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REPORT ON THE 1987 YAP STATE CENSUS OF POPULATION

VOLUME I

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REPORT ON THE 1987 YAP STATE CENSUS OF POPULATION

Volume II

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PREFACE

It is with pleasure that I present our second publication on the 1987 Yap State Population Census. The present report gives estimates of mortality and fertility derived from the census. Although these estimates are subject to some uncertainty they show that our population is growing relatively fast. Nevertheless, the population is small and our likely population size by the year 2000 is no more than about 13,000.

Our population size before the turn of the century was much bigger than it is today. For Yap proper it has been estimated that there may have been between 40,000 and 50,000 persons in the early nineteenth century. Although such a figure never can be statistically confirmed, it is clear that we have experienced a considerable decline in population size until the end of World War II.

The population is now regaining its strength and we are slowly approaching a point where our population size is in relatively good harmony with our resources. However, in order to ensure that we share the amenities of the new technological world, we must place emphasis on education and accommodate for change towards a new society. This is not easy, for there is no general recipe for human happiness and prosperity. In Yap State our goal must be to preserve our quality of life while at the same time we meet new challenges and demands for modernization. The production of social, economic and demographic statistics for planning, administration and research is an important step in this direction.

Although, perhaps, there is an invisible hand that steers population growth and change, this growth and change must, insofar as is possible, be controlled in a desirable direction. The present report gives data and information on where we are going population wise. It is my hope it will stimulate discussions concerning health care, education and, more generally, discussions about our future.

I wish to express my sincere thanks to Dr Michael Hartmann, Coordinator, FSM National Census Program, for writing the report and to Ben Ruan, Special Assistant to the Governor, for commenting on drafts of the report.

Petrus Tun
Governor Yap State
March 1, 1988

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1.0 INTRODUCTION

1.1 The FSM National Census Program

The 1987 population census in Yap is the first one taken by a local office since the Japanese administration ended in 1945. During the period of the Trust Territory of the Pacific Islands (TTPI), the US Bureau of the Census was delegated the responsibility of census taking. With the formation of the Federated States of Micronesia (FSM) in 1979, the responsibility of census taking became an internal one. Hence, the present census was conducted as part of a National Census Program by the FSM Office of Planning and Statistics in collaboration with the Office of Planning and Budget in Yap. Similar censuses have been carried out in Pohnpei in 1985 and in Kosrae in 1986. Previous population censuses in the TTPI were taken by the US Department of the Navy in 1949-50, by the Office of the High Commissioner in 1958, by the US Bureau of the Census in 1960, 1970 and 1980 and, by the Office of the High Commissioner in 1973.

1.2 Anthropological studies

Over the years several anthropologists have studied Yapese society. Most of the anthropologists who have produced papers on Yap have collected their own data. In fact, anthropologists have collected several sample data sets on various characteristics of the Yapese population. Although it is generally true that these sample data sets have been collected with little reliance on modern sampling methodology, they nevertheless portray several aspects of Yapese society that otherwise would have remained undocumented or subject to speculation. In fact, there can be little doubt that it is due to the efforts of individual American anthropologists that the sociology of Yap is documented to its present extent. From a demographic point of view, however, the anthropological studies have given relatively little information about mortality, fertility and population growth.

1.3 Focus and objectives in the analysis of the 1987 population census

The present analysis of the 1987 Yap State census is not a comprehensive one. Due to time constraints there is no reference to mortality and fertility work carried out by anthropologists. Furthermore, several other sources of information concerning the past population situation in Yap have not been incorporated into the present study. This is especially true of the censuses taken during the Japanese administration which lasted from about 1914 to 1945. The present analysis, by and large, focuses on estimating mortality and fertility from the 1987 census. There is a descriptive analysis of the census tabulations on education, economic activity and socioeconomic status. The report is essentially of a preliminary nature, and is intended to give planners and administrators new population data and results for use in their work. It should be noted, however, that vital registration in the

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* Authored by Michael Hartmann, Coordinator, FSM National Census Program and staff member of the Demographic Section in Statistics Sweden, Stockholm. The author wishes to express his sincere thanks to Robert Retherford, East-West Population Institute, Honolulu, for his constructive comments on the mortality and fertility chapters and the appendix in the report, and to Leif Johansson, Ingrid Lyberg, Tuia Meisaari-Polsa and Ingrid Bergström Levander, Statistics Sweden, for their assistance in reviewing the report. The report was written in Yap during October 1987.

TTPI was incomplete and that it is dubious to what extent historical data could be of use in a retrospective analysis of mortality and fertility. Nevertheless, an analysis incorporating the old Japanese censuses and the ones taken during the TTPI period is warranted at least for historical reasons.

1.4 Demographic estimation in the Pacific island region

As already noted, there is a shortage of demographic data in Yap. This situation, regrettably, is found throughout the Pacific island region (PIR). Although there are more demographic data available in the South than in the North Pacific it is generally true that demographic research in the PIR is sparse. The only, or at least one of the very few, traditional Pacific island nations for which fairly reliable life tables are available is Western Samoa. In most other parts of the PIR, the estimation of life tables is mostly done on the basis of model life table applications. With respect to fertility, the situation is equally unfortunate. Consequently, it must be conceded that years of discussions concerning the need for family planning programs to slow down population growth have been based more so on speculation and Malthusian beliefs than on actual data. It does not follow from this conclusion, of course, that family planning programs in the Pacific are unwarranted. However, it does follow that the need for curbing population growth often has rested on ill-founded beliefs.

1.5 The lack of demographic data and its reflection of current development

In the general context of social and economic development, it is often argued that the presence or absence of elementary demographic data is an indicator of social, economic and cultural development. For instance, according to Brass (1975, p. 1),

"Time series data are very important for population projections, and for understanding changes in such important variables as fertility, especially in relation to the family planning program. This information is generally unavailable in developing countries and, to exaggerate slightly, the presence or absence of such information can be considered as an indication of development of a country."

While this view, no doubt, is widely acknowledged, it must be admitted that in small societies it is much more difficult to promote population studies than in larger ones. How large a population must be in order to exceed the critical limit for establishing a central statistical office, institutions of higher learning, theaters, museums, public libraries and other avenues of civilization, of course, cannot be answered numerically. However, with the formation of the FSM a need was created for population data which did not exist previously. These data needs concern monitoring (1) infant and childhood mortality, (2) adult mortality, (3) the fertility of women, especially with a view to falling fertility, (4) school attendance and educational achievement, (4) changes in the socioeconomic structure, and, (5) overseas migration and, not least, the increased urbanization in Colonia due to outer island settlers. Understanding the changes in the age structure of the population and their implications for the future is also important.

Indeed, serious discussions concerning social, economic and cultural development invariably overlap with discussions concerning population characteristics. Moreover, the fact that most populations in the Pacific are demographically young, i.e. a large proportion of the population is below 15 years of age, especially is an important matter to bear in mind because it implies that, sooner or later, the Pacific will have a large proportion of its population at retirement ages. Falling fertility throughout the PIR is expected to cause a slow but steady increase in the proportion of elderly people. The consequences of this demographic aging must be carefully studied if ongoing and future development plans are to become successful. Given these circumstances, it is important that demographic data and other essential data for planning and administration are produced on a regular basis.

1.6 Data quality and general circumstances affecting data and estimates

In this report we give a collection of statistical tables which supplement the tables given in **Report on the 1987 Yap State Census of Population, Volume I.** (The present report also gives tables on child survival for the Pohnpei 1985 and Kosrae 1986 censuses.) Whereas most of the tabulations in **Volume II** have been made for the present analysis, they may also assist other researchers in gaining insight into the demographic regime of Pohnpei, Kosrae and Yap. In the Statistical Appendix we have given a number of methodological illustrations which we hope will be useful to the readers.

It is our preliminary assessment that the data collected in the censuses of Kosrae (1986) and Yap (1987) are of good quality, i.e. none of the questions asked in these two censuses appears to have been misunderstood by the respondents. For instance, the levels of mortality and fertility reflected by the census data are in good agreement with the corresponding levels given by the TTPI census of 1980.

Given the lack of vital registration data for Yap, it might seem that perhaps we should have identified *own children* in the questionnaires (see e.g. Cho 1973; Cho and Feeney, 1978; Cho, Retherford and Choe, 1986; Levin and Retherford, 1986) and asked questions concerning parental survival (see e.g. Brass, 1975, pp. 67-84). With such data one could apply the own children method of fertility estimation and the technique of estimating adult mortality from parental survival data. The reason why we did not ask these questions in the census was that we wanted to keep the questionnaire as simple as possible. Questions of this nature have not previously been asked in the TTPI censuses and we felt that it would involve too much of a data collection experiment to include them in the new census program. Furthermore, the time available for planning the censuses in Kosrae and Yap was rather limited which gave us little, or no, possibility for field testing the above-mentioned type of census questions.

Because of the smallness of the populations in the FSM, birth and death frequencies are subject to large variation, and one might suspect that, in fact, the populations are too small to give reliable estimates of mortality and fertility with the observational plans provided by the census. Fortunately, our findings do not confirm this view.

Comments concerning the validity of the data are made throughout the text. We feel that this is proper because it is important to the reader to get an impression of the nature of the data weaknesses and in which contexts they appear. Below we highlight some of the difficulties of estimating mortality and fertility from census data.

Mortality

In this report we estimate infant and childhood mortality from child survivorship data obtained in the 1980 TTPI census and in the recent FSM censuses taken in Pohnpei (1985), Kosrae (1986) and Yap (1987). These data reflect a retrospective observational plan where women are asked how many children they have born and how many of the children are still living. From these returns, one may calculate the proportion of deceased children reported by women in different age groups. For women aged between 20 and 25 years, the proportion of deceased children is somewhat higher than infant mortality but, nevertheless, can be used as a (rough) estimate of infant mortality. Assuming that childbearing starts at age 15, the reports from women aged 20-24, refer to a period that goes back between 5 and 10 years. Roughly speaking, one could say that the reference period is the past 7.5 years. The reference period, however, has no direct bearing on the number of person-years lived by each reported child. The reports do not say when the children were born and, if they died before the census, they do not give age at death for the deceased children. Consequently, the traditional statistical/actuarial method of relating vital events (deaths) to person-years cannot be used with this observational plan. Instead, one has to infer from the data the likely proportions of newborn children dying before the ages 1,2,3,4, and 5. This is known as indirect estimation of infant and childhood mortality. The method hinges partly on estimating fertility of women, partly on estimating the underlying (hypothetical) mortality function which, in combination with the fertility function, has generated the proportions of deceased children. The method we have used in the report for estimation of childhood mortality from child survivorship data, as already noted, is outlined in the Statistical Appendix.

The death of a child is always a painful experience to the mother. The reporting of a child death to an enumerator whom the mother may not personally know is a difficult matter. One may suspect that some of the mothers who have been unfortunate enough to lose a child may suppress this information to the enumerators. Specially if the child death is a recent event, the mother may not be psychologically prepared to reveal it to the enumerator. Experiences from e.g. Western Samoa suggest that in some of the censuses the responses to child survivorship data have been rather inaccurate (Hartmann, 1979, pp. 140-144). Here it should not be overlooked that adoption is widespread in the PIR. Children do not necessarily live with their biological parents but may live and grow up with relatives. In Western Samoa, at least in some of the censuses, it would seem that reporting women have included adopted children in their reports on children ever born and children surviving (Banister, 1979, pp. 5-8). This misunderstanding easily occurs if the enumerators, instead of asking how many children a woman has given birth to in her lifetime, asks how many children she has (implicitly meaning how many children she has to take care of).

In the case of the censuses in Kosrae (1986) and in Yap (1987), it was explained during the training of the enumerators how various errors could arise in the reporting of child survivorship data. The enumerators were made aware of the necessity to ask the questions in such a way so as to obtain the correct information. However, enumerating a household is not a simple matter and on some occasions incorrect information, invariably, is recorded in the questionnaires. This is a situation that cannot be helped.

In small populations, there are considerable variations from year to year in recorded infant mortality. With increasing population size, the variations in infant mortality decrease. For large populations, there is little variation. All the populations in Micronesia are small. Consequently, even if accurate vital registration data were available, the figures would display large annual variation. Over a five-year period, the fluctuations would be less pronounced. Given this particular situation, the observational plan of asking women in a census how many children they have born and how many of the children are still alive has some merit because of the cumulation of events. If changes in infant and childhood mortality have been modest in the recent past, the proportions of children dying before the ages 1,2,3,4 and 5 can be estimated with reasonable accuracy. In our estimation of childhood mortality, we focus on children dying before these ages, and denote by q(x) the probability of a child dying before reaching age x. We refer to q(x) as the mortality function.

Because of the incomplete vital registration, we have estimated a life table for Yap from estimates of infant and childhood mortality and by making use of a life table for Western Samoa. The Samoan life table has been adjusted by means of the Brass logit method (Brass, 1971, pp. 69-110) so as to reflect a level of mortality which is in agreement with infant and childhood mortality in Yap in 1987 (see Statistical Appendix). Estimating a life table by means of indirect estimation is not an accurate procedure. However, until such time that accurate data on mortality are obtained either from complete vital registration or from a survey, it is virtually the only possible way of sketching a life table.

