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ESTIMATE OF CHUM SALMON (*ONCORHYNCHUS KETA*) OF JAPANESE ORIGIN CAUGHT IN THE U.S. JUNE FISHERY CONDUCTED IN THE SHUMAGIN/UNIMAK WATERS

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ABSTRACT

Based on the results of tagging experiments conducted by the Alaska Department of Fish and Game in 1987, we estimated the number of chum salmon of Japanese origin caught in the U.S. June fishery conducted in the Shumagin/Unimak waters. Because the chum salmon of Japanese origin experience a longer period between release and capture than the North American chum salmon, in this analysis, the time-dependent mortality and tag shedding are taken into consideration which were not considered by Eggers and Barrett (1988).

The results correspond fairly well with the results of scale pattern analysis by Conrad (1984). The incidental take rate of Japanese chum salmon by the U.S. fishery is estimated to be 0.9-7.9% in Unimak waters and 18.4-35.3% in Shumagin waters.

Based on our analysis and the results obtained by Eggers and Barrett (1988) and Conrad (1984), the average number of Japanese chum salmon caught by the U.S. June fishery in 1980-88 is estimated to be 4,000-114,000 in Unimak waters and 17,000-53,000 in Shumagin waters, a total of 21,000-167,000.

In this analysis, parameters such as mortality rates had to be assumed with wide range, and it is desirable that future estimates of these parameters have narrower confidence limits. Estimation methods in addition to tagging are suggested. These results also suggest that a significant number of Japanese chum salmon may be taken incidentally in the groundfish fishery in the U.S. 200 miles zone and the necessity of further study on this subject is pointed out.

1. Foreword

The Alaska Department of Fish and Game (ADFG) conducted a large-scale tagging experiment in 1987 to ascertain the origin of the chum and sockeye salmon caught in the waters of Shumagin/Unimak in June (Eggers and Barrett, 1988). In this research, actual tag recovery data are corrected by the proportion of tagged fish to fish caught by the Western and Central Alaska fisheries and it is possible to analyze the result quantitatively.

A total of 6,323 chum salmon were tagged and released under this program with 833 recaptures recorded, of which 36 recaptures were reported by the Japanese coastal set net fishery and 11 by the U.S.S.R. coastal fishery.

In this paper, the number of Japanese origin chum salmon intercepted by the U.S. June fishery were estimated using data collected by Eggers et al.

2. Method

Eggers and Barrett (1988) estimated the proportion of the origin of the chum salmon by the formulae below:

$$P_i = R_i \;/\; U_i \;(M - M_{mort} - M_{spf}) \quad \text{......................} \quad (1)$$

$$P^*_i = R_i \;/\; U_i \;(M - M_{mort} - M_{spf} - M_{asian}) \quad \text{..............} \quad (2)$$

here,

- P_i = the proportion of *i*th stock without consideration of the Asian origin
- P^*_i = the ratio of the *i*th stock with consideration of the Asian origin
- U_i = exploitation rate of the *i*th stock
- R_i = number of tagged fish in the catch from the *i*th stock (reported recaptures are corrected by sampling of the catch)
- M = number of tagged fish
- M_{mort} = number of tagged fish that died as a result of tagging (M_{mort} = 0.358M, using the estimate from the sockeye salmon)
- M_{spf} = number of the tagged fishes recaptured in the June fishery
- M_{asian} = number of tagged fish of Asian origin

where,

$$M_{asian} = M - M_{mort} - M_{spf} - \Sigma\, R_i \;/\; U_i \quad \text{.....................} \quad (3)$$

The proportion of the fish of Asian origin were estimated to be 48.9% for Unimak, and 66.9% for Shumagin from the formula (3) above.

The proportion of the fishes of the Asian origin estimated by Eggers and Barrett (1988) is, as it were, the value after subtraction of returning fishes to North America, the catch in the June fishery and tagging mortality, hence the error in the tagging mortality estimate, for example, is straightforwardly taken as the error of the fishes of the Asian origin. Apparently, they used the above method because the main purpose of their research was to estimate the relative proportion of origin within the North American fish.

Eggers and Barrett (1988) assumed that the tagging mortality only occurs immediately after the release without stock dependent variation, and adopted a constant mortality rate over all stocks. However, in the case of the salmon of Japanese origin, where longer time period lapses between the time of release and the time of recapture than the case of North American salmon, it is necessary to take into account the time dependent natural mortality and tag shedding.

In consideration of the above, the following formulae have been made by assuming two separate components that exist in the mortality and tag shedding, i.e. those occurring immediately after release which is time-independent, and those occurring during the elapse of time after release which is time-dependent.

$$R_i = M\ (1-I)\ U_i P'_i e^{(-mTi)} \quad \text{.............................. (4)}$$

$$\sum_{i=1} P'_i = 1 \quad \text{.. (5)}$$

where,

R_i = estimated number of recaptured tagged fish in the ith stock

M = number of tagged fish

I = time-independent mortality and tag shedding rate

m = time-dependent mortality and tag shedding coefficient (per day)

U_i = exploitation rate of the ith stock

P'_i = mixing rate of the ith stock

T_i = mean length of time between the release and recapture of the tagged fish of the ith stock

from (4) ... $P'_i = R_i \ / \ \{ M(1-I)\ U_i e^{(-mTi)} \}$ .... (6)

from (6)(5) ... $\Sigma \{ R_i \ / \ M(1-I)\ U_i e^{-mTi} \} = 1$ .... (7)

In formula (7), R_i, U_i of the Asian fisheries, I and m are unknown, of which U_i of the Japanese fishery may be appropriately considered to be 1.0, while R_i is difficult to obtain precisely since no sampling is conducted in the catch of the Asian fishery, unlike the case of the Western and Central

Alaskan fisheries. However, it would be reasonable to consider that the rate of recapture reporting is lower in the Asian fisheries than in the Western and Central Alaskan fisheries, since in the latter case considerable effort was made to encourage reporting of recaptures by radio announcement, etc. in conjunction with the tagging research program. Therefore, the value of the R_i for the Asian fisheries is obtained by the following formula, adopting the actual number of recapture reported and the lowest value (53.5%) of the reporting rate of Western and Central Alaska fisheries estimated by Eggers and Barrett (1988).

$$R_i = r_i \; / \; 0.535$$

where, r_i = actual number of recapture reporting in the ith stock, (Asian origin)

Because of the difficulty in obtaining I and U_i of the Soviet fishery (U_{USSR}), a set of values taken at each 0.05th from 0 to 0.75 for I and a set of values taken at each 0.1st from 0.1 to 0.9 for U_{USSR} have been adopted (total 16 x 9 = 144 sets). R_i, U_i for the salmon of North American origin were determined from Table 17 and 18 by Eggers and Barrett (1988); T_i was determined from their Appendix F. Table 1 a, b show the data used.

m and P_i are obtained by formulae (6) and (7) using these data (in the actual calculation, the computer iteration process was conducted to obtain the value of m that satisfies $\left| \Sigma \; (R_i/M(1-I) \; U_{i}e^{-mT_i}) - 1 \right| < 0.001$.

