FRI-UW 8313
August 1983

Life History of Pink Salmon (*Oncorhynchus gorbuscha*) and Implications for Management

by

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This work was sponsored by

Salmon Processors in S.E. Alaska

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PREFACE

This report summarizes studies on the pink salmon in Southeast Alaska sponsored by the salmon processing industry in this region of Alaska. In this, the second year of the investigations as well as in the first year, the emphasis was on the life history strategies of pink salmon in particular in S.E. Alaska. On this basis it was possible to interpret the effect on the stocks of removal of fish through commercial fishing operations, and the effect generated by management decisions was interpreted with reference to this. Decline has generally been associated with overfishing, but management and regulatory actions were in the past and still are factors which can contribute to population decline. The simple question of escapement goal is confounded by a secondary question not how many fish, but what kind of fish. Dr. W. F. Thompson, with his visionary insight into salmon biology, raised the question in 1952 at the Second Salmon Conference of the Fisheries Research Institute, but little heed was paid to his statements. The same question is being raised today, three decades later. Today we have more knowledge of the genetic structure of salmon populations, creating a more rational basis for formulating management regulations.

The pink salmon is unique among the members of the genus Oncorhynchus as it normally has a two-year life span. Other salmonids have multi-age structures providing for future spawners even when disaster befalls the population in a single year. Pink salmon in unusual cases do spawn at 3 years as well as two, the Great Lakes transplanted populations being a case in point, but throughout its indigenous range pink salmon spawn at two years.

Straying is suggested as the buffering mechanism enabling pink salmon to recolonize and maintain populations. The evidence for this is circumstantial,

for instance the rapid recolonization of the uplifted beaches of Montague Island after the 1964 earthquake. The lack of genetic diversity between populations within regions as measured electrophoretically suggests population interchange occurs. Direct verification and measurements of the extent of straying are long overdue using tagging, either traditional or genetic tagging methods. A second question raised is whether straying is greater in years with large runs, not only in absolute numbers but perhaps also proportionally. As a corollary maintaining escapement at an even relatively low level may be detrimental as interchange will be minimized in all years including years of high returns. Other benefits from large escapements in peak years may be the cleaning of the spawning beds from the ever ongoing process of silting. The consequences of these questions for management should be considered. One implication is that pink salmon populations are best considered in groups defined by geographic proximity and similar spawning time. These groups then become logical management units, defined on a biological basis.

The accumulations of fish on the spawning beds in a creek or along a belt of the intertidal zone usually builds up and vanishes according to a bell-shaped curve. While it is true that the peak of this curve reflects the actual survival rate of the progeny, the mere presence of the plus and minus deviates and their continued existence testifies to their importance in the survival of the species, although their function is not very well understood today. However, the management implications are clear, i.e., an escapement should be secured from each segment of the run. In last year's report the effect of the White Act Management was explored. This regulated for 50% escapement which was predominantly taken from the last half of the run. As a net result, peak run timing was consistently retarded and production declined, possibly a result of retardation in spawing time.

Today a similar process can be operating, if run strength is gauged primarily by periodic aerial surveys. Aside from inherent errors in such surveys, the numbers are derived when part of these fish are not readily exploitable any longer. Once desired escapement goals have been reached, there is always a tendency to open the fishery and transfer a heavier fishing pressure on late segments of the runs.

The task of the manager is becoming progressively more difficult with the increasing efficiency of the fleet. To counteract this the manager can artificially reduce the efficiency of the fleet by curtailing fishing time and by reducing the fishing area. However, certain run segments stand in danger of being lost or severely reduced if large effort is concentrated in a small area. This probably always will be the case as long as the fleet is free to move around and fishing power increases even though the number of units remain the same. The decline of some other species in Alaska can be interpreted as the result of this form of management which successively removes units or reduces them so there is no commercial value left. The distribution of the fishing intensity by whatever means are available then becomes a separate issue aside from the biological aspects.

The purpose of this report is to discuss (1) the life history and adaptive traits of pink salmon (O. gorbuscha) which enable it to successfully maintain populations throughout its range, (2) the implications of these traits to management of exploited pink salmon populations in S.E. Alaska and in particular the importance of migratory timing and its use in management.

LIFE HISTORY AND ADAPTIVE TRAITS

The life history pattern of a species is related to its ability to survive in its environment. Cole (1954) states that "...(life history) phenomena may be related in numerous ways to the ability of the species to survive in a changed physical environment..., natural selection will be influential in shaping life history patterns to correspond to efficient populations." Within salmonids a variety of life history patterns have evolved. Salmo species are iteroparous (repeat spawners) while Oncorhynchus species are semelparous (spawn once). Most species have an anadromous form, yet are able to complete their life cycle totally in freshwater.

The genus Oncorhyncus is believed to have originated from a Salmo-like progenitor in the area of the present day Sea of Japan (Neave 1958). O. masu which is limited to the western Pacific is held to be closest to this oncorhyncoid ancestor. Coho (O. kisutch) and chinook (O. tshawytcha) are considered the closer to the original Salmo life history as they are stream residents during some part of their post emergent stage. Sockeye (O. nerka), chum (O. keta) and pink salmon are considered the more distant as these species are less dependent on the stream environment (Miller and Brannon 1982). They exhibit strong schooling behavior on emergence (Hoar 1976), and are adapted to a more typically marine lifestyle. Pink salmon are considered the most specialized of the genus as they are least dependent on freshwater, regularly spawning in intertidal areas.

Simon (1963) looked at chromosome numbers and characteristics in Oncorhyncus and found pink salmon to have the smallest diploid number of chromosomes (2n=52). This Simon stated to suggest that pink salmon were the most specialized of the group.

Pink salmon spawning populations range in Asia from Peter the Great Bay north to the Lena River and in North American from the Sacramento River north to the delta of the Mackenzie River. In addition there are several populations in the Great Lakes from one release, in Newfoundland from releases there and in some northern European rivers from Soviet releases (Hart 1973).

Pink salmon spawn mainly in the lower reaches of streams, although they do spawn in the upper reaches of some larger river systems such as the Fraser River (Ward 1958) and in the Tikchik region of Bristol Bay, 300 miles upstream. They regularly spawn in intertidal areas of streams. In Prince William Sound prior to the 1964 earthquake intertidal spawners comprised over 50% of the production in even years (Helle et al. 1964). Spawning occurs at two years of age. Although three year old spawners have been observed in introduced populations (Wagner and Stauffer 1982), they are a rare occurrence in the original range of the species. The time of spawning ranges from July to October depending on the stream location.

The female pink salmon carries 1500-1900 eggs and the fry hatch between December and February, emerge and migrate downstream from March to May (Hart 1973). They remain in estuarine areas for some months, where several populations school together and later move offshore where they remain until the next spring (Neave 1953, Martin 1966).

The alterations in odd/even brood year dominance may be due to random fluctuations of the environment affecting the brood years differently. Pink salmon spawn in small coastal streams subject to extremes in temperature and water flow and the eggs and sac-fry probably suffer very variable density independent mortalities between years, causing large natural fluctuations in population size. Other mortality factors may be compensatory as in the case of redd- superimposition when spawners are overabundant (Heard 1978) or

depensatory predation, for instance when fry numbers are very small (Neave 1953).

Commercial fisheries have exploited pink salmon since the early part of this century and they are the most numerous salmon in the fisheries and sustained high fishing mortalities over a long period. In North America a record catch of 89 million was recorded in 1941 (Takagi et al. 1981). However subsequent to this the populations and catches declined. Exploitation today is still high, e.g., it is estimated at 73% in 1982 in Alaska (ADF&G 1983). High fisheries exploitation as a major source of mortality in present day pink salmon populations is probably most damaging in years when abundances are low. The fishery would act as a depensatory mortality factor, to further depress a population already at a low point. The two year life cycle prevents any buffering effect which is gained from a multi-aged population structure in other salmonid species.

A crucial factor in the ability of pink salmon to maintain populations despite heavy mortality may be found in the high frequency of straying which is thought to occur. Pink salmon appear to be great opportunists, and to have the ability to maintain populations by colonization and recolonization. This could be an important characteristic in a species with one year class, which inhabits streams subject to extreme fluctuations. Strays may supply spawners where the population has been depressed, and as discussed later maintain genetic variability. In years of large abundance pink salmon may "spill over" into areas outside their normal spawning areas with straying a function of large numbers rather than a constant proportion in all years. In either case numerically higher numbers will stray in large years.

Several examples of the colonization ability of pink salmon are found in the literature although specific studies which examined straying could not be

found. In one study in Sashin Creek, S.E. Alaska the even year line of pink salmon was systematically exterminated over two years. However in subsequent years spawning occurred at increasing abundances, presumably due to strays from neighboring streams (Ellis 1969). Releases of pink salmon have resulted in strays being reported over wide areas. When releases were made by the Soviets in the sixties into the Arctic, strays were reported from as far as Iceland (Gudjonsson 1961) and populations may have established themselves in northern Norway (Hart 1973). A more interesting case is that of the Great Lakes release, which occurred accidentally in 1956, when pink salmon fry of an odd year stock were released in a tributary of Lake Superior. By 1979, 24 years or 12 generations later, the pink salmon had reached abundances of over 10,000 spawners in Lake Superior, had spread to Lake Huron and Lake Michigan, and three year old spawners had established even year spawning populations in all three lakes (Wagner and Stauffer 1982). The populations increases from 1977 to 1979 in Lake Superior were tenfold and Wagner and Stauffer suggest similar increase may be expected later in populations which were established later. They also point out that these populations are in all likelihood multi-aged, i.e., two and three year olds and will perhaps not be subject to the large fluctuations that occur in the original range.

Factors Controlling Stock Specificity

The pink salmon is a successful salmonid species with a wide distribution and high natural production. They have several unique life history and behavioral characteristics amongst the salmonids. The two year life cycle produces odd and even brood lines. Over the range of pink salmon in North America there is a trend in these two brood lines. In the southern extreme,

in Washington and the Fraser River only odd year populations are found, in the north only even years are presently found. In the center of the range both brood lines are found and alternate as to which is the larger. In Asia there does not appear to be such a difference in brood years by area (Takagi et al. 1981).

Genetic variation in pink salmon populations has been studied with electrophoretic techniques by several workers (Aspinwall 1974, Johnson 1979, Altukhov and Salmenkova 1981 and McGregor 1982). Altukhov and Salmenkova (1981) reported significant genetic distinction between Asian and American stocks on the basis of comparison with results reported by Aspinwall (1974). Genetic differences are most pronounced between the two broodlines, supporting the assumption that few pink salmon in indigenous populations spawn as three year olds and that there is little mixture between the two lines. The two broodlines exhibit some behavioral differences. Even year runs in most of Alaska arrive later than odd. Intertidal spawners are predominately even year spawners (Royce 1962, Helle et al. 1964). There is good reason to regard the odd and even lines as two different populations. Aspinwall (1974) and McGregor (1982) in S.E. Alaska and Johnson (1979) in Kodiak all found considerable uniformity in genetic structure between populations within regions within broodlines. Johnson (1979) and McGregor (1982) found that between broad geographical regions genetic differences reflected geographical distances. Within a population McGregor (1982) found little diversity between areas, intertidal or upstream spawners, or time segments, early and late.

The greater part of genetic variation measured in pink salmon occurs among individuals rather than among streams and genetic heterozygosity is high among Alaskan pink salmon (McGregor 1982). Johnson (1979) and Utter et al. (1980) suggest that the high level of heterozygosity is maintained by the

straying habit of pink salmon, but that the rate of straying is not high enough to homogenize the populations completely. As pink salmon are subject to severe constrictions in population size, random differences may arise by random loss of alleles. Higher diversity among regions than within could be due to lower rates of straying as geographic distance increased. McGregor (1982) found his results supported this hypothesis. The high levels of heterozygosity may be important to a species which must remain flexible in order to utilize environments which are subject to fluctuations and drastic change.

In his review of the environmental and genetic factors affecting salmon populations Ricker (1972) discussed several traits that were under genetic influence, morphological as well as behavioral. He later reported (1982) on the effect of selection for size in pink salmon in the British Columbia gillnet and troll fisheries, showing that over the period 1951-1979 size decreased. Ricker estimated a "realized heritability" of 0.2-0.3, which he considered reasonable in comparison to other studies on size and heredity.

Time of spawning and migration is geared to the temperature of each location. Temperature is an important controlling factor in determining time of spawning, as was demonstrated by Sheridan (1962). He found a correlation between time of spawning and the temperature regime of the stream in S.E. Alaska, where colder streams had earlier spawning populations. Similar results were found by Vernon (1962) in pink salmon of the Fraser River, and in Asia Takagi et al. (1981) report that northern Okhotsk Sea populations spawn earlier than those of west Kamchatka and the stocks of the islands further south spawn progressively later. The presence of a cline such as this may indicate the selective action of an environmental gradient, but clines alone are not evidence of selection (Hartl 1980). The presence of the same cline in

two or more discontinuous areas populated by a species provides additional evidence of the same selective action effecting these populations. In the case of pink salmon the cline observed in spawning times in relation to temperature on both sides of the Pacific Ocean suggest there is a selective component at work. In his study Sheridan (1962) showed that fry emergence occurred at the same time regardless of time of spawning. The governing factor is the optimum time of fry emergence and the time needed to accumulate the degree-days required for hatching and emergence at this optimum time. Timing of seaward migration and feeding in saltwater are thus synchronized to coincide with food development in saltwater. This is a trait common to all salmonids. Miller and Brannon (1982) in their discussion of the development of Pacific salmon have suggested that temperature regime is one of the most important factors in the ecological isolation of stocks. Alexandersdottir and Mathisen (1982) report on apparent selection for later arriving pink salmon in the trap fishery in S.E. Alaska from 1925 to 1945. The fishery only exploited the earlier segments over these 20 years and the result was an apparent retardation of the runs. This retardation was also observed in a stream population where time of arrival was shifted by almost a month and survival of the fry decreased in the stream. This may have been due to the time of arrival being shifted with a concomitant delay in egg deposition and fry emergence and higher juvenile mortality as the result of a population out of phase with its environment. A contributing factor is that spawners are observed to distribute in Sashin Creek according to timing in that early spawners in large runs spawn upstream where fry survival is higher (Merrell 1962, McNeil 1966). Upstream spawners may represent a separate spawning group that was exposed to higher exploitation in the fisheries, leaving the later group in sole possession of Sashin Creek. In either case the fishery has

operated as a selective force, selecting less productive sections of the population.

Bams (1976) reported on an experiment with pink salmon to determine the possible genetic influence on migratory behavior and homing. He crossed males from a non-native donor stock with native females, which along with the pure donor stock were raised in a hatchery on the local stream. Bams found that time of migration was genetically controlled. The donor stock was of an earlier migrating race and the hybrids returned at a time closer to the donor stock than to the native stock. Bams concluded that time of adult migration had a male genetic component. In the same study Bams also found that the hybrid stock returned more successfully to the stream and the hatchery than did the pure donor stock, although both stocks occurred equally in a nearby fishery. He concluded that there was a genetic complement in homing which was important in homing to the stream.

Migratory behavior, homing and timing are important factors to all salmonid species. Both of these traits depend on the location and environment of the stream, so a population is genetically adapted to its home stream. In the Great Lakes the pink salmon released in 1956 took 24 years and 12 generations to exhibit any substantial increase in abundance and to be considered as successfully having established populations. This may be the time it took the pink salmon to adapt to the new environment in which they found themselves. That they were able to may be due to the fact that pink salmon are the species of the oncorhyncoids least dependent on freshwater and most adapted to marine.

Stock specificity in salmonid species depends on the freshwater environment and both adults and juvenile salmon possess traits adapted to the freshwater environment to which the population homes. Behavior of sockeye fry

immediately on emergence depends on stream and lake orientation and is under genetic control (Brannon 1967). Age at spawning in multi-aged species may depend on the effort required to reach the spawning area (Schaffer and Elson 1975). Riddell et al. (1981) suggest that body size and shape were adapted to river conditions for juvenile Atlantic salmon and were heritable. As already discussed, time of spawning is dependent on freshwater temperature and is under genetic control. Species exhibiting strong specificity over a large range of traits will be less likely to succeed in new freshwater environments whether they arrive naturally by straying or are released or transplanted by man.

Pink salmon are single aged and most populations travel only short distances in freshwater to spawning grounds which are mostly in small streams. The fry leave on emergence not to return until they spawn 1-1/2 years later. The success of pink salmon strays may depend primarily on the temperature regime of the new environment, in relation to the old. The ability of pink salmon to recolonize or colonize streams may depend on higher success among strays (or transplants) rather than, or in addition to a higher frequency of straying, and as suggested by the electrophoretic evidence populations close in space and with similar stream environments can be considered as a population group or stock group rather than as separate populations.

S.E. ALASKA PINK SALMON POPULATIONS

S.E. Alaska represents the center of the range of pink salmon in North America. Over 2,000 streams have spawning populations composing a complex system of populations. Tagging has shown that S.E. Alaskan populations are conservative in the migration routes followed into and through the

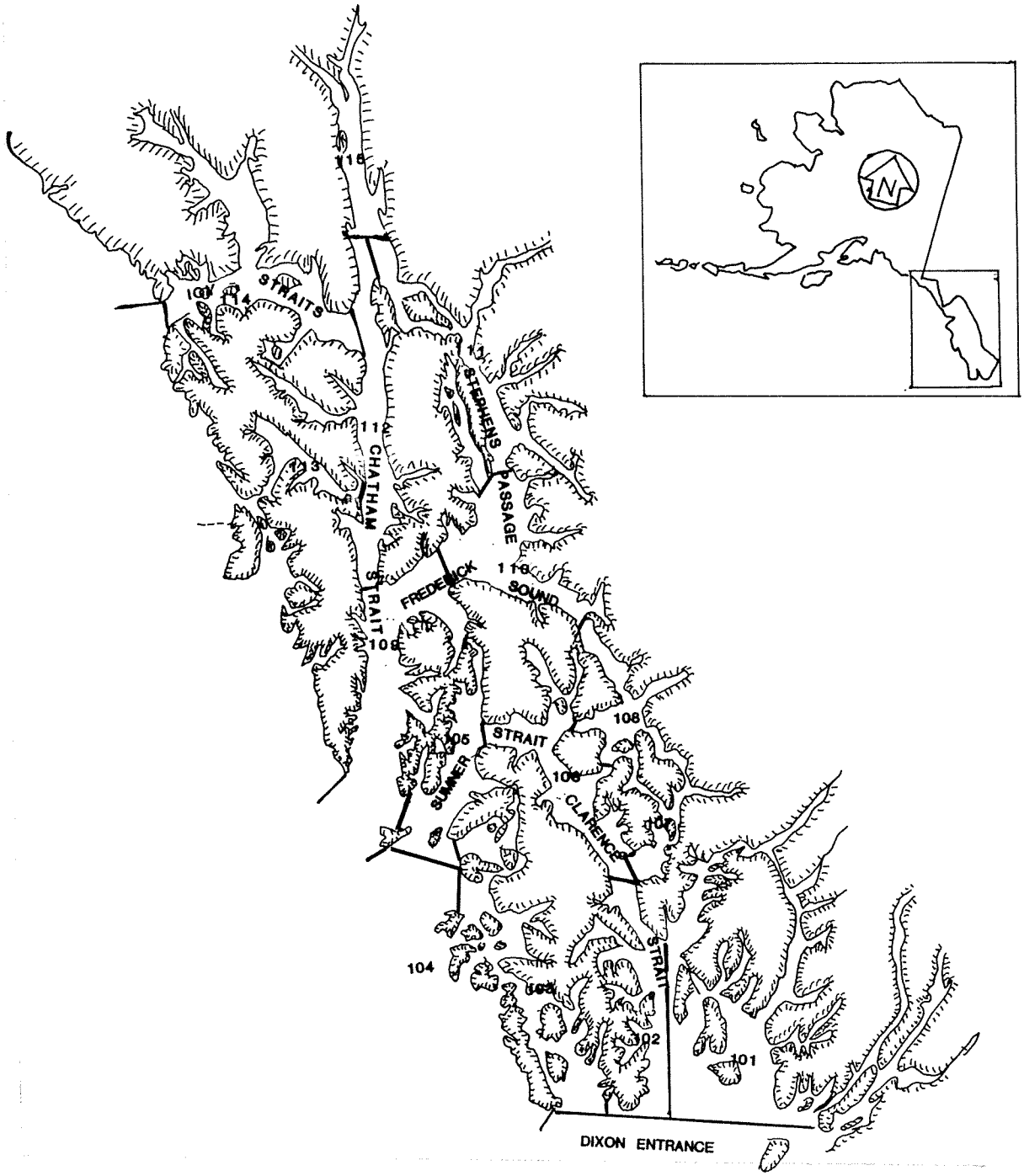


Figure 1. S.E. Alaska map shows division of region into statistical areas.

archipelago. The migrations commence in June, and time of entry depends on spawning time and distance to spawning area. Populations within larger regions follow the same migration routes.

