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INTER-DEPARTMENTAL REPORT

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BRISTOL BAY PACIFIC SALMON SPAWNING ESCAPEMENT GOAL WORKSHOP

By

Stephen M. Fried

Alaska Department of Fish and Game
Division of Commercial Fisheries

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PREFACE

A workshop to review and revise escapement goals for Bristol Bay salmon spawning systems was held in King Salmon during 23-24 January, 1984. The focus of the workshop was sockeye salmon, the most abundant and commercially important species, but all other salmon species were discussed. The results of the workshop, specific recommendations of spawning escapement goals for each river system, are summarized in Table 1. Supporting data and associated discussions are included in the workshop summary, which I organized according to agenda topic (Appendix A). Names and affiliations of people attending the workshop have been included as a list (Appendix B), and I have also referenced these people within the workshop summary when they made formal presentations or made important contributions to discussions. Any omissions of names or facts were unintentional - I often found it difficult to take good notes, follow the discussions, and identify the sources of every useful suggestion and contribution. I would like to note that this was a particularly fruitful workshop and that all people involved made valuable contributions during the meeting. I think that workshops such as this one, which focus attention on an important aspects of salmon management and bring together workers from different agencies, should continue to be a part of annual staff meetings.

OVERVIEW (Eggers)

In the early 1970's a commercial fishing industry crisis occurred within Bristol Bay due to disasterously low returns of sockeye salmon to the various river systems. However, since 1975 the sockeye runs have increased enormously. Two factors appear to be responsible for the decline and subsequent recovery of the runs: high seas fishery interceptions and climatic changes. During the 1960's and early 1970's Japan harvested large numbers of Bristol Bay sockeye on the high seas (average harvest of 2.1 million each year 1964-1973). During this time period temperatures were below average. In 1974, and again in 1978, high seas interceptions of Bristol Bay sockeye were sharply curtailed due to various agreements. During this same time period temperatures rose to average and then above average levels. Therefore, it is difficult to separate the effects of these two factors (i.e. interceptions and temperature conditions) upon sockeye production and survival.

Since the 1974 brood year, returns per spawner (R/S) for all Bristol Bay river systems except the Kvichak have risen dramatically. Trends for the Kvichak have not been as clear since 1974: R/S was low for some years (e.g. 1978) and, even though recent R/S has been increasing, it has not been as marked as in other systems. There is a greater variation in returns of four, five and six year old sockeye to the Kvichak than observed in other systems.

In the past there has been a marked relationship between mean sockeye length and total return: mean size decreased with increased total returns (depensatory growth). However, this effect has not been as dramatic in more recent years, which indicate that "better" growing conditions exist in the marine environment.

It should be noted that increased returns to some systems is also largely a part of improved management practices, as well as lower interceptions and higher temperatures. There is no question that depression of sockeye populations within the Wood, Nuyakuk and Ugashik systems was due to overfishing, and that recovery depended in large part on changes in management practices which allowed larger spawning escapements into these systems.

Rogers: Temperature probably was a more important factor than high seas interceptions in restoring depressed sockeye runs. Bristol Bay runs did not begin to increase until 1978; ocean temperatures did not increase greatly until 1977. Interceptions were decreased greatly in 1974, but Bristol Bay returns did not dramatically respond until temperatures warmed also. The primary effect of interceptions may be upon the age structure of sockeye returns. Recent returns, which have not be subjected to high interceptions, have more large sockeye than in the past.

The mechanism underlying the relationship between temperature and sockeye survival is probably the response of sockeye to marine conditions. Distribution of sockeye during the marine phase of their life history is probably quite different during "cold" and "warm" winters. During cold winters sockeye may move south and become more concentrated within their winter range (since the warm water boundary in the south does not shift very far south even during cold winters). During warm winters, sockeye may not be as concentrated (i.e. their winter range is bigger), and so survival is better. Changes in survival may not be due to competition for food, but to differences in predation pressure. Sockeye should be more susceptible to predators during cold winters since sockeye would be less able to avoid predators (i.e. sockeye are poikilotherms while their major predators, possibly northern fur seals, are homoiotherms) and would be more concentrated.

Increased sockeye returns have probably been due to changes in marine survival and not due to improved freshwater conditions. Warmer spring conditions do provide longer periods for freshwater growth, although they do not affect actual growth rate greatly. (i.e. Daily growth rate is fairly constant over the range of temperatures encountered; longer growing seasons are, thus, the more critical factor). Temperature has the greatest effect upon freshwater residence time and resulting age of return. For example, a warm winter and early spring would result in a greater return of four year old rather than five year old sockeye for a brood year. However, if the density of juvenile sockeye is very high within the nursery area, it could negate such temperature effects.

ESCAPEMENT GOALS (Eggers: Ugashik, Egegik, Naknek, Kvichak, Wood, Nuyakuk, Igushik, Togiak; General Discussion: Nushagak-Mulchatna, Branch and Snake)

General Comments: A Ricker model of the relationship between spawning escapement and resulting returns was used to examine optimum escapement goals for most systems discussed below. The form of the equation used was:

$$R = Eae^{-BE},$$

where R = returns from each brood year escapement (including estimates of high seas catches), E = brood year escapement, and a and B = constants determining the shape of the curve. The values assigned to the constants were estimated by fitting a regression line to ln(R/E) and E. The slope of the regression of ln(R/E) on E is an estimate of B; the intercept is an estimate of ln(a). Yield can then be calculated by rearranging the equation:

$$Y = R - E = E(ae^{-BE} - 1),$$

where Y = yield. Optimal escapement can then be found by setting the first derivative of Y with respect to E equal to one and solving for E:

$$E = \frac{1 - (1/ae^{-BE})}{B}$$

This equation can be solved interactively by substituting an estimated value for E on the right side of the equation and using the resulting value of E on the left side of the equation as the new estimated value for E on the right. The values of E on both sides of the equation will converge towards the optimal escapement value.

For some systems the data base was not available for the above type of analysis to be done (i.e. Branch, Snake, Nushagak-Mulchatna). For other systems the data did not provide enough contrast to estimate optimal escapement (Nuyakuk). The Kvichak system, due to its complexity, was not amenable to simple Ricker curve analysis to determine optimal escapement. For the remaining systems Ricker curves were computed for the entire available data base (usually 1956-1978 brood years) and for the recent period in which high seas interceptions have been low and temperatures high (1974-1978 brood years). For Ugashik and Togiak systems 5 and 6 year old returns were estimated for the 1979 brood year, based upon the long term historical averages, and this brood year was used for Ricker curve calculations. Results of these analyses are summarized in Tables 1 and 2. Proposed revisions sometimes reflect modifications of theoretical goals based upon decisions made by workshop participants (Appendix B) and ADF&G Headquarters staff (i.e. Steven Pennoyer, Deputy Commissioner, ADF&G John H. Clark, Chief Fisheries Scientist, Commercial Fisheries Division, ADF&G).

During the workshop there was much discussion concerning the problem of setting an optimal escapement range, rather than just a point estimate, for each system. There was general agreement among all present that this range should be based upon the shape of the various Ricker curves. For example, a sharply domed curve would indicate that large changes in returns occur when escapements are either over or under the optimal value. This would necessitate greater care in ensuring that the optimal value was achieved and, thus, would be reflected in having a narrow range of optimal (acceptable) escapements. In contrast, a flatter curve would indicate that large variations in escapement produce only small changes in returns. This would necessitate less need for ensuring that the optimal value was achieved and, thus, would be reflected in having a wide range of optimal escapements. Meacham suggested that the range be set as $\pm$ 25% of the optimal escapement point estimate. After the workshop Eggers calculated the range of escapement values that would produce returns greater than or equal to 0.75 of the yield

Table 1. Comparisons of revised 1984 sockeye salmon spawning escapement goals with those used in past years for Bristol Bay river system.

	Past Goal 1/		Revised Goal (1984) 2/	
River System	Escapement (millions)	Yield (millions)	Escapement (millions)	Yield (millions)
Ugashik	0.50	0.49	0.70	0.53
Egegik	0.60	1.55	1.00	2.01
Naknek	0.80	1.52	1.00	1.59
Kvichak	Peak Year 14.00 Pre-peak 6.0 Off-cycle 2.00	N/A N/A N/A	10.0 ***Long term goal awaits completion of further analyses***	
Branch	0.185	N/A	0.185	N/A
Nushagak-Mulchatna	0.05	N/A	0.05	N/A
Nuyakuk	0.25	N/A	0.50	N/A
Wood	0.80	0.99	1.00	1.08
Snake	0.04	N/A	0.04	N/A
Igushik	0.15	0.44	0.20	0.46
Togiak	0.10	0.59	0.15	0.69

1/ Estimated yield from past escapement goals based upon spawner-recruitment relationship analyses used to set revised goals.

2/ Estimated yields from Ricker curves calculated from all available brood year data except Togiak, which is based upon Ricker curve fitted to only recent brood years (1973-1979).

Table 2. Theoretical and proposed sockeye salmon spawning escapement goals and ranges for Bristol Bay river systems. Theoretical goals and ranges were estimated from Ricker spawner-recruitment relationships calculated for all available data as well as only recent data. Theoretical optimal goals would produce maximum sustainable yield (MSY); ranges would produce yields greater than or equal to 95% MSY.