Analyses for 30 categories in total have been conducted for all the North American fisheries adopted from the Table 17 by Eggers and Barrett (1988) plus five Asian fisheries (July and November fisheries of Hokkaido, September and December fisheries of Honshu, and the U.S.S.R. fishery). At this stage, the catches by the June fishery were treated in the same manner as the return in other fisheries.

Then, the following formula was used to obtain the proportion of origin after subtraction of the catches of the June fishery.

$$P_i = P'_i/(1-P'_{June}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

However, P_i = proportion of origin in ith stock

P'_{June} = mixing rate of the June fishery obtained by formula (6).

3. Results

Table 2 a, b show estimated "m" by each I and U_{USSR}. The values of m, within the ranges of 0.01-0.75 of I and 0.1-0.9 of U_{USSR}, was 0-0.0282 for Unimak release, and 0-0.0230 for Shumagin release.

As for the average monthly mortality rate of the chum salmon at its final oceanic life stage, Parker (1962) estimated 0.011 to 0.016 for the final two years and Taguchi (1961) estimated 0.381 for the final one hundred days.

The value of 0.381 by Taguchi (1961) seems to be an overestimate in comparison with other estimates of the mortality rate for the oceanic life stage of the salmonid.

Since the value of m estimated in this paper includes time-dependent tag shedding and tagging mortality in addition to the natural mortality coefficient under the normal circumstances without tag, using the value by Taguchi as the upper limit of m value seems to present no problems. Therefore, the lower limit of m is set at the lowest of the estimates for the final two years (0.011: coefficient at 0.00037 when converted by coefficient per day), and the upper limit is set at the estimate for the final hundred days (0.381: coefficient at 0.0160 when converted by coefficient per day). In Table 2 a, b, I and U_{USSR} giving this range of m (0.00037-0.0160) are shown in brackets. Furthermore, since no differences by the area of tagging seems to exist in I and U_{USSR}, the range where estimates of I and U_{USSR} overlap between the two release areas (shown in Table 2 a, b in double brackets) are considered to be the final values of I and U_{USSR}.

Table 3 a, b show the proportion of origin calculated by formulae (6) and (8) for each I and U_{USSR} above. A total of eleven stocks are shown in Table 3 a, b which consist of the nine stocks of North American origin divided by Eggers et al. (1988) in their Table 19 with addition of the stocks of the Japanese and the Soviet origin.

The mixing rate of the chum salmon of Japanese origin is estimated to be 0.9%-7.9% in the case of the Unimak fishery, and 18.4%-35.3% in the case of the Shumagin fishery.

4. Discussion

(1) Parameters

In quantitative analyses of tagging research, we often experience that the estimation of the recapture reporting rate is a big problem. In the case of the Central-Western Alaskan fishery, however, the estimate obtained by the sampling of the catch can be utilized. In the case of the values used for the fish of Asian origin, some doubts remain as to the appropriateness of such values in this analysis.

Dissemination for the need of recapture reporting by posters and other means has been conducted in Japan; but in comparison with the rigorous efforts made in Central and Western Alaska offering lottery-type rewards and the use of radio announcements to encourage the reporting, the incentive for reporting in Japan is judged to be much weaker. Therefore, the reporting rate for Japan could be lower than the value used in this analysis. If that is the case, the proportion of the salmon of Japanese origin in the catch would have been underestimated. Reference is made to the case of the large-scale tagging research on red sea-bream conducted in the area around Japan, in which the reporting rate was estimated to be 0.25 (Kanagawa Prefectural Fisheries

Research Institute, 1986). The set net fishery is used for most of the harvests of the red sea-bream on the tagging area, this reporting rate may be reasonable for the set net fishery on the Japanese coastal waters.

The reporting rate of the Soviet recaptures is also uncertain, and it is difficult to know whether the value of 0.535 used in this analysis was appropriate. On the other hand, it is possible to revise formula (6) as follows:

$$P'_i = R_i/U_i \quad (1/M\ (1-I)e^{-mT_i})$$

Furthermore, if the reporting rate is A_i,

$$P'_i = r_i/U_iA_i(1/M(1-I)e^{-mT_i})$$

In our analysis, U_i of the salmon of the Soviet origin are given a wide range values from 0.1-0.9, and accordingly wide range is applied to U_iA_i. On the other hand, the low values such as 0.1 or 0.2 and the high values such as 0.8 or 0.9 applied to the U_i for the Soviet origin do not seem to be realistic. With these in mind, even if the actual reporting rate of the Soviet origin was inconsistent with the values used in our analysis, U_iA_i would fit within the range of the data given in the analysis. Therefore, it is reasonable to believe that the effect of the reporting rate estimate of the Soviet origin in the result is not significant.

(2) <u>Fish returning in the following year and later</u>

This analysis assumes that all released fish fall into one of the following four categories:

1) being caught in the June fishery with tag
2) mortality (due to tagging or other factors)
3) tag shedding
4) returning with the tag

At first, the number of fish included in categories 1) and 4) was estimated from recapture data. Then the difference between the number estimated above and total number of released fish is regarded to be the number of fish included in categories 2) and 3). Therefore, if the number of fish under categories 1) and 4) was underestimated, I and m would be overestimated.

Since the recapture data only contains the recaptures of the tagging year, if the fish that return in the following year and later are included within the tagged fish, the values of 2) mortality and 3) tag shedding would be overestimated. In this tagging research such data as the age and length of the tagged fish were not available. Therefore the possibility of inclusion of fish that return in the following year and later can not be denied. In this analysis mortality and the tag shedding rate immediately after the release are estimated to be 45-65% which is higher than the value (35.8%) used by Eggers and Barrett (1988). This may be due to the effect of the fishes returning in the following year and later. However, in cases where the proportion of the tagged fish returning in the following year and later is small, or where there is no significant variation of this proportion among stocks, the estimate itself of the mixing rate in each stock would not be seriously affected. In any case, if a substantial number of recaptures occur in 1988 of the fish tagged in 1987, reanalysis including this data will be needed.

(3) <u>Comparison with the past estimates</u>

Table 4 a, b and Fig. 1 a, b show the comparison of the result of this analysis with the result by Eggers and Barrett (1988) and the results of scale pattern analysis of chum salmon in the June fishery in 1983 (Conrad 1984). In the scale pattern analysis by Conrad, due to absence of sufficient samples available for the age 0.3 fish of Soviet origin, two standard samples of Western Alaskan origin and Japanese origin were used for the analysis of 0.3 years old fish. Therefore, the values appear in table 4 a, b and Fig. 1 a, b are the weighted mean value of results on age 0.4 fish, for which three standard samples of Western Alaskan, Japanese and Soviet origin were available, by 1987 catch by fishing period. The use of 1987 catch data by fishing period was due to the unavailability of the 1983 catch data. Table 5 shows the procedure for the weighted average.