S.E. Alaska is divided into statistical areas (101-115) for reporting purposes. Areas 101-108 are in the southern district, 109-115 in the north (Figure 1). Each area is further divided into subareas and streams identified by number within a subarea.

The Fishery

The fishery for pink salmon in S.E. Alaska dates to the late 19th century and eventually expanded to become the largest salmon fishery in Alaska. During the 1950's the fishery declined and has since not returned to its pre-World War II levels. The history of the fishery and the decline of the pink salmon populations of S.E. Alaska is discussed more fully in a previous report (Alexandersdottir and Mathisen 1982) and will only be described briefly here.

The fishery in Southeast occurs mostly in the inside areas, although there is a sizeable seine fishery offshore in southern Southeast and troll fisheries offshore all along the coast. The fisheries exploit the pink salmon as they migrate through the straits and channels enroute to their spawning ground and several populations may be harvested together, depending on the time and location of the fishery.

Prior to 1950 the fishery was mainly a trap fishery. Although purse seiners increased in numbers, the bulk of the production came from the large pile and floating traps which were located along the migration pathways of the returning pink salmon. Traps were banned in the 1950's except for one area on Annette Island at the Metlakatta Indian reservation and purse seines became the dominant gear in the pink salmon fishery. Management prior to the late

1940's, in order to comply with the White Act, which called for a 50% escapement, allowed fishing on the earlier portion of the pink salmon runs and then closed to allow escapement. This policy as discussed above, caused selective exploitation of the early run populations in Southeast resulting in retardation of the runs over the same period, 1925-1945. After 1945 the open period extended later and presumably late run populations were then exposed to heavier pressure.

Fredin et al. (1968) suggest overfishing in small years as a crucial factor in the decline. The management policy of the pre-WWII years may also have been crucial, exploiting early-run populations more heavily. In northern Southeast where early populations predominate this selective exploitation may have depressed all streams within large areas, disturbing the system of interchange and buffering which enables pink salmon to recover from heavy losses naturally. Fishing effort has been reduced in northern Southeast especially in the last 10 years, but recovery has been slow, and 1982 saw the first large year (over 10 million caught) in a decade.

Alexandersdottir and Mathisen (1982) discuss the necessity of managing pink salmon as stocks comprising several populations where a stock is defined by geographical location and time of spawning. Migration or straying between populations provides for interchange of genetic material, maintains variation and is a mechanism for colonization. If all populations within an area are overexploited straying would be less frequent, delaying any recovery.

Thus several factors may have contributed to the decline and slow recovery of S.E. Alaska pinks. Overfishing, especially in years when the returning populations were depressed surely contributed to the decline. Early populations were more heaviliy exploited due to the selective nature of the management policy. This had most impact in northern Southeast where early

spawners are more prevalent. Early mainland spawners in the northern region were also exposed to fisheries over longer periods as their migration routes are longer within the archipelago than in the southern region. A third factor is the effect the fisheries may have had on the genetic composition within populations. Loss of genetic variation due to small numbers of spawners or due to selection for later arrivals in spawning may have left the populations with less ability to recover from a depressed state. The fourth possible effect pertains to the possible life history strategy of pink salmon, i.e., straying as a mechanism of population renewal and buffering.

The year 1960 saw the lowest catch of pink salmon in S.E. Alaska, about 2 million fish. Since then the catch has ranged from 3 to 25 million. Trends in catch have differed between lines and regions (north and south).

Effort has concentrated in the south, especially since the early seventies. Catches (Figure 2) are higher in even years and the pattern differs (Table 1). In even years catches in area 101 make up on the average 25% of total seine catch, but only 12% in odd years (Table 2). This could be due to absence or loss of some segment of the run entering through area 101 or it could be due to a difference in behavior between even and odd years in migratory patterns. Area 106 has relatively higher catches in odd years (Table 1) and a larger percentage of total catch. Odd populations may tend more to migrate through Sumner Strait rather than into Dixon Entrance.

In northern Southeast depressed populations (Figure 3) and decreased effort (Tables 3, 4) contributed to low catches in both odd and even years. In 1976 catches were at 143,600 and with the escapement index at only 967,000, the total was just over 1 million pink salmon. During early years most catches were made in areas 114 and 112. Since 1975 the catches have occurred mainly in 113, although in 1982, a record year, the catch was distributed

Table 1. Seine catches by area in southern Southeast.

Year	101	102	103	104	105	106	107	Total
1970	1,588,437	970,664	1,548,754	137,736	53,667	92,693	264,385	5,411,600
72	2,950,366	1,292,954	609,302	1,627,527	35,314	140,740	1,651,098	9,153,100
74	943,077	639,909	661,725	1,017,798	158,660	37,360	201,574	4,220,900
76	285,994	1,850,416	867,701	317,182	9,092	239,535	391,343	5,157,400
78	3,330,422	5,621,157	835,114	2,050,555	103,076	125,984	1,551,327	18,425,000
80	4,311,725	1,707,340	2,998,889	2,358,357	39,032	0	0	12,907,300
82	4,359,452	1,656,289	902,417	4,569,316	99,543	0	109,482	12,400,000
Even avg	2,538,496	1,962,675	1,203,414	1,725,495	71,197	90,901	595,601	9,667,900
1969	50,095	222,708	28,761	473,949	5,702	57,789	31,935	1,197,700
71	830,371	1,618,151	869,825	672,759	209,080	673,753	728,087	6,247,600
73	563,470	1,456,781	187,895	806,261	66,206	357,006	430,639	4,555,100
75	322,840	1,156,151	572,865	71,410	5,518	449,379	247,481	3,330,200
77	3,315,573	2,424,302	452,111	917,529	38,768	717,909	1,670,136	11,242,200
79	307,493	1,515,953	948,979	191,319	96,157	960,687	1,038,240	6,992,000
81	1,449,378	848,709	5,260,977	3,724,494	309,471	383,507	31,428	12,661,300
Odd avg	977,031	1,320,393	1,188,773	979,674	104,414	514,290	596,849	6,599,442
Overall avg	1,757,763	1,641,534	1,196,093	1,352,585	87,806	302,595	596,225	8,133,671

Table 2. Percent seine catch by area in southern Southeast.

Year	101	102	103	104	105	106	107
1970	0.29	0.18	0.29	0.02	0.01	0.02	0.05
72	0.32	0.14	0.07	0.18	0.004	0.01	0.18
74	0.22	0.15	0.16	0.24	0.04	0.008	0.05
76	0.05	0.36	0.17	0.06	0.002	0.05	0.08
78	0.18	0.30	0.04	0.11	0.006	0.007	0.08
80	0.33	0.13	0.23	0.18	0.002	0	0
82	0.35	0.13	0.07	0.37	0.008	0	0.009
1969	0.04	0.19	0.02	0.40	0.0005	0.05	0.03
71	0.13	0.26	0.14	0.11	0.03	0.11	0.12
73	0.12	0.32	0.04	0.18	0.01	0.08	0.09
75	0.10	0.35	0.17	0.02	0.002	0.13	0.07
77	0.29	0.22	0.04	0.08	0.003	0.06	0.15
79	0.04	0.22	0.14	0.03	0.01	0.14	0.15
81	0.11	0.07	0.41	0.29	0.02	0.03	0.003

Table 3. Maximum number of boats fishing in one week in purse seine fishery in SE Alaska.

	Year												
Area	69	70	71	72	73	74	75	76	77	78	79	80	81
101	23	104	55	135	65	112	33	54	144	205	55	169	92
102	45	96	92	109	121	80	152	153	107	182	65	91	77
103	30	121	66	103	78	82	95	99	75	69	102	151	223
104	47	33	33	82	69	64	90	103	113	157	159	222	159
105	16	15	17	20	11	52	6	-	8	12	14	8	18
106	18	23	45	32	37	18	45	25	60	27	73	-	32
107	16	37	52	75	54	45	75	139	109	81	113	-	10
109	43	46	58	42	35	31	<3	6	21	20	51	66	15
110	8	41	<3	42	18	51	-	-	-	-	10	<3	57
111	-	11	-	17	-	-	-	-	-	-	6	-	-
112	125	150	136	123	87	111	-	-	-	81	51	85	68
113	20	18	6	7	19	14	44	19	83	67	79	33	121
114	200	203	180	158	165	165	103	56	-	-	-	55	77

Sources: ADF&G computer summaries 1969-1981.

Table 4. Days fished per year by area in SE Alaska purse seine fishery.

	Year														
Area	65	67	69	70	71	72	73	74	75	76	77	78	79	80	81
101	25	4.5	4.5	36.6	22	34.1	9.8	15.7	8	11	10.1	21.7	9	20.6	.6
102	25.5	12.9	8.7	37	25.3	37.8	24.3	17.7	11	14.45	13.6	21.7	7.8	22.5	1.2
103	21.5	4	3.5	20	20.4	16.9	5.5	10.5	6.5	10.3	7.1	13.1	4	19.4	14
104	43	19	26.5	40.8	20.4	36.1	21.4	22.5	7	11.1	15.0	15.8	19.1	28.9	16
105	21.5	7.6	3.5	19	19.4	6	6.5	7.1	3	1.25	5.2	4.2	6.9	3.2	11.7
106	27.5	4	6	20.6	18.3	16.3	10	8.1	8	8.1	3.7	10.5	5.4	-	6.5
107	19	-	13.5	29	23.2	36.5	13	7.7	8	6.65	7.4	22.7	2.6	-	1.6
109	30.5	13.7	6.8	31.9	21.4	28	10	11.8	2.5	1.25	5.7	12.1	8.9	14.7	11.7
110	7.5	7.5	1.8	26.9	18.2	13	3	3.7	-	-	-	-	4.9	.6	3.9
111	-	-	-	11.5	-	7	-	-	-	-	-	-	3.3	-	-
112	30.5	20.4	16	35.4	18.9	14.8	7	9	-	-	-	13.2	13	11.1	15.6
113	32.2	22	8.8	30.0	16.6	20.7	13.5	15.2	8	3.5	11.6	11	14.5	6.2	16.2
114	30.5	18.4	17.8	19.8	16.7	26.4	12.4	3.0	1.5	1.8	-	-	-	3.7	10.2
TOTAL	264.7	134.	117.4	358.5	240.8	292.9	136.4	132.	59.3	69.4	79.4	146.	109.7	130.9	109.2
MEAN	18.9	9.6	8.4	25.61	17.2	20.9	9.7	9.4	4.2	4.9	5.7	10.4	7.8	9.35	7.8

Source: ADF&G files, Juneau.

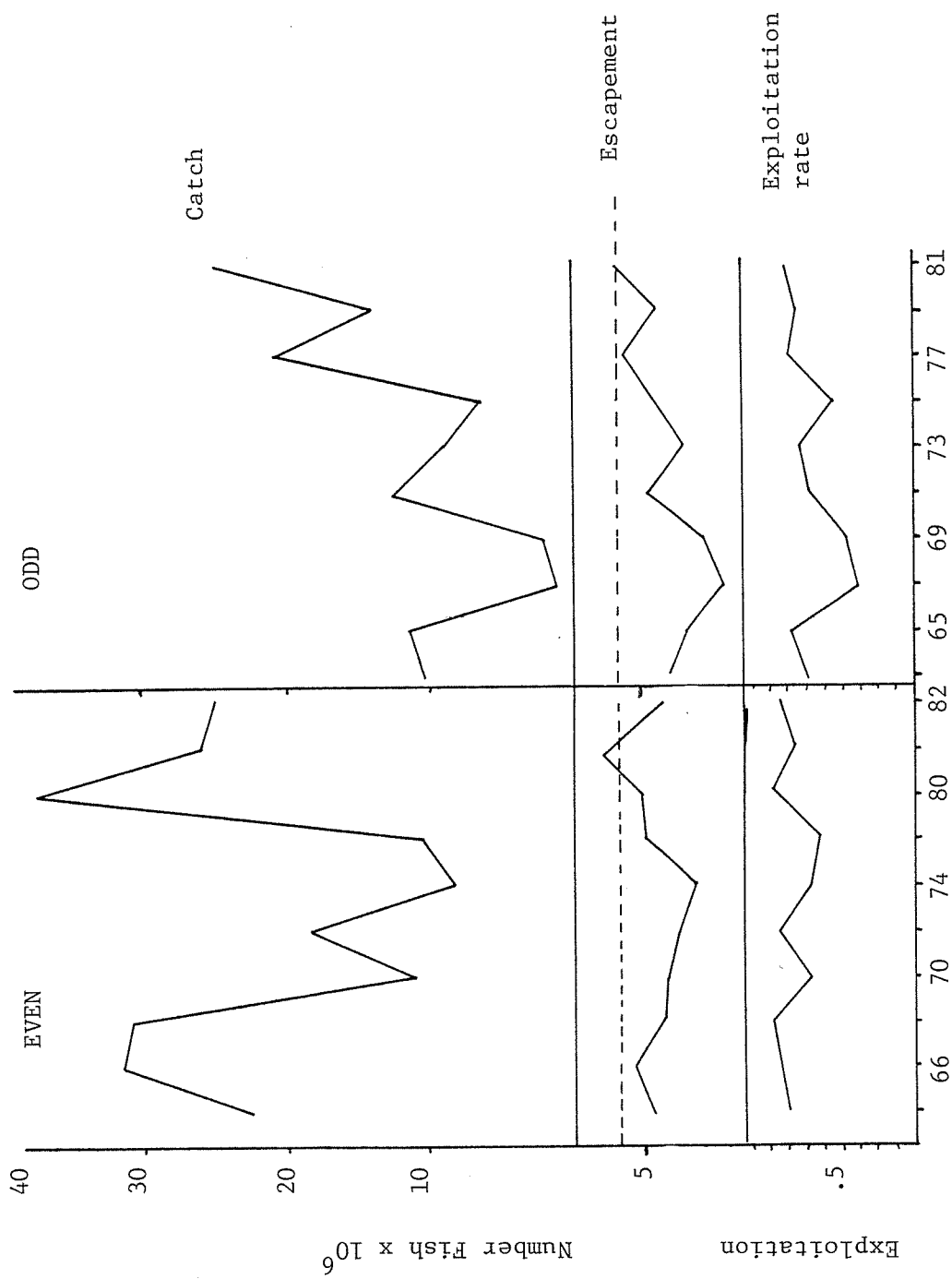


Figure 2. Catch, escapement and exploitation in southern S.E. Alaska 1963-1982. Dotted line indicates escapement goal (6 x 10^6).

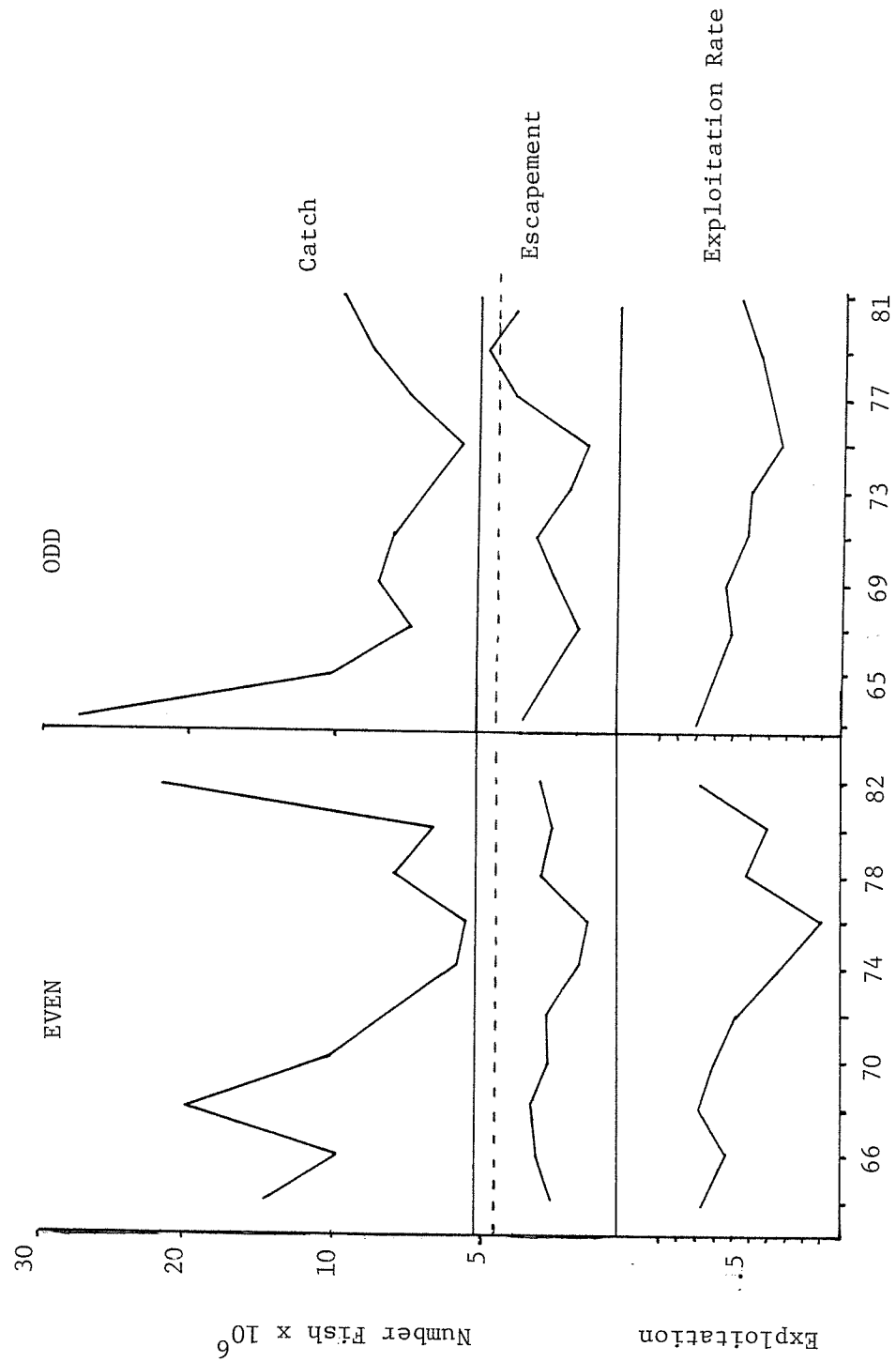


Figure 3. Catch, escapement and exploitation in northern S.E. Alaska 1963-1982. Dotted line is escapement goal (4.6×10^6).

throughout the region (Table 5).