		Theoretical Goal		Theoretical Range		Proposed Escapement Values 1/	
River System	Brood Years	Escapement (millions)	Yield (millions)	Escapement (millions)	Yield (millions)	Goal (millions)	Range (millions)
Ugashik	1974-1979	0.89	5.30	0.65-1.17	5.04		
	1956-1979	0.71	0.53	0.52-0.90	0.50	0.70	0.50-0.90
Egegik	1974-1979	0.51	4.89	0.37-0.68	4.65		
	1956-1978	1.37	2.12	1.00-1.76	2.01	1.00	0.80-1.20 a/
Naknek	1974-1978	1.55	3.11	1.14-2.00	2.95		
	1956-1978	1.06	1.60	0.80-1.36	1.52	1.00	0.80-1.40
Wood	1974-1978	0.91	3.68	0.67-1.18	3.50		
	1956-1978	1.28	1.12	0.95-1.65	1.06	1.00	0.70-1.20 b/
Igusik	1974-1978	0.19	2.41	0.14-0.26	2.29		
	1956-1978	0.20	0.46	0.15-0.25	0.44	0.20	0.15-0.25
Togiak	1973-1979	0.19	0.71	0.14-0.25	0.67		
	1956-1979	0.28	0.40	0.21-0.35	0.38	0.15	0.14-0.25 c/

1/ Proposed goals and ranges based upon Ricker equation calculated using all available data (i.e. 1956-1978 or 1979 brood years) unless otherwise indicated.

a/ Recent data indicated lower goal than when all available data considered. However, since actual spawner-recruitment data available always above replacement level (i.e. recruitment always exceeded escapement), proposed values were set between levels estimated by the two Ricker equations.

b/ Proposed goal and range based upon most recent brood year data. However, this system is managed upon age composition of run: if run primarily 3-ocean, goal will be at lower end of range; if run primarily 2-ocean, goal will be at upper end of range. Three-ocean sockeye are primarily river spawners which show low production of recruits at high spawning densities. Two-ocean sockeye are primarily lake beach spawners which show high production over a greater range of densities.

c/ Proposed goal and range based upon most recent brood year data. However, the proposed goal only concerns escapement past the counting tower into Togiak Lake. It is assumed that escapement below Togiak Lake would cause actual escapement to approach the theoretical goal of 0.19 million.

achieved at the optimal point value. Upon examination of these ranges, Meacham felt that they were too broad to be of practical value. Therefore, ranges that would produce returns greater than or equal to 0.95 of the yield achieved at the optimal point value were calculated by Fried (Table 2). It should be realized that the selection of an optimal range (e.g. ± 0.25 versus ± 0.05) was somewhat arbitrary and did not necessarily reflect the precision of the actual point estimate.

Ugashik (Figure 1) Proposed revision: 0.70 million spawners.

The current escapement goal for this system is 0.50 million spawners. The Ricker curve for recent data (1974-1979 brood years) indicated that the goal should be 0.89 million. Russell indicated that this system is difficult to manage since escapement estimates are difficult to obtain during the season. Sockeye tend to mill around in the lower river before they travel upriver and past the counting tower. With present management tools, escapement indices are not available until two days after sockeye pass through the fishery and can be caught in test fishing nets. Also, since all sockeye within this system spawn in streams, this system could be prone to overescapement problems unless each spawning segment can be identified during the season. Eggs deposited in streams may also suffer heavy mortalities from scouring during heavy fall rains.

There was much discussion concerning whether 0.89 million spawners was too high an escapement goal since the data for the entire historic time period available (1956-1979 brood years) indicated that 0.71 million spawners was the optimum "long range" goal. In the past there has been great variation in

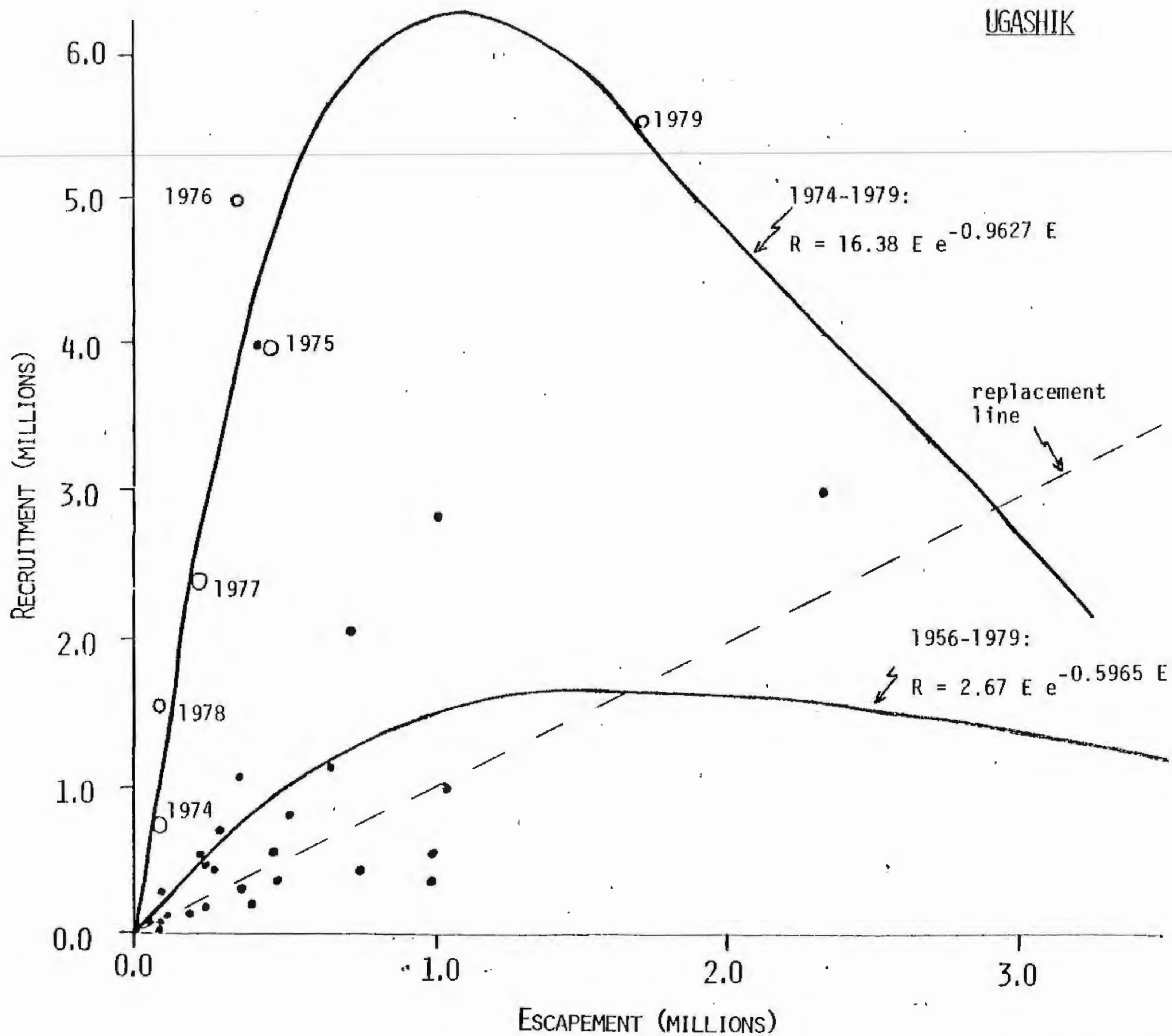

Figure 1. Spawning escapement and resulting recruitment for Ugashik River sockeye salmon. Ricker curves for all brood years and recent years only (open circles) are shown.

returns resulting from similar escapement levels. Concern was also expressed that high, constant escapements could result in an increase of predatory fishes within the system which could eventually limit or deplete sockeye production.

Research needs which would address the above concerns were discussed and included:

1. increasing aerial survey coverage to obtain information on spawner distribution;
2. escapement sample analysis to determine whether different spawning segments of the population can be identified to avoid overescapement into each stream;
3. exploring the use of sonar to enumerate escapement;
4. indexing egg mortality due to scouring by making late fall stream surveys; and
5. monitoring predatory fish populations to examine effects of increasing sockeye escapements.

Mathiesen considered research needs 1 and 5 to be the most promising ones to pursue. He considered need 2 insoluble, need 3 better tested elsewhere, and need 4 too costly to be worthwhile.

Egegik (Figure 2) Proposed revision: 1.00 million spawners

The current escapement goal for this system is 0.60 million spawners. The Ricker curve for recent data (1974-1978 brood years) indicated that the goal should be only 0.51 million. However, the curve for all available data

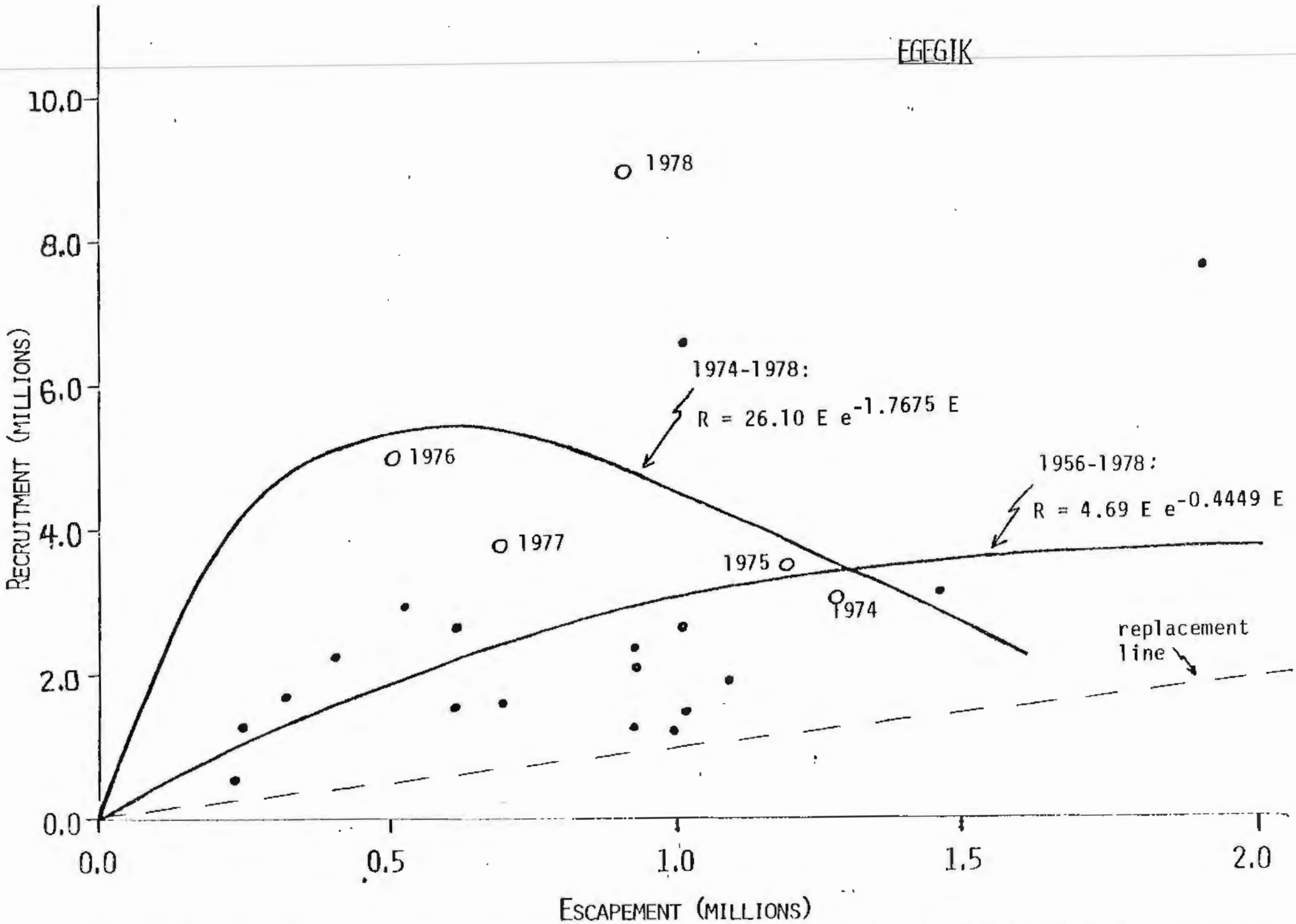

Figure 2. Spawning escapement and resulting recruitment for Egegik River sockeye salmon. Ricker curves for all brood years and recent years only (open circles) are shown.