As for the mixing rate of the fish of North American origin for both Unimak and Shumagin release, the result of this analysis falls between the two proportions estimated by Eggers and Barrett (1988) one with the consideration of Asian origin (P_1 in formula (1)), another without consideration of Asian origin (P^*_1 in formula (2)). The only exception is the mixing rate of the fall fishery in the Yukon River that substantially exceeds the estimate by them. This Yukon River case is because of the inclusion of the time dependent mortality and tag shedding in this analysis: the mixing rate thus obtained for stocks with longer lapse of time between the release and the catch shows greater value than the estimation which does not evaluate these factors.

The mixing rate of the fish of Asian origin in this analysis shows smaller estimates (3.6-17.8% for Unimak, and 22.0-43.2% for Shumagin) than the estimates made by Eggers and Barrett (1988) (48.9% for Unimak, and 66.9% for Shumagin). As already stated in this paper, this may be due to the error of tag mortality estimated by them. Moreover, in their method, the proportion of fish returning in the following year and later are apportioned to be the fish of Asian origin, therefore, their method would overestimate the proportion of Asian origin, if the fish returning in the following year and later are included in the liberated fish.

In comparing the result of the scale pattern analysis by Conrad (1984) with the result of this analysis, the former falls within the estimated ranges of this analysis in the cases of fishes of Alaskan origin and of Soviet origin in Unimak waters, and Soviet origin in Shumagin waters, while in the cases of the fish of Japanese origin in Unimak waters and those of Alaskan origin in Shumagin waters, the scale pattern analysis shows higher values than the estimated ranges of this analysis. In the case of fish of Japanese origin in Shumagin, the scale pattern analysis results show the lower value than the estimation range of this analysis. These differences may be attributed to the methodological inaccuracies inherent to the scale pattern analysis as well as to the error created by the weighting on the result of the 1983 analysis with the 1987 catch data. These differences in the results of the two analyses, however, are not so great: they fall within 4% and, as a whole, the two analyses have produced relatively consistent results.

(4) Estimate of interception of chum salmon of Japanese origin by the U.S. June fishery

Based on the estimation made by this analysis, estimates are made for the interception of chum salmon of Japanese origin by the U.S. June fishery from 1980 to 1987. Although the mixing rate of the salmon of Japanese origin is estimated to be 0.9-7.9% in Unimak, 10% had been estimated by the scale pattern analysis. Therefore, we have set its lower limit at 0.9% and its upper limit at 10%. In Shumagin, our estimates were 18.4-35.3% while the scale pattern analysis estimated it to be 17.7%. Therefore, we adopted the lower limit at 17.7% and upper limit at 35.3% in the same manner as we did in the case of Unimak.

The result of the calculation is shown in Table 6. The estimates of the interceptions are:

in Unimak on average between 4-46 thousand fish
in Shumagin on average between 17-33 thousand fish
in both waters, the total is estimated to be between 21-77 thousand fish

Table 7 shows the number of fish of Japanese origin as the result of a preliminary calculation based on the proportion estimated by Eggers and Barrett (1988) (0.489 for Unimak and 0.669 for Shumagin). It was necessary to divide the fish of the Asian origin into those of Japanese origin and Soviet origin in this calculation. The division was made on the basis of the number of tag recovery reported (7 fish of Japanese origin and 5 of Soviet origin from the Unimak releases, and 29 of Japanese origin and 5 of Soviet origin from the Shumagin releases). The following method was used by adopting the exploitation rate at 1.0 for Japanese origin and 0.1-0.9 for Soviet origin.

In Unimak

Lower limit of Japanese origin ... 0.489 x 7/(7 + 6/0.1) = 0.0511
Upper limit of Japanese origin ... 0.489 x 7/(7 + 6/0.9) = 0.250

In Shumagin

Lower limit of Japanese origin ... 0.669 x 29/(29 + 5/0.1) = 0.246
Upper limit of Japanese origin ... 0.669 x 29/(29 + 5/0.4) = 0.561

In this preliminary calculation the estimated interceptions are:

Unimak ... 23-114 thousand fish
Shumagin ... 23-53 thousand fish
Both areas Total ... 46-167 thousand fish

5. Future research

The tagging research conducted by ADFG, unlike other tagging research, makes it possible to analyze the result quantitatively. However, no accurate data is available for mortality, tag shedding and the exploitation rate of the fish of Soviet origin. Our analysis in this paper had to use wide ranges for those uncertain data. Subsequently, the number of interceptions of the fish of Japanese origin had to be estimated with wide ranges. It is desirable that future research estimates these parameters within narrower confidence limits.

Simultaneously, study for stock identification using scale pattern, parasite and isozyme would be needed.

Our analysis has demonstrated that the chum salmon of Japanese origin are migrating to the coastal waters of Alaska and suggests that a considerable number of the salmon of Japanese origin may be included in the chum salmon by-catch in the groundfish fishery within the U.S. 200 nautical miles zone. In this regard, additional research is necessary to ascertain the extent of such inclusion.

References

Conrad, Robert H. 1984. Origin of chum salmon in the Unimak Island and Shumagin Island fisheries during June, 1983 determined by scale pattern analysis. (Document submitted to the annual meeting of INPFC, Vancouver, B.C., Canada, November 1984.) 21 pp. Alaska Department of Fish and Game, Anchorage.

Eggers, D.M., K. Rowell and B.M. Barrett. 1988. The stock composition of the catches of sockeye and chum salmon in the 1987 South Peninsula June fishery based on Tagging. 73 pp. Regional Information Report No. 5J88-03

Kanagawa Prefectural Fisheries Research Institute. 1986. The report of cooperative experiment and research on release of migratory fish. (In Japanese.) 40 pp.

Parker, R.R. 1962. Estimations of ocean mortality rates for Pacific salmon (*Oncorhynchus*). J. Fish. Res. Board Can. 19: 561-589.

Taguchi, K. 1961. A trial to estimate the instantaneous rate of natural mortality of adult salmon (*Oncorhynchus* sp.) and the consideration of rationality of offshore fishing. I. For chum salmon (*Oncorhynchus keta*). Bull. Jpn. Soc. Sci. Fish. 27: 963-971.

Table 1b List of the input data for Shumagin releases.