Fertility

The comments we have made about the smallness of the population are also valid in the case of fertility. In a small population, there is considerable temporal variation in estimated age-specific fertility rates. If the estimated rates reflect accurate recording, a graduation technique may be used in order to bring out the underlying age-pattern of fertility. In this report we have used a third-degree polynomial to graduate the age-specific fertility rates obtained from census reports on children born during the year before the census.

2.0 MORTALITY

2.1 The Western Samoa Vital Statistics Sample Survey

The mortality of human beings is closely related to the quality of life they enjoy. Monitoring changes in mortality, to a large extent, is tantamount to monitoring the well being of society. In the PIR relatively little is known about mortality. Because discussions concerning the significance of different levels of mortality inevitably must be relative, we have decided to make use of some of the data collected in the Western Samoa Vital Statistics Sample Survey. This survey was started in 1975 in response to a demand for reliable data on mortality and fertility. Between 1975 and 1983, the survey brought out data for assessment of mortality, fertility and migration. The choice of the Samoan data is more or less dictated by the fact that it is the only small island population in the PIR for which we have mortality and fertility data of reasonable quality.

The Vital Statistics Sample Survey in Western Samoa contacted 10 percent of the households. The persons included in the samples were asked questions concerning mortality, fertility and migration during retrospective reference periods. The reference period in the 1975 survey was about 3.5 years. In the surveys taken in 1981, 1982 and 1983, the reference periods were about half a year long, i.e. the survey population was contacted twice a year. The interviewers recorded if a woman had given birth to a child, if a person in the household had died and, in particular, if a newborn had died. It was also recorded if persons had moved out from the sample population.

Even though it is clear that Western Samoa not necessarily has the same mortality pattern as Yap, the mortality experiences recorded by the survey are, nevertheless, a better basis for comparison than those afforded by traditional model life tables. The reason for this is that e.g. the Coale-Demeny model life tables (Coale and Demeny, 1966) reflect a combination of childhood and adult mortality that appears to be uncommon in the Pacific. More specifically, for a given life expectancy (level of mortality) in the Coale-Demeny model life tables, infant and childhood mortality is much higher than in e.g. the life tables for Western Samoa. In our view, the Western Samoa life tables are more expressive of mortality in Micronesia than existing model life tables. Relative to Swedish life tables, the life tables for Western Samoa are characterized by low infant mortality and high adolescent and adult mortality.

While it is outside the scope of the present report to analyze the Western Samoa Vital Statistics Sample Survey (VSSS) data in detail, the data clearly suggest that there have been modest improvements in mortality in Western Samoa during the ten-year period 1975-1984. The life expectancy has remained more or less constant, and improvements in infant and childhood mortality have been marginal. Our reference-data reflect a stability which we think is also found in Yap. To further the discussion, we give the life tables brought out by the VSSS data (Tables 1, 2 and 3).

Table 1.-Life table for Western Samoa, 1975*

Age	$\hat{m}_x$	$\hat{q}_x$	$\hat{p}_x$	$\hat{s}(x)$	$\hat{L}(x)$	$\hat{T}(x)$	$\hat{e}(x)$
MALES							
0		0.0400	0.9600	1.0000	0.9660	59.9	59.9
1-4	0.0054	0.0214	0.9786	0.9660	3.7990	58.9	61.4
5-14	0.0004	0.0040	0.9960	0.9395	9.3760	55.1	58.7
15-24	0.0043	0.0421	0.9579	0.9357	9.1600	45.8	48.9
25-34	0.0052	0.0507	0.9493	0.8963	8.7360	36.6	40.8
35-44	0.0032	0.0315	0.9685	0.8509	8.3750	27.6	32.7
45-54	0.0143	0.1332	0.8668	0.8241	7.6920	19.5	23.6
55-64	0.0345	0.2918	0.7082	0.7143	6.1010	11.8	16.5
65-74	0.0566	0.4322	0.5678	0.5059	3.9655	5.7	11.2
75+	0.0599			0.2872	1.7232	1.7	6.0
FEMALES							
0		0.0300	0.9700	1.0000	0.9745	65.0	65.0
1-4	0.0066	0.0261	0.9739	0.9700	3.8294	64.0	66.0
5-14	0.0009	0.0090	0.9910	0.9447	9.4045	60.2	63.7
15-24	0.0014	0.0139	0.9861	0.9362	9.2970	50.8	54.2
25-34	0.0031	0.0305	0.9695	0.9232	9.0910	41.5	44.9
35-44	0.0055	0.0535	0.9465	0.8950	8.7105	32.4	36.2
45-54	0.0059	0.0573	0.9427	0.8471	8.2285	23.7	28.0
55-64	0.0192	0.1747	0.8253	0.7986	7.2885	15.4	19.3
65-74	0.0566	0.4322	0.5678	0.6591	5.1665	8.2	12.4
75+	0.0821			0.3742	2.9936	3.0	8.0
BOTH SEXES							
0		0.0350	0.9650	1.0000	0.9703	62.3	62.3
1-4	0.0060	0.0237	0.9763	0.9650	3.8142	61.4	63.6
5-14	0.0007	0.0070	0.9930	0.9421	9.3880	57.6	61.1
15-24	0.0029	0.0286	0.9714	0.9355	9.2215	48.2	51.5
25-34	0.0041	0.0402	0.9598	0.9088	8.9050	38.9	42.9
35-44	0.0044	0.0430	0.9570	0.8722	8.5345	30.0	34.4
45-54	0.0101	0.0961	0.9039	0.8347	7.9460	21.5	25.8
55-64	0.0273	0.2389	0.7611	0.7545	6.6440	13.6	18.0
65-74	0.0566	0.4132	0.5868	0.5743	4.5565	6.9	12.0
75+	0.0722			0.3370	2.3590	2.4	7.0

*

Vital events and person-years were obtained from the sample data and used for estimation of age-specific mortality and fertility rates (Vital Statistics Sample Survey Report, 1975, 1982 and 1983. Department of Statistics, Apia, Western Samoa).

The central death rate for the age interval [x,x+n] is denoted ${}_nm_x$. The central death rate is the number of deaths occurring between ages x and x+n divided by the number of person-years lived by the population while at ages x to x+n. Denoting this number of deaths by ${}_nD_x$ and the

Since the data come from a survey of 10 percent of the households in Western Samoa, there is, of course, a sampling variance attached to each of the estimated life table functions. A statistical test which takes into account the number of person-years lived by the survey population does not lead to a rejection of the hypothesis that the central death rates were constant from period to period. A similar test shows that there is a significant difference in mortality between males and females. Consequently, the sample size of 10 percent was big enough to capture this common sex differential in mortality. Because it would burden the report unnecessarily to delve into the details of testing for differences between the experiences, we have abstained from illustrating it in the present context. Nevertheless, we emphasize that the survey appears to have brought out reliable data. Notice, for example, that the estimated life expectancies, (and the estimated infant mortality rates) are in good agreement with one another (Table 4). In the absence of reliable vital registration data for Yap, it seems reasonable, therefore, to use the Western Samoa life tables as a reference for discussing mortality. As such we focus on the levels of mortality in Western Samoa between 1975 and 1983 and in Yap around 1987. We begin our mortality discussion by studying infant and childhood mortality estimated from the 1980 TTPI censuses and the recent censuses from Pohnpei (1985), Kosrae (1986) and Yap (1987).

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corresponding number of person-years lived by the population at risk by ${}_nR_x$, the central death rate is ${}_nm_x = {}_nD_x/{}_nR_x$. The probability for a person aged x to die before reaching age x+n is denoted ${}_nq_x$. The probability for a person aged x to survive to age x+n is ${}_np_x = 1 - {}_nq_x$. For n = 1, we write q_x. The annual probability of death is estimated from the central death rate by letting ${}_nq_x = 1 - \exp(-n\,{}_nm_x)$ which assumes that the central death rate is constant on [x,x+n[. The survival function s(x) gives the probability for a person aged 0 to survive to age x. The survival function is $s(x) = \prod_{i=0}^{x-1} {}_np_i$. The number of person-years lived by a person in the life-table population between ages x and x+n is $L(x) = n\{[s(x) + s(x+n)]/2\}$. For estimation of the life expectancy at age x, we let $T(x) = \sum_{i=x}^{75} L(i)$, where we assume $L(75+)/s(75) = 6$ years for males, and $L(75+)/s(75) = 8$ years for females. The latter assumptions are of marginal importance for estimating the life expectancy. For the first year of life, we let $L(0) = 0.15 + 0.85\, s(1)$. The life expectancy at age x, is $e(x) = T(x)/s(x)$. We also write e_0 for e(0). In the survey, it was noted how many babies survived one year, and q_0 was estimated directly from that proportion. For this reason m_0 is not given in the life tables. For the remaining age groups, ${}_nq_x$ was estimated from ${}_nm_x$. The data were obtained from Vital Statistics Sample Survey Report, 1975. Department of Statistics, Apia, Western Samoa. Throughout a circumflex (^) is used to denote an observed or estimated quantity.

Table 2.-Life table for Western Samoa, 1981-82*

Age	$\hat{m}_x$	$\hat{q}_x$	$\hat{p}_x$	$\hat{s}(x)$	$\hat{L}(x)$	$\hat{T}(x)$	$\hat{e}(x)$
~~BOTH SEXES~~							
0		0.0417	0.9593	1.0000	0.9654	61.41	61.4
1-4	0.0051	0.0202	0.9798	0.9593	3.7984	60.44	63.0
5-14	0.0002	0.0020	0.9980	0.9399	9.3895	56.64	60.3
15-24	0.0033	0.0325	0.9675	0.9380	9.2280	47.26	50.4
25-34	0.0028	0.0276	0.9724	0.9076	8.9505	38.03	41.9
35-44	0.0054	0.0526	0.9474	0.8825	8.5930	29.08	32.9
45-54	0.0189	0.1722	0.8278	0.8361	7.6410	20.48	24.5
55-64	0.0238	0.2118	0.7882	0.6921	6.1880	12.84	18.6
65-74	0.0511	0.4001	0.5999	0.5455	4.3640	6.66	12.2
75+	0.1290			0.3273	2.2911	2.29	7.0

*

The survey report, Vital Statistics Sample Survey Report, 1982. Department of Statistics, Apia, Western Samoa, only gives data for both sexes.

Table 3.-Life table for Western Samoa, 1982-83*.

Age	$\hat{m}_x$	$\hat{q}_x$	$\hat{p}_x$	$\hat{s}(x)$	$\hat{L}(x)$	$\hat{T}(x)$	$\hat{e}(x)$
MALES							
0		0.0415	0.9585	1.0000	0.9647	60.64	60.6
1-4	0.0047	0.0186	0.9814	0.9585	3.7984	59.68	62.3
5-14	0.0008	0.0080	0.9920	0.9407	9.3690	55.88	59.4
15-24	0.0030	0.0296	0.9704	0.9331	9.1930	46.51	49.8
25-34	0.0013	0.0129	0.9871	0.9055	8.9965	37.32	41.2
35-44	0.0036	0.0354	0.9646	0.8938	8.7800	28.32	31.7
45-54	0.0211	0.1902	0.8098	0.8622	7.8020	19.54	22.7
55-64	0.0360	0.3023	0.6977	0.6982	5.9265	11.74	16.8
65-74	0.0462	0.3700	0.6300	0.4871	3.9700	5.81	11.9
75+	0.1061			0.3069	1.8414	1.84	6.0

Table 3.-Life table for Western Samoa, 1982-83*, Cont'd

Age	$\hat{m}_x$	$\hat{q}_x$	$\hat{p}_x$	$\hat{s}(x)$	$\hat{L}(x)$	$\hat{T}(x)$	$\hat{e}(x)$
FEMALES							
0		0.0238	0.9762	1.0000	0.9798	66.11	66.1
1-4	0.0045	0.0178	0.9822	0.9762	3.8700	65.13	66.7
5-14	0.0007	0.0070	0.9930	0.9588	9.5545	61.26	63.9
15-24	0.0010	0.0100	0.9900	0.9521	9.4735	51.71	54.3
25-34	0.0013	0.0129	0.9871	0.9426	9.3650	42.23	44.8
35-44	0.0034	0.0334	0.9666	0.9304	9.1490	32.87	35.3
45-54	0.0124	0.1166	0.8834	0.8994	8.4695	23.72	26.4
55-64	0.0245	0.2173	0.7827	0.7945	7.0815	15.25	19.2
65-74	0.0478	0.3800	0.6200	0.6218	5.0555	8.12	13.1
75+	0.1593			0.3893	3.1144	3.11	8.0
BOTH SEXES							
0		0.0330	0.9670	1.0000	0.9720	63.15	63.1
1-4	0.0046	0.0182	0.9818	0.9670	3.8328	62.18	64.3
5-14	0.0008	0.0080	0.9920	0.9494	9.4560	58.34	61.5
15-24	0.0020	0.0198	0.9802	0.9418	9.3250	48.89	51.9
25-34	0.0013	0.0129	0.9871	0.9232	9.1720	39.56	42.9
35-44	0.0035	0.0344	0.9656	0.9112	8.9555	30.39	33.4
45-54	0.0168	0.1546	0.8454	0.8799	8.1190	21.43	24.4
55-64	0.0305	0.2629	0.7371	0.7439	6.4615	13.32	17.9
65-74	0.0470	0.3750	0.6250	0.5484	4.4555	6.85	12.5
75+	0.1369			0.3427	2.3989	2.39	7.0

*

Source: Vital Statistics Sample Survey Report, 1983. Department of Statistics, Apia, Western Samoa. Survey data for later periods are not available.

