54.87	45.13	1,047	55.42	44.58
Average	520	55.67	44.33	399	68.06	31.94	1,016	60.23	39.77

1/ Sex ratios are not representative of the total season catch due to inadequate sampling during portions of the season.
2/ Preliminary.

(Sources: 8 and 63)

Appendix Table 23. Round weight of male and female chinook salmon from the commercial catch, Nushagak District, Bristol Bay, 1964-86. 1/

	Sample Size and Round Weight in Pounds						
	Age-Weight-Length Samples 2/						Processor Catch Reports 3/
	Male		Female		Sexes Combined		
Year	Sample Size	Average Weight	Sample Size	Average Weight	Sample Size	Average Weight	Average Weight
1964	160	12.32	49	24.64	209	15.20	
65	155	16.98	89	25.50	244	19.93	
66	468	14.85	245	23.94	713	17.89	
67	469	14.76	321	25.39	790	18.44	
68	292	19.54	195	26.60	487	22.59	21.60
69	170	18.06	172	24.97	342	21.71	19.20
1970	137	18.33	116	24.75	253	20.81	18.30
71	101	19.78	160	26.69	261	24.95	21.70
72	129	16.02	123	24.66	252	19.95	19.80
73	41	22.64	56	23.61	97	23.10	22.60
74	29	21.34	31	29.22	60	25.92	23.20
75	40	20.97	65	21.67	105	21.36	18.80
76	76	19.36	87	25.15	163	21.93	18.70
77	82	21.89	95	25.74	177	23.69	23.36
78	129	19.03	100	27.90	229	22.66	22.34
79	152	14.83	63	26.22	215	18.11	21.06
1980	76	18.06	72	23.17	148	20.31	19.61
81	219	14.87	99	23.78	318	17.45	19.63
82	116	19.07	95	21.25	211	20.09	20.40
83	266	15.14	140	24.02	406	18.63	20.96
84	79	15.75	40	23.36	119	18.24 4/	20.78
85	175	12.34	102	22.86	277	15.73 4/	16.90
86	147	18.44	114	24.31	261	21.03 4/	19.87
Average	161	16.85	114	24.70	276	19.92	20.48

1/ Samples were weighted by the commercial catch of each sample period.
2/ A.D.F.G. sample program to provide average weight by age class.
3/ Weight data provided by processor reports from the commercial catch.
4/ Preliminary.

(Sources: 1, 8 and 63)

Appendix Table 24. Egg fecundity by age, weight and length of chinook salmon from the commercial gill net fishery, Nushagak District, Bristol Bay, 1966 and 1968.

Year				Mean 2/		
Brood	Return	Age 1/	Date	Length	Weight	Number of Eggs 3/
1961	1966	1.3/5(2)	6/24	779	17.5	8,414
			24	772	17.0	8,222
			24	815	20.0	8,498
			24	774	18.0	8,484
			7/ 4	780	20.0	9,270
1960	1966	1.4/6(2)	6/15	883	24.5	9,915
			15	821	21.0	8,538
			15	785	17.0	8,891
			15	918	37.0	10,378
			6/21	924	30.0	11,714
			21	829	23.0	8,701
			21	898	26.5	8,935
			21	943	33.5	11,362
			21	916	29.5	9,995
			21	829	23.0	6,719
			21	818	21.0	6,362
			6/24	903	29.0	11,083
			24	842	23.0	9,052
			24	961	35.0	13,496
			24	978	39.0	15,503
			24	815	20.0	8,299
			6/27	903	31.0	8,688
			27	897	27.5	16,049
			27	852	24.0	9,584
			7/ 6	943	30.5	13,069
			6	794	19.5	9,429
			6	931	30.0	12,580
1959	1966	1.5/7(2)	6/21	951	31.0	7,666
			21	1,039	36.0	15,321
			6/24	970	32.0	10,776
			7/ 4	929	26.0	12,471
1963	1968	1.3/5(2)	6/12	730	17.0	8,540
			12	767	17.8	9,916
			6/26	753	14.9	5,302
			6/27	790	19.4	7,843
			27	806	20.5	9,090