Fishery	Ri	Ui	Ti
1Kotzebue	2.0000	0.7950	33.0000
2Norton Sound	7.0000	0.6630	28.7500
3Yukon summer run	9.0000	0.6240	20.2000
4Yukon fall run	7.0000	0.3890	74.0000
5Kuskokwim Bay	4.0000	0.3570	56.0000
6Kuskokwim River	84.0000	0.5480	24.9300
7Togiak	24.0000	0.5180	22.7000
8Nushagak	45.0000	0.6340	20.2400
9Naknek/Kvichak	18.0000	0.4080	22.2100
10Egegik	5.0000	0.8040	16.0000
11Ugashik	4.0000	0.7560	13.6700
12Aleutian Island	0.0000	0.0000	0.0000
13Northern District	13.0000	0.4840	17.1600
14Northwestern District	2.0000	0.3240	27.0000
15Unimak June (S.W)	38.0000	1.0000	4.4600
16Shumagin June	2.0000	1.0000	4.5000
17S.E. Mainland	0.0000	1.0000	0.0000
18Southwestern July	14.0000	0.3550	10.0000
19Southcentral July	25.0000	0.5890	22.7000
20Shumagin July	18.0000	0.9510	17.0700
21S.E. Mainland July	9.0000	0.6160	22.5000
22Chignik	17.0000	0.6110	19.2200
23Kodiak	7.0000	0.4610	40.0000
24Cook Inlet	6.0000	0.4140	32.6600
25Prince William Sound	0.0000	0.8560	0.0000
26Hokkaido Sept.	13.0000	1.0000	90.9200
27Hokkaido Nov.	7.0000	1.0000	142.5000
28Honshu Nov.	11.0000	1.0000	148.3000
29Honshu Dec. Jan.	19.0000	1.0000	174.8000
30U.S.S.R	9.0000	0.1-0.9	50.2500

Table 2a Estimated "m", Unimak release

USSR exp. rate / Initial Mortality	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.0	0.0268	0.0276	0.0278	0.0279	0.0280	0.0281	0.0281	0.0281	0.0282
0.05	0.0261	0.0269	0.0272	0.0273	0.0274	0.0274	0.0275	0.0275	0.0275
0.10	0.0252	0.0261	0.0264	0.0266	0.0267	0.0267	0.0268	0.0268	0.0268
0.15	0.0243	0.0253	0.0256	0.0258	0.0259	0.0259	0.0260	0.0260	0.0260
0.20	0.0233	0.0243	0.0247	0.0249	0.0250	0.0250	0.0251	0.0251	0.0251
0.25	0.0221	0.0232	0.0236	0.0238	0.0239	0.0240	0.0241	0.0241	0.0241
0.30	0.0207	0.0220	0.0224	0.0226	0.0227	0.0228	0.0229	0.0229	0.0229
0.35	0.0190	0.0204	0.0209	0.0211	0.0213	0.0214	0.0214	0.0215	0.0215
0.40	0.0170	0.0186	0.0191	0.0194	0.0195	0.0196	0.0197	0.0198	0.0198
0.45	0.0146	0.0163	0.0169	0.0172	0.0174	0.0175	0.0176	0.0176	0.0177
0.50	0.0116	0.0135	0.0141	0.0144	0.0146	0.0148	0.0149	0.0149	0.0150
0.55	0.0079	0.0099	0.0106	0.0109	0.0111	0.0113	0.0114	0.0115	0.0115
0.60	0.0034	0.0054	0.0061	0.0064	0.0066	0.0068	0.0069	0.0070	0.0070
0.65	<0	<0	0.0004	0.0008	0.0010	0.0011	0.0012	0.0013	0.0014
0.70	<0	<0	<0	<0	<0	<0	<0	<0	<0
0.75	<0	<0	<0	<0	<0	<0	<0	<0	<0

Table 2b Estimated "m". Shumagin release

USSR exp. rate / Initial Mortality	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.0	0.0221	0.0226	0.0228	0.0228	0.0229	0.0229	0.0229	0.0230	0.0230
0.05	0.0216	0.0221	0.0223	0.0223	0.0224	0.0224	0.0225	0.0225	0.0225
0.10	0.0210	0.0216	0.0217	0.0218	0.0219	0.0219	0.0219	0.0220	0.0220
0.15	0.0204	0.0210	0.0212	0.0212	0.0213	0.0213	0.0214	0.0214	0.0214
0.20	0.0197	0.0203	0.0205	0.0206	0.0207	0.0207	0.0207	0.0208	0.0208
0.25	0.0190	0.0196	0.0198	0.0199	0.0200	0.0200	0.0201	0.0201	0.0201
0.30	0.0181	0.0188	0.0190	0.0192	0.0192	0.0193	0.0193	0.0193	0.0193
0.35	0.0172	0.0179	0.0182	0.0183	0.0184	0.0184	0.0185	0.0185	0.0185
0.40	0.0161	0.0169	0.0172	0.0173	0.0174	0.0175	0.0175	0.0175	0.0175
0.45	0.0149	0.0158	0.0160	0.0162	0.0163	0.0163	0.0164	0.0164	0.0164
0.50	0.0134	0.0144	0.0147	0.0149	0.0150	0.0150	0.0151	0.0151	0.0151
0.55	0.0116	0.0127	0.0131	0.0133	0.0134	0.0135	0.0135	0.0135	0.0136
0.60	0.0094	0.0107	0.0111	0.0113	0.0114	0.0115	0.0116	0.0116	0.0116
0.65	0.0066	0.0080	0.0085	0.0087	0.0089	0.0090	0.0091	0.0091	0.0091
0.70	0.0028	0.0044	0.0050	0.0053	0.0054	0.0056	0.0056	0.0057	0.0057
0.75	<0	<0	<0	0.0003	0.0005	0.0006	0.0007	0.0008	0.0008

Table 3a Estimated proportion of each fishery group, Unimak release.