Table 4.-Life expectancies and infant mortality in Western Samoa 1975-1983

	Infant mortality $\hat{q}_0$	Life expectancy $\hat{e}_0$
1975		
Both sexes	0.035	62.3
Males	0.040	59.9
Females	0.030	65.0
1981-82		
Both sexes	0.042	61.4
1982-83		
Both sexes	0.033	63.1
Males	0.042	60.6
Females	0.024	66.1

2.2 Infant and childhood mortality estimated from the 1980 TTPI population census

The child survival data for Kosrae, Pohnpei, Truk and Yap are given in Table 5. This table also shows the average number of live births per women in the broad age groups 15-19, 20-24, and 25-29. These averages are referred to as mean parities. For example, women between the ages of 25 and 30 in Kosrae in 1980 reported an average of 2.2353 children[1]. More specifically, there were 204 women in this age group. They reported that they had given birth to 456 children of whom 436 were alive at the time of the census. For the age group 20-24, 263 women in Kosrae in 1980 reported that they had given birth to 238 children of whom 224 were alive at the time of the census. This means that women in the age group 20-24 reported that 5.88 percent of their children had died. It is from such a measure that one can estimate infant mortality which is defined as the proportion of live born children surviving one year. The estimate, however, needs to take into account the mean age at childbearing for women.

For Kosrae in 1980, a first (rough) estimate of infant mortality would be 58.8 per 1,000 live births. The technique of estimating infant mortality from the proportion of deceased children reported by women between the ages of 20 and 25 is one of adjusting this proportion so that it agrees with infant mortality. Before we embark on actual estimation of infant and childhood mortality, we comment on the characteristics of the collected child survivorship data.

We notice (Table 5) that the proportions of deceased children vary relatively little from district to district. If the proportions of deceased children reported by women aged

[1] In several of the calculations shown in this report we give results with four decimal places. This has merely been done for computational convenience. It does not suggest that the accuracy is of that order.

20-24 had exhibited large variation, this might have implied the existence of widely different health environments in Micronesia. (Alternatively it might imply that the populations are too small for meaningful analysis with the given observational plan and estimation technique). However, since the environments in Micronesia with respect to education and health are known to be relatively uniform, we would not expect a large variation in infant and childhood mortality between Kosrae, Pohnpei, Truk and Yap. We may, therefore, be relatively confident that the data in Table 5 depict a realistic picture of infant and childhood mortality.

We will now comment on the mortality functions (Table 6) estimated from the data in Table 5[2]. (As already noted, the estimation technique is given in the Statistical Appendix.)

According to our estimates, Truk has the highest infant mortality, namely 56.1 per 1,000 live births. Kosrae is a little lower with 53.6. Yap and Pohnpei appear to fall in the same group with estimates of 43.3 and 43.2, per 1,000 population, respectively. Before we comment further on the mortality estimates from the 1980 census, we turn to the estimates from the census in Pohnpei (1985), Kosrae (1986) and Yap (1987).

2.3 Infant and childhood mortality estimated from the FSM population censuses

Tables 7, 8 and 9 give the child survivorship data by single-year ages of women. The immediate advantage of doing this is that the smallness of the figures is brought out. Especially for Kosrae and Yap, the number of reporting women is very small. Consequently, one might suspect that even though the observational plan is retrospective, so that each woman in the age group 20-24 reports on fertility experiences that go back in time between five and ten years, the numbers are too small to give the stability necessary for accurate estimation of childhood mortality. We believe the uniformity of the above-mentioned estimates as well as the ensuing discussion rejects this possibility. Table 10 summarizes the estimated mortality functions. We notice that among the four FSM states, Kosrae has the highest infant mortality (49.3 per 1,000), followed by Pohnpei (46.3 per 1,000) and Yap (44.6 per 1,000). When separating Yap into Yap proper and Yap outer islands, we notice a clear differential in infant and childhood mortality. For the outer islands, infant mortality is of the order 57 per 1,000 live births. For Yap proper, it is 39 per 1,000 live births. Despite the fact that the estimates are affected by some uncertainty, the difference between the estimates for the outer islands and Yap proper, without doubt, reflects a reality. The fact that the data have captured this (obvious) mortality differential speaks well in favor of their reliability.

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[2] In Tables 5, 6 and 7, μ indicates the mean age of the observed fertility schedule for women and P_i, $i = 1, 2$ and 3 the mean parities for the age groups 15-19, 20-24 and 25-29, respectively. D_2 denotes the proportion of deceased children reported by women aged 20-24.

Table 5.-Child survival for Kosrae, Pohnpei, Truk and Yap recorded in the 1980 TTPI population census

Age	Women	Children ever born	Surviving children	Mean parity
Kosrae				
15-19	283	12	12	0.0424
20-24	263	238	224	0.9049
25-29	204	456	436	2.2353
$\hat{P}_1/\hat{P}_2 = 0.0469$;	$\hat{P}_2/\hat{P}_3 = 0.4048$			
$\hat{\mu} = 29$;			$\hat{D}_2 = 0.0588$	
Pohnpei				
15-19	1,154	253	241	0.2192
20-24	993	1,415	1,347	1.4250
25-29	788	2,277	2,170	2.8896
$\hat{P}_1/\hat{P}_2 = 0.1538$;	$\hat{P}_2/\hat{P}_3 = 0.4931$			
$\hat{\mu} = 27$			$\hat{D}_2 = 0.0481$	
Truk				
15-19	1,978	292	269	0.1476
20-24	1,657	1,803	1,692	1.0881
25-29	1,419	3,750	3,510	2.6427
$\hat{P}_1/\hat{P}_2 = 0.1356$;	$\hat{P}_2/\hat{P}_3 = 0.4117$			
$\hat{\mu} = 29$			$\hat{D}_2 = 0.0616$	
Yap				
15-19	371	72	70	0.1941
20-24	388	513	488	1.3222
25-29	327	830	779	2.5382
$\hat{P}_1/\hat{P}_2 = 01468$;	$\hat{P}_2/\hat{P}_3 = 0.5209$			
$\hat{\mu} = 26$			$\hat{D}_2 = 0.0487$	

Table 6.-Estimates of infant and childhood mortality obtained from the 1980 TTPI population census

District	Estimated mortality function				
	$\hat{q}(1)$	$\hat{q}(2)$	$\hat{q}(3)$	$\hat{q}(4)$	$\hat{q}(5)$
Kosrae	0.0536	0.0592	0.0627	0.0654	0.0675
Pohnpei	0.0432	0.0477	0.0505	0.0527	0.0544
Truk	0.0561	0.0620	0.0657	0.0685	0.0707
Yap	0.0433	0.0478	0.0507	0.0528	0.0545

Table 7.-Child survival for Pohnpei recorded in the 1985 FSM population census

Age	Women	Children ever born	Surviving children	Mean parity
15	333	9	9	
16	329	23	19	
17	303	49	46	
18	266	83	77	
19	291	156	149	
15-19	1,522	320	300	0.2102
20	253	222	215	
21	249	254	238	
22	227	308	290	
23	264	398	381	
24	229	425	400	
20-24	1,222	1,607	1,524	1.3151
25	230	506	472	
26	212	577	537	
27	219	633	578	
28	214	637	604	
29	199	689	655	
25-29	1,074	3,042	2,846	2.8324

$\hat{P}_1/\hat{P}_2 = 0.1598$; $\hat{P}_2/\hat{P}_3 = 0.4643$

$\hat{\mu} = 27$ $\hat{D}_2 = 0.0516$

Source: FSM Office of Planning and Statistics, Pohnpei.

Table 8.-Child survival for Kosrae recorded in the 1986 FSM population census

Age	Women	Children ever born	Surviving children	Mean parity
~~15~~	~~65~~	~~2~~	~~2~~	
16	95	1	1	
17	72	7	7	
18	68	9	8	
19	52	8	8	
15-19	352	27	26	0.0767
20	69	29	27	
21	45	22	20	
22	55	30	29	
23	61	80	76	
24	44	44	42	
20-24	274	205	194	0.7482
25	47	83	78	
26	56	102	100	
27	44	113	103	
28	53	172	154	
29	47	146	137	
25-29	247	616	572	2.4939

$\hat{P}_1/\hat{P}_2 = 0.1025$; $\hat{P}_2/\hat{P}_3 = 0.3000$

$\hat{\mu} = 31$ $\hat{D}_2 = 0.0537$

Source: FSM Office of Planning and Statistics, Pohnpei.

Table 9.-Child survival for Yap State, Yap proper and Yap outer islands recorded in the 1987 FSM population census

Age	Women	Children ever born	Surviving children	Mean parity
Yap State				
15	94	4	3	
16	85	6	6	
17	106	16	16	
18	102	29	26	
19	84	35	33	
15-19	471	90	84	0.1911
20	99	83	79	
21	69	61	61	
22	73	68	64	
23	111	134	125	
24	83	137	130	
20-24	435	483	459	1.1103
25	83	136	130	
26	91	175	166	
27	68	151	146	
28	91	238	222	
29	81	232	215	
25-29	414	932	879	2.2512

$\hat{P}_1/\hat{P}_2 = 0.1721$; $\hat{P}_2/\hat{P}_3 = 0.4932$

$\hat{\mu} = 27$ $\hat{D}_2 = 0.0497$

Source: Office of Planning and Budget, Yap.

Table 9.-Child survival for Yap State, Yap proper and Yap outer islands recorded in the 1987 FSM population census, Cont'd

Age	Women	Children ever born	Surviving children	Mean parity
Yap proper				
15-19	201	59	54	0.2100
20-24	286	340	325	1.1888
25-29	280	642	611	2.2929

$\hat{P}_1/\hat{P}_2 = 0.1766$; $\hat{P}_2/\hat{P}_3 = 0.5185$

$\hat{\mu} = 26$ $\hat{D}_2 = 0.0441$

Age	Women	Children ever born	Surviving children	Mean parity
Yap outer islands				
15-19	190	31	30	0.1632
20-24	149	143	134	0.9597
25-29	134	290	268	2.1642

$\hat{P}_1/\hat{P}_2 = 0.1701$; $\hat{P}_2/\hat{P}_3 = 0.4434$

$\hat{\mu} = 28$ $\hat{D}_2 = 0.0629$

Source: Office of Planning and Budget, Yap.

Table 10.-Estimated infant and childhood mortality for Kosrae, Pohnpei and Yap based on the 1985-87 FSM population censuses

District	Estimated mortality function $\hat{q}(1)$	$\hat{q}(2)$	$\hat{q}(3)$	$\hat{q}(4)$	$\hat{q}(5)$
Kosrae	0.0491	0.0545	0.0578	0.0602	0.0621
Pohnpei	0.0463	0.0512	0.0542	0.0565	0.0583
Yap State	0.0446	0.0493	0.0522	0.0544	0.0562
Yap proper	0.0392	0.0433	0.0459	0.0478	0.0494
Yap outer islands	0.0568	0.0627	0.0665	0.0693	0.0715
Yap State*	0.0484	0.0536	0.0568	0.0591	0.0610

* This is a an estimate that builds on an estimate of Yapese current fertility with $\hat{\mu} = 29.6$ (see Statistical Appendix). Because we believe this choice of fertility function to be better than the one inferred from the ratio of mean parities, we accept this mortality estimate as our final estimate of infant and childhood mortality in Yap around 1987.

Because the estimation of infant and childhood mortality from child survivorship data depends on the underlying fertility function, we have given an estimate of q for Yap State in Table 10 (*) which builds on the fertility function estimated from the census returns on children born during the year before the census. (The calculations are given in the Statistical Appendix). These estimates point to an infant mortality rate of about 48 per 1,000 live births.

As judged from the estimates in Tables 4 and 10, infant and childhood mortality in the FSM is high relative to Western Samoa, and it would seem that there have been no improvements since 1980. This suggests an interesting similarity to Western Samoa where mortality improvements appear to have been very modest since 1975.

From the point of view of developing countries in general, the PIR enjoys relatively low infant and childhood mortality. Here it must be noted that famine, severe droughts and the miserable living conditions of e.g. African nations are unknown in the PIR.

Current levels of infant mortality in industrialized countries, of course, are much lower. In Sweden and Japan, countries with very low infant mortality, only about 6 per 1,000 live births die before reaching age one (Statistics Sweden, 1986, p. 36). While it is true that the FSM hardly could bring down infant mortality to such levels, it is, nevertheless, true that given a better dissemination of health education to mothers and of health care services in general, infant and childhood mortality could be halved before the year 2000.

2.4 A life table for both sexes for Yap around 1987

Table 11 gives a life table that has been estimated by means of the Brass logit life table approach (Brass, 1975, pp. 85-105). As a standard life table we have used the life ~~table for both sexes for Western Samoa for the period 1981-82 (Table 2). (T~~he calculations are given in the Statistical Appendix). The table gives a life expectancy of 59.9 years for both sexes. How well the table describes Yapese mortality is, to some extent, a matter of conjecture. We do not believe, however, that the estimated life expectancy is in error by more than about two years, i.e. the life expectancy in Yap could be as low as 57.9 years but no higher than about 61.9 years. For males we would estimate the life expectancy at about 58 years and for females at about 62 years.