Exploitation fluctuates from 20-80% as estimated using escapement indices (Figures 2 and 3). The fishery is apparently not taking a constant proportion of the total return, but is exploiting the large runs more heavily, and thus escapement is maintained at a relatively steady level (Figures 2 and 3).

Management

Management of salmon populations has two major goals, to provide sufficient escapement and to allow timely harvest of the surplus, i.e., the difference between the total run and the escapement goal. These goals can be in direct conflict with each other. Pre-season abundance forecasts are made for all major fisheries, based on pre-emergent fry sampling and environmental variables (Jones and Thomason 1981). These forecasts provide estimates by area and timing. In-season escapement surveys, both aerial and ground, provide information on the progress of the run. Fisheries are opened or closed depending on the numbers observed in spawning areas. In latter years especially in the northern region the trend has been to fewer areas open to fishing where stocks are mixed such as Icy Straits and Chatham Straits and more fishing in terminal areas. When escapement is considered well-achieved, fisheries are opened. If escapement appears less than expected the fisheries are closed.

Mixed stock harvest is difficult to manage and the goal of most managers is to minimize the problem as much as possible by harvesting as close to the spawning streams as possible where few populations intermingle. Selective exploitation can occur if two or more populations in one fishery are of unequal strength (Ricker 1958, Paulik et al. 1967), if the fish are of unequal size in a gillnet fishery (Todd and Larkin 1971) or they have different timing

Table 5. Seine catches by area in northern Southeast.

Year	109	110	111	112	113	114	Total
1970	376,635	337,049	46,443	2,018,297	102,032	2,080,548	5,241,600
72	376,137	324,722	24,737	1,073,635	28,386	1,117,531	3,243,700
74	92,410	97,569	0	204,590	33,508	86,042	663,500
76	3,385	0	0	0	74,825	2,565	143,600
78	205,903	0	0	604,812	1,587,790	0	2,781,900
80	530,043	583	0	286,783	46,021	36,169	1,428,300
82	1,769,221	2,191,435	0	5,885,635	354,132	167,264	10,500,000
1969	125,481	9,624	0	784,961	114,552	2,407,304	3,608,100
71	349,198	1	0	667,121	72,665	1,646,526	3,016,900
73	83,275	38,987	0	40,450	239,648	921,233	1,883,000
75	658	0	0	0	559,922	24,714	616,200
77	28,385	0	0	0	2,035,492	0	2,523,100
79	1,192,479	86,971	7,695	341,115	1,600,919	1	3,831,800
81	129,589	263,050	0	813,254	2,608,231	735,131	4,755,200

(Hartman and Raleigh 1964, Dahlberg 1968). One population may be selectively affected if a fishery is selective for size (Ricker 1982; Paloheimo and Elson 1974) or on timing (Alexandersdottir and Mathisen 1982). Harvesting close to spawning areas will minimize multi-stock harvest problems. However the second type of selective exploitation, (within a single population) or populations with similar neighboring population parameters, (stocks as defined here) may still exist.

Figure 4 shows recoveries in catch and escapement in Tenakee Inlet in 1978 as described by tagging data (Larson 1978, 1979, Hoffman 1980, 1981, 1982 a & b). The true migratory timing is probably best described by summing the distributions. Under the assumption that recovery efforts were equal for the escapement and seine harvest then Table 6 shows the differences in harvest rate over the season in Tenakee Inlet and Peril Strait 1978. The rate of harvest changes, which results in unequal escapement of each time segment. One time segment of the total migration provides the escapement, while the fishery largely harvests a separate time segment. This illustrates two of the problems inherent in the fishery today. Openings are short and the fishery is intense, which can result in a high harvest rate over a short time. The effort is also unequally distributed over time, which results in heavy exploitation of one time segment and not the rest. The sum result is selective exploitation which if consistent over time, can be detrimental to the population (Alexandersdottir and Mathisen 1982).

Stock Groups

In the proceedings of the symposium on the Stock Concept in Pacific Salmon, Larkin (1972) outlined some of the information needed to develop a harvest policy for separate salmon stocks. The inputs he considered necessary

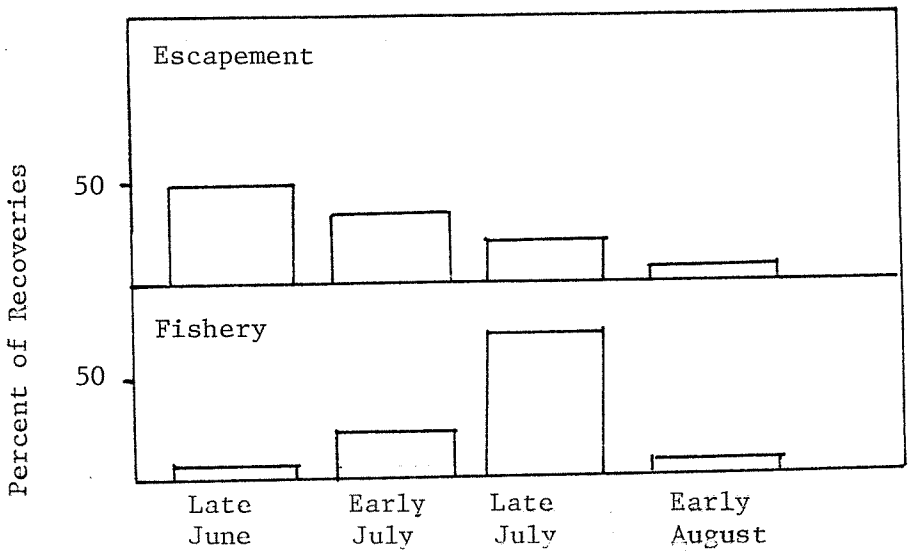


Figure 4. Percent tag recovery in Tenakee Inlet escapement and fishery by time period tagged in Upper Chatham Strait in 1978.

Table 6. Tag recoveries and percent exploitation in 1978 in northern S.E. Alaska (Larson 1979).

Tagging Point:	Upper Chatham						Mid-Chatham					
Tagging Time: Area	Late June	Early July	Late July	Early Aug.	Late Aug.	Sub-Total	Early July	Late July	Early Aug.	Late Aug.	Sub-Total	Total
Peril Strait												
Escapement	7	25	32	7	13	84	26	30	9	14	79	163
Seine Fishery	30	222	248	13	10	523	151	178	21	17	367	890
Exploitation	0.81	0.89	0.88	0.65	0.76	0.86	0.85	0.86	0.70	0.55	0.83	0.84
Tenakee Inlet												
Escapement	106	239	94	3	0	242	65	46	4	0	115	357
Seine Fishery	6	88	353	6	3	456	43	183	12	5	243	699
Exploitation	0.05	0.27	0.79	0.66	--	0.65	0.40	0.80	0.75	--	0.68	0.66

were:

1. degree to which salmon are adapted to their environment, to what degree this is hereditary and to what degree environmental.
2. a better understanding of the genetic basis for variability in salmon populations.
3. population dynamics of each stock so as to be able to distribute catch over all stocks and their components.
4. accurate measure of the amount of harvest on mixed stocks.

Since 1972 there has been considerable increase in our knowledge of the environmental and genetic influences on salmon populations. As discussed above interchange between neighboring populations may be an important component in the life history strategy of pink salmon, with populations forming groups or stocks which should be defined on the basis of time and space. This is not abandoning the concept of single stock management, but is rather a redefinition of the stock concept based on the timing of migration and spawning and on gene flow between subgroups, which may be important to the survival of pink salmon populations.

Management on the basis of such stock groups necessitates first of all definition of these stocks and three criteria are used in this definitions:

1. geographic location
2. spawning time, or arrival time at the spawning stream
3. migratory route

The second criterion is most difficult to define. It is necessary to differentiate between spawning time and migratory timing. Although the two are by definition closely related, migratory timing can be viewed at several points along the migratory path of the stock and depends on the distance of these locations from the spawning grounds. The stocks will be defined with

respect to time of spawning or arrival. The migratory timing of each stock through any given fishery, however is of primary interest to the manager.

In order to define these stock groups three sources of information were used. First of all stream escapement surveys give information of time of peak escapement to the streams of Southeast. Escapement indices for Southeast are estimated using peak escapement counts (Jones and Dangel 1981). The week of peak escapement count is assumed here to be indicative of the mean time of arrival, but several points need to be noted here. Escapement surveys are carried out through the season for management purposes. The counts can be used to obtain an estimate of the time of maximum escapement and escapement size. They are, however, relative indices and not absolute counts. The stream survey reports published by the Fish and Wildlife Service (Martin 1959; Orell 1963 a, b; Rosier et al. 1965; Parker 1970; Huiser 1970 a, b, c) are a second source of spawning times and comparison of these with the later escapement surveys by the Alaska Department of Fish and Game shows that areas which are considered to be late spawning areas (after Sept. 15) have mean week of peak escapement in the middle range (Aug. 15 - Sept. 15). This may be an artifact since escapement surveys carried out for management purposes may not be continued long enough to observe later peak escapement in late September. The third source of information on time of spawning and migration were tagging reports. Tagging has been carried out in S.E. Alaska since the early part of this century. However, few studies have included stream recoveries and these are used for information on the migratory routes of the different populations and also for estimation, where possible, of time of migration.

It should be noted that as discussed above the fishery can also be influencing the pattern of escapement in some years which may not reflect natural timing.

In order to ascertain whether the stock groups thus defined did include streams with similar spawning times, the escapement counts were summed over streams within a subarea and a weekly escapement calculated and annual week of peak escapement found. These were compared between subareas within a defined group using a Kruskal-Wallis non-parametric analysis of variance (Bickel and Doksum 1977), since the distribution of the data is unknown. The majority of the tests performed were non-significant, but highly significant chi-squares were calculated in certain cases which are listed in Table 7.

A possible explanation for the differences found within a group is that the area in question includes streams with populations that do not fall into the same spawning range. This is certainly true of Chatham Strait where some of the streams are lake-fed and have populations which spawn much later than nearby non lake-fed streams. Clarence Straits and Icy Straits also appear to be areas of mixed populations. In Icy Straits some populations spawn very early especially in outer Icy Straits. Clarence Strait should probably be divided into middle and late spawners.

In Ernest Sound the early spawning group had a significant chi-square in even years. This area includes Anan Creek which is historically a very early run (Elling and Macy 1981). Depending on the strength of this stream the week of peak escapement may vary significantly from year to year.

Tables 8 and 9 show the stock groups as suggested by the above. The tables include location, spawning times and migratory routes as derived from the stream survey reports, data files and tagging reports. There are a total of 11 in the northern section and 12 in the southern.

Northern S.E. Alaska

Northern S.E. Alaska includes the area north of Kuiu and Kupreanof

Table 7. Areas with significant Kruskal-Wallis x^2 test in comparison of week of peak escapement.

		Odd years			Even years		
Area	Name	df	x^2	Sign.	df	x^2	Sign.
106	U. Clarence	46	21.2	0.0001	43	16.9	0.002
107	Ernest S. early			NS	21	11.4	0.001
109	L. Chatham			NS	31	16.4	0.003
112	U. Chatham	98	46.11	0.0001	100	43.7	0.0001
114	Icy Straits	79	29.4	0.002	67	33.4	0.0001

Table 8. Pink salmon stock groups in southern S.E. Alaska.

	Geographical area	Stat. area	Spawning time	Major entry area	Tagging points passed
1	E. Behm Canal	101	Early	Dixon	Noyes Island, Clarence Strait
2	W. Behm "	101	Middle	Dixon	"
3	L. Clarence Str.	101,102	Late	"	"
4	W. Prince of Wales	103	Late	--	Noyes Island
5	Outer Islands	104	Late	--	"
6	Outer Sumner Str.	105	Middle	Sumner	Sumner Strait
7	Inner Sumner Str.	106	Middle/late	"	"
8	Upper Clarence Str.	106	Late	Sumner/Dixon	Sumner Strait, Clarence Str.
9	"	106	Middle	"	"
10	Ernest Sound	107	Early	Sumner/Dixon	"
11	Ernest Sound	107	Middle	"	"
12	Stikine	108	Early/middle	"	"

Table 9. Pink salmon stock groups in northern S.E. Alaska.

	Geographical area	Stat. area	Spawning time*	Entry area	Tagging points passed
1	Mainland--Seymour Canal	110 111	Early	Icy Straits	U. Chatham, Basket Bay Mid-Chatham and Freder. Sound
2	Northern Stephen's--Lynn Canal	111 115	"	Icy Straits	Upper Chatham
3	Kadashan	112	"	"	U. Chatham, Basket Bay
4	Tenakee Inlet	112	"	"	"
5	Peril Strait	113	Early to middle	"	U. Chatham, Basket Bay Mid-Chatham
6	Icy Straits "	114 "	Early Middle	"	Upper Chatham "
7	Chatham	112	Middle	"	U. Chatham, Basket Bay Mid-Chatham
8	Chatham	112	Late	"	"
9	Auke Creek	111	"	"	Upper Chatham
10	Frederick Sound	109 110	Middle	Icy Straits and Lower Chatham	Upper to Lower Chatham Mid-Chatham
	Lower Chatham	109	Middle	Lower Chatham	Lower Chatham

*From Stream Survey Reports, USFWS. Early = before Aug. 15; Middle = Aug. 15 - Sept. 15; Late = after Sept. 15.

Islands. Pink salmon spawn throughout the area, most streams being in the inside areas. The populations migrate in through two entry areas, Icy Straits and Lower Chatham Straits, but the weight of the migration appears to be through Icy Straits. These populations range from early mainland streams to late streams in area 112. Thus the migration starts early in Icy Straits and fisheries management in Icy and Chatham Straits is faced with a very difficult mixed stock problem.

In tagging studies in 1950 Elling and Macy (1955) tagged at two Icy Strait locations and two in Upper Chatham. Verhoeven (1952) in 1948 tagged at several locations in Icy and Chatham Straits, and over the period 1977-1980 ADF&G carried out tagging in Upper and Lower Chatham Straits, and Frederick Sound.

The populations are divided here into 11 groups, 10 of which pass through Icy Strait.

Mainland-Seymour Canal (110, 111)

The streams found in this area, the largest in northern S.E. Alaska, are all colder early spawning streams and include streams from 110 and 111. These populations migrate into Southeast through Icy Straits and Chatham Straits. Tagging in 1977 and 1978 showed they move through Upper Chatham Straits in late June and early July, and appeared to move along the eastern shore. Elling and Macy (1955) in their Icy Strait tagging, however, found no difference between sides of the Strait in subsequent recoveries.

Northern Stephen's Passage - Lynn Canal and Taku-Snettisham (111, 115)

Pink salmon destined for the northern part of area 111, except Auke Creek and 115, also have early spawning times and move through Icy Straits in late

June to early July, but migrate north in Chatham Straits into Lynn Canal and south again.

Tenakee Inlet and Kadashan (112)

This district in area 112 includes early spawning populations, and these migrate through Icy Strait and into Upper Chatham. One stream system, Kadashan, was found to have a population that migrated earlier than the rest of the streams in late June and early July (Hoffman 1982b, Elling and Macy 1951, Verhoeven 1952). The remainder of the Tenakee Inlet streams migrated through Chatham Straits in July. Therefore Kadashan should perhaps be considered a separate stock group.

Peril Strait (113)

Pink salmon spawning in Peril Strait streams, area 113, have been found in several tagging experiments to enter Southeast through Icy Straits, with little movement occurring from Salisbury Sound on the outer coast of Chichagof and Baranof Islands (Nakatani et al. 1975). Peak observed escapements occur in the early to middle spawning range (August 6-August 25). In Peril Strait pink salmon were found to migrate through Upper Chatham Strait in July (Hoffman 1982b, Elling and Macy 1955).

Icy Straits (114)

Pink salmon populations in Icy Strait streams spawn in the early and middle time range. Only eastern populations were recovered in the tagging studies in 1977-1980 and these were in Upper Chatham during late July and early August. In 1951 majority of recoveries were of fish tagged in early August, however, tagging was not carried out in July (Elling and Macy 1955).

Chatham Straits (112)

Streams in the region of Upper and Mid Chatham Straits have populations spawning either in middle range or late range. Those with late spawning populations are lake-fed streams and therefore have warmer temperature regimes. The middle spawning populations migrate through Upper Chatham in late July and early August and the late spawners in August.

Frederick Sound (109, 110)

These populations are classified as middle spawners and were found to migrate chiefly by Icy Straits in late July and early August (Hoffman 1982 and Elling and Macy 1955). Some of these populations do however appear to come in through Lower Chatham.

Lower Chatham Straits (109)

Pink salmon in this area spawn in late August to mid September, in the middle range. They appear to migrate into southeast through Lower Chatham with little movement down from Icy Straits (Hoffman 1982a). Past tagging studies have indicated little movement between Upper and Lower Chatham Straits (Nakatani et al. 1975) and that migration from Lower Chatham appears to be limited to populations destined for streams in southern Frederick Sound.

The above groupings of northern Southeast are somewhat different from that of Larson (1977 and 1978) and Hoffman (1982a), in that these are grouped across management area boundaries. Where populations have similar spawning times, migration paths and can be expected to occur together in the fisheries they should be considered as a group in management.

Southern S.E. Alaska

The southern area has been more productive during recent years. The pink salmon populations enter the inner areas through two major straits and there are also extensive populations on the outer islands off the west coast of Prince of Wales Island as well as on the west coast of Prince of Wales Island itself. Several tagging studies with stream recoveries have been carried out in southern Southeast. Elling and Macy (1981) tagged at two locations in Sumner Strait in 1955, Verhoeven (1952) tagged at several locations in the area of southern Clarence Strait and Dixon Entrance, Noerenberg (1959) tagged in the Noyes Island area and most recently Alaska Department of Fish and Game has started a series of tagging experiments (Hoffman 1982b).

A major drawback of the earlier studies was that tagging did not start until late July or early August, and good information on the migratory paths and timing of the southern populations can only be expected to be available when the present studies are completed. The region has been divided into 10 stock groups here based on stream survey reports and tagging done so far.

East Behm Canal (101)

This area on the mainland of Southeast Alaska is an early spawning area. Tagging studies by Elling and Macy (1981) and Hoffman (1982b) indicate that these populations migrate in from the south. Verhoeven (1952) and Hoffman (1982b) found they were in the Clarence Strait area in July. Peak escapement for the area is in mid-August.