	U.S.S.R exp. rate	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
I=0.45	Kotzebue	0.00432								
	Norton Sound	0.01246								
	Yukon summer run	0.02976								
	Yukon fall run	0.01605								
	Kuskokwim	0.25636								
	Bristol Bay	0.34300								
	North Peninsula	0.08532								
	South Peninsula July	0.06610								
	Other U.S. Stocks	0.00895								
	Japan	0.05994								
	U.S.S.R.	0.11811								
I=0.50	Kotzebue	0.00432	0.00459	0.00469	0.00474	0.00477	0.00479	0.00481	0.00482	0.00483
	Norton Sound	0.01279	0.01338	0.01359	0.01369	0.01376	0.01380	0.01383	0.01386	0.01387
	Yukon summer run	0.03086	0.03207	0.03249	0.03271	0.03284	0.03293	0.03299	0.03304	0.03308
	Yukon fall run	0.01419	0.01630	0.01709	0.01751	0.01777	0.01794	0.01807	0.01816	0.01823
	Kuskokwim	0.26481	0.27582	0.27972	0.28171	0.28292	0.28373	0.28431	0.28474	0.28508
	Bristol Bay	0.35811	0.37051	0.37489	0.37711	0.37846	0.37936	0.38001	0.38050	0.38088
	North Peninsula	0.08849	0.09194	0.09316	0.09378	0.09416	0.09441	0.09459	0.09473	0.09483
	South Peninsula July	0.06579	0.07015	0.07171	0.07251	0.07301	0.07333	0.07357	0.07375	0.07389
	Other U.S. Stocks	0.00894	0.00951	0.00971	0.00982	0.00988	0.00993	0.00996	0.00998	0.01000
	Japan	0.03941	0.05445	0.06092	0.06447	0.06673	0.06827	0.06940	0.07026	0.07094
	U.S.S.R.	0.11269	0.06169	0.04243	0.03233	0.02611	0.02190	0.01885	0.01655	0.01475
I=0.55	Kotzebue	0.00426	0.00454	0.00465	0.00470	0.00473	0.00476	0.00477	0.00478	0.00479
	Norton Sound	0.01306	0.01368	0.01391	0.01402	0.01409	0.01414	0.01418	0.01420	0.01422
	Yukon summer run	0.03190	0.03320	0.03367	0.03391	0.03406	0.03415	0.03423	0.03428	0.03432
	Yukon fall run	0.01204	0.01392	0.01465	0.01503	0.01527	0.01543	0.01555	0.01564	0.01571
	Kuskokwim	0.27234	0.28416	0.28845	0.29066	0.29201	0.29291	0.29357	0.29406	0.29444
	Bristol Bay	0.37318	0.38666	0.39153	0.39403	0.39535	0.39658	0.39732	0.39787	0.39830
	North Peninsula	0.09147	0.09518	0.09653	0.09722	0.09764	0.09793	0.09813	0.09828	0.09840
	South Peninsula July	0.06466	0.06912	0.07076	0.07162	0.07214	0.07249	0.07274	0.07293	0.07308
	Other U.S. Stocks	0.00882	0.00941	0.00963	0.00974	0.00981	0.00985	0.00989	0.00991	0.00993
	Japan	0.02356	0.03276	0.03683	0.03910	0.04053	0.04153	0.04229	0.04284	0.04329
	U.S.S.R.	0.10511	0.05776	0.03981	0.03037	0.02455	0.02060	0.01774	0.01558	0.01389
I=0.60	Kotzebue	0.00414	0.00442	0.00452	0.00457	0.00461	0.00463	0.00464	0.00466	0.00467
	Norton Sound	0.01323	0.01386	0.01409	0.01422	0.01429	0.01434	0.01438	0.01440	0.01442
	Yukon summer run	0.03284	0.03417	0.03466	0.03491	0.03507	0.03517	0.03525	0.03530	0.03535
	Yukon fall run	0.00975	0.01125	0.01185	0.01216	0.01236	0.01250	0.01259	0.01267	0.01273
	Kuskokwim	0.27871	0.29073	0.29517	0.29747	0.29888	0.29984	0.30052	0.30104	0.30145
	Bristol Bay	0.38816	0.40207	0.40718	0.40983	0.41145	0.41255	0.41333	0.41393	0.41439
	North Peninsula	0.09421	0.09800	0.09940	0.10012	0.10057	0.10087	0.10108	0.10125	0.10137
	South Peninsula July	0.06263	0.06690	0.06850	0.06934	0.06986	0.07021	0.07046	0.07065	0.07080
	Other U.S. Stocks	0.00859	0.00916	0.00937	0.00948	0.00955	0.00959	0.00963	0.00965	0.00967
	Japan	0.01269	0.01742	0.01953	0.02072	0.02148	0.02201	0.02240	0.02269	0.02293
	U.S.S.R.	0.09545	0.05242	0.03614	0.02758	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 3a Estimated proportion of each fishery group, Unimak release. (continued)

	U.S.S.R exp. rate	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
I=0.65	Kotzebue			0.00430	0.00435	0.00438	0.00440	0.00442	0.00443	0.00444
	Norton Sound			0.01414	0.01425	0.01432	0.01437	0.01440	0.01443	0.01445
	Yukon summer run			0.03544	0.03569	0.03584	0.03594	0.03602	0.03607	0.03612
	Yukon fall run			0.00896	0.00919	0.00933	0.00942	0.00949	0.00955	0.00959
	Kuskokwim			0.29960	0.30181	0.30318	0.30410	0.30477	0.30526	0.30566
	Bristol Bay			0.42180	0.42440	0.42599	0.42707	0.42785	0.42844	0.42889
	North Peninsula			0.10172	0.10242	0.10285	0.10314	0.10335	0.10351	0.10363
	South Peninsula July			0.06490	0.06565	0.06611	0.06643	0.06666	0.06683	0.06696
	Other U.S. Stocks			0.00893	0.00903	0.00909	0.00913	0.00916	0.00919	0.00921
	Japan			0.00904	0.00953	0.00985	0.01007	0.01023	0.01035	0.01045
	U.S.S.R.			0.03158	0.02408	0.01946	0.01632	0.01406	0.01235	0.01101

Table 3b Estimated proportion of each fishery group, Shumagin release.