Here it is not amiss to focus on the mortality differential between males and females. In the case of the Samoan life tables, the estimated differential was about 5.1 years about 1975 and 5.5 years about 1983 (Table 4). The estimated differentials are higher than one would expect on the basis of e.g. model life tables. The large difference in life expectancies between Samoan males and females, of course, is a reflection of the large differential in infant and childhood mortality between boys and girls (Table 4). But whether in Samoa infant mortality for girls is about half of that for boys (Table 4), of course, is difficult to tell in the absence of more detailed data. However, that there is an unusually large mortality differential between Samoan men and women is almost certainly true. Part of the excess male mortality could be due to over consumption of alcohol (a health problem of increasing and alarming significance throughout the PIR). In the case of Western Samoa it should also be noted that suicide rates for men are known to be very high.

In the case of Yap, we believe that the mortality differential between men and women is of the order of four years. Admittedly, this is a guess that cannot be supported by existing survival records for Yap. It is, however, supported by e.g. model life tables.

The errors in the estimated life table (Table 11) come from two principal sources. First, estimating a life table from infant and childhood mortality always carries with it a degree of uncertainty (see e.g. Gabriel and Ronen, 1959, pp. 164-165). Second, the standard life table (the life table for both sexes for Western Samoa, 1981-82) is not a graduated table. There are some anomalies in it, e.g. that the central death rate for the ages 25-34 ($_{10}\hat{m}_{25} = 0.0028$) is less than for the ages 15-24 ($_{10}\hat{m}_{15} = 0.0033$). Nevertheless, despite irregularities in the central death rates, the survival function, from which the life expectancy is estimated, is relatively smooth. Therefore, the fluctuations in the central death rates more or less cancel in the estimation of the life expectancy.

Since infant and childhood mortality is relatively high, the life expectancy in the life table estimated for Yap is low. On the outer islands, the much higher infant mortality, no doubt, reflects a life table with a relatively lower life expectancy.

Current life expectancies in Sweden and Japan are about 74 years for men and 80 years for females (Statistics Sweden, 1986, p. 36). This shows that there is considerable latitude for improving mortality at all ages on Yap proper and, especially, on the outer islands. Increasing the life expectancy and general health of Yapese men and women should be seen as a health services priority during the coming years.

Table 11.-Estimated life table for both sexes in Yap around 1987

Age x	Estimated survival function $\hat{s}(x)$	Person-years lived in life-table population $\hat{L}(x)$*	Sum of person-years $\hat{T}(x)$	Estimated life expectancy $\hat{e}(x)$
0	1.0000	0.9610	59.9308	59.9
1	0.9541	3.7730	58.9698	61.8
5	0.9324	9.3135	55.1968	59.2
15	0.9303	9.1340	45.8833	49.3
25	0.8965	8.8270	36.7493	41.0
35	0.8689	8.4355	27.9223	32.1
45	0.8182	7.4150	19.4868	23.8
55	0.6648	5.8955	12.0718	18.2
65	0.5143	4.0735	6.1763	12.0
75	0.3004	2.1028	2.1028	7.0

* $\hat{L}_0 = 0.15 + 0.85\,\hat{s}(1)$. Infant mortality in the life table is a little lower than in Table 10 where the final estimate is given as $\hat{q}_0 = 0.0484$. The reason for this discrepancy is that all the estimates below age 5 (q^* in Table 10) have been used to fit the standard life table (see Statistical Appendix). In our exposition, we have made use of the survival function s. The number-living column of the life table (with a radix of 1,000) is $l_x = 1{,}000\ s(x)$. Thus at e.g. age 65 there are 514 survivors meaning that little more than about half a birth cohort survives beyond age 65.

2.5 The crude death rate for Yap around 1987

The estimated central death rates[3] for Yap are given in Table 12 which also illustrates the estimation of the crude death rate. The crude death rate is estimated at 11.2 per 1,000 population per year.

Table 12.-Estimated central death rates for Yap and estimation of the crude death rate around 1987

Age x	Population in age group x to x+n	Estimated central death rate $_n\hat{m}_x$	Estimated number of annual deaths in age group x to x+n
0	310	0.0478	15
1-4	1,230	0.0058	7
5-14	2,727	0.0002	1
15-24	1,746	0.0037	7
25-34	1,599	0.0031	5
35-44	916	0.0060	6
45-54	591	0.0207	12
55-64	469	0.0255	12
65-74	335	0.0525	18
75+	216	0.1429	31
Total	10,139		114

Estimated number of annual deaths: 114
Estimated crude death rate: 114/10,139 = 11.2 per 1,000 population

2.6 Completeness of death registration in Yap around 1987

The registered deaths between 1980 and 1985 are given in Table 13. During this period a total of 415 deaths were registered. Assuming that the crude death rate between 1980 and 1985 was close to 11.2 per 1,000 population, the estimated total number of deaths becomes 591. This means that death registration was about {415/591} X 100 = 70.2 percent complete. Even if this is an approximation to the completeness of death registration, it points to death registration being too incomplete for demographic estimation purposes. The degree of registration, however, is better than in Western Samoa about 1982

[3] Estimated by letting $_nm_x = [s(x) - s(x+n)] / {}_nL_x$.

when it was estimated that about 39 percent of the deaths were registered (Vital Statistics Sample Survey Report, 1983, Department of Statistics, Apia, Western Samoa).

Table 13.-Registered total number of deaths for the period 1980-85

Year	Total number of registered deaths	Registered infant deaths	Estimated* population
1980	99	23	8,100
1981	60	13	8,365
1982	92	19	8,637
1983	69	17	8,919
1984	44	11	9,210
1985	51	13	9,510

Total registered deaths between 1980 and 1985: 415

*

The population was estimated by assuming exponential growth between 1980, when the enumerated population was 8,100, and 1987 when the enumerated population was 10,139. Source: Yap State Statistical Bulletin, 1985. Office of Planning and Budget, P.O. Box 471, Colonia, Yap, Western Caroline Islands 96943.

3.0 FERTILITY

3.1 Age-specific fertility rates for Yap estimated from the 1987 census

In the censuses in Kosrae and Yap, women aged 15 and over were asked if they had given birth to a child during the past year. A total of 300 births was recorded for Yap during the period 23 March 1986 to 22 March 1987.

Retrospective questions concerning child births often give poor responses. For instance, in the Western Samoa censuses the question concerning childbirth during the twelve months before the census have given data of relatively little value for estimation of fertility. This was also one of the main reasons for taking the vital statistics sample survey. Of course, much hinges on the extent to which the census enumerators are trained and how motivated they are to obtain accurate information. In the case of taking a survey, one of the advantages is that interviewers can be selected and trained to a much better extent than for the taking of a population census. In the case of Yap and Kosrae, it was emphasized to the enumerators that they would have to probe well into the question of childbirth during the year before the census if useful data were to be obtained.

When estimating fertility rates for a small number of women, one is faced with considerable variation in the individual rates. It is necessary therefore to graduate the rates in order to use them for meaningful estimation. Graduating the observed rates (Table 14) by means of a third-degree polynomial, gives new (graduated) rates for which the mean age is $\hat{\mu}$ = 29.5 years and the variance is $\hat{\sigma}^2$ = 55.0. The total fertility rate for the graduated rates is $\hat{R}$ = 4.0540 (see Statistical Appendix). It will be seen that the graduated rates do not display the anomaly of the observed ones where the maximum rate is in the age group 30-34.

The estimated total fertility rate gives the number of children a woman would give birth to if she were to survive to the end of the reproductive period, i.e. if she were to survive to age 50. In Yap State in 1986-87, our prior estimate is that women, on average, produce 4.05 children. This estimate, however, may be a little on the low side.

Table 14.-Age-specific fertility estimated from the 1987 Yap Census

Age (1)	Women (2)	Childbirths (3)	Observed fertility rate (4)	Graduated fertility rate (5)
15-19	471	39	0.0828	0.0786
20-24	435	71	0.1632	0.1700
25-29	414	76	0.1836	0.1945
30-34	373	74	0.1984	0.1715
35-39	264	29	0.1098	0.1207
40-44	146	8	0.0548	0.0616
45-49	166	3	0.0181	0.0139

While it may seem a simple matter for women to report on childbirths during the past twelve months, experience shows that (1) some women forget to report about a birth, (2) the enumerator may assume that the interviewed woman has not given birth to a child and enter this response in the questionnaire, (3) some women may respond negatively to the question because they feel it is none of the enumerator's business to probe into their family life, (4) the returns may be given by a proxy, e.g. the head of the household, who, on occasion, may not report correctly, and (5) women may (inadvertently) relate to a reference period shorter than one year. By and large, the above-mentioned sources of error would give age-specific fertility rates that are on the low side.

If fertility and mortality have remained more or less constant during the recent past, e.g. during the past ten years, the average number of children reported by women aged 20-24 ought to agree with the age-specific fertility rates estimated from the census. More specifically, the hypothetical mean parities estimated from the children born during the year before the census ought to be nearly the same as the ones reported in the census. In reality, this will never be the case; for there is hardly any society for which fertility and mortality remain constant over such a long period. However, if there have been no drastic changes in mortality and fertility in the past there should be some agreement between the mean parities reported in the census and those inferred from the births during the year before the census. The Brass P_i/F_i method (Brass, 1975, pp. 18-23.) builds on this simple assumption. The application of this method is illustrated in Table 15.

Table 15.-Age specific fertility rates estimated from children born during the year before the census and the mean parities reported in the 1987 Yap census

Age (1)	Fertility rates (2)	Cumulative Fertility (3)	Multiplying factors $\hat{\mu} = 29.5$ (4)	Adjusted cumulative fertility (5)	Mean parity (6)	Ratio (7)
15-19	0.0786		1.682	0.1322	0.1911	1.4455
20-24	0.1700	0.3930	2.708	0.8534	1.1103	1.3010
25-29	0.1945	1.2430	2.965	1.8197	2.2512	1.2371
30-34	0.1715	2.2155	3.079	2.7435	3.6676	1.3368
35-39	0.1207	3.0730	3.195	3.4586	4.5303	1.3099
40-44	0.0616	3.6765	3.387	3.8851	5.7671	1.4844
45-49	0.0139	3.9845	3.946	4.0393	6.4458	1.5958
50		4.0540				

Column 7 (Table 15) gives the correction factors by which the age-specific fertility rates in column 2 should be upgraded in order to yield mean parities similar to those reported in the census. We have chosen to work with the mean of the ratios for the age groups 20-24, 25-29, 30-34 and 35-39. These ratios are about the same suggesting that the age-specific fertility rates should be upgraded by about 30 percent to be in agreement with the reported mean parities. The mean correction factor is $\hat{\rho} = 1.2962$. The corresponding (adjusted) age-specific fertility rates are given in Table 16. The adjusted rates give a total fertility rate of $\hat{R}_B = 5.2550$. In order to check this result we have applied an alternative technique (see Statistical Appendix). This technique gives a total fertility rate of $\hat{R}_H = 5.2820$. Because the two techniques are different, yet point to the same level of fertility, we are fairly confident that the census mean parities point to a total fertility rate of about 5.3.

Table 16.-Estimated (upgraded) age-specific fertility rates derived from the Brass P_i/F_i method

Age	Observed age-specific fertility rates (1)	Brass adjusted age-specific fertility rates (2) = 1.2962 (1)
15-19	0.0786	0.1019
20-24	0.1700	0.2204
25-29	0.1945	0.2521
30-34	0.1715	0.2223
35-39	0.1207	0.1565
40-44	0.0616	0.0798
45-49	0.0139	0.0180
		5.2550

3.2 The crude birth rate in Yap around 1987

The estimated age-specific fertility rates in Table 16 point to a crude birth rate of 38.5 per 1,000 population. We think this estimate is too high. The population aged 0 in the census was 310 (see Table 12). Adjusting (backward projecting) this population segment for mortality with $\hat{L}_o$ = 0.9610 (see Table 11) points to an annual number of births of about 310/0.9610 = 323. This gives a crude birth rate of 323/10,139 = 31.9 per 1,000 population. Even if some of the children below age one escaped enumeration in the census, it is not very likely that they were significantly more undercounted than the remaining population[4]. Furthermore, the upgrading of the age-specific fertility rates in Table 14 indicates that birth during the year before the census were underreported by about 30 percent. While it is inevitable that there has been some underreporting, we do not find it plausible that as many as 30 percent of the births were omitted. Consequently, we estimate the crude birth rate at 32 per 1,000 population and upgrade the reported age-specific fertility rates (Table 14, column 5) by 321/300 = 1.07. This gives an estimated total fertility rate of 4.3. The net-reproduction rate, i.e. the number of daughters each woman produces in her lifetime (allowing for the risks of mortality) is about 1.9.

[4] In general one must caution against such an argument. In developing countries it is quite typical that underenumeration is more prevalent among children, especially, infants, than in the adult population. In the case of Yap we have no evidence from the listings and from the enumeration that children were significantly more underenumerated than the population as a whole.

Here it is proper to mention that the upgrading by 7 percent is somewhat subjective. An upgrading factor of 1.10 might be equally accurate.

