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TIMING AND RATE OF MIGRATION OF BABINE SOCKEYE
STOCKS THROUGH THE SKEENA AND BABINE RIVERS

by

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INTRODUCTION

From 1944-1967 a number of tagging programs on Skeena River sockeye salmon measured rates of travel, exploitation by the commercial fishery, and the extent of separation of stocks by time of occurrence at various locations along migration paths (Pritchard 1944, 1945, 1947, 1948, 1953a, 1953b; Milne 1949; Shepard, Aro and Withler 1962; Aro and McDonald 1968; Giovando 1969).

Release and recovery data from these experiments were reviewed by Takagi while at the Pacific Biological Station as a visiting scientist during 1969-1970, and in this paper we have considered rates of travel and order of passage of fish according to stream of origin and other factors. We also inspected release and recovery data for any indication that sockeye bound for the same spawning streams on Babine Lake may migrate together through coastal waters, the estuary and the Skeena and Babine rivers. We believe that the latter is important for, if fish derive some mutual benefit from travelling together to the same destinations, anything which tends to scatter or divide them, e.g., commercial gillnet fishing which removes certain sizes and permits others to escape (Todd and Larkin 1971) might then affect precision of homing, adherence to regular migration routes and speed of travel along them, and possibly other activities of importance to the success of the population. We have used the term "travelling units" to describe these groupings and assume that, should they exist, their members would at some point in their migration come together and develop a bond which would persist from then, at least until they reached their natal streams.

Killick (1955) found stocks (races) of Fraser River sockeye maintained a persistent chronological order during migration, spawning and death, and taggings at the Babine counting fence and observations on the Babine spawning grounds have indicated a similar order during the final months of adult life (Smith and Jordan MS 1973; Miki and Smith, unpublished MS). Thus considerable grouping en route through the Skeena and Babine rivers seemed likely at the outset.²

THE STUDY AREA

The commercial fishing area

The bulk of the Skeena River commercial sockeye catch is made in Fisheries Statistical Area 4 within 100 km of the river mouth (Fig. 1) though substantial numbers are also taken at considerable distances from the river, including waters of the west coast of Southeastern Alaska (Anon. 1965). Fishing has historically been by gillnet in the estuary and by both gillnets and (particularly in recent years) by purse seines outside the present Area 4 boundaries. A few Skeena sockeye are also caught by troll gear.

²Such an order during migration and spawning does not always occur however. Smith (1964) found a complete mixing of stocks in time of passage of Alaska sockeye through the Kvichak River and Iliamna Lake in each of three successive years of tagging.

The fishing boundary and test fishing site

The upstream boundary of Statistical Area 4 is in the Skeena River at a straight line between Mowitch Point and Veitch Point just below Tyee Station, where a test fishing program provides a daily index to escapement into the river.

The Babine River system

About 90% of Skeena River sockeye are produced in the Babine system -- in streams entering Babine Lake and in the Upper and Lower Babine rivers at its outlet (Fig. 2). Some fish travel 180 km from the outlet through Nilkitkwa and Babine lakes to tributary streams near the lakehead and all are counted each year at a fence spanning the Lower Babine River (Aro MS 1961; Jordan MS 1968; Jordan and Smith MS 1972).

General timing of the run

Sockeye arrive on the Area 4 commercial fishing grounds from early June to late August, and according to Aro and McDonald (MS 1968) Babine fish are among them as early as June 17 and as late as August 24 -- virtually throughout the period.

Sockeye take 3 to 5 weeks to travel the 360 km from the fishing boundary to the counting fence (an average rate of about 13 km/day) where the bulk of them pass during a 2-month period from mid-July to mid-September.

Fifteen or more stocks (stock is defined here as 1,000 or more sockeye destined to spawn in a single stream) are usually present in the escapement annually. The earliest of these enter eight small streams spaced along the full length of the lake, and commence spawning about August 1 (almost immediately after entering); the latest begin spawning in Lower Babine River and Upper Babine River beginning about September 20.

History of tagging programs

Aro and McDonald (MS 1968, Table 13) list tagging locations and tag recoveries in 14 Fisheries Research Board experiments with Skeena River sockeye from 1944-1958. Tagging locations differed among years; those during 1944-1948 were primarily in Area 4, but from 1956-1958 some were also in the more northerly Statistical Sub-areas 3X and 3Y. Others were tagged at the river boundary (Tyee) in 1955, 1956 and 1957 and personnel of the Canada Department of Fisheries Operations Branch tagged some in northern British Columbia coastal waters in 1966, 1967 and 1968. Operations Branch records of 1966 and 1967 were made available through courtesy of Mr. D. Harding. These experiments and numbers of recoveries in the Babine system are listed in Table 1. The largest number of recoveries, 588, were from the 1947 experiment and were particularly useful in our studies.

In all coastal and estuarine experiments appreciable numbers of tagged fish were recovered twice; first at the Babine River counting fence where tag numbers were recorded, and again, usually after death on the spawning grounds. Occasional tags recovered in native food fisheries along the migration route gave little or no information on the destination of the tagged fish. Tagging for other purposes at the counting fence in 1946, 1947, 1955, 1958, 1963 and

1964, as well as in 1953 at the site of a major land slide on Babine River (Godfrey et al. 1954) was summarized by Smith and Jordan (MS 1973) and provides further information on stock timing.

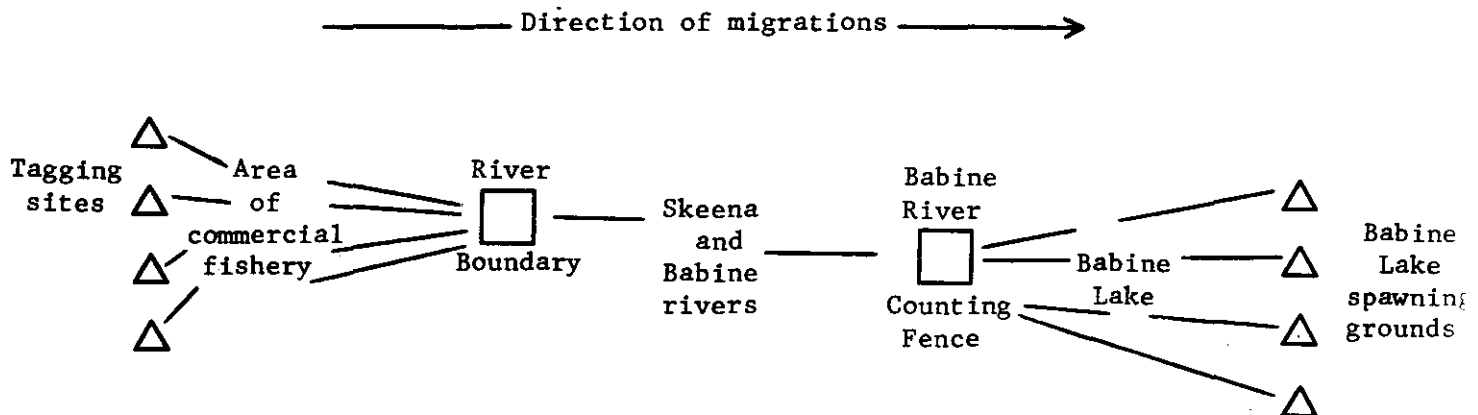
METHODS OF ANALYSIS

Only approximations to total time out between points of release and ultimate recovery can be made, because spawning grounds were visited irregularly and exact dates when tagged fish arrived on the grounds were seldom known. In addition, different tagging locations and dates annually and different migration routes from them to the river also pose special problems when interpreting differences in time out between release points and the river mouth. We believed, however, that once in the river tagged fish would be affected by fewer variables; certainly the possibilities for alternate migration routes would be eliminated. We therefore restricted our consideration of travel rates to the period commencing with entry at the river boundary and ending at the Babine fence. Since there is a consistent annual order of arrival of stocks at the counting fence (Smith and Jordan MS 1973) we could be fairly confident that fish in the river at particular times during the season were bound for one or more specific streams or groups of streams.

If there was a tendency for groups of fish to form "travelling units" en route to their home streams that would be reflected as an orderly clustering on both release and recovery dates, i.e., particular stocks would predominate among tag releases on certain days and corresponding clusters of tags would pass through the counting fence together.

Differences in mean time out were tested for significance at the 95% confidence level by the "t" test. Because a considerable number of tests were made there is likelihood (one in 20 with $p = .05$) that some tests would be accepted as showing significant differences when no real differences existed. Such errors should not affect our conclusions however. Tables giving results of all tests are appended.

The relation of tagging sites to the river boundary, counting fence and spawning grounds is shown diagrammatically as follows:



RESULTS AND DISCUSSION

Aro and McDonald (MS 1968) used annual median number of days to estimate time out between tagging sites and the boundary and these are summarized in Table 2 and used here to estimate times tagged fish entered the river. The usual timing and order of passage of stocks at the fence are illustrated in Fig. 3 (after Smith and Jordan MS 1973).

Results from 1947 tagging

Histograms on the left of Fig. 4 show time at the boundary of tagged fish in several individual and combined stocks; those on the right show their timing at the fence. (Some tagged fish found on streams avoided capture at the fence, hence the greater numbers in the left column.)

In general, order of arrival of groups at the boundary and fence was similar. Fish bound for early streams were usually first at the boundary while late spawning fish bound for Upper and Lower Babine river usually passed latest. However, there was some suggestion of different rates of travel among groups (mean time out) thus suggesting a change in chronological order of passage of tagged fish may have occurred between the boundary and fence in a few cases. For instance, fish arriving at the boundary as late as July 25 to 30 included substantial numbers of early as well as late spawning stocks but few of the former and many of the latter passed the fence after mid-August. Also, both Upper and Lower Babine river and Pinkut Creek fish were most numerous at the boundary from July 25 to 30 but Pinkut fish passed through the fence on the average five days or more ahead of those bound for the rivers.

In Fig. 5 the dates when each tagged fish arrived at the river boundary and fence are joined by a straight line. The steeper the slope of these lines, the greater the indicated migration speed (shorter time out). Early stream sockeye and Pinkut and Grizzly creek sockeye passing the boundary during July 26 to 29 were most numerous at the fence during August 13 to 14 (median time out = 18 days). Fulton and Morrison sockeye which passed the boundary at the same time were most numerous at the fence during August 11 to 18 (median 14 days later) and Upper and Lower Babine river fish arrived during August 12 to 27 (median 21 days later). The generally steeper slopes of lines joining arrival dates of the two "middle-run" groups of fish is apparent. Two fish which passed the boundary July 15 were recorded at the fence July 30 and August 4 and recaptured on Babine River within three days. Recapture method was not recorded but since Babine River fish begin spawning about September 15 they were likely caught in the Indian net fishery while bound for uplake spawning grounds (see lower section, Fig. 5).

The figure also indicates a particularly slow migration rate for early stream sockeye passing the boundary from June 20 to 25. (Fence counts began June 30, 1947 so tagged fish would have had about the same likelihood of being recaptured regardless of their date of arrival there.) The median time out for these fish was 24.5 days -- similar to the 21.3 days for sockeye at the boundary in late July and bound for Upper and Lower Babine river. Thus, the earliest and latest fish of the entire 1947 run at the fence migrated at similar rates and slower than those intermediate in timing. Differences in timing shown most clearly in the 1947 data apparently persisted over most other years when tagging was conducted, as will be shown below.

Among-years variation

Because coastal tagging during 1966 and 1967 was often conducted at considerable distances from the river the estimates of time out to the river are correspondingly doubtful, hence, we have omitted data from those years in some of the analyses which follow.

Figure 6 shows frequency histograms of days out of tagged fish in 1946-1947 and 1956-1958, separated to coastal and Tyee (river boundary) taggings, and by month at the boundary (right column) and principle age group (left column). The latter two arrays will be discussed under "between-year variations."

Distributions of days out are rather similar in most years but three mild contradictions should be noted: first, 1946 and (particularly) 1947 tagged fish migrated somewhat faster than in succeeding years and their time out in the river appeared less variable; second, the 1955 fish were clearly slower than those of all other years having a mean time out which was about 30% higher than the mean of all experiments and their time out was highly variable; third, fish tagged at the river boundary apparently migrated more slowly than those from coastal taggings.

Differences between 1946 and 1947 may reflect different composition and timing of the runs of those two years. For instance Fig. 7 (after Aro MS 1961) reflects a relatively low abundance of late (slow-moving fish) in 1947, and this is supported by historic Babine system escapement data. These show large populations of late running fish on Upper and Lower Babine river in 1946 but small ones in 1947 (Smith and Lucop MS 1969). Apparently there was no appreciable difference in mean body length of sockeye in these two years though considerable between-year variation does occur (Fig. 8, after Aro MS 1961). Thus, swimming speed was not likely influenced by fish size.