(continued)

Appendix Table 24. (continued)

Year				Mean 2/		
Brood	Return	Age 1/	Date	Length	Weight	Number of Eggs 3/
1962	1968	1.4/6(2)	5/31	834	-	10,058
			6/11	933	34.2	12,936
			11	974	33.0	11,222
			11	925	33.5	11,449
			11	970	34.2	10,848
			11	800	19.0	8,791
			6/12	840	22.0	9,802
			12	910	25.0	10,272
			12	900	27.0	14,668
			12	795	20.7	8,782
			6/18	828	20.5	8,860
			18	881	26.6	10,630
			18	870	23.0	9,285
			18	856	25.0	9,130
			18	832	20.5	10,871
			18	1,010	45.8	13,508
			6/26	942	29.7	9,612
			26	938	-	11,031
			26	878	23.3	8,236
			26	866	22.2	9,801
			26	940	30.6	8,928
			26	895	25.5	11,300
			26	810	19.0	7,383
			6/27	858	24.2	8,007
1961	1968	1.5/7(2)	5/29	940	-	10,915
			6/11	1,060	-	12,211
			6/12	895	30.0	14,254
			12	962	36.0	11,664
			12	1,025	41.3	13,658
			12	990	35.3	10,990
			6/26	910	26.5	10,996
			26	980	32.5	14,607
			6/27	1,005	39.3	13,256

1/ Age designations are the European/Gilbert-Rich methods.
2/ Length in mm (mid-eye to fork of tail), and weight in pounds to the nearest tenth.
3/ Egg fecundity determined via the "hand counting" method in 1966, and with volumetric and hand counting methods in 1968.

(Source: 1)

Appendix Table 25. Egg fecundity of chinook salmon from other areas of North America compared with stocks from Nushagak District, Bristol Bay.

Year(s)	River System/Area	Sample Size	Mean 1/ Length	Mean 1/ Weight	Egg Fecundity Mean	Egg Fecundity Range
		CALIFORNIA				
1892	McCloud River	1,576	-	-	4,510	-
1920-22	Klamath River	106	803	14.5	3,760	1,718- 8,406
1922	Ft. Bragg, CA	53	808	-	5,034	-
1922-52	Sacramento River	108	837	-	5,449	-
1950	Trinity River	71	-	-	3,466	-
		OREGON/WASHINGTON				
1892	Clackimas River	1,926	-	-	4,629	-
1940	Middle Fork of Willamette River	-	-	-	5,084	-
1940	McKenzie River	-	-	-	4,928	-
1940	N. Santiam River	-	-	-	5,200	-
1940	S. Santiam River	-	-	-	4,000	-
1959	Columbia River	62	846	-	5,090	2,148- 7,705
1959-65	Columbia River 2/	385	884	-	5,015	-
1960-63	Seattle, WA 3/	416	799	14.7	4,864	-
1961	Seattle, WA 3/	197	774	-	4,064	-
		CANADA				
1934	Fraser River	12	871	21.7	4,944	-
1934	Namu, B.C.	11	1,034	35.5	8,426	-
1935	Cowichan River	25	864	18.4	3,885	-
		ALASKA				
1959	Cook Inlet	60	850	23.0	8,517	4,242-13,619
1966	Nushagak River	31	877	26.2	10,241	6,362-16,049
1968	Nushagak River	38	892	26.9	10,491	5,302-14,668
1968	Kuskokwim River	23	879	28.0	10,746	7,657-14,427
1964	Yukon River	4	-	-	9,215	-
1965	Yukon River	25	918	23.9	7,587	4,645-12,203
1966	Yukon River	22	952	26.9	9,351	6,044-14,419
1968	Yukon River	25	-	-	8,442	-

1/ Fork length in mm and weight in pounds.
2/ From Rocky Reach, Priest Rapids and McNary artificial spawning channels in the upper Columbia River.
3/ From University of Washington holding pond; fish originally from the Soos Creek hatchery.

(Sources: 1, 25, 27, 31, 58 and 62)