THE STOCK COMPOSITION OF THE CATCHES OF SOCKEYE AND CHUM SALMON IN THE 1987 SOUTH PENINSULA AND JUNE FISHERY BASED ON TAGGING

Report to the Alaska Board of Fisheries
Presented March 7, 1988

By

Douglas M. Eggers

Katherine Rowell

and

Bruce Barrett

Regional Information Report[1] No. 5J88-03

Alaska Department of Fish and Game
Division of Commercial Fisheries
P.O. Box 3-2000
Juneau, Alaska 99802

April 1988

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ABSTRACT

The stock composition of the 1987 South Peninsula June fishery catches of sockeye and chum salmon was estimated based on release and subsequent recovery of tagged fish in western and central Alaska terminal fishing areas. 6,987 sockeye salmon and 6,323 chum salmon were released to coincide with the timing and area of the South Peninsula June fishery. As of 3/1/88, 1,912 or 27.3% of the total releases of sockeye salmon tags and 833 or 13.2% of the total releases of chum salmon tags were recovered in terminal fisheries throughout Alaska, from a voluntary recovery program. The chum salmon releases were more far ranging than sockeye, with 36 recoveries in Japanese coastal fisheries and hatcheries, 11 recoveries in coastal USSR fisheries, 3 recoveries in Kotzebue Sound, and 1 recovery in the coastal British Columbia fishery.

The voluntary recoveries in western and central Alaska fisheries were adjusted for tags not reported, based on reported fraction from a concurrent fishery sampling program for recoveries in western and central Alaska fisheries. The estimated recoveries in catches were then expanded to the entire return by dividing by the rate of exploitation realized by the respective fishery.

4,757 sockeye tags were estimated to occur in the western and central Alaska sockeye returns. Assuming negligible contribution of Asian sockeye stocks based on earlier tagging work, the tagging mortality rate was 31.9%. Bristol Bay stocks dominated the recoveries accounting for 84.7 of the combined Unimak and Shumagin releases. Alaska Peninsula, Chignik, and Kodiak sockeye stocks were collectively more important in the Shumagin releases (40%) than in the Unimak releases (10%).

1,792 chum tags were estimated to occur in the western and central Alaska chum salmon returns. Assuming that tagging mortality was similar to that estimated for sockeye, then Asian contribution may be as high as 57%. The following stock composition estimate were calculated assuming that Asian stocks were not present. This assumption leads to over-estimated stock composition, and therefore these estimates represent more of an upper bound rather than mean estimate. Bristol Bay, Kuskokwim, and North Peninsula chum salmon stocks dominated the recoveries, accounting for 82.2% of the combined Unimak and Shumagin releases. South Peninsula, Chignik, and central Alaska chum stocks were collectively more important in the Shumagin releases (29.1%) than in the Unimak releases (7.5%). Yukon fall chums were a minor component (1.7%) of the combined area releases.

There was little difference in mean date of release among recoveries of chum salmon in various western and central Alaska fisheries. Indicating that almost total overlap in timing occurs for western and central Alaska chum salmon stocks in the area of the South Peninsula June fishery.

INTRODUCTION

Migrating sockeye and chum salmon have been harvested in the South Unimak and Shumagin Islands June fisheries since 1911. The chum salmon harvest is incidental to the more intensely managed sockeye salmon harvest. Several tagging studies conducted during the period 1923, 1956-1983 (Gilbert and Rich 1925; Thorsteinson and Merrell 1964; Aro et al. 1971; Aro 1972, 1974, 1977, 1980; Meyer 1983) have showed that a substantial fraction of the sockeye and chum salmon available to these fisheries were not of local origin. For chum salmon, the pattern of tag recoveries indicated that these fisheries were intercepting fish primarily of western Alaska origin although tags were recovered from widely dispersed areas throughout the Alaska Peninsula, Japan, the U.S.S.R., British Columbia, and Puget Sound (Brannian 1984). The pattern of tag recoveries indicated that these fisheries were intercepting primarily Bristol Bay sockeye salmon with minor interceptions of sockeye salmon bound for North Alaska Peninsula river systems.

Considerable controversy has developed in recent years over the level of chum salmon catches in these fisheries. During the period 1980 - 1987, chum salmon harvests in the South Unimak and Shumagin Islands fisheries have averaged 566 thousand fish, including a record harvest of chum during 1982 (1.1 million fish) and 1983 (784 thousand fish). These large catches, well above the average harvests of 1970-1979 (306 thousand fish) and 1960-1969 (186 thousand fish), are a result of the large sockeye salmon catch quotas established in response to increased sockeye salmon returns to Bristol Bay. Sockeye salmon catch quotas are based on a fixed percentage of the forecasted harvest in the Bristol Bay inshore districts. While the current management strategy appears adequate to maintain a consistent level of exploitation on Bristol Bay sockeye salmon, this fishing strategy is independent of chum salmon abundance. Exploitation rates for chum salmon may have reached a level where the inshore returns of some stocks may be adversely impacted.

In recent years, the inshore returns of several western Alaskan chum salmon runs, most notably Yukon River fall chum and Kotzebue Sound chums, have been less than expected (Buklis and Barton 1984, Buklis 1987). It is suspected that interceptions in the South Unimak and Shumagin Island fisheries may have contributed to these lower than expected returns. Most western Alaskan chum salmon stocks are fully utilized in terminal commercial and subsistence fisheries, therefore it would be impossible to sustain chum salmon production in the face of increased exploitation in marine interception fisheries. Since marine fisheries occur before terminal harvests each year, the long term result of increased marine exploitation is an inevitable reduction in harvest levels in the respective terminal fisheries. However, it is impossible to quantify the impact of the South Unimak fishery on western Alaskan chum production

without adequate knowledge of the stock composition of the catch.

Unfortunately several problems associated with previous studies have limited their relevancy to resolving current allocation and conservation disputes. The most important problem with previous studies is that tagging occurred in a broad area that included, but was not limited to, the present area of the fishery. Stock composition may differ across time and space and the historical tagging effort was insufficient to detect these differences. For instance, the Shumagin Island catches may be composed of different stocks than the South Unimak catches.

The complexities associated with the deployment and recovery of tags were such that contribution rates could not be quantified in the earlier tagging studies. Since fisheries differ markedly in their intensity, the proportion of recoveries in various fisheries provide very biased estimates of stock composition. Even the presence of very small numbers of tags will be detected by a commercial fishery with high levels of effort, whereas a low intensity subsistence fishery conducted on stocks containing large numbers of tags might result in only a few recoveries. Without estimates of the rate of exploitation of fish stocks by fisheries and/or escapement sampling programs specifically designed to recover tags, neither the size nor the direction of this bias can be understood. Without a knowledge of bias the flawed estimates cannot be corrected. In past tagging studies the then underdeveloped commercial fisheries of western Alaska were the primary sources of tag recoveries. It is certain that the numbers of tag recoveries in these underdeveloped fisheries were low compared to the numbers which would have been recovered by contemporary western Alaskan fisheries.

Past tagging studies were concluded 20 years ago, and stock composition around the Pacific and Bering Sea rim has changed dramatically during that time; most notable is the huge increase in Japanese hatchery production. Gross changes in relative abundance could alter our perception of which stocks are major contributors to these fisheries. Finally, no attempt has been made to annually examine stock composition over a period of years to determine the extent to which stock composition exhibits annual variation.

Scale pattern analysis (SPA), may provide a more cost- effective method of estimating stock composition. The feasibility of using SPA to identify major component stocks of the South Unimak and Shumagin Islands chum salmon harvest was demonstrated by Conrad (1984). Results of this study indicated that approximately 70% of the 1983 chum salmon harvest was of western Alaskan and Bristol Bay origin, followed in order of importance by Alaskan Peninsula and Asian stocks. The major problem with that study was that the Asian standards were not collected in the proper fashion and therefore not adequately represented in the classification model. A second problem with the classification procedure used in SPA was that classification accuracy decreases as the number of

stocks increases. Thus with the classification procedure only a limited number of stocks can be discriminated. Thus stocks must be aggregated over broad geographic areas and the method may not be suitable for identifying specific stocks such as Yukon fall chums.

SPA methods would be feasible for separating Yukon fall chums only if western Alaska chum stocks other than the Yukon fall chums could be aggregated. To check this possibility, SPA was applied to 1987 samples from fall and summer chum salmon stocks within the Yukon River, (Wilcock, personal communication). There were only slight differences in scale patterns among these stocks. Based on these results it is not feasible to use current SPA technology to discriminate between Yukon fall chum and other western Alaska chum stocks in South Peninsula catches.

To provide estimates of the stock composition of the South Peninsula June fishery catches, a comprehensive tagging study was conducted in 1987. The study was designed to correct the deficiencies of earlier tagging studies. In the 1987 study substantial numbers of tags were deployed in the area of the South Peninsula June fishery and a comprehensive tag recovery programs were conducted in all western and central Alaska fisheries.

In addition to stock composition estimates, the tagging study was envisioned to provide evidence for differential migratory timing among stocks in the South Peninsula fishery. There has been concern that certain stocks may be more vulnerable to the South Peninsula Fishery because their migratory timing is concurrent with the South Peninsula fishery. These include 2 ocean Bristol Bay sockeye stocks such as Kvichak River and the Wood River beach spawners, Ugashik sockeye salmon, and Yukon fall chum salmon. With the exception of Ugashik sockeye salmon, there have been some conservation concerns associated with the management of terminal fisheries on these stocks.

METHODS

The objective of the South Peninsula tagging study was to apportion the tagged populations of sockeye and chum salmon to stock of origin. A population of tagged fish was captured, marked, and released to coincide with the area and timing of catches in the South Peninsula June fishery. The apportionment was based on recoveries in various fisheries conducted in the terminal harvest areas of the respective stock of origin. The fishery recoveries were adjusted by the fraction reported as determined by sampling catches in terminal harvest areas for tagged fish. The recoveries were further adjusted based on the fraction of return that was harvested to provide an estimate of the number of tagged fish in the return to the respective stock. The relative magnitude of the tagged fish in the total return of the respective stock provided an estimate of the stock composition of the South Peninsula June catches.

Stock definitions generally correspond to fishery unit definitions by which Alaska salmon catches and preseason forecasts are reported (Eggers and Dean 1988). These were determined based on the extent of tag recoveries. Chum salmon fishery units include, Kotzebue, Yukon Summer, Yukon Fall, Kuskokwim, Bristol Bay, North Peninsula, South Peninsula June, South Peninsula July, Chignik, Kodiak, Cook Inlet, Prince William Sound, Southeast Alaska, Japanese coastal fisheries, USSR coastal fisheries, and British Columbia coastal fisheries (Figure 1). Sockeye salmon fishery units include, Kuskokwim, Bristol Bay, North Peninsula, South Peninsula June, South Peninsula July, Chignik, Kodiak, Cook Inlet, Prince William Sound, and Southeast Alaska. Tag recoveries were reported by statistical and sub-statistical areas by fishing district within each fishery unit. Fishery unit definitions, maps of statistical and sub-statistical areas, and the specific assignments of these statistical and sub-statistical areas to fishery units is provided in Appendix A.

Theory

The possible fate of individual fish in the tagged population consists of the following: direct mortality due to capture and handling, recapture in the South Peninsula June fishery, occurrence in the returns to Alaskan terminal harvest areas either as catch or as escapement, or occurrence in the returns to terminal harvest areas outside Alaska. The most likely areas outside Alaska include Soviet fisheries and Japanese coastal fisheries and returns to hatcheries. These possibilities are diagramed in Figure 2. If one assumes that mortalities and interceptions of tagged fish in the South Peninsula June fishery are not stock specific and that the timing and location releases are representative of the catches in the South Peninsula June fishery, then an accurate estimate of the tagged fish in the

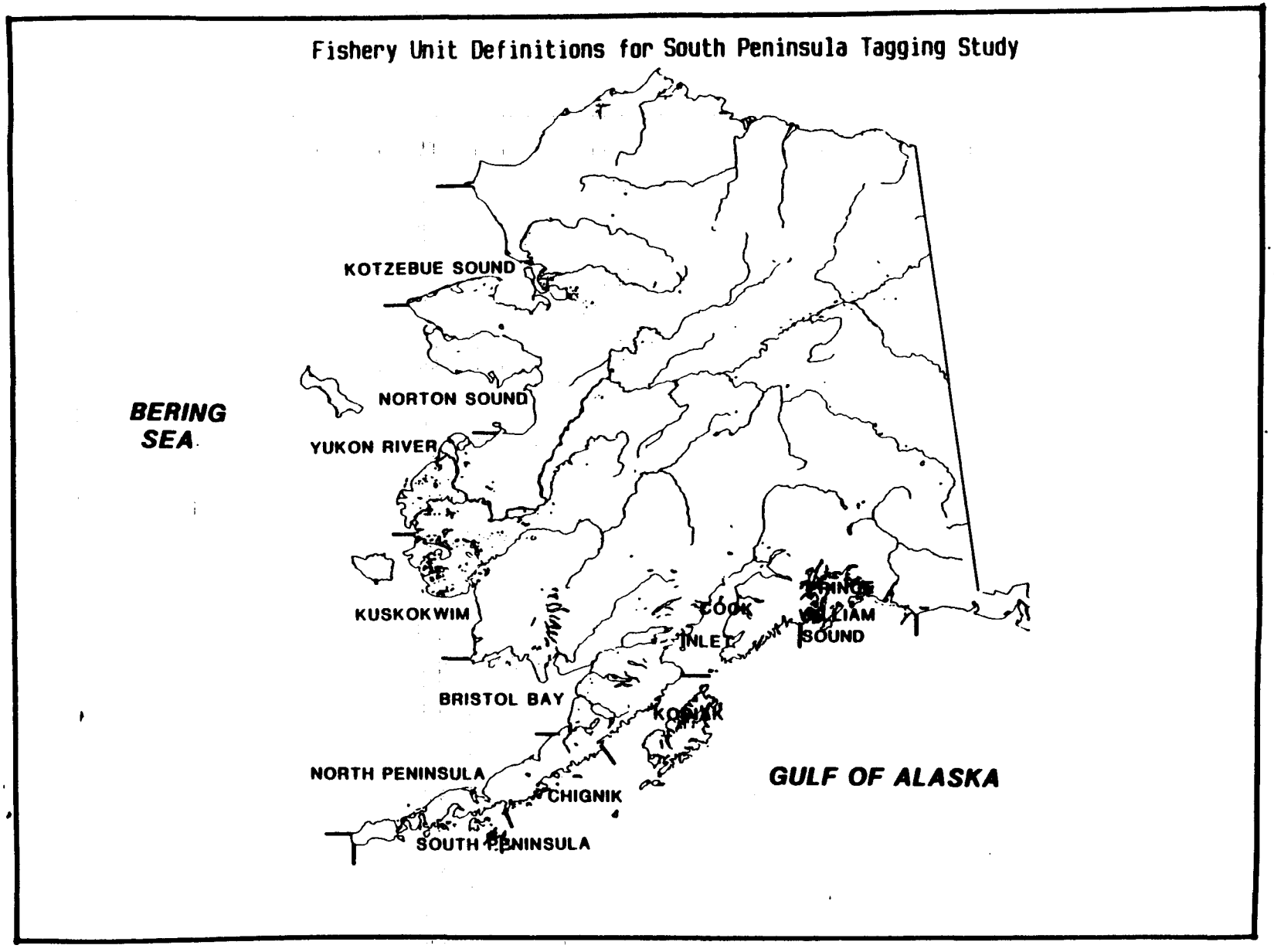

Figure 1. Fishery unit definitions by which 1987 tag recoveries, catches and escapements were reported for Western and Central Alaska salmon fisheries.

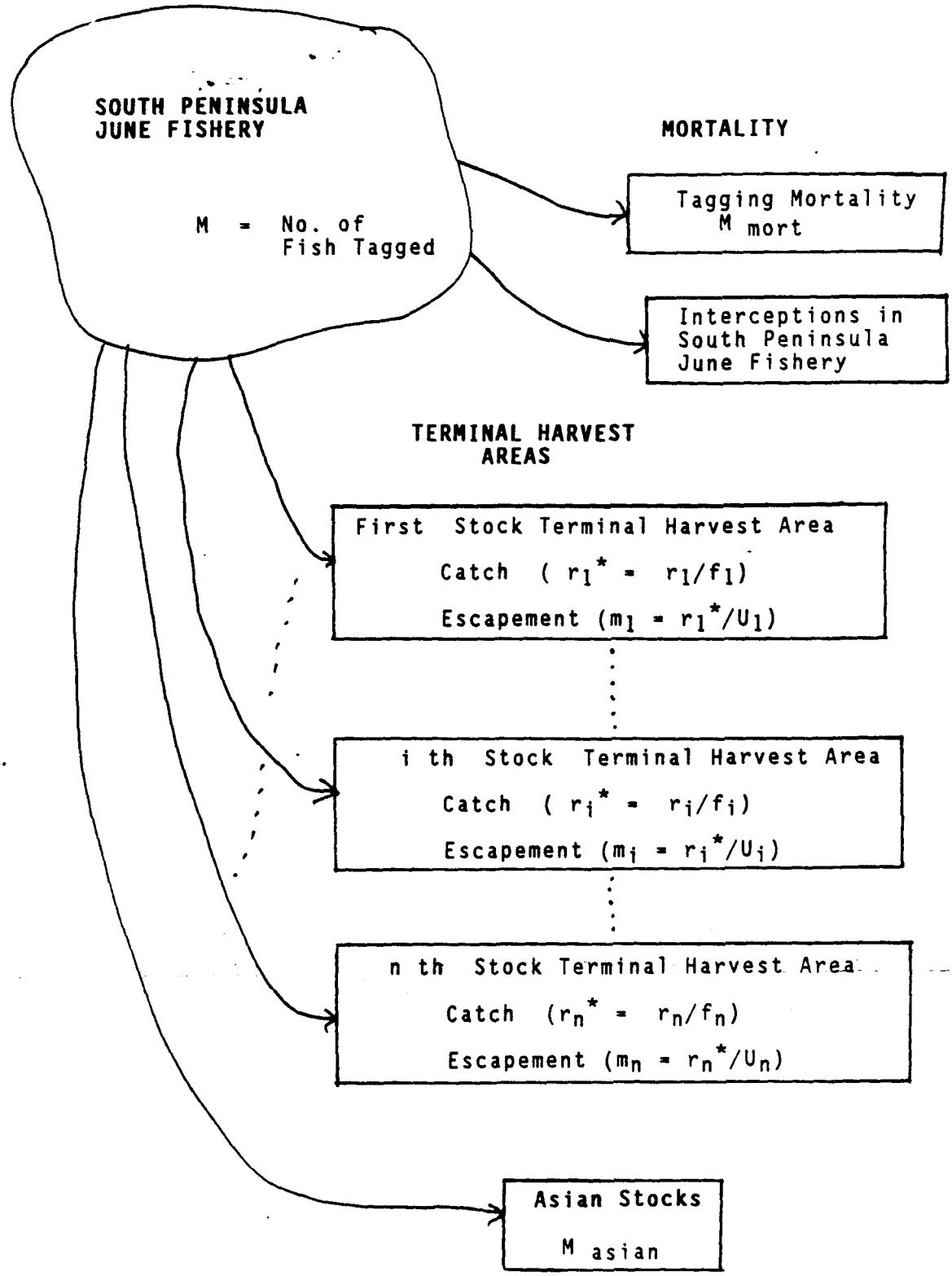

Figure 2. Schematic of the possible fates of individual tagged fish released in the area of the South Peninsula june fishery.

various Alaska terminal harvest area returns can provide an accurate estimate of the stock composition of the South Peninsula catches.

Tag recovery effort in Asian terminal harvest areas is poor, thus Asian recoveries will under-represented and Alaskan recoveries will be over-represented. Consequently if the actual Asian contribution is high then the relative magnitude of recoveries in the Alaskan terminal area returns will over-estimate the contribution of specific stocks. This problem is more pronounced for chum salmon than for sockeye salmon, based on the historical tagging data.