(1956-1978 brood years) indicated a goal of 1.37 million. Russell indicated that, like Ugashik, Egegik sockeye were all stream spawners (although there are very small beach spawning components in Becharof Lake and King Salmon River drainage lakes). However, even with the high escapements in 1974 and 1975, there was no indication that overcrowding was a problem on the spawning grounds. Therefore, in his opinion, the optimal spawning goal should probably be between 0.80 and 0.90 million.

There was much discussion concerning whether an escapement goal of 0.51 million was too low. Mathiesen indicated that at this level of escapement an exploitation level of 0.90 was needed to crop off production in excess of the optimum goal. Any system which can tolerate this level of harvest and still produce maximum sustained yield (MSY) should be able to tolerate higher escapement levels. Rogers pointed out that the Ricker curve was based on data grouped at only one end of the curve. Egegik has always had surplus production (i.e. production above the replacement line) and so the system has never been fully challenged. Based solely on the size of Becharof Lake, spawning escapements in excess of 2.0 million may be supportable (assuming 2,000 spawners per unit area). Russell pointed out the possibility that there may be unused spawning habitat within the system, particularly if the population consists of different spawning subunits. Meacham and Russell indicated that fishermen talk about different "runs" of sockeye during the season. If mean catch per day is graphed over time, three distinct peaks can be identified. Everyone appeared to agree that based upon the above information an increase in the escapement goal was warranted. However, some restraint was needed in view of the Ricker curve results obtained from the most recent data. During the meeting a goal of 0.80 million was selected.

Discussions with Headquarters staff after the meeting led to a revised goal of 1.00 million spawners. It was felt that although the Ricker curve for the most recent data did indicate a lower goal than that obtained from analysis of all available data, more weight should be placed on the long term results (especially since production has always been above the replacement line).

Research needs which would address the above concerns were discussed and included:

1. increasing spawning ground survey coverage to obtain data on future escapements; and
2. exploring the possibility of obtaining higher escapements to provide better contrast when looking at the spawner-recruitment relationship.

<u>Naknek</u> (Figure 3) Proposed revision: 1.00 million spawners
The current escapement goal for this system is 0.80 million spawners. The Ricker curve for recent data (1974-1978 brood years) indicated that the goal should be 1.06 million. However, the curve for all available data (1956-1978 brood years) indicated that the goal should be about 1.00 million. It was pointed out that the data for this system was similar to that from the Egegik in that most of the returns have been above the replacement line. Therefore, the escapement should be higher than in the past. Naknek is a very productive system with complex habitats and produces returns with complex age structures.

There was little discussion concerning the revised, increased escapement goal. Florey asked whether the Naknek run could be separate more clearly from the Kvichak run. Bill indicated that it would depend upon the year, since

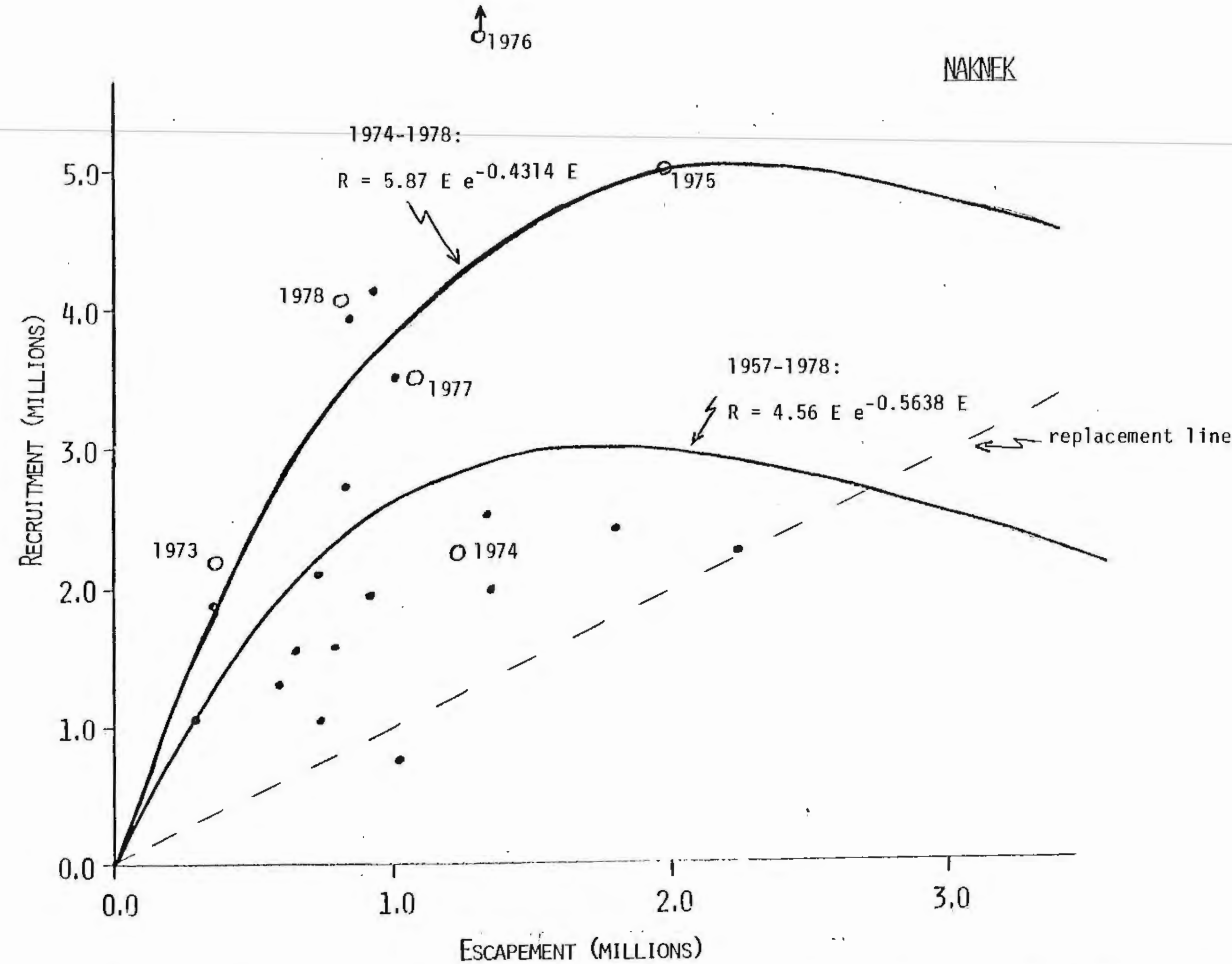

Figure 3. Spawning escapement and resulting recruitment for Naknek River sockeye salmon. Ricker curves for all brood years and recent years (open circles) are shown.

migration patterns vary. Generally, it has been relatively easy to achieve escapement goals into the Naknek. Due to the relatively flat shape of the Ricker curve, the range of desired escapements could be wide.

The only research need mentioned was increasing spawning ground survey coverage to determine spawner distribution.

<u>Kvichak</u> Proposed revision: 10.00 million spawners (pending further analyses)

The current escapement goal for this system has been used since 1975 and is 14.0 million for the peak year of the five year cycle, 6.0 million for the pre-peak year, and 2.0 million for the three off-cycle years. The management policy and theory adapted for the Kvichak River system sockeye salmon runs is based upon the same strategy and theory used in management of Frazier River sockeye salmon. Frasier River sockeye exhibit clearly defined cycles in abundance which are thought to be due to depensatory mortality during the time of freshwater residence. The cyclic nature of abundance of Frasier River sockeye persisted even after the run was severely reduced by the Hell's Canyon blockage and then rebuilt when fish passage was restored. However, the cyclic nature of Kvichak sockeye runs is not as clearly defined as that for the Frazier. In fact, the Kvichak cycle of abundance may be due to harvest patterns rather than to natural effects.

Rogers discussed some of the preliminary results of work he is doing, under contract to ADF&G, to evaluate escapement goals to the Kvichak system. He has found that it may be possible to explain the cyclic nature of Kvichak returns in terms of weather cycles and escapements. Therefore, he thinks it would be wise to attempt to smooth out the cycle by allowing escapements of 5.0 to 10.0 million spawners for two to three consecutive years. From the results of analysis done thus far, Rogers believes that optimum escapement is probably about 10.0 million.

Eggers presented the results of a simulation model he has been developing to examine various conditions which could produce cyclic patterns of returns to the Kvichak and to determine whether harvest patterns can modify such cycles. Preliminary results indicated that there is no reason to manage for a cyclic escapement goal rather than a fixed goal. In fact, a fixed goal should result in improved overall production and higher harvests. The Kvichak cycle is probably enhanced, if not caused, by the way in which the fishery is managed (i.e. the harvest policy). However, the model cannot address the question of whether predator populations will increase in response to a non-cyclic escapement pattern and eventually cause sockeye abundance to again become cyclic.

