A Model to Predict Pacific Herring Age Composition in Early and Late Spawning Migrations in Kamishak Bay, Alaska

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ABSTRACT. Observations of a mid-April spawning migration of older-aged Pacific herring *Clupea pallasi* in Kamishak Bay, Alaska, followed by a younger-aged herring spawning migration in May was supported with a two-sided, two-sample Smirnov test. When a shift in age composition occurred, those in mid-May reflected an influx of age-3 and older herring, whereas late April transitions were due to increased numbers of age-4 and older herring. A model was developed to predict a composite age composition from the early age composition for those years when late age composition samples are absent and the following-year age composition indicates an unexplained recruitment of age-4 herring. The model does not use survival rates and is independent of forecast models.

INTRODUCTION

Alaska's purse seine sac roe fishery for Pacific herring *Clupea pallasi* in the Kamishak Bay District of the Lower Cook Inlet Management Area (Figure 1) targets a spawning migration that appears to be bimodal. The second mode is younger because of higher proportions of age-3 and -4 herring (Schroeder 1989). Accordingly, the Alaska Department of Fish and Game harvest management strategy for the Kamishak Bay District has been to open the district to commercial fishing in April when the fish are presumed to be older, instead of mid-May or later. The older-aged fish increase roe recovery rates and allow the younger-aged herring to mature. Samples have been collected with a purse seine through the entire spawning migration to obtain complete (early and late) age composition. This age composition is used to estimate survival and recruitment rates, which in turn are used to forecast the next season's abundance and to measure the effect of fishing on the health of the spawning population.

Beginning in 1990, post-fishery age composition data were not collected during the months of May and June because of budget reductions. The objective of this investigation, therefore, was to determine if differences between early and late age composition attributed to a younger age component were statistically significant and to build a model to estimate total age composition from the early age composition. I also documented editing changes to the historical age composition database for aging errors.

METHODS

Although catch sampling in Lower Cook Inlet for age began in 1971, the database did not begin until 1973 because the original data forms and scales could not be located for 1971. The data were also missing for 1982. No age-weight-length (AWL) samples were collected during 1980, 1982, and 1984. The data from 1981 were not used because age-7 and older herring were completely absent in the samples. The original data summaries for the years between 1971 and 1987 can be found in Schroeder (1989) and thereafter in Yuen et al. (1989, 1990, 1991, 1994a, 1994b).

The 1973 to 1992 age-weight-length (AWL) database was edited for aging errors in two stages. First a weight-length relationship for Kamishak herring was estimated by sex and harvest year for all years of historical data. For each length in the data set, a 99% confidence interval around the expected weight was calculated from the standard error of the prediction (Snedecor and Cochran 1967). The original data forms were researched for all lengths having weights outside the 99% confidence interval. Keypunch or transposition errors were corrected. Marginal outliers were retained in the database, but conspicuous outliers that

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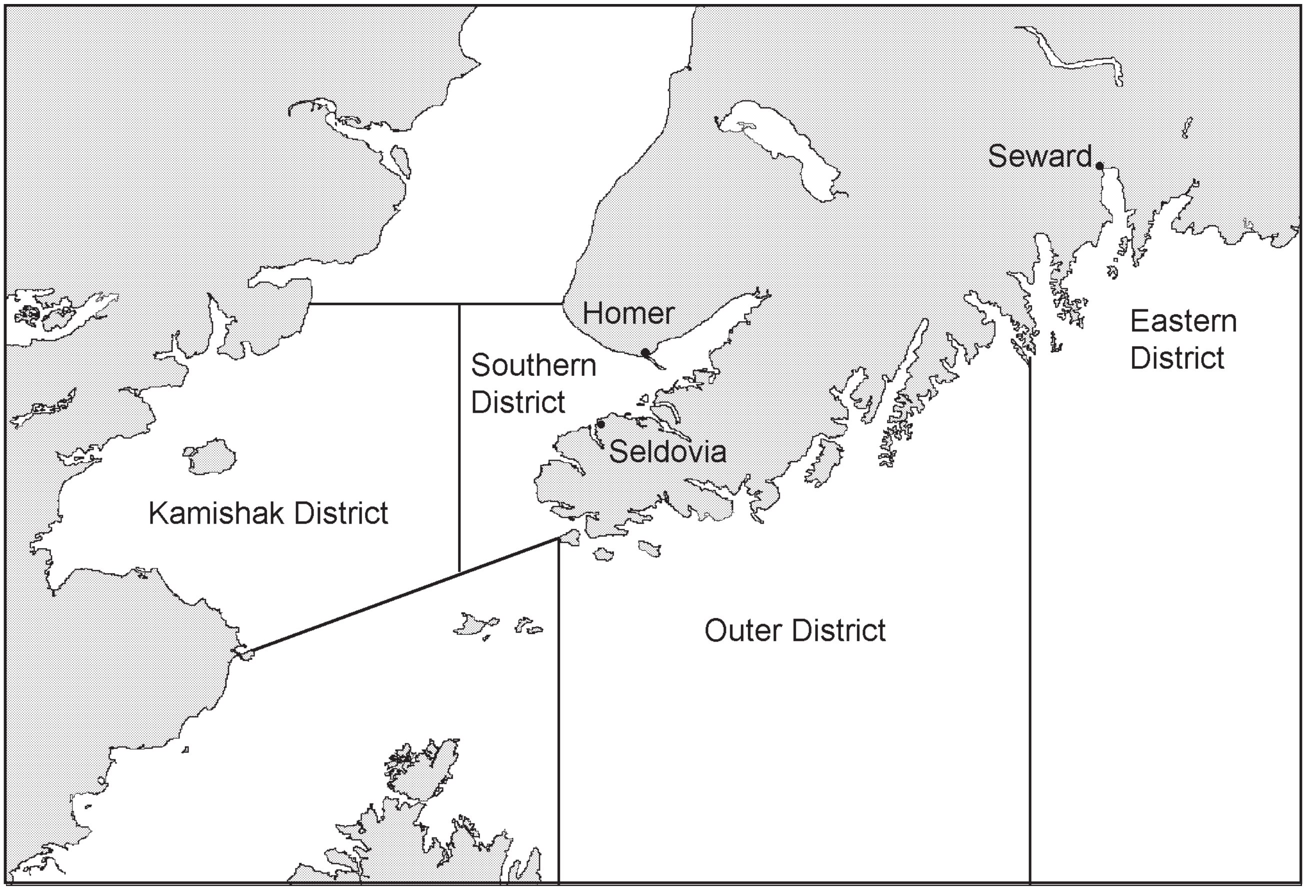

Figure 1. Kamishak Bay, Southern, Outer, and Eastern Districts of Lower Cook Inlet Management Area, Alaska.

could not be explained by a keypunch or transposition error were assigned age-error code "19." This indicates the scale was problematic and was excluded from further data analysis. The other two error codes available were *scale regenerated* and *scale missing.* Means, standard errors (SE), and the 99% confidence interval were recalculated, and the process repeated until no further prominent outliers could be found. Second, mean length- and weight-at-age statistics were then used to find specimens that were outside two SE for its age group. All outliers were aged again from archival scale collections. Aging, keypunch, or transposition errors were corrected. Scales that were correctly aged but disagreed with the size range for that age by 2 years or more were also assigned age error code "19" that excluded them from further analysis. This process was also repeated until no new outliers could be found.

I tested for differences in age compositions using cumulative age proportions, *S*, from 1973–79, 1983, and 1985–90, compared with a two-sided, 2-sample Smirnov test (Conover 1980). If the null hypothesis, H_0: $S_{late} = S_{early}$, was rejected ($P \leq 0.005$), the alternative hypothesis was that herring in the two samples had different age distributions. To control the overall a-level when drawing conclusions across multiple annual tests, the individual tests were set at the lowest values in the tables (0.005). Using the Bonferroni inequality (Mendenhall et al. 1986), 10 simultaneous tests within a year could be completed with $\Sigma\alpha < 0.1$.

I compared ages 3 to 11 and a category with ages 12 through 16 combined. Ages 1 and 2 were excluded because they are sexually immature. I did not consider them part of the spawning migration. While they can be caught with a shrimp trawl, they rarely appeared in any purse seine catch samples. Sample sizes of early and late samples were never equal.

To find the change-over date, $d_{m,y}$, when the proportion, *P*, of younger-aged herring increased, I systematically compared samples adjacent in time and searched for a date when the age composition changed abruptly. In this scheme, D_y-1 pairs of early and late samples were compared with the Smirnov test, D_y being the last sample date in year *y*. When the null hypothesis was rejected, the midpoint between samples was used to delineate the early and late age compositions for each year in the data set.

I also considered another scheme in which the change-over date $d_{m,y}$ was systematically advanced from $m = 1$ to D_y-1. In this search for a gradual change, all samples up to and including that date were assigned to the early component:

$$p_{i,early,y} = \frac{\sum_{d=1}^{d_{m,y}} n_{i,d,y}}{\sum_{i=3}^{16}\sum_{d=1}^{d_{m,y}} n_{i,d,y}}. \qquad (1)$$

All samples after that date were assigned to the late component:

$$p_{i,late,y} = \frac{\sum_{d=d_{m+1,y}}^{Dy} n_{i,d,y}}{\sum_{i=3}^{16}\sum_{d=d_{m+1,y}}^{D_y} n_{i,d,y}} \qquad (2)$$

The first date of significant differences would be chosen as the change-over date.

Finally, models were built to predict either a late,

$$p_{i,late} = e^{a+b_1 \ln(i)+b_2 \ln(p_{i,early})}, \qquad (3)$$

or composite (early and late) age composition,

$$p_{i,early+late} = e^{a+b_1 \ln(i)+b_2 \ln(p_{i,early})}, \qquad (4)$$

from the early age composition by age group, where *a* and *b* are multivariate regression coefficients, *n* = frequency of samples in age group *i*, with log transformations because the trend was nonlinear. This model was intended only for those years without late age composition data and only if a biologist was confident that a late season influx of ages 3 and 4 had occurred, as indicated by the age composition of ages 4 and 5 during the following year. This model uses proportions instead of abundance within the early stratum and does not require knowledge of the fraction of an age group represented in each stratum. The model does not use survival rates and is independent of forecast models. Results of these regressions should be interpreted with some caution because both dependent and independent variables have approximately the same amount of error. Also, errors are not independent because age composition proportions within a year must sum to 1.

RESULTS

Of 26,305 samples collected between 1973 and 1991, 6 had length or weight keypunch errors that were corrected (Table 1). There were another 669 samples outside of the length-weight relationship 99% confidence interval, but these were left unchanged in the database. None were removed from the database because of discrepancies related to length-weight relationship.

There were 16 age keypunch errors that were corrected (Table 1). I changed the ages of 228 samples after re-reading the scales. There were 1,778 herring with ages that did not agree with their size. I made no changes to 1,429 but reclassified 349 as either *scale regenerated* when appropriate or *scale illegible* to exclude them from this and future analysis. Some of the discrepancy between age and body size were due to attempts at aging regenerated scales, while others were more difficult to explain. Perhaps they were the result of loose scales from other herring adhering to the specimen being sampled.