The conspicuous difference between the mean parities reported in the census and the mean parities emerging from the births which took place during the year before the census suggests that fertility now is falling rapidly. This, of course, is also what we would expect. In the case of Western Samoa, the VSSS pointed to a noticeable fall in fertility after the mid-1970s. While it must be confessed that there are very substantial cultural differences between Polynesia and Micronesia and notably between Western Samoa and Yap, we think it is reasonable to refer to the Western Samoa fertility experience as relevant in a discussion of fertility trends in Yap.

The fertility decline in Western Samoa has taken place in the absence of family planning propaganda. In contrast to Fiji, family planning, for the purpose of curbing population growth, has never been seen as a priority in Western Samoa. In fact, in the two Samoas, family planning has been offered by the health services principally as a means of improving the health of mothers and children. Open and informative discussions on the radio in the Samoas encouraging the use of family planning have never taken place. On the contrary, in American Samoa the radio has often brought the (*sensible*) message that "The children are our most important asset." Yet, it is a fact that in both American and Western Samoa, the net reproduction rate has decreased sharply during the past ten or fifteen years. (For an analysis of fertility trends in the PIR, see Levin and Retherford, 1986.) Because of the lack of focus on demographic analysis in the PIR and, in particular, in American and Western Samoa, the rapid decrease in reproduction, no doubt, has escaped the attention government officials and planners.

We believe that Micronesia is about to experience a continuing decline in fertility which is parallel to that of Western Samoa. One reason for this could be that Micronesians to an increasing extent pay for their food. The consumption of food imported from the U.S. is quite considerable. Even on the outer islands there is a relatively large import of food, especially rice, chicken and turkey tails.

Of course, in the absence of reliable vital registration data, questions concerning fertility declines necessarily must be more or less conjectural. It is fair to say, therefore, that the findings in this report are subject to further validation by other researchers. The main point is that the governments in the PIR ought to pay more attention to the production of social, economic and demographic statistics. The present situation leaves too much room for uncertainty and, more seriously, for misunderstanding current and future population developments.

Table 17 gives the age-specific fertility rates brought out by the VSSS for the years around 1975, 1981 and 1983, and for Yap in 1987.

Table 17.- Age specific fertility for Western Samoa given by the Vital Statistics Sample Survey, and for Yap, 1987

	Age-specific fertility rates Period			
	Western Samoa			Yap*
Age	1975	1981	1983	1987
15-19	0.0335	0.0486	0.0499	0.0841
20-24	0.2110	0.2158	0.2349	0.1819
25-29	0.2910	0.2782	0.2666	0.2081
30-34	0.2774	0.2060	0.2161	0.1835
35-39	0.2032	0.1370	0.1373	0.1291
40-44	0.1021	0.0375	0.0503	0.0659
45-49	0.0461	0.0297	0.0265	0.0149
Total fertility rate	5.8215	4.7640	4.9080	4.3375

*

These rates are 1.07 times the rates in Table 14, column 5. The estimates of the total fertility rate brought out by the survey in Western Samoa are not in very good agreement with the ones given my Levin and Retherford (1986). For the period around 1971, their estimate is about 7.8. Relative to this estimate, the survey estimate 5.8, is rather low. The reason for the discrepancy is most likely that the own children tabulations have been made from artificial matchings of mothers and children. In Western Samoa the questionnaires do not identify own children. For this reason one matches women and children by means of a special matching program. Because of the large scale labor force migration of young women to American Samoa, the own children estimates for Western Samoa, most likely, are significantly inflated.

3.3 Completeness of birth registration in Yap State around 1987

Applying a crude birth rate of 32 per 1,000 to the population figure for 1985 (Table 18) gives 304 births as opposed to the 228 registered births. This suggests a coverage of about 75 percent. In Western Samoa around 1983, birth registration was about 55 percent complete (Vital Statistics Sample Survey Report, 1983, Department of Statistics, Apia, Western Samoa). It will be seen from Table 18 that even if registration of births is far from complete, the crude birth rates show a declining tendency suggesting that fertility is falling.

Given the smallness of the population in Yap State, the registration of births and deaths ought to be made complete during the coming years. This would give better data for assessment of demographic changes.

Table 18.-Registered births and observed crude birth rates for the years 1980-1985

Period	Registered births	Estimated Population	Observed CBR*
1980	292	8,100	36.0
1981	326	8,365	39.0
1982	300	8,637	34.3
1983	308	8,919	34.5
1984	271	9,210	29.4
1985	228	9,510	24.0

*

Even if the registration of births is not complete and considering that the completeness of birth registration might fluctuate from year to year, the obvious decline in the number of registered births suggests that mortality is falling.

4.0 POPULATION GROWTH

4.1 Population growth between 1987 and the year 2000

To estimate the population growth between the censuses (Table 19), we let

$$P_t = P_0 e^{rt}$$

where r is the growth rate and P_t the population at time t. Hence, we estimate the intercensal growth as $\hat{r} = (1/t) \ln (P_t/P_0)$. Between the 1973 and the 1987 census, the annual growth was about 2.0 percent. Between the 1980 and 1987 census, it was about 3.3 percent. These estimates, of course, assume that the censuses had the same coverage.

Based on the estimates of the crude birth rate (32 per 1,000) and the crude death rate (11.2 per 1,000), current annual population growth is about 2.0 percent. If this growth rate continues during the remaining part of the century, the estimated total population for Yap in the Year 2000 is about 13,150.

It is, however, not very likely that the population size in the year 2000 will be that high. Even if the growth rate may remain at about 2 percent per year, overseas migration to Guam, Hawaii, and the US mainland is likely to bring about a smaller population in the year 2000. In the event fertility falls but mortality remains more or less constant, the annual growth rate may be no more than about 1.5 percent in which case the population size in the year 2000 would be about 12,300. Even if these estimates are very approximate, they point to a future population size of Yap which is well below the potential resources of the island.

Table 19.-Enumerated populations in the 1973, 1980 and 1987 population censuses of Yap

	Enumerated Populations		
	1973	1980	1987
Total	7,613	8,100	10,139
Males	3,866	4,137	5,223
Females	3,747	3,963	4,946
Sex-ratio	1.03	1.04	1.06

Source: Yap State Statistical Bulletin, 1985. Office of Planning and Budget, P.O. Box 471, Colonia, Yap State, Western Caroline Islands 96943.

5.0 EDUCATION

5.1 School attendance

It is, to a large extent, the length of exposure to an educational institution that decides the level of education received by a child. Whereas the number of years a child spends in school may not be directly related to its success in adult life, it is no exaggeration to say that a person who has spent altogether five or six years in school has very limited possibilities in a world which to an increasing degree asks for skilled labor.

The law which regulates school attendance is the one established during the former TTPI administration. According to the Trust Territory Code (Title 41, Section 27) every child in Yap between the ages of 6 and 14 years must attend school regularly, or until he or she has graduated from elementary school. In the Yap and Kosrae censuses it was asked of the population aged 6 years and over if they attended school regularly (in the Pohnpei 1985 census, questions concerning education, economic activity and socioeconomic status were not asked). The returns for the question concerning school attendance are given in Table 5 (p. 33) in Volume I.

Whereas the early years of schooling are important, we focus on children between the ages of 10 and 19 years. These are the ages during which the children receive the scholastic foundations for higher studies and for taking advantage of specialized vocational training. Table 20 gives the attendance figures for boys and girls for Yap State, Yap proper, and the outer islands.

It would appear that overall school attendance for children between the ages of 10 and 20 years is about 83 percent for boys and about 70 percent for girls. It will be noted that the proportion of girls not regularly attending school is much higher than for boys. This is particularly the case on the outer islands. It can be concluded, therefore, that many children, and young men and women, have a discontinuous and weak relationship with the available education services. This is a matter of serious concern in a young nation where the most important capital is a well educated society that can meet the challenges of modernization.

Table 20.-School attendance for the population aged 10 to 19 years recorded in the 1987 Yap State population census

Geographical division	Attend school regularly		Do not attend school regularly	
	Boys	Girls	Boys	Girls
Yap State	904	741	185	324
Percent	83.2	69.6	16.8	30.4
Yap proper	524	474	141	168
Percent	78.8	73.8	21.2	26.2
Outer islands	378	267	44	156
Percent	89.6	63.1	10.4	36.9

Source: **Report on the 1987 Yap State Census of Population, Vol. 1**, Office of Planning and Budget, Colonia, Yap (Table 5, p. 33).

5.2 Educational attainment

Educational attainment, i.e. how far the individual progresses in the education system, is perhaps the most crucial element in a person's history. In industrialized societies, there is no single element more decisive for a person's social status and standard of living than his educational history. In traditional societies, formal education, of course, does not play the same salient role as in industrialized societies. However, it would be wrong to believe that formal education in Pacific island societies is of marginal importance for a person's social standing. Since the beginning of the 1950s it has become increasingly common among the higher social classes in the PIR to send children overseas for higher education. In fact, higher education in the PIR is as socially restricted as in many industrialized societies. It is recognized as important by the wealthy and influential families, and it is regarded as immaterial by the masses who are taught the virtues of traditional life. As society develops economically, socially (and culturally), the need for educated labor increases. It is when the demand for an educated and skilled labor force is brought into existence that the traditional education system is converted into one that serves the needs of modern society.

Micronesia has inherited the American school system or, perhaps, to be more precise, a US-influenced school system. The American school system is remarkable in several ways. It allows a flexibility that is unequaled by most other government-controlled education systems. It appeals to individualism. It promotes the interested and bright student. And, it often lets down the less motivated student. To this must be added that in the United States, the quality of teachers varies along a broader nominal scale than, for example, in France, Germany, the Netherlands and Scandinavia where the demands for accreditation are higher and more uniform. The American school system is heterogeneous in nature; it is not uniformly bad or uniformly good, its performance oscillates between excellent in some areas and deplorable in others. In terms of overall quality, it certainly falls below and lacks the uniformity of French, German, Dutch or Scandinavian education systems. For these reasons, it does not mean very much that a student has completed grade 12, say, in the American public education system. A person who has proceeded that far may be fluent in English and have a good knowledge of world history. He may also lack fluency in English and be ignorant of the world around him. In the case of the North-West Pacific, it can be safely assumed that completing grade 12 by no means is comparable to completing grade 12 in a good school in Hawaii. The never ceasing school debate in Guam, where, incidentally, many of the teachers fail the English language proficiency test, is a continuous reminder of the quality of education in this part of the world. It must not be forgotten, however, that the school, like so many other social institutions, at least in part, is a product of its environment.

Yap does not have a public library. The FSM does not have its own newspaper. Television programs in Yap are mostly imported from the United States (reruns of programs and program sequences that are several months old), and the proportion of PBS (Public Broadcasting Service) programs is marginal. News programs are often interrupted locally and, consequently, give the average listener truncated and inadequate information about the outside world. In Yap, television principally serves the purpose of entertaining. The chosen items of entertainment often display the English language at its worst. Programs, in general, have little educational and/or informative value. Considering that English is the official language of the Federated States of Micronesia, the high frequency of low life items of entertainment on television has little improving effect on spoken and written English in Yap. Considering that the spreading of VCRs is relatively fast and that the selection of video films is limited to items of little cultural or educational value, it is very important that local television in Yap counterbalances the spreading of VCRs by offering a broad selection of PBS programs.

Considering that it is Yap State Government that pays for television broadcasting in Yap, it seems reasonable to argue that some kind of advisory board should be established for the purpose of increasing the quality of programs. The problem here is that many people might see this as an attempt to impose censorship. However, given that there are virtually no news broadcasts on television at the moment, one could also argue that the lack of news and information about the outside world constitutes far more censorship than the establishment of an advisory board which ensures that news programs from the United States are shown in full, that the selection of PBS programs is expanded, and that television sees its role as one of promoting knowledge and understanding. It should be added, however, that some of the programs shown on Yap television meet all the requirements of good taste. Improving Yap television is not a matter of censorship but principally one of proper editing and selection of programs. In the case of the outer islands, one would like to see the establishment of a (free) library service providing people with a broad selection of literature.

With these comments as a general background, it is now in place to look at the educational achievement figures recorded in the census. We focus on the population aged 20 years and over. This is the population which provides the main pool of labor.

Questions concerning educational attainment focused on the highest grade each person aged 6 years and over had completed. The possible responses were completion of grade 1, grade 2, etc. up to grade 12. Educational attainment for those who had completed grade 12 and completed a higher education, e.g. an associate of arts or science degree, a bachelor's degree, a master's degree or a doctoral degree was also recorded.

With some doubt, a question concerning whether the respondent had at all attended school was also included in the questionnaire. It was believed that perhaps the respondents would feel ashamed and avoid answering such a question. However, both in the case of the Kosraen census and in the case of Yap, a large number of respondents indicated to the enumerators that they had not received any education. (Those of the elders who had attended school under the Japanese administration had their acquired grades translated into the U.S. grade system.)

Table 21 gives educational attainment in numbers and percent for males and females aged 20 years and over in Yap State. (The figures for preparation of Table 21 come from Table 6 (pp. 34-36), Table 13 (pp. 49-51) and Table 20 (pp. 73-75) in **Report on the 1987 Yap State Census of Population, Vol. 1,** Office of Planning and Budget, Colonia, Yap.