Mathiesen cautioned that predators may very well play a role in the cyclic pattern of sockeye salmon abundance seen for the Kvichak system. However, Russell stated that he found no evidence that predators play a large role in sockeye fry mortality within most creeks and streams he had surveyed during spring. Meacham also indicated that he was not aware of any evidence from the Kvichak system that predators respond to increased sockeye salmon abundance in terms of population size increases. Eggers felt that a rise in predator populations would certainly be possible in response to long term increases in sockeye abundance, but questioned whether this would actually play a large role in affecting future sockeye abundance. Nevertheless, Mathiesen recommended that before cyclic management of the Kvichak was abandoned, one should be relatively certain that constant escapement goals would actually be beneficial. It is important to look at the potential costs of changing management practices.

There was a great deal of discussion on management strategies to use for the Kvichak in 1984. Several participants seemed to feel that the goal for management should be to increase off-cycle escapements to smooth out the cyclic nature of the runs. Rogers pointed out that there will probably only be another two years in which Kvichak returns will be greater than 10.0 million. Eggers indicated that the Kvichak 1984 forecast was not reduced from the standard ADF&G method, although the total Bristol Bay forecast was reduced in view of results from Japanese high seas sampling. Therefore, if the run comes in below forecast in 1984, and if the Japanese forecast is correct, it is possible that the total return to the Kvichak will be 10.0 million rather that 17.0 million. Rogers felt that if the return to the Kvichak was between 5.0 and 10.0 then only 1.0 million should be harvested and the rest allowed to spawn. However, Rogers felt that returns may very well be higher than anticipated. He had little faith in the 1984 Japanese forecast, since he felt their sampling program was not representative of salmon distribution during the summer of 1983. Water temperatures were below normal at this time and this should have affected salmon distribution. This would account for the low catches made during the Japanese sampling program.

Meacham summarized the main points made during the discussion and advised that the following strategy be adopted for the 1984 season: If the return to the Kvichak is primarily composed of 5_3 sockeye, then the escapement goal should be 6.0 million since about half of these sockeye would probably spawn within the Newhalen River and Lake Clark. However, if there are significant numbers of 4_2 and 5_2 sockeye within the return, then the escapement goal should be 10.0 million since most of these sockeye will spawn within Iliamna. After discussion with Headquarters staff, a point goal of 10.0 million was adopted for 1984 to ensure that at least one large escapement was allowed into this system in view of the uncertainty of whether the cycle had shifted or collapsed. The important point to keep in mind is that the future goal may be to increase escapements during off-cycle years in an attempt to smooth out the cyclic nature of the run. Further revisions of goals must await completion of Roger's contracted studies.

Research needs were discussed and included:

1. examing the dynamics of stock subunits within the Kvichak system to obtain information comparable to that for Wood River system stock composition [Mathiesen's 1983 tagging study may provide some needed information];
2. examing interactions between brood years to determine whether this could cause cyclic dominance (e.g. if the brood year from a large escapement remains within the system an additional season it could depress abundance for the subsequent brood year) [Roger's present contract work will address this]; and
3. exploring possible problems in attempting to manage Kvichak and Naknek systems separately (i.e. is this possible?).

<u>Wood</u> (Figure 4) Proposed revision: 1.00 million spawners (modified by age composition of return)

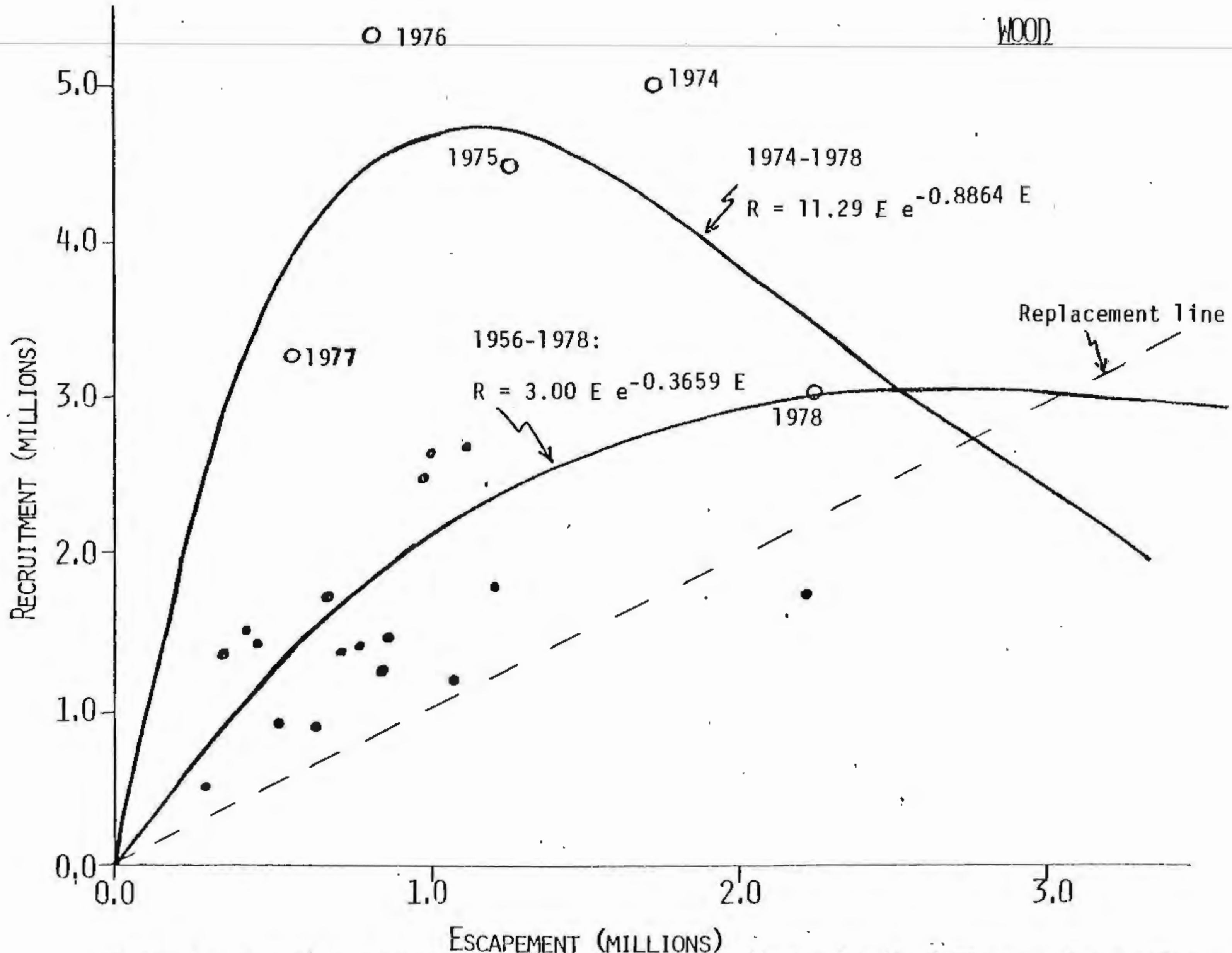

Figure 4. Spawning escapement and resulting recruitment for Wood River sockeye salmon. Ricker curves for all brood years and recent years only (open circles) are shown.

The long term escapement goal for this system has been 0.80 million spawners, although the 1983 goal was set at 1.00 million (Appendix C). The Ricker curve for recent data (1974-1978 brood years) indicated that the goal should be 0.91 million. The curve for all available data (1956-1978 brood years) indicated that the goal should be higher, 1.28 million. There is a great deal of information available on stock subunit composition within this system. In general, two groups can be recognized: river spawners, composed primarily of 3-ocean sockeye, and beach spawners, composed primarily of 2-ocean sockeye. These two groups tend to cycle, and cycles are often independent of each other. River spawners tend to have peaked Ricker curves and tend to be sensitive to over - and underescapements. Beach spawners have flat Ricker curves and wide ranges of escapements tend to produce good returns. Creek spawners are usually mostly 2-ocean sockeye (but can often be 50% 3-ocean), and tend to have Ricker curves similar to river spawners (i.e. well defined optimal escapement). The above information indicates that it is important to monitor the age composition of the Wood River system sockeye run to determine optimum escapement goals for any specific year. Since 1977 Nelson has managed this system as follows: escapement goal of 0.60 million, if return primarily (60-65%) 3-ocean sockeye; escapement goal of up to 1.5 million, if return primarily (60-65%) 2-ocean sockeye; general point estimate goal of 0.80 million.

There was some general discussion concerning management of this system. However, it was apparent that the revised goal and range were only slightly higher than those already being used. This reflected the fact that much detailed information has been available for this system in the past and had been carefully analysed. The slight increase in escapement numbers and mean sockeye size in recent years suggests that the productivity of the lakes has increased. Interestingly, when optimum escapement levels were calculated by fitting separate Ricker curves to beach, river and creek spawning populations, the total optimal level for the entire system was about the same as that indicated by fitting separate Ricker curves to beach, river and creek spawning populations, the total optimal level for the entire system was about the same as that indicated by fitted a single curve to total escapements and returns. Rogers stated that results of his 1983 tagging studies showed that stock subunits are not segregated by time. Sockeye tagged early in the run tended to spawn earlier than sockeye tagged later in the run, but they did not tend to spawn within specific areas (e.g. no segregation by time of beach and river spawners). He also voiced the opinion that smolt age composition is a more reliable indicator of future returns than is the smolt population size estimate; he felt the population estimate was not accurate due to annual changes in catchability or countability which are not predictable or quantifiable at the present time.

<u>Nuyakuk</u> (Figure 5) Proposed revision: 0.50 million spawners.