Define the following:

P_i = Proportion of i th. stock in the tagged population

C_i = Catch in the i th. stock terminal harvest area.

E_i = Escapement of the i th. stock.

N_i = Abundance of the i th. stock = $(C_i + E_i)$

r_i = No. of recoveries of tagged fish in the catch (C_i)

r_i^* = Recoveries, adjusted for under-reporting, of tagged fish in the catch

M_i = Numbers of the i th. stock tagged surviving to the terminal harvest area.

U_i = Rate of exploitation on the i th. stock in the i th. terminal harvest area.

M_{mort} = Number of tagged fish that died as a result of tagging (ie. tagging mortality)

M_{spf} = Number of tagged fish that were intercepted in the South Peninsula June fishery.

M_{asian} = Number of tagged salmon of Asian origin

The tagged population can be apportioned into mortality (M_{mort}), interception in the South Peninsula June fishery (M_{spf}), Asian stocks (M_{Asian}) and returns to Alaskan terminal harvest areas (sum of M_i).

$$M = \sum_i M_i + M_{mort} + M_{spf} + M_{asian} \qquad (1)$$

In western and central Alaska fisheries all sockeye and chum salmon stocks are fully exploited, with exploitation rates at least 50 %. Because of this high exploitation rate the fishery

is the most efficient means to sample for tagged fish in the returns to terminal harvest areas. Because fisheries are prosecuted in remote areas with varying degrees of difficulty encountered by fishermen in returning tagged fish, the number of tagged fish that are voluntarily returned to ADF&G will be less than the actual number of tagged fish caught in fisheries. In addition fishermen do not always provide complete information regarding the specific time and area that the tagged fish was recovered. This under-reporting of tagged fish will occur despite an active advertisement campaign and cash rewards for returned tags.

To estimate the number of tagged fish in the i th. stock return (M_i), we must adjust the voluntary number of recoveries (r_i) by the reported fraction (f_i).

$$r_i^* = r_i / f_i \qquad (2)$$

The reported fraction is estimated in a fishery sampling program, where tag recoveries are verified by interviewing fishermen and examining catches in a significant fraction of the catch. The reported fraction is estimated by comparing the number of recoveries estimated in the fishery sampling program to the number of recoveries returned in the voluntary program.

It is not feasible under current budget limitations, to sample a large enough fraction of the escapement to reliably estimate the number of tagged fish in the escapement. However, estimates of the rate of exploitation (U_i) is available for all Alaska terminal harvest areas. Because terminal harvests are generally managed to spread the harvest equitably over the entire run and presence of a Floy spaghetti tag does not affect the probability of capture, the proportion of tagged fish in the catch and escapement are expected to be similar. Thus:

$$M_i = r_i^* / U_i \qquad (3)$$

The proportion of the i th. stock in the tagged population is:

$$P_i = Mi / (M - M_{mort} - M_{spf}) \qquad (4)$$

At present we do not have access to information regarding catches and escapements of all Asian stocks of sockeye and chum salmon. It is not possible to estimate M_{Asian} directly. Also it is not possible to estimate tagging mortality (M_{mort}) directly. These can be estimated collectively as the tags that cannot be accounted for based on estimated tag recoveries in returns to Alaskan terminal harvest areas. For sockeye salmon in the area of the South Peninsula June fishery, the Asian contribution based on historical tagging data is negligeable. Therefore, the tags not accounted for can be considered as tagging mortality.

Thus for sockeye, the tagging mortality rate (m) is:

$$m = 1 - (\sum_i M_i / M) \quad (5)$$

Assuming that the tagging mortality is similar for sockeye and chum salmon, this rate can be applied to the number of tagged chum salmon and estimate the Asian contribution by difference. Thus for chum salmon:

$$M_{asian} = M - m M - \sum_i M_i \quad (6)$$

Releases of Tagged Fish

The capture, tagging and release of fish was contracted to LGL Alaska Research and Associates, (David R. Schmidt, project leader, Suite 501, 505 W. Northern Lights Blvd., Anchorage, AK 99503). Detailed documentation of tagging methods, numbers of releases by species, area and date, as well as specific location and date of release by individual tag numbers are reported in Schmidt (1987).

The contract called for the application of 7,000 tags on sockeye and 13,500 tags on chum salmon. The criteria for tag application was two-fold: 1) the relative tagging effort should reflect the historical fishing effort in the two areas (South Unimak and Shumagin Islands), and 2) tags were to be applied in proportion to relative abundance with respect to date.

Purse seine vessels, participating in the fishery were chartered to capture and tag fish. A tagging strategy (Table 1, Schmidt 1987) was devised to meet the above tagging objectives, based on analysis of historical performance of the South Peninsula June fishery. The strategy consisted of allocation of boat days of tagging effort to meet weekly guideline tagging goals by species and area. Various tagging vessels were utilized in an opportunistic manner, based on their availability during fishery closures and progress to date on tagging objectives.

Tagging operations were conducted in the two South Peninsula fishing areas (Figure 3), Shumagin Islands and South Unimak. Field operations were based in Sand Point where daily tagging schedules and catch totals were maintained. Manpower aboard each tagging vessel consisted of the vessel's crew and skipper, and one LGL research scientist or technician. LGL personnel provided tagging instruction to the crew, insured quality control, and recorded the tag release data.

During fishing operations the seine was typically set for 15-20 minutes. Occasionally set times or locations were modified to avoid large catches and/or rough seas. The pursing procedure was identical to that used in commercial fishing operations. The bag of the seine was held open with stand-off poles or plunger poles

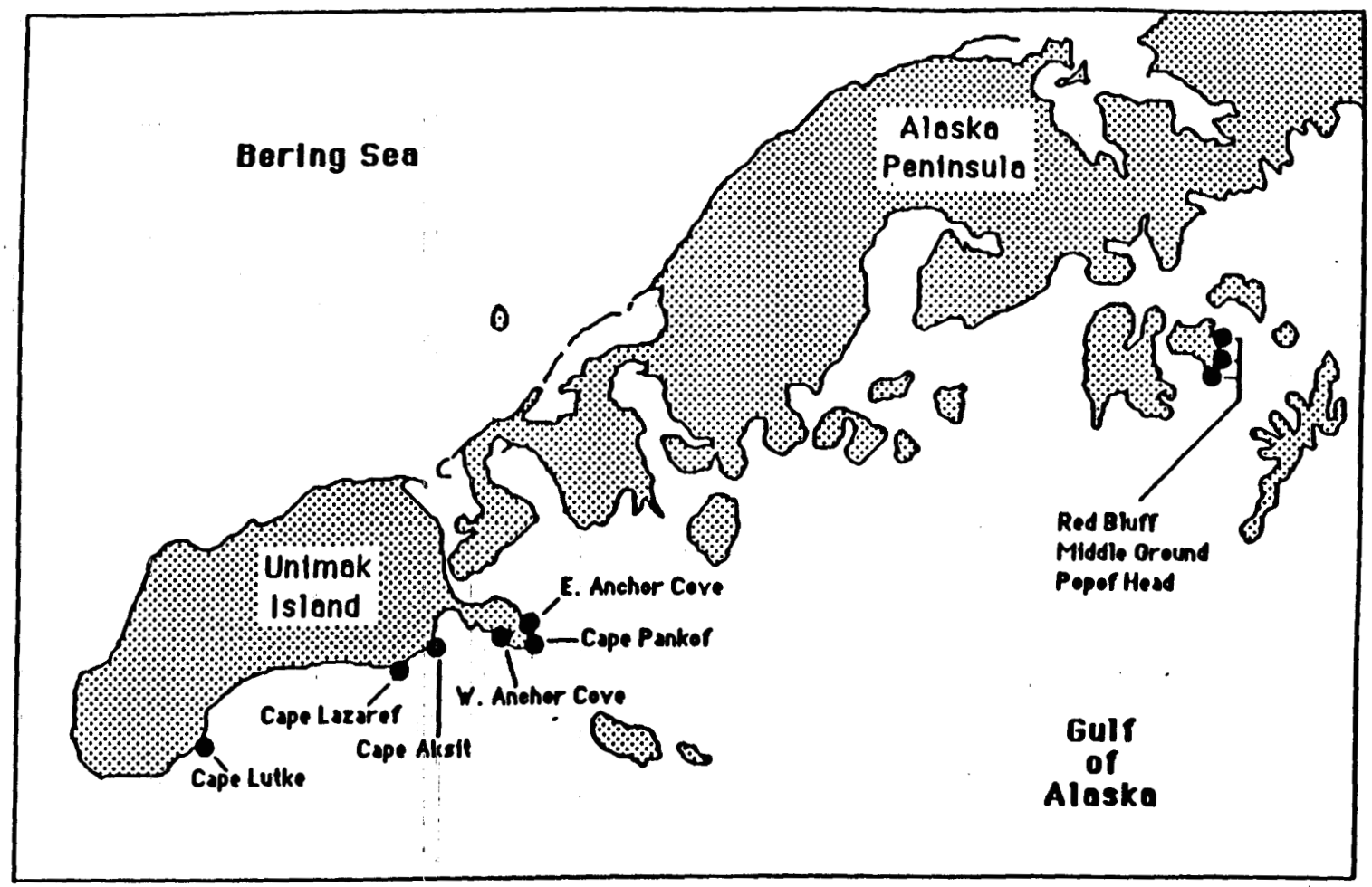

Figure 3. Tagging locations in the Unimak and Shumagin Islands area used during the South Peninsula tagging study, 1987.

and the fish were lifted onto the deck, usually 2-4 at a time with long-handled dip nets. Each salmon was then placed into individual tagging boxes, constructed of a rectangular plywood frame with a canvas cradle, and tagged with an appropriately colored and individually numbered Floy spaghetti tag. Sockeye and chum salmon were tagged with yellow tags and red tags, respectively. Occasionally sockeye and chums were tagged with the wrong color, but, these were noted and documented in Schmidt (1987). Tags were penetrated through the fleshy tissue behind and slightly below the posterior insertion point of the dorsal fin. The tags were then secured with either a double-overhand knot or a square knot. Fish were visually inspected to insure that no injured or weak fish were tagged. Rejected fish were enumerated and released without a tag.

Estimating Number of Recoveries in Western and Central Alaska Terminal Fisheries

Two methods were used to estimate the number of recoveries for various western and central Alaska terminal fisheries. The first was through voluntary returns of tags with information on species, date and area of capture. The second was through a fishery sampling program, where a known fraction of the catches was sampled for tagged fish. The tags recovered from the sampled catches were expanded to the total catches based on the sampling fraction. These were compared to the number of tags returned through the voluntary program to estimate reported fraction.

Voluntary Program

A large scale publicity campaign was conducted prior to the season. This campaign had three purposes: 1) to informed the industry about the project, 2) provide and opportunity for industry to express their concerns and make suggestions prior to tagging, and 3) provide instructions for returning tags. The latter stressed the importance of providing the specific location and date that the tagged fish was captured. Publicity packets were prepared and distributed by the contractor LGL Research Associates, to 1069 industry groups and agencies (cf. Appendix A-1 in Schmidt 1987) prior to the 1987 season.

In addition, there was an active publicity campaign during the season in all western and central Alaska salmon fisheries. Information packets materials were available in ADF&G area offices. Announcements advising fishermen to return tags with relevant information were routinely made over public radio stations and in conjunction with the communication of emergency orders. Two $500 rewards were offered to fishermen as a further incentive to return tags. Pre-addressed envelopes with postage paid, were also available and widely distributed to further facilitate the returning of tags.

Fishery Sampling Program

Because western and central Alaska fisheries differ in terms of remoteness and access of respective fishermen to the publicity campaign and ADF&G area offices, differences in the fraction of tags actually recovered that were reported, were expected to occur among various fisheries. To provide an independent estimate of the tag recoveries a fishery sampling program for tagged fish was initiated in the terminal harvest areas for Kotzebue, Yukon River, Kuskokwim River, Bristol Bay and Alaska Peninsula salmon fisheries.

ADF&G technicians were stationed at processing and tender facilities and met fishermen as they delivered catches. An interview was conducted for each delivery. During the interview, the technician recorded the fish ticket number, fisherman's name, permit number, number of fish in the delivery, harvest location. The technician also collected any tags that were recovered and for each tag recovered, the tag number, recovery date, recovery location and fisherman's name and address. ADF&G technicians then examined the delivery for presence of tags that were overlooked by the fisherman. The target sampling level was 10% for each fishery that was sampled, based on the experience with similar tagging programs in the boundary area fisheries of Southeast Alaska and British Columbia (Pella et al. 1988).

Small boats and skiffs dominated the Kotzebue, Yukon River and Kuskokwim River fisheries. Fish were individually handled during the delivery for transfer from the fishing boat to the braille net at the processing facility, enabling ADF&G technicians to examine individual fish in each delivery for tags.

In the Bristol Bay and Alaska Peninsula fisheries, catches were transferred to processors and tenders from holds lined with braille nets. The entire net with the harvest was transferred to the processing facility, preventing direct examination of the catch for tags by ADF&G technicians. ADF&G technicians were stationed on tenders and interviewed all fishermen delivering to the respective tenders. The entire tender load was subsequently examined for tagged fish. Examination of fish for tags from these tenders occurred at the chute leading into the processing facility from the unloading area and at the grading tables on the processing line. The entire tender load was treated as a sample, and date and location of fishing, number of fish by species that were delivered to the tender, and all tag recovery information were recorded.

Commercial harvest data (numbers of fish) that corresponded to fishing period and district sampled were obtained post-season. This data was used to determine the fraction of the catch (s_i) that was sampled. The total number of tags in the fishery (r_i^*)

was estimated based on the number of tags recovered in the sampling program (z_i) and sampling fraction.

$$r_i^* = z_i / s_i \qquad (7)$$

The fishery sampling program was designed to be reflective of recoveries from commercial harvests only. An attempt was made to sample all fishery openings and areas in an equitable manner. In some cases, catches from several openings and/or areas were combined in tender loads. In these situations the catches were appropriately aggregated to insure that the sample was representative. In cases where this could not be assured samples were excluded from further analysis.

Estimates of Western Alaska Chum and Sockeye Salmon Catches and Escapement

Methods used to estimate catches and escapements for Western and Central Alaska sockeye and chum salmon fisheries are summarized in Table 1. Catches were estimated from receipts for catches delivered to processors (fish tickets). Catches were tabulated by statistical and sub-statistical areas and assigned to Fishery Units based on the respective assignment of statistical and sub-statistical areas to fishery units (Appendix A).

Escapements were estimated from a variety of methods, including comprehensive aerial surveys of spawning streams, sonar counting, tower counting, test fishing, and estimating escapement from catches based on an assumed rate of exploitation. Counts of spawning salmon made in aerial surveys were always lower than actual escapements due to several factors, including: poor viability, incomplete migration into the natal stream at the time of the survey, and fish continuously spawning and subsequently not available to the aerial survey. Both area under the curve methods (Cousens et al. 1982, Johnson and Barrett 1987) and direct application of expansion factors were used to adjust aerial survey counts for the under-counting bias.

Table 1. Description of methods used to estimate the 1987 sockeye and chum salmon catch and escapement by fishery unit.

Fishery Unit/Stock		Methods
Kotzebue	Catch	Combined area commercial and estimated subsistence harvest data.
	Escapement	Escapement estimated from catches based on a 73% rate of exploitation.
Norton Sound	Catch	Combined area commercial and subsistence harvests data. Documented Subsistence harvest is expanded two fold to account for the undocumented subsistence harvest throughout the management area.
	Escapement	Sum of peak aerial survey counts for all systems and tower counts (Kwiniuk and North Rivers). Sum of peak aerial survey counts for the Sinuk (Nome Subdistrict) and Pilgrim River (Port Clarence section) systems.
Yukon Summer Chum	Catch	Combined commercial and subsistence harvest for the entire drainage and subsistence catches for Hooper and Scammon Bay.
	Escapement	Tower and aerial survey counts for Andreafsky River, sonar counts from the Main River site at Pilot Station expanded to account for a 20% under-count, less upriver commercial and subsistence harvests.
Yukon Fall Chum	Catch	Commercial and subsistence harvests for the entire drainage (US & Canada) .
	Escapement	Expanded aerial survey indices of four index tributaries (2X expansion).
Kuskokwim Bay	Catch	Combined commercial and subsistence harvest for Districts W-4 and W-5 (Quinhagak and Goodnews Bay).
	Escapement	Goodnews River tower count and peak escapement counts expanded by tower count/peak escapement ratio. Kanektok River sockeye and chum escapement estimated from Goodnews Bay catches based on a 35% exploitation rate.

Table 1 (Coninued). Description of methods used to estimate the 1987 sockeye and chum salmon catch and escapement by fishery unit.

Fishery Unit/Stock		Methods
Kuskokwim Bay	Catch	Combined commercial and subsistence harvest for Districts W-4 and W-5 (Quinhagak and Goodnews Bay).
	Escapement	Goodnews River tower count and peak escapement counts expanded by tower count/peak escapement ratio. Kanektok River sockeye and chum escapement estimated from Goodnews Bay catches based on a 35% exploitation rate.
Kuskokwim River	Catch	Combined commercial and subsistence harvest for Districts W-1 and W-2 in the Kuskokwim River.
	Escapement	Estimated from gillnet test fishery less upriver commercial subsistence catches.
Bristol Bay	Catch	Commercial harvest by fishing district and species.
Togiak District	Escapement	Chum escapements extimated from catches based on the rate of exploitation observed for sockeye in the Naknek/Kvichak District. Combined tower counts and aerial survey estimates for sockeye salmon.
Nushagak District	Escapement	Nushagak River sonar counts, tower counts at Wood and Igushik Rivers for sockeye. Chum escapements extimated from catches based on the rate of exploitation observed for sockeye in the Naknek/Kvichak District.
Naknek/Kvichak District	Escapement	Sockeye escapements from Tower counts (Naknek & Kvichak Rivers) and expanded aerial survey counts (Branch River) Chum escapements extimated from catches based on the rate of exploitation observed for sockeye in the Naknek/Kvichak District.
Egegik District	Escapement	Sockeye escapement from Tower counts (Egegik River). Chum escapements extimated from catches based on the rate of exploitation observed for sockeye in the Egegik District.

Table 1 (Coninued). Description of methods used to estimate the 1987 sockeye and chum salmon catch and escapement by fishery unit.

Fishery Unit/Stock		Methods
Ugashik District	Escapement	Sockeye escapement from Tower counts (Ugashik River). Chum escapements extimated from catches based on the rate of exploitation observed for sockeye in the Ugashik District.
Aleutian Islands	Catch	Commercial harvest data.
	Escapement	Expanded aerial survey counts based on area under the curve the curve (AUTC) with 15 day stream life.
North Peninsula	Catch	Commercial harvest data.
Northern District	Escapement	Chum salmon escapements based on expanded aerial survey counts based on area under the curve (AUTC) with 15 day stream life. Sockeye escapement based on Nelson R. tower, Bear R. weir, and expanded aerial survey counts (AUTC, 15 day stream life).
Northwestern District	Escapement	Expanded aerial survey counts based on area under the curve the curve (AUTC) with 15 day stream life.
South Peninsula - June	Catch	Commercial harvest data for Unimak District and Shumagin Islands, including commercial harvest for the Southeast Mainland section less 80% of the East Stepovak, West Stepovak, Balboa Bay, and Beaver Bay sections which are assigned to the Chignik commercial harvest.
	Escapement	None

Table 1 (Coninued). Description of methods used to estimate the 1987 sockeye and chum salmon catch and escapement by fishery unit.