Age compositions are presented in Figure 2. The results of the Smirnov tests for abrupt change in age composition (i.e., cumulative early and late age proportions, differences between the two by group, sample sizes *m* and *n*, maximum, and critical difference or value) are presented in Appendix A. Significant differences between samples adjacent in time are enclosed within a box in Appendix A. If the later sample was younger, the boxes were double-lined. For example, in 1977 the 12 May sample was older for ages 3–8 combined than the 10 May sample because the differences between the two cumulative proportions within an age group exceeded the critical value of 0.200 ($P \leq 0.005$, $m = 99$, $n = 199$). Those differences were 0.298, 0.406, 0.422, 0.407, 0.331, and 0.246.

Between 1973 and 1992, catch sampling dates slowly moved away from June and toward April (Figure 2) as fishery dates were moved forward to focus on age-5 and older herring (Schroeder 1989). There were 8 years when an abrupt change in age composition occurred to support Schroeder's observations that later age compositions tend to be younger. All significant shifts in Figure 2 are enclosed within a box. Those

Table 1. Results of screening Kamishak herring age, weight, and length (AWL) data.

		Number weights outside 99% confidence interval			Number of ages that disagree with size					
							No Keypunch Error			
								Agree with Age		
Year[a]	Original Number AWL Samples w/ Age	Total	With Keypunch Error[b]	No Keypunch Error	Total	Keypunch Error Found[c]	Disagree w/ Age[d]	Retain	Remove	Revised Number AWL Sample w/ Age
1973	283	2	0	2	17	1	0	16	0	283
1974	369	9	0	9	29	0	10	17	2	367
1975	490	7	1	6	107	0	54	23	30	460
1976	193	11	2	9	85	0	26	43	16	177
1977	785	8	0	8	139	8	42	56	33	752
1978	611	11	0	11	53	6	11	30	6	605
1979[e]	265	1	0	1	23	0	9	14	0	265
1981[f]	31	0	0	0	5	0	0	5	0	31
1983	567	6	0	6	44	1	0	38	5	562
1985	1,089	22	0	22	82	0	1	73	8	1,081
1986	2,334	47	0	47	183	0	2	146	35	2,299
1987	2,871	40	0	40	307	0	0	276	31	2,840
1988	4,069	31	3	28	310	0	11	245	54	4,015
1989	3,191	182	0	182	236	0	17	195	24	3,167
1990	8,139	252	0	252	328	0	30	201	97	8,042
1991	1,018	47	0	47	74	0	15	51	8	1,010
Total	26,305	676	6	669	2,022	16	228	1,429	349	25,956

[a] No AWL sampling in 1980, 1982, 1984.
[b] Size corrected in database.
[c] Age or size corrected in database.
[d] Age revised in database.
[e] Found 24 more samples than originally reported in 1979.
[f] No age 7 and older in 1981 samples.

that pertain to ages-3 and -4 herring have arrows pointing to direction of shift from previous date.

While some of the abrupt changes occurred during mid-May to June, e.g. 1977, 1978, 1979, and 1986, as suggested by Schroeder (1989), an influx of age-3 or -4 herring has occurred as early as late-April to early May (1988, 1990, and 1992). While the trend in change-over date may be related to the forward shift in fishing dates, it may also be related to the age of the herring participating in the change-over. For example, three of the four late April to early-May transitions coincided with increased numbers of age-4 and older herring (1988, 1990, and 1992), and all four mid- to late May shifts reflected an influx of age-3 and older herring (e.g., 1977, 1978, 1979, and 1986). Shift in age composition toward age-3 or -4 herring may involve as few as one age group (1978 and 1979) or as many as five or more (1986 and 1988).

There were four years when there were abrupt changes toward older age groups. During 1978 and 1990 a younger age composition was followed by older, and during 1977 and 1988 an older sample was found between two younger samples. These samples, although adjacent in time, were geographically separated suggesting either the migration of younger-aged herring was staggered between areas and overlapping in time or perhaps a third migration occurred. There were six years (1973, 1974, 1975, 1976, 1987, and 1989) when no change in age composition was detected, which may have been due to the lack of samples during the April to May period of expected age transition.

There were also eight instances when the Smirnov test indicated an abrupt change shift in age composition that did not include age-3 and -4 herring. I believe the increase in ages 5–7 on 7 May 1985 was part of a gradual shift toward age 4 that was not detected by the test for abrupt change. I do not believe the decrease of age 7 on 31 May 1975 was noteworthy. Instead, the absence of age-5 herring on that date (Figure 2) suggest persistent aging errors in the database. There was no apparent pattern for the remaining shifts: (1) fewer age 8 on 20 May 1976, age 5 on 30 April 1989, age-6 on 23 April 1990, and ages 6 and 7

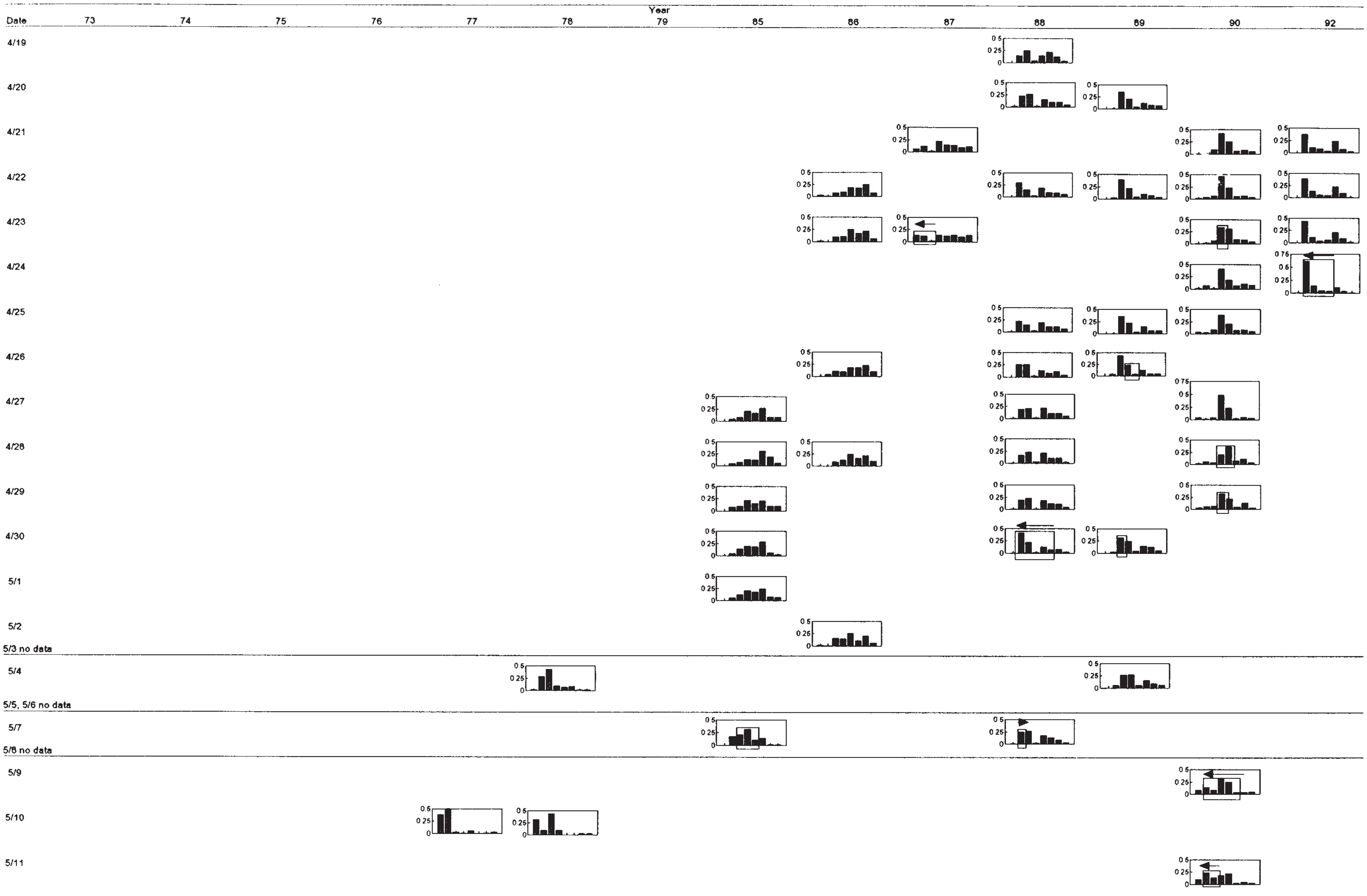

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Figure 2. Age composition by date of sampling for age-3 to -10 Kamishak herring. Significant abrupt changes from previous date are enclosed in a box. Arrows indicate shift toward or away from age-3 or -4 compared to previous date.