West Behm Canal (101)

These streams spawn later than in east Behm Canal and peak escapement is observed around late August. Verhoeven (1952) found they passed through lower

Clarence Strait in August.

Lower Clarence Strait (101, 102)

The populations are classified as late spawning, although peak escapements are observed in late August and early September. This may be due to the cut-off point of stream survey, or the populations may arrive some time before their spawning.

Noerenberg (1959) found in his tagging study in the Noyes Island area that late July and early August taggings were recovered on the mainland of southern Southeast while those tagged in mid-August were recovered in Lower Clarence streams. During these periods he suggested that the pink salmon were migrating south along the outer coast before turning north into Dixon Entrance.

West Coast or Prince of Wales Island (103) and outer islands (104)

These populations are all late spawning. Although fish tagged in inner areas of southern Southeast have been recovered in these areas, it was only in small numbers, and the migration route appears to be to enter from the outer coastal area or up through Cordova Bay.

Noerenberg (1959) found that stream recoveries in these areas were tagged in the Noyes Island area in late August, when few of the fish tagged were recovered in any inner areas.

Sumner Strait (105, 106)

This is the second major migratory path of the inland stream populations. Local stream spawning occurs in mid to late August. Elling and Macy (1981) found a difference in migratory paths between the inside populations which

were mostly tagged at the eastern site, Pt. Baker, while the local Sumner Strait populations migrated past the western site, Pt. Amelius, in August. Some inner Sumner Strait populations are classified as late spawners in stream survey records.

Upper Clarence Strait (106)

These are middle range populations, with peak escapement in late August. Elling and Macy (1981) found recoveries in this area were largely from fish migrating along the eastern side of Sumner Strait. Few of these populations appear to use Dixon entrance as an entry area according to tagging by Verhoeven (1952) and Hoffman (1982b).

Ernest Sound (107)

This area includes early and middle spawners. The early spawning streams are mainly in Upper Ernest Sound and Bradfield Canal. Elling and Macy (1981) concluded that migrations to these areas was largely completed by August 12. Peak escapement is observed to be in early August. The populations in Lower Ernest Sound reach peak escapement later and migrate through Sumner Strait in August in 1951 (Elling and Macy 1981).

Stikine Area (108)

Peak escapement for pink salmon is observed to be in mid-August. Tagging information is insufficient for determining migration paths. In this group and to some extent in Ernest Sound and Upper Clarence some migration may occur through Lower Clarence and Dixon Entrance and from Icy Straits in northern Southeast (Hoffman 1982a).

Use of Migratory Timing

The success of the pre-season forecasts has been variable (Table 10) in S.E. Alaska, and considering the complexity and size of the area involved this is not surprising. In order to achieve greater accuracy in harvest control, in-season observations of the buildup of the run are needed. In S.E. Alaska this is basically after-the-fact, i.e. escapement surveys are used as indicators of run strength. However, as discussed above, this can lead to unequal exploitation between populations or within a population. In-season indicators that would provide information on run strength and time distribution at an earlier stage, i.e. before the fish enter the major fishing areas, is one way by which to distribute fishing pressure more evenly on all run segments by allowing harvest to commence earlier in the run.

In-season management based on migratory time distributions has been used in Bristol Bay sockeye fisheries (Mundy and Mathisen 1979; Brannian 1982) and in Yukon chinook fisheries (Mundy 1981) with some measure of success. Use of these time densities involves either the use of an empirical historical average (Brannian 1982; Walters and Buckingham 1961) or fitting functions to the historical data (Vaughan 1952; Mundy 1979).

In Southeast Alaska escapement is estimated by surveys of index streams and cannot provide data for daily or even weekly total return estimates in season, and catch or catch per unit of effort (CPUE) are the only available data for estimation of migratory time densities.

During the previous year the trap records from 1914-1950's were used to estimate migratory time curves for several entry areas of S.E. Alaska (Alexandersdottir and Mathisen 1982). The trap fishery supplied excellent data for this purpose as the traps were located on major migratory routes and they are a passive, non-selective gear. The daily catches were assumed to be

Table 10. Forecast and return of S.E. Alaska pink salmon.(source: ADF&G Inform. Leaflets).

	South			North		
Year	Forecast	Return	Prop. diff.	Forecast	Return	Prop. diff.
1967	4.8	2.2	1.18	4.9	4.6	0.06
68	21.5	20.6	0.04	6.2	12.6	-0.51
69	3.1	3.2	-0.03	4.2	5.8	0.28
70	18.7	9.7	0.93	9	7.6	0.18
71	4.3	11.3	-0.62	8.5	5.5	0.54
72	13.7	13.1	0.05	12.9	5.7	1.26
73	14.1	7.4	0.90	6.0	3.9	0.54
74	6.8	7.0	-0.03	9.3	2.0	3.65
75	2.0	7.5	-0.73	4.6	2.1	0.12
76	4.1	9.5	-0.57	1.8	0.9	1.00
77	12.0	16.7	-0.28	2.9	6.1	-0.52
78	22.1	22.6	-0.02	5	4.9	0.02
79	15.4	10.4	0.48	9.2	8.7	0.06
80	9.5	19.5	-0.61	4.5	3.7	0.22
81	14.6	18.6	-0.21	6.8	8.3	-0.18
82	27.8	16.7	0.66	7.6	13.8	-0.45
Average			0.46			0.60

*Source: ADF&G Inform. Leaflets.

representative of the abundance of fish migrating past any trap location. Catch distributions from outer traps estimated migratory time distributions prior to exploitation.

Today the fishery is mainly a purse seine fishery, with gillnets and trollers making smaller contributions to the pink salmon catch (Table 11). However, the seine fishery is subject to irregular openings and closures and the catch data cannot be used for estimation of runtiming with the possible exception of area 104 which has been fished more consistently over the years. The gillnet and troll fisheries offer the best source of data for this purpose.

The gillnet fisheries are all located in terminal areas and may give a picture of timing into the area of the spawning grounds. The troll fisheries historically have not exploited pink salmon, but this has changed in latter years. Troll catches in outer areas offer a source for preliminary estimation of the migratory time distribution. This can be improved upon by use of test fisheries in the entry areas for more formal estimation of CPUE indices.

As the catch distributions in the outer areas of interest are the sums of the arrival patterns of several populations, their use for in-season management requires an understanding of the contributing populations. In any one year the shape, location (mean) and duration (variance) of the migratory curve will depend on the relative strengths of the returning populations, as well as on any other factors, e.g. environmental, which may influence time of migration.

Appendix 1 shows migratory time distributions as represented by catch per boat day in the troll fisheries in outer areas. As these are least affected by management decisions (except for area 114, Icy Straits) the variations observed are assumed to be due to other factors.

Table 11. Pink salmon catches in SE Alaska 1960-1982 by gear. (Yakutat excluded).

	Traps	Gillnet	Troll	Seine	Total
60	156.4	76.7	25.5	2,726.3	2,985.0
61	932.3	428.4	19.3	1,123.7	12,637.5
62	620.1	535.7	75.1	1,035.4	11,585.2
63	86.8	734.8	106.9	18,216.7	19,145.3
64	351.5	794.6	124.6	17,310.8	18,581.5
65	33.6	703.6	81.1	10,061.6	10,879.9
66	576.0	880.8	63.6	18.917.7	20,438.2
67	6.9	239.2	57.4	2,807.8	3,111.2
68	242.0	617.3	126.3	24,099.8	25,085.4
69	29.2	444.2	83.5	4,312.9	4,869.9
70	101.9	848.2	69.8	9,629.1	10,649.0
71	-	629.7	100.7	8,505.8	9,236.2
72	178.4	300.0	162.5	11,370.8	12,011.7
73	41.7	652.3	119.5	5,609.5	6,423.0
74	109.1	337.7	255.6	4,174.0	4,876.4
75	108.2	350.5	75.4	3,411.0	3,945.1
76	435.8	384.0	186.9	4,437.3	5,444.0
77	293.5	1,500.5	261.6	8,932.3	10,987.9
78	702.2	847.0	603.0	19,045.9	20,655.1
79*		934.1	480.5	9,038.0	10,452.6
80*		1,215.2	173.3	12,134.9	13,703.4
81*		1,333.7	484.6	16,577.9	18,396.2
82**	404.5	511.2	359.0	15,862.6	17,128.3

* trap catch excluded.

** 1982 figures preliminary and as of August 31, 1982.

Sources: INPFC Statistical Yearbooks 1960-1978
ADF&G Catch Files

The next step in the development of a model of migratory distribution is to assess these factors and their relative importance. These include the effect of environmental variables, e.g., temperature, of changes in relative stock strength between years, and of variation in effort over the years. Separate models of migratory time distribution need to be developed for each entry area. The objective of developing such a model is to use CPUE (e.g., catch per boat day) in outer area fisheries to indicate incoming run strength and the run's distribution over time relative to stock strength. The frame of the model is provided by a computer data base system and programs which provide access to the historical data base by species, gear, subarea and time period (Alexandersdottir 1982). In season catch and effort data entry will be possible. The data base includes catch, boats and fishing time. Estimates of lag times between areas and estimated percent contribution by fishery to various escapement groups will also be included.

The catch distribution data base system will provide the user, once completed, with similar tables and plots of catch, CPUE and/or effort by year or areas requested, in numbers or percentages. The capability to distribute catches to various stock groups if information is available on relative stock strengths will also be available. The feasibility of this approach is illustrated by an example.

Case Study - Icy Straits (114)

Icy Straits serves as the entry point to population groups throughout most of northern Southeast. Pink salmon appear in the troll fisheries as early as late June. The run entering divides into two groups, one entering Lynn Canal destined for Stephen's Passage and the Taku River. The second enters Chatham Strait. Tagging (Hoffman 1982a) indicates that the earliest

fish (late June - mid July) are enroute to mainland streams in districts 110, 111 and Seymour Canal, Kadashan Creek in Tenakee Inlet and Icy Strait streams. Late July fish are headed for area 111, Chatham Straits and areas 109 and 108. Later arrivals are pink salmon from mid Chatham and Auke Creek near Juneau.

The two troll fisheries have had similar trends over the season in CPUE (Figure 5).

CPUE as an Indicator of Abundance

A major part of northern populations enter through Icy Straits. The troll fishery CPUE may then be an indicator of total abundance into the region.

Total abundance can only be estimated as the sum of catch and estimated escapement. This is plotted against CPUE in area 114 in Figure 6 and the relation has a linear trend. A timely source of CPUE may well provide an early indicator of run strength into Icy Strait.

Population Distribution

Figure 5 shows the weekly percent CPUE in troll fisheries in 114. In some years these distributions are bi- or even trimodal, others unimodal. The question then is whether these various distributions can indicate differential stock strength, a difficult question as stock separation by means other than past tagging has been unsuccessful thus far. The relative abundance of stocks in a fishery will change each year as stocks trends (early, middle or late) may differ. Tagging studies have provided information on the timing of stocks. Pre-season forecasts provide some information on expected relative strength, which might be used to estimate an expected percentage contribution over time of the stocks.

Lagtimes

Nakatani et al. (1975) estimated travel rates from trap catches for 1938-

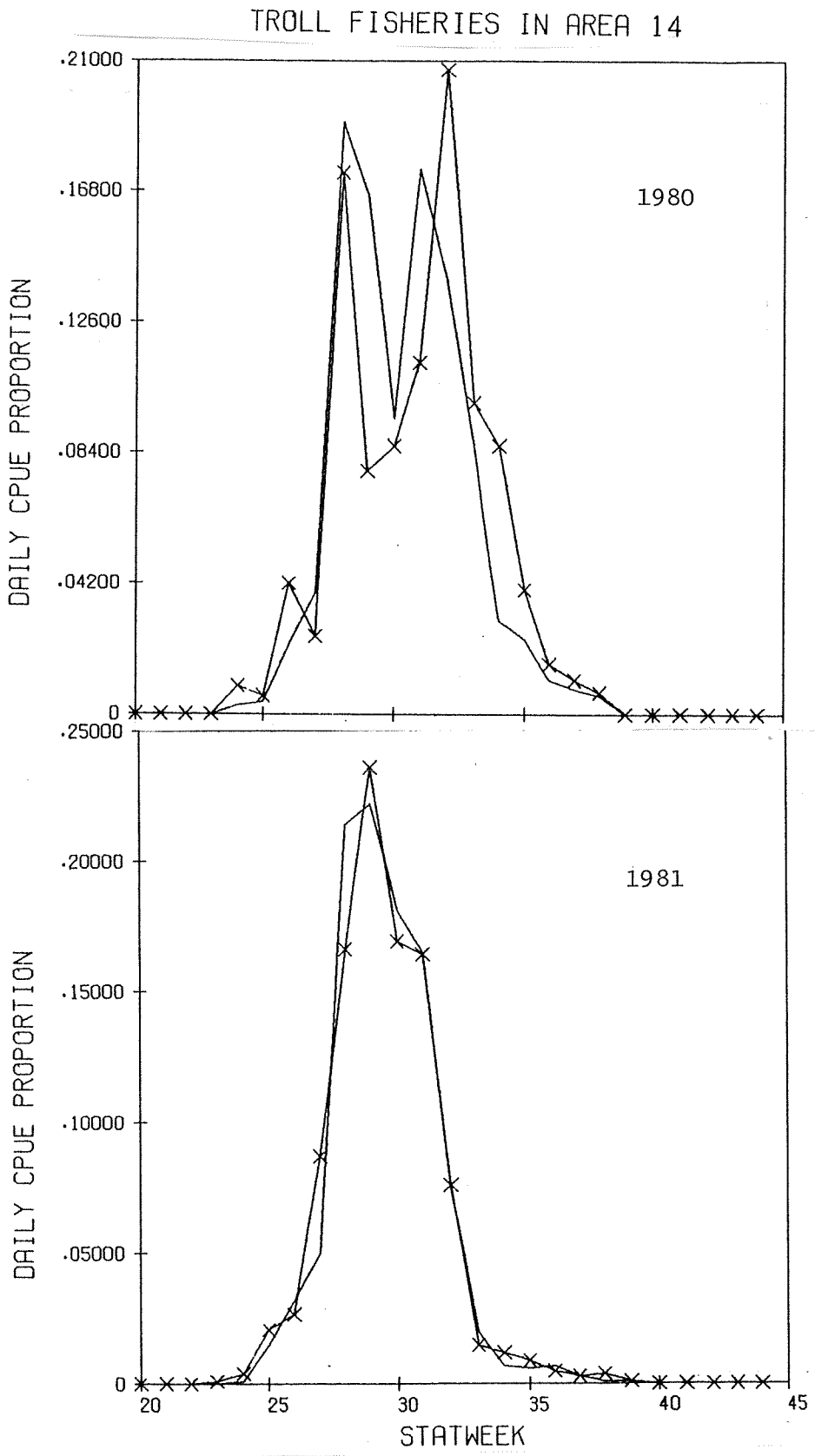


Figure 5. Power and handtroll percent catch per boat day in Icy Straits 1980 and 1981.

_____ power troll

_____x handtroll

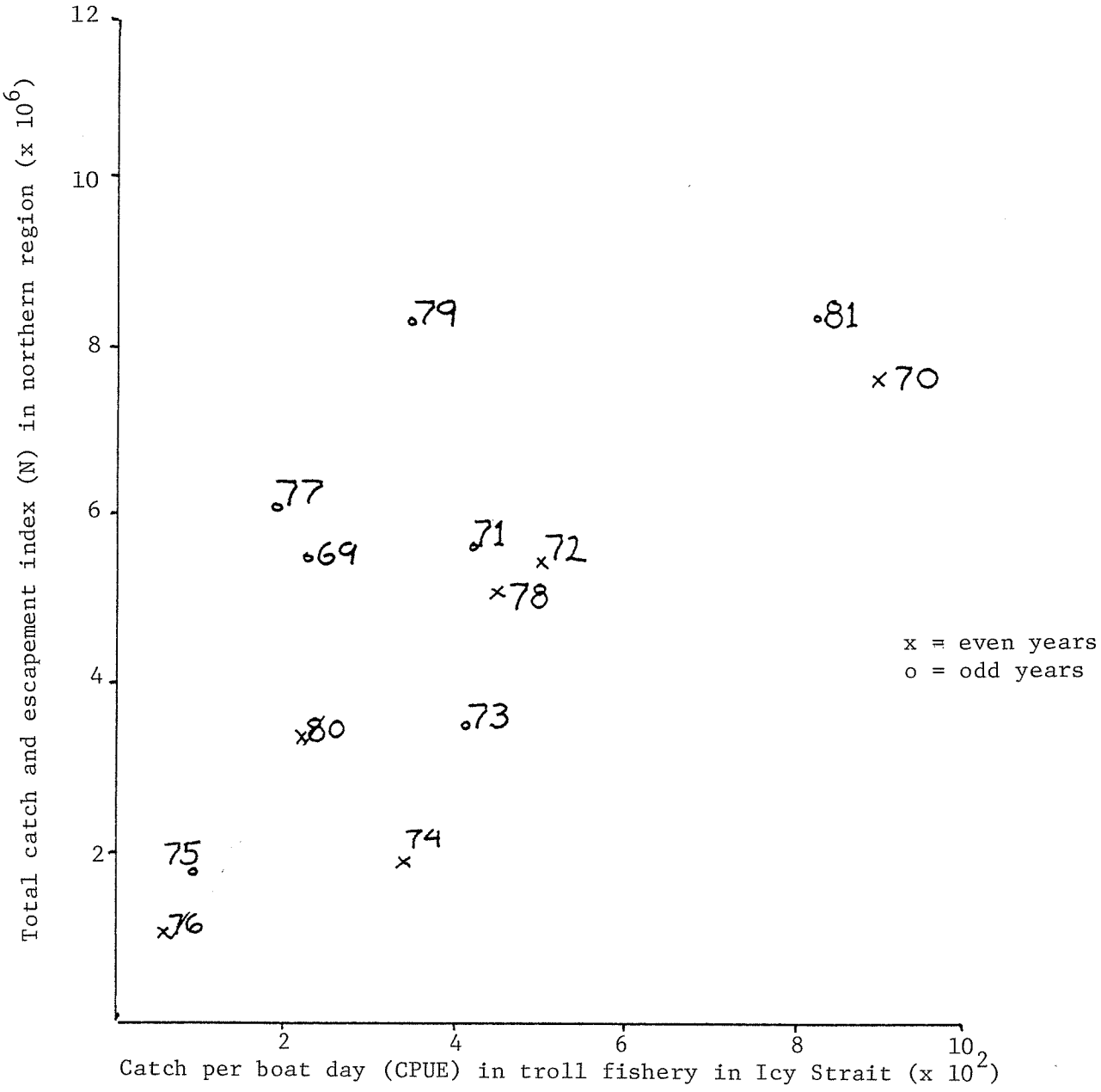


Figure 6. Catch per boat day in Icy Strait troll fishery and total abundance in northern S.E. Alaska.

1942 and found the runs traveled 3-7 miles/day passing from Icy Straits to Chatham in about 1-2 weeks. These estimates were simplified by the use of trap catches at all locations. In the present day fisheries the separate gear types cannot be compared as easily.