Fishery Unit/Stock		Methods
South Peninsula - July	Catch	Commercial harvest data from Southwestern, Southcentral, Shumagin, and Southeast Mainland Districes, except that 80% of the sockeye catch taken in East Stepovak, West Stepovak, Beaver Bay sections through 7/25 which are assigned to the Chignik commercial harvest.
	Escapement	Sockeye escapements based on 1.25 - 2 fold expansion of peak aerial survey counts. Chum salmon escapements based on expanded aerial survey counts based on area under the curve (AUTC) with 15 day stream life.
Chignik	Catch	Commercial harvest by early and late run in the Chignik Management Area in addition to 80% of the sockeye slmon catch from the Southease Mainland Balboa Bay, Beaver Bay, East Stepovak and West Stepovak sections through 7/25 and 80% of the sockeye salmon caught in the Cape Igvak section of the Kodiak Management area through 7/25.
	Escapement	Chum salmon escapements based on expanded aerial survey counts based on area under the curve (AUTC) with 15 day stream life. Sockeye escapements based Chignik weir counts and late run estimates based on a 1.25 - 2 fold expansion of peak aerial survey counts.
Kodiak	Catch	Commercial harvest data less 80% sockeye salmon catch from Cape Igvak section throuth 7/25 which is assigned to the Chignik commercial harvest.
	Escapement	Chum salmon escapements based on expanded aerial survey counts based on area under the curve (AUTC) with 15 day stream life. Sockeye escapements based on weir counts on 10 systems and minor system escapements based on a 2 fold expansion of peak aerial survey counts.

Table 1 (Coninued). Description of methods used to estimate the 1987 sockeye and chum salmon catch and escapement by fishery unit.

Fishery Unit/Stock		Methods
Cook Inlet	Catch	Combined commercial harvest data for Upper and Lower Cook Inlet.
	Escapement	Chum salmon escapement in Upper Cook Inlet based 60 % rate of exploitation. Chum salmon escapements in Lower Cook Inlet based on expanded aerial survey counts based on area under the curve (AUTC) with 17.5 day stream life. Sockeye escapements in Upper Cook inlet based on sonar estimates for Kenai, Kasilof, Yentna, and Crescent Rivers, weir counts for Packers Creek and Fish Creek plus 10% (+) correction applied to account for unmonitored sockeye salmon producing systems.
Prince William Sound	Catch	Commercial harvest data, includes Copper/Bering Rivers.
	Escapement	Combined sonar counts (Miles Lake, includes subsistence harvest), Coghill weir counts, expanded aerial survey counts for Eshamy Lake and Copper River Delta.

RESULTS

Tag Releases

A total of 6,987 sockeye were tagged with 5,442 and 1,545 released in the Unimak and Shumagin Districts, respectively. A total of 6,323 chum salmon were tagged with 3,495 and 2,828 tagged fish released in the Unimak and Shumagin Districts, respectively. Tagging occurred June 6 through July 2, on days when the South Peninsula June fishery was closed. Catches and number of tags released for both sockeye and chum salmon, by day are given for Unimak and Shumagin Districts combined, Unimak District, and Shumagin District in Tables 2, 3, and 4, respectively.

The numbers of tagged chum salmon actually released was far less than the target goal of 13,500. Because the catches of sockeye in the Unimak District were relatively poor there were few days when the fishery was closed and vessels were available for tagging. To compensate for the less than desired tagging effort early in the season, additional effort was conducted later in the season. However, the chum salmon tagging goal was not achieved even with the additional late tagging effort.

Because the commercial fishing effort in the Unimak District was high relative to recent levels, it was not possible to time the release of tags to reflect the timing of the catches (Figure 3, 4, and 5). The mean date of the tag releases was 3.15 and 4.4 days later than the mid-point of the fishery for sockeye and chum salmon, respectively for the combined Unimak and Shumagin Districts (Table 2, Figure 3). This difference also occurred for the separate Unimak and Shumigan Districts, (Tables 3 and 4, Figures 4 and 5). The effect of the late timing of the releases on the estimates of stock composition for the South Peninsula catches will be discussed in the run timing section of this report.

Recoveries in Western and Central Alaska Salmon Fisheries

Voluntary Program

Commercial fishermen, subsistence fishermen, sports fishermen and various processors returned tags by two means. The first was direct return through the mail to the address imprinted on the tag. The second was to return the tag to a local ADF&G offices which forwarded the tag information to the ADF&G Headquarters Office in Juneau. Upon arrival in Juneau, each tag was read and the tag number and other accompanying information was entered into a temporary data base.

Table 2. Comparison of catches and tag releases, by species, for Unimak and Shumagin Districts combined.

Date Month	Day	Sockeye Salmon Catch (# fish)	Sockeye Salmon Catch (prop.)	Sockeye Salmon Tags Released (# fish)	Sockeye Salmon Tags Released (prop.)	Chum Salmon Catch (# fish)	Chum Salmon Catch (prop.)	Chum Salmon Tags Released (# fish)	Chum Salmon Tags Released (prop.)
June	1								
	2								
	3								
	4								
	5								
	6			123	1.8%			73	1.2%
	7			4	0.1%			27	0.4%
	8	4,497	0.6%	41	0.6%	4,893	1.1%	49	0.8%
	9								
	10	41,637	5.3%			19,818	4.5%		
	11	17,786	2.2%			22,480	5.1%		
	12			35	0.5%			31	0.5%
	13			486	7.0%			367	5.8%
	14	67,752	8.5%			30,898	7.0%		
	15	47,812	6.0%			30,213	6.8%		
	16			612	8.8%			186	2.9%
	17	85,411	10.8%			63,805	14.4%		
	18	66,708	8.4%	376	5.4%	54,898	12.4%	602	9.5%
	19			513	7.3%			456	7.2%
	20	111,563	14.1%			36,264	8.2%		
	21	97,780	12.3%			48,047	10.8%		
	22	76,509	9.6%	326	4.7%	42,731	9.6%	378	6.0%
	23			659	9.4%			750	11.9%
	24			1,238	17.7%			840	13.3%
	25	45,022	5.7%			24,173	5.5%		
	26	130,487	16.5%			64,799	14.6%		
	27			1,170	16.7%			905	14.3%
	28			1,161	16.6%			688	10.9%
	29								
	30								
July	1			201	2.9%			595	9.4%
	2			42	0.6%			376	5.9%
Totals		792,964		6,987		443,019		6,323	
Mean		6		6		6		6	
Date		19.49		22.59		18.98		23.49	

Table 3. Comparison of catches and tag releases,by species, for Unimak District.

Date Month	Day	Sockeye Salmon Catch (# fish)	Sockeye Salmon Catch (prop.)	Sockeye Salmon Tags Released (# fish)	Sockeye Salmon Tags Released (prop.)	Chum Salmon Catch (# fish)	Chum Salmon Catch (prop.)	Chum Salmon Tags Released (# fish)	Chum Salmon Tags Released (prop.)
June	1								
	2								
	3								
	4								
	5								
	6								
	7			4	0.1%			27	0.8%
	8	4,383	0.7%			4,889	1.2%		
	9								
	10	10,017	1.5%			10,880	2.7%		
	11	17,786	2.7%			22,480	5.5%		
	12								
	13			486	8.9%			367	10.5%
	14	44,185	6.8%			24,095	5.9%		
	15	47,812	7.3%			30,213	7.4%		
	16			165	3.0%			90	2.6%
	17	85,411	13.1%			63,805	15.7%		
	18	66,708	10.2%	173	3.2%	54,898	13.5%	68	1.9%
	19			513	9.4%			342	9.8%
	20	56,463	8.7%			23,116	5.7%		
	21	97,780	15.0%			48,047	11.8%		
	22	76,509	11.7%			42,731	10.5%		
	23			659	12.1%			750	21.5%
	24			1,238	22.7%			840	24.0%
	25	45,022	6.9%			24,173	6.0%		
	26	100,321	15.4%			56,628	13.9%		
	27			998	18.3%			538	15.4%
	28			1,061	19.5%			373	10.7%
	29								
	30								
July	1			145	2.7%			53	1.5%
	2							47	1.3%
Totals		652,397		5,442		405,955		3,495	
Mean		6		6		6		6	
Date		19.80		23.5		19.08		22.79	

Table 4. Comparison of catches and tag releases, by species, for Shumagin District.

Date Month	Day	Sockeye Salmon Catch (# fish)	Sockeye Salmon Catch (prop.)	Sockeye Salmon Tags Released (# fish)	Sockeye Salmon Tags Released (prop.)	Chum Salmon Catch (# fish)	Chum Salmon Catch (prop.)	Chum Salmon Tags Released (# fish)	Chum Salmon Tags Released (prop.)
June	1								
	2								
	3								
	4								
	5								
	6			123	8.0%			73	2.6%
	7								
	8	114	0.1%	41	2.7%	4	0.0%	49	1.7%
	9								
	10	31,620	22.5%			8,938	24.1%		
	11								
	12			35	2.3%			31	1.1%
	13								
	14	23,567	16.8%			6,803	18.4%		
	15								
	16			447	28.9%			96	3.4%
	17								
	18			203	13.1%			534	18.9%
	19							114	4.0%
	20	55,100	39.2%			13,148	35.5%		
	21								
	22			326	21.1%			378	13.4%
	23								
	24								
	25								
	26	30,166	21.5%			8,171	22.0%		
	27			172	11.1%			367	13.0%
	28			100	6.5%			315	11.1%
	29								
	30								
July	1			56	3.6%			542	19.2%
	2			42	2.7%			329	11.6%
Totals		140,567		1,545		37,064		2,828	
Mean		6		6		6		6	
Date		18.02		19.40		17.81		24.36	

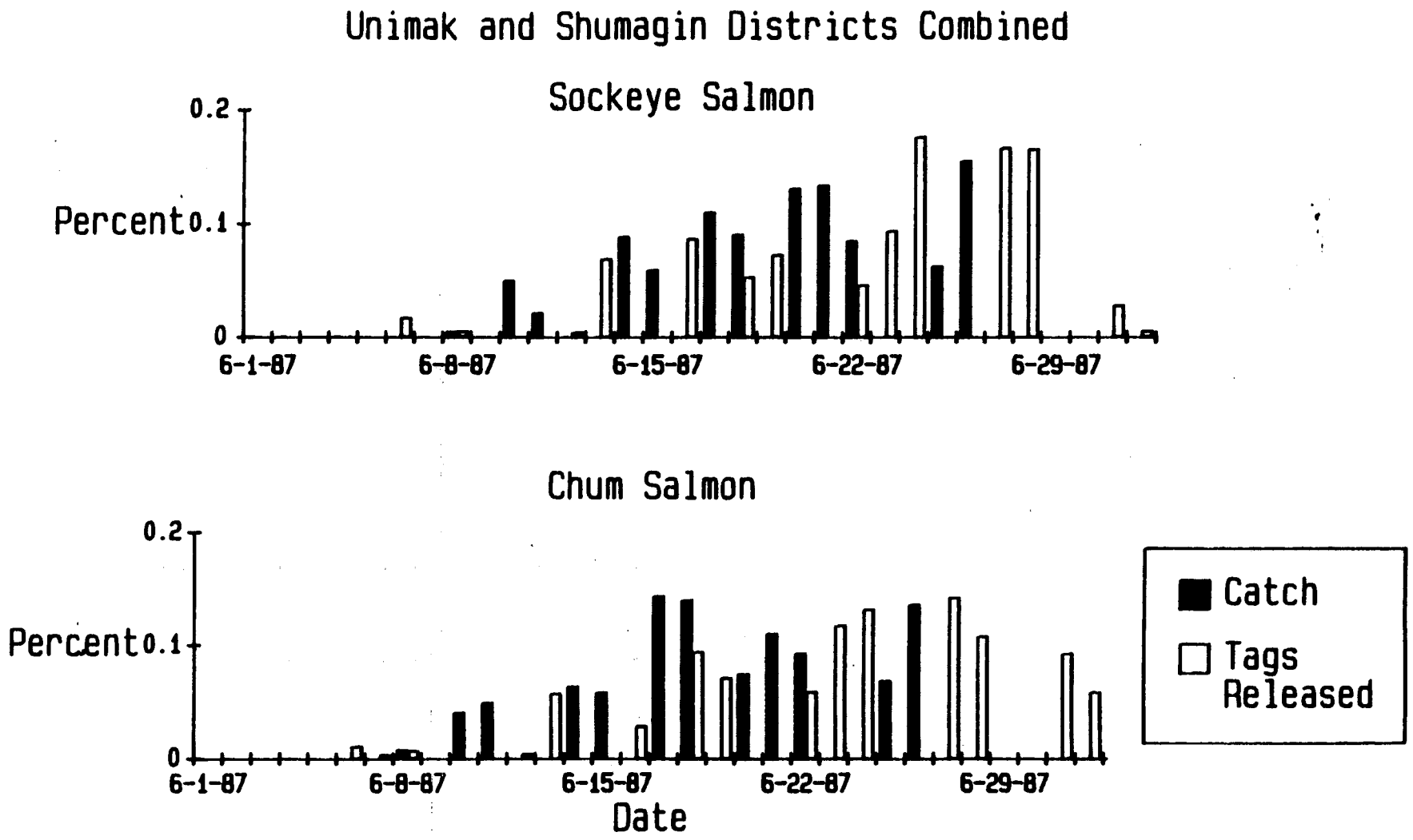

Figure 4. Timing of 1987, tag releases and catches of sockeye and chum salmon in the Combined Unimak and Shumagin district.

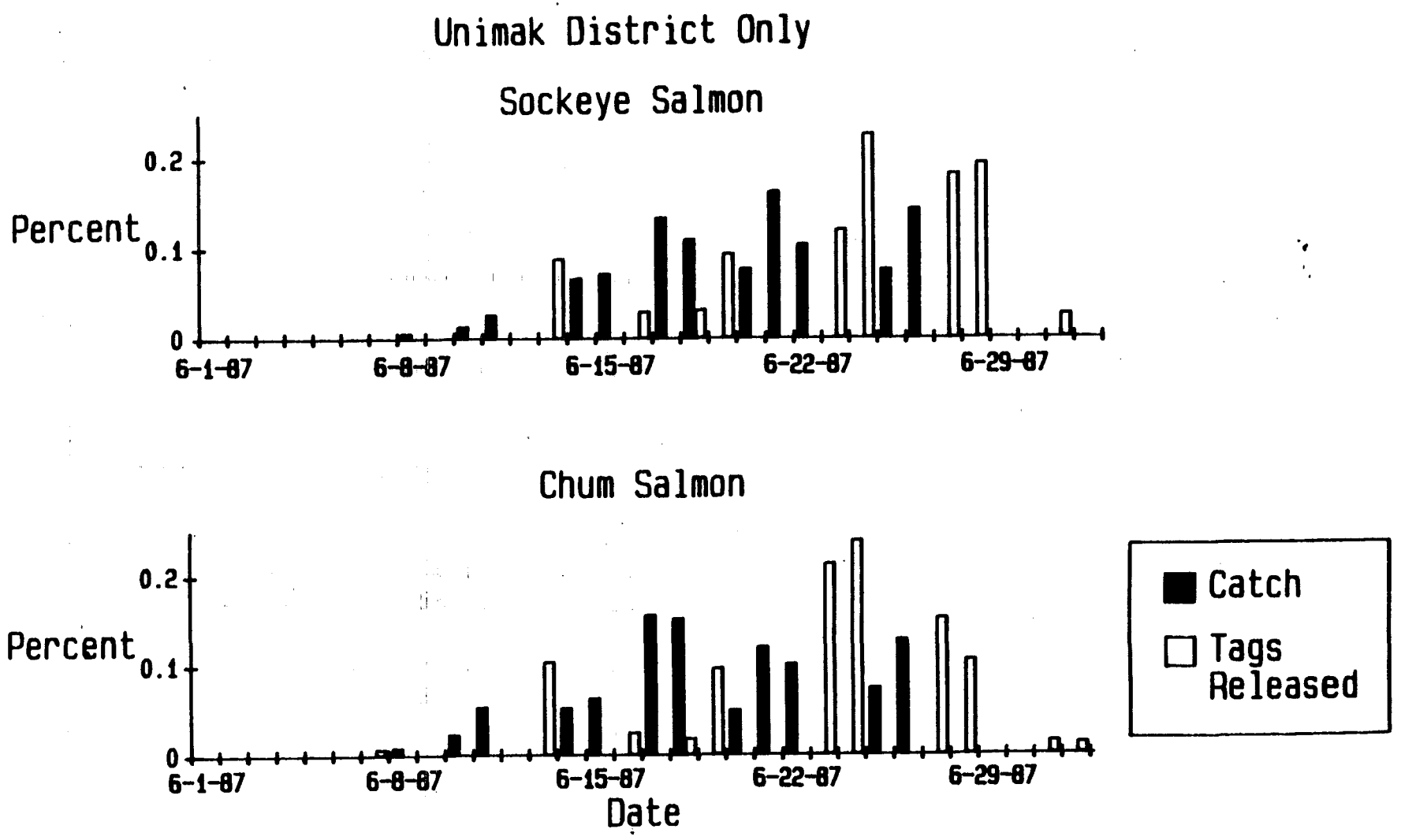

Figure 5. Timing of 1987, tag releases and catches of sockeye and chum salmon in the Unimak district.

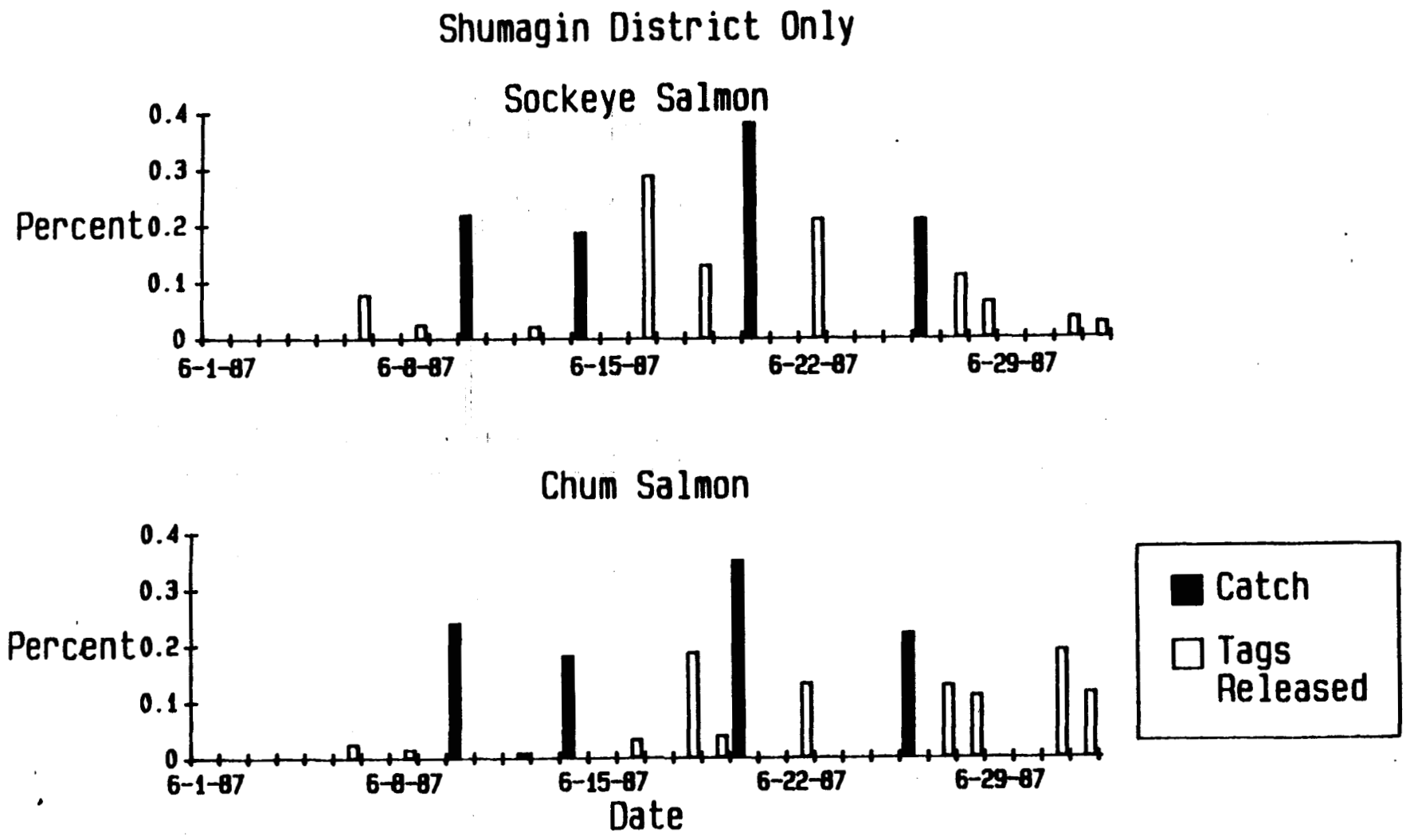

Figure 6. Timing of 1987, tag releases and catches of sockeye and chum salmon in the Shumagin district.