The long term escapement goal for this system has been 0.25 million, although the 1983 goal was increased to 0.30 million (Appendix C). The Ricker curve for recent data (1973-1978 brood years) indicated a goal of 1.97 million. However, the data from this system does not contain enough contrast for the results of Ricker curve analysis to be accepted with any degree of confidence. Returns from more recent, higher escapements need to be enumerated before a new escapement goal can be determined. This cannot be accomplished before 1986 when returns from the higher brood year escapement have been added to the

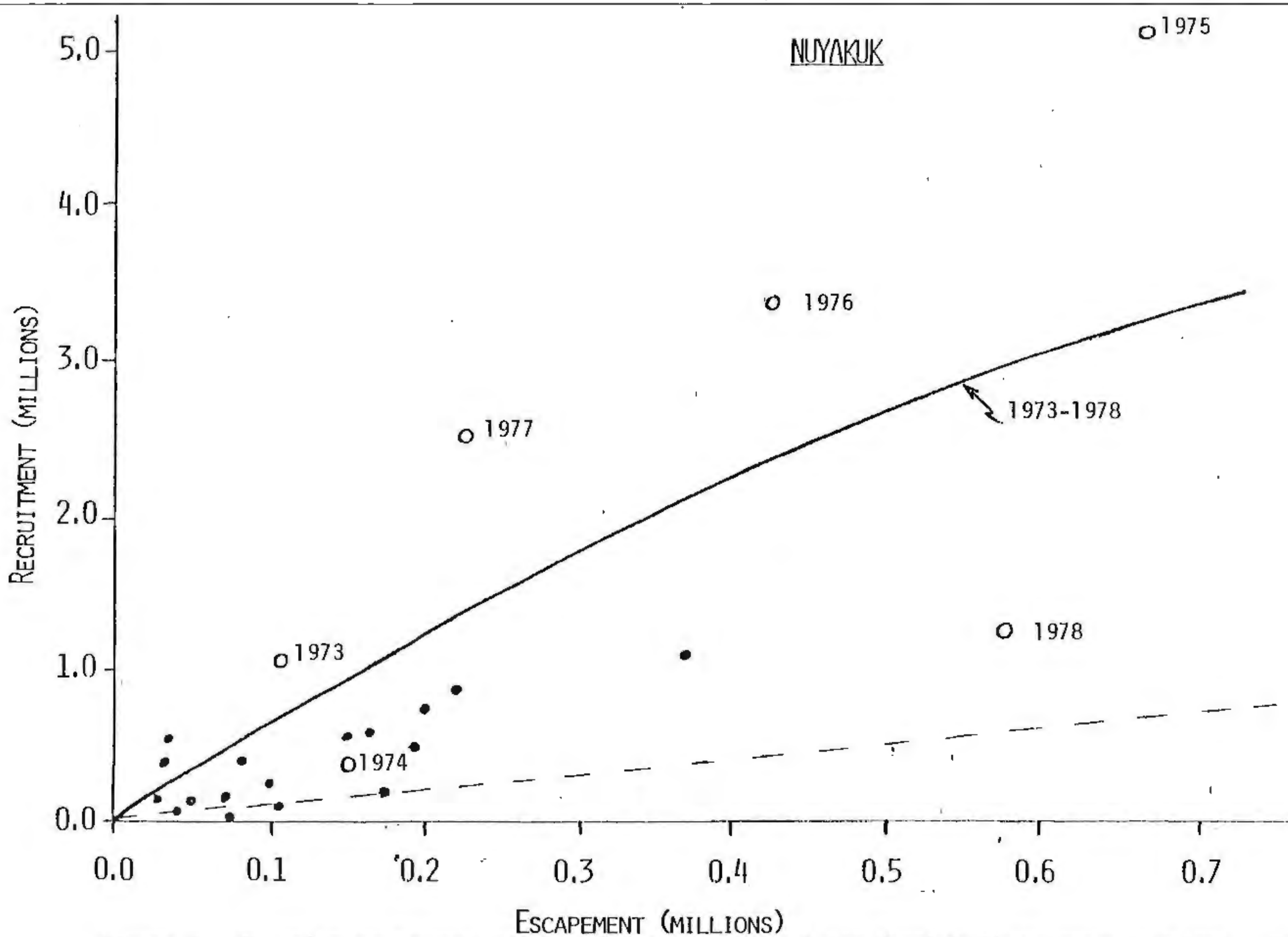

Figure 5. Spawning escapement and resulting recruitment for Nuyakuk River sockeye salmon. Only Ricker curve for recent years (open circles) is shown.

data base.

Discussion of escapement goals centered mainly on management problems encountered for this system. Rogers felt that a goal of about 2.0 million would be too high for available spawning habitat. However, everyone seemed to agree that it was too early to set a specific goal based upon available data. Nelson indicated that Nuyakuk was a difficult system to manage. Most years Nuyakuk sockeye appear to be mixed with Wood River sockeye within the district. Meacham asked whether it would be possible to split the district to help manage the systems separately. However, Florey thought that the district was too small to split. Rogers suggested that age composition could be used to separate sockeye from the two systems in years in which the age structure was sufficiently different. Eggers stressed the need for risk analysis to be done to determine the possible results of different management schemes. In general, participants agreed that 0.30 million should be a minimum goal for 1984. While it might be difficult to allow higher escapement most years, due to stock mixing problems, it would be desirable to allow even higher escapements.

Headquarters staff indicated that the goal for 1984 should be 0.50 million, since available data did indicate that this system was capable of handling escapements at least of this level. Management for Wood River at the expense of Nuyakuk needs to be moderated so that Nuyakuk production is not unduely surpressed. More importance needs to be attached to achieving higher escapement into Nuyakuk.

An interesting sideline to the above discussion concerned the small average size of sockeye smolts produced within this system. Minard stated that average length of age I smolt was about 79 mm. This may be due to the short growing season within the Tikchik Lakes, which are at the northern range of sockeye nursery lakes within Bristol Bay, and to the presence of large numbers of predatory fishes. To minimize mortality due to predation, Nuyakuk sockeye may be selected to smolt at a small size and migrate at age I, rather than spend another season within the system. Systems which produce large smolts may have low predation pressure, as well as longer growing seasons.

Igushik (Figure 6) Proposed revision: 0.20 million spawners

The long term escapement goal for this system has been 0.15 million spawners, although the 1983 goal was increased to 0.20 million (Appendix C). The Ricker curve for recent data (1974-1978) indicated that the goal should be 0.19 million. There was little discussion on the revised goal. This system is the most productive one within Bristol Bay. Returns are generally dominated by 5_2 sockeye, although 4_2 sockeye can compose a major portion of the run during some years.

Togiak (Figure 7) Proposed revision: 0.15 million spawners (Togiak Lake only, does not include the main river, associated tributaries or other systems within the District).

The current escapement goal for this system is 0.10 million spawners. The Ricker curve for recent data (1973-1979 brood years) indicated that the goal should be 0.19 million. There was little discussion on the revised goal, but Skrade indicated that there is a need to improve the management tools

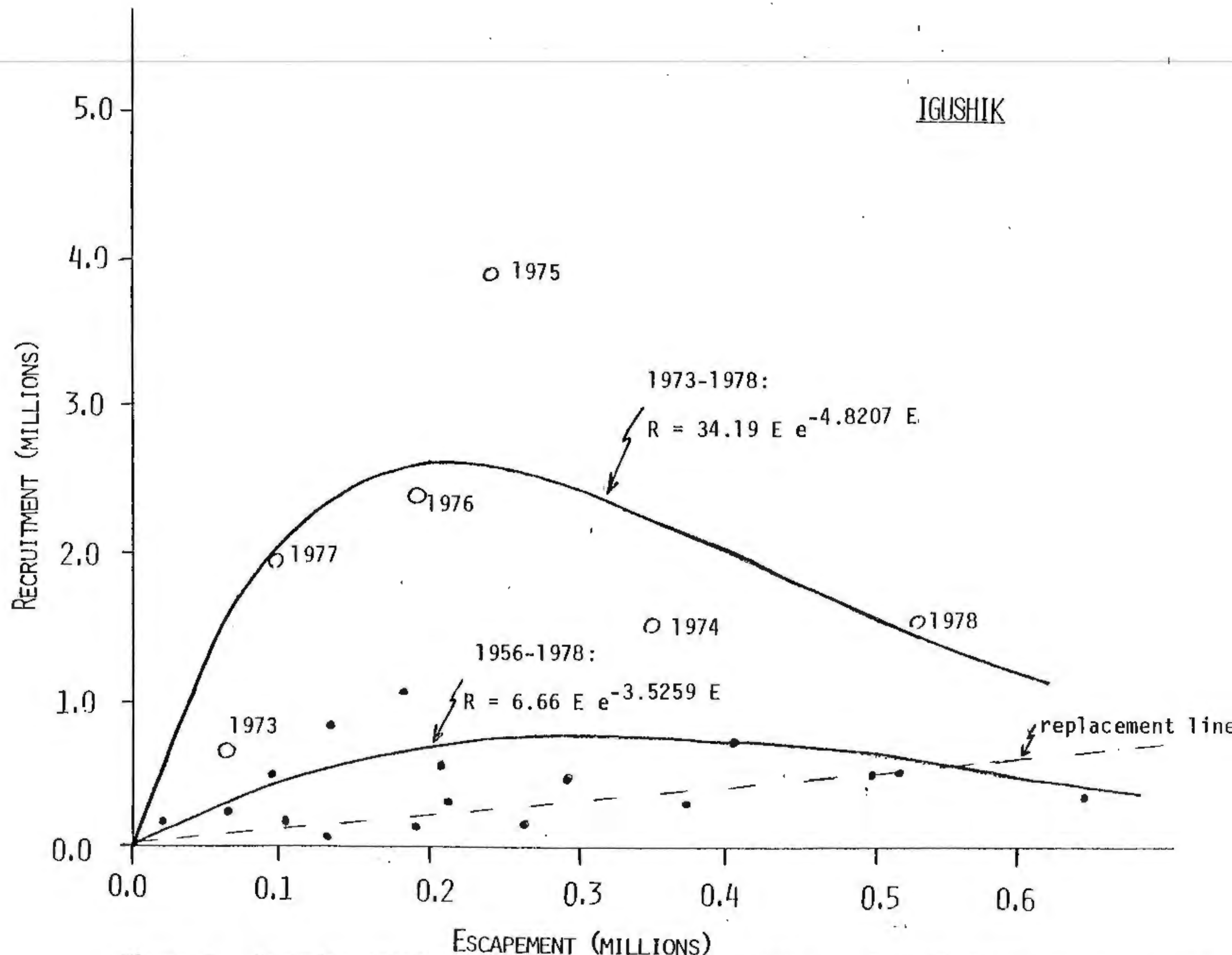

Figure 6. Spawning escapement and resulting recruitment for Igushik River sockeye salmon. Ricker curves for all brood years and recent years only (open circles) are shown.