Figure 7 shows the CPUE in the 114 troll fishery and 111 gillnet fishery, even years. The lagtimes appear to vary from 10 to 20 days. In 1982 a lagtime of about 14 days was apparent (Figure 7).

These are all preliminary results using the information which will be available through the data base system being developed, and as methods are developed.

CONCLUSIONS

Management in S.E. Alaska presently makes decisions based on the development of catch and escapement by areas with reference to historical performances in the fishery.

A data base system under development will provide the manager with easy and quick access to the historical data base. The data on catch, CPUE effort and even escapement will be available in several formats, e.g., tables or graphs. Thus the manager will be able to consider several different years or combinations of years and plot alternative strategies quickly for aid in management decisions.

The above discussion suggests that time of return is a crucial factor in pink salmon survival and that management must consider time of harvest and escapement as well as number. A harvest spread out more evenly may be a strategy which will, in the long run, be less detrimental to the pink salmon populations. A fishery which is concentrated in time on the pink salmon runs will inevitably exploit some populations more than others, and within

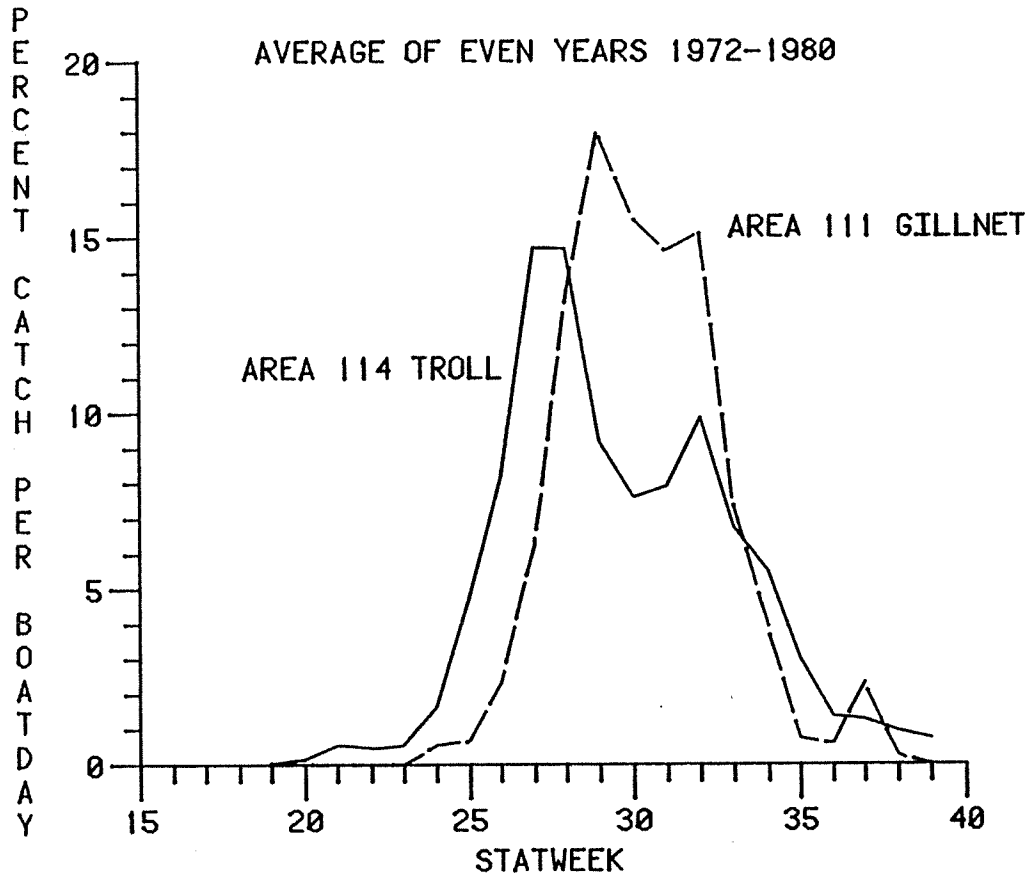


Figure 7. Mean percent CPUE in troll fishery in Icy Strait (114) and gillnet fishery in Taku-Snettisham (111) for 1972-1980, even years.

populations one time segment more than another. This is a problem not unique to S.E. Alaska pink salmon but is present in any salmon fishery which harvests at a point in space or time, through which several populations pass enroute to their spawning grounds. However, if timing is as crucial to progeny and population survival as is suggested, then equal exploitation over time may be a factor as important as actual numbers escaping to spawn.

The data base and program system will hopefully be a tool that can be used in considering such management decisions as it can provide a picture of timing at several points of the migration and into terminal areas.

REFERENCES

Alaska Department of Fish and Game. 1983. Preliminary forecasts and projections for 1983 Alaskan Salmon Fisheries. Inform. leafl. 209, pp. 41.

Alexandersdottir, M. 1982. Runtime model. Alaska Department of Fish and Game Manuscript. Preliminary Report.

Alexandersdottir, M. and O. A. Mathisen. 1982. Changes in S.E. Alaska pink salmon (Oncorhyncus gorbuscha) populations 1914-1960. FRI-UW-8212. pp. 55.

Altukhov, Y. T. and E. A. Salmenkova. 1981. Applications of the stock concept to fish populations in the U.S.S.R. Can. J. of Fish. Aquat. Sci. 38(12):1591-1600.

Aspinwall, N. 1974. Genetic analysis of North American populations of the pink salmon (O. gorbuscha), possible evidence for the neutral mutation random drift hypothesis. Evol. 28:295-305.

Bams, R. A. 1976. Survival and propensity for homing as affected by presence or absence of locally adapted paternal genes in two transplanted populations of pink salmon (O. gorbuscha). J. Fisher. Res. Bd. Can. 33:2716-25.

Bickel, P. J. and K. A. Doksum. 1977. Mathematical statistics. Basic ideas and selected topics. Holden-Day, Inc., San Francisco. pp. 493.

Brannian, L. K. 1982. The estimation of daily escapement and total abundance from catch per unit effort of the sockeye salmon fishery in Togiak Bay, Alaska. Masters Thesis, Univ. Wash., Seattle.

Brannon, E. L. 1967. Genetic control of migrating behavior of newly emerged sockeye salmon fry. Int. Pac. Salm. Fish. Comm. Progr. Rep. 16:1-31.

Cole, L. C. 1954. The population consequences of life history phenomena. Quart. Rev. Biol. 29(2):103-137.

Dahlberg, M. L. 1968. Analysis of the dynamics of sockeye salmon returns to the Chignik Lakes, Alaska. Ph.D. Dissertation, Univ. Wash., Seattle, pp. 337.

Elling, C. H. and P. T. Macy. 1955. Pink salmon tagging experiments in Icy Strait and Upper Chatham Strait, 1950. U.S. Fish Wildl. Serv. Fish. Bull. 56:331-371.

Elling, C. H. and P. T. Macy. 1981. Pink salmon tagging experiments in Sumner Strait, 1951. N.M.F.S., Seattle Manuscript.

Ellis, R. J. 1969. Return and behavior of adults of the first generation of transplanted pink salmon and survival of their progeny, Sashin Creek, Baranof Island, Alaska. USFWS Spec. Sci. Rep. Fisher. No. 589:1-13.

Fredin, R. A., S. Pennoyer, K. R. Middleton, R. S. Roys, S. C. Smedley and A. S. Davis. 1968. Information on recent changes in the salmon fisheries of Alaska and the condition of the stocks. I.N.P.F.C. Doc. 1134, 74 pp.

Gudjonsson, T. 1961. Occurrence of pink salmon (O. gorbuscha) in Iceland in 1960 and 1961. ICES 1961 4 pp.

Hart, J. L. 1973. Pacific fishes of Canada. Fish. Res. Bd. Canada Bull. 180. pp. 740.

Hartl, P. L. 1980. Principles of population genetics. Sinauer Assoc. Inc., pp. 488.

Hartman, W. L. and R. F. Raleigh. 1964. Tributary homing of sockeye salmon at Brooks and Karluk Lakes. J. Fish. Res. Bd. Can. 21:485-504.

Heard, W. R. 1978. Probable case of streambed overseeding - 1967 pink salmon, O. gorbuscha, spawners and survival of their progeny in Sashin Creek, Southeast Alaska. Fisher. Bull. 76(13):569-582.

Helle, J. R., R. S. Williamson and J. E. Bailey. 1964. Intertidal ecology and life history of pink salmon at Olsen Creek, Prince William Sound, Alaska. U.S. Fish Wildl. Spec. Sci. Rep. Fish. No. 483:1-26.

Hoar, W. S. 1976. Smolt transformation:evolution, behavior and physiology. J. Fish. Res. Bd. Can. 33:1234-1252.

Hoffman, S. H. 1980. Northern Southeastern pink salmon tagging investigations 1979. Southeast Alaska Stock Separation Res. Proj. Ann. Rep. 1979. ADF&G Comm. Fish. Ketchikan, AK. pp. 54.

Hoffman, S. H. 1981. Northern Southeastern pink salmon tagging investigations 1980. Southeast Alaska Stock Separation Res. Proj. Ann. Rep. 1980. ADF&G Comm. Fish. Ketchikan, AK. pp. 74.

Hoffman, S. H. 1982a. Southern Southeast Alaska pink salmon tagging investigations, 1981. Southeast Alaska Stock Separ. Res. Proj. Ann. Rep. 1982 ADF&G Comm. Fish, Ketchikan, AK. pp. 91.

Hoffman, S. H. 1982b. Northern Southeastern Alaska pink salmon (Oncorhynchus gorbuscha) tagging investigations, 1977-1980. ADF&G Inform. Leafl. 196:1-55.

Huiser, E. J., T. H. Richardson, N. Johnston. 1970. Stream catalog of Southeastern Alaska regulatory districts nos. 10 and 11. U.S.F.W Serv. Data Rep. 44, pp. 207.

Huiser, E. J. and T. H. Richardson. 1970. Stream catalog of Southeastern Alaska regulatory districts nos. 14 and 15. U.S.F.W. Serv. Data Rep. 45, pp. 208.

Huiser, E. J., T. Richardson, E. C. Larson. 1970. Stream catalog of Southeastern Alaska Regulatory district no. 12. U.S.F.W. Serv. Data. Rep. 46. pp. 222.

Johnson, N. 1979. Genetic variance in populations of pink salmon O.

gorbuscha from Kodiak Island. Ph.D. Diss. U. Wash., Seattle, pp. 94.

Johnston, N. 1965. Southeastern Alaska stream catalog for regulatory district no. 9. U.S.F.W Serv. Spec. Sci. Rep. 524.

Jones, D. J. and J. Dangel. 1981. Southeastern Alaska 1980 brood year pink (Oncorhynchus gorbuscha) and chum (O. keta) escapement surveys and pre-emergent fry program. ADF&G Tech. Data. Rep. 66.

Jones, D. J. and G. Thomason. 1981. Forecasts of pink salmon returns use environmental data and fry length. Coast. Oceanogr. Climatol. News 4(1):5-6.

Larkin, P. A. 1972. The stock concept and management of Pacific salmon p:11-15 In R. C. Simon and P. A. Larkin (eds.) The Stock Concept in Pacific Salmon H.R. MacMillan Lect. Fisher. U.B.C, Vancouver.

Larson, P. 1978. Northern Southeastern pink salmon tagging investigations 1977. Southeast Alaska Stock Separation Research Project Ann. Rep. 1978. ADF&G Comm. Fish. Juneau, AK. pp. 46.

Larson, P. 1979. Northern Southeastern pink salmon tagging investigations 1978. Southeast Alaska Stock Separation Research Project Ann. Rep. 1977. ADF&G Comm. Fish. Juneau, AK. pp. 40.

Martin, J. W. 1959. Stream catalog of eastern section of Ketchikan Management district of Southeastern Alaska. U.S.F.W. Serv. Spec. Sci. Rep. Fisher. 305.

Martin, J. W. 1966. Early sea life of pink salmon. Proc. 1966 N.E. Pacific Pink Salmon Workshop. Alaska Dept. Fish. Game Inform Leafl. 87, pp. 168.

McGregor, A. J. 1982. A biochemical genetic analysis of pink salmon (Oncorynchus gorbuscha), from selected streams in north Southeast Alaska. M.S. Thesis, Univ. Alaska, Juneau. pp. 94.

McNeil, W. J. 1966. Distribution of spawning pink salmon in Sashin Creek, S.E. Alaska and survival of their progeny. U.S.F.W. Serv. Spec. Sci. Rep. Fisher. No. 538:1-12.

Merrell, T. R. 1962. Freshwater survival of pink salmon at Sashin Creek, Alaska. In: N. J. Wilimovsky (ed.) Symposium on pink salmon. H. R. MacMillan Lect. Fish., Inst. Fish. U.B.C., Vancouver: 59-79.

Miller, R. J. and E. L. Brannon. 1982. The origin and development of life history patterns in Pacific salmonids. In: Proc. Salmon Trout Migr. Behav. Symp. eds. Brannon, E. L. and E. O. Salo, School of Fish., U.W., Seattle, WA. 296-309.

Mundy, P. R. 1979. A quantitative measure of migratory timing illustrated by application to the management of commercial salmon fisheries. Ph.D. Diss. U. Wash., Seattle, pp. 86.

Mundy, P. R. 1982. Computation of migratory timing statistics for adult chinook salmon in the Yukon River, Alaska, and their relevance to fisheries management. N. Amer. J. Fisher. Mgmt. 4:359-370.

Mundy, P. R. and O. A. Mathisen. 1981. Abundance estimation in a feedback control system applied to the management of a commercial salmon fishery. p. 81-98 In: K. B. Haley (ed.) Appl. Operations Res. in Fishing. Prlnum Publ. Corp., New York.

Nakatani, R. E., G. J. Paulik and R. VanCleeve. 1975. Pink salmon Oncorhynchus gorbuscha, tagging experiments in Southeastern Alaska, 1938-42 and 1945. NOAA Techn. Rep. NMFS SSRF-686, pp. 39.

Neave, F. 1953. Principles affecting the size of pink and chum salmon populations in British Columbia. J. Fish. Res. Bd. Canada 9(9):451-491.

Neave, F. 1958. The origin and speciation of Oncorynchus. Trans. Roy. Soc. Can. Ser. III Sec. v52:25-39.

Noerenberg, W. H. 1959. Salmon migrations in Southeastern Alaska. Fish. Wildl. Circ. 59:8-12.

Orrell, R. F. 1963a. Stream catalog of Southeastern Alaska. Regulatory District 2. U.S.F.W. Serv. Spec. Sci. Rep. 453.

Orrell, R. F. 1963b. Stream catalog of Southeastern Alaska. Regulatory Districts 3 & 4. U.S.F.W. Serv. Spec. Sci. Rep. 465.

Paulik, G. J., A. S. Hourston, P. A. Larkin. 1967. Exploitation of multiple stocks by a common fishery. J. Fish. Res. Bd. Can. 24:2527-2537.

Parker, J. W. 1970. Stream catalog of Southeastern Alaska. Regulatory District No. 13. U.S.F.W. Serv. Data Rep. 47, pp. 325.

Ricker, W. E. 1958. Maximum sustained yields from fluctuating environments and mixed stocks. J. Fish. Res. Bd. Can. 15:991-1006.

Ricker, W. E. 1972. Heredity and environmental factors affecting certain salmonid populations. In: Simon, R. and P. A. Larkin (eds.) The stock concept in Pac. Salmon. H. R. MacMillan lect. in Fish. Inst. Animal Resource Ecol. U.B.C., Vancouver: 19-160.

Ricker, W. E. 1982. Changes in the average size and average age of Pacific salmon. Can. J. Fish. Aquat. Sci. 38(12):1636-1656.

Riddell, B. E. and W. C. Leggett. 1981. Evidence of an adaptive basis for geographic variation in body morphology and time of downstream migration of juvenile Atlantic salmon (Salmo salar). Can. J. Fish. Aquat. Sci. 38:308-320.

Rosier, C., N. Johnson, and P. F. Orrell. 1965. Southeastern Alaska stream catalog for regulatory district nos. 5, 6, 7 and 8. U.S.F.W. Serv. Spec. Sci. Rep. Fisher. 523.

Royce, W. F. 1962. Pink salmon fluctuations in Alaska. p. 15-33. In: N. J. Wilimovsky (ed.) Symp. on pink salmon. H. R. MacMillan Lect. Fish.,

Inst. Fish. U.B.C.

Schaffer, W. M. and P. F. Elson. 1975. The adaptive significance of variation in life history among local populations of Atlantic salmon in North America. Ecology 56:577-590.

Sheridan, W. E. 1962. Relation of stream temperature to timing of pink salmon escapement in Southeast Alaska. pp. 87-102 in: N. J. Wilimovsky (ed.) Symposium on pink salmon. H. R. MacMillan Lect. Fish., Inst. Fisher. U.B.C., Vancouver.

Simon, R. C. 1963. Chromosome morphology and species evolution in the five North American species of Pacific salmon (Oncorynchus). J. Morphol. 112:77-97.

Takagi, K., K. V. Aro, A. C. Hartt and M. B. Dell. 1981. Distribution and origin of pink salmon (O. gorbuscha) in offshore waters of the North Pacific Ocean. I.N.P.F.C. Bull. 40:1-194.

Taylor, S. G. 1980. Marine survival of pink salmon fry from early and late spawners. Trans. Amer. Fish. Soc. 109:79-82.

Thorpe, J. E. 1982. Migration in salmonids, with special reference to juvenile movements in freshwater p. 86-97. In: E. L. Brannon, and E. O. Salo Proc. Salm. Trout Migrat. Behav. Symp. School Fisher., U. Wash. pp. 309.

Todd, I. and P. A. Larkin. 1971. Gillnet selectivity on sockeye (Oncorhynchus nerka) and pink salmon (O. gorbuscha) of the Skeena River system, B. C. J. Fish. Res. Bd. Can. 28:821-842.

Utter, F. M., D. C. Campton, S. Grant, G. Milner, J. Seeb and L. Wishard. 1979. Population structures of indigenous salmonid species of the Pacific Northwest p. 285-302. In: Proc. Symp. Salm. Ecosyst. Nth. Pac., Newport, Oregon.

Vaughan, E. 1954. The use of catch statistics for estimating parameters of the pink salmon migration pattern in Icy Strait. In Science in Alaska 1952. A.A.A.S. Alaskan Div. Anch., Alaska.

Verhoeven, L. A. 1952. A report to the salmon fishing industry of Alaska on the results of the 1947 tagging experiments. Fish. Res. Inst., Univ. Wash., Seattle. Manuscript 22 pp.

Vernon, E. H. 1962. Pink salmon populations of the Fraser River system. pp. 53-58. In: N. J. Wilimovsky (ed.) Symposium on pink salmon. H. R. McMillan Lect. Fish., Inst. Fisher. U.B.C., Vancouver.