After most of the recoveries had been returned, ADF&G and LGL personnel created a permanent tag recovery data base (Appendices A - D) where the date and location of release, date and location of capture for each tag returned was fully documented. During this period, a verification of the date, statistical area and sub-statistical area of capture, and classification of recovery as fishery or non-fishery recovery was based on the presence of the actual tag and associated information. Recoveries without a verifiable recovery date and location were classified as not usable.

The voluntary recoveries from terminal commercial and subsistence fisheries were the primary basis for stock composition estimates, and thus had to be classified to respective terminal fishery of recovery. The raw recoveries were classified by fishery and non-fishery recoveries and by fishery unit and districts within fishery unit of recovery (Appendix Table A3 and A5 for chum and sockeye salmon, respectively) based on respective assignment of statistical and sub-statistical area assignments to these fisheries (Appendix Table A4 and A6 for chum and sockeye, respectively).

The raw recovery data base is presented by fishery unit for chum and sockeye salmon in Appendix B and C, respectively. There was a total of 833 chum salmon recoveries (Table 5) with 812 recoveries that could be assigned to specific commercial and subsistence fishery units. There was a total of 1912 sockeye salmon recoveries (Table 6) with 1881 recoveries that could be assigned to specific commercial and subsistence fishery units. Note that some recoveries from Bristol Bay and the Alaska Peninsula could not be assigned to specific districts. These were treated as not usable (Tables 5 and 6). Since the estimates of recoveries were made in the fishery sampling program by district within fishery unit, any recoveries without specific information of district within fishery unit of recovery would be considered as an unreported tag.

The Yukon chum salmon recoveries were further classified into summer and fall chum salmon stocks (Table 7), based on both the area and time of capture. These classifications followed the same procedures that have been used to classify the Yukon commercial and subsistence chum salmon catches.

The Alaska Peninsula sockeye and chum salmon recoveries were assigned to the June or July fishery based on the respective month of capture. In addition all of the June and 80 % of the July sockeye recoveries in the Southeast Mainland District were classified as Chignik origin. As with the Yukon this classified followed the procedures that have been used to classify commercial catches.

Fishery Sampling Program

Table 5. Summary of unadjusted chum salmon recoveries from voluntary program, South Peninsula tagging study.

Fishery	Recoveries in Fisheries					Non-fishery Recoveries	
	Unimak Releases (#'s)	Unimak Releases (%)	Shumagin Releases (#'s)	Shumagin Releases (%)	Combined Area Releases	Unimak Releases	Shumagin Releases
Kotzebue	2	66.7%	1	33.3%	3		
Norton Sound	6	60.0%	4	40.0%	10	3	
Yukon							
Summer Run	14	73.7%	5	26.3%	19	1	
Fall Run	2	33.3%	4	66.7%	6		
Total Yukon	16	64.0%	9	36.0%	25	1	
Kuskokwim							
Kuskokwim Bay	6	75.0%	2	25.0%	8	5	1
Kuskokwim River	94	67.6%	45	32.4%	139	1	1
Total Kuskokwim	100	68.0%	47	32.0%	147	6	2
Bristol Bay							
Togiak	69	77.5%	20	22.5%	89	1	1
Nushagak	132	77.6%	38	22.4%	170		
Naknek/Kvichak	23	60.5%	15	39.5%	38	1	
Egegik	12	75.0%	4	25.0%	16		
Ugashik	8	72.7%	3	27.3%	11		
Total Bristol Bay	244	75.3%	80	24.7%	324	2	1
North Peninsula							
Northern District	25	67.6%	12	32.4%	37		
Northwestern District	18	90.0%	2	10.0%	20		
Total	43	75.4%	14	24.6%	57		
South Peninsula June							
Unimak(Southwestern)	37	49.3%	38	50.7%	75		
Shumagin		0.0%	2	100.0%	2		
S.E. Mainland		0.0%		0.0%	0		
Total	37	48.1%	40	51.9%	77		

Table 5 (Continued). Summary of unadjusted chum salmon recoveries from voluntary program, South Peninsula tagging study.

Fishery	Recoveries in Fisheries: Unimak Releases (#'s)	Unimak Releases (%)	Shumagin Releases (#'s)	Shumagin Releases (%)	Combined Area Releases	Non-fishery Recoveries: Unimak Releases	Non-fishery Recoveries: Shumagin Releases
South Peninsula July							
Southwestern	6	35.3%	11	64.7%	17		1
Southcentral	10	33.3%	20	66.7%	30		
Shumagin	4	22.2%	14	77.8%	18		
S.E. Mainland	13	65.0%	7	35.0%	20		
Total	33	38.8%	52	61.2%	85		1
Chignik	1	10.0%	9	90.0%	10		
Kodiak		0.0%	4	100.0%	4		
Cook Inlet	1	25.0%	3	75.0%	4		2
Prince William Sound	1	100.0%		0.0%	1		2
Southeast							1
Coastal British Columbia	0	0.0%	1	100.0%	1		
Coastal Japan	7	19.4%	29	80.6%	36		
Coastal USSR	6	54.5%	5	45.5%	11		
Unknown Area	14	82.4%	3	17.6%	17		
All Areas Combined	511		301		812	12	9
Total Recoveries	833						

Table 6. Summary of unadjusted sockeye salmon recoveries from voluntary program, South Peninsula tagging study.

Fishery	Recoveries in Fisheries: Unimak Releases (#'s)	Unimak Releases (%)	Shumagin Releases (#'s)	Shumagin Releases (%)	Combined Area Releases	Non-fishery Recoveries: Unimak Releases	Non-fishery Recoveries: Shumagin Releases
Norton Sound	1	100.0%		0.0%	1		
Kuskokwim							
Kuskokwim Bay	5	100.0%		0.0%	5		
Kuskokwim River		0.0%		0.0%	0		
Total Kuskokwim	5	100.0%		0.0%	5		
Bristol Bay							
Togiak	13	81.3%	3	18.8%	16		
Nushagak	222	87.4%	32	12.6%	254		
Naknek/Kvichak	372	88.4%	49	11.6%	421	8	1
Egegik	292	89.6%	34	10.4%	326		
Ugashik	103	88.8%	13	11.2%	116		
Total Bristol Bay	1002	88.4%	131	11.6%	1133	8	1
North Peninsula							
Northern District	86	83.5%	17	16.5%	103	17	1
Northwestern District	14	63.6%	8	36.4%	22		
Total	100	80.0%	25	20.0%	125	17	1
South Peninsula June							
Unimak(Southwestern)	192	65.8%	100	34.2%	292	1	
Shumagin	1	5.3%	18	94.7%	19		
S.E. Mainland		0.0%	2	0.0%	2		
Total	193	61.7%	120	38.3%	313	1	

Table 6 (Continued). Summary of unadjusted sockeye salmon recoveries from voluntary program, South Peninsula tagging study.

Fishery	Recoveries in Fisheries					Non-fishery Recoveries	
	Unimak Releases (#'s)	Unimak Releases (%)	Shumagin Releases (#'s)	Shumagin Releases (%)	Combined Area Releases	Unimak Releases	Shumagin Releases
South Peninsula July							
Southwestern	37	78.7%	10	21.3%	47		
Southcentral	17	60.7%	11	39.3%	28		
Shumagin	8	50.0%	8	50.0%	16		
S.E. Mainland	1	50.0%	1	50.0%	2		
Total	63	67.7%	30	32.3%	93		
Chignik							
Early Run	29	40.8%	42	59.2%	71		
Late Run	3	42.9%	4	57.1%	7		
S.E. Mainland	7	35.0%	13	65.0%	20		
Total	39	39.8%	59	60.2%	98		
Kodiak	6	26.1%	17	73.9%	23		1
Cook Inlet	2	50.0%	2	50.0%	4	2	
Prince William Sound	1	100.0%		0.0%	1		
Unknown Area	73	85.9%	12	14.1%	85		
All Areas Combined	1485		396		1881	28	3
Total Recoveries	1912						

Table 7. Date and location of release, date and fishing district of recovery, and fall or summer run designation for tagged chum salmon returning to the Yukon River.

Tag Number a/	Release Area	Release Date	Fishing District of Recovery	Statistical Area of Recovery	Recovery Date	Run Designation b/
15600	Shumagins	6/08/87	Hooper Bay	337 - 00	6/24/87	Summer
16007	Unimak	6/13/87	Hooper Bay	337 - 00	6/27/87	Summer
16654	Unimak	6/23/87	Y-1	334 - 10	7/10/87	Summer
24749	Shumagins	6/18/87	Y-1	334 - 10	7/07/87	Summer
22082	Unimak	6/24/87	Y-1	334 - 11	7/10/87	Summer
15501	Shumagins	6/06/87	Y-1	334 - 12	6/29/87	Summer
16260	Unimak	6/16/87	Y-1	334 - 13	7/02/87	Summer
16689	Unimak	6/23/87	Y-1	334 - 13	7/13/87	Summer
24654	Shumagins	6/18/87	Y-1	334 - 13	7/10/87	Summer
16591	Unimak	6/19/87	Y-1	334 - 13	7/10/87	Summer
17157	Unimak	6/24/87	Y-1	334 - 14	7/10/87	Summer
24905	Shumagins	6/19/87	Y-1	334 - 15	7/10/87	Summer
17115	Unimak	6/24/87	Y-1	334 - 17	7/10/87	Summer
15371	Unimak	6/19/87	Y-2	334 - 20	7/19/87	Fall
16164	Unimak	6/13/87	Y-2	334 - 20	7/02/87	Summer
16319	Unimak	6/18/87	Y-2	334 - 20	7/09/87	Summer
16384	Unimak	6/19/87	Y-2	334 - 20	7/19/87	Fall
16033	Unimak	6/13/87	Y-2	334 - 21	7/01/87	Summer
24818	Shumagins	6/19/87	Y-2	334 - 22	7/19/87	Fall
16401	Unimak	6/19/87	Y-2	334 - 23	7/12/87	Summer
24522	Shumagins	6/18/87	Y-4	334 - 40	8/19/87	Fall
16182	Unimak	6/13/87	Y-4	334 - 41	7/14/87	Summer
17130	Unimak	6/24/87	Y-4	334 - 42	7/31/87	Summer
26038	Shumagins	7/01/87	Y-6	334 - 62	9/27/87	Fall
26052	Shumagins	7/01/87	Y-6	334 - 62	9/11/87	Fall

a/ Includes only tag recoveries for which the date and location of recovery are known.

b/ Date and location serve as criteria for classification of each recovery to the summer or fall run of chum salmon. In accordance with management strategy and implementation of guideline harvest levels, all chum salmon through District Y-1 prior to 7/16 are classified as summer chum salmon. fish passing through District Y-1 on 7/16 and after are fall chum salmon. Estimated travel time between Districts Y-1 and Y-2 is three days. Chum salmon passing through District Y-2 prior to 7/19 are summer chum salmon. Fish passing through District Y-2 on 7/19 and after are considered fall run chum salmon. District Y-4a is closed by regulation 8/1 to conserve fall chum salmon returns.

Estimates of sockeye and chum salmon recoveries based on the fishery sampling programs, in Kotzebue Sound, Bristol Bay, North Peninsula and South Peninsula fishery units are documented in Appendix E. The results for the Yukon and Kuskokwim fishery units, because of the AYK chum salmon interception issue, are presented below.

Yukon River. Harvests of Yukon River chum salmon stocks occurred in five commercial fishing districts. Subsistence harvest comparable in magnitude to the commercial harvest occurred throughout the Yukon drainage. Because of the remoteness and dispersed nature of the fishing effort in this fishery it was possible to conduct fishery sampling programs only in selected areas. A sampling program was conducted in commercial summer chum salmon fishery in the lower river districts (Y1 and Y2), June 15 - July 10, (Table 8). Only 3 tagged salmon were found, and those tags were found in the final commercial fishing period. The estimate of summer chum recoveries in the total Y1 and Y2 catches was 25 tagged fish.

A commercial fishery did not occur on fall chum salmon in the lower river. Significant numbers of Yukon fall chum salmon were directly observed in a variety of biological sampling, test fishing, spawning ground survey, and tagging programs by various Governmental Agencies. In addition, a subsistence survey was conducted in districts Y1 and Y5 specifically to look for tagged fall chum salmon. Finally Yukon fall chum salmon were counted and sampled for tags at the Fishing Branch weir. In this collective sampling effort, approximately 120 thousand fall chum salmon were examined for tags (Table 9). This effort represented 16.1% of Yukon fall chum salmon return. A single tag was sighted during the Fishing Branch weir operations but not recovered. Based on the 16.1% sampling fraction, 6 tagged fish would be expected in the Yukon Fall chum return.

Kuskokwim River. A sampling program in District W1 was conducted from June 18 - July 22, (Table 10). A total of 57 thousand chum salmon were examined for tags representing approximately 8.3% of the Kuskokwim River commercial and subsistence harvest of chum salmon. Twenty-three tagged fish were found through sampling the commercial fishery catches, and based on the 8.3% sampling fraction, 260 tagged chum salmon were estimated to occur in the Kuskokwim catch.

Estimates of Reported Fraction. The pool of fish from which tagged fish could be found and voluntarily returned by fishermen include both the commercial and subsistence catches for Kuskokwim River fisheries and commercial catches for Bristol Bay and Alaska Peninsula fisheries. Estimates of tag recoveries made with the fishery sampling program (cf. Appendix E) were compared with those from voluntary recoveries to estimate reported fraction (Table 11). These estimates were prepared for Kuskokwim, Bristol, North Peninsula, South Peninsula June, and South Peninsula July chum salmon and sockeye salmon fisheries. The

Table 8. Estimated number of tagged summer run chum salmon in the Y1 and Y2 commercial catch, by fishing period, based on the fishery sampling program.

Date	Commercial Catch a/	Interviewed Catch	Fraction Sampled	Recovered Tags	Expanded Recoveries
6/15	10951	60	0.5%	0	0
6/17-6/18 b/	10323	0	0.0%	0	0
6/18-6/19	19817	1059	5.3%	0	0
6/21-6/22 *	12415	0	0.0%	0	0
6/22-6/23	13586	1811	13.3%	0	0
6/24-6/25 *	17911	2219	12.4%	0	0
6/25-6/26	23488	1608	6.8%	0	0
6/29-6/30 *	4337	408	9.4%	0	0
6/29-6/30	67330	2742	4.1%	0	0
7/01-7/02 *	39737	2177	5.5%	0	0
7/02-7/03	50698	1624	3.2%	0	0
7/06 *	15666	768	4.9%	0	0
7/09 *	21961	3269	14.9%	0	0
7/10 *	37028	4479	12.1%	3	25
Total	345248	22224	6.4%	3	25
		Total Expanded Recoveries C.Catch			25

a/ Preliminary harvest data. Includes commercial harvest data for District Y-1 and the statistical areas for District Y-2 down river and within the vicinity of the Main River sonar site at Pilot Station.

b/ Fishermen in both Districts Y-1 and Y-2 were interviewed. Data displayed with '*' represents the District Y-2 harvest, otherwise, the harvest is from District Y-1.

Table 9. Estimated number of Yukon River fall chum in the 1987 return based on the sampling program for Yukon River fall chum salmon tag recoveries. Shown are the description of project, agency conducting the project, location of project, number of fish examined for tags, and number of tags reported.

Project	Location	Number of Fish	Tags Reported
ADF&G Test Fisheries	District Y-1	4,343 a/	0
	District Y-2	1,065 b/	0
	District Y-4	4,500 c/	0
	Subtotal	9,908	0
Biological Sampling d/ (ADF&G)	Delta River	450	0
	Bluff Cabin Slough	150	0
	Toklat River	450	0
	Sheenjek River	909 e/	0
	Subtotal	1,959	0
Biological Sampling d/ (US Fish and Wildlife Service) ce)			
	Nulato River	260	0
	Gisasa River	190	0
	Koyukuk River drainage	154	0
	Subtotal	604	0
Subsistence Harvest Surveys	District Y-1	1,357	0
	District Y-5	5,606	
	Subtotal	6,963	0
Escapement Studies			
Spawning Ground Surveys (ADF&G) f/	Delta River	20,014	0
	Bluff Cabin Slough	9,245	0
	Toklat River	17,400	0
	Sheenjek River	2,125	0
	Subtotal	48,784	0
Escapement Enumeration	Fishing Branch River Weir	48,956	1 h/
Tagging Project g/ (Department of Fisheries and Oceans)		3,022	0

Table 9 (Continued). Estimated number of Yukon River fall chum in the 1987 return based on the sampling program for Yukon River fall chum salmon tag recoveries. Shown are the description of project, agency conducting the project, location of project, number of fish examined for tags, and number of tags reported.

Total number of fish examined and tags reported:	120,196	1
Percent of fall chum salmon run handled or observed by agency personnel:	16.1% i/	
Expanded number of tagged fall run chum salmon relative to the total estimated run size and number of fish examined by agency personnel:	6	
Percent of the fall chum salmon run examined, including fish caught during commercial and subsistence fishery openings:	55.1% j/	

a/ Combined test fish catches by gill net at Big Eddy and Middle Mouth.
b/ Test gill net catches at the Main River Sonar site, Pilot Station.
c/ Test fishwheel catches at Ruby.
d/ Fish sampled for length, scales and tissue for electrophoresis analysis.
e/ Number of fish handled. Fish actually sampled for biological data totaled 450 chum salmon.
f/ Foot surveys. Numbers do not include fish sampled for biological data.
g/ Fishwheels operated above the US/Canada border to attain data for population estimates.
h/ Tag sighted 9/15/87, not recovered; visibility moderate to good.
i/ Based on total run estimate for fall run chum salmon of 745,000 fish derived from escapement surveys, and available subsistence and commercial harvest figures for the US and Canada.
j/ Based on estimated harvest of 290,097 fall chum salmon in the US subsistence subsistence, Canadian subsistence and Canadian commercial fisheries. in addition to the number of chum salmon examined by agency personnel. chum salmon handled by agency personnel.

Table 10. Estimated number of tagged Kuskokwim River chum salmon in the W1 commercial catch, by fishing period, based on the fishery sampling program.

Date	Commercial Catch a/	Interviewed Catch	Fraction Sampled	Recovered Tags
6/18	14137	523	3.7%	0
6/24	54454	6057	11.1%	0
6/30	112963	7921	7.0%	1
7/03	66783	6838	10.2%	1
7/07	103059	11074	10.7%	4
7/11	72118	7919	11.0%	6
7/15	71923	9000	12.5%	8
7/20	55135	7371	13.4%	3
7/21-9/07	5927	0	0	0
Totals	640436 b/	56703	8.9%	23
	Total Expanded Recoveries C.Catch		0	260

a/ Final harvest data representing commercial catches in District W-1.

b/ Includes 76,100 subsistence caught chum salmon from the Kuskokwim River drainage and 7,837 commercially caught chum salmon from District W-2.