The 1951 Babine River slide may have destroyed segments of the Babine run and evoked the changed distribution and perhaps indirectly the exceptionally slow migration rates of 1955. It has been suggested that the low return of 4-year-old fish in 1955 was at least partially due to the slide (Anon. 1955), and as indicated in Fig. 6 and elaborated on below these tend to move through the river more rapidly than do 5-year-olds.

Mean time out of tagged fish from coastal taggings in 1956 and 1957 were corrected according to estimated times from release points to the boundary (see Table 2), then compared with time out of boundary tags in corresponding years. As shown in Table 3 boundary fish averaged 2.6 to 3.4 days longer in the river than those from the grounds though only the 1957 difference is statistically significant. That difference is unlikely to result through underestimates of time out from release points to the boundary since the 1957 corrections averaged only five days -- slightly more than the observed difference.

Fish tagged at the boundary in 1955 were out significantly longer than those tagged there in both 1956 and 1957.

Within-year variation

Seasonal differences in migration rates of Babine sockeye have been reported earlier but have not been quantified (Anon. 1956). This has been done in Table 3 where mean days out between the fishing boundary and the fence of fish present at the boundary in each of June, July and August and over the entire season are shown for several tagging experiments. (Boundary and coastal tagging in 1956 and 1957 are treated as separate experiments.)

Because of the overlap in timing of stocks and the rather long periods when most pass into the river it is somewhat an oversimplification to use mean rates of travel of fish at the boundary in each of June, July and August to represent that of groups, or individual stocks. However, Fig. 3, 4 and 5 show that most early run fish enter the river in June, most middle run fish enter in July and early August, and that Upper and Lower Babine river fish pass latest -- in late July and in August. Rates of travel in stocks may therefore be approximated on this basis.

In all comparisons possible from Table 3, July fish were out fewer days than both June fish (mean difference 4.2 days) and August fish (mean difference 5.0 days), and in four of five possible within-year comparisons means were significantly different. The 1955 means for tagged fish at the boundary in July and August were not significantly different, nor were those for June and July 1957 at the same location.

There were no significant differences in three possible comparisons of June with August tags.

Variation due to body size

Largest fish might be expected to ascend the river more rapidly than smaller ones. However, histograms on the left side of Fig. 6 suggest otherwise, so in Table 4 we have arrayed estimates of ³mean time out by year and principal age group to facilitate further comparison.

In eight of ten experiments mean time out was greater for 5-year-old (mean 28.3 days) than for 4-year-old fish (mean 26.4 days). However, differences were, in several years, quite small as was the overall difference of 1.9 days. Six tests within years yielded significant differences in means.

Apparently 3-, 4- and 5-year-old fish travelled about the same rate in the pre-slide year 1947. So also did 4- and 5-year-olds in 1955, the year of unusually slow migration.

Variation among individual fish

In Fig. 9 to 18 recovery dates are plotted against corresponding release dates for individual fish. Horizontal axes show dates at the boundary,

³ More than 95% of Babine sockeye migrate after one year in the lake and return after one, two or three years at sea. Hence the principal age groups are 1.1, 1.2 and 1.3.

and vertical axes, dates at the fence. Different symbols indicate recoveries in the vertical plane from different sets made on the same day, and short vertical and horizontal lines have been drawn on several figures to emphasize some considerable ranges of recovery dates for tags from single gear sets, and recoveries on particular days from widely separated tagging dates. Figures 9 to 11 depict results from tagging at the boundary during 1955-1957. The spacing of symbols in vertical columns indicates a range of 15 days between first and last recoveries from individual sets in several instances. Similarly, recoveries were on some days drawn from sets made as much as 15 days apart at the boundary. Some recoveries from single sets were made in successive or closely adjoining days.

These figures show that tagged fish tend to arrive at the counting fence in the same order as tagged, i.e., chronological order is rather well-preserved during migration. However, in view of the within-season changes in migration speed, straight lines cannot be fitted to give seasonal linear expressions for average days out in the river according to time at the boundary.

Skewed distribution of recoveries from coastal tagging

Figures 12 to 16 and Fig. 17 to 18 show estimated dates of arrival at the boundary and actual dates of recovery at the fence from coastal tagging by personnel of the Fisheries Research Board in 1946-1947 and 1956-1958, and Resource Development Branch in 1966 and 1967. These distributions tend to be more skewed than boundary taggings and have modal values smaller than means. This is particularly noticeable in recoveries from tagging in July 23, 1946, July 25 to 29, 1947, July 20, 1957 and July 29, 1958, and is emphasized in Fig. 19 where we have expanded the data of five separate days, July 25 to 29, 1947 and indicated by marginal arrows the days yielding most recoveries -- in each case the third day. The five daily histograms were then aligned so that modal values would be superimposed, then summed to give the large histogram tabled summation. In this the mode necessarily falls on the third day while the range extends over 20 days.

The shape of the summation and component graphs suggest that most fish from a given day of tagging travel at about the same rate but the remainder more often travel slower than faster. This might be expected since there are finite limits to fewest days out (governed by distance, river conditions and swimming ability) whereas greatest number of days out could theoretically total a month or more.

Data of Fig. 19 also permit a direct comparison of time out among members of stocks entering the river during the same 5-day interval. In the lower right section we have allocated as many as possible of the recoveries to four stock groupings. The now familiar timing of groups at the fence is seen to emerge, i.e., arrival of early stream fish first, Pinkut fish second, Fulton and Morrison fish third and fish from Upper and Lower Babine river last. Mean time out in the four groups was as follows:

Stocks	Number of tags	Days out	
		mean	s.d.
Early streams	5	18.0	2.5
Pinkut Creek	8	17.8	4.0
Fulton-Morrison rivers	20	18.4	2.1
Upper-Lower Babine river	21	21.0	3.9

Upper and Lower Babine river tags were out significantly longer than each of the other three groups. However, the estimate for early stream fish is considerably lower than that for combined "June fish" appearing in Table 3.

GENERAL DISCUSSION

Travel rates

Estimated time out of tagged sockeye between the commercial fishing boundary near Tyee on the Skeena River and the Babine River counting fence has been used to indicate travel rates among years, and within years according to age, time of migration and stock membership.

Small among-years' differences appear to occur regularly. However, in view of the great distances travelled and the doubtless high variability in river conditions the salmon encounter, we feel it is remarkable that the differences are so small.

Differences in travel rate of fish tagged at the boundary and those tagged on the grounds may simply imply a period of disorientation in the first hours or days following release. Disoriented "river fish" might be swept out of the river initially. By contrast, those from the grounds may recover from their disorientation by the time they reach the river and migrate rather directly through it. Their period of delay would be reflected in time out to the river, not thereafter.

Skewed distributions from coastal taggings seem something of a contradiction but may reflect a period of searching which delays some fish en route from tagging sites to the river.

Possible changes in mean migration rate after the 1951 slide suggest that results of 1946 and 1947 experiments might best be considered separately from those of later years. Perhaps those of 1955 which the slide appears to have affected substantially should be considered separately.

Migration rate differed according to month tagged fish were at the boundary, thus stocks which predominate in different months could also be expected to travel at different rates.

The extent to which such differences are attributable to heritable or environmental factors is unclear. It was apparent that fish at the boundary July 25 to 29, 1947, travelled toward Pinkut Creek and Fulton and Morrison rivers at different rates than those bound for the outlet streams. This difference appears to have been a property of the populations. On the other hand early stream fish entering the river from July 25 to 29 (very late for this group) and shown in Fig. 19 moved quite rapidly through the river. Since their travel rate was more like that of "July fish" than of "June fish" external factors related to season of travel may have the strongest influence on migration rate.

Upper and Lower Babine river fish have a substantially shorter distance to travel than the middle run group so there is a possibility that migration rate and migration distance are also interdependent. However, because early run fish are primarily slow migrants and some travel quite as far as middle run fish, due consideration is given here to some non-heritable factors influencing migration rates.

Variables affecting migration rates in the river

Handling and tagging procedures are sure to account for some aberrant behaviour among tagged fish and will affect migration rates. Unhealthy tagged fish often appear at the ends of runs subjected to tagging programs suggesting that many tagged fish behave differently from non-tagged ones similar in other respects. Seasonally changing skills and attitudes of tagging crews can also lead to seasonal trends in tagged fish behaviour. Because fish were tagged from gillnets in the estuary rather more injuries might be expected there than from the fishing grounds where seine-caught fish were tagged. Slower rates among the former could be expected. About 40% of sockeye recovered from river taggings of 1955-1957 were taken in the commercial fisheries (Aro, unpublished MS 1967).

Rates of travel of tagged fish could also be affected by amounts of suspended materials and currents in the Skeena estuary. Discharge in the Skeena and Babine rivers varies appreciably from year to year and it seems unlikely that fish swimming at a rate commensurate with arrival at a destination at a biologically desirable time would detect changed or changing water velocities and make appropriate adjustments in swimming speed. However, the runs and their component stocks pass the counting fence in remarkably similar time-frames most years and some scrutiny of migration rates relative to discharge levels was desirable.

Daily discharge measurements are recorded on the Skeena River at Usk, about 140 km above the mouth, by Water Survey of Canada (Anon. Annual Reports), and likely indicate fluctuations in discharge encountered by migrating sockeye. In a first analysis we plotted mean daily discharge from July 4 to September 5 when 90% of the annual sockeye run is thought to be in the rivers, against mean days out in six years when that was known (see Table 3).

There was evidence of a weak positive relationship, i.e., time out generally increased with an increase in discharge. Time out was greatest in 1955 when discharge was about 20% higher than the next to highest. However, it was about average in 1958, a year of comparatively low discharge, and

the relationship was not statistically significant at the 95% confidence level ($r = .684 < .75$ with 5 df).

In the second analysis we compared discharge from July 4 to August 20, July 31 to September 5 and July 4 to September 5 against the dates when, respectively, 50%, 90% and (again) 90% of the escapement passed the counting fence to see if a positive relationship existed between either early or late parts of the run and water conditions during probable migration periods (two possible periods were tested against 90%). Data were available for 21 of the 27 years of fence operation.

Again, there was a weak positive relationship in each case but regression statistics were non-significant at the 95% confidence limit. The highest value was for the period July 31 to September 5, against the 90% date ($r = .379 < .413$ with 21 df).

These analyses suggest that mean river discharge is not a major influence on rate of travel of sockeye salmon ascending the Skeena and Babine rivers, and is therefore unlikely to account for changes in migration rates among early, middle and late groups of migrants.

Possibly increased discharge has only a small effect upon velocity of water in parts of the river where the salmon are swimming. Sockeye frequently follow the banks of large swift rivers and even though discharge increases they may continue to find regions which do not undergo great velocity changes and still migrate through the river in a predictable number of days. It is also true that as the rivers rise they inundate regions where velocities will be low and thus provide advantages to migration. Regions in the main river where long low gravel bars are inundated at higher water levels may fall into this category.

If the fish are able to detect and swim in water of a specific velocity they might ascend the rivers in a similar mean number of days regardless of fluctuations in discharge.

Possible formation of travelling units

Apparently Babine sockeye stocks have appeared over the years in the same chronological order on the fishing grounds, at the river boundary and through the counting fence. Thus there is assurance that some members of stocks will always be somewhat consolidated in time and space en route to the spawning grounds. On the other hand we found no indication from tagging data that within stocks, pairs or other small groups of sockeye had come together and persisted as "travelling units" throughout their coastal and river migrations, though our review leaves the matter in some doubt.

Fishing gear does not capture all the fish in schools it intercepts, and of those captured, not all fish are likely to be tagged and only a few of the latter may be recaptured. Furthermore, there is clearly such an overlap in timing of some stocks at tagging locations that many small groups of fish travelling together toward as many small streams could be captured in the same set but because of their different rates of travel, and because observations are limited to only a few individuals, the grouping would not be reflected in the data when arrayed as in Fig. 9 to 18.

Nevertheless, we believe that if some stock members regularly, or often, sought each other and remained together, many distinct clusters would be apparent on the vertical scales of the figures. We therefore suggest that when Babine sockeye destined to spawn in the same stream migrate together it is an association of chance and no unique benefits are likely to result for the fish.

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Table 1. Coastal tagging areas and number of tagged sockeye recovered at Babine Lake, 1944-1967. (1944-1958 totals from Aro & McDonald MS 1968; 1966-1967 from Can. Dept. Fish. Operations Branch - D. Harding personal communication.)