	U.S.S.R exp. rate	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
I=0.45	Kotzebue	0.00272								
	Norton Sound	0.01070								
	Yukon summer run	0.01287								
	Yukon fall run	0.03573								
	Kuskokwim	0.16380								
	Bristol Bay	0.15638								
	North Peninsula	0.02901								
	South Peninsula July	0.09918								
	Other U.S. Stocks	0.05823								
	Japan	0.30622								
	U.S.S.R:	0.12554								
I=0.50	Kotzebue	0.00285	0.00295	0.00298	0.00300	0.00301	0.00301	0.00302	0.00302	0.00302
	Norton Sound	0.01131	0.01164	0.01175	0.01181	0.01184	0.01186	0.01188	0.01189	0.01190
	Yukon summer run	0.01378	0.01406	0.01416	0.01420	0.01423	0.01425	0.01426	0.01427	0.01428
	Yukon fall run	0.03534	0.03804	0.03897	0.03944	0.03972	0.03991	0.04005	0.04015	0.04023
	Kuskokwim	0.17335	0.17826	0.17991	0.18074	0.18124	0.18156	0.18180	0.18198	0.18211
	Bristol Bay	0.16720	0.17076	0.17195	0.17254	0.17289	0.17313	0.17330	0.17343	0.17352
	North Peninsula	0.03110	0.03171	0.03191	0.03201	0.03207	0.03211	0.03214	0.03216	0.03217
	South Peninsula July	0.10686	0.10847	0.10911	0.10943	0.10962	0.10975	0.10984	0.10991	0.10996
	Other U.S. Stocks	0.06152	0.06334	0.06395	0.06425	0.06444	0.06456	0.06464	0.06471	0.06476
	Japan	0.26878	0.31353	0.32987	0.33832	0.34349	0.34692	0.34943	0.35134	0.35277
	U.S.S.R.	0.12861	0.06760	0.04581	0.03464	0.02785	0.02328	0.02000	0.01753	0.01560
I=0.55	Kotzebue	0.00300	0.00311	0.00315	0.00317	0.00318	0.00319	0.00319	0.00320	0.00320
	Norton Sound	0.01198	0.01237	0.01251	0.01257	0.01261	0.01264	0.01266	0.01267	0.01268
	Yukon summer run	0.01482	0.01516	0.01527	0.01533	0.01537	0.01539	0.01540	0.01542	0.01543
	Yukon fall run	0.03485	0.03751	0.03855	0.03907	0.03939	0.03960	0.03976	0.03987	0.03996
	Kuskokwim	0.18387	0.18970	0.19167	0.19265	0.19324	0.19364	0.19393	0.19414	0.19430
	Bristol Bay	0.17952	0.18381	0.18525	0.18597	0.18640	0.18669	0.18690	0.18705	0.18717
	North Peninsula	0.03351	0.03424	0.03448	0.03460	0.03468	0.03472	0.03476	0.03479	0.03481
	South Peninsula July	0.11508	0.11740	0.11817	0.11856	0.11879	0.11895	0.11906	0.11914	0.11921
	Other U.S. Stocks	0.06512	0.06727	0.06800	0.06836	0.06858	0.06873	0.06883	0.06891	0.06897
	Japan	0.22784	0.27044	0.28623	0.29442	0.29944	0.30285	0.30530	0.30711	0.30859
	U.S.S.R.	0.13112	0.06934	0.04709	0.03564	0.02867	0.02398	0.02061	0.01807	0.01608
I=0.60	Kotzebue	0.00315	0.00328	0.00333	0.00335	0.00337	0.00338	0.00338	0.00339	0.00339
	Norton Sound	0.01270	0.01317	0.01333	0.01342	0.01346	0.01350	0.01352	0.01354	0.01355
	Yukon summer run	0.01601	0.01643	0.01657	0.01664	0.01668	0.01671	0.01673	0.01674	0.01676
	Yukon fall run	0.03314	0.03639	0.03754	0.03813	0.03848	0.03872	0.03889	0.03902	0.03912
	Kuskokwim	0.19531	0.20232	0.20471	0.20591	0.20663	0.20711	0.20745	0.20771	0.20791
	Bristol Bay	0.19354	0.19880	0.20058	0.20147	0.20201	0.20236	0.20262	0.20281	0.20296
	North Peninsula	0.03628	0.03717	0.03748	0.03763	0.03772	0.03778	0.03782	0.03786	0.03788
	South Peninsula July	0.12498	0.12784	0.12880	0.12928	0.12957	0.12977	0.12990	0.13001	0.13009
	Other U.S. Stocks	0.06900	0.07158	0.07246	0.07290	0.07316	0.07334	0.07347	0.07356	0.07364
	Japan	0.18373	0.22275	0.23751	0.24522	0.24997	0.25318	0.25549	0.25722	0.25861
	U.S.S.R.	0.13255	0.07063	0.04809	0.03645	0.02934	0.02456	0.02111	0.01851	0.01649

Table 3b Estimated proportion of each fishery group, Shumagin release. (continued)

	U.S.S.R exp. rate	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
I=0.65	Kotzebue			0.00351	0.00354	0.00356	0.00357	0.00358	0.00358	0.00359
	Norton Sound			0.01422	0.01432	0.01438	0.01442	0.01445	0.01447	0.01449
	Yukon summer run			0.01806	0.01815	0.01820	0.01824	0.01827	0.01828	0.01830
	Yukon fall run			0.03560	0.03625	0.03664	0.03691	0.03709	0.03724	0.03735
	Kuskokwim			0.21884	0.22032	0.22121	0.22181	0.22224	0.22256	0.22281
	Bristol Bay			0.21815	0.21928	0.21995	0.22041	0.22073	0.22097	0.22116
	North Peninsula			0.04096	0.04116	0.04127	0.04135	0.04140	0.04145	0.04148
	South Peninsula July			0.14131	0.14192	0.14229	0.14253	0.14271	0.14284	0.14295
	Other U.S. Stocks			0.07723	0.07777	0.07810	0.07832	0.07848	0.07859	0.07869
	Japan			0.18401	0.19088	0.19512	0.19801	0.20008	0.20167	0.20290
	U.S.S.R.			0.04850	0.03682	0.02968	0.02485	0.02137	0.01875	0.01670

Table 4a Comparison of estimated stock proportion (Unimak)

Group	Prescent Study	Eggers and Barret(1988) (With)*	Eggers and Barret(1988) (Without)**	Conrad(1984)***
Western and Central Alaska	0.813-0.969	0.507	0.992	0.885 (0.075-1.000)
Kotzebue	0.004-0.005	0.002	0.004	-
Norton Sound	0.013-0.015	0.008	0.015	-
Yukon summer	0.030-0.036	0.019	0.037	-
Yukon fall	0.009-0.018	0.005	0.009	-
Kuskokwim	0.256-0.306	0.160	0.312	-
Bristol Bay	0.343-0.429	0.226	0.441	-
North Peninsula	0.085-0.104	0.054	0.106	-
South Peninsula July	0.063-0.074	0.034	0.066	-
Other U.S. Stocks	0.009-0.010	0.004	0.008	-
Japan	0.009-0.079	-	-	0.100 (0.000-0.225)
U.S.S.R.	0.011-0.118	-	-	0.015 (0.000-0.059)
Combined Asian Stock	0.022-0.178	0.489	-	0.115 (0.000-0.225)

* Proportion with Asian stock.

** Proportion without Asian stock.

*** Proportion of 0.4 age

Table 4b Comparison of estimated stock proportion (Shumagin)

Group	Prescent Study	Eggers and Barret(1988) (With)‡	Eggers and Barret(1988) (Without)‡‡	Conrad(1984)‡‡‡
Western and Central Alaska	0.510-0.702	0.299	0.905	0.742 (0.686-0.932)
Kotzebue	0.003-0.004	0.001	0.003	-
Norton Sound	0.011-0.015	0.006	0.019	-
Yukon summer	0.013-0.018	0.008	0.026	-
Yukon fall	0.031-0.040	0.011	0.032	-
Kuskokwim	0.164-0.228	0.092	0.279	-
Bristol Bay	0.156-0.221	0.096	0.290	-
North Peninsula	0.029-0.042	0.020	0.060	-
South Peninsula July	0.099-0.143	0.065	0.196	-
Other U.S. Stocks	0.058-0.079	0.032	0.095	-
Japan	0.184-0.353	-	-	0.177 (0.068-0.211)
U.S.S.R.	0.016-0.133	-	-	0.078 (0.000-0.103)
Combined Asian Stock	0.220-0.432	0.669	-	0.255 (0.068-0.314)

‡ Proportion with Asian stock.