Table 11. Summary of results of ADF&G sampling program for sockeye and chum salmon tag recoveries in various Western Alaska salmon fisheries and estimates of reported fraction.

	Sockeye Salmon			Chum Salmon		
Fishery	Estimated	Actual Reported	Reported Fraction	Estimated	Actual Reported	Reported Fraction
Kuskokwim	___	___	___	260	139	53.5%
Bristol Bay	2083	1122	53.9%	381	324	85.0%
North Peninsula	102	125	122.5%	64	57	89.1%
South Peninsula June	281	313	111.4%	77	77	100.0%
South Peninsula July	28	94	335.7%	107	85	79.4%

estimated reported fraction for Bristol Bay sockeye salmon was 53.9%. The reported fraction for Alaska Peninsula sockeye was taken to be 100%. The reported fraction for Kuskokwim, Bristol Bay, North Peninsula, South Peninsula June, and South Peninsula July chum salmon were 53.5%, 84.8%, 89.1%, 100%, and 79.4%, respectively.

It was not possible to sample the subsistence catches for Yukon summer chum salmon. Only 3 tags were found in lower river commercial fishery sampling program and occurred late in the summer chum season. The accuracy of estimates of number of tags in the summer chum return from these limited recoveries cannot be guaranteed. This problem also occurred in the collective sampling effort for Yukon fall chum salmon. Only 1 tag was found in this program and the accuracy of estimate of the number tagged fish in the Yukon fall chum return based on this limited sample is questionable.

The voluntary recoveries from Yukon chum salmon reflect the pool of fish from which tags could be potentially found by fishermen and returned to ADF&G, and include both commercial and subsistence harvests. It was not possible to estimate accurately the number of recoveries from commercial and subsistence harvests based on the fishery sampling program. Thus, estimates of reported fraction are not available for Yukon chum salmon fisheries.

There were 25 Yukon chum salmon tags found in the voluntary program. In view of the limited fishery sampling program for the Yukon chum salmon fisheries, the reported fraction estimated for the Kuskokwim River was applied to the voluntary recoveries. This was based on the similarity of the fisheries in the Yukon and Kuskokwim Rivers.

Apportionment of the Sockeye Salmon Releases in the Area of the South Peninsula June Fishery

Recoveries in Western and Central Alaska Sockeye Salmon Returns.

The recoveries from catches in western and central Alaska salmon fisheries obtained through the voluntary program were expanded to tagged fish in the total return for each area. Worksheets were constructed that accomplished this expansion, for the combined Unimak and Shumagin releases (Table 12), the Unimak releases (Table 13), and the Shumagin releases (Table 14). Reported fraction estimated in the fishery sampling program (Table 11) were used to expand the respective fishery unit voluntary recoveries to account for tags that were caught but not reported to ADF&G. The estimated recoveries in the catch were expanded to represent the entire return by dividing by the rate of exploitation (ie the catch divided by the total return).

Table 12. Apportionment of the released sockeye salmon population to various western and central Alaska fisheries, combined Unimak and Shumagin releases.

Fishery	Return (thousands)				Estimated Recoveries in Catches Based on Voluntary Recoveries			Estimated Tagged Fish in Population	
	Catch	Escapement	Total	% of W. & C. Alaska Return	Unadj. Recovs.	Reported Fraction	Adj. Recovs.	Number of Fish	Prop. of Tagged Pop.
Norton Sound	0	7	7	0.0%	1	53.9%	2	1	0.0%
Kuskokwim									
Kuskokwim Bay	35	65	100	0.2%	5	53.9%	9	27	0.6%
Kuskokwim River	163	241	404	0.8%	0	53.9%	0	0	0.0%
Total	198	306	504	1.0%				27	0.6%
Bristol Bay									
Togiak	340	316	656	1.3%	16	53.9%	30	57	1.3%
Nushagak	3,253	1,894	5,147	9.9%	254	53.9%	471	746	16.8%
Naknek/Kvichak	4,949	7,282	12,231	23.5%	421	53.9%	781	1930	43.4%
Egegik	5,387	1,273	6,660	12.8%	326	53.9%	605	748	16.8%
Ugashik	2,119	687	2,806	5.4%	116	53.9%	215	285	6.4%
Total	16,048	11,452	27,500	52.8%				3766	84.7%
Aleutian Islands	0	18	18	0.0%	0	100.0%	0	0	0.0%
North Peninsula									
Northern District	1,065	576	1,641	3.1%	103	100.0%	103	159	3.6%
Northwestern District	143	60	203	0.4%	22	100.0%	22	31	0.7%
Total	1,208	636	1,844	3.5%				190	4.3%

Table 12 (Continued). Apportionment of the released sockeye salmon population to various western and central Alaska fisheries, combined Unimak and Shumagin releases.

Fishery	Return (thousands)				Estimated Recoveries in Catches Based on Voluntary Recoveries			Estimated Tagged Fish in Population	
	Catch	Escapement	Total	% of W. & C. Alaska Return	Unadj. Recovs.	Reported Fraction	Adj. Recovs.	Number of Fish	Prop. of Tagged Pop.
South Peninsula June									
Unimak(Southwestern)	652	0	652	1.3%	292	100.0%	292	292	---
Shumagin	141	0	141	0.3%	19	100.0%	19	19	---
S.E. Mainland	56	0	56	0.1%	2	100.0%	2	2	---
Total	849	0	849	1.6%				313	---
South Peninsula July									
Southwestern	68	51	119	0.2%	47	100.0%	47	82	1.9%
Southcentral	39	4	43	0.1%	28	100.0%	28	31	0.7%
Shumagin	249	3	252	0.5%	16	100.0%	16	16	0.4%
S.E. Mainland	55	23	78	0.1%	2	100.0%	2	3	0.1%
Total	411	81	492	0.9%				132	3.0%
Chignik									
Early Run	1,685	610	2,295	4.4%	71	53.9%	132	179	4.0%
Late Run	576	193	769	1.5%	7	53.9%	13	17	0.4%
S.E. Mainland	170	0	170	0.3%	20	100.0%	20	27	0.6%
Total	2,431	803	3,064	5.9%				224	5.0%
Kodiak	1,450	1,709	3,159	6.1%	23	53.9%	43	93	2.1%
Cook Inlet	9,750	2,404	12,154	23.3%	4	53.9%	7	9	0.2%
Prince William Sound	1,738	789	2,527	4.8%	1	53.9%	2	3	0.1%
All Areas Combined	34,083	18,205	52,118					4,757	

Table 13. Apportionment of the released sockeye salmon population to various western and central Alaska fisheries, Unimak releases.

Fishery	Return (thousands)				Estimated Recoveries in Catches Based on Voluntary Recoveries			Estimated Tagged Fish in Population	
	Catch	Escapement	Total	% of W. & C. Alaska Return	Unadj. Recovs.	Reported Fraction	Adj. Recovs.	Number of Fish	Prop. of Tagged Pop.
Norton Sound	0	7	7	0.0%	1	53.9%	2	1	0.0%
Kuskokwim									
Kuskokwim Bay	35	65	100	0.2%	5	53.9%	9	27	0.7%
Kuskokwim River	163	241	404	0.8%	0	53.9%	0	0	0.0%
Total	198	306	504	1.0%				27	0.7%
Bristol Bay									
Togiak	340	316	656	1.3%	13	53.9%	24	47	1.3%
Nushagak	3,253	1,894	5,147	9.9%	222	53.9%	412	652	17.5%
Naknek/Kvichak	4,949	7,282	12,231	23.5%	372	53.9%	690	1706	45.8%
Egegik	5,387	1,273	6,660	12.8%	292	53.9%	542	670	18.0%
Ugashik	2,119	687	2,806	5.4%	103	53.9%	191	253	6.8%
Total	16,048	11,452	27,500	52.8%				3327	89.4%
Aleutian Islands	0	18	18	0.0%	0	100.0%	0	0	0.0%
North Peninsula									
Northern District	1,065	576	1,641	3.1%	86	100.0%	86	133	3.6%
Northwestern District	143	60	203	0.4%	14	100.0%	14	20	0.5%
Total	1,208	636	1,844	3.5%				152	4.1%

Table 13 (Continued). Apportionment of the released sockeye salmon population to various western and central Alaska fisheries, Unimak releases.

Fishery	Return (thousands)				Estimated Recoveries in Catches Based on Voluntary Recoveries			Estimated Tagged Fish in Population	
	Catch	Escapement	Total	% of W. & C. Alaska Return	Unadj. Recovs.	Reported Fraction	Adj. Recovs.	Number of Fish	Prop. of Tagged Pop.
South Peninsula June									
Unimak(Southwestern)	652	0	652	1.3%	192	100.0%	192	192	---
Shumagin	141	0	141	0.3%	1	100.0%	1	1	---
S.E. Mainland	56	0	56	0.1%	0	100.0%	0	0	---
Total	849	0	849	1.6%				193	---
South Peninsula July									
Southwestern	68	51	119	0.2%	37	100.0%	37	65	1.7%
Southcentral	39	4	43	0.1%	17	100.0%	17	19	0.5%
Shumagin	249	3	252	0.5%	8	100.0%	8	8	0.2%
S.E. Mainland	55	23	78	0.1%	1	100.0%	1	1	0.0%
Total	411	81	492	0.9%				93	2.5%
Chignik									
Early Run	1,685	610	2,295	4.4%	29	53.9%	54	73	2.0%
Late Run	576	193	769	1.5%	3	53.9%	6	7	0.2%
S.E. Mainland	170	0	170	0.3%	7	100.0%	7	10	0.3%
Total	2,431	803	3,064	5.9%				90	2.4%
Kodiak	1,450	1,709	3,159	6.1%	6	53.9%	11	24	0.7%
Cook Inlet	9,750	2,404	12,154	23.3%	2	53.9%	4	5	0.1%
Prince William Sound	1,738	789	2,527	4.8%	1	53.9%	2	3	0.1%
All Areas Combined	34,083	18,205	52,118					3,914	

Table 14. Apportionment of the released sockeye salmon population to various western and central Alaska fisheries, Shumagin releases.

Fishery	Return (thousands)				Estimated Recoveries in Catches Based on Voluntary Recoveries			Estimated Tagged Fish in Population	
	Catch	Escapement	Total	% of W. & C. Alaska Return	Unadj. Recovs.	Reported Fraction	Adj. Recovs.	Number of Fish	Prop. of Tagged Pop.
Norton Sound	0	7	7	0.0%	0	53.9%	0	1	0.1%
Kuskokwim									
Kuskokwim Bay	35	65	100	0.2%	0	53.9%	0	0	0.0%
Kuskokwim River	163	241	404	0.8%	0	53.9%	0	0	0.0%
Total	198	306	504	1.0%				0	0.0%
Bristol Bay									
Togiak	340	316	656	1.3%	3	53.9%	6	11	1.5%
Nushagak	3,253	1,894	5,147	9.9%	32	53.9%	59	94	13.0%
Naknek/Kvichak	4,949	7,282	12,231	23.5%	49	53.9%	91	225	31.0%
Egegik	5,387	1,273	6,660	12.8%	34	53.9%	63	78	10.8%
Ugashik	2,119	687	2,806	5.4%	13	53.9%	24	32	4.4%
Total	16,048	11,452	27,500	52.8%				439	60.7%
Aleutian Islands	0	18	18	0.0%	0	100.0%	0	0	0.0%
North Peninsula									
Northern District	1,065	576	1,641	3.1%	17	100.0%	17	26	3.6%
Northwestern District	143	60	203	0.4%	8	100.0%	8	11	1.6%
Total	1,208	636	1,844	3.5%				38	5.2%

Table 14 (Continued). Apportionment of the released sockeye salmon population to various western and central Alaska fisheries, Shumagin releases.

Fishery	Return (thousands)				Estimated Recoveries in Catches Based on Voluntary Recoveries			Estimated Tagged Fish in Population	
	Catch	Escapement	Total	% of W. & C. Alaska Return	Unadj. Recovs.	Reported Fraction	Adj. Recovs.	Number of Fish	Prop. of Tagged Pop.
South Peninsula June									
Unimak(Southwestern)	652	0	652	1.3%	100	100.0%	100	100	---
Shumagin	141	0	141	0.3%	18	100.0%	18	18	---
S.E. Mainland	56	0	56	0.1%	2	100.0%	2	2	---
Total	849	0	849	1.6%				120	---
South Peninsula July									
Southwestern	68	51	119	0.2%	10	100.0%	10	18	2.4%
Southcentral	39	4	43	0.1%	11	100.0%	11	12	1.7%
Shumagin	249	3	252	0.5%	8	100.0%	8	8	1.1%
S.E. Mainland	55	23	78	0.1%	1	100.0%	1	1	0.2%
Total	411	81	492	0.9%				39	5.4%
Chignik									
Early Run	1,685	610	2,295	4.4%	42	53.9%	78	106	14.7%
Late Run	576	193	769	1.5%	4	53.9%	7	10	1.4%
S.E. Mainland	170	0	170	0.3%	13	100.0%	13	18	2.4%
Total	2,431	803	3,064	5.9%				134	18.5%
Kodiak	1,450	1,709	3,159	6.1%	17	53.9%	32	69	9.5%
Cook Inlet	9,750	2,404	12,154	23.3%	2	53.9%	4	5	0.6%
Prince William Sound	1,738	789	2,527	4.8%	0	53.9%	0	0	0.0%
All Areas Combined	34,083	18,205	52,118					844	

As an example of this procedure, consider the expansion of the tags from combined Unimak and Shumigan Districts that were reported from Bristol Bay, Nushagak District catches (Table 12). The number of voluntary recoveries reported for Nushagak district totaled 254. If you assume that voluntary recoveries represent 53.9% of the tagged fish actually caught, then 471 tagged fish were actually caught by Nushagak District fishermen. Since the catch in the Nushagak District was 3,253/5,147 or 63.3% of the total return, there was estimated to be 471/0.633 or 746 tagged fish in the Nushagak District total return.

This procedure was repeated for each fishery in western and central Alaska. The total number of tagged sockeye salmon accounted for in the Western and Central Alaska return was 4,757. This figure included 313 tagged fish intercepted in the South Peninsula June fisheries.

Releases not Accounted For.

There were 6,987 sockeye salmon released in the Unimak and Shumagin Districts. Of these 4,575 were estimated to occur in western and central Alaska returns. Thus, 2,229 tagged fish that were released, could not be accounted for in the western and central Alaska returns of sockeye salmon. Earlier tagging work indicated that stocks other than western and central Alaska sockeye stocks did not occur in the area of the South Peninsula June fishery. Based on this result, the releases not accounted for represented mortality associated with the tagging operations. The tagging mortality rate was 31.9%, 28.1%, and 45.5% for the combined Unimak and Shumagin, Unimak, and Shumagin releases, respectively (Table 15). These mortality rates were consistent with those observed (40 - 45 percent) in a tagging program to determine stock interception rates in the Southeast Alaska - British Columbia boundary area pink and sockeye salmon fisheries, (Pella et al. 1988).

Estimates of Stock Composition for the Sockeye Releases.

Stock Composition estimates for the combined Unimak and Shumagin, Unimak, and Shumagin sockeye releases (Table 15) were calculated assuming that tagging mortality was not stock specific. The stock composition for a given fishery unit was the number of releases estimated in the respective return divided by the total releases less tagging mortality and estimated recaptures in the South Peninsula June fishery. Tagged fish of Bristol Bay origin were dominant in the releases, accounting for 84.7% of the combined area, 89.4% of the Unimak, and 60.6% of the Shumagin releases.

The stock composition of the releases was also compared to relative abundance as indexed by the respective fishery unit return as a proportion of the total western and central Alaska

Table 15. Summary of results of 1987 South Peninsula tagging study for sockeye salmon. Included are numbers and proportions of tagged fish in returns to various Western and Central Alaska salmon fisheries and tagged fish dying from tagging mortality.

	Combined Releases		Unimak Releases		Shumagin Releases	
Fishery	Numbers of Tagged Fish in Return	Proportion	Numbers of Tagged Fish in Return	Proportion	Numbers of Tagged Fish in Return	Proportion
Kuskokwim	27	0.6%	27	0.7%	0	0.0%
Bristol Bay	3766	84.7%	3327	89.4%	439	60.6%
North Peninsula	190	4.3%	152	4.1%	38	5.2%
South Peninsula July	132	3.0%	93	2.5%	39	5.4%
Chignik	224	5.0%	90	2.4%	134	18.5%
Kodiak	93	2.1%	24	0.6%	69	9.5%
Other Stocks	13	0.3%	9	0.2%	5	0.7%
Total Alaskan Stocks	4445	100.0%	3722	100.0%	724	100.0%
Tagging Mortality	2229	---	1527	---	701	---
South Peninsula June Fishery Removals	313	---	193	---	120	---
Asian Stocks	0	0.0%	0	0.0%	0	0.0%
Total Releases	6987		5442		1545	
Tagging Mortality Rate	31.9%		28.1%		45.4%	

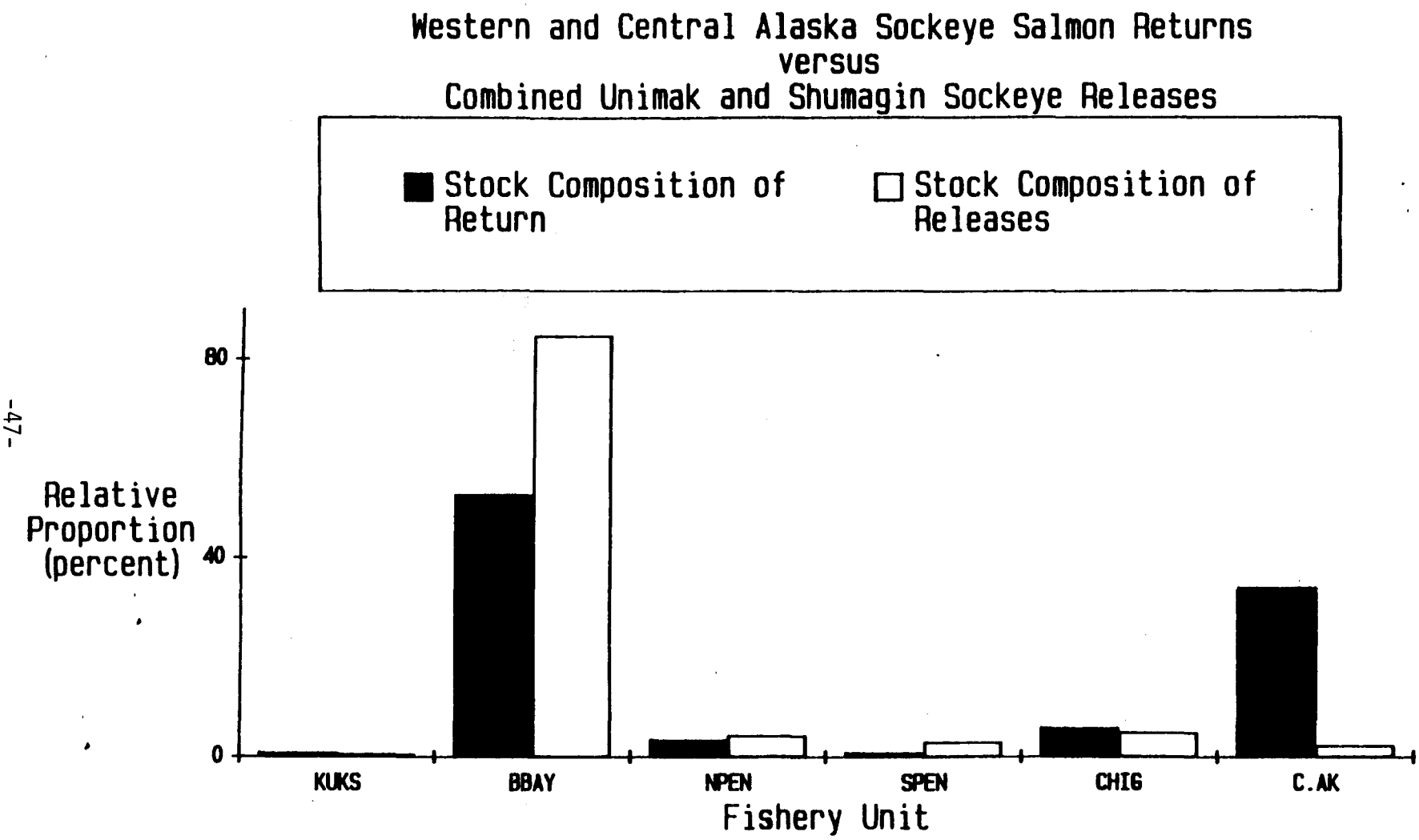

Figure 7. Stock composition (% of total return) of Western and Central Alaska sockeye returns versus stock composition (% of surviving releases) of combined Unimak and Shumagin releases of sockeye salmon, for various fishery units.