Year	Tagging Area	Babine Recoveries
1944	Smith Island	21
1945	Smith Island	85
1946	Smith Island	321
1947	Smith Island	588
1948	Smith Island	127
1955	Tyee	49
1956	Tyee	157
1956	Areas 3, 4 and 5	37
1957	Tyee	120
1957	Areas 3, 4 and 5	202
1957	West Coast District	7
1958	Areas 3, 4 and 5	173
1958	West Coast District	95
1966	Areas 3, 4, and 5	57
1967	Areas 3, 4, and 5	63

Table 3. Average estimated number of days out from the fishing boundary to the Babine fence of sockeye tagged in 3 separate months and for the season 1946-1947 and 1955-1958.

Tagging area	Year	June		July		August		Season	
		average (days)	s.d.	average (days)	s.d.	average (days)	s.d.	average (days)	s.d.
Commercial fishing ground	1946	28.5	3.3	24.0	3.8	-	-	24.3	3.9
	1947	24.5	3.2	19.9	3.6	-	-	20.2	3.7
	1956	-	-	25.5	3.6	-	-	25.5	5.8
	1957	29.7	2.4	24.9	7.0	29.9	5.5	26.6	6.8
	1958	-	-	24.2	4.6	28.9	6.3	27.0	6.2
Test fishing site	1955	-	-	36.3	7.2	38.2	6.9	36.5	7.2
	1956	30.8	1.6	26.6	5.1	32.8	5.9	28.1	3.6
	1957	31.4	3.2	28.3	6.1	35.8	6.4	30.0	6.7

Table 4. Average estimated number of days out from the Skeena river boundary to the Babine fence, of tagged sockeye in each principal age group.

Tagging area	Year	Month	1.1		1.2		1.3	
			average (days)	s.d.	average (days)	s.d.	average (days)	s.d.
Commercial fishing ground	1947	-	20.7	3.8	20.0	4.0	20.2	3.5
	1957	-	-	-	25.3	5.9	28.4	6.6
	1958	-	-	-	23.5	3.9	27.3	5.1
Test fishing site	1955	-	-	-	37.1	6.3	35.9	8.0
	1956	-	-	-	28.6	5.9	26.5	4.8
	1957	-	-	-	29.5	6.7	31.0	7.0
Commercial fishing ground	1957	July	-	-	23.3	5.6	27.5	6.9
	1957	Aug.	-	-	28.9	4.7	30.9	4.3
	1958	July	-	-	22.6	3.8	25.2	4.8
	1958	Aug.	-	-	25.3	3.6	29.7	4.4

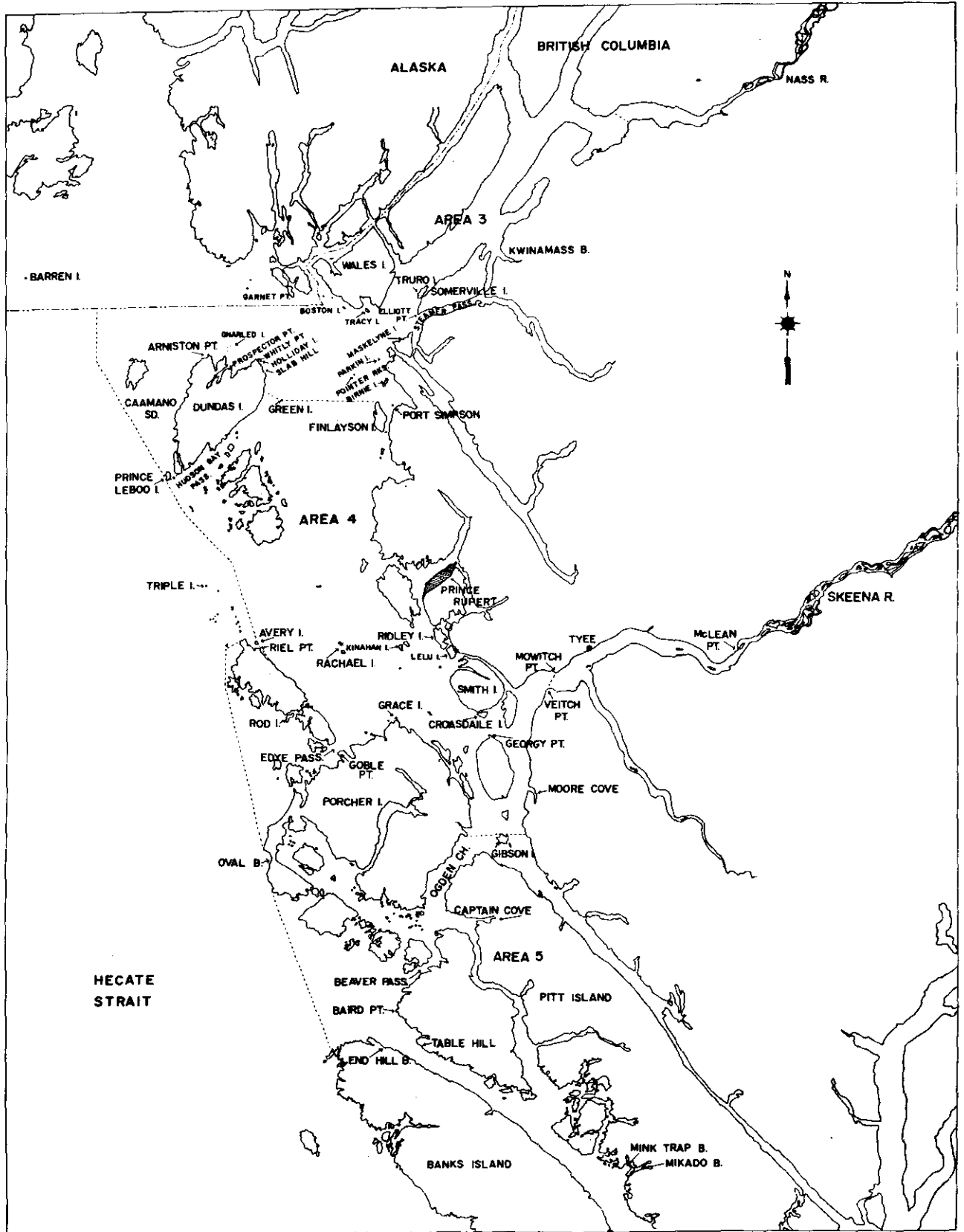


Fig. 1. Skeena River estuary and coastal tagging locations in Fisheries Statistical Areas 3, 4 and 5. (After Aro and McDonald, MS 1968 Fig. 3.)

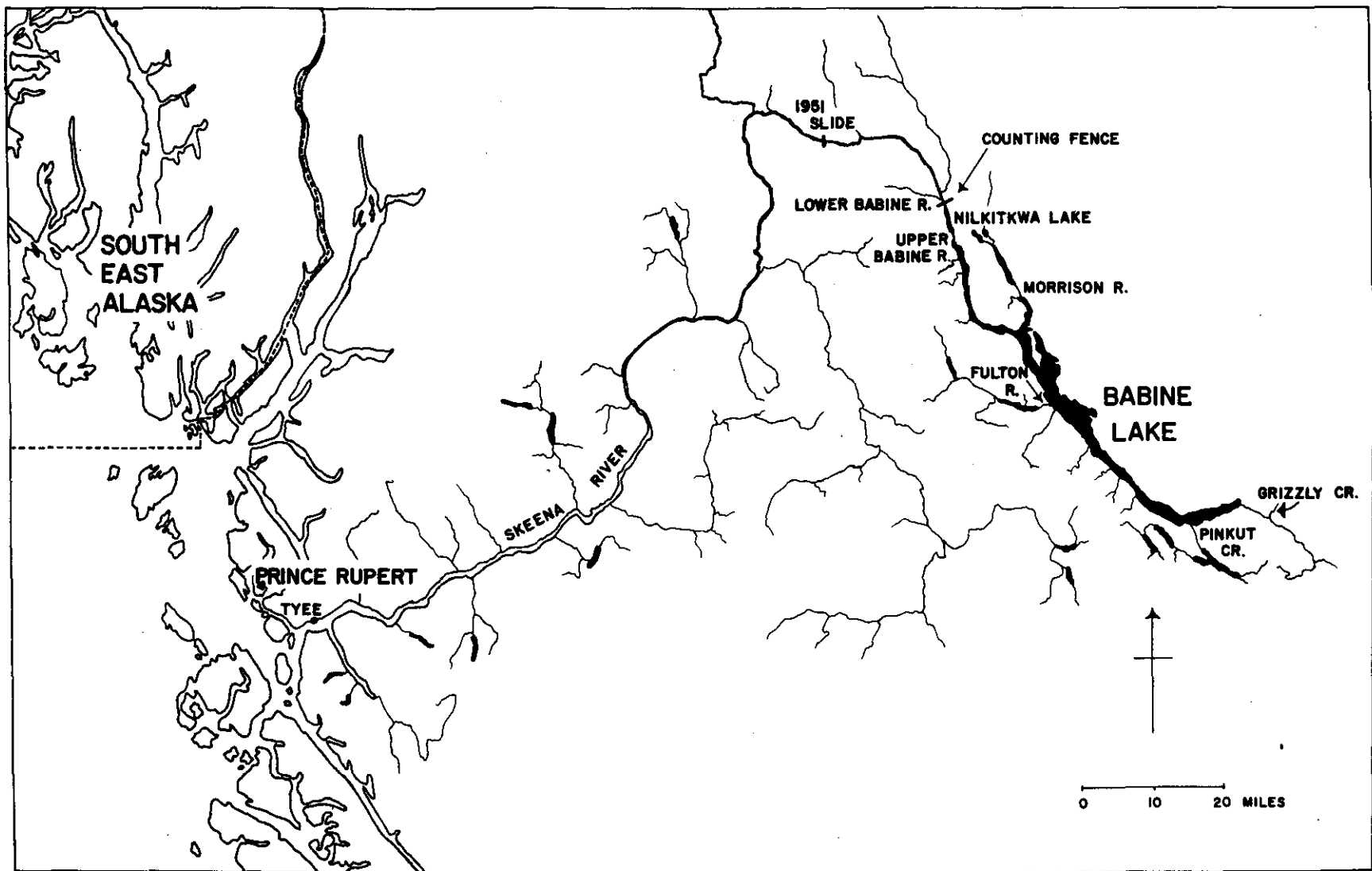


Fig. 2. Skeena and Babine river systems showing locations of major spawning streams on Babine Lake.

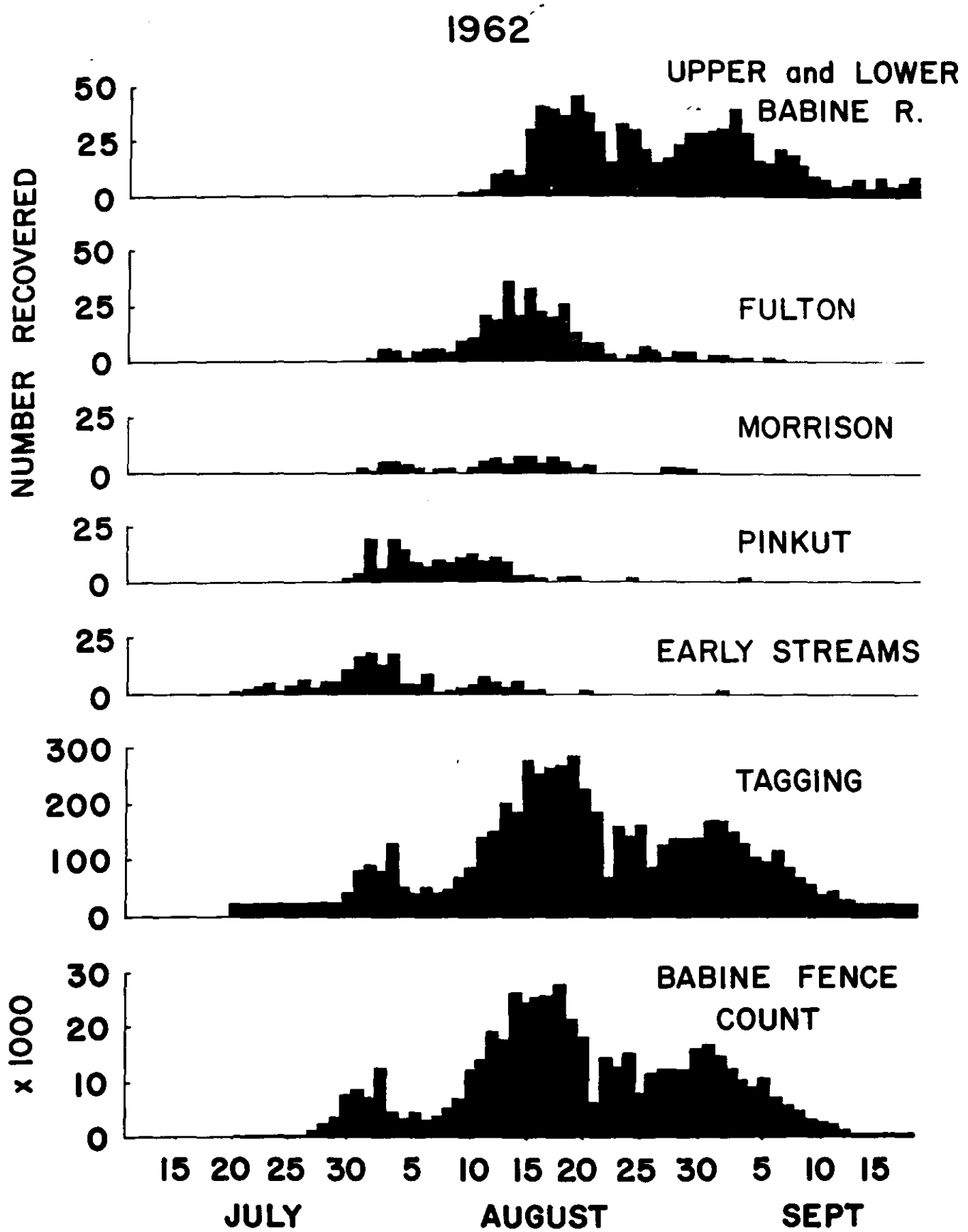


Fig. 3. Distribution of recoveries from 1962 sockeye tagging at the counting fence. Numbers tagged were equivalent to 1% of each preceding day's count. (After Smith and Jordan, MS 1972.)