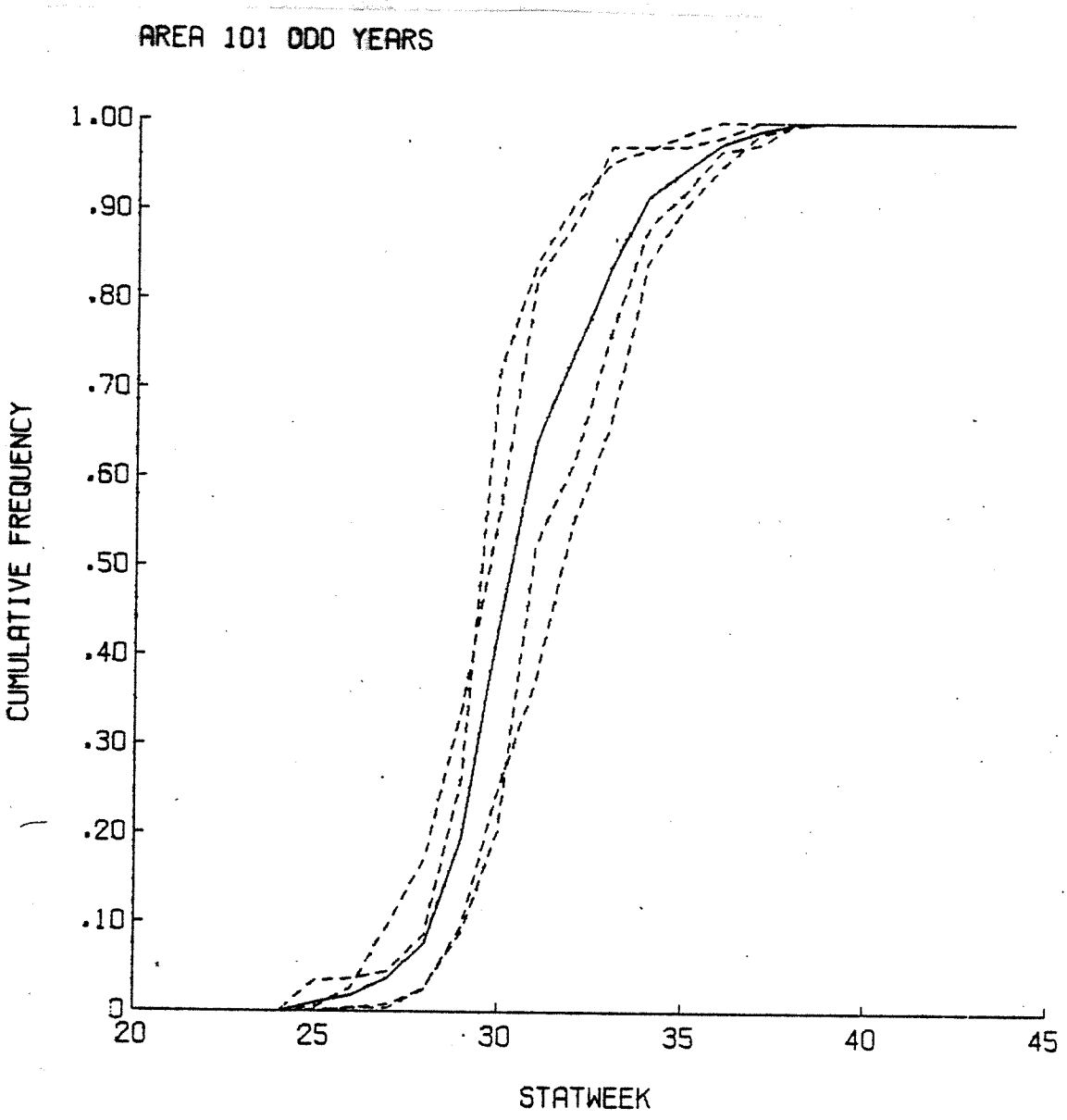
Wagner, W. C. and T. M. Stauffer. 1982. Distribution and abundance of pink salmon in Michigan tributaries of the Great Lakes 1967-1980. Trans. Amer. Fish. Soc. 111:523-526.

Walters, C. J. and S. J. Buckingham. 1975. A control system for intra-season salmon management. Int. Inst. Appl. Syst. Anal. Schloso Laxenburg, 2361 Laxenburg, Austria.

Ward, F. J. 1958. Characteristics of the migration of pink salmon to the Fraser River spawning grounds in 1957. I.P.S.F.C. Bull. 10:1-70.

Appendix 1. Figures. Cumulative proportions of catch per boat day in troll fisheries in areas 101-114, S.E. Alaska, for odd and even years, 1963-1981.