According to the census figures, 8.4 percent of the males and 18.8 percent of the females aged 20 years and over had never attended school. For the outer islands the similar figures are 21.3 percent for males and 40.6 percent for females. In terms of completing grade 8, i.e. completing elementary school, it will be seen that in Yap State the figures are 70.0 percent for males and 42.6 percent for females (in the population aged 20 years and over). For the outer islands, 65.5 percent of the males and 21.9 percent of the females declared that they had completed elementary school.

Table 21 also shows that 54.3 percent of the males in Yap State had completed grade 12 or achieved a higher degree. For females the corresponding figure is 25.8 percent. Roughly speaking, in Yap State, twice as many men as women complete grade 12 and proceed with a higher education. For the outer islands, 52.8 percent of the males and 12.1 of the females declared that they had completed at least grade 12.

With respect to meeting the former TTPI requirements of every person in Yap District completing elementary school, i.e. completing grade 8, it will be seen that even if the figures are affected by some reporting errors and must be seen as approximate, there can be no doubt that a substantial proportion of the men aged 20 and over have not completed elementary school. For women, the figures point to a situation which is significantly worse. For the outer islands, it would appear that about one woman out of every five aged 20 and over has completed elementary school. These are very grave figures.

Here it must be added that the census did not probe into the details of education. The only questions that were asked concerned (1) whether the respondent regularly attended school and (2) which was the highest grade the respondent had completed. Our figures do not show to which extent a person who has completed elementary school is literate in local language or in English.

It is true, no doubt, that many students in high school graduate without meeting the intended scholastic requirements. More specifically, low achievers graduate along with the best of students simply because the teachers wish to get rid of them. It is particularly important to notice that many girls, specially on the outer islands, are discouraged to go to school by their parents because it is believed that they have to fulfill a social role incommensurate with the benefits of higher learning. Here it is tempting to lash out at the traditional Pacific island culture but experiences from America and Western Europe that go back in time no more than some fifty years clearly show that the belief that young women should take no notice of higher learning and limit themselves for marriage preparations also is deeply rooted in western culture. This is sad; for women have as much to offer in terms of biological reproduction of the human species as they have in terms of human wisdom.

We believe that the above-mentioned figures and comments warrant a detailed investigation concerning school attendance and the relevance of the present education system in Yap.

Table 21.-Percentage of Yap State and outer island populations aged 20 years and over by educational attainment recorded in the 1987 Yap population census

Yap State

Males

Never attended school	Highest completed grade 1	2	3	4	5	6	7	8	9	10	11	12	12+
8.4	3.7	1.0	3.8	1.3	6.6	3.1	1.9	5.1	4.7	2.7	3.2	35.3	19.0

Proportion completed grade 8 or higher: 70.0
Proportion completed grade 12 or higher: 54.3

Females

Never attended school	Highest completed grade 1	2	3	4	5	6	7	8	9	10	11	12	12+
18.8	4.1	2.0	6.7	3.2	8.4	10.6	3.5	7.5	4.0	2.6	2.7	20.1	5.7

Proportion completed grade 8 or higher: 42.6
Proportion completed grade 12 or higher: 25.8

Outer islands

Males

Never attended school	Highest completed grade 1	2	3	4	5	6	7	8	9	10	11	12	12+
21.3	1.2	1.9	3.6	1.5	2.5	1.7	0.8	3.6	3.0	2.1	4.0	36.2	16.6

Proportion completed grade 8 or higher: 65.5
Proportion completed grade 12 or higher: 52.8

Females

Never attended school	Highest completed grade 1	2	3	4	5	6	7	8	9	10	11	12	12+
40.6	1.8	3.0	5.0	5.4	5.5	13.4	3.3	5.4	1.8	1.0	1.6	9.9	2.2

Proportion completed grade 8 or higher: 21.9
Proportion completed grade 12 or higher: 12.1

6.0 ECONOMIC ACTIVITY AND SOCIOECONOMIC STATUS

6.1 Social and economic development

Throughout the PIR there are daily discussions concerning social and economic development. In some circles, the discussion is limited to economic development, in others, there is reference to both social and economic development. Very rarely does the discussion involve cultural development. Yet, in the train of economic development is always social and cultural change. The three elements: economic development, social development and cultural development are inseparable processes. One does not come about without the other two being realized at the same time. For this reason it can be safely argued that the philosophy of the Pacific Way whereby economic development is endorsed and accepted as long as it does not interact with social and cultural norms is mythical in nature and of little relevance in serious discussions concerning palpable economic development. There is, however, one important point to be made here, namely that if the majority of people prefer to live a traditional Pacific island life, then it is their basic right to do so. Interestingly enough, the TTPI administration never pushed economic development beyond the point where it was accepted by local chiefs.

To the lay person economic development is tied to receiving a better salary, obtaining better working conditions, improved retirement benefits etc. Economic development is mostly perceived as a process by which the majority of income earners increase their incomes, expand their wealth and, above all, increase their consumption of industrially produced commodities. Some may hold the view that one must distinguish between, on the one hand the economist's basket of theoretical perceptions of economic development, and, on the other, the manifold practical manifestations of economic development. Be it as it may, to most people economic development is a process that brings about increased consumption. Increased consumption, in turn, brings about more jobs, more owned homes, more automobiles, more services etc. Economic development is a process that makes logical sense in a society where commodities are bought at a price and where money serves the purpose of acquiring the daily food.

It was not until recently that Micronesian society began moving towards becoming a consumer society. In the North-West Pacific the Compact of Free Association with the United States has led to an influx of capital which is unprecedented in the history of the Pacific Island Region. The partial termination of the Trust Territory of the Pacific Islands, the establishment of the Commonwealth of the Northern Mariana Islands, and the initiation of the compacts of free association with the FSM and the Republic of the Marshall Islands mark the beginning of a new time in the North-West Pacific. Although the compacts with the United States Government are time limited, the advances in the North-West Pacific towards establishing new societies are not. The question is not whether the North-West Pacific is changing socially, economically and culturally but, rather, in which directions these changes take place.

The challenge in Micronesia is to find the right way, if there is one, and to make investments that bring about improved employment possibilities. Ultimately the goal is increased self-reliance and, in particular, improved political independence. The extent to which such goals can be realized depends on a multivariate set of political and economic factors that are difficult to identify and project.

Micronesia is the gate to the North-West Pacific and, for historical reasons, under the protection of the United States. Economic development, at least in its initial stage, is financially supported by the United States and, it is, then, within the conceptual framework of a free market economy that economic development in Micronesia should be seen. Within this economic framework, industrialization and education are the main pillars. Promotion of tourism, small scale industry, industrial fishing and, generally speaking, money making activities is seen as necessary if the standard of living in Yap is to increase. However, whereas private enterprise is the main fuel for economic development, it must be supported, encouraged and (reasonably) controlled by the government if it is to fit into a comprehensive plan for improving the quality of life in Yap. The creation of comprehensive development plans, however, requires the availability of local technical and academic expertise.

In an environment where the values of higher education are minimized in favor of maintaining a traditional Pacific island life style there will always be a shortage of (local) technical and academic expertise. It is quite clear, therefore, that the lack of impetus in education policies in the former TTPI and, generally speaking, in today's PIR is a serious and, in many cases, overwhelming encumbrance to bringing about economic development; for it is in the area of education and enlightenment that the foundation for 'real' economic development is rooted.

The present situation in the Commonwealth of the Northern Mariana Islands and in Guam where many locals find themselves pushed out of jobs by imported labor is, by and large, a consequence of inadequate educational institutions. In response to this situation, there is a tendency for the government sector to expand and thus become a port of call for people with insufficient professional skills. Consequently, inadequate investment in education for the young may lead to costly employment when they become adults. One of the serious consequences of such a development is also that a large share of the government budget is used to meet the pressure of paychecks for low income earners in the public sector thus depriving those with a higher education and better professional skills of a higher paycheck that they have earned on account of achieving a higher education.

Because even small scale industrialization in Yap most likely will involve importing skilled labor from overseas, there is a risk that the employment problems of the Commonwealth of the Northern Mariana Islands and Guam will emerge in Yap, albeit at a lower level. It is important, therefore, that special attention is given to the areas in which vocational training of Yapese men and women can be set in motion in order to limit the import of foreign labor. We now turn to the data on economic activity collected in the census.

6.2 Economic data collected in the 1987 Yap State population census

The questions concerning economic activity asked in the Yap census were the same as those asked in the Kosrae 1986 census, namely if person (during the week before the census) was (1) working primarily to grow, gather or catch food for own consumption, (2) working primarily to earn money, (3) looking for work, (4) attending school full-time, (5) primarily engaged in unpaid household work, (6) unable to work or (7) other.

With respect to socioeconomic status the categories were: (1) employed by government, (2) employed by private organization, (3) employer, (4) own account worker, (5) unpaid family worker, (6) attending school full-time and (7) other. We begin our discussion with the data on economic activity and then turn to the data on socioeconomic status.

6.3 Economic activity

When the information on economic activity is obtained in the field, the enumerator is rather unlikely to ask the questions with reference to the week before the census (the reference period). We think that in the vast majority of cases, the enumerator asks "What do you do (for a living)?". The distribution of economic activity changes slowly, and whether the questions are asked with reference to a particular period or not is of relatively little importance. We mention this aspect of data collection because some census takers believe it to be important that there is a clearly delimited reference period. From the point of view of statistical design there should, indeed, be a reference period. The problem in the field is that the enumerators do not perceive the reference period as important; for they all know that a person's economic activity remains more or less stationary over time. Table 22 gives the distribution of economic activity by number of persons and by percent for Yap proper and the outer islands.

First, it will be seen that in Yap proper 17.7 percent of the men are engaged in basic agriculture. For women, the similar figure is 43.6 percent. On the outer islands, 51.2 percent of the men and 80.3 percent of the women are engaged in subsistence farming. This means that with better farming methods, a relatively large number of men and women could be released for industrial employment. Second, there is a large differential between men and women with respect to subsistence farming. In Yap, as elsewhere in the PIR, women are food producers and the corner stone in maintaining the Pacific island life style. Men, on the other hand, tend to become income earners. On Yap proper some 60 percent of the men and about 25 percent of the women work primarily to make money (Table 22). With respect to school-attendance it will be seen that 9.6 percent of the men and 8.7 percent of the women declared that they were in school full-time.

On the outer islands, about 80 percent of the women and 51 percent of the men are engaged in subsistence farming (Table 22). Some 21 percent of the men reported that they worked primarily for money. Only about 3 percent of the women indicated that they worked for money. With respect to school attendance, about 17 percent of the men and 6 percent of the women reported that they were in school full-time.

If economic development planning is to be successful in Yap, there are three main functions that must be initialized. First, the basic school system must be substantially improved. Second, vocational training that match the needs of industrial planning must be set in motion. Third, women must receive special attention in terms of vocational training and ordinary school education. In the context of formal education, the number of Yapese students pursuing higher studies in the United States must be increased with special emphasis on sending more women to college and university. Without such steps, the result of establishing local industry will most likely lead to a relatively large import of skilled labor.

Table 22.-Economic activity in numbers and ***percent*** for the population aged 15 years and over recorded in the 1987 Yap State population census

	Males	Females
Yap proper		
Working primarily to grow, gather or catch food to eat	363 ***17.7***	810 ***43.6***
Working primarily to earn money	1,138 ***55.5***	464 ***25.0***
Looking for work	86 ***4.2***	19 ***1.0***
Attending school full-time	196 ***9.6***	161 ***8.7***
Primarily engaged in unpaid household work	37 ***1.8***	236 ***12.7***
Unable to work	69 ***3.4***	69 ***3.7***
Other	161 ***7.9***	98 ***5.3***
	2,050	1,857

Table 22.-Economic activity in numbers and ***percent*** for the population aged 15 years and over recorded in the 1987 Yap Stat population census, Cont'd

	Males	Females
Outer islands		
Working primarily to grow, gather or catch food to eat	459 ***51.2***	858 ***80.3***
Working primarily to earn money	191 ***21.3***	30 ***2.8***
Looking for work	18 ***2.0***	5 ***0.5***
Attending school full-time	153 ***17.1***	61 ***5.7***
Primarily engaged in unpaid household work	8 ***0.9***	58 ***5.4***
Unable to work	48 ***5.4***	45 ***4.2***
Other	20 ***2.2***	11 ***1.0***
Total	897	1,068

Source: **Report on the 1987 Yap State Census of Population, Vol. 1,** Office of Planning and Budget, Colonia, Yap (Table 14, pp. 52-53 and Table 21, pp. 76-79.

6.4 Socioeconomic status

Because the categorization of the adult population into economically active and not economically active meets some difficulties in a society where people mostly are engaged in subsistence farming, we have abstained from elaborating with these concepts. The instructions to the enumerators were that if a person declared himself (herself) as engaged in subsistence farming, he (she) should be put in the category "other" under socioeconomic status. Persons who declared that they were attending school full-time under economic activity were put into the same category under socioeconomic status. Even though the questionnaire is quite simple, there are many problems to consider when one collects data on economic activity and socioeconomic status. Perhaps the main problem with collecting such data is that people do many different things at the same time. Few people are involved in one and only one activity.