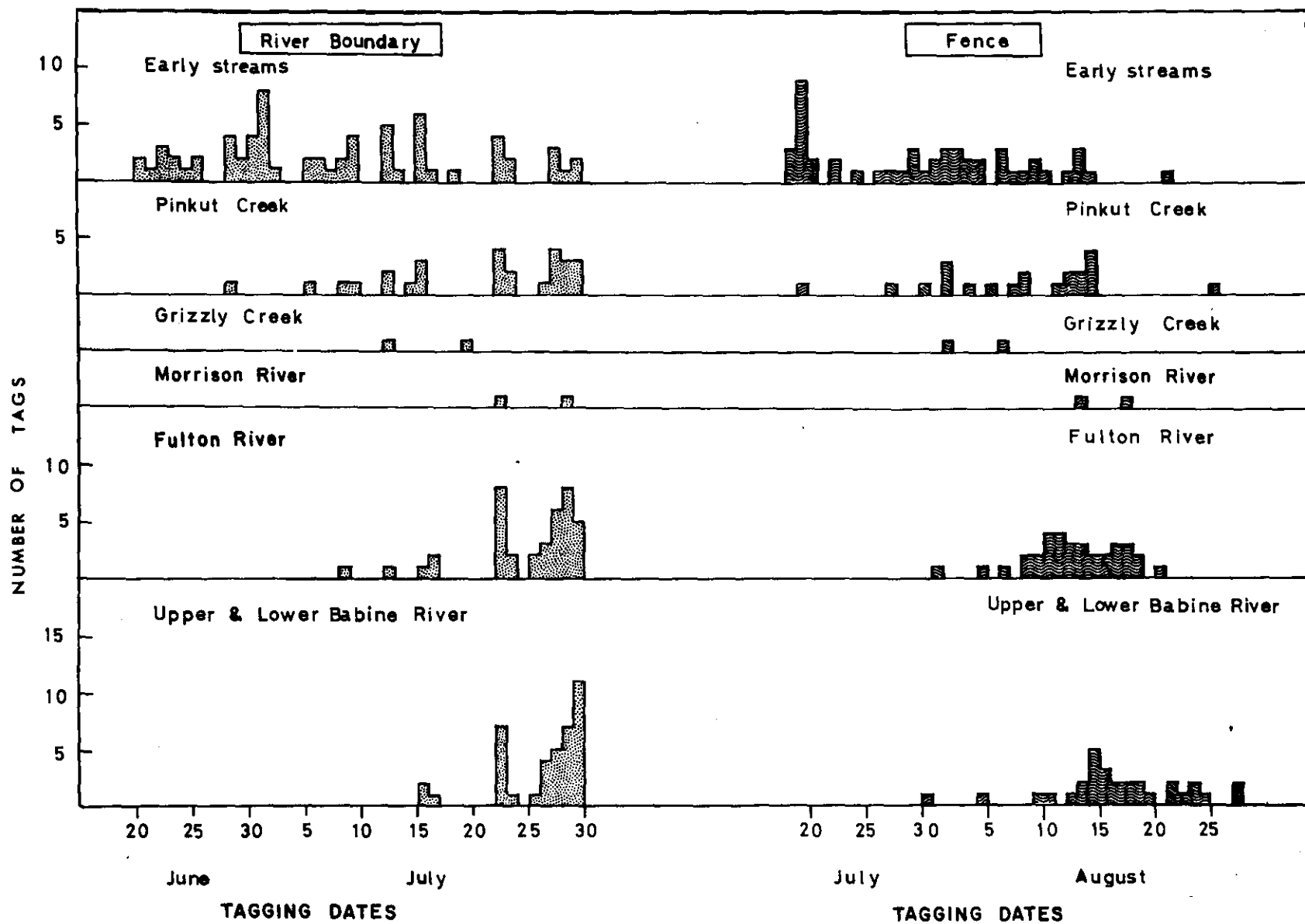


Fig. 4. Timing at the river boundary and counting fence of tagged sockeye in several individual and groups of stocks in 1947.

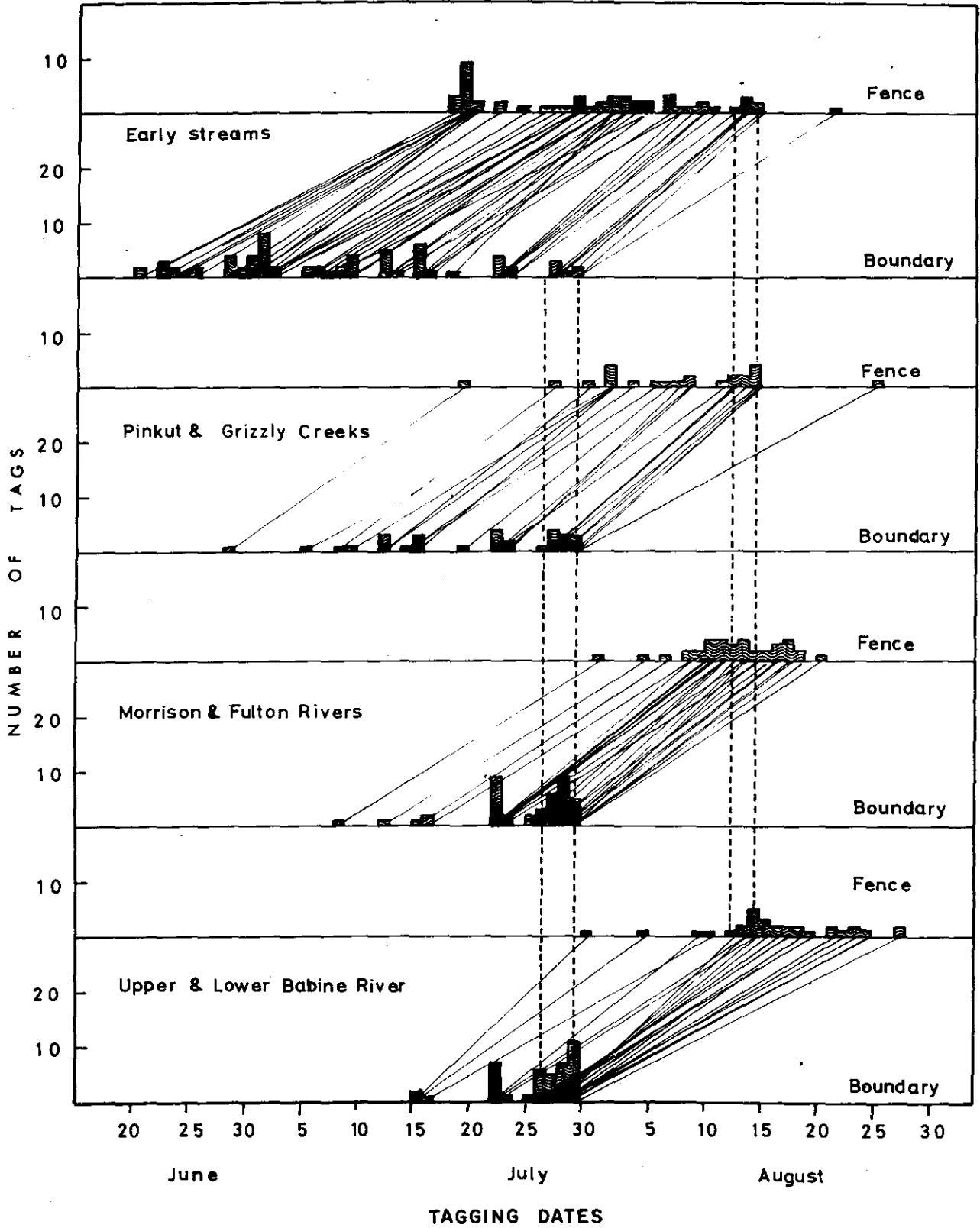


Fig. 5. Relative speed of migration of tagged sockeye as indicated by timing at the river boundary and counting fence of individuals in several groups of stocks in 1947.

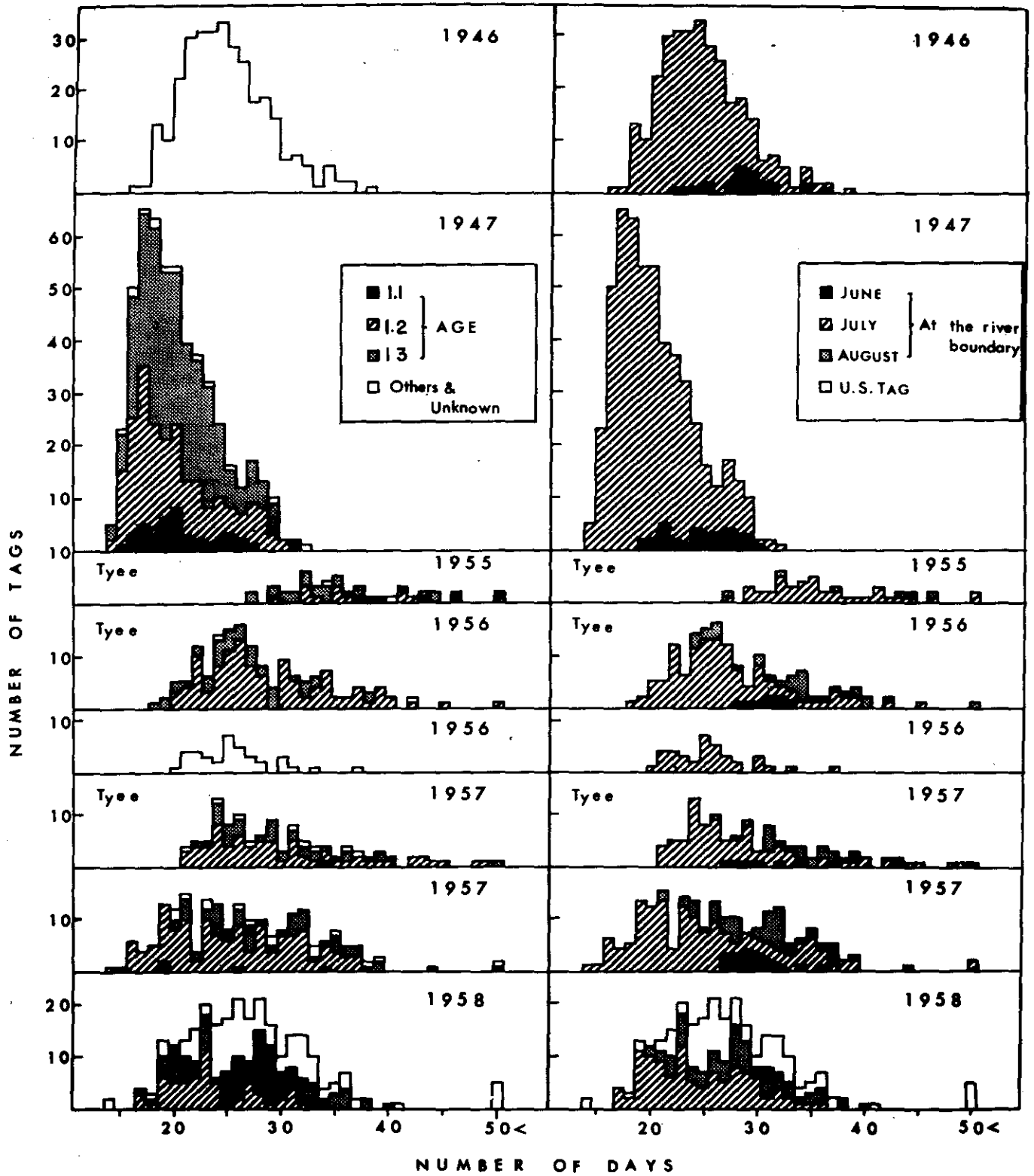


Fig. 6. Number of days out between the river boundary and counting fence of tagged sockeye in 3 principal age groups and in 3 separate months.