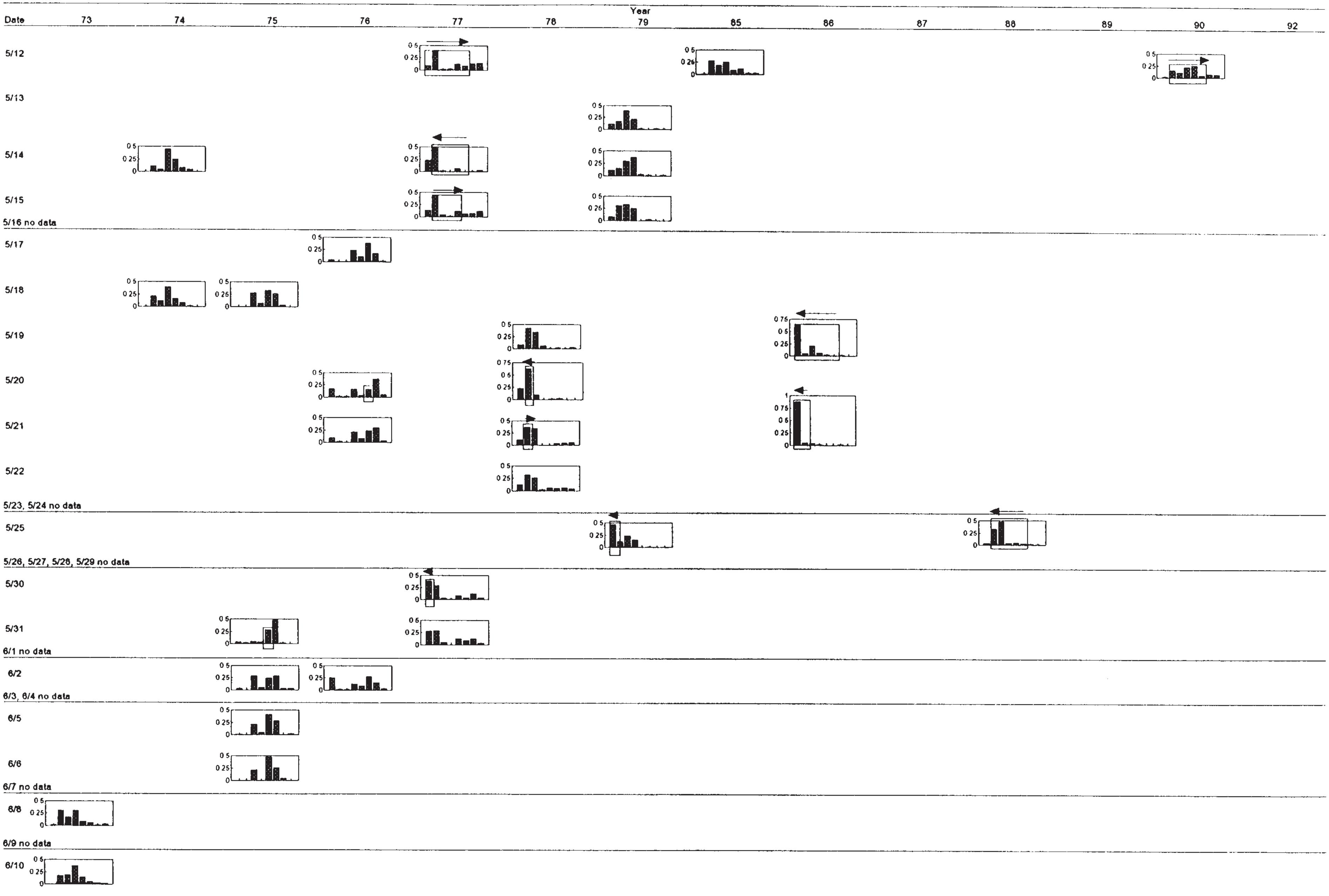

Figure 2. (page 2 of 2)

Table 2. Early- and late-sample periods used build model to predict late age composition from early age composition.

Year	Period Dates
Early Period:	
1977	May 10 to May 15
1978	May 5 to May 19
1979	May 13 to May 15
1985	April 27 to May 1
1986	April 22 to May 2
1988	April 19 to April 29
1990	April 21 to April 29
1992	April 21 to April 23
Late Period:	
1977	May 30 to May 31
1978	May 20 to May 22
1979	May 25
1985	May 7 to May 12
1986	April 19 to May 21
1988	April 30 to May 25
1990	May 9 to May 12
1992	April 24

Data from the following years were not used to build the prediction model:
1991, only 1 d of samples.
1973, 1974, 1987 had only 2 d of samples.
1975, 1976, 1989 had no discernible change.

on 28 April 1990, and (2) more of ages 6 and 7 on 26 April 1989 and age 6 on 29 April 1990. These may be the result of oversensitivity in the abrupt tests.

The test for gradual changes, which employed equations (1) and (2) to define early and late components, produced mixed results (Appendix B). The gradual approach was superior during 1985 when it successfully detected a gradual shift toward age 4, a shift that was not detected by the abrupt test (Figure 2). Both schemes agreed that an increase of age-4 herring occurred on 20 May 1978 and a shift toward age 3 herring occurred on 23 April 1978. Both detected unexplained shifts among the older ages during 1989.

Overall, the gradual scheme tended to be oversensitive. If a significant influx of younger-aged herring occurred, then in the worse case scenario, all late components would exhibit significant differences regardless of the start date of the late component. During 1979 the gradual scheme indicated a change toward ages 3 and 4 as early as 15 May, whereas the abrupt scheme and Figure 2 suggest a shift toward age 3 did not occur until 25 May. During 1986 the gradual scheme signaled a shift toward age 3 as early as 26 April 1986, whereas Figure 2 and the abrupt scheme indicate that a dramatic change in the age-3 composition did not occurred until 19 May. During 1988 all late group groupings were found to be significantly different, but the abrupt method did not signal a change until 29 April. Likewise, in 1990 catch sampling began on 21 April, and a surge in age-4 and older herring occurred on 10 May, as indicated by the abrupt scheme and Figure 2. However, all late groupings (equation 2) with start dates, $D_{m+1,y}$, between 22 April or 10 May were found to be significantly younger by the gradual scheme. Again during 1992, all late groups indicated a shift toward age-4 herring, whereas the abrupt scheme and Figure 2 suggest 24 April as the date of significant change.

Oversensitivity of the gradual test, however, was used to verify the results of the abrupt tests. For example, in 1977 there were two dates when the second of two adjacent samples were found to be younger by the abrupt test. The gradual test results indicated that splitting the samples between 15 and 30 May would produce two aggregates that were statistically different, whereas a split between 12 and 14 May did not. Likewise, the gradual tests did not detect changes among the older age groups during 1976 and 1990 whereas the abrupt tests did.

There was not enough data to build a separate prediction model for the three scenarios: (1) abrupt change in age-3 and older herring, (2) abrupt change in age-4 and older, and (3) gradual change in age-4 and older. Instead, a general model was built to predict a relatively younger composite age composition from a known early age composition using dates in Table 2. The relationship shown in Figure 3 between early and late age composition ($r^2 = 0.68$, df= 66) was

$$p_{i,late} = e^{2.365853 - 1.984164 ln(i) + 0.593118 ln(p_{i,early})}, \quad (5)$$

where i = age group. This model was rejected because most of the data was clustered near the origin. Instead, the relationship shown in Figure 4 between early and composite age composition ($r^2 = 0.78$, df= 73) was selected for the prediction model, i.e.,

$$p_{i,composite} = e^{0.443238 - 0.419468 ln(i) + 0.877642 ln(p_{i,early})}, \quad (6)$$

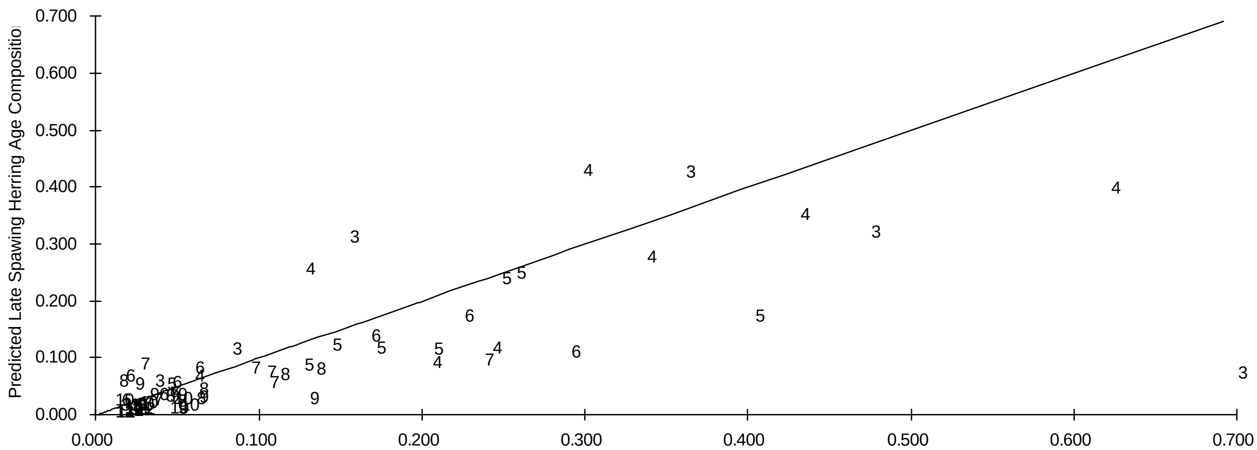

Figure 3. Observed late Kamishak Bay District age composition and that predicted from early age composition using *2.365853-1.984164 ln* (age) + *0.593118 ln* (early age composition by age). Data points are represented by the age class. Straight line shows perfect prediction.

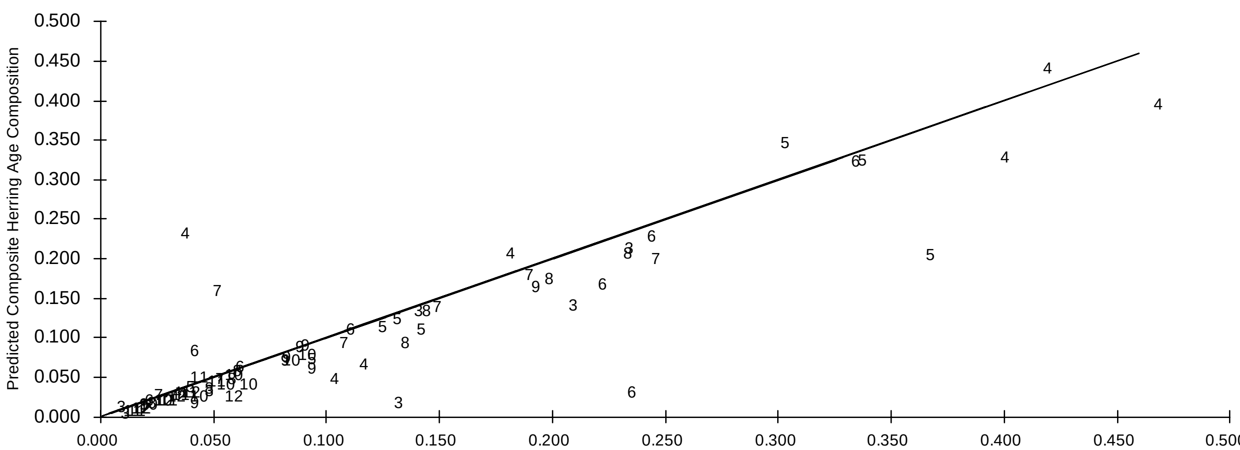

Figure 4. Observed composite (early + late) Kamishak Bay District age composition and that predicted from early *0.443238-0.419468 ln* (age) + *0.877642 ln* (early age composition by age). Data points are represented by the age class. Straight line shows perfect prediction.

DISCUSSION

This study produced three scenarios depicting change in age composition. The most common was an abrupt change in age composition toward age-3 and -4 herring. There was only one example for each of the other two scenarios: no change (1989) and a gradual change toward age4 (1985). Among the abrupt change scenarios, there was an influx of age-4 and older herring, typically in late April to early May (e.g., 1988, 1990, and 1992) or an increase in the abundance of age-3 and older herring, typically from mid-May to June (e.g., 1977 and 1986). Unfortunately, there were temporal exceptions, and I could not find any basis for predicting which scenario would occur within a year. Instead, I have to examine the age composition from the following year before deciding on the appropriate scenario.

For example, all of the 1991 catch samples were collected on 23 April, which if a shift occurred, was too early to estimate the total age-3 and -4 component. In 1992 a high proportion of age-4 herring was detected, which indicates a late-season influx of age-3 herring did occur during 1991. With that information, a composite 1991 age composition should have been estimated from the 1991 April samples. The forecast of the 1992 spawning migration (Yuen and Bucher 1992), however, was prepared without this information and greatly underestimated the abundance of age-4 herring in 1992.