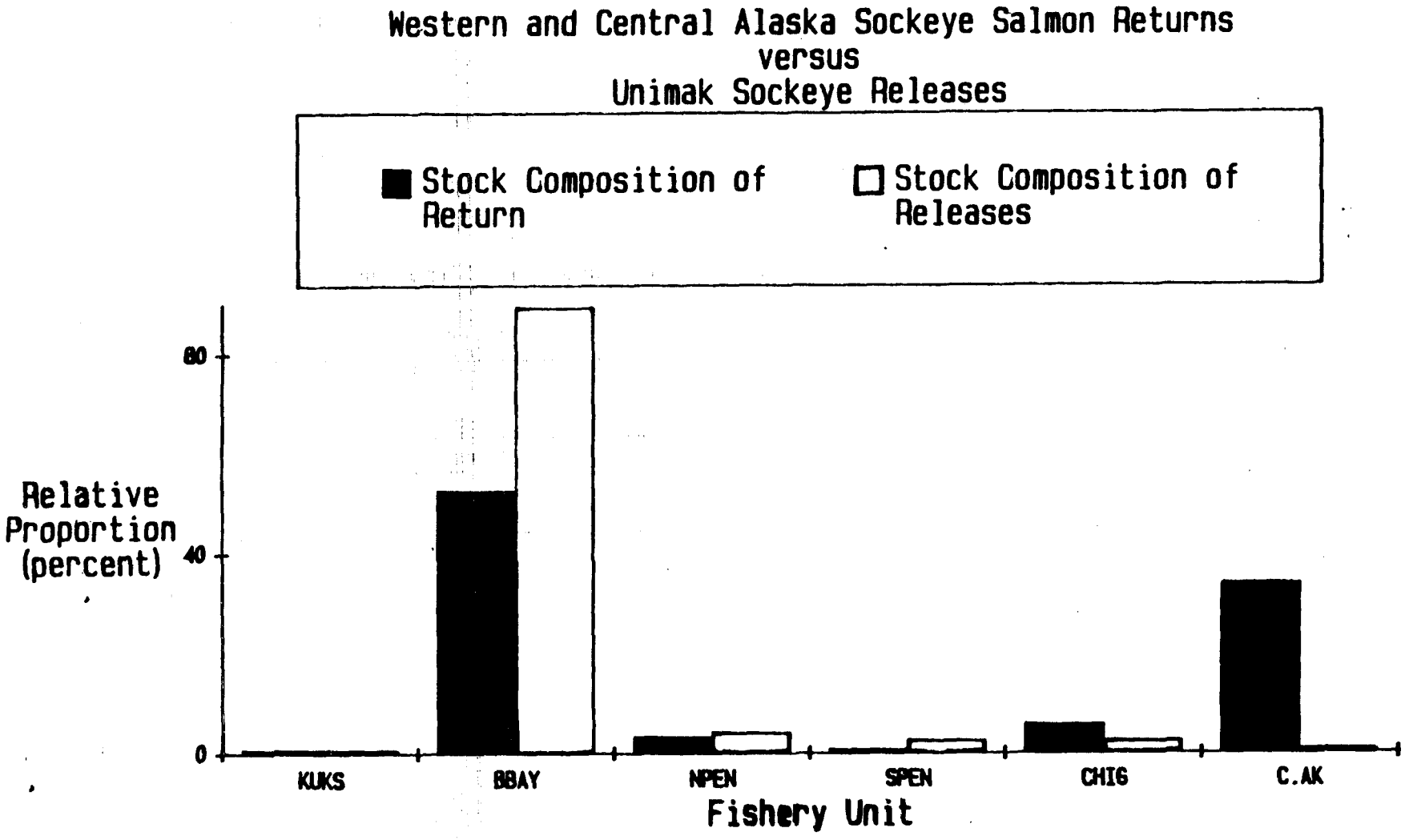

Figure 8. Stock composition (% of total return) of Western and Central Alaska sockeye returns versus stock composition (% of surviving releases) of Unimak releases of sockeye salmon, for various fishery units.

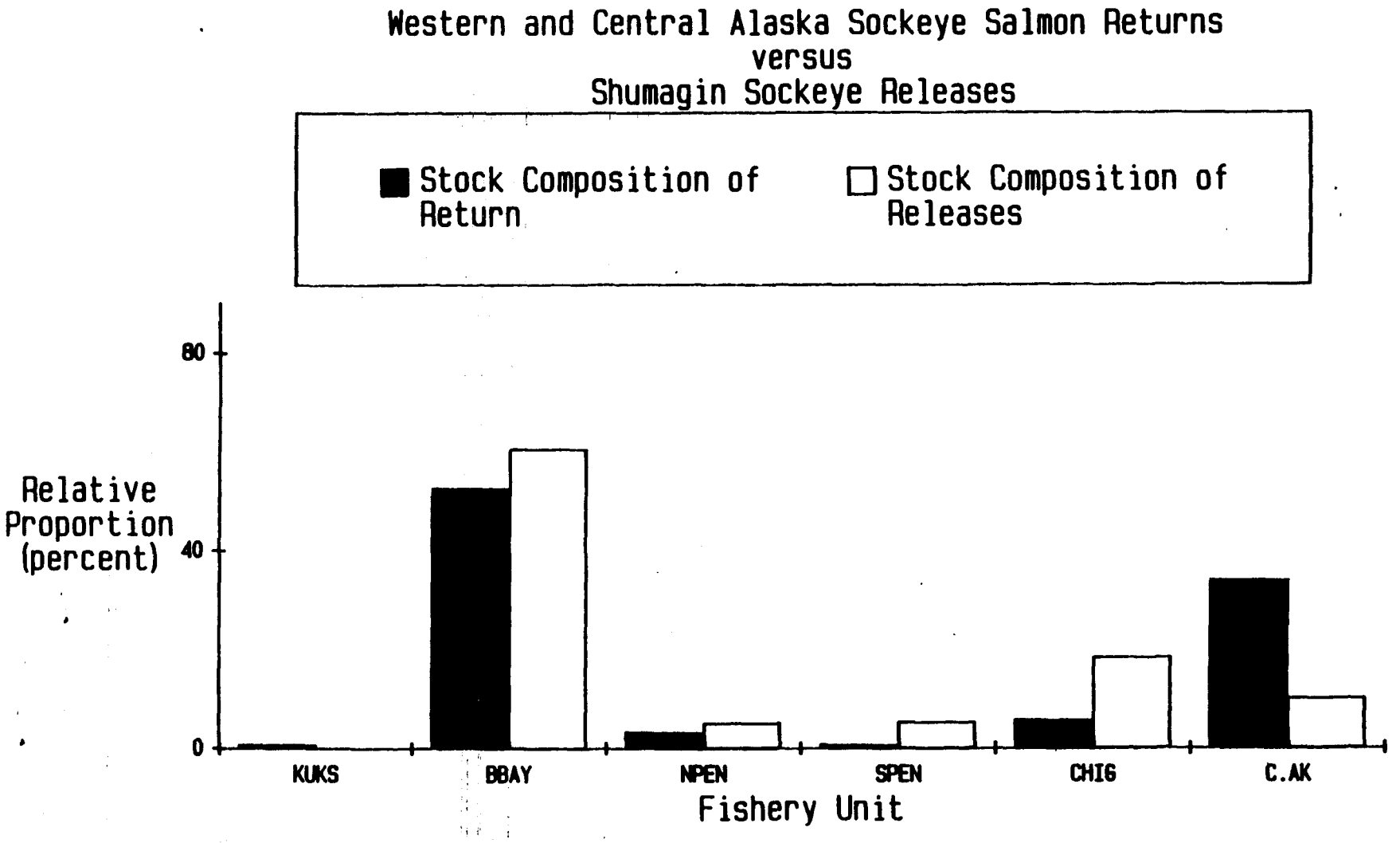

Figure 9. Stock composition (% of total return) of Western and Central Alaska sockeye returns versus stock composition (% of surviving releases) of Shumagin releases of sockeye salmon, for various fishery units.

return of sockeye salmon. These comparisons were made for Kuskokwim, Bristol Bay, North Peninsula, South Peninsula July, Chignik and central Alaska (ie Kodiak, Cook Inlet, and Prince William Sound) stocks of sockeye (Figure 7, 8, and 9). For the combined releases, the stock composition of the releases was higher than the respective relative abundance for Bristol Bay, North Peninsula, and South Peninsula July (Figure 7). For Chignik and central Alaska stocks the stock composition of the releases was lower than respective relative abundance (Figure 7).

The stock composition of the Unimak releases (Figure 8) was different from the stock composition of the Shumagin releases (Figure 9). Bristol Bay constituted the vast majority (almost 90%) of the Unimak releases. Whereas, Bristol Bay was a smaller component (60.6%) of the Shumagin releases. The North Peninsula, South Peninsula, Chignik, and central Alaska (ie. Kodiak, Cook Inlet, and Prince William Sound) stocks were collectively more important in the Shumagin releases, contributing 40% of the Shumagin releases compared to 10% in the Unimak releases. This indicated that the stocks of sockeye salmon closest to the South Peninsula June fishery were more vulnerable to the fishery.

Apportionment of the Chum Salmon Population Released in the Area of the South Peninsula June Fishery

Recoveries in Western and Central Alaska Chum Salmon Returns.

The recoveries from catches in western and central Alaska salmon fisheries returns obtained through the voluntary program were expanded to tagged fish in the return. Worksheets were constructed that accomplished this expansion, for the combined Unimak and Shumagin releases (Table 16), the Unimak releases (Table 17), and the Shumagin releases (Table 18). Reported fractions estimated in the fishery sampling program (Table 11) were used to expand the respective fishery unit voluntary recoveries to account for tags that were caught but not reported to ADF&G. The estimated recoveries in the catch were expanded to represent the entire return by dividing by the rate of exploitation (ie the catch divided by the total return).

As an example of this procedure, consider the expansion of the tags from combined Unimak and Shumigan Districts that were reported from Yukon Fall chum salmon fishery catches (Table 16). Six voluntary recoveries were reported for Yukon fall chum salmon. Assuming that the voluntary recoveries represent 53.5% of the tagged fish actually caught, then 11 tagged fish were actually caught by Yukon River fishermen. The commercial and subsistence harvests of fall chum salmon in the entire Yukon River drainage was 290 thousand fish and the total estimated return was 745 thousand fish. Since this harvest represented 38.9% of the total return, there were estimated to be 11 / 0.389

Table 16. Apportionment of released chum salmon population to various Western and Central Alaska fisheries, combined Unimak and Shumagin releases.

Fishery	Return (thousands)				Estimated Recoveries in Catches Based on Voluntary Recoveries			Estimated Tagged Fish in Population	
	Catch	Escapement	Total	% of W. & C. Alaska Return	Unadj. Recovs.	Reported Fraction	Adj. Recovs.	Number of Fish	Prop. of Tagged Pop.
Kotzebue	159	41	200	1.4%	3	53.5%	6	7	0.4%
Norton Sound	118	60	178	1.2%	10	53.5%	19	28	1.6%
Yukon									
Summer Run	827	499	1,326	9.0%	19	53.5%	36	57	3.3%
Fall Run	290	455	745	5.1%	6	53.5%	11	29	1.7%
Total	1,117	954	2,071	14.1%				86	5.0%
Kuskokwim									
Kuskokwim Bay	30	54	84	0.6%	8	53.5%	15	42	2.4%
Kuskokwim River	640	527	1,167	8.0%	139	53.5%	260	474	27.6%
Total	670	581	1,251	8.5%				516	30.1%
Bristol Bay									
Togiak	422	392	814	5.6%	89	85.0%	105	202	11.8%
Nushagak	403	233	636	4.3%	170	85.0%	200	315	18.4%
Naknek/Kvichak	441	639	1,080	7.4%	38	85.0%	45	109	6.4%
Egegik	148	36	184	1.3%	16	85.0%	19	23	1.4%
Ugashik	96	31	127	0.9%	11	85.0%	13	17	1.0%
Total	1,510	1,331	2,841	19.4%				667	38.9%
Aleutian Islands	0	1	1	0.0%	0	100.0%	0	0	0.0%

Table 16 (Continued). Apportionment of released chum salmon population to various Western and Central Alaska fisheries, combined Unimak and Shumagin releases.

Fishery	Return (thousands)				Estimated Recoveries in Catches Based on Voluntary Recoveries			Estimated Tagged Fish in Population	
	Catch	Escapement	Total	% of W. & C. Alaska Return	Unadj. Recovs.	Reported Fraction	Adj. Recovs.	Number of Fish	Prop. of Tagged Pop.
North Peninsula									
Northern District	155	165	320	2.2%	37	89.1%	42	86	5.0%
Northwestern District	176	367	543	3.7%	20	89.1%	22	69	4.0%
Total	331	532	863	5.9%				155	9.0%
South Peninsula June									
Unimak(Southwestern)	406	0	406	2.8%	75	100.0%	75	75	---
Shumagin	37	0	37	0.3%	2	100.0%	2	2	---
S.E. Mainland	3	0	3	0.0%	0	100.0%	0	0	---
Total	446	0	446	3.0%				77	---
South Peninsula July									
Southwestern	216	392	608	4.1%	17	79.4%	21	60	3.5%
Southcentral	198	138	336	2.3%	30	79.4%	38	64	3.7%
Shumagin	311	16	327	2.2%	18	79.4%	23	24	1.4%
S.E. Mainland	241	150	391	2.7%	20	79.4%	25	41	2.4%
Total	966	696	1,662	11.3%				189	11.0%
Chignik	127	81	208	1.4%	10	53.9%	19	30	1.8%
Kodiak	682	798	1,480	10.1%	4	53.9%	7	16	0.9%
Cook Inlet	506	715	1,221	8.3%	4	53.9%	7	18	1.0%
Prince William Sound	1,920	319	2,239	15.3%	1	53.9%	2	2	0.1%
All Areas Combined	12,922	9,622	14,661					1,792	

Table 17. Apportionment of the released chum salmon population to various western and central Alaska fisheries, Unimak releases.

Fishery	Return (thousands)				Estimated Recoveries in Catches Based on Voluntary Recoveries			Estimated Tagged Fish in Population	
	Catch	Escapement	Total	% of W. & C. Alaska Return	Unadj. Recovs.	Reported Fraction	Adj. Recovs.	Number of Fish	Prop. of Tagged Pop.
Kotzebue	159	41	200	1.4%	2	53.5%	4	5	0.4%
Norton Sound	118	60	178	1.2%	6	53.5%	11	17	1.5%
Yukon									
Summer Run	827	499	1,326	9.0%	14	53.5%	26	42	3.7%
Fall Run	290	455	745	5.1%	2	53.5%	4	10	0.9%
Total	1,117	954	2,071	14.1%				52	4.6%
Kuskokwim									
Kuskokwim Bay	30	54	84	0.6%	6	53.5%	11	31	2.8%
Kuskokwim River	640	527	1,167	8.0%	94	53.5%	176	320	28.4%
Total	670	581	1,251	8.5%				352	31.2%
Bristol Bay									
Togiak	422	392	814	5.6%	69	85.0%	81	157	13.9%
Nushagak	403	233	636	4.3%	132	85.0%	155	245	21.7%
Naknek/Kvichak	441	639	1,080	7.4%	23	85.0%	27	66	5.9%
Egegik	148	36	184	1.3%	12	85.0%	14	18	1.6%
Ugashik	96	31	127	0.9%	8	85.0%	9	12	1.1%
Total	1,510	1,331	2,841	19.4%				498	44.2%
Aleutian Islands	0	1	1	0.0%	0	100.0%	0	0	0.0%

Table 17 (Continued). Apportionment of the released chum salmon population to various western and central Alaska fisheries, Unimak releases.

Fishery	Return (thousands)				Estimated Recoveries in Catches Based on Voluntary Recoveries			Estimated Tagged Fish in Population	
	Catch	Escapement	Total	% of W. & C. Alaska Return	Unadj. Recovs.	Reported Fraction	Adj. Recovs.	Number of Fish	Prop. of Tagged Pop.
North Peninsula									
Northern District	155	165	320	2.2%	25	89.1%	28	58	5.1%
Northwestern District	176	367	543	3.7%	18	89.1%	20	62	5.5%
Total	331	532	863	5.9%				120	10.7%
South Peninsula June									
Unimak(Southwestern)	406	0	406	2.8%	37	100.0%	37	37	---
Shumagin	37	0	37	0.3%	0	100.0%	0	0	---
S.E. Mainland	3	0	3	0.0%	0	100.0%	0	0	---
Total	446	0	446	3.0%				37	---
South Peninsula July									
Southwestern	216	392	608	4.1%	6	79.4%	8	21	1.9%
Southcentral	198	138	336	2.3%	10	79.4%	13	21	1.9%
Shumagin	311	16	327	2.2%	4	79.4%	5	5	0.5%
S.E. Mainland	241	150	391	2.7%	13	79.4%	16	27	2.4%
Total	966	696	1,662	11.3%				75	6.6%
Chignik	127	81	208	1.4%	1	53.9%	2	3	0.3%
Kodiak	682	798	1,480	10.1%	0	53.9%	0	0	0.0%
Cook Inlet	506	715	1,221	8.3%	1	53.9%	2	4	0.4%
Prince William Sound	1,920	319	2,239	15.3%	1	53.9%	2	2	0.2%
All Areas Combined	8,552	6,109	14,661					1,164	

Table 18. Apportionment of the released chum salmon population to various western and central Alaska fisheries, Shumagin releases.

Fishery	Return (thousands)				Estimated Recoveries in Catches Based on Voluntary Recoveries			Estimated Tagged Fish in Population	
	Catch	Escapement	Total	% of W. & C. Alaska Return	Unadj. Recovs.	Reported Fraction	Adj. Recovs.	Number of Fish	Prop. of Tagged Pop.
Kotzebue	159	41	200	1.4%	1	53.5%	2	2	0.4%
Norton Sound	118	60	178	1.2%	4	53.5%	7	11	1.9%
Yukon									
Summer Run	827	499	1,326	9.0%	5	53.5%	9	15	2.6%
Fall Run	290	455	745	5.1%	4	53.5%	7	19	3.3%
Total	1,117	954	2,071	14.1%				34	5.8%
Kuskokwim									
Kuskokwim Bay	30	54	84	0.6%	2	53.5%	4	10	1.8%
Kuskokwim River	640	527	1,167	8.0%	45	53.5%	84	153	26.1%
Total	670	581	1,251	8.5%				164	27.9%
Bristol Bay									
Togiak	422	392	814	5.6%	20	85.0%	24	45	7.7%
Nushagak	403	233	636	4.3%	38	85.0%	45	71	12.0%
Naknek/Kvichak	441	639	1,080	7.4%	15	85.0%	18	43	7.4%
Egegik	148	36	184	1.3%	4	85.0%	5	6	1.0%
Ugashik	96	31	127	0.9%	3	85.0%	4	5	0.8%
Total	1,510	1,331	2,841	19.4%				170	28.9%
Aleutian Islands	0	1	1	0.0%	0	100.0%	0	0	0.0%

Table 18 (Continued). Apportionment of the released chum salmon population to various western and central Alaska fisheries, Shumagin releases.