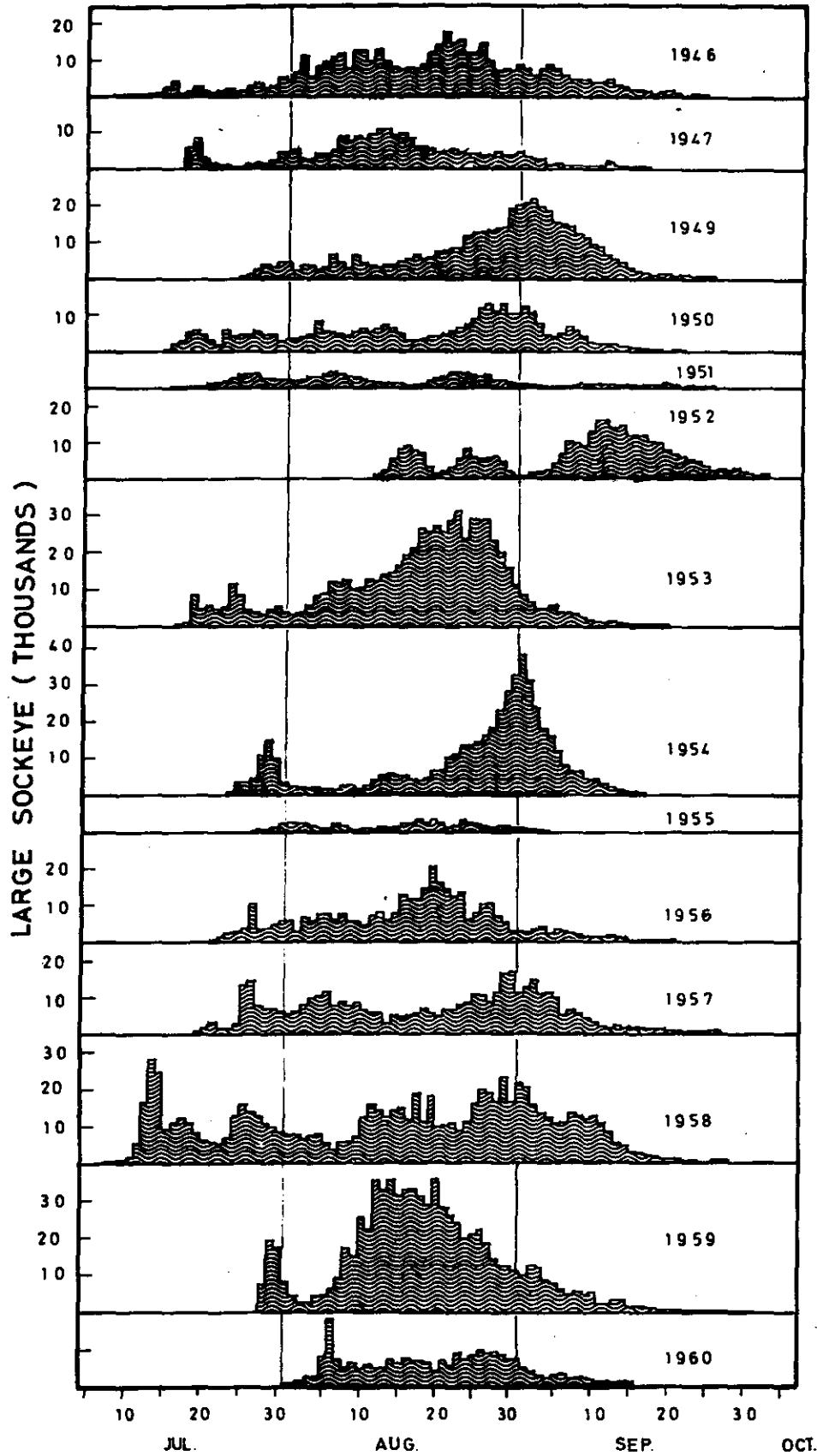


Fig. 7. Daily escapements of large sockeye at the counting fence 1946-1960. (After Aro, MS 1961.)

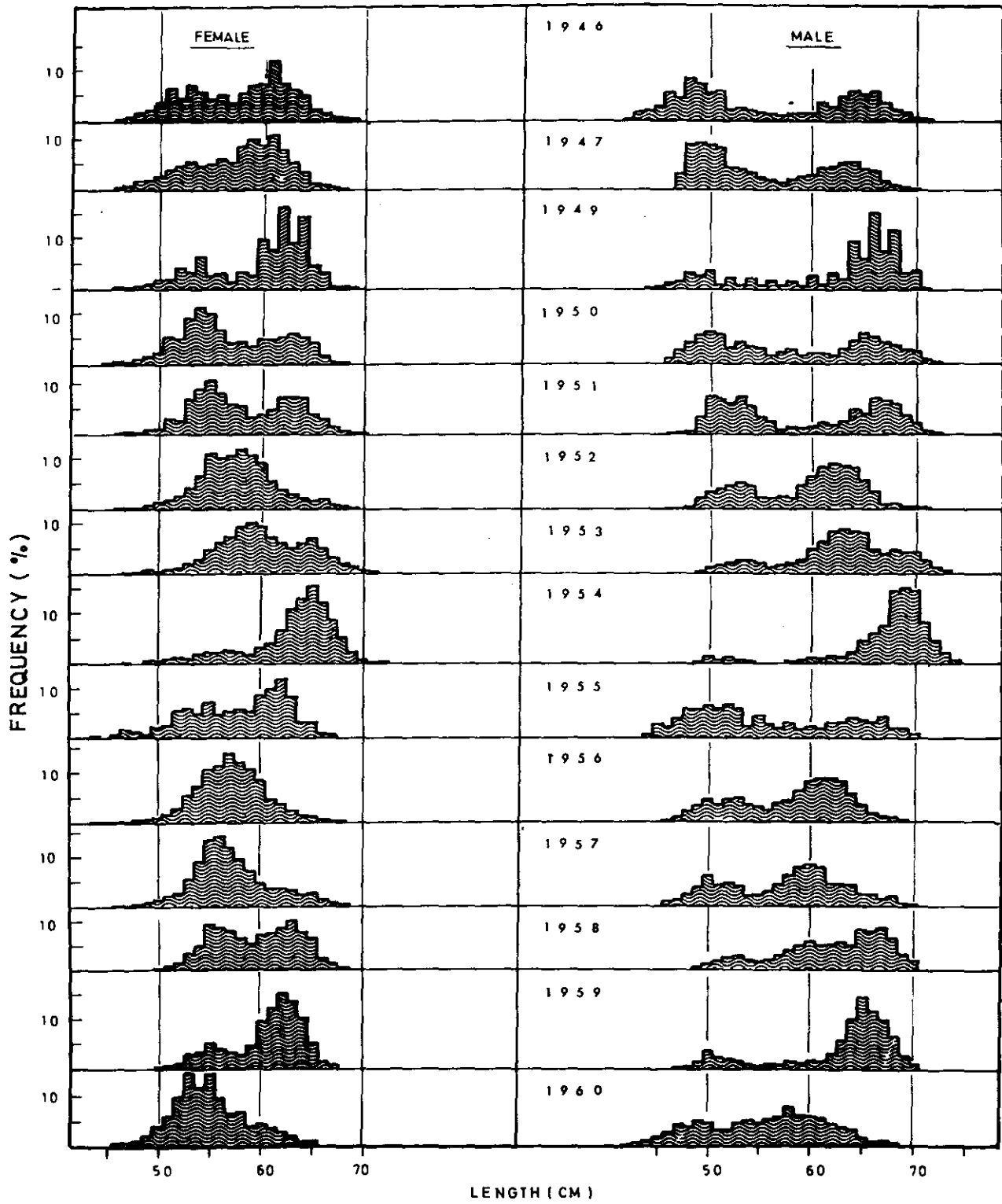


Fig. 8. Length frequency distributions of female and large male sockeye at the counting fence 1946-1960. (After Aro, MS 1961.)

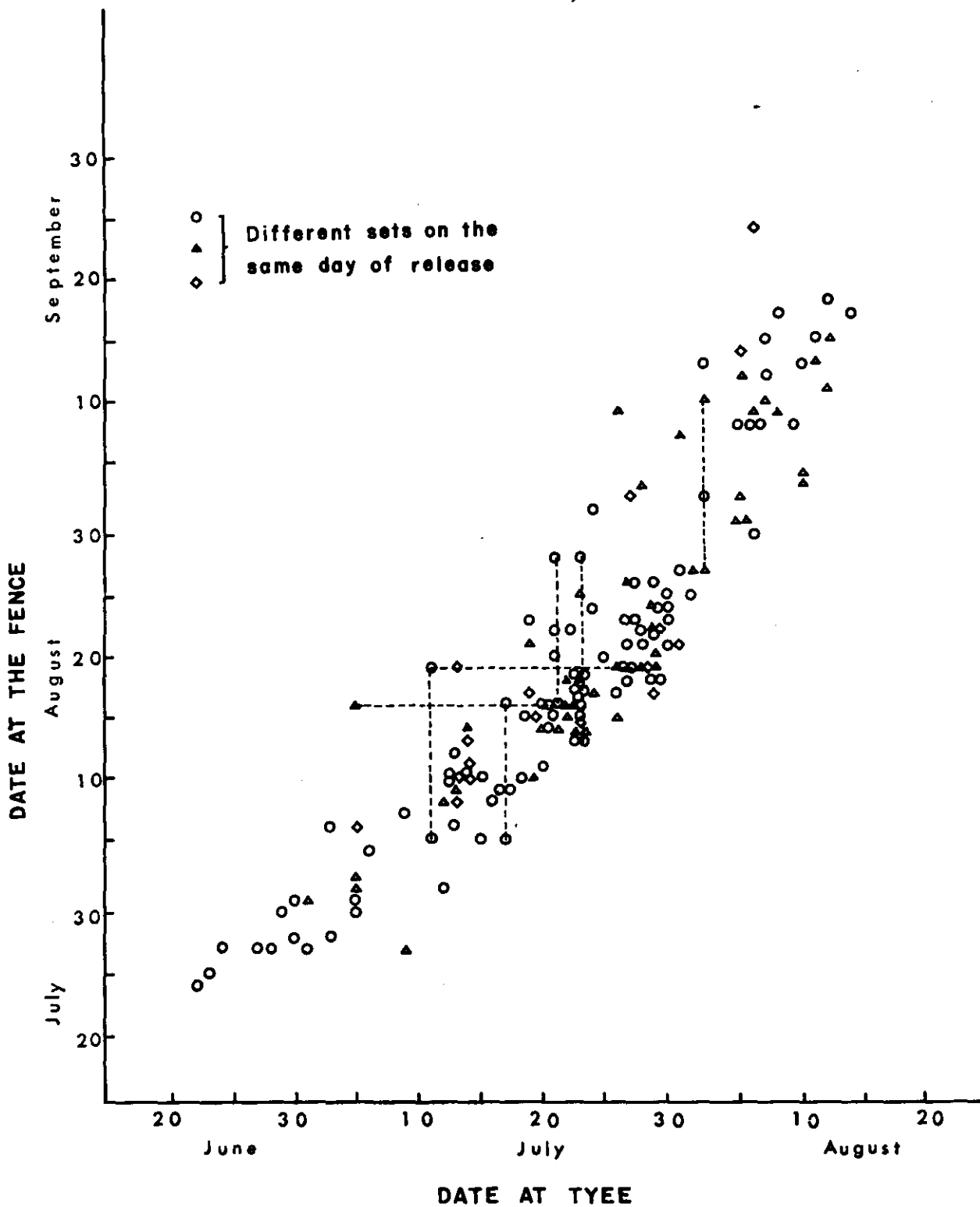


Fig. 10. Relationship of dates of tagging at Tyee and recovery at the counting fence in 1956.