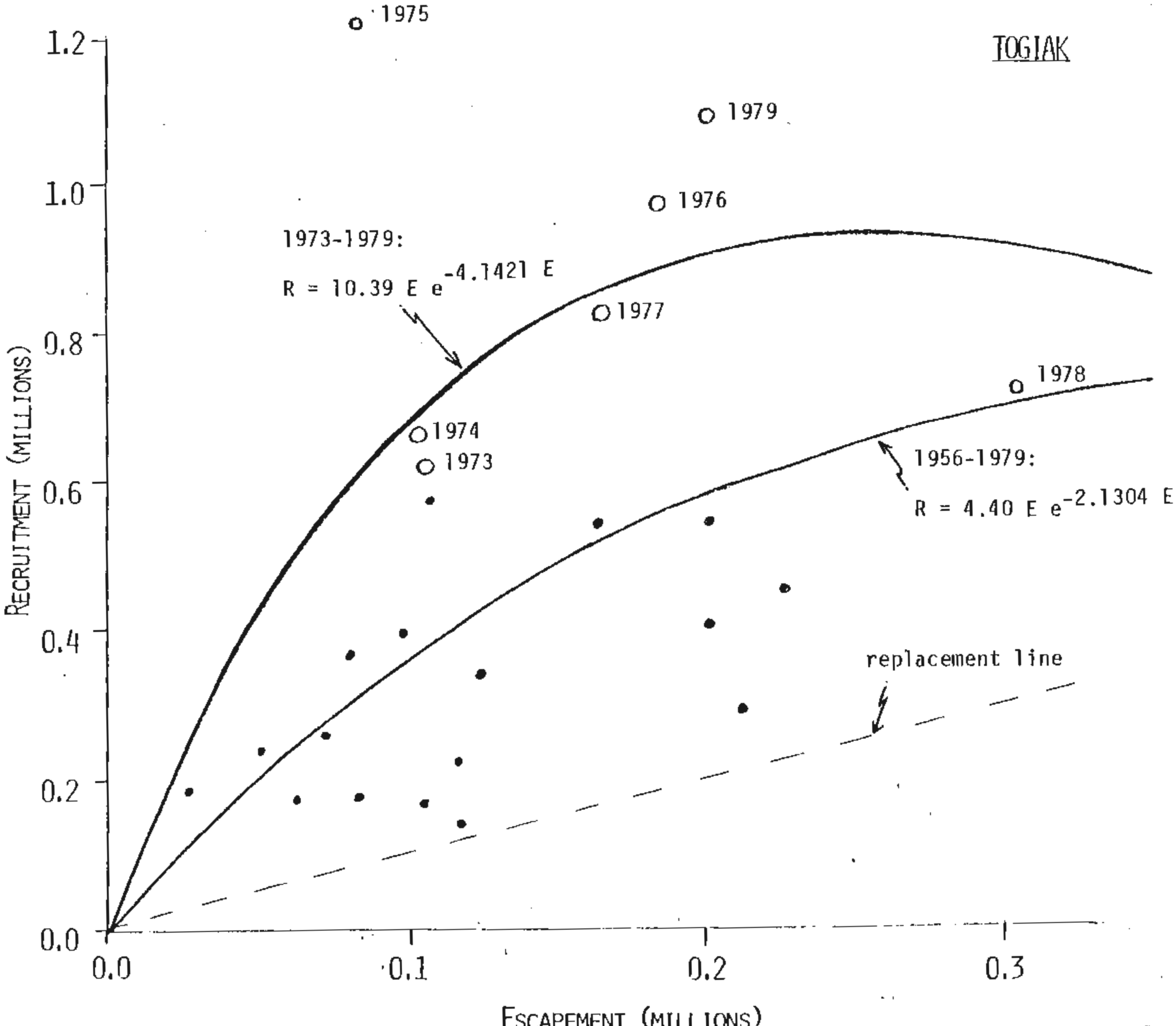

Figure 7. Spawning escapement and resulting recruitment for Togiak River sockeye salmon. Ricker curves for all brood years and recent years only (open circles) are shown.

available for this system. In the past the only indications of escapement came from the counting tower, which is several days travel time for sockeye passing through the fishing district, and aerial surveys, which are often hindered by turbid water. Meacham commented that the CPUE model developed by Brannian provided more timely estimates. Operation of a sonar counter was also suggested, by Minard, to provide more timely escapement estimates for inseason management. In 1983 sonar was used late in the season to count coho salmon.

Nushagak-Mulchatna, Branch, and Snake Proposed revisions: None .

No changes in current escapement goals were suggested for the above systems since Ricker curves were not fitted to the small, often unreliable, amount of available data. However, there was some discussion on future needs and reasons for past deficiencies in data.

Nushagak-Mulchatna: The current goal for this system is 0.05 million spawners. Escapements into this system are usually underestimated. Although there is a sonar counter on the Nushagak River in the vicinity of Portage Creek, it is not possible to separate Nushagak-Mulchatna sockeye from Nuyakuk sockeye. Generally, there is a poor correlation between sonar counts and escapement estimates obtained from Nuyakuk counting tower and Nushagak-Mulchatna aerial survey counts. Nelson indicated that it is not possible to manage the fishery to achieve Nushagak-Mulchatna escapement. Apparently about 5% of the total district production comes from this system. Escapement into the Nushagak River appears to be composed of about 16% Nushagak-Mulchatna sockeye and 84% Nuyakuk sockeye. Due to the poor information available for the Nushagak-Mulchatna, forecast reliability is poor. This could be improved somewhat if age composition information was available for this system. This could be accomplished by obtaining sockeye samples during late summer king salmon sampling trips. Minard cautioned that it may be difficult to obtain sockeye samples during such trips without seriously impacting king salmon sampling.

Branch: The current goal for this system is 0.185 million spawners. There was not enough data available to really set an optimal goal. Aerial survey information and escapement age composition data are available, but commercial catch allocation within the district is a problem.

Snake: The current goal for this system is 0.04 million spawners. Returns to this system have been extremely low for a long period of time, and it is not possible to determine whether this system had ever produced large numbers of sockeye in the past. Enhancement efforts by F.R.E.D. Division (i.e. East Creek Hatchery) have been abandoned. Nelson indicated that it has been impossible to manage the district fishery to achieve Snake River escapement goals and that the present goal was too high. It was agreed that aerial surveys of this system would continue, but brood year tables and forecasts would no longer be done.

MIXED STOCK PROBLEMS (General Discussion)

There was a general discussion of management strategies that could be used to minimize errors when trying to achieve escapement goals within mixed stock fisheries. Eggers suggested that a logical approach would be to list all possible combinations of errors, prioritize them regarding their potential detrimental impacts, and then make decisions which were associated with the least risk. The two most important areas in which mixed stocks could be a problem in achieving escapement goals were the Wood-Nuyakuk and Naknek-Kvichak stocks.

Wood-Nuyakuk: The worse case scenario for management was a year in which Wood River had a strong run and Nuyakuk had a weak run. If the Nuyakuk run was above 1.0 million, there was usually little difficulty in achieving escapement goals. However, if the Nuyakuk run was below 1.0 million, there was a good possibility that the goal could not be met, if management decisions continue to be based upon achieving escapement goals to Wood, due to its perceived greater importance. Several participants, however, felt that Nuyakuk production was being greatly surpressed by past management policy which weighted decisions heavily in favor of Wood River.

There was discussion on research needs to address and help alleviate the above mixed stock problem. A tagging study might help identify stocks and determine whether run timing differences exist between these systems. Presently, for management purposes, Nelson assumes that early in the season the run consists mainly of Nuyakuk sockeye (i.e. 66% Nuyakuk, 33% Wood). However, this may not always be true. It would be helpful to have information that would indicate whether the Nuyakuk run was early, late, or arriving concurrently with Wood River stocks. There was further discussion concerning the desirability of tagging sockeye "inside" and "outside" the Nushagak District. In 1979 a tagging study was done "inside" at Grassy Island to look at timing and separability of Wood and Nushagak River runs. In 1980 stock separation studies were conducted "outside", but proved to be of limited usefulness. However, since 1980 many refinements have be made in scale pattern analysis techniques and procedures. Florey suggested that it might be possible to use scale samples collected since 1980 to look at the feasibility of doing further stock separation studies. Eggers suggested that a combination of "outside" stock separation work and "inside" tagging might eventually help address the mixed stock problem.

Naknek-Kvichak: During non-peak cycle years for the Kvichak it is considered more important to achieve Kvichak escapement rather than Naknek escapement, since Naknek generally produces about two recruits per spawner. When the Kvichak run is weak and the Naknek run is strong it has been difficult to achieve the desired escapement into the Kvichak during off-cycle years such as 1981 and 1982.

RELATED PROBLEMS

Exploitation Rates (Mathiesen and Rogers)

Mathiesen and Rogers strongly feel that there is a need for a policy concerning allowable levels of exploitation for Bistol Bay sockeye salmon stocks. Presently, once the escapement goal is achieved for a system, then the commercial fishery is allowed to remain open with few, if any, closures. This may be detrimental to stocks since the tail end of runs are usually harvested at a 90% exploitation rate. It is probably necessary to obtain adequate escapements throughout the duration of each run to protect the genetic and ecological integrity of stocks. Also, any fishing closure should be of sufficient duration to allow sockeye to pass through the fishing district "untouched." Observations indicate that sockeye which escape through the district when fishing is occurring tend to be in poor condition and, thus, may not contribute as much to the spawning population as sockeye which were not subjected to fishing pressure (e.g. sockeye subjected to fishing pressure may not survive to spawn, may not deposit all of their eggs, may not be able to defend redds or dig adequate redds, etc.). Rogers stressed that any formal policy statement should be worded so that it did not dictate specific actions managers must take, but rather provided managers with greater flexibility in allowing sufficient escapement from all portions of a particular run.