Back calculating abundances using the same mortality and recruitment schedules used to prepare the forecast is not recommended. Using the same example, if the 1991 age composition was back calculated from survival rates, neither the 1991 nor the 1992 age composition data could be used to revise future mortality and recruitment schedules. Instead, the 1991 age composition should be independently estimated from the regression model. This allows the biologist the option of recalculating the missing data periodically in the future as more shift-in-age-composition data become available or of excluding the 1991 age composition when the mortality and recruitment schedules are revised.

When I prepared the preliminary 1993 forecast (Bucher and Hammerstrom 1992, Yuen and Bucher 1993), I did not adjust the 1992 age composition. This was fortuitous because it was the appropriate response; i.e., the no-change scenario probably occurred during 1992. Unfortunately, I restated the historical age composition instead, specifically 1986, in an effort to make the historical data comparable with the 1992 data, which had no-late season samples. The restatements were not necessary because I incorrectly assumed our samples in 1992 missed the late-season influx of younger herring. In Yuen and Bucher (1993), a one-sided, *k*-sample Smirnov test was used; the variable *k* was mistaken for *n* and consequently only 1986 was identified as a year with a late-season influx of age-3 and older herring.

Considering the small sample size in this study, the models have to be updated with additional data (i.e., samples from April through May) . Because I was making a global conclusion from about 64 Smirnov tests, I selected the lowest possible significance value, $\alpha = 0.005$, found in Conover (1980); this minimized the probability of rejecting the null hypotheses by chance alone.

This is the first application of a Smirnov-type cumulative distribution test to detect changes in age composition that I am aware of. Contingency tables, usually with a chi-square test, are used in Prince William Sound, Lower Cook Inlet, and elsewhere to detect differences between catch samples. However, the Smirnov test takes advantage of the fact that ages can be ordered, whereas the contingency table approach merely assigns each age to a category, which does not require ordering. The Smirnov test should have more power to detect changes along this ordering than contingency table tests.

Most of the changes in Kamishak Bay herring age composition were abrupt, and the adjacent sample method was successful in isolating the date of the abrupt change. Nevertheless, both abrupt and gradual tests were required in the analysis because testing adjacent samples was insensitive to gradual trends in age composition over time and was oversensitive to changes among the older age classes. Although the gradual test was not used to determine when an abrupt change occurred, it was used to verify and eliminate oversensitive abrupt test results.

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— *Appendix A.* —

Appendix A. Search for date with abrupt change in age composition using cumulative age proportions from youngest to oldest by date, differences by age, and Smirnov test results. Significant differences are enclosed in a box; differences where the second sample was younger, i.e., more ages-3 or 4 herring, are enclosed in a double-lined box.

		Age in Years											Critical Value	
Year	Date	3	4	5	6	7	8	9	10	11	12–16	n	P=0.995	D(max)
1973														
	6 8	0.016	0.326	0.495	0.800	0.889	0.947	0.968	1.000	1.000	1.000	190		
	6 10	0.000	0.172	0.366	0.742	0.892	0.946	0.978	1.000	1.000	1.000	93		
	difference	0.016	0.154	0.129	0.058	0.003	0.001	0.010	0.000	0.000	0.000		0.206	0.154
1974														
	5 14	0.000	0.115	0.162	0.608	0.854	0.938	0.985	0.992	1.000	1.000	130		
	5 18	0.000	0.207	0.329	0.722	0.886	0.970	0.992	0.996	1.000	1.000	237		
	difference	0.000	0.091	0.168	0.114	0.032	0.032	0.007	0.003	0.000	0.000		0.178	0.168
1975						later of 2 samples had less age 7								
	5 18	0.000	0.000	0.282	0.359	0.684	0.951	0.990	0.995	1.000	1.000	206		
	5 31	0.033	0.049	0.098	0.131	0.410	0.885	0.902	0.902	0.951	1.000	61		
	difference	0.033	0.049	0.183	0.228	0.275	0.066	0.089	0.094	0.049	0.000		0.238	0.275
	5 31	0.033	0.049	0.098	0.131	0.410	0.885	0.902	0.902	0.951	1.000	61		
	6 2	0.034	0.034	0.322	0.379	0.621	0.908	0.943	0.977	0.989	1.000	87		
	difference	0.002	0.015	0.223	0.248	0.211	0.023	0.041	0.075	0.038	0.000		0.272	0.248
	6 2	0.034	0.034	0.322	0.379	0.621	0.908	0.943	0.977	0.989	1.000	87		
	6 5	0.011	0.011	0.218	0.264	0.678	0.966	0.966	0.989	0.989	1.000	87		
	difference	0.023	0.023	0.103	0.115	0.057	0.057	0.023	0.011	0.000	0.000		0.247	0.115
	6 5	0.011	0.011	0.218	0.264	0.678	0.966	0.966	0.989	0.989	1.000	87		
	6 6	0.000	0.000	0.211	0.211	0.684	0.947	1.000	1.000	1.000	1.000	19		
	difference	0.011	0.011	0.008	0.054	0.006	0.018	0.034	0.011	0.011	0.000		0.413	0.054
1976							later of 2 samples had less age 8							
	5 17	0.044	0.050	0.062	0.302	0.411	0.790	0.962	0.982	0.982	1.000	338		
	5 20	0.173	0.185	0.198	0.358	0.395	0.556	0.926	0.975	1.000	1.000	81		
	difference	0.128	0.135	0.135	0.056	0.016	0.234	0.036	0.007	0.018	0.000		0.202	0.234
	5 20	0.173	0.185	0.198	0.358	0.395	0.556	0.926	0.975	1.000	1.000	81		
	5 21	0.096	0.112	0.118	0.326	0.410	0.646	0.949	0.989	0.989	1.000	178		
	difference	0.077	0.073	0.080	0.032	0.015	0.091	0.024	0.013	0.011	0.000		0.218	0.091
	5 21	0.096	0.112	0.118	0.326	0.410	0.646	0.949	0.989	0.989	1.000	178		
	6 2	0.258	0.271	0.284	0.406	0.497	0.774	0.929	0.968	0.981	1.000	155		
	difference	0.163	0.159	0.166	0.081	0.087	0.128	0.020	0.021	0.008	0.000		0.179	0.166
1977		later of 2 samples had less ages 3 through 8												
	5 10	0.384	0.869	0.899	0.909	0.960	0.960	0.970	1.000	1.000	1.000	99		
	5 12	0.085	0.462	0.477	0.503	0.628	0.714	0.844	0.990	1.000	1.000	199		
	difference	0.298	0.406	0.422	0.407	0.331	0.246	0.125	0.010	0.000	0.000		0.200	0.422
			later of 2 samples had more ages 4 through 8											
	5 12	0.085	0.462	0.477	0.503	0.628	0.714	0.844	0.990	1.000	1.000	199		
	5 14	0.231	0.851	0.876	0.876	0.942	0.942	0.959	0.992	1.000	1.000	121		
	difference	0.146	0.389	0.399	0.374	0.314	0.229	0.114	0.002	0.000	0.000		0.188	0.399
			later of 2 samples had less ages 4 through 7											
	5 14	0.231	0.851	0.876	0.876	0.942	0.942	0.959	0.992	1.000	1.000	121		
	5 15	0.137	0.577	0.620	0.637	0.750	0.810	0.880	0.996	1.000	1.000	284		
	difference	0.094	0.274	0.256	0.239	0.192	0.132	0.078	0.005	0.000	0.000		0.177	0.274
		later of 2 samples had more age 3												
	5 15	0.137	0.577	0.620	0.637	0.750	0.810	0.880	0.996	1.000	1.000	284		
	5 30	0.382	0.671	0.700	0.710	0.797	0.836	0.957	0.995	1.000	1.000	207		
	difference	0.244	0.094	0.081	0.073	0.047	0.026	0.076	0.001	0.000	0.000		0.149	0.244

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Appendix A. (page 2 of 5)

Year	Date	Age in Years: 3	4	5	6	7	8	9	10	11	12–16	n	Critical Value P=0.995	D(max)
1977														
	5 30	0.382	0.671	0.700	0.710	0.797	0.836	0.957	0.995	1.000	1.000	207		
	5 31	0.278	0.570	0.620	0.620	0.747	0.835	0.962	1.000	1.000	1.000	79		
	difference	0.103	0.102	0.080	0.090	0.050	0.000	0.006	0.005	0.000	0.000		0.216	0.103
1978														
	5 4	0.016	0.302	0.730	0.825	0.889	0.968	0.984	1.000	1.000	1.000	63		
	5 10	0.313	0.406	0.844	0.938	0.938	0.938	0.969	1.000	1.000	1.000	32		
	difference	0.297	0.105	0.114	0.112	0.049	0.031	0.015	0.000	0.000	0.000		0.354	0.297
	5 10	0.313	0.406	0.844	0.938	0.938	0.938	0.969	1.000	1.000	1.000	32		
	5 19	0.089	0.515	0.861	0.931	0.941	0.960	0.970	1.000	1.000	1.000	101		
	difference	0.223	0.109	0.018	0.007	0.003	0.023	0.002	0.000	0.000	0.000		0.331	0.223
			later of 2 samples had more age 4											
	5 19	0.089	0.515	0.861	0.931	0.941	0.960	0.970	1.000	1.000	1.000	101		
	5 20	0.230	0.850	0.947	0.947	0.965	0.991	0.991	0.991	1.000	1.000	113		
	difference	0.141	0.335	0.086	0.016	0.024	0.031	0.021	0.009	0.000	0.000		0.223	0.335
			later of 2 samples had less age 4											
	5 20	0.230	0.850	0.947	0.947	0.965	0.991	0.991	0.991	1.000	1.000	113		
	5 21	0.109	0.477	0.816	0.822	0.828	0.868	0.920	0.977	0.989	1.000	174		
	difference	0.121	0.373	0.131	0.125	0.137	0.123	0.072	0.014	0.011	0.000		0.197	0.373
	5 21	0.109	0.477	0.816	0.822	0.828	0.868	0.920	0.977	0.989	1.000	174		
	5 22	0.123	0.443	0.705	0.730	0.795	0.852	0.918	0.959	1.000	1.000	122		
	difference	0.014	0.034	0.111	0.092	0.033	0.015	0.002	0.018	0.011	0.000		0.192	0.111
1979														
	5 13	0.116	0.289	0.686	0.901	0.926	0.934	0.959	0.975	0.983	1.000	121		
	5 14	0.111	0.259	0.556	0.926	0.963	0.981	0.981	1.000	1.000	1.000	54		
	difference	0.005	0.030	0.130	0.025	0.037	0.048	0.023	0.025	0.017	0.000		0.267	0.130
	5 14	0.111	0.259	0.556	0.926	0.963	0.981	0.981	1.000	1.000	1.000	54		
	5 15	0.077	0.385	0.718	0.974	0.974	1.000	1.000	1.000	1.000	1.000	39		
	difference	0.034	0.125	0.162	0.048	0.011	0.019	0.019	0.000	0.000	0.000		0.343	0.162
		later of 2 samples had more age 3												
	5 15	0.077	0.385	0.718	0.974	0.974	1.000	1.000	1.000	1.000	1.000	39		
	5 25	0.467	0.587	0.827	0.987	0.987	1.000	1.000	1.000	1.000	1.000	75		
	difference	0.390	0.202	0.109	0.012	0.012	0.000	0.000	0.000	0.000	0.000		0.322	0.390
1985														
	4 27	0.000	0.042	0.127	0.324	0.493	0.761	0.845	0.930	0.986	1.000	71		
	4 28	0.000	0.045	0.117	0.252	0.378	0.685	0.869	0.928	0.973	1.000	222		
	difference	0.000	0.003	0.010	0.072	0.115	0.076	0.024	0.002	0.013	0.000		0.222	0.115
	4 28	0.000	0.045	0.117	0.252	0.378	0.685	0.869	0.928	0.973	1.000	222		
	4 29	0.000	0.082	0.178	0.397	0.548	0.753	0.849	0.945	1.000	1.000	73		
	difference	0.000	0.037	0.061	0.145	0.170	0.069	0.020	0.017	0.027	0.000		0.220	0.170
	4 29	0.000	0.082	0.178	0.397	0.548	0.753	0.849	0.945	1.000	1.000	73		
	4 30	0.000	0.050	0.189	0.384	0.566	0.849	0.912	0.943	1.000	1.000	159		
	difference	0.000	0.032	0.011	0.014	0.018	0.096	0.063	0.002	0.000	0.000		0.230	0.096
	4 30	0.000	0.050	0.189	0.384	0.566	0.849	0.912	0.943	1.000	1.000	159		
	5 1	0.000	0.054	0.174	0.379	0.558	0.799	0.875	0.942	1.000	1.000	224		
	difference	0.000	0.003	0.015	0.004	0.008	0.050	0.037	0.001	0.000	0.000		0.169	0.050
				later of 2 samples had more ages 5 through 7										
	5 1	0.000	0.054	0.174	0.379	0.558	0.799	0.875	0.942	1.000	1.000	224		
	5 7	0.000	0.173	0.387	0.707	0.813	0.953	0.973	0.987	1.000	1.000	150		
	difference	0.000	0.120	0.213	0.327	0.255	0.154	0.098	0.045	0.000	0.000		0.172	0.327