‡‡ Proportion without Asian stock.

‡‡‡ Proportion of 0.4 age

Table 5 Calculation of weighted proportion from scale pattern analysis by ADFG in 1983

Period	Sampl. Area	Sampl. Date	Estimated Proportion			Catch (1987)	Weighted Proportion		
			V.Al.	Jpn	Kamc.	(%)	V.AL.	Jpn	Kamc.
(Unimak)									
6.01-6.10	S.Unimak	6.6	97.5	0	2.5	3.9	3.8	0	0.1
6.10-6.18	S.Unimak	6.12-6.14	79.3	14.9	5.9				
	Cape Lutka	6.14-6.16	95.9	4.1	0.1				
	Average		87.6	9.5	3	48.2	42.2	4.6	1.4
6.19-6.30	S.Unimak	6.19,6.21	77.5	22.5	0				
	Cape Lutka	6.20-6.23	100	0	0				
	Average		88.8	11.2	0	47.9	42.5	5.4	0.0
Average							88.5	10.0	1.5
(Shumagin)									
6.01-6.10	Sand Point	6.02-6.06	93.2	6.8	0	24.1	22.5	1.7	0.0
	Sand Point	6.13-6.14	68.6	21.1	10.3	75.9	52.1	16.0	7.8
Average							74.2	17.7	7.8

Table 6 Estimated Interception of Japanese Chum Salmon by June Fisheies.

(1,000 fish)

Year	Unimak Catch	Japanese Salmon		Shumagin Catch	Japanese Salmon		Total	
		Lower limit	Upper limit		Lower limit	Upper limit	Lower limit	Upper limit
	a	b=a*0.009	c=a*0.10	d	e=d*0.177	f=d*0.3528	b+e	c+f
1980	457	4	46	71	13	25	17	71
1981	521	5	52	54	10	19	14	71
1982	875	8	88	140	25	49	33	137
1983	615	6	62	169	30	60	35	121
1984	229	2	23	109	19	38	21	61
1985	321	3	32	107	19	38	22	70
1986	238	2	24	96	17	34	19	58
1987	406	4	41	37	7	13	10	54
1988	453	4	45	63	11	22	15	68
Average	457	4	46	94	17	33	21	79

Table 7 Estimated Interception of Japanese Chum Salmon June Fisheies from Eggers et al. 1988.

(1,000 fish)

Year	Unimak Catch	Japanese Salmon		Shumagin Catch	Japanese Salmon		Total	
		Lower limit	Upper limit		Lower limit	Upper limit	Lower limit	Upper limit
	a	b=a*0.0511	c=a*0.250	d	e=d*0.246	f=d*0.561	b+e	c+f
1980	457	23	114	71	17	40	41	154
1981	521	27	130	54	13	30	40	161
1982	875	45	219	140	34	79	79	297
1983	615	31	154	169	42	95	73	249
1984	229	12	57	109	27	61	39	118
1985	321	16	80	107	26	60	43	140
1986	238	12	60	96	24	54	36	113
1987	406	21	102	37	9	21	30	122
1988	453	23	113	63	15	35	39	149
Average	457	23	114	94	23	53	46	167

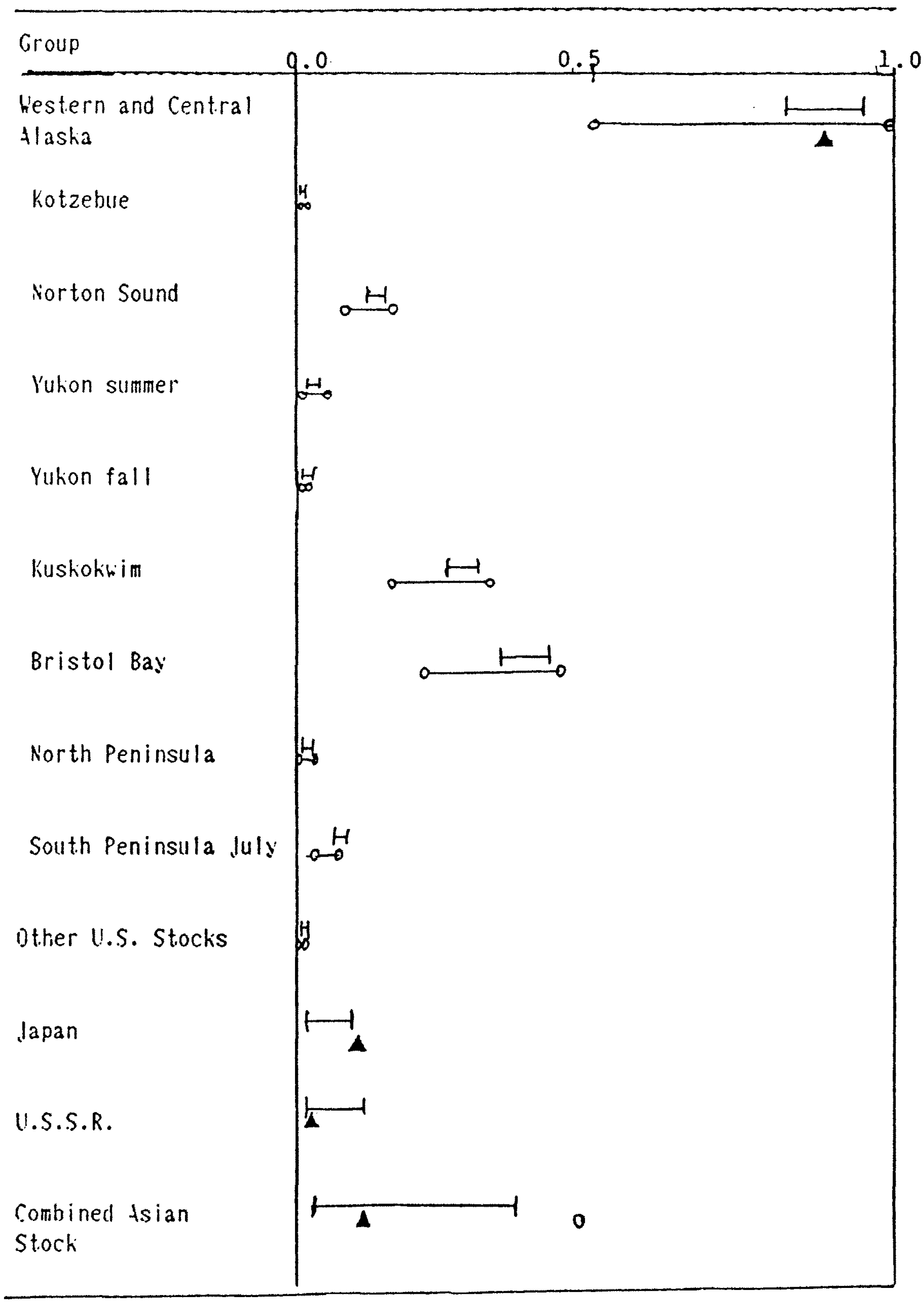

Fig. 1a Compaison of estimated stock proportion (Unimak)