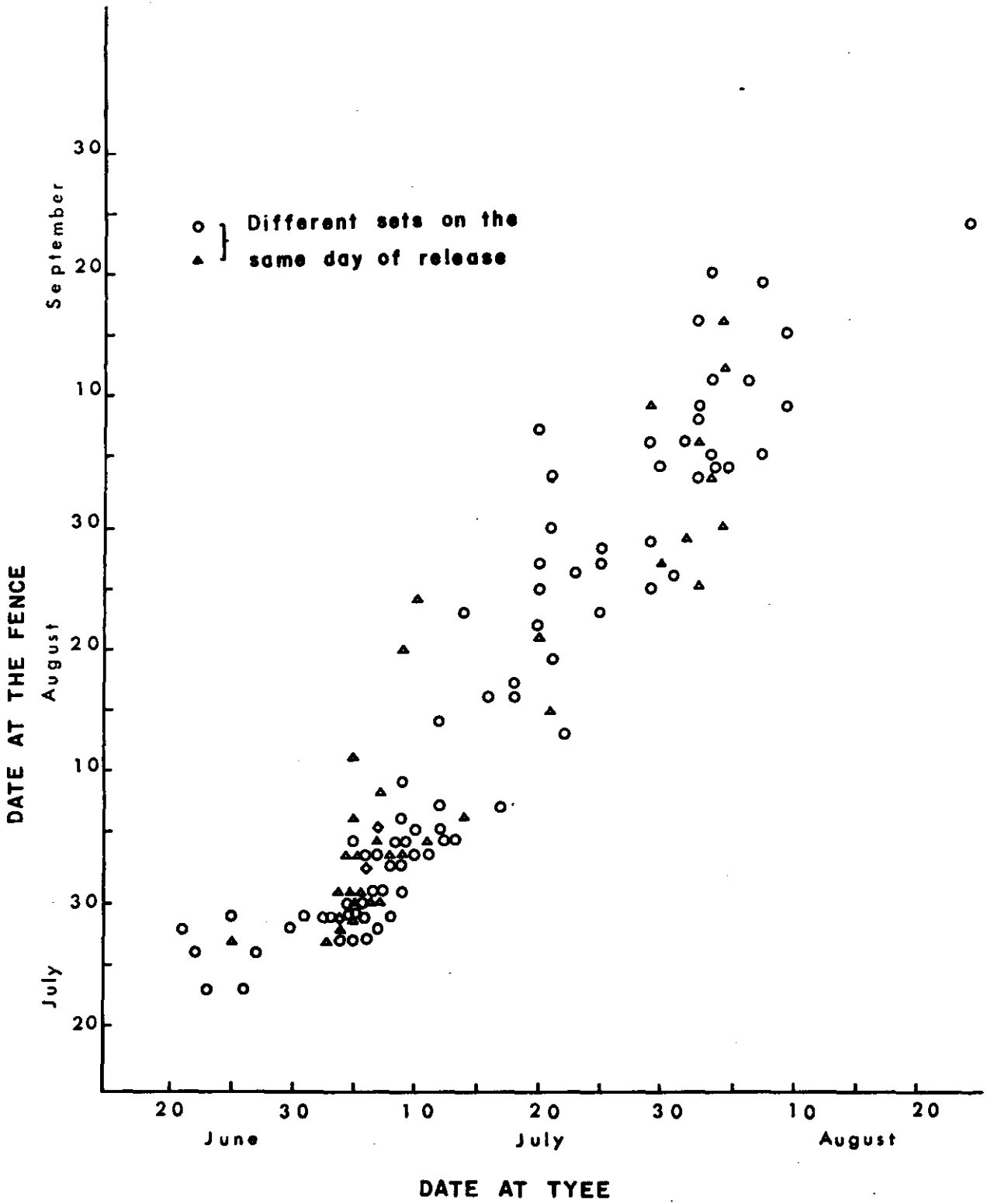


Fig. 11. Relationship of dates of tagging at Tyee and recovery at the counting fence in 1957.

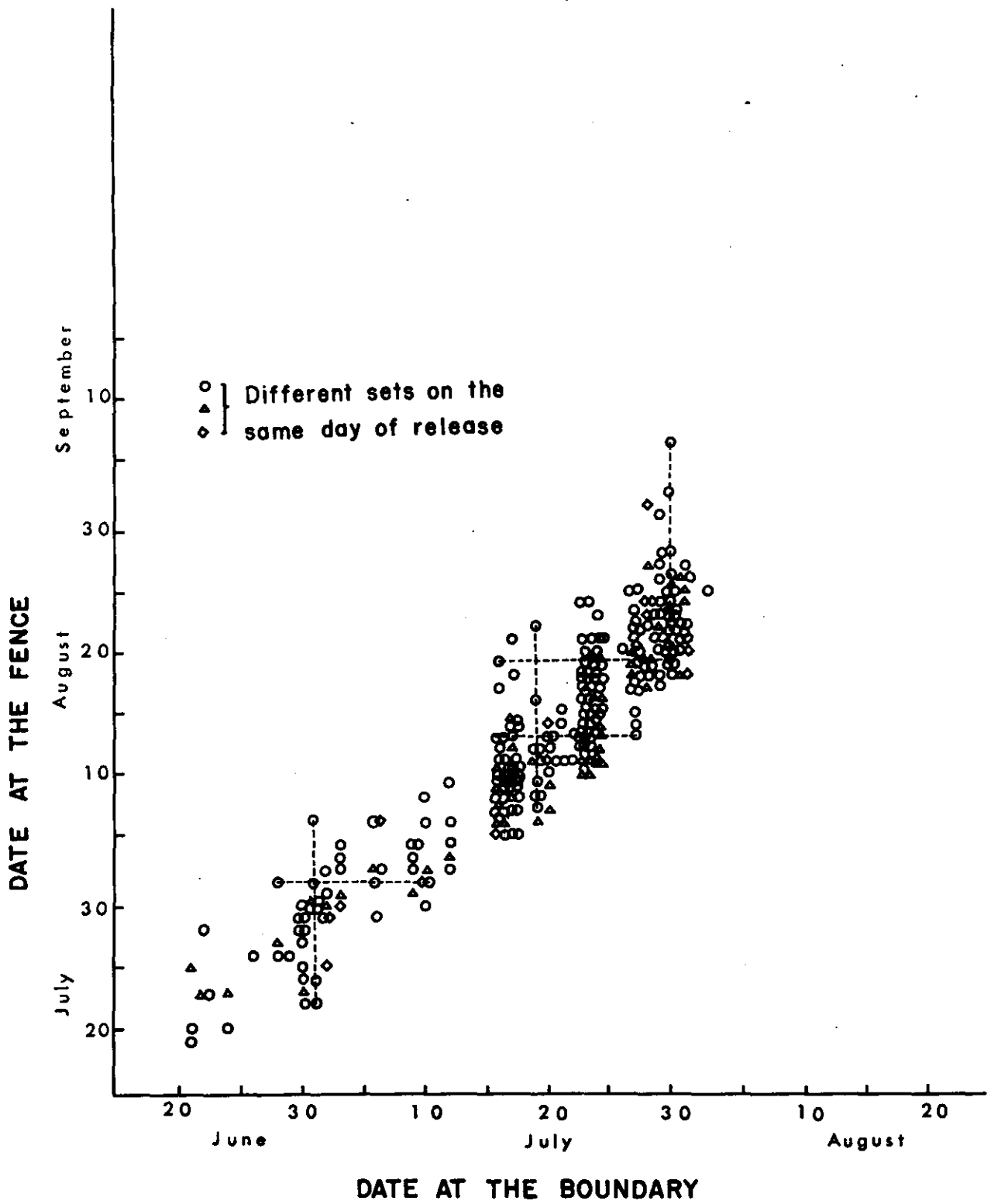


Fig. 12. Relationship of estimated dates of passage at the river boundary and recovery at the counting fence of sockeye tagged at Smith Island in 1946.

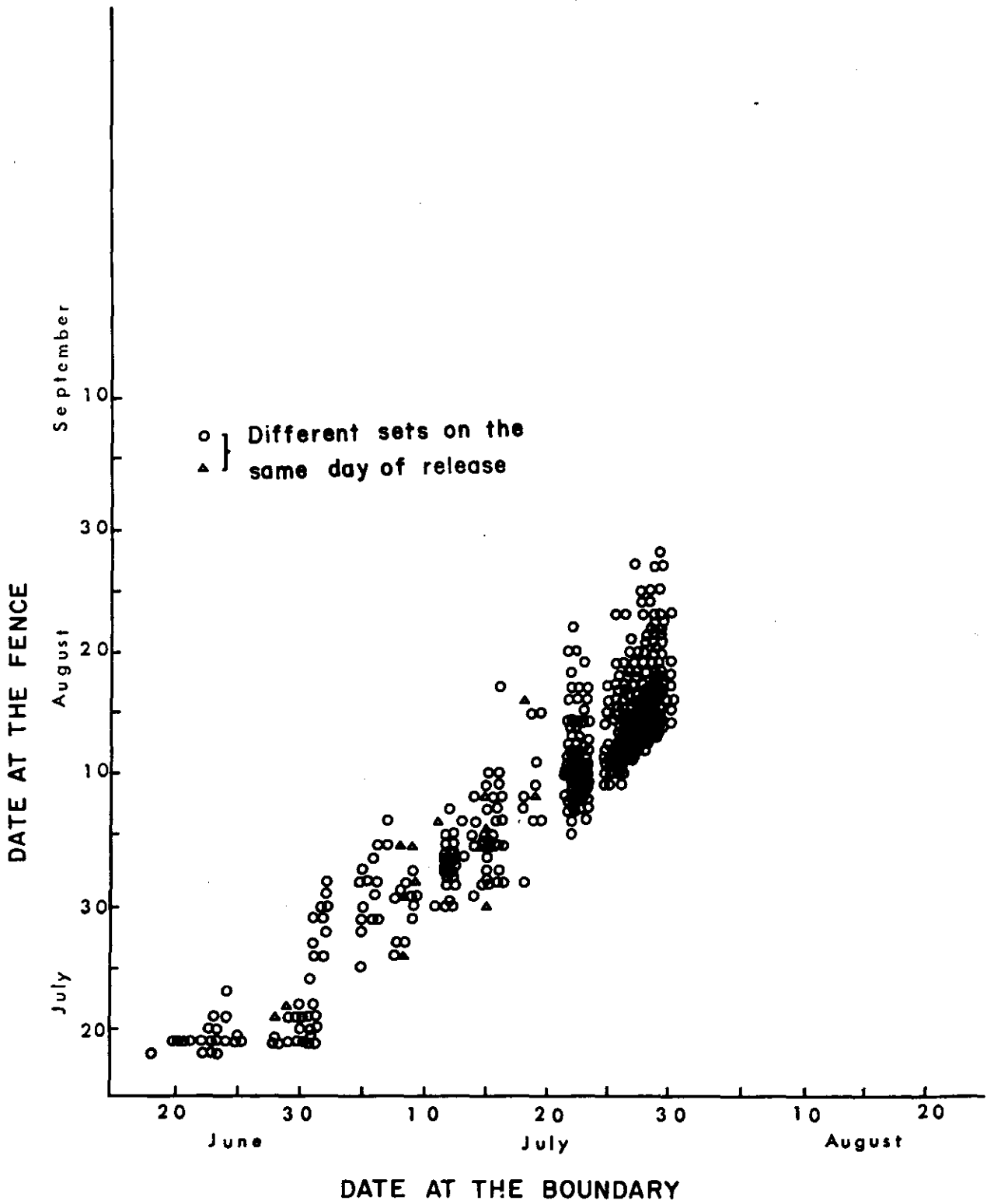


Fig. 13. Relationship of estimated dates of passage at the river boundary and recovery at the counting fence of sockeye tagged at Smith Island in 1947.