_____ mean cumulative proportions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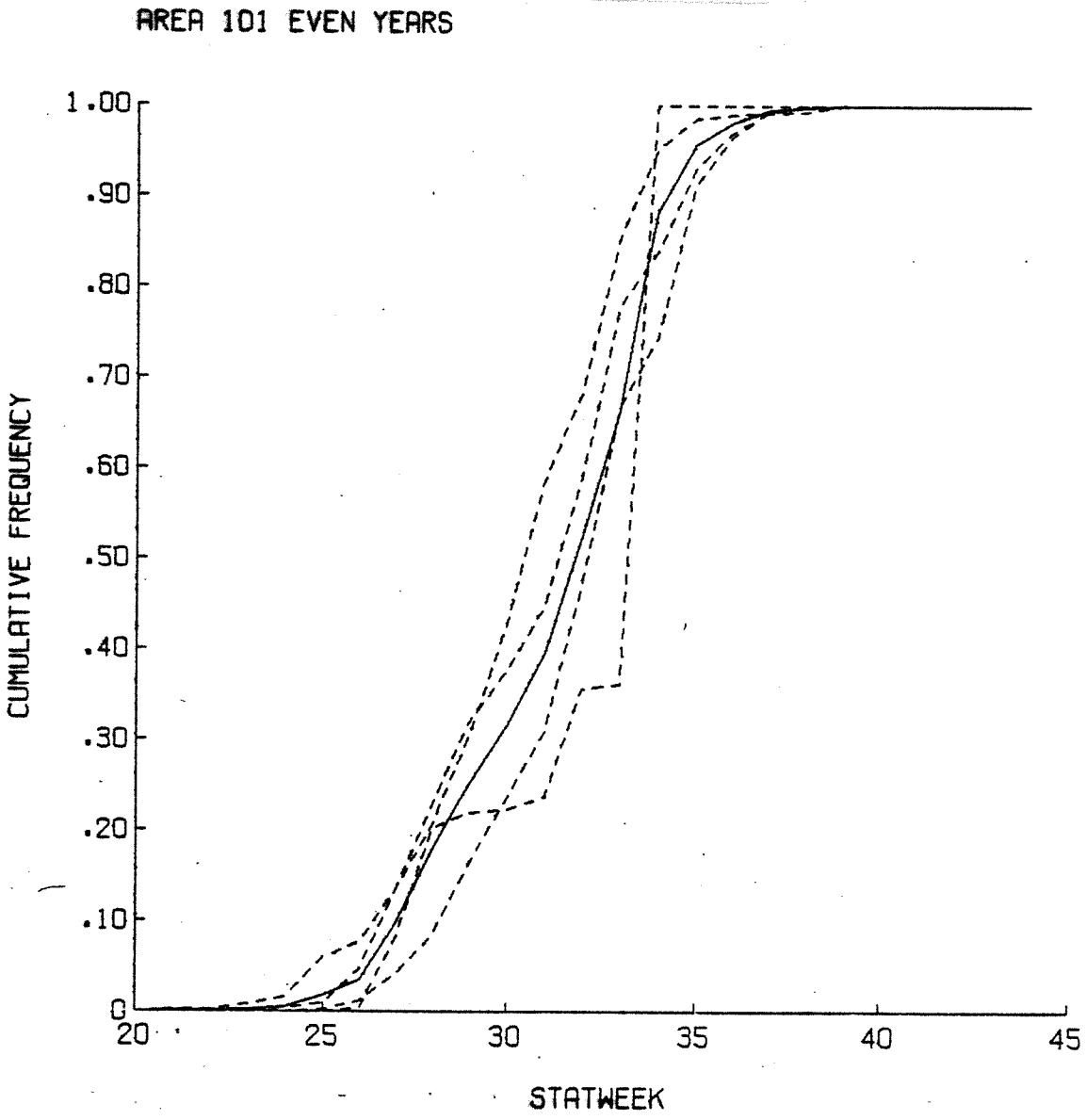
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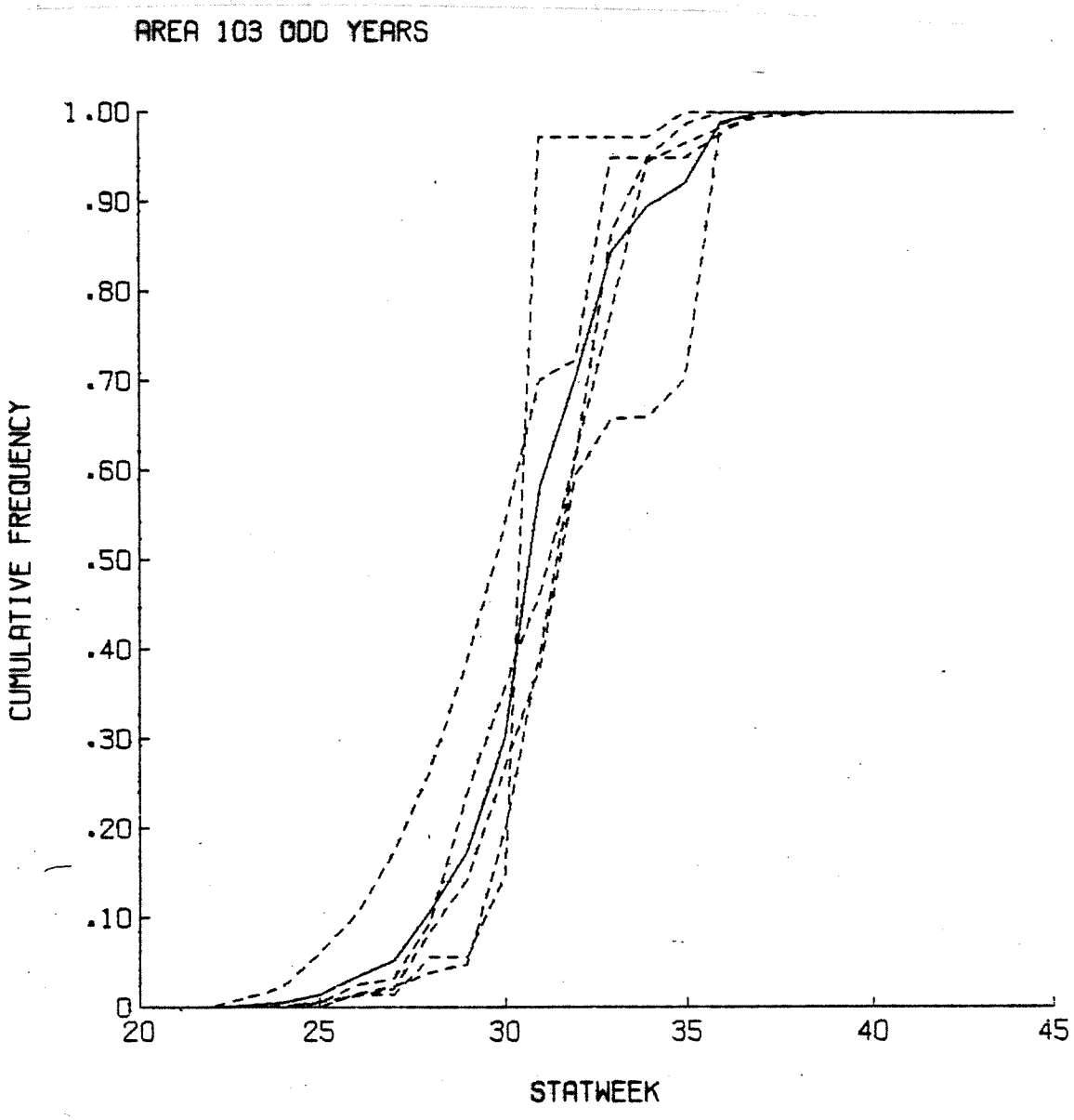
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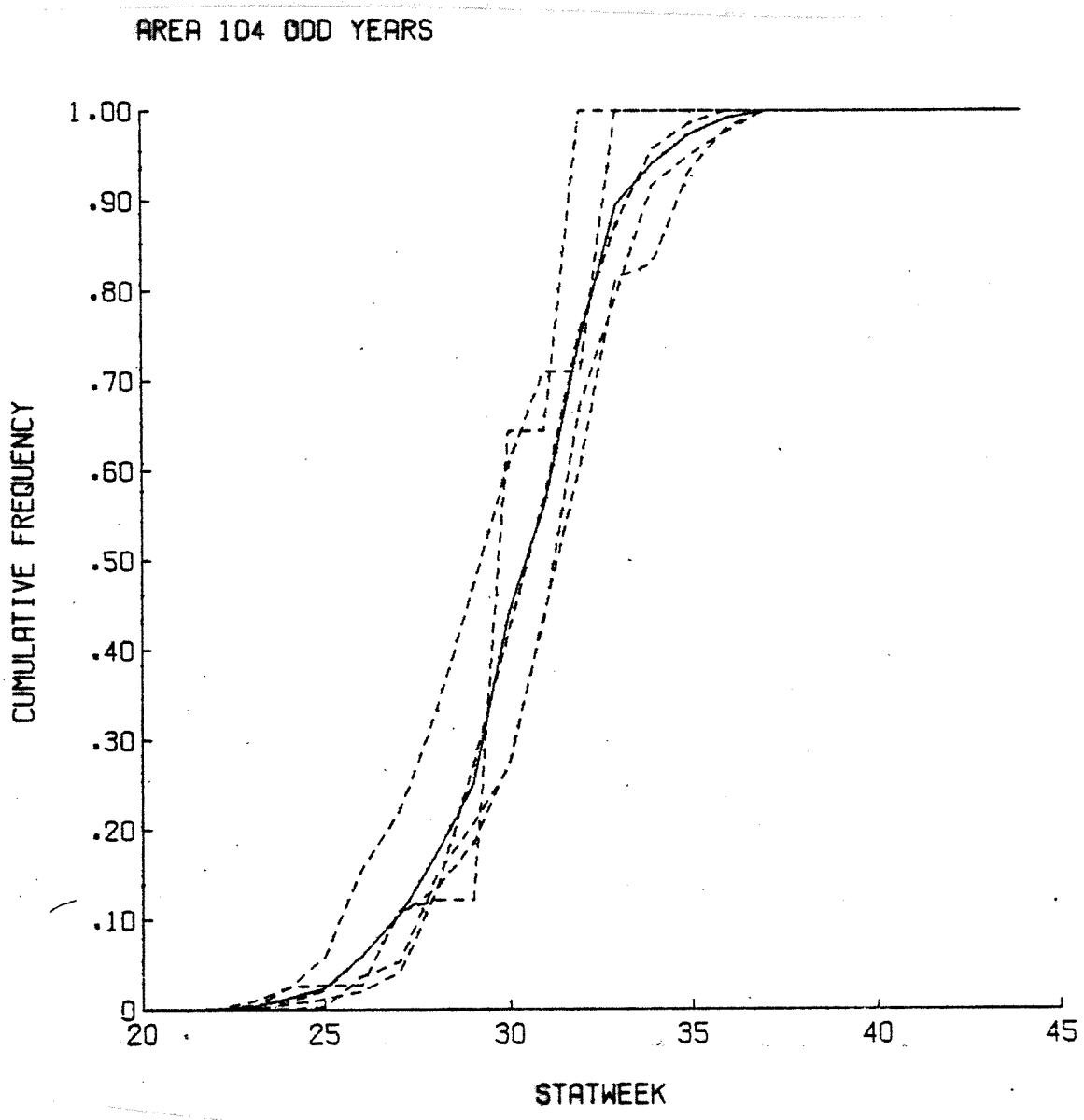
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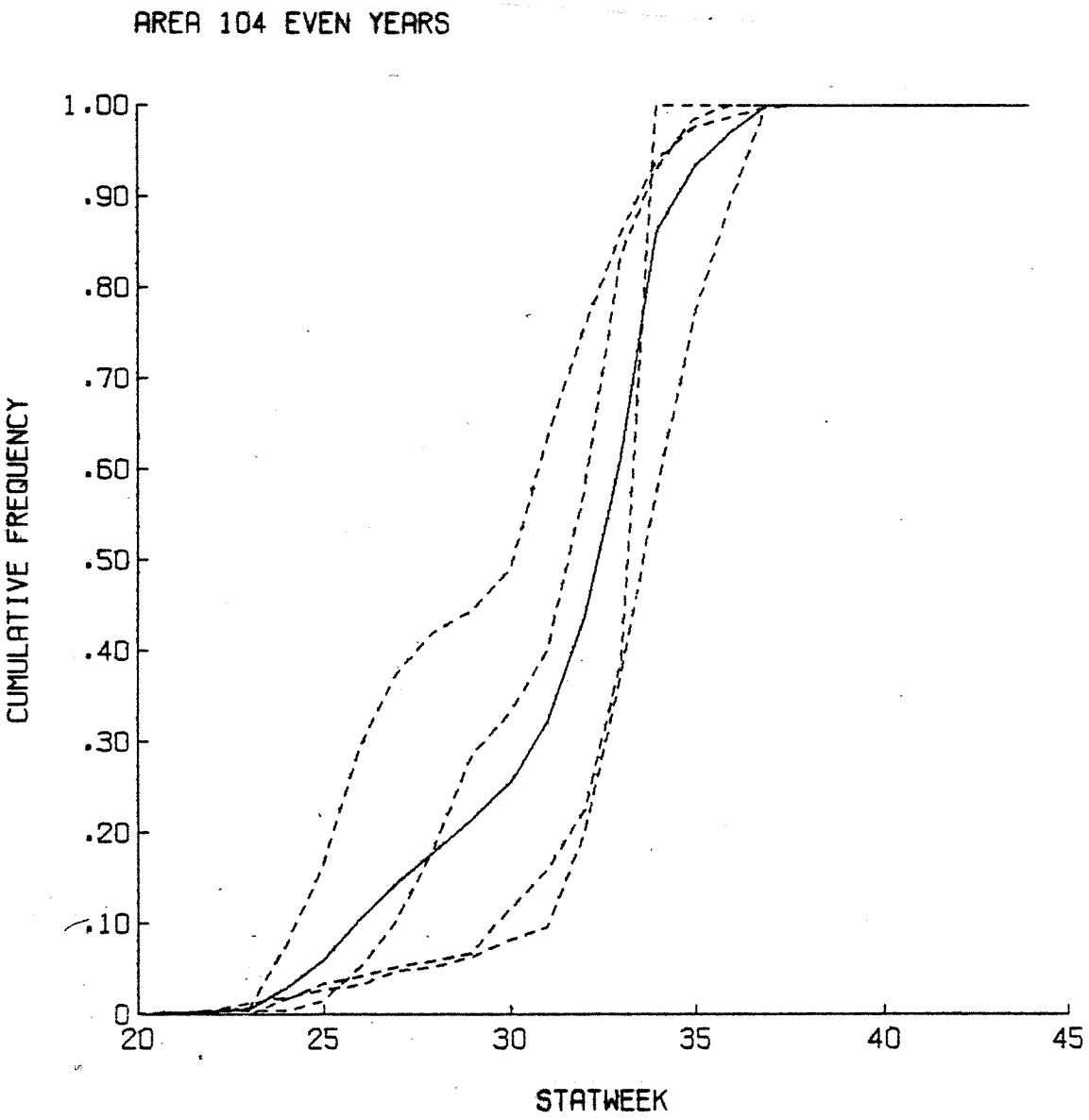
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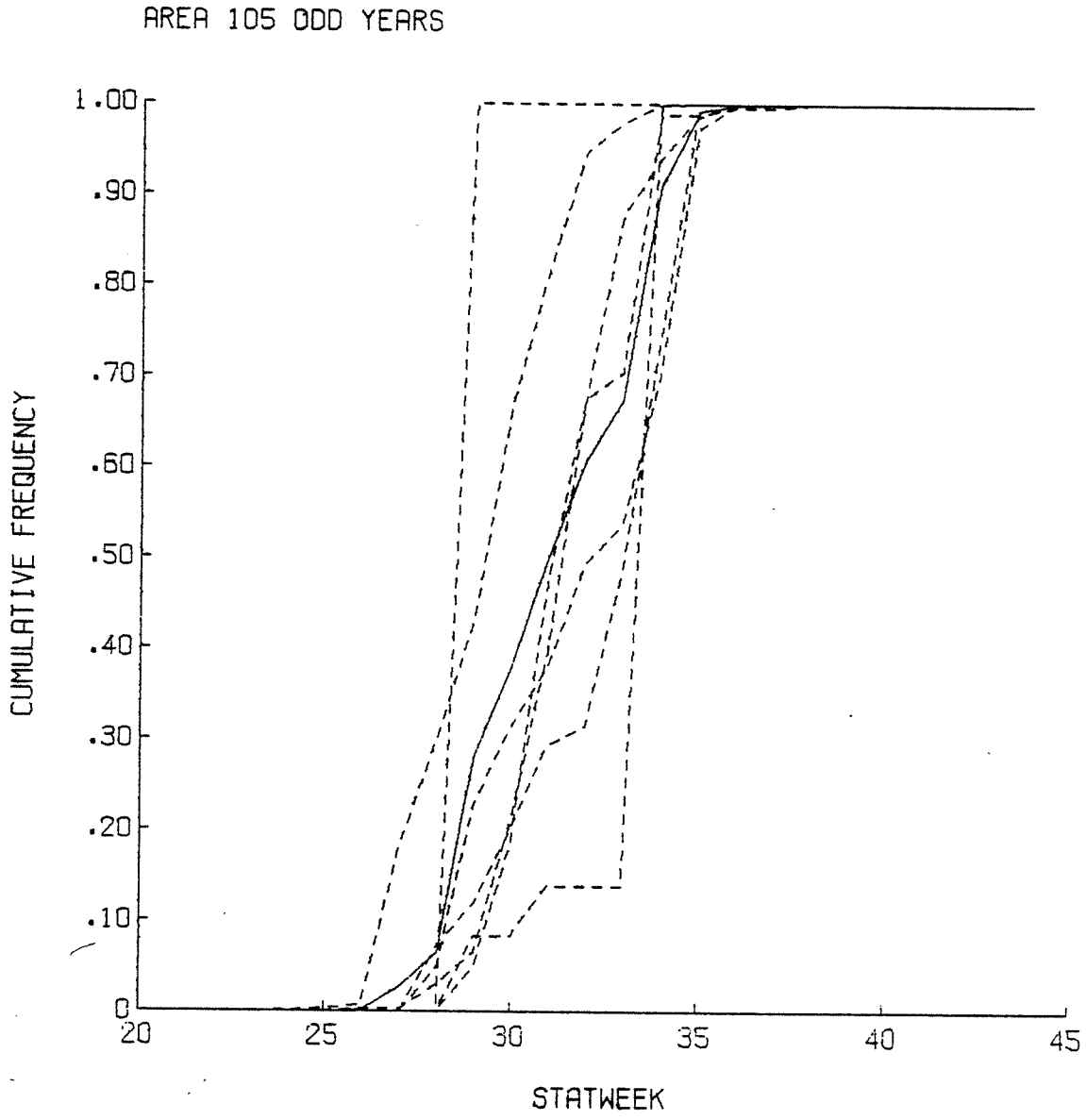
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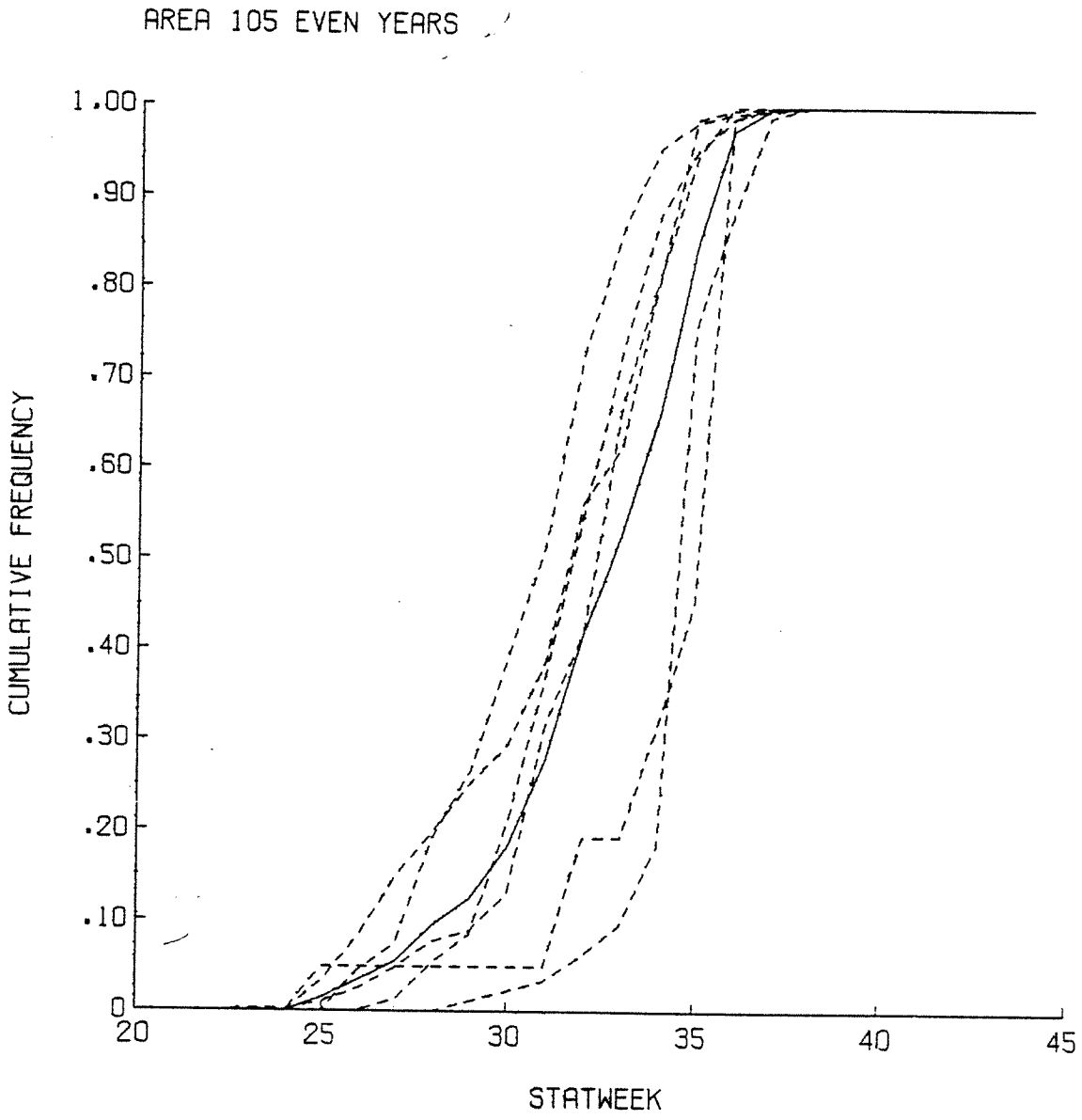
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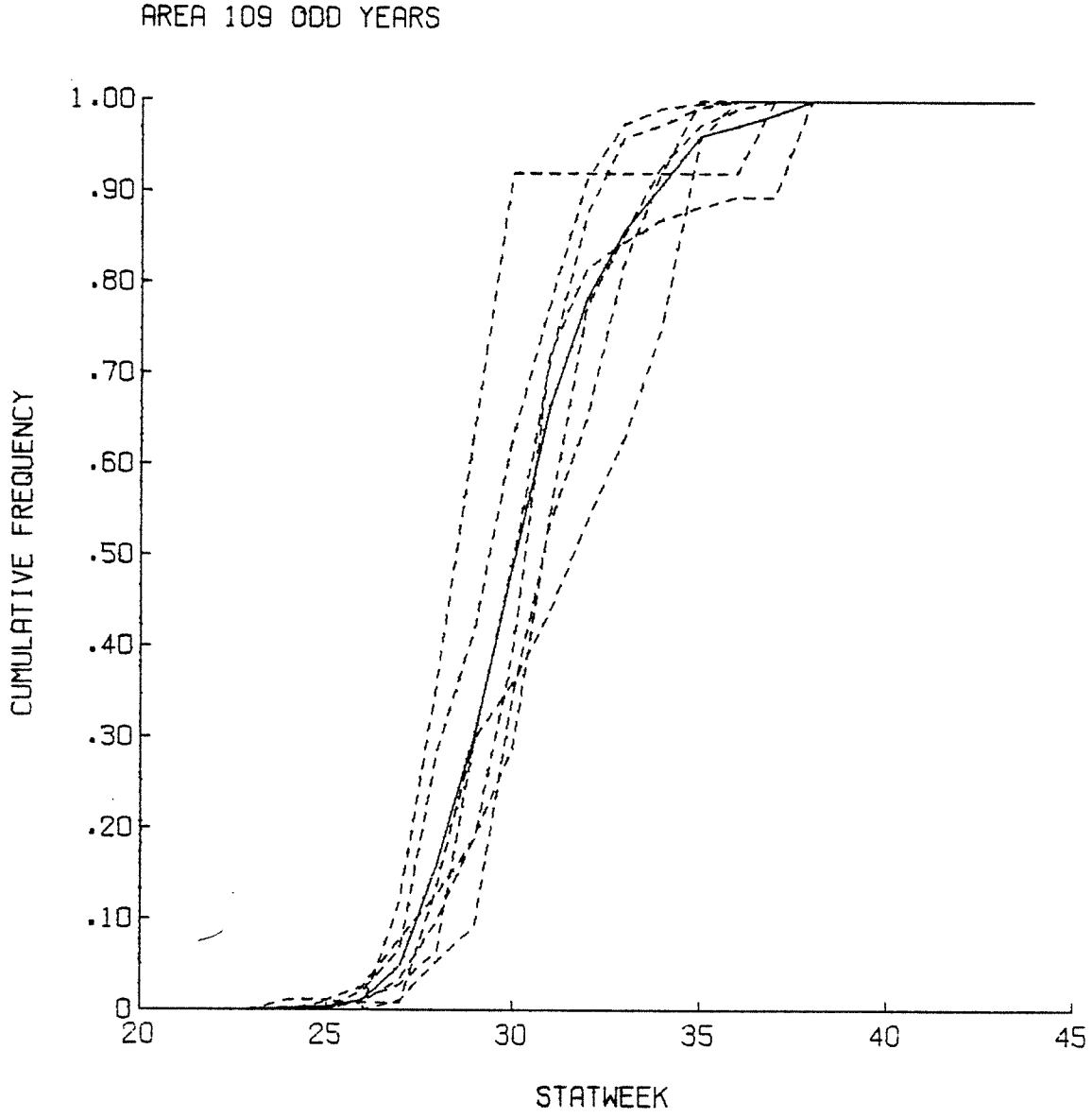