Fishery	Return (thousands)				Estimated Recoveries in Catches Based on Voluntary Recoveries			Estimated Tagged Fish in Population	
	Catch	Escapement	Total	% of W. & C. Alaska Return	Unadj. Recovs.	Reported Fraction	Adj. Recovs.	Number of Fish	Prop. of Tagged Pop.
North Peninsula									
Northern District	155	165	320	2.2%	12	89.1%	13	28	4.7%
Northwestern District	176	367	543	3.7%	2	89.1%	2	7	1.2%
Total	331	532	863	5.9%				35	5.9%
South Peninsula June									
Unimak(Southwestern)	406	0	406	2.8%	38	100.0%	38	38	---
Shumagin	37	0	37	0.3%	2	100.0%	2	2	---
S.E. Mainland	3	0	3	0.0%	0	100.0%	0	0	---
Total	446	0	446	3.0%				40	---
South Peninsula July									
Southwestern	216	392	608	4.1%	11	79.4%	14	39	6.6%
Southcentral	198	138	336	2.3%	20	79.4%	25	43	7.3%
Shumagin	311	16	327	2.2%	14	79.4%	18	19	3.2%
S.E. Mainland	241	150	391	2.7%	7	79.4%	9	14	2.4%
Total	966	696	1,662	11.3%				115	19.5%
Chignik	127	81	208	1.4%	9	53.9%	17	27	4.7%
Kodiak	682	798	1,480	10.1%	4	53.9%	7	16	2.7%
Cook Inlet	506	715	1,221	8.3%	3	53.9%	6	13	2.3%
Prince William Sound	1,920	319	2,239	15.3%	0	53.9%	0	0	0.0%
All Areas Combined	8,552	6,109	14,661					627	

or 29 tagged fish in the Yukon fall chum return.

This procedure was repeated for each fishery in western and central Alaska. The total number of tagged chum salmon that could be accounted for in the western and central Alaska return totaled 1,791. This figure includes 77 tags that were recaptured in the South Peninsula June fisheries.

Releases not Accounted For.

There were 6,323 chum salmon released in the Unimak and Shumagin Districts. Thus, 4,531 released fish could not be accounted for in the western and central Alaska returns of chum salmon. Earlier tagging work indicated that Asian stocks occurred in the area of the South Peninsula June fishery. This result has been verified in the 1987 tagging study with 36 tags recaptured in Japanese coastal fisheries and 11 tags recaptured in USSR coastal fisheries (Table 5). The tags recovered from Japanese coastal fisheries originated from Japanese hatchery stocks which were not developed at the time of the earlier tagging work. Soviet stocks of chum salmon were important contributors in the earlier work. Estimates of total return were not available for Asian stocks of chum salmon. Thus, there was no direct means to estimate the Asian contribution to the 1987 South Peninsula tag releases.

For chum salmon, the releases not accounted for include both tagging mortality and Asian stocks. Tagging mortality rates estimated for sockeye salmon were applied to the chum salmon releases. Releases that could not be accounted for in western and central Alaska chum salmon returns and in tagging mortality (Table 19) were assumed to be Asian contribution. The tagging mortality rate estimated for chum salmon (35.8%) was the average of the tagging mortality rate observed for the Unimak and Shumagin sockeye releases weighted by the respective proportions of chum salmon released in the two areas.

Of the combined Unimak and Shumagin releases, 2,268 tags could not be accounted for in total returns to western and central Alaska or tagging mortality. Assuming these releases were of Asian origin, then the Asian contribution to the combined Unimak and Shumagin releases was 57%.

Estimates of Stock Composition for the Chum Salmon Releases.

Stock composition estimates for the combined Unimak and Shumagin, Unimak, and Shumagin sockeye releases (Table 19) were calculated assuming that tagging mortality was not stock specific. These were calculated in two ways. In the first method, the stock composition for a given fishery unit was the number of releases estimated in the respective return divided by the total releases less tagging mortality and estimated recaptures in the South

Table 19. Summary of results of 1987 South Peninsula tagging study for chum salmon. Included are numbers and proportions of tagged fish in returns to various Western and Central Alaska salmon fisheries and tagged fish dying from tagging mortality, and Asian stocks.

Fishery	Combined Releases			Unimak Releases			Shumagin Releases		
	Numbers of Tagged Fish in Return	Proportion With Asian Stocks	Proportion Without Asian Stocks	Numbers of Tagged Fish in Return	Proportion With Asian Stocks	Proportion Without Asian Stocks	Numbers of Tagged Fish in Return	Proportion With Asian Stocks	Proportion Without Asian Stocks
Kotzebue	7	0.2%	0.4%	5	0.2%	0.4%	2	0.1%	0.3%
Norton Sound	28	0.7%	1.6%	17	0.8%	1.5%	11	0.6%	1.9%
Yukon Summer	57	1.4%	3.3%	42	1.9%	3.7%	15	0.8%	2.6%
Yukon Fall	29	0.7%	1.7%	10	0.5%	0.9%	19	1.1%	3.2%
Kuskokwim	516	13.0%	30.1%	352	16.0%	31.2%	164	9.2%	27.9%
Bristol Bay	667	16.8%	38.9%	498	22.6%	44.1%	170	9.6%	29.0%
North Peninsula	155	3.9%	9.0%	120	5.4%	10.6%	35	2.0%	6.0%
South Peninsula July	189	4.7%	11.0%	75	3.4%	6.6%	115	6.5%	19.6%
Other Stocks	66	1.7%	3.9%	9	0.4%	0.8%	56	3.2%	9.5%
Total Alaskan Stocks	1714	43.0%	100.0%	1128	51.1%	100.0%	587	33.1%	100.0%
Tagging Mortality	2264	---		1252	---		1012	---	
South Peninsula June Fishery Removals	77	---		37	---		40	---	
Asian Stocks	2268	57.0%		1078	48.9%		1189	66.9%	
Total Releases	6323			3495			2828		
Surviving Releases	3982			2206			1776		
Tagging Mortality Rate	35.8%			35.8%			35.8%		

Peninsula June fishery (proportion without Asian stocks in Table 19). Note that the divisor was the estimated number of tagged fish surviving to return to western and central Alaska areas, and was less than the releases surviving the tagging operation, because of documented occurrence of Asian stocks in the releases. Thus, the Asian contribution was treated as mortality and the estimates of stock composition for western and central Alaskan stocks ignoring the Asian contribution were higher than the true value of stock composition.

In the second method that stock composition estimates were calculated, the number of releases estimated in the respective return was divided by the estimated number surviving releases including Asian stocks (proportion with Asian stocks in Table 19). The stock composition estimates were lower, because of the high (57%) Asian contribution.

The estimate of Asian contribution was higher than past estimates. It is impossible, without comprehensive sampling of Soviet stocks of chum salmon, to verify the Asian contribution rates. There is no question that the recovery rate for chum salmon was lower than that observed for sockeye salmon. This could be due to high Asian contribution, higher tagging mortality, or low estimates of spawning escapement levels for western and central Alaskan chum salmon stocks. In view of this uncertainty, the true stock composition values for the releases probably lie between the high and low values provided in Table 19. In subsequent discussions, the high estimates of stock composition are used, recognizing that these estimates reflect upper bounds on actual value for western and central Alaska stock composition of the South Peninsula June fishery catches.

Bristol Bay and Kuskokwim stocks dominated the chum salmon releases accounting for 38.9% and 30.1% of the combined area releases, respectively. The stock composition of the chum salmon releases were also compared to relative abundance as indexed by the respective fishery unit return as a proportion of the total western and central Alaska return of chum salmon. These comparisons were made for Kotzebue, Norton Sound, Yukon summer, Yukon fall, Kuskokwim, Bristol Bay, North Peninsula, South Peninsula July, Chignik and central Alaska (ie Kodiak, Cook Inlet, and Prince William Sound) stocks of chum salmon (Figure 10, 11, and 12). For the combined releases, the stock composition of the releases was higher than the respective relative abundance for Kuskokwim, Bristol Bay, and North Peninsula, (Figure 10). For Yukon fall, Yukon summer, South Peninsula july, Chignik and central Alaska stocks the stock composition of the releases was lower than respective relative abundance (Figure 10).

The stock composition of the Unimak releases (Figure 11) was different from the stock composition of the Shumagin releases (Figure 12). Kuskokwim, Bristol Bay, and North Peninsula constituted vast majority (almost 86.2%) of the Unimak releases.

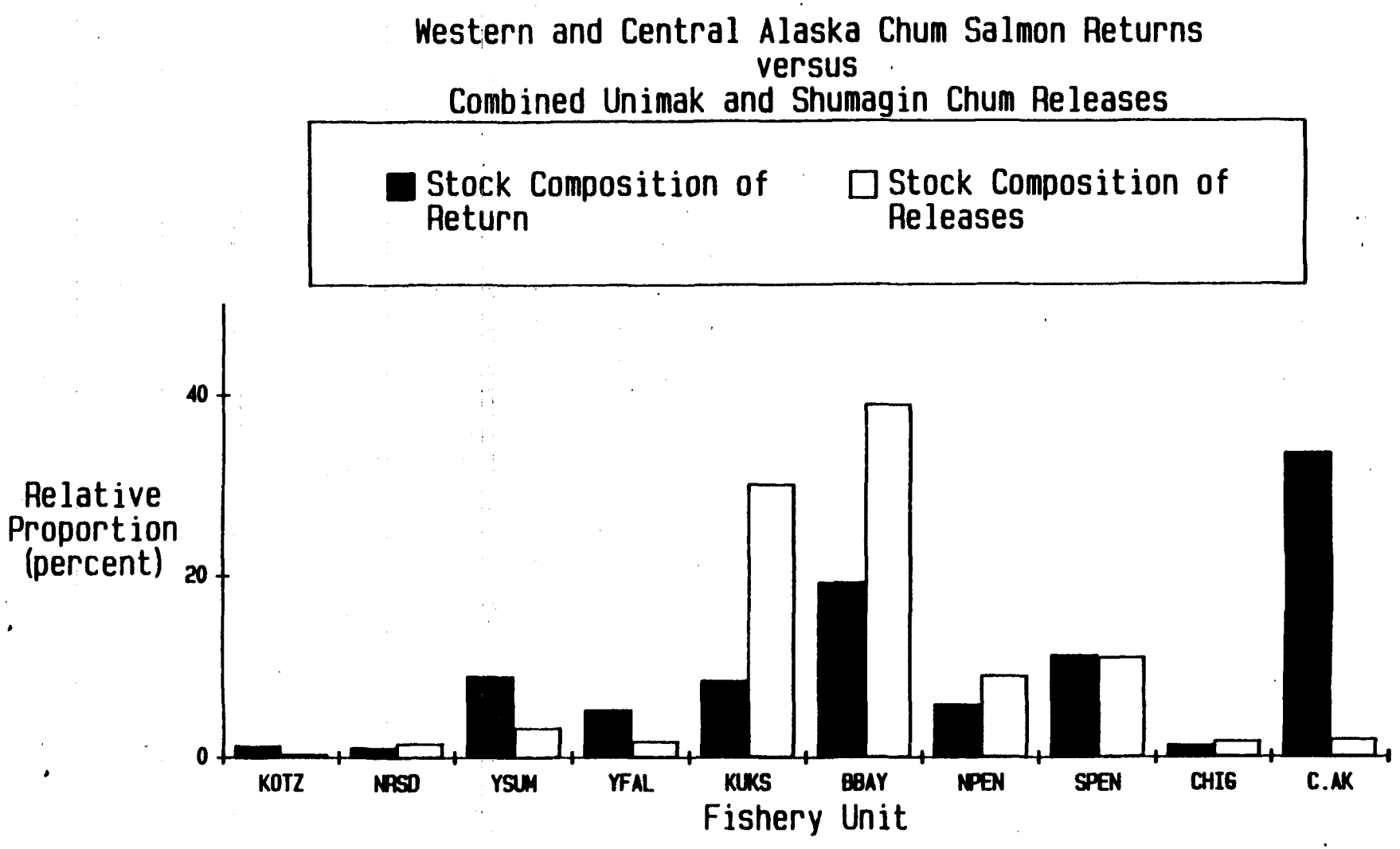

Figure 10. Stock composition (% of total return) of Western and Central Alaska chum returns versus stock composition (% of surviving releases less estimated Asian stocks) of combined Unimak and Shumagin releases of chum salmon, for various fishery units.

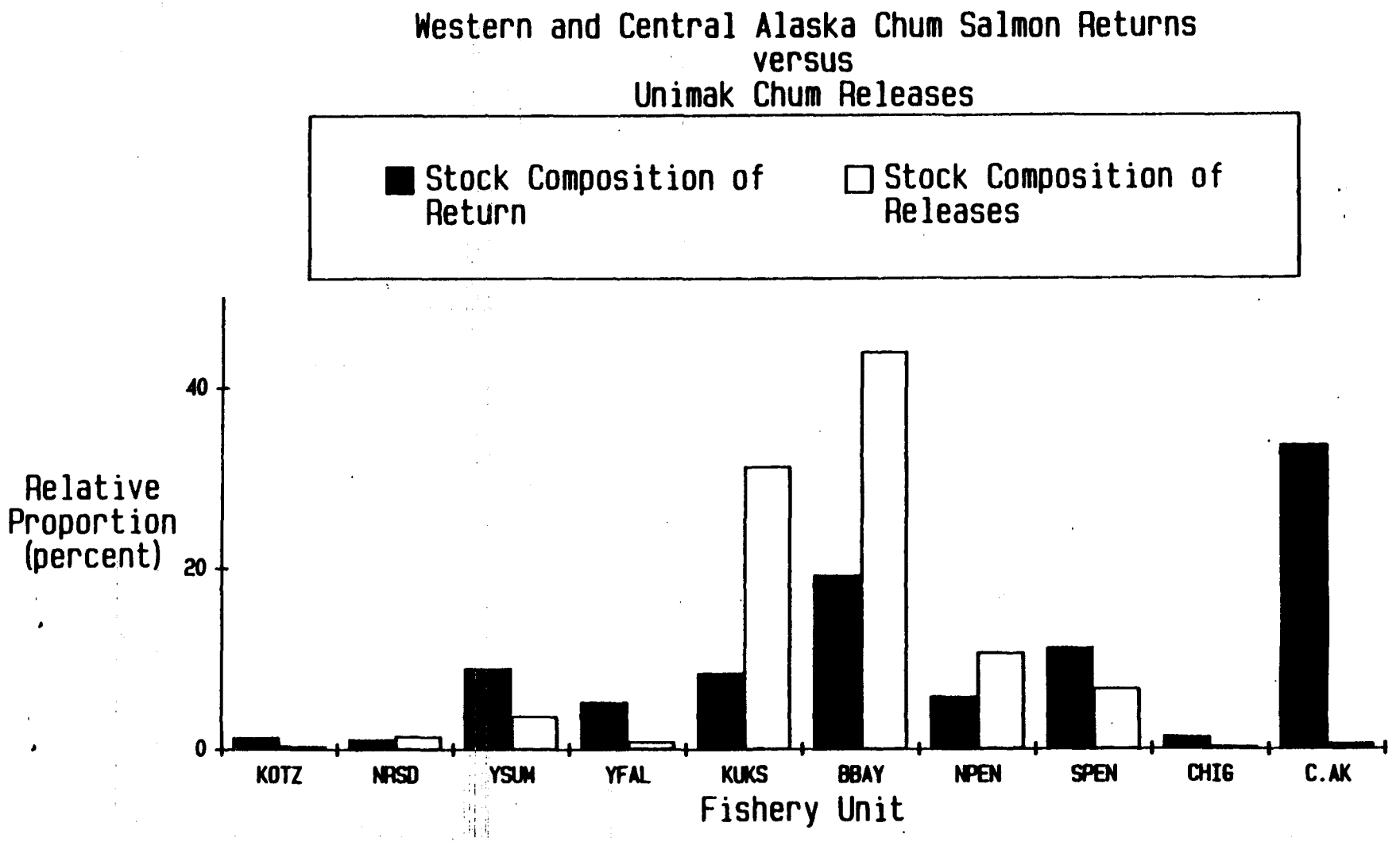

Figure 11. Stock composition (% of total return) of Western and Central Alaska chum returns versus stock composition (% of surviving releases less estimated Asian stocks) of Unimak releases of chum salmon, for various fishery units.

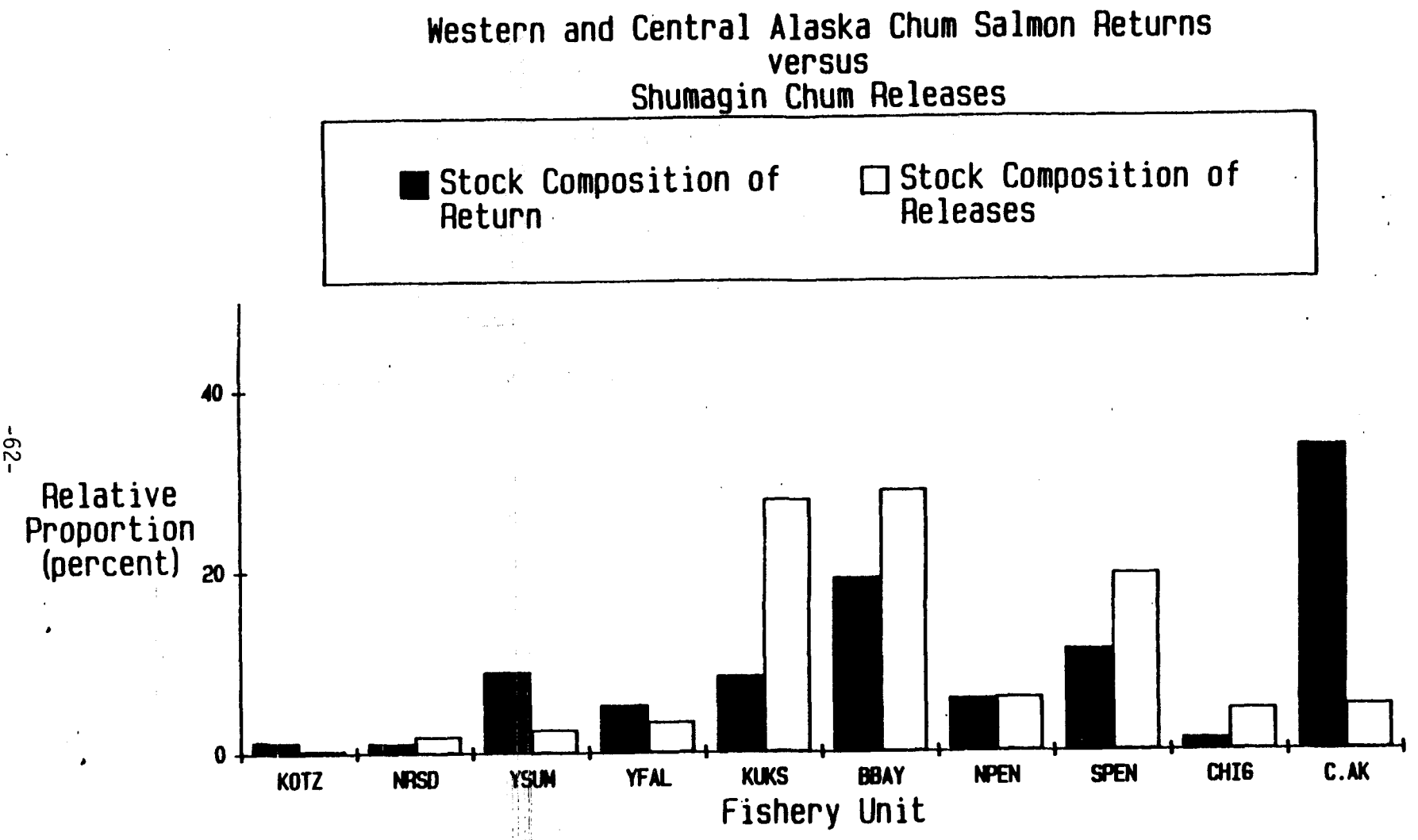

Figure 12. Stock composition (% of total return) of Western and Central Alaska chum returns versus stock composition (% of surviving releases less estimated Asian stocks) of Shumagin releases of chum salmon, for various fishery units.