Prescent study

Eggers and Barret(1988)

Conrad(1984)

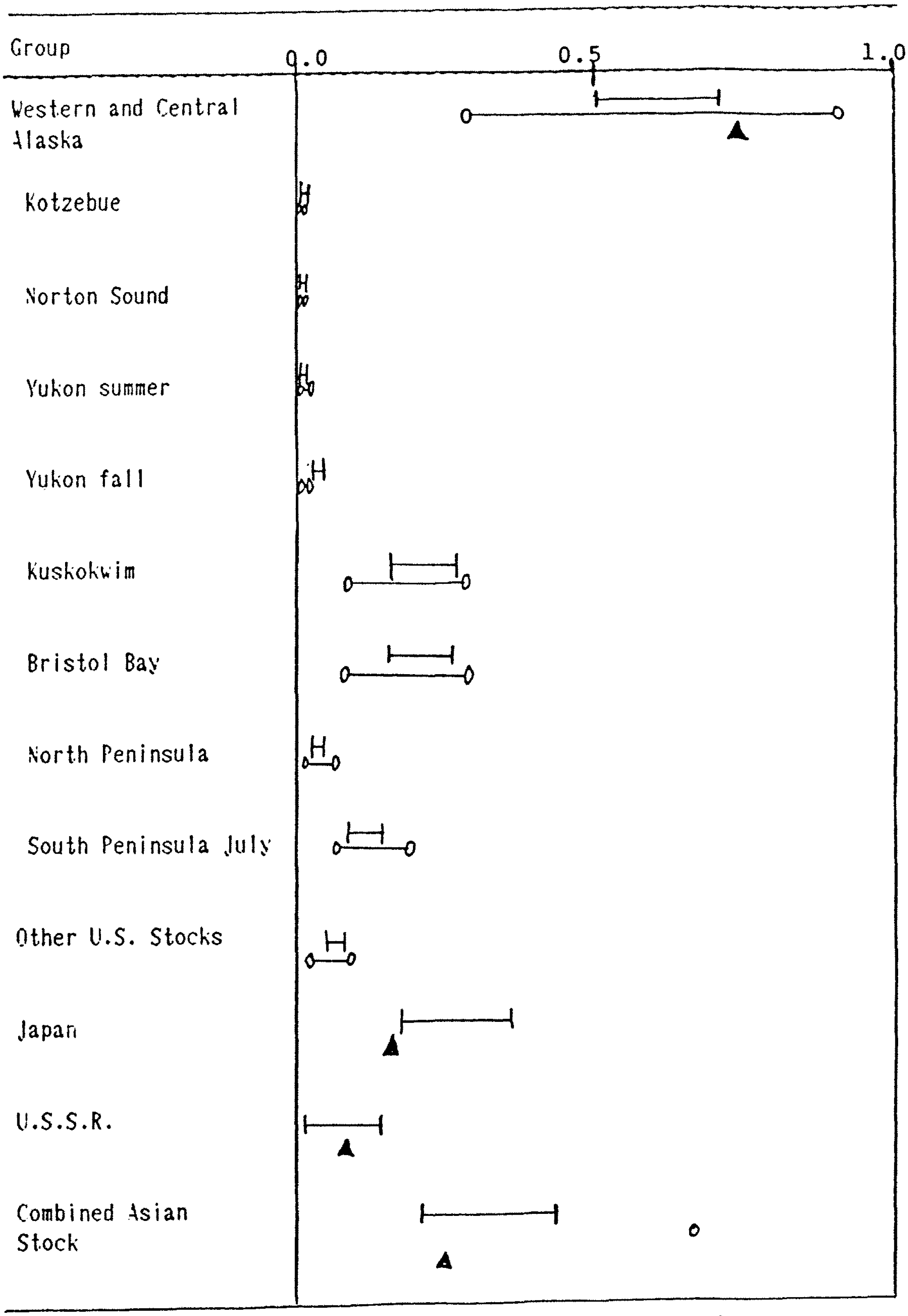

Fig. 1b Compaison of estimated stock proportion (Shumagin)

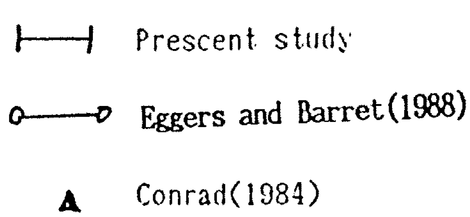

Table 1a List of the input data for Unimak releases.

Fishery	Ri	Ui	Ti
1Kotzebue	4.0000	0.7950	33.0000
2Norton Sound	11.0000	0.6630	23.8300
3Yukon summer run	26.0000	0.6240	20.3600
4Yukon fall run	4.0000	0.3890	74.0000
5Kuskokwim Bay	11.0000	0.3570	21.4000
6Kuskokwim River	176.0000	0.5480	21.7300
7Togiak	81.0000	0.5180	20.8800
8Nushagak	155.0000	0.6340	16.9700
9Naknek/Kvichak	27.0000	0.4080	16.7100
10Egegik	14.0000	0.8040	14.4000
11Ugashik	9.0000	0.7560	16.6300
12Aleutian Island	0.0000	0.0000	0.0000
13Northern District	28.0000	0.4840	16.8400
14Northwestern District	20.0000	0.3240	23.3800
15Unimak June (S.W)	37.0000	1.0000	2.4700
16Shumagin June	0.0000	1.0000	0.0000
17S.E. Mainland	0.0000	1.0000	0.0000
18Southwestern July	8.0000	0.3550	28.3300
19Southcentral July	13.0000	0.5890	36.9000
20Shumagin July	5.0000	0.9510	26.2500
21S.E. Mainland July	16.0000	0.6160	37.6600
22Chignik	2.0000	0.6110	34.0000
23Kodiak	0.0000	0.4610	0.0000
24Cook Inlet	2.0000	0.4140	30.0000
25Prince William Sound	2.0000	0.8560	37.0000
26Hokkaido Sept.	2.0000	1.0000	87.0000
27Hokkaido Nov.	0.0000	1.0000	0.0000
28Honshu Nov.	4.0000	1.0000	152.0000
29Honshu Dec. Jan.	4.0000	1.0000	195.5000
30U.S.S.R	11.0000	0.1-0.9	48.3300