For example, a woman may engage in subsistence farming not only in order to feed her family but also to sell food in an open market in order to earn money. The question is then whether she should be classified as subsistence farmer, as own account worker, or as unpaid family worker. Evidently, she could, depending on the circumstances, fall into all three categories. To facilitate recording of the responses, it was emphasized to the enumerators that it is what the person does most of the time that should be recorded in the questionnaire. Even so, one can imagine many situations where the recording of a person's economic activity and socioeconomic status is somewhat haphazard. This will always be the case when one asks standard census questions that reflect a division of people into those who work for money and those who do not. (After all, even if a person does not work for money, he or she may still produce social and economic wealth.)

Table 23 outlines the distribution of the population aged 15 years and over by socioeconomic status. In Yap proper 31.0 percent of the men and 12.4 percent of the women are employed by Yap State Government. And, 20.1 percent of the men and 8.6 percent of the women are employed in the private sector. With respect to the remaining categories, except attending school full-time and other, the percentages are small.

For the outer islands, it will be seen (Table 23) that 19.8 percent of the men and 2.6 percent of the women are employed by Yap State Government. The remaining categories, except attending school full-time and other, are marginal.

Table 23.-Population aged 15 years and over by socioeconomic status in numbers and in percent

Yap proper

	Males	Females
Employed by government	635	231
	31.0	*12.4*
Employed by private organization	412	160
	20.1	*8.6*
Employer	18	7
	0.9	*0.4*
Own account worker	18	6
	0.9	*0.3*
Unpaid family worker	10	41
	0.5	*2.2*
Attending school full-time	196	161
	9.6	*8.7*
Other	761	1,251
	37.1	*67.4*
Total	2,050	1,857

Table 23.-Population aged 15 years and over by socioeconomic status in numbers and in percent, Cont'd

Outer islands

	Males	Females
Employed by government	178 *19.8*	28 *2.6*
Employed by private organization	8 *0.9*	2 *0.2*
Employer	1 *0.1*	0 *0.0*
Own account worker	0 *0.0*	0 *0.0*
Unpaid family worker	1 *0.1*	0 *0.0*
Attending school full-time	153 *17.1*	61 *5.7*
Other	556 *62.0*	977 *91.5*
Total	897	1,068

Source: **Report on the 1987 Yap State Census of Population, Vol, 1**, Office of Planning and Budget, Colonia, Yap (Table 15, pp. 55-57 and Table 22, pp. 79-81)

7.0 POPULATION PROJECTIONS

7.1 Some general remarks concerning population projections

Before we give our projected populations for the years between 1988 and 2000, we emphasize that, save for calculation errors, there is no such thing as a wrong population projection. A population projection is the arithmetic outcome of assumptions concerning (1) the initial age-distribution, (2) mortality during the projection period, (3) fertility for women during the projection period and (4) migration during the projection period. Whether the projected figures happen to coincide with the ones observed in the future depends on several factors that are only partially imbedded in the above-mentioned assumptions.

It is true, however, that statisticians, demographers and lay persons use the term population projection to mean a forecast of the future population. It is probably true to say, however, that most population projections have failed to forecast the future population development. Especially population projections at the regional level present a considerable statistical forecasting problem. Demographers cannot foretell with certainty the actual future population development neither at the local nor at the global level some 30 or 50 years from now. For one thing, the future population development, i.e. population distribution and composition, mortality and fertility trends, labor force migration etc., depends on a multitude of economic, social and cultural factors that are difficult to translate into numerical variables. Another point is that the interaction/dependence between population variables, on the one hand, and social, economic and cultural variables, on the other, at least at the moment, is poorly understood. For example, by looking at the demographic situation of a society, we could not make any inferences concerning whether it is a democracy, whether it producers fine literature and arts or whether it is about to become a lost civilization. Demographic statistics tell a demographic story. Economic statistics an economic one. Although the two stories share many chapters, the book that combines them is yet to be written.

7.2 Projecting the Yap State Population to the year 2000

Projecting a population one or two years ahead of time can be done with relatively good accuracy. The longer the projection period, the more uncertainty we face. In this report we have chosen to make use of the ESCAP population projection package developed by Robert Hannenberg (Population Division, Social and Economic Commission for Asia and the Pacific, Bangkok). It is a very simple package, yet sufficient for our purposes. We have made the assumptions that the total fertility rate is 4.3 and that West Model Life Table 18 apply throughout the projection period. This means that we assume that the life expectancy for men is 58.8 years and for females 62.5 years. These life expectancies are quite close to the ones we have estimated for Yap. It is assumed that there is no migration in and out of the Yapese population. The essential purpose of our projection is to show what would happen if the current estimates of mortality and fertility were to remain valid until the year 2000.

Table 24 gives the projected populations by five-year age groups for both sexes for the years 1988, 1990, 1992, 1994, 1996, 1998 and 2000. During the projection period the population size advances from 10,139 in 1987 to 13,493 in the year 2000. The growth rate remains in the neighborhood of 2.2 percent per year. The crude birth rate increases from 31.4 to 33.2 per 1,000 population. The crude death rate, on the other hand, exhibits a decline from 11.4 to 9.9 per 1,000 population.

These projections illustrate that there is a strong intrinsic growth potential in the Yapese population. But, as we have already noted, the population is small and even if the current growth potential is high, it is not very likely that the population will outgrow the resources of the island. We wish to emphasize that different specialists may view this question from different points of view and that, at any rate, the future population development depends on too many uncertain factors to be predicted with certainty.

The projections assume that there is no out migration from Yap between 1987 to the year 2000. This is hardly a realistic assumption. However allowing for the effects of migration in the projections would lead to rather speculative figures.

Table 24.-Population projections for Yap State between 1988 and the year 2000

	Projected populations						
Age	1988	1990	1992	1994	1996	1998	2000
0-4	1,517	1,504	1,567	1,657	1,741	1,837	1,940
5-9	1,527	1,547	1,501	1,465	1,483	1,566	1,650
10-14	1,290	1,399	1,482	1,526	1,518	1,463	1,450
15-19	969	1,088	1,216	1,333	1,429	1,495	1,515
20-24	828	851	910	1,010	1,137	1,258	1,364
25-29	820	810	809	822	860	938	1,053
30-34	792	807	806	798	791	797	819
35-39	636	709	758	783	788	784	775
40-44	360	466	573	656	715	751	765
45-49	308	293	315	395	505	597	665
50-54	282	295	299	287	283	333	431
55-59	264	262	263	271	281	278	264
60-64	210	225	238	241	239	243	254
65-69	208	191	181	189	204	210	209
70-74	136	159	169	161	147	147	158
75-79	79	77	88	104	116	117	107
80+	119	99	81	71	67	69	74
Total	10,345	10,782	11,256	11,763	12,304	12,884	13,493
Crude birth rate	31.4	31.6	32.0	32.2	32.5	32.9	33.2
Crude death rate	11.4	11.1	10.4	10.2	10.1	10.0	9.9
Growth rate	2.0	2.1	2.2	2.2	2.2	2.3	2.3

8.0 SUMMARY

The FSM National Census Program

The 1987 population census in Yap is the first one taken by a local office since the Japanese administration ended in 1945. During the period of the Trust Territory of the Pacific Islands (TTPI), the US Bureau of the Census was delegated the responsibility of census taking. With the formation of the Federated States of Micronesia (FSM) in 1979, the responsibility of census taking became an internal one. Hence, the present census was conducted as part of a National Census Program by the FSM Office of Planning and Statistics in collaboration with the Office of Planning and Budget in Yap.

The present analysis of the 1987 Yap State census is not a comprehensive one. Due to time constraints there is no reference to mortality and fertility work carried out by anthropologists. Furthermore, several other sources of information concerning the past population situation in Yap have not been incorporated into the present study. This is especially true of the censuses taken during the Japanese administration which lasted from about 1914 to 1945. The present analysis, by and large, focuses on estimating mortality and fertility from the 1987 census. There is a descriptive analysis of the census tabulations on education, economic activity and socioeconomic status. The report is essentially of a preliminary nature, and is intended to give planners and administrators new population data and results for use in their work. It should be noted, however, that vital registration in the TTPI was incomplete and that it is dubious to which extent historical data could be of use in a retrospective analysis of mortality and fertility. Nevertheless, an analysis incorporating the old Japanese censuses and the ones taken during the TTPI period is warranted at least for historical reasons.

Vital statistics

The study of mortality is prompted by several circumstances. First, the well-being of human beings is closely related to their mortality. In a society where people have good education, sensible diets and proper health care, they live longer and are not ill as often as people enjoying the calcifying qualities of poor diets, poor education, marginal health care etc. Second, there are always temporal changes in mortality. These must be recorded in order to study the effects of epidemics, changes in the environment at large and, ultimately, for the purpose of being informed about living conditions. Third, in the enlightened and free society demographic data are an integral part of the official records system enabling the individual free man and woman to check the honesty and integrity of government. Vital statistics form a salient part of the body of official relevant statistics that should be produced for the benefit of the individual, for the benefit of researchers, for the benefits of planners and administrators; to make the list more concise, for the benefits of **WE THE PEOPLE.**

Estimates of infant and childhood mortality

Infant mortality is defined as the proportion of infants who die before reaching age one. For example, if out of 1,000 children born at the same time, 950 survive to age one - and 50 die before reaching age one - infant mortality becomes 50 per 1,000 live born babies. An infant mortality rate of 50 per 1,000 live births does not say very much in itself. All mortality measures are relative. It is necessary, therefore, to compare different societies with one another in order to establish what is high and what is low.

In this report, we have chosen to make comparisons with Western Samoa which has fairly reliable data on mortality. These data come from a vital statistics sample survey initiated about 1975 by the United Nations Office of Technical Cooperation (now re-named the United Nations Department of Cooperation for Development). Table 4 gives estimated mortality for Western Samoa between 1975 and 1983.

It would appear that in Western Samoa changes in infant mortality have been rather modest. About 1975 it was estimated at 35 per 1,000 live births for both sexes (boys and girls combined). Between 1981 and 1982, it was estimated at 42 per 1,000 live births. Then, between 1982 and 1983, it was estimated at 33 per 1,000 live births (Table 4).

In this report we have estimated infant and childhood mortality for Kosrae, Pohnpei, Truk and Yap using data from the 1980 TTPI population census (Table 6), and for Kosrae, Pohnpei and Yap using data from the recent FSM censuses (Table 10). We have given the estimated proportions of infants surviving 1, 2, 3, 4 and 5 years. These estimated proportions are denoted $\hat{q}(1)$, $\hat{q}(2)$, $\hat{q}(3)$, $\hat{q}(4)$ and $\hat{q}(5)$, respectively. For example $\hat{q}(5)$ is the estimated proportion of children surviving from birth until age 5.

These estimates have been obtained from data on the number of children born in the lifetime of women and the corresponding number of surviving children. More specifically, in the censuses each woman aged 15 years and over was asked how many children she had given birth to altogether and how many of these children were still alive (at the time of the census). Estimating childhood mortality from statistical reports of this nature meets a number of difficulties that are discussed in detail in the <u>Statistical Appendix</u>. Here it is sufficient to mention that such data were collected because vital registration in Yap is too incomplete to facilitate proper statistical/demographic estimation of mortality and fertility. Estimating infant and childhood mortality from the above-mentioned type of data (referred to as child survivorship data) requires two kinds of consideration. First, the application of a well chosen statistical estimation method. Second, that the reliability of the data is assessed in the process of using them for estimation of childhood mortality.

We notice (Table 6 and Table 10) that the proportions of deceased children vary relatively little from district to district. If the proportions of deceased children had exhibited large variation, this would have implied the existence of widely different health environments in Micronesia. However, since the environments in Micronesia with respect to education and health are known to be relatively uniform, we would not expect a large variation in infant and childhood mortality between Kosrae, Pohnpei, Truk and Yap. This observation speaks in favor of the reliability of the data.

According to our estimates from the 1980 TTPI census, Truk had the highest infant mortality, namely 56.1 per 1,000 live births. Kosrae was a little lower with 53.6. Yap and Pohnpei fell in the same group with estimates of 43.3 and 43.2, per 1,000 population, respectively. We notice (Table 6) that the FSM around 1980 had higher infant and childhood mortality than Western Samoa in 1975 (Table 4).

The general level of infant and childhood mortality in the FSM around 1980 was about the same as in Sweden around 1925. Infant mortality in Sweden and Japan is now (1987) around 6 per 1,000 live births. This means that around 1980, the proportion of children dying during infancy was six or seven times higher than in today's Japan and Sweden. Relative to Western Samoa, the proportion of children dying in Yap was about 30 percent higher (Table 4). We now turn to the estimates obtained for the censuses of Pohnpei (1985), Kosrae (1986) and Yap (1987).

Table 10 shows the estimates of infant and childhood mortality for Pohnpei, Kosrae and Yap. (An FSM census has not yet been taken in Truk for which reasons we cannot give any figures for this FSM State.) Once again, we notice that the estimates of infant mortality display relatively little variation from one FSM State to another. For Pohnpei the estimate is 46.3 per 1,000 live births. For Kosrae the similar estimate is 49.3 per 1,000 live births. For Yap State we have 48.4 per 1,000 live births.

We notice, therefore, that the levels of infant mortality appear to have remained the same since 1980. In that sense the FSM shares the mortality stability of Western Samoa where there have been little or no improvement between 1975 and 1983. With respect to the outer islands in Yap, it is clear that they have much higher infant mortality than Yap proper. In the case of the Yap outer islands, we have 56.8 per 1,000 live births. For Yap proper, infant mortality is estimated at 39.2 per 1,000 live births. This is a 45 percent difference.