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Appendix A. (page 3 of 5)

Year	Date	Age in Years 3	4	5	6	7	8	9	10	11	12–16	n	Critical Value P=0.995	D(max)
1985														
	5 7	0.000	0.173	0.387	0.707	0.813	0.953	0.973	0.987	1.000	1.000	150		
	5 12	0.011	0.295	0.481	0.732	0.820	0.934	0.962	0.984	0.995	1.000	183		
	difference	0.011	0.122	0.094	0.026	0.006	0.019	0.012	0.003	0.005	0.000		0.180	0.122
1986														
	4 22	0.027	0.040	0.120	0.213	0.400	0.573	0.827	0.907	0.960	1.000	75		
	4 23	0.018	0.018	0.115	0.220	0.472	0.642	0.862	0.927	0.959	1.000	218		
	difference	0.008	0.022	0.005	0.007	0.072	0.069	0.036	0.020	0.001	0.000		0.218	0.072
	4 23	0.018	0.018	0.115	0.220	0.472	0.642	0.862	0.927	0.959	1.000	218		
	4 26	0.005	0.047	0.157	0.256	0.434	0.615	0.840	0.937	0.965	1.000	805		
	difference	0.013	0.029	0.042	0.036	0.039	0.027	0.023	0.010	0.007	0.000		0.124	0.042
	4 26	0.005	0.047	0.157	0.256	0.434	0.615	0.840	0.937	0.965	1.000	805		
	4 28	0.006	0.008	0.092	0.214	0.450	0.612	0.828	0.932	0.970	1.000	500		
	difference	0.001	0.039	0.065	0.042	0.016	0.003	0.012	0.005	0.005	0.000		0.093	0.065
	4 28	0.006	0.008	0.092	0.214	0.450	0.612	0.828	0.932	0.970	1.000	500		
	5 2	0.013	0.022	0.175	0.314	0.565	0.670	0.863	0.921	0.959	1.000	315		
	difference	0.007	0.014	0.083	0.100	0.115	0.058	0.035	0.011	0.011	0.000		0.117	0.115
		later of 2 samples had more ages 3 through 8												
	5 2	0.013	0.022	0.175	0.314	0.565	0.670	0.863	0.921	0.959	1.000	315		
	5 19	0.619	0.673	0.885	0.950	0.975	0.982	0.996	1.000	1.000	1.000	278		
	difference	0.606	0.650	0.710	0.635	0.410	0.312	0.133	0.079	0.041	0.000		0.134	0.710
		later of 2 samples had more ages 3 through 4												
	5 19	0.619	0.673	0.885	0.950	0.975	0.982	0.996	1.000	1.000	1.000	278		
	5 21	0.880	0.926	0.963	0.981	0.981	0.981	1.000	1.000	1.000	1.000	108		
	difference	0.261	0.253	0.078	0.032	0.007	0.001	0.004	0.000	0.000	0.000		0.185	0.261
1987														
		later of 2 samples had more ages 3 through 5												
	4 21	0.066	0.183	0.200	0.421	0.566	0.708	0.800	0.911	0.960	1.000			
	4 23	0.135	0.253	0.273	0.409	0.527	0.660	0.755	0.893	0.946	1.000	909		
	difference	0.069	0.070	0.073	0.011	0.039	0.048	0.045	0.018	0.014	0.000		0.066	0.073
1988														
	4 19	0.000	0.143	0.387	0.429	0.571	0.790	0.916	0.950	0.992	1.000	119		
	4 20	0.016	0.248	0.523	0.539	0.693	0.794	0.895	0.935	0.993	1.000	306		
	difference	0.016	0.106	0.136	0.111	0.121	0.004	0.021	0.015	0.002	0.000		0.176	0.136
	4 20	0.016	0.248	0.523	0.539	0.693	0.794	0.895	0.935	0.993	1.000	306		
	4 22	0.003	0.303	0.456	0.484	0.667	0.759	0.849	0.906	0.963	1.000	756		
	difference	0.014	0.055	0.067	0.055	0.026	0.035	0.046	0.029	0.031	0.000		0.110	0.067
	4 22	0.003	0.303	0.456	0.484	0.667	0.759	0.849	0.906	0.963	1.000	756		
	4 25	0.010	0.231	0.380	0.409	0.601	0.716	0.827	0.894	0.957	1.000	208		
	difference	0.007	0.072	0.077	0.075	0.066	0.043	0.022	0.012	0.006	0.000		0.128	0.077
	4 25	0.010	0.231	0.380	0.409	0.601	0.716	0.827	0.894	0.957	1.000	208		
	4 26	0.003	0.258	0.513	0.539	0.677	0.755	0.870	0.917	0.966	1.000	384		
	difference	0.007	0.027	0.133	0.130	0.076	0.039	0.043	0.022	0.009	0.000		0.140	0.133
	4 26	0.003	0.258	0.513	0.539	0.677	0.755	0.870	0.917	0.966	1.000	384		
	4 27	0.005	0.196	0.408	0.426	0.643	0.753	0.865	0.916	0.974	1.000	392		
	difference	0.002	0.061	0.105	0.113	0.034	0.003	0.005	0.001	0.008	0.000		0.117	0.113
	4 27	0.005	0.196	0.408	0.426	0.643	0.753	0.865	0.916	0.974	1.000	392		
	4 28	0.008	0.177	0.405	0.442	0.656	0.769	0.878	0.912	0.976	1.000	913		
	difference	0.003	0.019	0.003	0.016	0.013	0.016	0.014	0.003	0.001	0.000		0.098	0.019

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Appendix A. (page 4 of 5)

Year	Date	3	4	5	6	7	8	9	10	11	12–16	n	Critical Value P=0.995	D(max)
		Age in Years												
1988														
	4 28	0.008	0.177	0.405	0.442	0.656	0.769	0.878	0.912	0.976	1.000	913		
	4 29	0.007	0.199	0.424	0.436	0.623	0.738	0.852	0.901	0.972	1.000	573		
	difference	0.001	0.022	0.019	0.006	0.033	0.031	0.027	0.012	0.004	0.000		0.087	0.033
			later of 2 samples had more ages 4 through 8											
	4 29	0.007	0.199	0.424	0.436	0.623	0.738	0.852	0.901	0.972	1.000	573		
	4 30	0.000	0.408	0.629	0.647	0.776	0.850	0.929	0.959	0.984	1.000	434		
	difference	0.007	0.209	0.205	0.211	0.153	0.112	0.077	0.058	0.012	0.000		0.104	0.211
			later of 2 samples had less age 4											
	4 30	0.000	0.408	0.629	0.647	0.776	0.850	0.929	0.959	0.984	1.000	434		
	5 7	0.007	0.258	0.528	0.550	0.730	0.855	0.939	0.971	0.988	1.000	407		
	difference	0.007	0.150	0.101	0.097	0.047	0.005	0.010	0.012	0.004	0.000		0.112	0.150
			later of 2 samples had more ages 4 through 8											
	5 7	0.007	0.258	0.528	0.550	0.730	0.855	0.939	0.971	0.988	1.000	407		
	5 25	0.040	0.367	0.845	0.880	0.930	0.960	0.980	0.987	0.995	1.000	1554		
	difference	0.033	0.109	0.317	0.330	0.200	0.105	0.041	0.017	0.007	0.000		0.091	0.330
1989														
	4 20	0.002	0.016	0.363	0.564	0.608	0.732	0.814	0.887	0.920	1.000	564		
	4 22	0.000	0.032	0.426	0.641	0.686	0.789	0.864	0.904	0.937	1.000	907		
	difference	0.002	0.016	0.062	0.077	0.078	0.057	0.051	0.018	0.017	0.000		0.087	0.078
	4 22	0.000	0.032	0.426	0.641	0.686	0.789	0.864	0.904	0.937	1.000	907		
	4 25	0.000	0.007	0.364	0.583	0.618	0.760	0.823	0.883	0.946	1.000	429		
	difference	0.000	0.025	0.062	0.058	0.068	0.030	0.042	0.021	0.009	0.000		0.096	0.068
					later of 2 samples had more ages 6 and 7									
	4 25	0.000	0.007	0.364	0.583	0.618	0.760	0.823	0.883	0.946	1.000	429		
	4 26	0.000	0.039	0.471	0.700	0.737	0.859	0.908	0.954	0.975	1.000	433		
	difference	0.000	0.032	0.107	0.117	0.119	0.099	0.085	0.070	0.028	0.000		0.111	0.119
				later of 2 samples had less age 5										
	4 26	0.000	0.039	0.471	0.700	0.737	0.859	0.908	0.954	0.975	1.000	433		
	4 30	0.002	0.029	0.351	0.597	0.639	0.781	0.904	0.958	0.978	1.000	407		
	difference	0.002	0.010	0.120	0.103	0.098	0.078	0.003	0.004	0.003	0.000		0.113	0.120
	4 30	0.002	0.029	0.351	0.597	0.639	0.781	0.904	0.958	0.978	1.000	407		
	5 4	0.000	0.054	0.319	0.590	0.644	0.794	0.888	0.953	0.979	1.000	427		
	difference	0.002	0.024	0.033	0.007	0.005	0.013	0.017	0.005	0.001	0.000		0.113	0.033
1990														
	4 21	0.006	0.020	0.107	0.520	0.769	0.834	0.915	0.964	0.978	1.000	494		
	4 22	0.016	0.053	0.121	0.576	0.804	0.856	0.919	0.961	0.980	1.000	861		
	difference	0.010	0.033	0.014	0.056	0.034	0.022	0.004	0.003	0.003	0.000		0.092	0.056
					later of 2 samples had less age 6									
	4 22	0.016	0.053	0.121	0.576	0.804	0.856	0.919	0.961	0.980	1.000	861		
	4 23	0.003	0.021	0.088	0.421	0.727	0.821	0.906	0.953	0.977	1.000	385		
	difference	0.014	0.033	0.032	0.155	0.076	0.035	0.012	0.007	0.004	0.000		0.100	0.155
	4 23	0.003	0.021	0.088	0.421	0.727	0.821	0.906	0.953	0.977	1.000	385		
	4 24	0.019	0.090	0.109	0.521	0.701	0.773	0.886	0.967	0.991	1.000	211		
	difference	0.016	0.069	0.021	0.101	0.026	0.048	0.020	0.014	0.014	0.000		0.140	0.101
	4 24	0.019	0.090	0.109	0.521	0.701	0.773	0.886	0.967	0.991	1.000	211		
	4 25	0.035	0.063	0.142	0.527	0.724	0.794	0.877	0.930	0.974	1.000	431		
	difference	0.016	0.027	0.033	0.005	0.022	0.021	0.009	0.036	0.016	0.000		0.137	0.036
	4 25	0.035	0.063	0.142	0.527	0.724	0.794	0.877	0.930	0.974	1.000	431		
	4 27	0.046	0.067	0.113	0.593	0.825	0.851	0.902	0.943	0.979	1.000	194		
	difference	0.012	0.004	0.028	0.066	0.101	0.057	0.025	0.013	0.005	0.000		0.141	0.101