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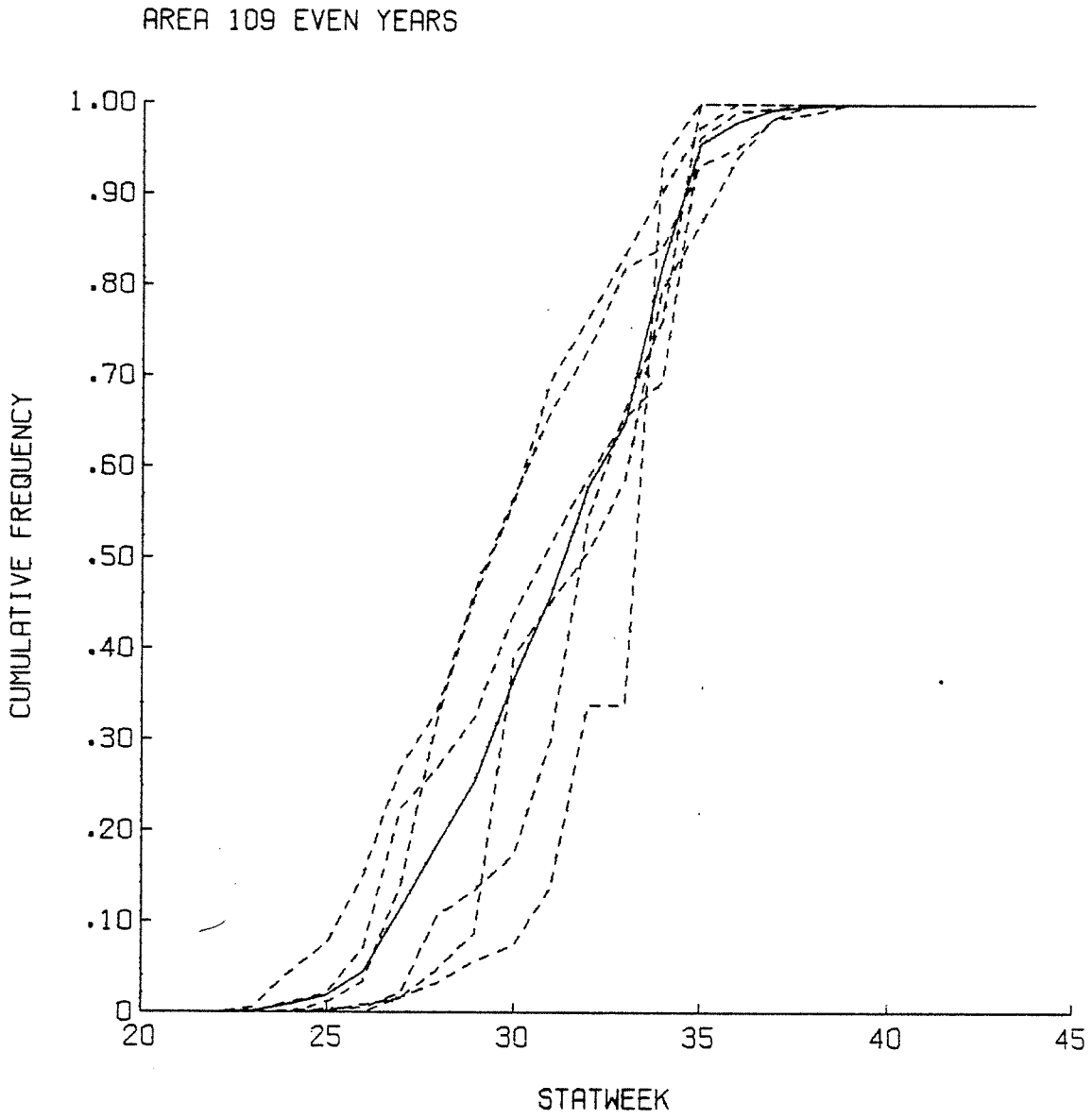
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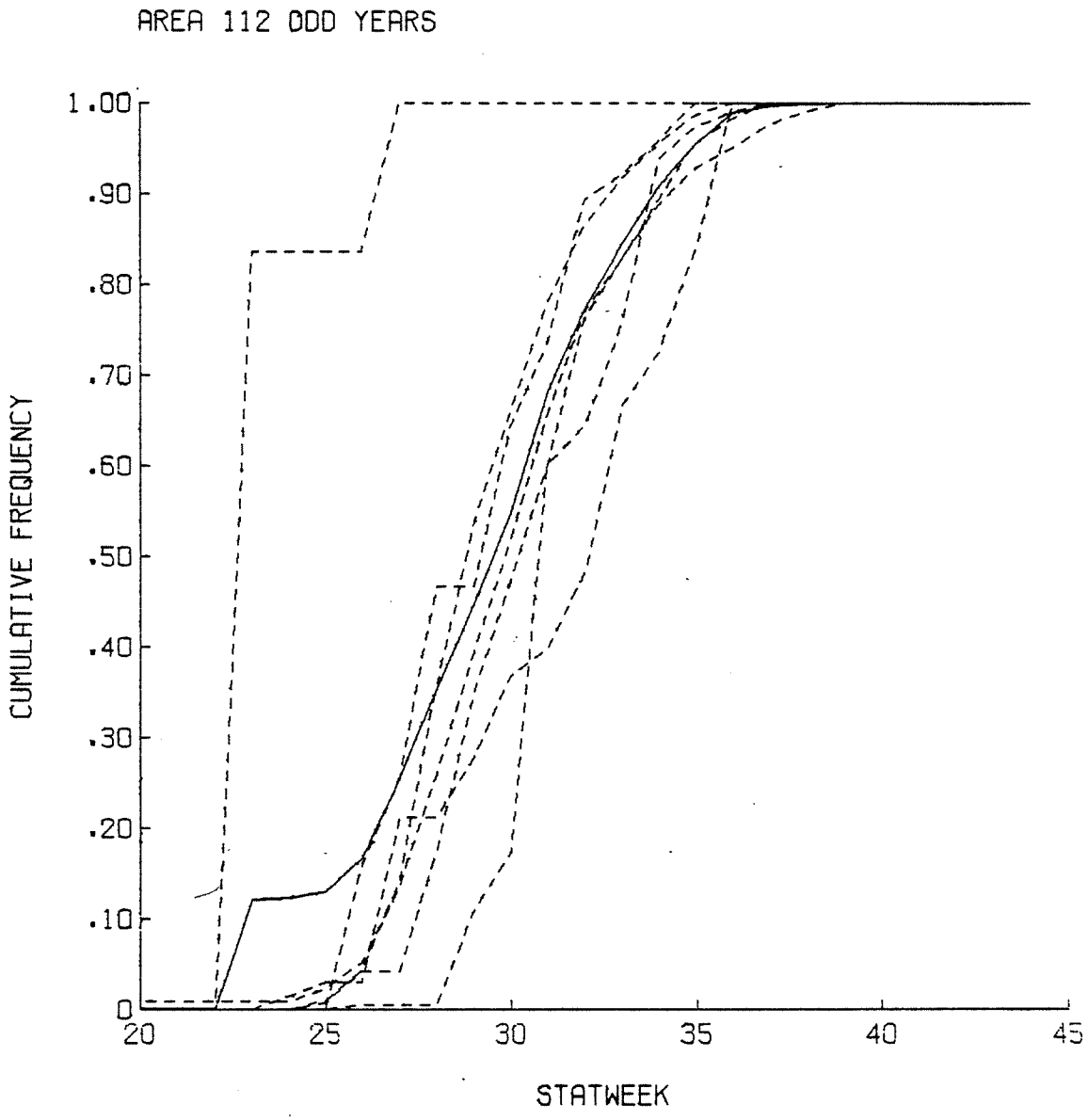
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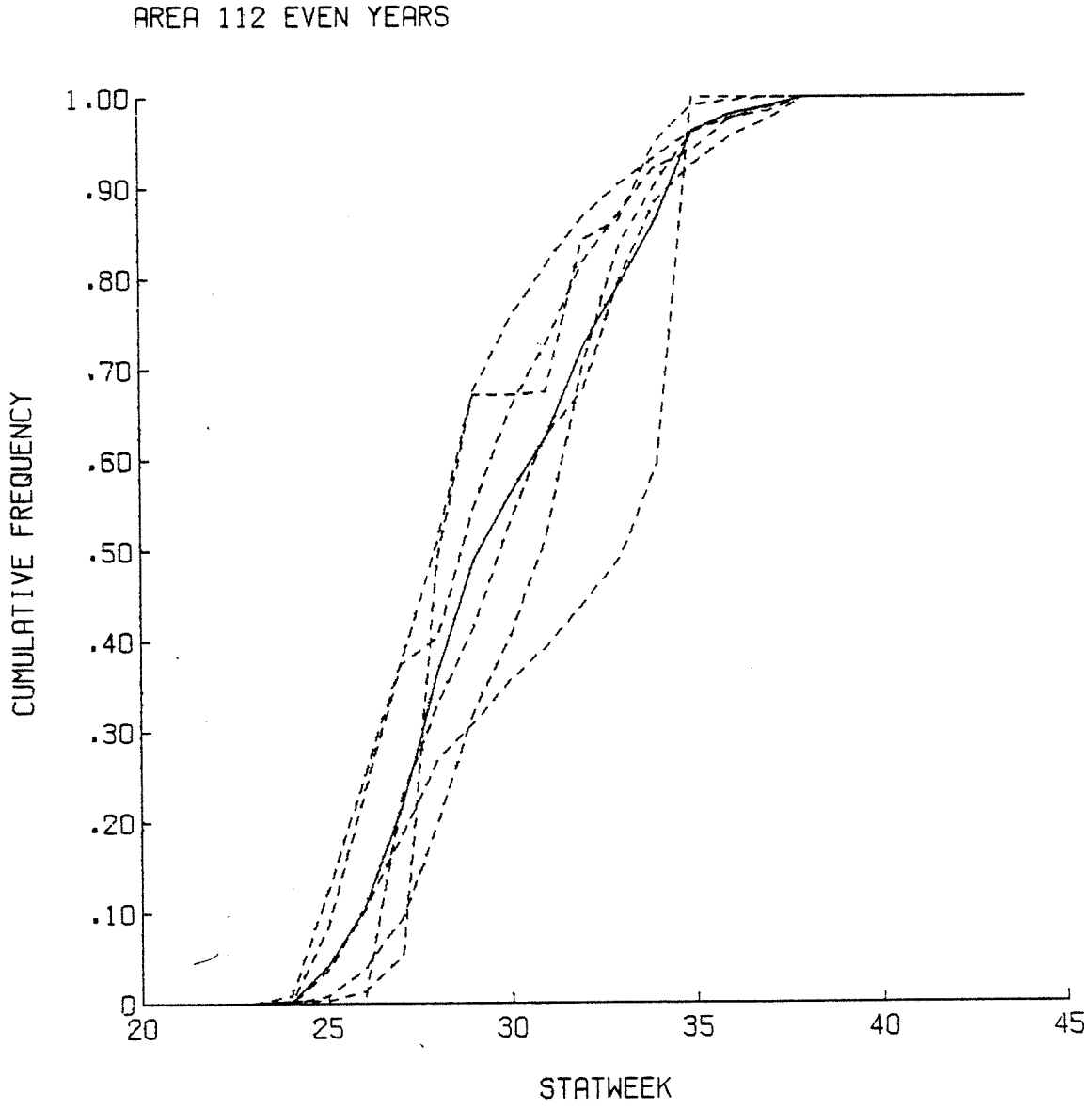
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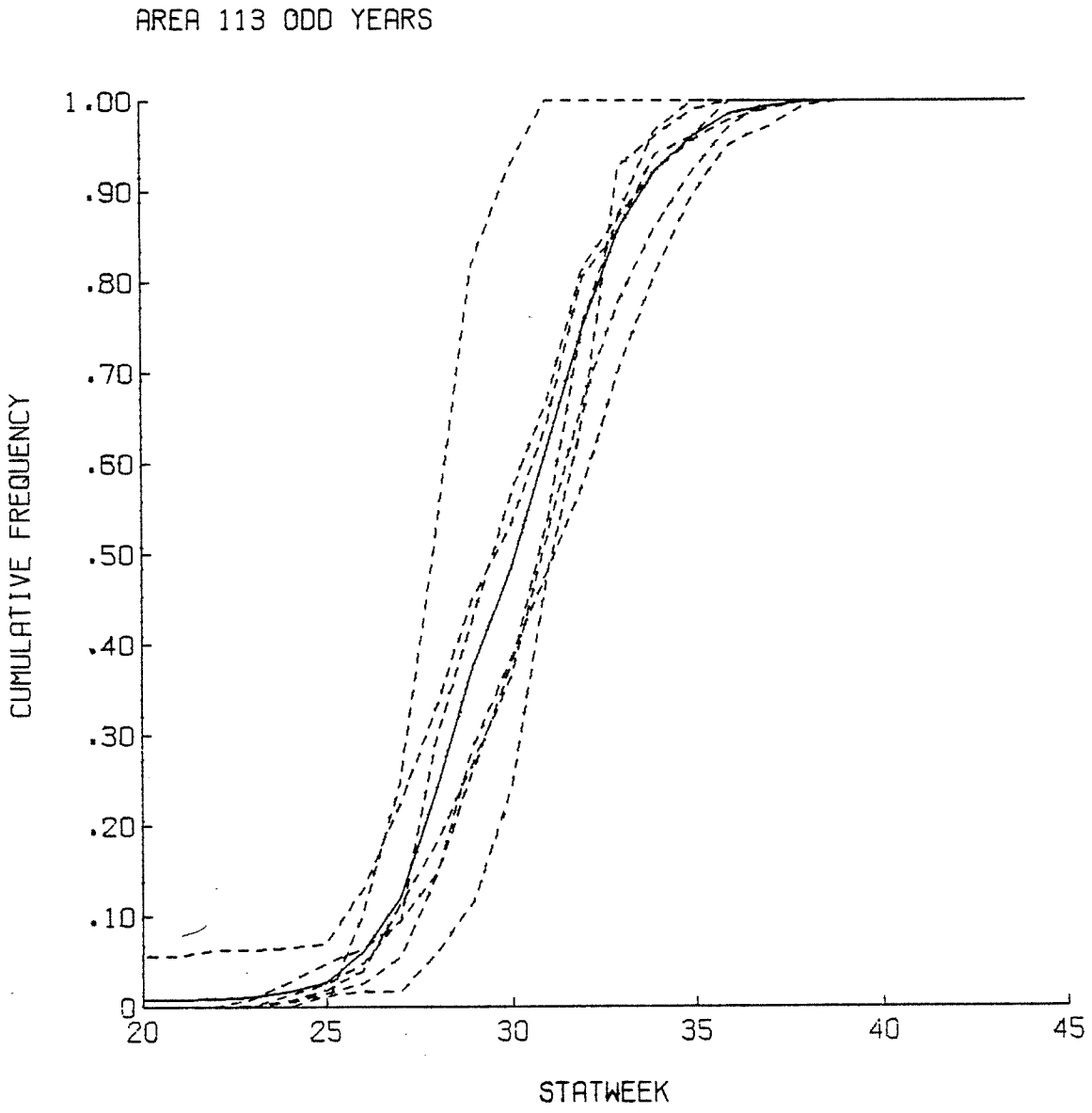
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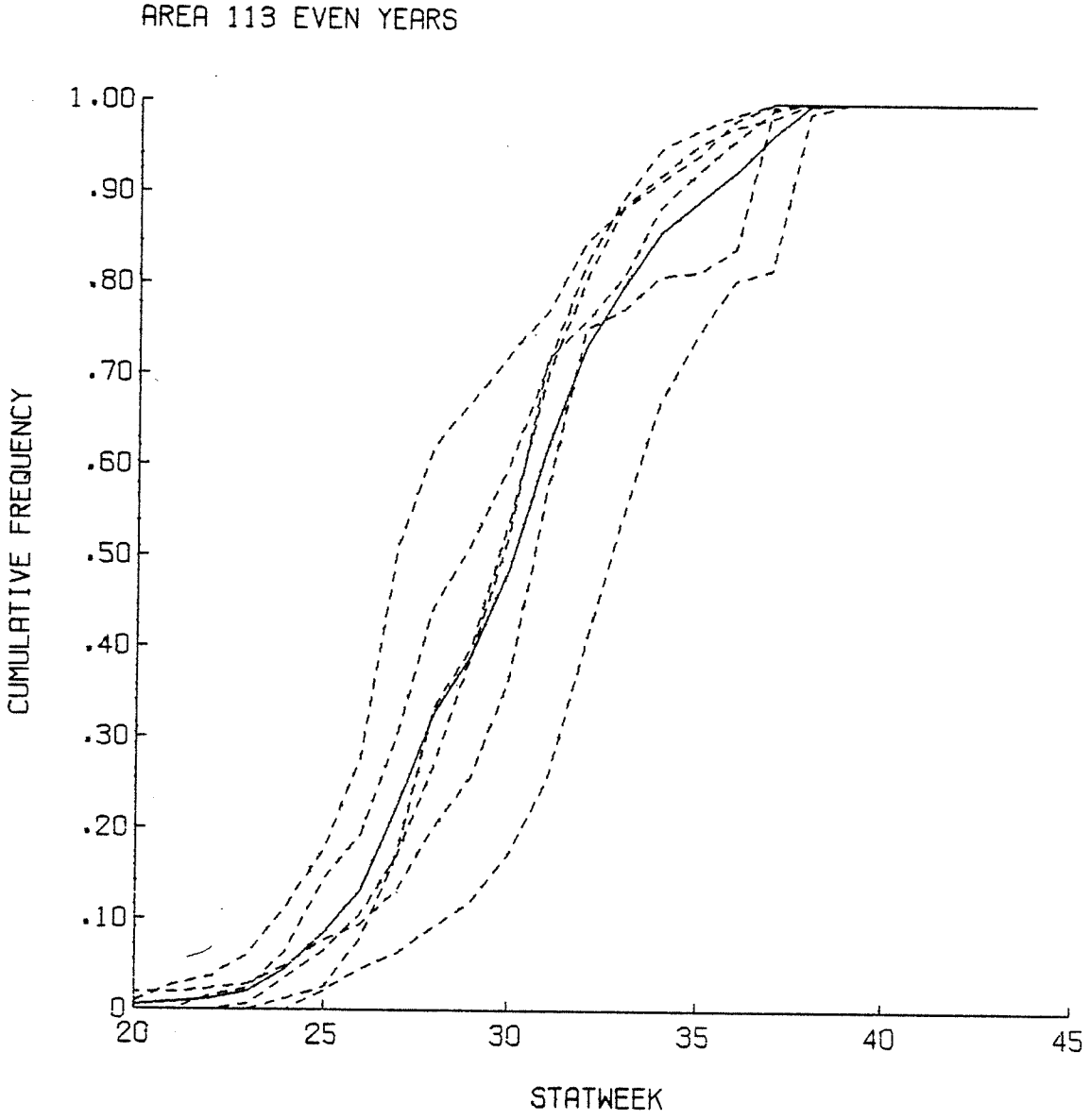
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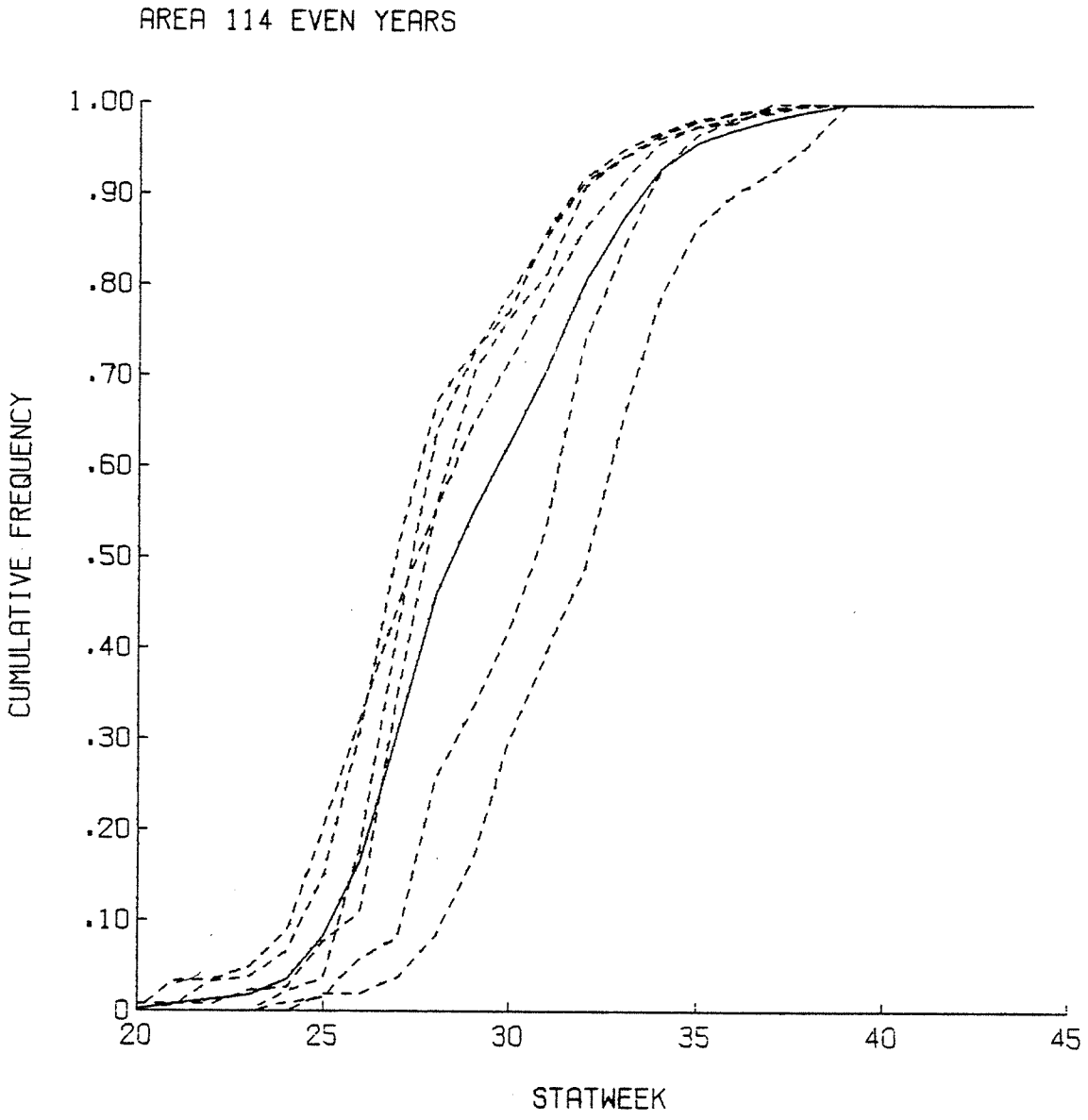
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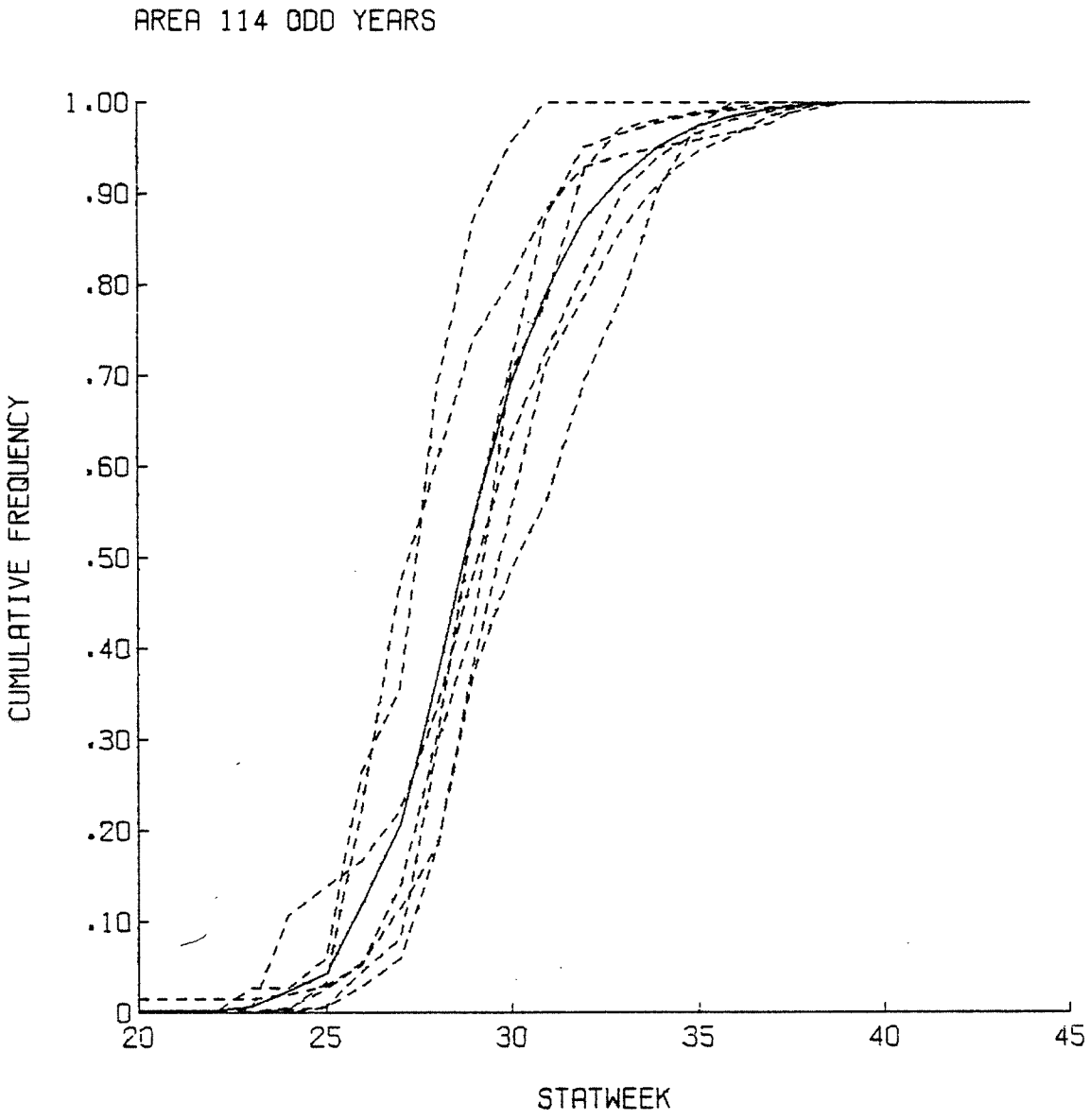
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