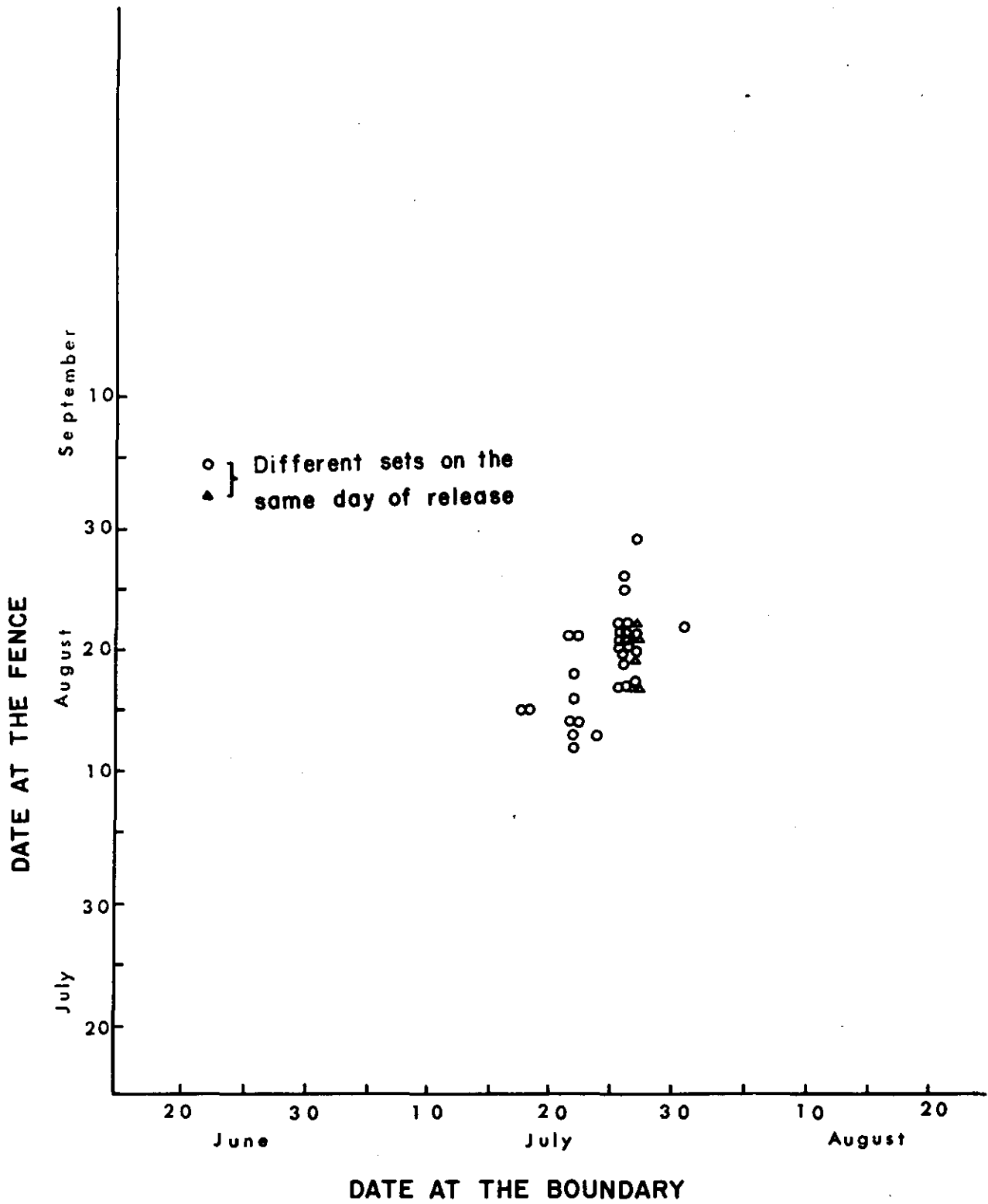


Fig. 14. Relationship of estimated dates of passage at the river boundary and recovery at the counting fence of sockeye tagged in coastal waters in 1956.

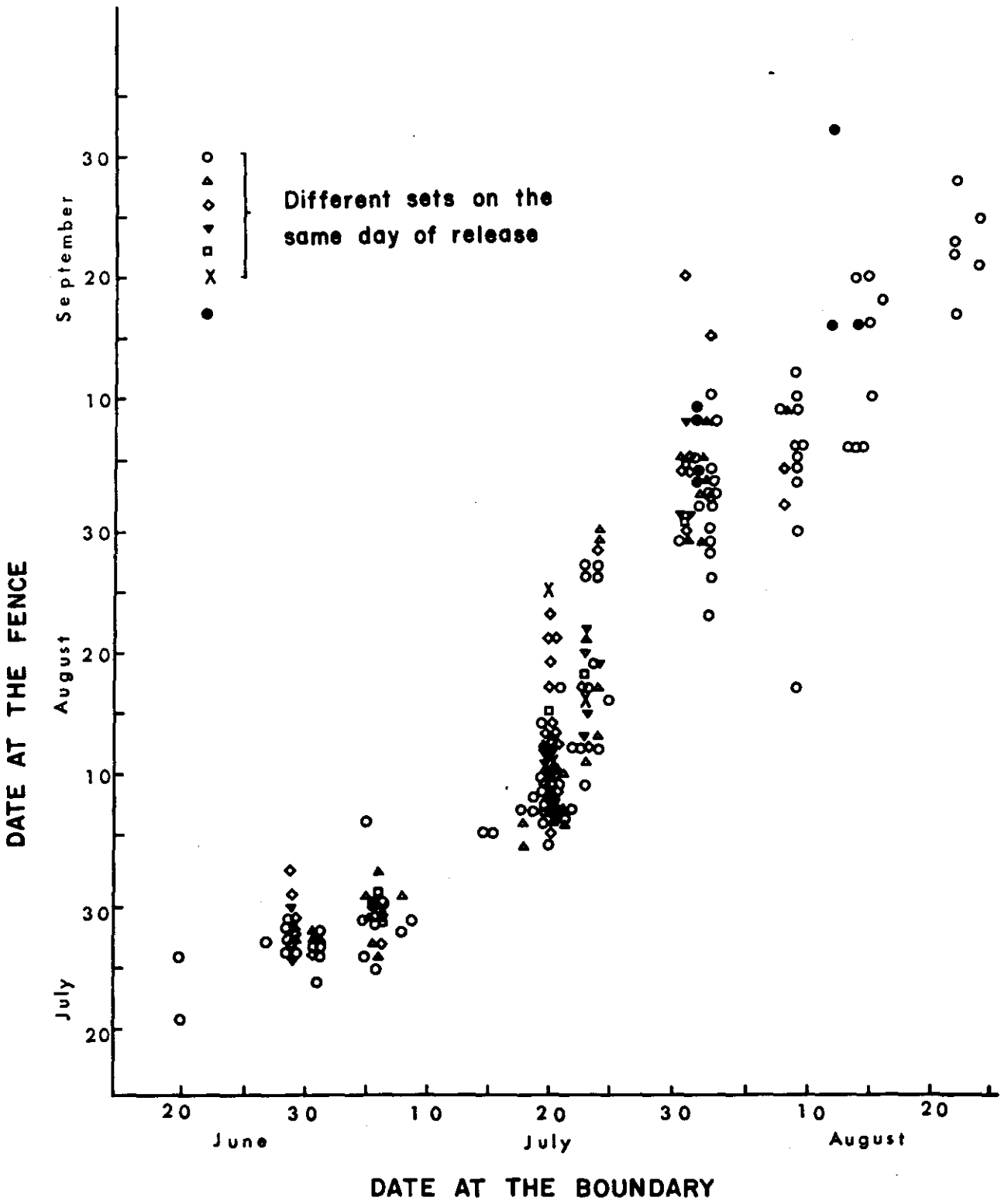


Fig. 15. Relationship of estimated dates of passage at the river boundary and recovery at the counting fence of sockeye tagged in coastal waters in 1957.

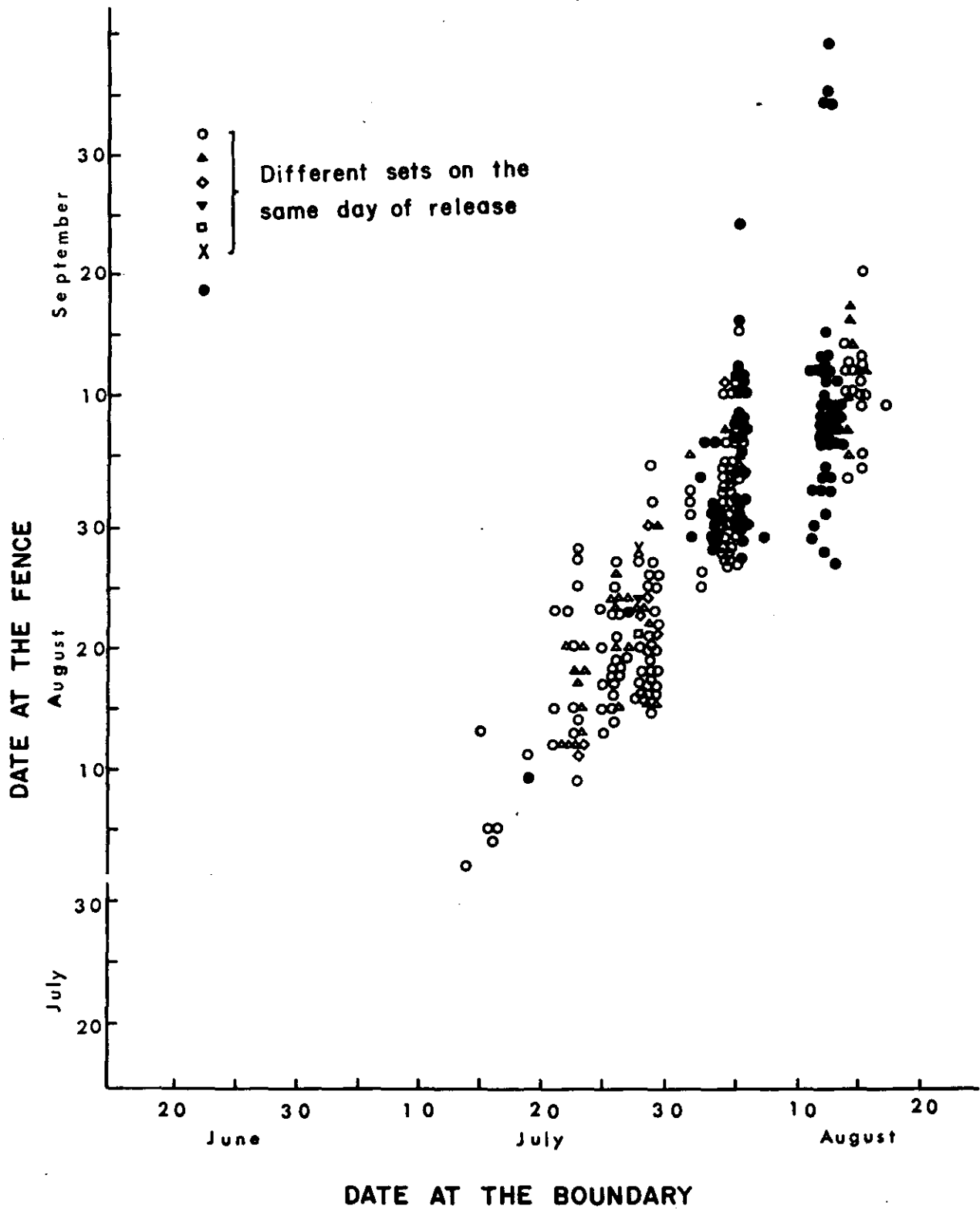


Fig. 16. Relationship of estimated dates of passage at the river boundary and recovery at the counting fence of sockeye tagged in coastal waters in 1958.