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Appendix A. (page 5 of 5)

Year	Date	Age in Years 3	4	5	6	7	8	9	10	11	12–16	n	Critical Value P=0.995	D(max)
1990		later of 2 samples had less ages 6 and 7												
	4 27	0.046	0.067	0.113	0.593	0.825	0.851	0.902	0.943	0.979	1.000	194		
	4 28	0.016	0.070	0.107	0.311	0.664	0.734	0.844	0.877	0.930	1.000	244		
	difference	0.030	0.003	0.007	0.281	0.161	0.117	0.058	0.066	0.049	0.000		0.157	0.281
		later of 2 samples had more age 6												
	4 28	0.016	0.070	0.107	0.311	0.664	0.734	0.844	0.877	0.930	1.000	244		
	4 29	0.032	0.092	0.156	0.473	0.689	0.733	0.860	0.892	0.949	1.000	315		
	difference	0.015	0.022	0.049	0.162	0.025	0.000	0.016	0.015	0.019	0.000		0.139	0.162
		later of 2 samples had more ages 4 through 8												
	4 29	0.032	0.092	0.156	0.473	0.689	0.733	0.860	0.892	0.949	1.000	315		
	5 9	0.082	0.220	0.305	0.613	0.859	0.897	0.935	0.985	0.994	1.000	341		
	difference	0.050	0.128	0.149	0.140	0.170	0.164	0.075	0.093	0.045	0.000		0.127	0.170
		later of 2 samples had more ages 4 and 5												
	5 9	0.082	0.220	0.305	0.613	0.859	0.897	0.935	0.985	0.994	1.000	341		
	5 11	0.101	0.341	0.478	0.662	0.876	0.899	0.947	0.976	0.987	1.000	971		
	difference	0.019	0.121	0.173	0.049	0.017	0.002	0.012	0.009	0.008	0.000		0.103	0.173
		later of 2 samples had less ages 4 through 8												
	5 11	0.101	0.341	0.478	0.662	0.876	0.899	0.947	0.976	0.987	1.000	971		
	5 12	0.023	0.180	0.289	0.509	0.756	0.808	0.883	0.947	0.974	1.000	532		
	difference	0.078	0.160	0.188	0.153	0.121	0.091	0.064	0.029	0.013	0.000		0.088	0.188
1992														
	4 21	0.000	0.371	0.480	0.564	0.602	0.839	0.916	0.946	0.973	1.000	367		
	4 22	0.000	0.390	0.526	0.587	0.638	0.857	0.952	0.967	0.982	1.000	392		
	difference	0.000	0.020	0.046	0.023	0.036	0.018	0.036	0.021	0.009	0.000		0.118	0.046
	4 22	0.000	0.390	0.526	0.587	0.638	0.857	0.952	0.967	0.982	1.000	392		
	4 23	0.002	0.440	0.552	0.591	0.641	0.851	0.940	0.957	0.980	1.000	562		
	difference	0.002	0.049	0.026	0.004	0.003	0.007	0.012	0.010	0.002	0.000		0.107	0.049
		later of 2 samples had more ages 4 through 7												
	4 23	0.002	0.440	0.552	0.591	0.641	0.851	0.940	0.957	0.980	1.000	562		
	4 24	0.006	0.620	0.756	0.794	0.830	0.934	0.970	0.979	0.992	1.000	471		
	difference	0.005	0.180	0.204	0.203	0.190	0.084	0.031	0.021	0.011	0.000		0.102	0.204

— *Appendix B.* —

Appendix B. Search for gradual change in age composition using cumulative age proportions from youngest to oldest by date, differences by age, and Smirnov test results. Significant differences are enclosed in a box; differences where the second sample was younger, i.e., more ages-3 or 4 herring, are enclosed in a double-lined box.

Year	Sample Period	Age in Years 3	4	5	6	7	8	9	10	11	12–16	n	Critical Value P=0.995	D(max)
1973	6/8	0.016	0.326	0.495	0.800	0.889	0.947	0.968	1.000	1.000	1.000	190		
	6/10	0.000	0.172	0.366	0.742	0.892	0.946	0.978	1.000	1.000	1.000	93		
		0.016	0.154	0.129	0.058	0.003	0.001	0.010	0.000	0.000	0.000		0.206	0.154
1974	5/14	0.000	0.115	0.162	0.608	0.854	0.938	0.985	0.992	1.000	1.000	130		
	5/18	0.000	0.207	0.329	0.722	0.886	0.970	0.992	0.996	1.000	1.000	237		
		0.000	0.091	0.168	0.114	0.032	0.032	0.007	0.003	0.000	0.000		0.178	0.168
1975	5/18	0.000	0.000	0.282	0.359	0.684	0.951	0.990	0.995	1.000	1.000	206		
	5/31–6/6	0.024	0.028	0.224	0.268	0.594	0.925	0.945	0.965	0.980	1.000	254		
		0.024	0.028	0.057	0.092	0.090	0.026	0.045	0.031	0.020	0.000		0.153	0.092
	5/18–5/31	0.007	0.011	0.240	0.307	0.622	0.936	0.970	0.974	0.989	1.000	267		
	6/2–6/6	0.021	0.021	0.264	0.311	0.653	0.938	0.959	0.984	0.990	1.000	193		
		0.013	0.009	0.025	0.004	0.031	0.001	0.011	0.011	0.001	0.000		0.154	0.031
	5/18–6/2	0.014	0.017	0.260	0.325	0.621	0.929	0.963	0.975	0.989	1.000	354		
	6/5–6/6	0.009	0.009	0.217	0.255	0.679	0.962	0.972	0.991	0.991	1.000	106		
		0.005	0.008	0.043	0.070	0.058	0.033	0.008	0.016	0.002	0.000		0.18	0.07
	5/18–6/5	0.014	0.016	0.252	0.313	0.633	0.937	0.964	0.977	0.989	1.000	441		
	6/6	0.000	0.000	0.211	0.211	0.684	0.947	1.000	1.000	1.000	1.000	19		
		0.014	0.016	0.041	0.102	0.052	0.011	0.036	0.023	0.011	0.000		0.382	0.102
		later samples had more ages 3 through 5												
1976	5/17	0.044	0.050	0.062	0.302	0.411	0.790	0.962	0.982	0.982	1.000	338		
	5/20–6/2	0.171	0.186	0.196	0.362	0.440	0.676	0.937	0.978	0.988	1.000	414		
		0.127	0.136	0.134	0.061	0.028	0.114	0.024	0.004	0.006	0.000		0.119	0.136
	5/17–5/20	0.069	0.076	0.088	0.313	0.408	0.745	0.955	0.981	0.986	1.000	419		
	5/21–6/2	0.171	0.186	0.195	0.363	0.450	0.706	0.940	0.979	0.985	1.000	333		
		0.102	0.110	0.107	0.051	0.042	0.039	0.015	0.002	0.001	0.000		0.12	0.11
		later samples had more ages 3 through 5												
	5/17–5/21	0.077	0.087	0.097	0.317	0.409	0.715	0.953	0.983	0.987	1.000	597		
	6/2	0.258	0.271	0.284	0.406	0.497	0.774	0.929	0.968	0.981	1.000	155		
		0.181	0.184	0.187	0.090	0.088	0.059	0.024	0.016	0.006	0.000		0.147	0.187
		later samples had less ages 3 through 7												
1977	5/10	0.384	0.869	0.899	0.909	0.960	0.960	0.970	1.000	1.000	1.000	99		
	5/12–5/31	0.208	0.610	0.642	0.655	0.760	0.815	0.908	0.994	1.000	1.000	890		
		0.176	0.259	0.257	0.254	0.200	0.145	0.062	0.006	0.000	0.000		0.173	0.259
	5/10–5/12	0.185	0.597	0.617	0.638	0.738	0.795	0.886	0.993	1.000	1.000	298		
	5/14–5/31	0.243	0.653	0.689	0.699	0.797	0.844	0.926	0.996	1.000	1.000	691		
		0.059	0.055	0.071	0.061	0.059	0.048	0.040	0.002	0.000	0.000		0.113	0.071
	5/10–5/14	0.198	0.671	0.692	0.706	0.797	0.838	0.907	0.993	1.000	1.000	419		
	5/15–5/31	0.246	0.611	0.649	0.661	0.767	0.823	0.919	0.996	1.000	1.000	570		
		0.048	0.060	0.043	0.045	0.030	0.015	0.012	0.004	0.000	0.000		0.105	0.06