There was a great deal of discussion on whether it would be possible or desirable to actually set an upper limit of exploitation. However, there did not seem to be any studies done which would identify an upper limit of exploitation. Several participants indicated that exploitation rates of 80 or 90% were most probably not sustainable over long time periods. Eggers expressed concern that over several consecutive years of high exploitation, the probability of impacting certain segments of the run increases. Therefore, the risk of overexploiting stocks or stock subunits may remain high, even though overall escapement goals are reached. Egegik sockeye may prove to be such an example, since these sockeye have been harvested at high exploitation rates for several consecutive seasons. Most Bristol Bay sockeye populations appear to sustain exploitation rates between 40-60%. Florey pointed to the fact that this type of protection was most critical at the tail end of the run, since managers generally tended to be most conservative early in the season and sufficient escapement was generally available during the peak of the run. Rogers further stated that the problem of harvesting some segments of a run at too high a level was really most pronounced during large runs. During poor runs there were usually lots of closed periods during the entire duration of the season.

Sex Ratios (Russell)

Russell presented some preliminary results of a short study he did comparing production from escapements with more females than males and from escapements with more males than females. In every system examined, he found that higher production (R/S) occurred when males outnumbered females. Although this finding needs to be examined in greater detail, since other factors may have been more important in producing the results (e.g. age composition, escapement size, exploitation rates, etc.), it was quite surprising in view of currently accepted theory. One usually assumes, and pen studies have been done which show, that a single male sockeye is capable of fertilizing several females. Thus, escapements in which the number of males is equal to or less than the number of females should produce complete fertilization of all available eggs. Therefore, males can be harvested at a higher rate than females without decreasing potential production. In fact, current mesh size restrictions are based on this way of thinking and should cause catches to be biased in favor of males (i.e. catches should contain a higher proportion of males than females). Mathiesen indicated that gill net catches during the early years of the Nushagak fishery contained 70-80% males, while trap catches were only 50% males. Over a 20 year period no effects upon production were noted.

This presentation resulted in some lively discussions concerning possible underlying mechanisms and potential effects upon setting escapement goals and changing gillnet mesh size restrictions. However, further study is needed before it is determined that the sex ratio is actually the factor responsible for changes in sockeye production. This will entail examination of daily age composition and sex ratios within escapements, determining whether exploitation rates affects sex ratios and production, etc. If sex ratio does affect production, this information could be used to modify escapement goals and mesh size restrictions, as well as to improve forecasting procedures.

Miscellaneous

Rogers cautioned that there may be a problem in aging escapement samples. He suspects that this was primarily be due to reading errors, however, it also raises questions concerning the reliability of using scales to estimate age. Last year Rogers compared age composition of sockeye salmon sampled at the Wood River counting tower (aged using scales) to age composition of sockeye sample on the spawning grounds (aged using otoliths) and found:

	4_2	5_3	5_2
tower samples (scales)	73%	12%	14%
spawning ground samples (otoliths)	50%	27%	23%

Unfortunately, Rogers did not re-read any of the scale samples - he simply used data supplied by ADF&G. It would probably be very useful to follow this up with a more extensive study as such discrepancies indicate that there could be serious problems in the data base and analyses which use this data. It also suggests that more time be taken in training new scale readers. Such reading errors would add an unpredictable degree of bias to age composition estimates.

Mathiesen suggested that the entire age-weight-length (AWL) sampling program be reviewed to determine, for example, whether the variance of age composition estimates could be decreased by using a different sampling design. This is particularly important when making forecasts from sibling ratios, where estimates of jack abundance are critical, as well as when determining optimal escapement goals.

OTHER SALMON SPECIES

Chinook salmon

Nushagak: Nelson manages the Nushagak system for an escapement goal of 0.05 to 0.10 million spawners. Escapements have averaged 0.08 million spawners since 1966. At this time there is not enough data (and some of the early data is suspect) to do a rigorous analysis. However, Meacham pointed out that the returns from some recent large escapements should provide enough information to generate a meaningful escapement goal in the future. More information will still be needed concerning distribution of spawners and spawning habitat availability in order to more clearly define goals. In general, escapements have generated an average of three recruits per spawner. The spawning populations is mainly composed of 5_2 and 6_2 king salmon. Recent returns to the Nushagak, and western Alaska in general, have been strong. Strong runs have also occurred in Prince William Sound and Cook Inlet. However, Yukon River stocks have been more variable and probably are still subjected to high seas interceptions of significant magnitude during at least some years.

<u>Togiak</u>: There is no formal escapement goal for this system. Generally,

escapements have averaged about 0.02 million. Only a limited number of commercial fishermen use chinook salmon gill nets prior to July. Chinook salmon are also harvested incidentally with sockeye salmon.

Ugashik: Little information on chinook salmon has been collected. Pumice Creek is an important spawning area. There may be increased interest in harvesting chinook salmon within Ugashik District as Nushagak District effort continues to climb. In 1983 about 10,000 chinook salmon were harvested within Ugashik District.

Egegik: There is no directed fishery for chinook salmon in this District. Escapement in the King Salmon River averages 3,000 to 6,000 spawners. However, aerial surveys are difficult to accomplish due to muddy water conditions.

Naknek-Kvichak: Total run into this Distict averages 20,000 to 40,000 chinook salmon. About 1,000 chinook salmon are taken for subsistence and 2,000 are taken for sport. The systems producing the bulk of the runs are Big Creek, King Salmon Creek, the main stem of the Naknek River, and the Branch River (which has a late run in the middle of July). These systems generally receive escapements of 2,000 to 10,000 chinook salmon. The size of the chinook salmon population spawning within the Kvichak River is unknown. As a general rule of thumb, early run chinook salmon spawn within tributary streams and late run chinook salman spawn within main stem rivers. The Naknek-Kvichak District may very well be the first in Bristol Bay to feel the "sport-commercial pinch" over allocation.

Pink Salmon

Pink salmon runs are of major consequence only in the Nushagak system, and only during even years. There has been little commercial interest in pink salmon due to their low marketability and the great variability in returns. The current optimal escapement goal is 1.0 million spawners for the District. Recent work by Rogers indicated that the optimal escapement range should be 0.5 to 1.5 million spawners. Pink salmon are very sensitive to overescapement problems; escapements over the optimal range result in low production.

Chum Salmon

Chum salmon are most important in the Nushagak and Togiak Districts. Data on escapement numbers are poor, but data on commercial catch numbers are good. Age composition information from the catches and escapements are probably adequate.

Nushagak: The current escapement goal for the Nushagak is 0.2 million spawners. The commercial catch has been stable and, due to the mesh size used, targets on four year old females. When chum salmon runs are weak and sockeye salmon runs are strong, the fishery is managed for sockeye salmon. Management to achieve chum salmon escapement goals is easiest when the chum salmon run is strong and the sockeye salmon run is weak.

Togiak: The current escapement goal is 0.2 million spawners.

Coho Salmon

Discussion centered on whether it was necessary or possible to determine spawning escapement goals for coho salmon. Florey stated that coho salmon are cannibalistic and, therefore, strong back-to-back escapements do not occur. However, coho salmon are a very resilient species with an extremely extended spawning period, and this makes them relatively easy to manage.

Nushagak: Mike felt that a minimum spawning goal for the Nushagak should be about 0.05 million. The recent average total run has probably been 300,000 to 400,000 coho salmon. Average long term catch has been about 65,000, but recent catches (1979 to present) have averaged 193,000. The record catch was 388,000 in 1982. The sonar project at Portage Creek can be used to count coho escapement, but the run is so long in duration (extends into September) that the cost of enumerating the entire run is prohibitive.

Togiak: Skrade indicated that a minimum escapement goal for this system is not known. Only three years of escapement index estimates are available and catch sampling is poor. Studies are being done with cooperation from the U.S. Fish and Wildlife Service to index coho escapement using a weir and to obtain escapement samples. There is State General Fund money available to continue coho salmon studies.

SUMMARY OF RESEARCH NEEDS

Several of the more important research needs were discussed at the close of the workshop and re-evaluated in terms of their importance and practicality:

1. Escapement goal ranges should be based upon the shape of the Ricker curve to reflect the productivity of specific systems.

   Everyone agreed that this was an important and achievable goal. After the meeting ranges were calculated for every system having a data base amenable to Ricker curve analysis (see II. ESCAPEMENT GOALS).

2. To provide more contrast to the data base and, thus, help determine the shape of the Ricker curve, experimental escapement goals should be set for various systems.

Although everyone agreed that several systems needed wider ranges of escapements to better determine the spawner-recruit relationship, most people felt that it was not feasible or necessary to set experimental goals. Many recent escapements have been above historical levels and would serve to provide enough contrast for future analyses.

3. To determine whether escapement "quality" is affected by the level of commercial exploitation, past data should be analysed and further studies devised for the future.

   It might be useful to determine whether the variation around the spawner-recruit relationship is correlated with exploitation rate. Other indices of stress due to the commercial fishery that could be examined would be the proportion of net marked salmon in escapements, and residual eggs in dead females (i.e. egg retention) during years with high and low exploitations levels.

4. Continued emphasis should be placed upon processing historic data, maintaining a complete data base, and summarizing available information by system.

This, of course, is a basic goal which must be pursued in order to properly manage the fishery, since analyses such as spawner-recruit relationships depend upon the availability of long series of data. Several new publications concerning this goal are available through the University of Washington, FRI:

*Data File for Bristol Bay Sockeye Salmon Lakes. 1983. Rogers, Poe, Hardy, Kline and Swanson. (Annual Report for Imarpik Regional Aquaculture Corp.);

*Evaluation of Nushagak Salmon Escapements. Rogers. (FRI Circular).

Also, ADF&G will continue to maintain the data file and produce publications such as catch and escapement reports, smolt migration estimates, etc.

5. Continuation of Russell's preliminary studies concerning the relationships between sex ratios of escapements and changes in production should be a high priority in subsequent years.

   More detailed analyses are needed using information on the sex ratio, age composition, etc. of daily escapements in relation to exploitation levels and subsequent production. The results of such studies could affect setting of escapement goals, changing mesh size restrictions, and forecasting salmon abundance.

6. Evaluation of the effectiveness of in-season management techniques in achieving escapement goals.

7. Studies upon other salmon species need to be continued and expanded, especially for systems on the east side of Bristol Bay, so that minimal and optimal escapement goals can be determined.