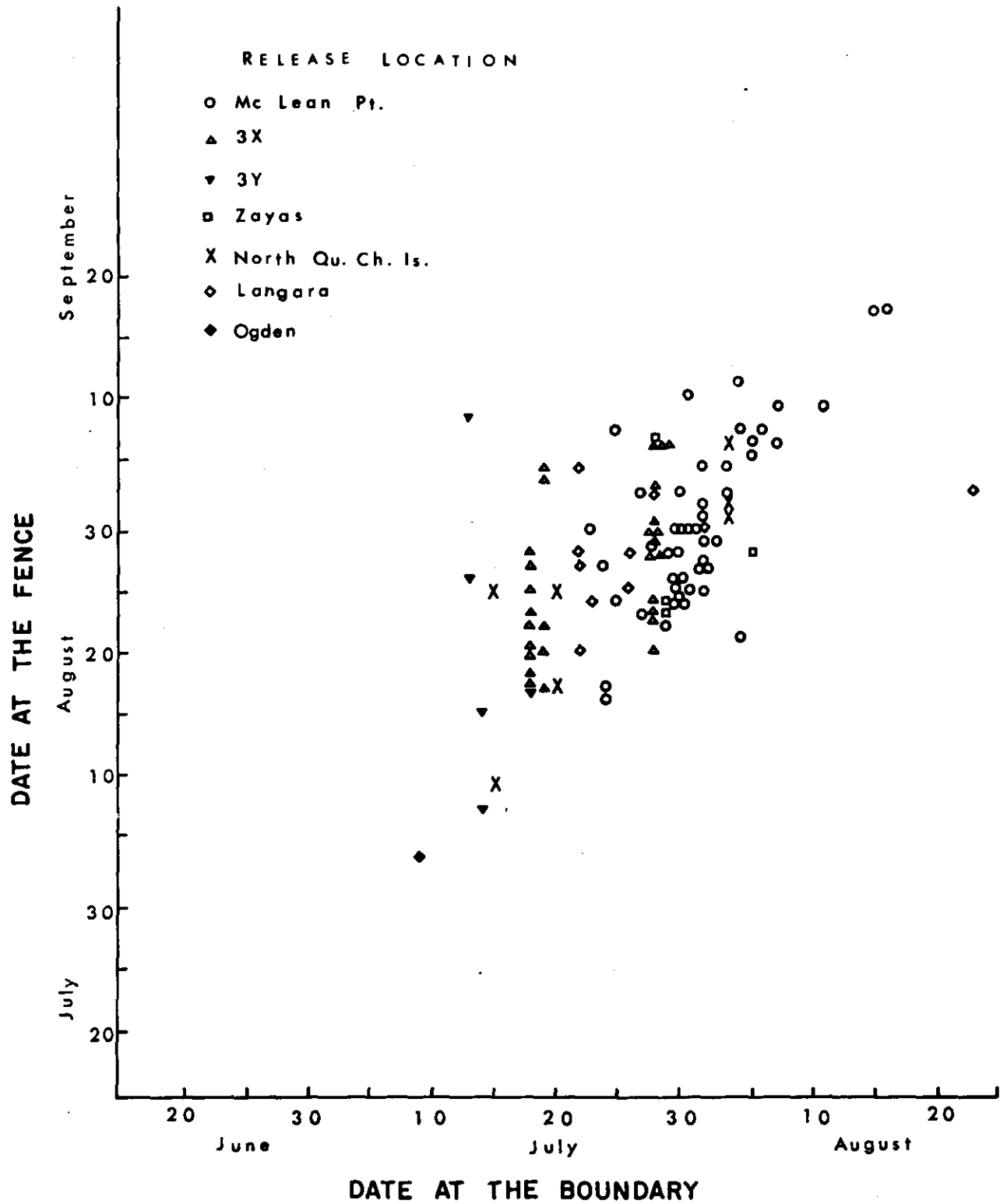


Fig. 17. Relationship of estimated dates of passage at the river boundary and recovery at the counting fence of sockeye tagged in coastal waters in 1966.

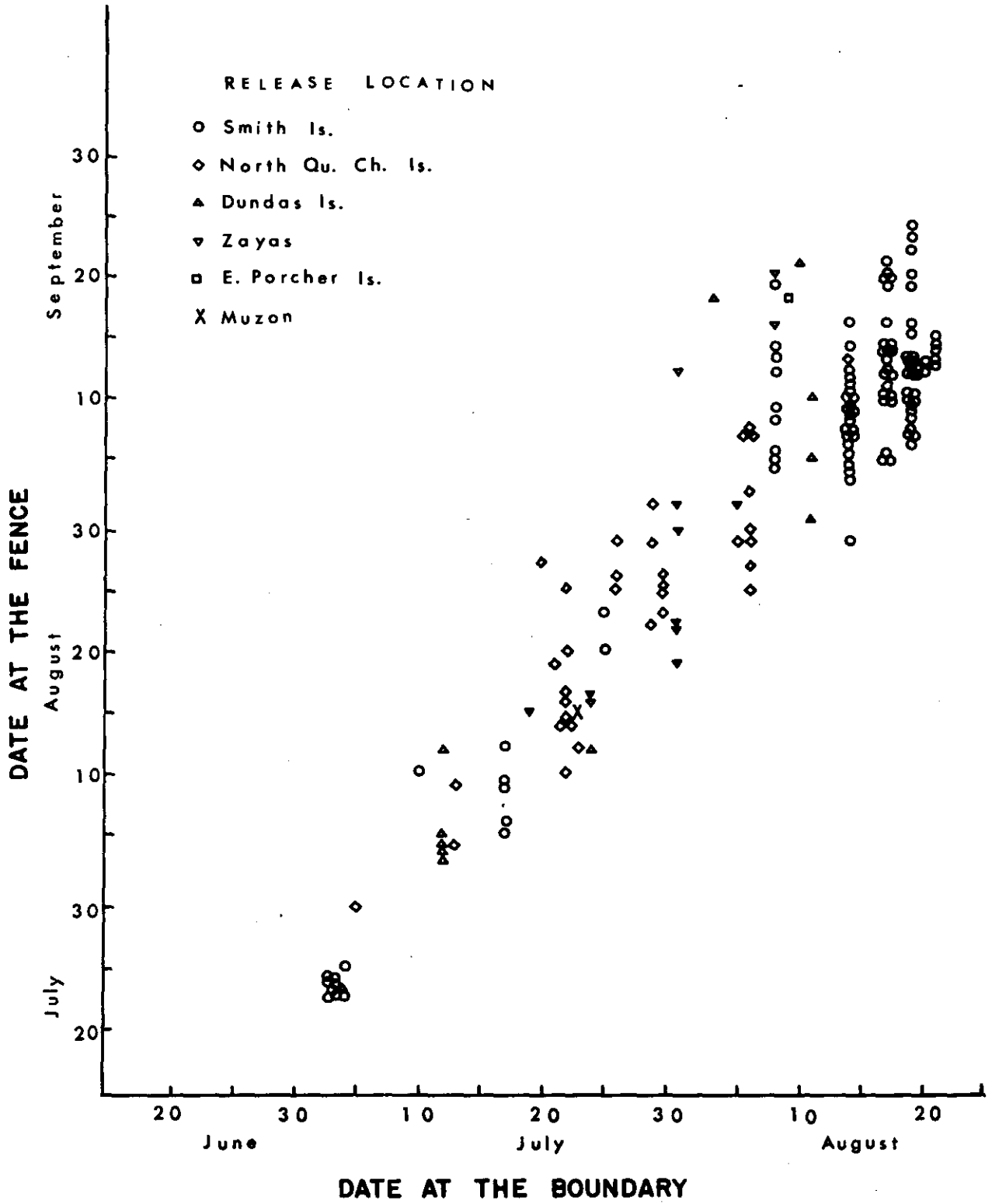


Fig. 18. Relationship of estimated dates of passage at the river boundary and recovery at the counting fence of sockeye tagged in coastal waters in 1967.

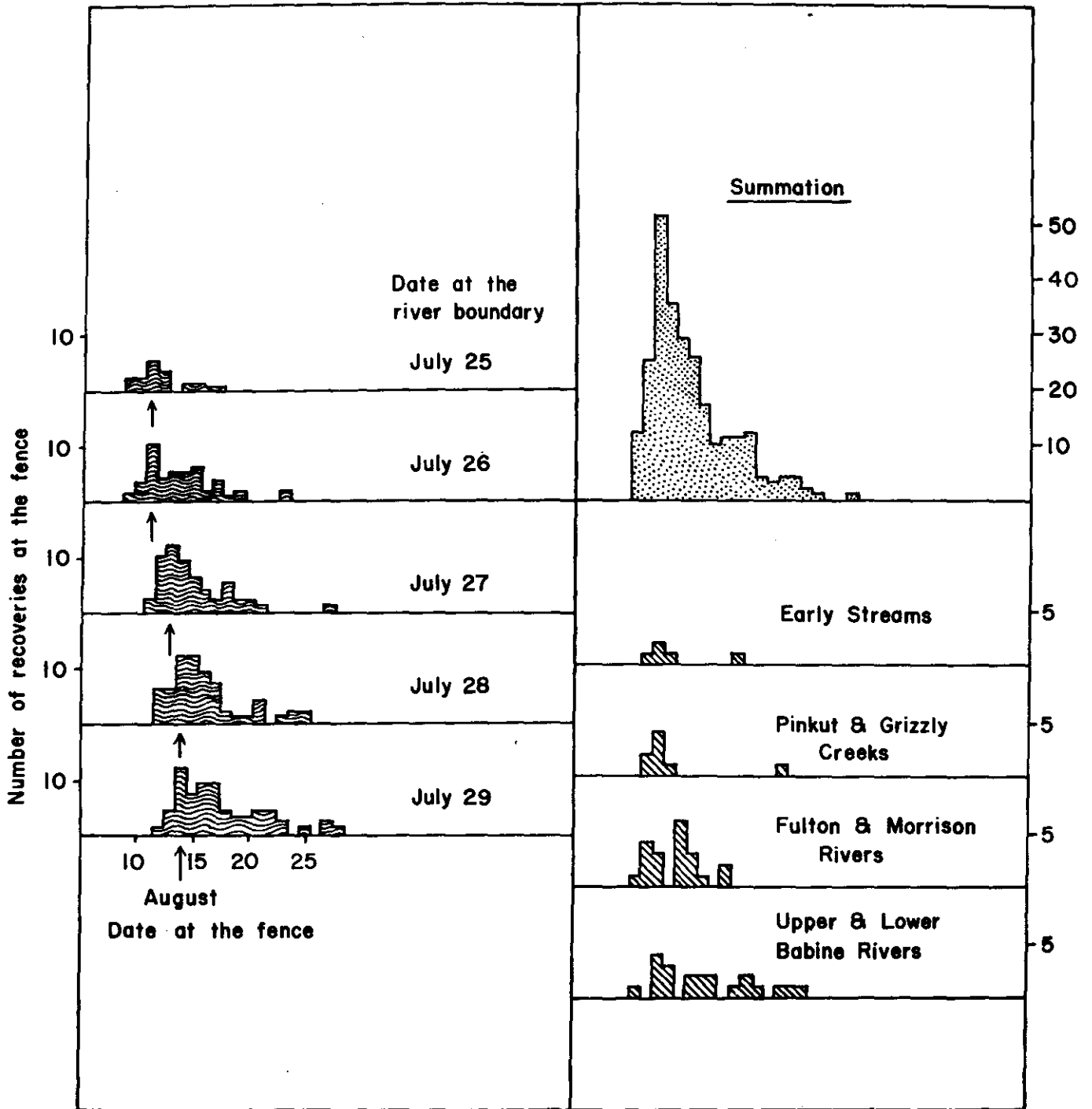


Fig. 19. Time of passage at the river boundary and counting fence of sockeye tagged at Smith Island in 1947.

APPENDIX

The following show pertinent statistics and results of t-tests to assess significance of differences in mean time out of tagged fish between and within coastal and river boundary tagging experiments:

**indicates significance at 1% level

*indicates significance at 5% level

v indicates not significant ($p > .05$)

I. Between-year variation

Statistics			
Year	n	\bar{x}	SD
Coastal			
1946	303	24.3	3.930
1947	519	20.2	3.719
1956	37	25.5	3.622
1957	204	26.6	6.801
1958	263	27.0	6.153
River Boundary			
1955	47	36.5	7.169
1956	155	28.1	5.774
1957	114	30.0	6.717

II. Within-year variation

Year	Month	n	\bar{x}	SD	test results
Coastal					
1946	June	23	28.5	3.348	**
	July	280	24.0	3.777	
1947	June	33	24.5	3.202	**
	July	486	19.9	3.570	
1956	July	37	25.5	3.622	
1957	June	18	29.7	2.353	**
	July	137	24.9	6.970	**
	Aug.	48	29.9	5.482	
1958	July	102	24.2	4.564	**
	Aug.	161	28.9	6.340	
River Boundary					
1955	July	41	36.3	7.182	v
	Aug.	6	38.2	6.866	
1956	June	8	30.8	1.561	**
	July	115	26.6	5.107	**
	Aug.	32	32.8	5.947	
1957	June	8	31.4	3.238	v
	July	83	28.3	6.080	**
	Aug.	23	35.8	6.440	

IV. Variation among stocks in 1947

Statistics			
Stock	n	\bar{x}	SD
Early streams	5	18.0	2.530
Pinkut	8	17.8	3.961
Fulton-Morrison	19	18.4	2.083
Upper-Lower Babine	22	21.0	3.949

Test Results			
	Early streams	Pinkut	Fulton-Morrison
Early streams	-	-	-
Pinkut	v	-	-
Fulton-Morrison	v	v	-
Upper-Lower Babine	*	*	**