Appendix B. (page 2 of 5)

Year	Sample Period	Age in Years 3	4	5	6	7	8	9	10	11	12–16	n	Critical Value P=0.995	D(max)
		later samples has more age 3												
1977	5/10–5/15	0.174	0.633	0.663	0.679	0.778	0.826	0.896	0.994	1.000	1.000	703		
	5/30–5/31	0.353	0.643	0.678	0.685	0.783	0.836	0.958	0.997	1.000	1.000	286		
		0.180	0.010	0.015	0.007	0.005	0.009	0.062	0.002	0.000	0.000		0.114	0.18
	5/10–5/30	0.221	0.642	0.671	0.686	0.782	0.829	0.910	0.995	1.000	1.000	910		
	5/31	0.278	0.570	0.620	0.620	0.747	0.835	0.962	1.000	1.000	1.000	79		
		0.058	0.072	0.051	0.065	0.036	0.007	0.052	0.005	0.000	0.000		0.191	0.072
			later samples had more age 4											
1978	5/4	0.016	0.302	0.730	0.825	0.889	0.968	0.984	1.000	1.000	1.000	63		
	5/10–5/22	0.146	0.550	0.828	0.854	0.876	0.911	0.946	0.982	0.996	1.000	542		
		0.130	0.248	0.098	0.029	0.013	0.057	0.038	0.018	0.004	0.000		0.217	0.248
			later samples had more age 4											
	5/4–5/10	0.116	0.337	0.768	0.863	0.905	0.958	0.979	1.000	1.000	1.000	95		
	5/19–5/22	0.135	0.559	0.827	0.849	0.873	0.910	0.945	0.980	0.996	1.000	510		
		0.020	0.222	0.059	0.014	0.033	0.048	0.034	0.020	0.004	0.000		0.182	0.222
			later samples had more age 4											
	5/4–5/19	0.102	0.429	0.816	0.898	0.923	0.959	0.974	1.000	1.000	1.000	196		
	5/20–5/22	0.147	0.570	0.819	0.829	0.856	0.897	0.939	0.976	0.995	1.000	409		
		0.045	0.141	0.003	0.069	0.068	0.062	0.036	0.024	0.005	0.000		0.142	0.141
	5/4–5/20	0.149	0.583	0.864	0.916	0.939	0.971	0.981	0.997	1.000	1.000	309		
	5/21–5/22	0.115	0.463	0.770	0.784	0.814	0.861	0.919	0.970	0.993	1.000	296		
		0.034	0.120	0.094	0.132	0.124	0.109	0.062	0.027	0.007	0.000		0.133	0.132
	5/4–5/21	0.135	0.545	0.847	0.882	0.899	0.934	0.959	0.990	0.996	1.000	483		
	5/22	0.123	0.443	0.705	0.730	0.795	0.852	0.918	0.959	1.000	1.000	122		
		0.012	0.102	0.142	0.152	0.103	0.081	0.041	0.031	0.004	0.000		0.165	0.152
1979	5/13	0.116	0.289	0.686	0.901	0.926	0.934	0.959	0.975	0.983	1.000	121		
	5/14–5/25	0.262	0.435	0.714	0.964	0.976	0.994	0.994	1.000	1.000	1.000	168		
		0.146	0.145	0.028	0.063	0.051	0.060	0.035	0.025	0.017	0.000		0.194	0.146
		later samples had more ages 3 and 4												
	5/13–5/14	0.114	0.280	0.646	0.909	0.937	0.949	0.966	0.983	0.989	1.000	175		
	5/15–5/25	0.333	0.518	0.789	0.982	0.982	1.000	1.000	1.000	1.000	1.000	114		
		0.219	0.238	0.144	0.074	0.045	0.051	0.034	0.017	0.011	0.000		0.196	0.238
		later samples had more ages 3 and 4												
	5/13–5/15	0.107	0.299	0.659	0.921	0.944	0.958	0.972	0.986	0.991	1.000	214		
	5/25	0.467	0.587	0.827	0.987	0.987	1.000	1.000	1.000	1.000	1.000	75		
		0.359	0.288	0.168	0.066	0.043	0.042	0.028	0.014	0.009	0.000		0.219	0.359
1985	4/27	0.000	0.042	0.127	0.324	0.493	0.761	0.845	0.930	0.986	1.000	71		
	4/28–5/12	0.002	0.115	0.251	0.466	0.604	0.826	0.908	0.954	0.993	1.000	1011		
		0.002	0.072	0.124	0.142	0.111	0.065	0.063	0.024	0.007	0.000		0.2	0.142
				later samples had more age 5, less ages 7 and 8										
	4/27–4/28	0.000	0.044	0.119	0.270	0.406	0.703	0.863	0.928	0.976	1.000	293		
	4/29–5/12	0.003	0.134	0.289	0.526	0.668	0.866	0.919	0.961	0.999	1.000	789		
		0.003	0.090	0.170	0.256	0.262	0.163	0.055	0.032	0.023	0.000		0.112	0.262
				later samples had more age 5, less ages 7 and 8										
	4/27–4/29	0.000	0.052	0.131	0.295	0.434	0.713	0.861	0.932	0.981	1.000	366		
	4/30–5/12	0.003	0.140	0.300	0.539	0.680	0.877	0.926	0.962	0.999	1.000	716		
		0.003	0.088	0.169	0.244	0.246	0.164	0.065	0.031	0.018	0.000		0.105	0.246

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Appendix B. (page 3 of 5)

Year	Sample Period	Age in Years 3	4	5	6	7	8	9	10	11	12–16	n	Critical Value P=0.995	D(max)
			later samples had more ages 4 through 8											
1985	4/27–4/30	0.000	0.051	0.149	0.322	0.474	0.754	0.876	0.935	0.987	1.000	525		
	5/1–5/12	0.004	0.165	0.332	0.583	0.713	0.885	0.930	0.968	0.998	1.000	557		
		0.004	0.114	0.184	0.262	0.238	0.131	0.054	0.032	0.012	0.000		0.099	0.262
			later samples had more ages 4 through 8											
	4/27–5/1	0.000	0.052	0.156	0.339	0.499	0.768	0.876	0.937	0.991	1.000	749		
	5/7–5/12	0.006	0.240	0.438	0.721	0.817	0.943	0.967	0.985	0.997	1.000	333		
		0.006	0.188	0.282	0.382	0.317	0.175	0.091	0.048	0.006	0.000		0.107	0.382
			later samples had more ages 4 through 8											
	4/27–5/7	0.000	0.072	0.195	0.400	0.552	0.799	0.892	0.945	0.992	1.000	899		
	5/12	0.011	0.295	0.481	0.732	0.820	0.934	0.962	0.984	0.995	1.000	183		
		0.011	0.223	0.286	0.332	0.268	0.136	0.070	0.038	0.002	0.000		0.132	0.332
1986	4/22	0.027	0.040	0.120	0.213	0.400	0.573	0.827	0.907	0.960	1.000	75		
	4/23–5/21	0.127	0.153	0.271	0.373	0.554	0.688	0.870	0.943	0.971	1.000	2224		
		0.100	0.113	0.151	0.160	0.154	0.115	0.043	0.037	0.011	0.000		0.191	0.16
		later samples had more ages 3 through 5, less ages 6 through 7												
	4/22–4/23	0.020	0.024	0.116	0.218	0.454	0.625	0.853	0.922	0.959	1.000	293		
	4/26–5/21	0.139	0.167	0.288	0.390	0.563	0.693	0.871	0.945	0.972	1.000	2006		
		0.118	0.144	0.172	0.171	0.109	0.069	0.018	0.024	0.013	0.000		0.102	0.172
		later samples had more ages 3 through 5, less ages 6 through 8												
	4/22–4/26	0.009	0.041	0.146	0.246	0.439	0.617	0.843	0.933	0.964	1.000	1098		
	4/28–5/21	0.228	0.248	0.376	0.480	0.649	0.746	0.892	0.951	0.977	1.000	1201		
		0.219	0.207	0.230	0.234	0.210	0.129	0.048	0.018	0.013	0.000		0.068	0.234
		later samples had more ages 3 through 5, less ages 6 through 9												
	4/22–4/28	0.008	0.031	0.129	0.236	0.442	0.616	0.839	0.932	0.966	1.000	1598		
	5/2–5/21	0.387	0.419	0.578	0.669	0.792	0.842	0.937	0.964	0.981	1.000	701		
		0.378	0.389	0.449	0.433	0.349	0.226	0.099	0.032	0.016	0.000		0.074	0.449
		later samples had more ages 3 through 5, less ages 6 through 9												
	4/22–5/2	0.009	0.029	0.136	0.249	0.463	0.625	0.843	0.930	0.964	1.000	1913		
	4/19-5/21	0.692	0.744	0.907	0.959	0.977	0.982	0.997	1.000	1.000	1.000	386		
		0.683	0.714	0.770	0.710	0.514	0.357	0.155	0.070	0.036	0.000		0.091	0.77
		later samples had more ages 3 through 5, less ages 6 through 8												
	4/22-5/19	0.086	0.111	0.231	0.338	0.528	0.670	0.862	0.939	0.969	1.000	2191		
	5/21	0.880	0.926	0.963	0.981	0.981	0.981	1.000	1.000	1.000	1.000	108		
		0.793	0.815	0.732	0.644	0.454	0.311	0.138	0.061	0.031	0.000		0.161	0.815
		later samples had more ages 3 through 5												
1987	4/21	0.066	0.183	0.200	0.421	0.566	0.708	0.800	0.911	0.960	1.000	1931		
	4/23	0.135	0.253	0.273	0.409	0.527	0.660	0.755	0.893	0.946	1.000	909		
		0.069	0.070	0.073	0.011	0.039	0.048	0.045	0.018	0.014	0.000		0.066	0.073
		later samples had more ages 3 through 5												
1988	4/19	0.000	0.143	0.387	0.429	0.571	0.790	0.916	0.950	0.992	1.000	119		
	4/20–5/25	0.015	0.280	0.566	0.593	0.740	0.824	0.904	0.938	0.980	1.000	5927		
		0.015	0.137	0.179	0.165	0.169	0.034	0.012	0.011	0.012			0.151	0.179
		later samples had more ages 3 through 5												
	4/19	0.012	0.219	0.485	0.508	0.659	0.793	0.901	0.939	0.993	1.000	425		
	4/20–5/25	0.015	0.281	0.568	0.596	0.743	0.826	0.905	0.939	0.979	1.000	5621		
		0.003	0.063	0.084	0.088	0.084	0.033	0.003	0.000	0.014	0.000		0.082	0.088
		later samples had more ages 3 through 8												
	4/19	0.006	0.273	0.467	0.493	0.664	0.771	0.868	0.918	0.974	1.000	1181		
	4/20–5/25	0.017	0.278	0.586	0.614	0.755	0.836	0.913	0.944	0.982	1.000	4865		
		0.011	0.005	0.119	0.121	0.091	0.065	0.045	0.026	0.008	0.000		0.053	0.121