Whereas, Kuskokwim, Bristol Bay, and North Peninsula were a smaller component (62.8%) of the Shumagin releases. The South Peninsula, Chignik, and central Alaskan stocks were collectively more important in the Shumagin releases, contributing 29.1 of the Shumagin releases compared to 7.5% in the Unimak releases. This indicated that the stocks closest to the South Peninsula fishery were more vulnerable to the fishery. Stocks that are north of the Alaska Peninsula showed greater representation in the Unimak releases and less in the Shumagin releases. Presence of stocks east of Unimak Island showed greater representation in the Shumagin releases and less in the Unimak releases.

Run Timing

Detailed timing statistics by species, fishery unit, and district within fishery unit for both Shumagin and Unimak releases are presented in Appendix F. Included are mean and range for date of release, mean and range for date of recovery, mean and range for travel times (days) from the release to recovery for both sockeye and chum salmon recoveries. Recoveries for which the exact date and location of recovery could not be verified were excluded unless otherwise noted.

The timing statistics for the combined area releases were summarized by fishery unit for chum salmon (Table 20) and for sockeye salmon (Table 21). The mean date of release for the combined area recoveries were compared (t-test) to mean date of release of the combined Unimak and Shumagin releases. Significant differences among stocks would indicate differential timing in the area of the South Peninsula June fishery.

No differences in the timing in the South Peninsula area were found among chum salmon stocks, except for Kuskokwim River (Table 20). The mean date of release for Kuskokwim River recoveries were 2.3 days earlier and this difference was statistically significant because of the large number of recoveries. However, the magnitude (2.3 days) of the difference is small compared to the 25 day breadth of the tag releases. The Kotzebue (mean 9 days later than combined area releases) and Yukon summer (mean 5.9 days earlier than combined area releases) chum stocks exhibited the greatest absolute difference in timing in the South Peninsula area. However, these were not statistically significant because of low number of recoveries in the terminal areas. It is clear that almost no differences in the time of occurrence in the area of the South Peninsula June fishery occurred for western and central Alaska chum salmon stocks. The overlap in timing is very apparent in box and whisker plots of the distribution of release dates for recoveries in various chum salmon stocks (Figure 13). Box and whisker plots show the range, the median, and middle 50% (ie. that between the lower and upper quartiles) of the data.

The mean date of release for the combined area chum salmon recoveries were compared (t-test) to mid-point of the combined

Table 20. Timing statistics for 1987 tag releases of chum salmon in the area of the South Peninsula June fishery. Also shown are statistical significance for simple (t - test) comparison of mean date of release for recoveries in respective Fishery Unit with the the mean date of release for Combined Unimak and Shumagin releases as well as with the mid-point of the combined Unimak and Shumagin District catches.

Fishery Unit of Recovery	Mean Date of Release	Std. Dev. (days)	Number of Recoveries	Significance: With Date of Release of Marked Pop.	Significance: With Mid-Point of Catches
Kotzebue	July 1.5	0.71	2	NS	* p < .05
Norton Sound	June 21.1	4.8	10	NS	NS
Yukon Summer	June 17.6	5.5	19	NS	NS
Yukon Fall	June 22.8	5.8	6	NS	NS
Kuskokwim River	June 21.2	4.9	139	* p < .05	* p < .05
Kuskokwim Bay	June 21.7	5	7	NS	NS
Bristol Bay	June 23.9	4.3	316	NS	* p < .05
North Penisula	June 23.6	5.7	57	NS	* p < .05
Japan	June 22.8	6.9	32	NS	* p < .05
Combined District Releases	June 23.5				
Combined District Catches	June 19.0				
Unimak Releases	June 22.8				
Unimak Catches	June 19.1				
Shumagin Releases	June 24.4				
Shumagin Catches	June 17.8				

Table 21. Timing statistics for 1987 tag releases of sockeye salmon in the area of the South Peninsula June fishery. Also shown are statistical significance for simple (t - test) comparison of mean date of release for recoveries in respective Fishery Unit with the the mean date of release for Combined Unimak and Shumagin releases as well as with the mid-point of the combined Unimak and Shumagin District catches.

Fishery Unit of Recovery	Mean Date of Release	Std. Dev. (days)	Number of Recoveries	Significance: With Date of Release of Marked Pop.	Significance: With Mid-Point of Catches
Kuskokwim River	June 15.5	5	4	NS	NS
Bristol Bay	June 24.4	4.65	1078	* $p < .05$	* $p < .05$
North Penisula	June 21.0	5.7	120	* $p < .05$	* $p < .05$
Chignik	June 19.0	5.9	73	* $p < .05$	NS
Kodiak	June 16.3	7.49	21	* $p < .05$	NS
Cook Inlet	June 22.25	4.65	4	NS	NS
Combined District Releases	June 22.6				
Combined District Catches	June 19.5				
Unimak Releases	June 23.5				
Unimak Catches	June 19.8				
Shumagin Releases	June 19.4				
Shumagin Catches	June 18.0				

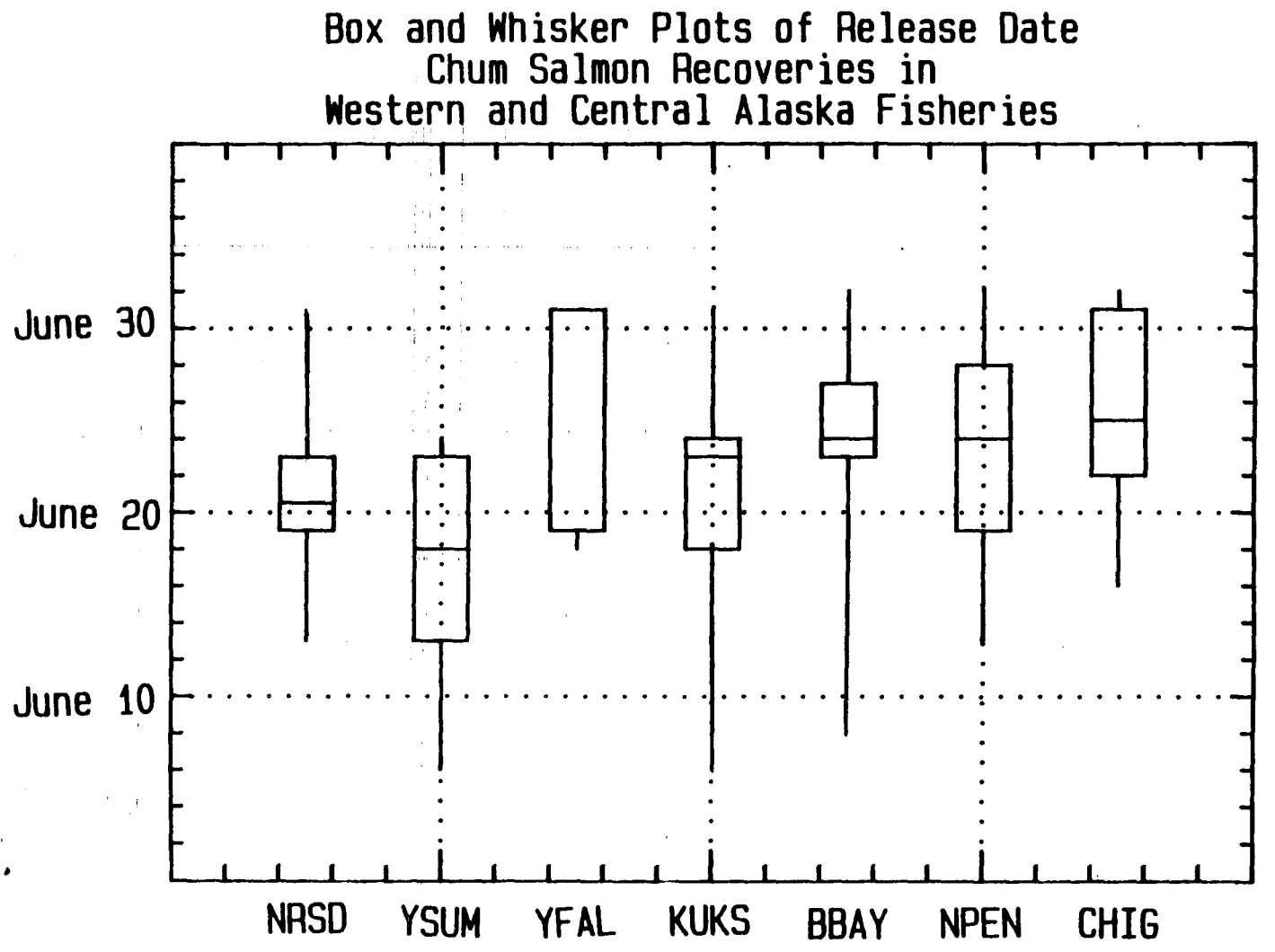

Figure 13. Range, central 50% of the distribution, and median (Box and Whisker plot) of release date for chum salmon recoveries of Norton Sound, Yukon fall, Yukon summer, Kuskokwim, Bristol Bay, North Peninsula and Chignik stocks.

Unimak and Shumagin chum salmon catches, by fishery unit (Table 20). There were statistical differences whenever tag recoveries were greater than 30 tags. These differences occurred because the mean date of release for combined area releases was 4.5 days greater than the mid-point of the combined Unimak and Shumigan catches. Therefore, the releases are not entirely representative of the South Peninsula June fishery catches. The effect of the late date of tag release on estimates of stock composition was small, in view of the small or non-existing difference in timing among stocks that had large numbers of recoveries in terminal areas.

In contrast to chum salmon, significant differences in the timing in the South Peninsula area were found among sockeye salmon stocks, (Table 21). The Bristol Bay stocks were 1.8 days later than the combined area releases. North Peninsula, Chignik, and Kodiak sockeye stocks were 1.6, 3.6, and 6.3 days earlier than the combined area releases. There was substantial separation in the central 50% of the distribution of release date for Bristol Bay recoveries and the central 50% of the distribution of release date for North Peninsula, Chignik, and Kodiak recoveries, (Figure 14).

The mean date of release for combined area sockeye releases was 3.1 days later than the mid-point of the combined Unimak and Shumigan catches. Therefore, the releases were not entirely representative of the South Peninsula June fishery catches of sockeye. Because of these differences the estimates of stock composition for the fishery catches based on the stock composition of the releases was biased in favor of the stocks with later timing in the South Peninsula Area. Thus the estimates of the proportion of Bristol Bay stocks was likely to be higher than the true proportions, and the estimates of proportions of North Peninsula, Chignik, and Kodiak was likely to be lower than the true proportions. However in view of the breadth of releases and dominance of the Bristol Bay recoveries, this bias was not significant.

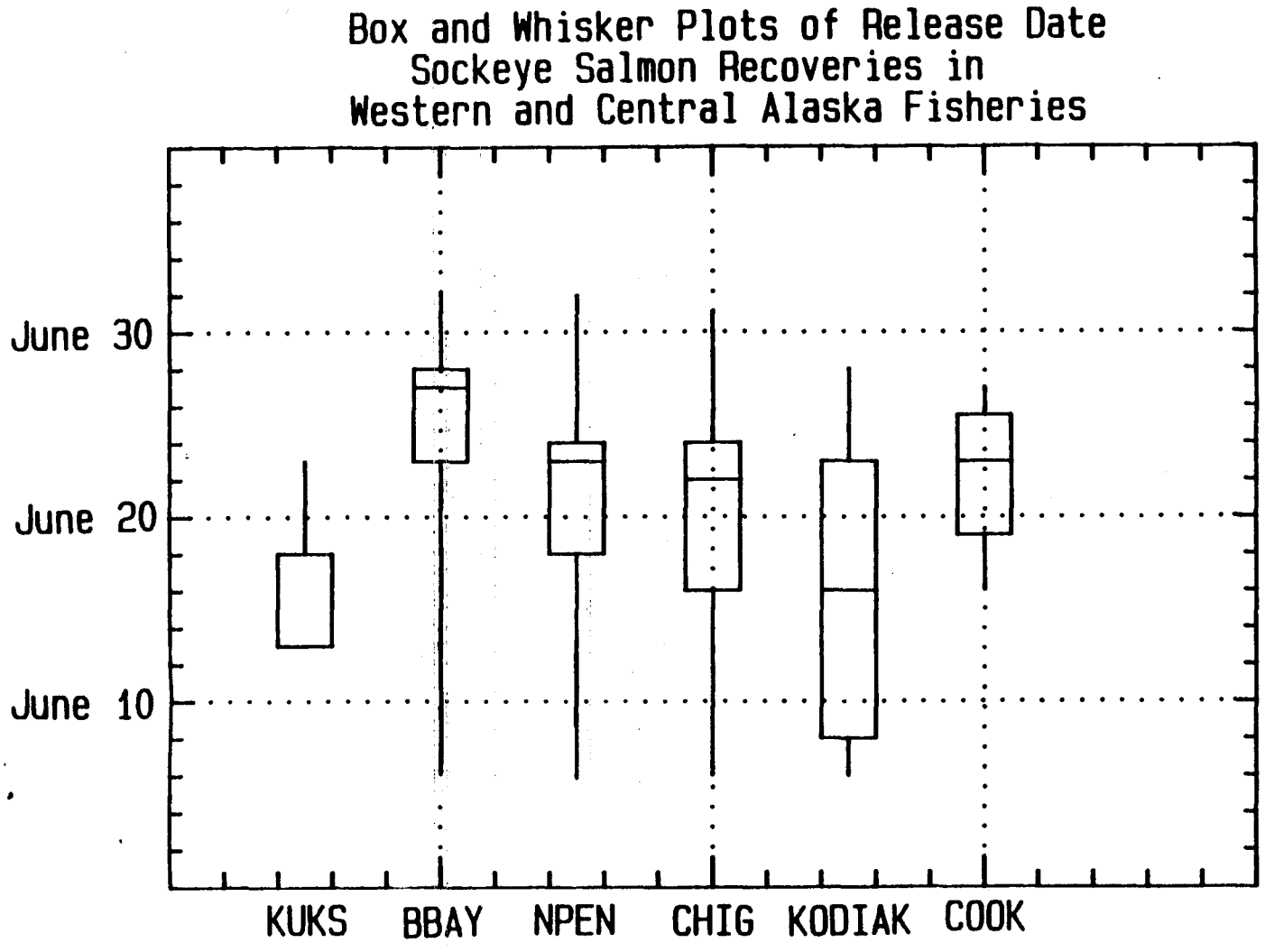

Figure 14. Range, central 50% of the distribution, and median (Box and Whisker plot) of release date for sockeye salmon recoveries of Kuskokwim, Bristol Bay, North Peninsula, Chignik, Kodiak, and Cook Inlet stocks.

DISCUSSION

The discussion is restricted to the estimates of Yukon fall chum composition of the tag releases in the area of the South Peninsula June fishery. The estimates of stock composition for Yukon fall chum salmon was 0.7% to 1.7% (Table 19) of the combined Unimak and Shumagin releases. The 1.7% reflects an upper limit, and was based on some assumptions which tended to inflate the estimate. First, the 1.7% value assumes there was no occurrence of stocks of Asian origin in the 1987 releases. This assumption is false based on the 36 tags returned from Japanese coastal fisheries, the 11 tags returned from USSR coastal fisheries, and the very low tag recovery rate compared with that achieved for sockeye salmon. This assumption may result in a two-fold inflation of estimates for western and central Alaska stock composition.

Secondly, the 1.7% value reflects an estimate of 29 tags occurring in the Yukon fall chum return. The 29 tags was based on an expansion of 6 voluntary recoveries. However, this estimate contrasts with the 6 tags estimated to occur in the Yukon fall chum return based on the collective sampling of 16 percent of Yukon fall chum return (Table 9) for tag recoveries. The 29 tag estimate was used to maintain consistency with methods used for other fishery units, and reflects a desire to provide an upper bound on the magnitude of the Yukon fall chum salmon interceptions in the South Peninsula June fishery.

The estimates of stock composition also assume that tagging mortality and/or tag loss occurs at the same rate for all stocks. Estimates of tag loss for spaghetti tags are thought to be minimal, especially when compared to alternative type tags such as disk tags. Mortality is assumed to occur soon after tagging and delayed mortality is assumed to be minimal. In experiments where captured and tagged fish have been held, mortality is immediate and delayed mortality is negligible. Unfortunately, in these experiments fish can not be held for extended periods because of confounding effects of disease and other manifestations of "tank effect".

The delayed mortality hypothesis been not been rigorously tested (Pella personal communication). Studies where mature sockeye were tagged with disk tags in terminal fishing areas and later recovered at distant (200 miles from release area) upstream weir sites, have demonstrated substantial mortality and/or tag losses of up to 80% occurring during the upstream spawning migration (Pella personal communication). However it is thought that these high estimates of mortality were due to high loss of the disk tags.

It is conceivable that stocks most distant from the release area may experience a higher tagging related mortality rate. If this were to occur, recoveries from more distant terminal fishing

areas would be under-represented because of higher mortality relative to less distant stocks. However, there is no compelling evidence for delayed stock-specific mortality tagging mortality.

Adoption of maximum estimate compensates for the possibility of delayed mortality and the 1.7% estimate of Yukon fall chum salmon composition is a reasonable upper bound to the actual stock composition.

The estimate of Yukon fall chum salmon stock composition of South Peninsula June fishery based on the 1987 tagging study was significantly lower than previous estimates. The previous estimate (unpublished report to the Alaska Board of fisheries 1986) was 10 %. This figure was the average Yukon fall chum harvest as a percentage of the total western Alaska chum salmon harvest, 1977 - 1985. The Yukon River harvest included both commercial and subsistence harvest. The western Alaska harvest included combined AYK commercial and subsistence catches and commercial catches for Bristol Bay, North Peninsula and South Peninsula.

The stock composition should reflect relative abundance. Estimates based on relative return magnitude rather than relative catch would be a better approximation of relative abundance if stocks were harvested at different rates. Although estimates of total return for western and central Alaska chum salmon returns are not available for years 1977 through 1985, the Yukon fall chum salmon return was probably harvested at a much greater rate than other western and central Alaska chum salmon stocks. If this were true, then relative catch would over estimate the relative abundance for heavily exploited stocks, and would explain the inconsistency of the tagging estimate of fall chum abundance with the earlier estimate.

However, estimates of 1987 Yukon fall chum stock composition based on relative western Alaska chum salmon catches (5.5%) and based on relative western Alaska chum salmon returns (7.8%) are higher than that based on tagging (1.7%). This indicates that the Yukon fall chum stocks are less vulnerable to the South Peninsula fishery than other western Alaska chum stocks, and less vulnerable than previously thought.

Recently, Rogers (1987) has analyzed the historical INPFC releases of maturing chum salmon in the North Pacific Ocean and Bering Sea. He compared the geographic area of releases for recoveries in various western fisheries with the geographic area of release for recoveries in the South Peninsula June fishery. Rogers (1987) found that the area of releases for chum salmon recovered in Bristol Bay and Kuskokwim River terminal areas coincided more with the release area for chum salmon caught in the South Peninsula June fishery than did releases of chum salmon bound for other western Alaska terminal harvest areas. The release area for Yukon Fall chum salmon tended to be further to

the south and to the west than the release area of chums caught in the South Peninsula June fishery. These results were consistent with the Kuskokwim and Bristol Bay chum stocks being dominant and the Yukon fall chum being under-represented in the 1987 South Peninsula tag releases.

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