   Presently, studies are being conducted on king and coho salmon, with particular emphasis placed on the Nushagak and Togiak systems. Such studies should be continued and aerial survey coverage extended into other areas.

   Several of the above studies can be done in cooperation with the U.S. Fish and Wildlife Service, since several Bristol Bay salmon systems lie within the boundaries of National Wildlife Refuges and, therefore, are of mutual concern to both State and Federal governments. Cooperative studies are presently being done on the Togiak (coho salmon escapement enumeration and sampling) and Egegik (sockeye salmon smolt enumeration and sampling) systems.

APPENDIX A

BRISTOL BAY SALMON ESCAPEMENT GOAL WORKSHOP AGENDA

I. Overview of effects of climate and reduction of high seas fishery interceptions on population dynamics of Bristol Bay sockeye salmon and implications for management. (Eggers, ADF&G; Rogers, FRI)

II. Escapement goals for sockeye salmon by river system (General Discussion, except where indicated)

   A. Ugashik
   B. Egegik
   C. Naknek
   D. Kvichak
      1. Escapement goal evaluation (Rogers)
      2. Changes in stock composition and implications (Mathiesen, UAJ)
      3. Simulation model results (Eggers)
   E. Wood
   F. Nuyakuk
   G. Igushik
   H. Togiak
   I. Nushagak-Mulchatna, Branch and Snake

III. Management strategy for mixed stock fisheries (General Discussion)

A. Nushagak

B. Naknek-Kvichak

IV. Related problems

A. Exploitation rates (Mathiesen and Rogers)

1. Effects upon escapement "quality"

2. Maximum exploitation rates

B. Sex ratio of escapement and resulting returns per spawner (Russell, ADF&G)

V. Other salmon species (General Discussion)

A. King Salmon

B. Pink Salmon

C. Pink Salmon

D. Coho Salmon

VI. Research needs summary (General Discussion)

APPENDIX B

LIST OF ESCAPEMENT GOAL WORKSHIP PARTICIPANTS

Alaska Department of Fish and Game

Commercial Fisheries Division

Doug Eggers (Chairman), Region I, Biometrician

Ken Florey, Region II, Regional Supervisor

Charles Meacham, Region II, Regional Research Supervisor

Dennis Haanpaa, Region II, Management Coordinator

Steve Fried, Region II, Bristol Bay Research Project Leader

Henry Yuen, Region II, Bristol Bay Salmon Research Biologist

Mike Nelson, Region II, Bristol Bay Senior Area Management Biologist

Don Bill, Region II, Bristol Bay Area Management Biologist

Robert (Mac) Minard, Region II, Bristol Bay Research Biologist

Dick Russell, Region II, Bristol Bay Assistant Area Management Biologist

Wes Bucher, Region II, Bristol Bay Assistant Area Management Biologist

Jeff Skrade, Region II, Bristol Bay Assistant Area Management Biologist

F.R.E.D. Division

Chris Pace, Regional Salmon Plan Coordinator

University of Alaska, Juneau

Ole Mathiesen, Dean, School of Fisheries

University of Washington, FRI

Don Rogers, Research Professor

U.S. Fish and Wildlife Service

Chris Dlugokenski, Becharof National Wildlife Refuge Fisheries Biologist

May, 1983

NUSHAGAK DISTRICT SOCKEYE SALMON ESCAPEMENT GOAL REVISIONS FOR 1983 AND FUTURE YEARS

Historically, Nushagak district has been the second most productive system in Bristol Bay, averaging a 5.0 million sockeye salmon catch for 20 years from 1899 to 1918, 2.8 million for the following 30 years, and finally dropping to an 882,000 average in the 29 year period from 1949 to 1977 (Figure 1). Total run statistics (catch and escapement) exhibited the same drastic decline in production. High sustained exploitation rates (up to 80%) in the early years of the fishery resulted in precipitious declines in production, and although the other districts in Bristol Bay have experienced a decline as well, it has been neither so distinct nor so drastic in nature as in Nushagak district.

In an effort to reverse the downward trend in Nushagak district sockeye production, larger escapements were provided by reduction in fishing time. The downward trend in force from the 1920's through the late 1950's were generally halted, and total run production was stabilized, but at a level well below that seen in the period of fishery development during the early 1900's.

Commencing in 1978 a remarkable transformation was experienced in Nushagak sockeye production, when 6.6 million fish returned, the largest inshore run recorded since the mid-1940's. The remarkable return in 1978 was followed by an equally strong return in 1979 (6.4 million), and in 1980 over 12.8 million sockeye returned to Nushagak district, breaking numerous long-held total run estimates, and establishing a record 8.3 million escapement to the district's river systems. Peak sockeye production continued in 1981 and 1982 when Nushagak district river systems produced total returns of 10.6 and 8.0 million fish, respectively.

Since 1978, Nushagak district's sockeye average catch production has increased to 4.9 million fish, while the total run from 1978-82 has averaged 8.9 million compared with the previous 20 year average (1958-77) of 2.3 million.

The recent five year total run average of 8.9 million sockeye is higher than any previous five year average in the long history of this fishery. Although it is apparent that exceptional survival conditions have greatly aided in boosting sockeye production in the last five years, increased and consistent escapements to major contributing Nushagak district river systems appear to be essential to increased and sustained production for this fishery.

In an effort to maintain the recent high production, it will be necessary to increase sockeye escapement goals to the major river systems of Nushagak district. Without escapement goal increases, it's probable that Nushagaks' sockeye runs will eventually revert back to the previous recent long-term average of 2 or 3 million fish. Accordingly, in 1983 Nushagak district escapement goals will be increased by 25% to the upper management range already in effect:

Wood River	- from	800,000	to	1.0 million
Igushik River	- from	150,000	to	200,000
Nuyakuk River	- from	250,000	to	300,000
Nushagak River	- from	40,000	to	50,000
Snake River	- from	30,000	to	40,000
Total District:		1,270,000		1,590,000

Additionally, sockeye escapement goal evaluations presently in progress will continue for all river systems of Bristol Bay, and the Department will present further updated escapement goal recommendations for public input at Advisory Committee meetings in the fall of 1983.

Through these adjustments to escapement goals, the Department hopes to sustain the recent high levels of salmon production in future years.

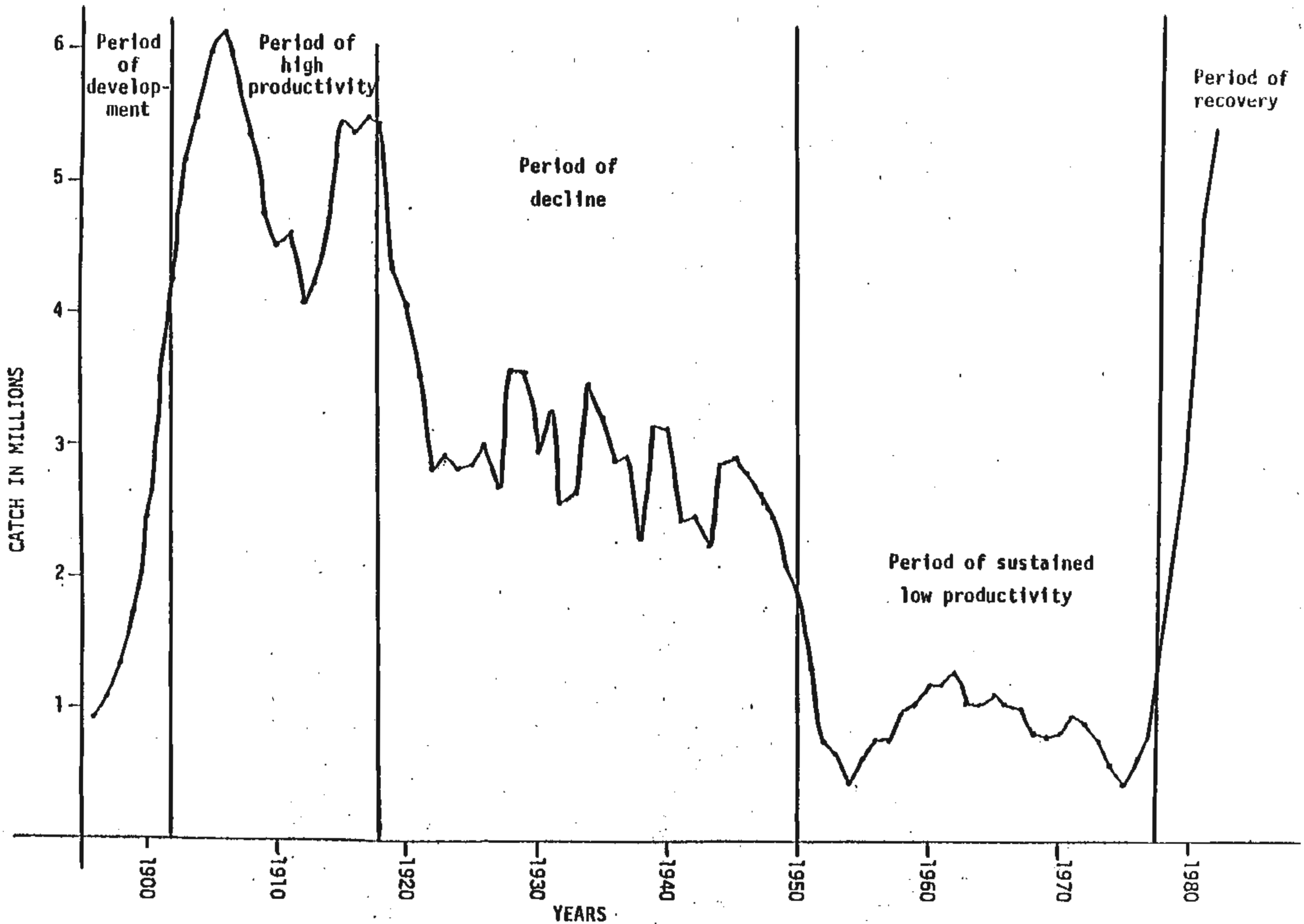

Fig. 1. Nushagak Bay sockeye salmon catch, 1893-1982 smoothed by 4-year moving average.