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Appendix B. (page 4 of 5)

Year	Sample Period	Age in Years 3	4	5	6	7	8	9	10	11	12–16	n	Critical Value P=0.995	D(max)
		later samples had more ages 3 through 9												
1988	4/19–4/25	0.006	0.266	0.454	0.480	0.654	0.763	0.862	0.914	0.971	1.000	1389		
	4/26–5/25	0.017	0.280	0.595	0.623	0.762	0.842	0.917	0.946	0.983	1.000	4657		
		0.010	0.014	0.141	0.143	0.107	0.078	0.055	0.032	0.011	0.000		0.05	0.143
		later samples had more ages 3 through 9												
	4/19–4/26	0.006	0.265	0.466	0.493	0.659	0.761	0.864	0.915	0.970	1.000	1773		
	4/27–5/25	0.018	0.282	0.602	0.630	0.769	0.849	0.921	0.949	0.984	1.000	4273		
		0.013	0.018	0.136	0.138	0.110	0.088	0.058	0.034	0.014	0.000		0.046	0.138
		later samples had more ages 3 through 9												
	4/19–4/27	0.006	0.252	0.456	0.481	0.656	0.760	0.864	0.915	0.971	1.000	2165		
	4/28–5/25	0.020	0.291	0.622	0.651	0.782	0.859	0.927	0.952	0.985	1.000	3881		
		0.014	0.039	0.166	0.170	0.126	0.099	0.063	0.037	0.014	0.000		0.044	0.17
		later samples had more ages 3 through 10												
	4/19–4/28	0.006	0.230	0.441	0.469	0.656	0.763	0.868	0.914	0.972	1.000	3078		
	4/29–5/25	0.023	0.326	0.689	0.715	0.821	0.887	0.942	0.964	0.988	1.000	2968		
		0.017	0.096	0.248	0.246	0.164	0.124	0.074	0.050	0.015	0.000		0.042	0.248
		later samples had more ages 3 through 10												
	4/19–4/29	0.006	0.225	0.438	0.464	0.651	0.759	0.866	0.912	0.972	1.000	3651		
	4/30–5/25	0.027	0.356	0.752	0.782	0.868	0.922	0.964	0.979	0.992	1.000	2395		
		0.021	0.131	0.314	0.318	0.217	0.164	0.098	0.067	0.019	0.000		0.043	0.318
		later samples had more ages 3 through 10												
	4/19–4/30	0.006	0.245	0.459	0.484	0.664	0.768	0.872	0.917	0.974	1.000	4085		
	5/7–5/25	0.033	0.345	0.779	0.812	0.888	0.938	0.971	0.984	0.993	1.000	1961		
		0.028	0.100	0.321	0.328	0.224	0.170	0.099	0.067	0.020	0.000		0.045	0.328
		later samples had more ages 3 through 10												
	4/19–5/7	0.006	0.246	0.465	0.490	0.670	0.776	0.878	0.922	0.975	1.000	4492		
	5/25	0.040	0.367	0.845	0.880	0.930	0.960	0.980	0.987	0.995	1.000	1554		
		0.034	0.122	0.380	0.391	0.260	0.184	0.102	0.065	0.020	0.000		0.048	0.391
1989	4/20	0.002	0.016	0.363	0.564	0.608	0.732	0.814	0.887	0.920	1.000	564		
	4/23–5/4	0.000	0.032	0.394	0.626	0.669	0.796	0.875	0.925	0.958	1.000	2603		
		0.001	0.016	0.030	0.062	0.061	0.063	0.061	0.039	0.038	0.000		0.076	0.063
	4/20–4/22	0.001	0.026	0.402	0.611	0.656	0.768	0.845	0.897	0.931	1.000	1471		
	4/25–5/4	0.001	0.032	0.377	0.618	0.660	0.799	0.880	0.937	0.969	1.000	1696		
		0.000	0.007	0.025	0.007	0.004	0.031	0.035	0.040	0.039	0.000		0.058	0.04
								later samples had more ages 9 and 10						
	4/20–4/25	0.001	0.022	0.393	0.605	0.647	0.766	0.840	0.894	0.934	1.000	1900		
	4/26–5/4	0.001	0.041	0.381	0.630	0.674	0.812	0.900	0.955	0.977	1.000	1267		
		0.000	0.019	0.012	0.025	0.027	0.046	0.060	0.061	0.043	0.000		0.059	0.061
				later samples had less age 5										
	4/20–4/26	0.000	0.025	0.408	0.622	0.664	0.783	0.853	0.905	0.942	1.000	2333		
	4/30–5/4	0.001	0.042	0.335	0.594	0.641	0.788	0.896	0.956	0.978	1.000	834		
		0.001	0.017	0.073	0.029	0.022	0.005	0.043	0.050	0.037	0.000		0.066	0.073
	4/20–4/30	0.001	0.026	0.399	0.619	0.660	0.783	0.860	0.913	0.947	1.000	2740		
	5/4	0.000	0.054	0.319	0.590	0.644	0.794	0.888	0.953	0.979	1.000	427		
		0.001	0.028	0.081	0.028	0.016	0.011	0.027	0.040	0.032	0.000		0.085	0.081
			later samples had more ages 4 and 5											
1990	4/21	0.006	0.020	0.107	0.520	0.769	0.834	0.915	0.964	0.978	1.000	494		
	4/22–5/12	0.043	0.147	0.232	0.548	0.784	0.834	0.907	0.951	0.977	1.000	4485		
		0.037	0.127	0.125	0.028	0.015	0.000	0.008	0.013	0.001	0.000		0.077	0.127

— continued —

Appendix B. (page 5 of 5)

Year	Sample Period	3	4	5	6	7	8	9	10	11	12–16	n	Critical Value P=0.995	D(max)
			later samples had more ages 4 and 5											
1990	4/21–4/22	0.013	0.041	0.116	0.556	0.791	0.848	0.917	0.962	0.979	1.000	1355		
	4/23–5/12	0.050	0.170	0.259	0.541	0.780	0.829	0.904	0.949	0.976	1.000	3624		
		0.037	0.128	0.143	0.014	0.012	0.019	0.014	0.013	0.004	0.000		0.052	0.143
			later samples had more ages 4 and 5											
	4/21–4/23	0.010	0.037	0.110	0.526	0.777	0.842	0.915	0.960	0.979	1.000	1740		
	4/24–5/12	0.056	0.187	0.279	0.556	0.786	0.830	0.903	0.948	0.976	1.000	3239		
		0.045	0.151	0.169	0.030	0.009	0.012	0.012	0.012	0.003	0.000		0.048	0.169
		later samples had more ages 3 through 5												
	4/21–4/24	0.011	0.043	0.110	0.525	0.769	0.834	0.912	0.961	0.980	1.000	1951		
	4/25–5/12	0.058	0.194	0.291	0.558	0.792	0.834	0.905	0.947	0.975	1.000	3028		
		0.047	0.152	0.181	0.033	0.023	0.000	0.007	0.014	0.005	0.000		0.047	0.181
		later samples had more ages 3 through 5												
	4/21–4/25	0.016	0.046	0.115	0.526	0.761	0.827	0.906	0.955	0.979	1.000	2382		
	4/27–5/12	0.062	0.216	0.315	0.563	0.803	0.841	0.909	0.950	0.975	1.000	2597		
		0.046	0.170	0.200	0.038	0.042	0.014	0.004	0.006	0.004	0.000		0.046	0.2
			later samples had more ages 4 and 5											
	4/21–4/27	0.018	0.048	0.115	0.531	0.766	0.829	0.905	0.954	0.979	1.000	2576		
	4/28–5/12	0.063	0.228	0.332	0.561	0.801	0.840	0.910	0.950	0.974	1.000	2403		
		0.045	0.180	0.216	0.030	0.036	0.011	0.004	0.004	0.005	0.000		0.046	0.216
		later samples had more ages 3 through 7												
	4/21–4/28	0.018	0.050	0.115	0.512	0.757	0.821	0.900	0.948	0.975	1.000	2820		
	4/29–5/12	0.069	0.246	0.357	0.589	0.817	0.852	0.917	0.958	0.979	1.000	2159		
		0.051	0.196	0.243	0.077	0.060	0.032	0.017	0.011	0.004	0.000		0.047	0.243
		later samples had more ages 3 through 7, less age 8												
	4/21–4/29	0.019	0.054	0.119	0.508	0.750	0.812	0.896	0.942	0.972	1.000	3135		
	5/9–5/12	0.075	0.272	0.392	0.609	0.838	0.873	0.927	0.970	0.984	1.000	1844		
		0.056	0.218	0.273	0.101	0.088	0.061	0.031	0.028	0.012	0.000		0.048	0.273
			later samples had more ages 4 through 7											
	4/21–5/9	0.025	0.070	0.137	0.518	0.761	0.820	0.900	0.946	0.974	1.000	3476		
	5/11–5/12	0.073	0.284	0.411	0.608	0.834	0.867	0.925	0.966	0.982	1.000	1503		
		0.048	0.214	0.274	0.090	0.073	0.047	0.025	0.020	0.008	0.000		0.05	0.274
				later samples had more age 5										
	4/21–5/11	0.042	0.129	0.211	0.550	0.786	0.837	0.910	0.953	0.977	1.000	4447		
	5/12	0.023	0.180	0.289	0.509	0.756	0.808	0.883	0.947	0.974	1.000	532		
		0.019	0.051	0.078	0.040	0.030	0.029	0.027	0.005	0.003	0.000		0.075	0.078
		later samples had more ages 4 and 5												
1992	4/21	0.000	0.371	0.480	0.564	0.602	0.839	0.916	0.946	0.973	1.000	367		
	4/22–4/24	0.003	0.486	0.612	0.657	0.702	0.880	0.953	0.967	0.985	1.000	1425		
		0.003	0.115	0.132	0.093	0.100	0.041	0.037	0.022	0.012	0.000		0.095	0.132
			later samples had more ages 4 and 5, less ages 6 and 7											
	4/21–4/22	0.000	0.381	0.503	0.576	0.621	0.848	0.934	0.957	0.978	1.000	759		
	4/23–4/24	0.004	0.522	0.645	0.683	0.727	0.889	0.954	0.967	0.985	1.000	1033		
		0.004	0.141	0.141	0.108	0.106	0.040	0.019	0.011	0.008	0.000		0.078	0.141
			later samples had more ages 4 and 5, less ages 6 and 7											
	4/21–4/23	0.001	0.406	0.524	0.582	0.629	0.849	0.936	0.957	0.979	1.000	1321		
	4/24	0.006	0.620	0.756	0.794	0.830	0.934	0.970	0.979	0.992	1.000	471		
		0.006	0.214	0.232	0.212	0.201	0.085	0.034	0.022	0.013	0.000		0.087	0.232

Age in Years: columns 3 through 12–16.