A life table for Yap

While the estimation of infant and childhood mortality meets a number of difficulties because of the absence of reliable registration of infant and childhood deaths, the estimation of mortality for all ages is particularly hampered by the lack of reliable vital registration data. The completeness of death registration in Yap State is about 70 percent. Estimating a life table, therefore, is a matter of statistical guesswork. A life table gives a statistical summary of the effects of mortality. According to the life table for Yap State (Table 11) the life expectancy for both sexes (males and females combined) is 59.9 years. This is a relatively low life expectancy. On the outer islands, the life expectancy is almost certainly lower. For males the life expectancy in Yap State is about 58 years and for females about 62 years. These are estimates which are subject to uncertainty. The life expectancy estimated for both sexes in Western Samoa around 1975 was close to 62 years (Table 4). The lower life expectancy in Yap State is primarily a result of higher infant mortality. The estimated life table for Yap leads to a crude death rate of 11.2 per 1,000 population.

Although the estimates of mortality we have given in the report are subject to some error that cannot be estimated at the moment, the estimates, no doubt, are sufficiently accurate to make some inferences about the need for improved health services in Yap State. The life expectancy is low and the coming years should be used to improve it. It is especially the relatively high infant and childhood mortality that is worrisome. There can be no doubt that infant and childhood mortality in the FSM needs to be discussed in detail by health care officials.

Estimates of fertility

In the censuses in Kosrae and Yap, women aged 15 and over were asked if they had given birth to a child during the past year. A total of 300 births was recorded for Yap during the period 23 March 1986 to 22 March 1987. This suggests that the crude birth rate is about 30 per 1,000 population. Because of some underreporting of births, our final estimate of the crude birth rate for Yap State in 1987 is 32 per 1,000 population.

The total fertility rate, i.e. the number of children a woman produces if she survives to the end of the reproductive period, is estimated at 4.3 children. The net-reproduction rate, i.e. the number of daughters a woman produces allowing for the risk of her death is about 1.9.

The completeness of birth registration is about 75 percent. This means that birth registration is slightly more efficient than the registration of deaths.

Population Growth

Based on the estimates of the crude birth rate (32 per 1,000) and the crude death rate (11.2 per 1,000), current annual population growth is about 2.0 percent. If this growth rate continues during the remaining part of the century, the estimated total population for Yap in the Year 2000 will be about 13,150.

The difference between the crude birth rate and the crude death rate which is know as the natural growth rate is sometimes a misleading index of how fast a population grows. For example, if the population is very small, like the one in Yap, even a high natural growth rate such as 2 percent per year will only lead to a small numerical increment over a twenty-year period. Another point to be made is that if there is substantial emigration from the population, a high natural growth rate may lead to no more than a marginal increase in population over time.

School attendance

The law which regulates school attendance is the one established during the former TTPI administration. According to the Trust Territory Code (Title 41, Section 27) every child in Yap between the ages of 6 and 14 years must attend school regularly, or until he or she has graduated from elementary school. In the Yap and Kosrae censuses it was asked of the population aged 6 years and over if they attended school regularly (in the Pohnpei 1985 census, questions concerning education, economic activity and socioeconomic status were not asked).

Whereas the early years of schooling are important, we have focused on children between the ages of 10 and 19 years. These are the ages during which the children receive the scholastic foundations for higher studies and for taking advantage of specialized vocational training. Table 20 gives the attendance figures for boys and girls for Yap State, Yap proper, and the outer islands.

It would appear that over all school attendance for children between the ages of 10 and 20 years is about 83 percent for boys and about 70 percent for girls. It will be noted that the proportion of girls not regularly attending school is much higher than for boys. This is particularly the case on the outer islands. It can be concluded, therefore, that many children, and young men and women, have a discontinuous and weak relationship with the available education services.

Educational attainment

Educational attainment, i.e. how far the individual progresses in the education system, is perhaps the most crucial element in a person's history. In industrialized societies, there is no single element more decisive for a person's social status and standard of living than his educational history. In traditional societies, formal education, of course, does not play the same salient role as in industrialized societies. However, it would be wrong to believe that formal education in Pacific island societies is of marginal importance for a person's social standing.

Since the beginning of the 1950s it has become increasingly common among the higher social classes in the PIR to send children overseas for higher education. In fact, higher education in the PIR is as socially restricted as in many industrialized societies. It is recognized as important by the wealthy and influential families, and it is regarded as immaterial by the masses who are taught the virtues of traditional life. As society develops economically, socially (and culturally), the need for educated labor increases. It is when the demand for an educated and skilled labor force is brought into existence that the traditional education system is converted into one that serves the needs of modern society.

Questions concerning educational attainment focused on the highest grade each person aged 6 years and over had completed. The possible responses were completion of grade 1, grade 2, etc up to grade 12. Educational attainment for hose who had completed grade 12 and completed a higher education, e.g. an associate of arts or science degree, a bachelor's degree, a master's degree or a doctoral degree was also recorded.

With some doubt, a question concerning whether the respondent had at all attended school was also included in the questionnaire. It was believed that perhaps the respondents would feel ashamed and avoid answering such a question. However, both in the case of the Kosraen census and in the case of Yap, a large number of respondents indicated to the enumerators that they had not received any education. (Those of the elderly who had attended school under the Japanese administration had their acquired grades translated into the U.S. grade system.

Table 21 gives educational attainment in numbers and percent for males and females aged 20 years and over in Yap State. According to the census figures, 8.4 percent of the males and 18.8 percent of the females aged 20 years and over had never attended school. For the outer islands the similar figures are 21.3 percent for males and 40.6 percent for females.

In terms of completing grade 8, i.e. completing elementary school, it will be seen that in Yap State the figures are 70.0 percent for males and 42.6 percent for females (in the population aged 20 years and over). For the outer islands, 65.5 percent of the males and 21.9 percent of the females declared that they had completed elementary school.

Table 21 also shows that 54.3 percent of the males in Yap State had completed grade 12 or achieved a higher degree. For females the corresponding figure is 25.8 percent. Roughly speaking, in Yap State, twice as many men as women complete grade 12 and proceed with a higher education. For the outer islands, 52.8 percent of the males and 12.1 of the females declared that they had completed at least grade 12.

With respect to meeting the former TTPI requirements of every person in Yap District completing elementary school, i.e. completing grade 8, it will be seen that even if the figures are affected by some reporting errors and must be seen as approximate, there can be no doubt that a substantial proportion of the men aged 20 and over have not completed elementary school. For women, the figures point to a situation which is significantly worse.

Here it must be added that the census did not probe into the details of education. The only questions that were asked concerned (1) whether the respondent regularly attended school and (2) which is the highest grade the respondent had completed. Our figures do not show to which extent a person who has completed elementary school is literate in local language or in English.

We believe that the above-mentioned figures warrant a detailed investigation concerning school attendance and the relevance of the present education system in Yap.

<u>Economic activity</u>

The questions concerning economic activity asked in the Yap census were the same as those asked in the Kosrae 1986 census, namely if a person (during the week before the census) was (1) working primarily to grow, gather or catch food for own consumption, (2) working primarily to earn money, (3) looking for work, (4) attending school full-time, (5) primarily engaged in unpaid household work, (6) unable to work or (7) other. Table 22 gives economic activity for the population aged 15 years and over for Yap proper and the outer islands.

In Yap proper 17.7 percent of the men are engaged in basic agriculture. For women, the similar number is 43.6 percent. On the outer islands, 51.2 percent of the men and 80.3 percent of the women are engaged in subsistence farming. This means that with better farming methods, a relatively large number of men and women could be released for industrial employment. Second, there is a large differential between men and women with respect to subsistence farming. In Yap, as elsewhere in the PIR, women are food producers and the corner stone in maintaining the Pacific island life style. Men, on the other hand, are income earners. On Yap proper some 60 percent of the men and about 25 percent of the women work primarily to make money. With respect to school attendance it will be seen that 9.6 percent of the men and 8.7 percent of the women declared that they were in school full-time.

On the outer islands, about 80 percent of the women and 51 percent of the men are engaged in subsistence farming. Some 21 percent of the men reported that they worked primarily for money. Only about 3 percent of the women indicated that they worked for money. With respect to school attendance, about 17 percent of the men and 6 percent of the women reported that they were in school full-time.

With respect to socioeconomic status the categories were: (1) employed by government, (2) employed by private organization, (3) employer, (4) own account worker, (5) unpaid family worker, (6) attending school full-time and (7) other.

Socioeconomic status

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Projecting the Yap State Population to the year 2000

Projecting a population one or two years ahead of time can be done with relatively good accuracy. The longer the projection period, the more uncertainty we face. We have made the assumptions that the total fertility rate is 4.3 and that West Model Life Table 18 apply throughout the projection period. This means that we assume that the life expectancy for men is 58.8 years and for females 62.5 years. These life expectancies are quite close to the ones we have estimated for Yap. It is assumed that there is no migration in and out of the Yapese population.

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STATISTICAL APPENDIX

1.0 INTRODUCTION

In the present appendix we outline the procedures for estimating childhood mortality from child survivorship data, and for estimating fertility from a combination of data on children born during the year before the census and mean parities reported in the census. We begin our discussion with estimation of child mortality from census returns on children ever born and surviving children.

2.0 ESTIMATION OF INFANT AND CHILDHOOD MORTALITY

Child survivorship data, i.e. reports on the number of ever born children and surviving children, by age of mother, reflect a retrospective observational plan. In addition, the plan confounds mortality and fertility. For these reasons, it is not an ideal one. However, because of the lack of reliable vital registration data in developing countries, it has become a widely used approach for estimating childhood mortality in developing societies. It was Brass (1961) and Brass et al. (1968) who developed the first method for estimating childhood mortality from census child survivorship data. Modifications of his approach have been given by Sullivan (1972); Trussel (1975), Feeney (1980), Hill and Trussel (1977), Kraly and Norris (1978), and Palloni (1979 and 1980).

Because the method we use in the present report is new and deviates in a number of ways from the one suggested by Brass (see e.g. Brass 1975, pp. 50-59), we outline the basic elements involved in making use of child survivorship data. Our method relies on mathematical modeling of the survivorship function for children and the fertility function for women (Hartmann, 1982). It is a method which affords more accurate estimation of childhood mortality (under conditions of near stationary mortality and fertility) than the ones previously suggested. It is a main advantage of the method that it gives an estimated continuous survival function for ages between 0 and 5 years.

We emphasize that the estimation of childhood mortality concerns women's own children and, of course, only the children for whom there are reports. Children born by women who have died are not included in the reports and their mortality, although perhaps higher than that of children whose mothers are still alive, cannot be estimated from the above-mentioned child survivorship data. Also, the mortality of children born by women who were not interviewed during the census, e.g. women in overseas labor force, cannot be estimated.

2.1 Modeling the proportion of surviving children reported by mothers aged x

To advance the discussion, we assume that the population is closed to migration. Let $W(x;t)$ be the age density of females at time t, i.e. there are $W(x;t)dx$ females between ages x and x+dx at time t. Consider females aged x, who are the survivors of the female cohort born x years ago, i.e. at time t-x and assume that this cohort of females has the fertility function f and that their children have the survival function s. The expected number of ever born children born by these women when they were between ages x-a and x-a+da is

$W(x-a;t-a)\, f(x-a)da.$

All of these children, however, cannot be reported since some of the women have died during the period t-a to t. Instead, the expected number of children to be reported is

$W(x;t)f(x-a)da$. Letting a_o denote the starting age of the fertility schedule given by f and extending the consideration to the whole of the sub-interval a_o to x, we have that the expected number of children to be reported is

$$B(x) = W(x;t) \int_0^{x-a_o} f(x-a)da \tag{1}$$

and that the corresponding number of surviving children to be reported is

$$S(x) = W(x;t) \int_0^{x-a_o} f(x-a)s(a)da \tag{2}$$

where s(a) is the probability of surviving from birth until age a. From (1) and (2) it follows that the proportion of children ever born who will be reported as surviving by mothers aged x is

$$A_x = \frac{\int_0^{x-a_o} f(x-a)s(a)da}{\int_0^{x-a_o} f(x-a)da} \tag{3}$$

and that the corresponding proportion of deceased children is

$$H_x = \frac{\int_0^{x-a_o} f(x-a)q(a)da}{\int_0^{x-a_o} f(x-a)da} \tag{4}$$

where $q(a) = 1 - s(a)$. Henceforth, we refer to q as the mortality function.

Using the mean value theorem for integrals and (4), it will be seen that there is an age $\xi_x = \xi(f,q,x)$, $0 < \xi_x < x-a_o$, so that $q(\xi_x) = H_x$. It is this elementary property that makes possible estimation of childhood mortality from child survivorship data.

In the original approach given by Brass (Brass et al. 1968, pp. 104-122), it was assumed that child survivorship data were given by five-year age groups of women. In order to work with the standard five-year age groups 15-19, 20-24, ... , 60-64, which we index i=1, ...,10, respectively, we let D_i denote the corresponding proportion of deceased children and P_i the average parity for females in age group i. Because the mean parities play an important role in the estimation process, we show how these appear under the assumption of a piecewise constant density of females. From (1) it follows that the total number of children ever born reported by females aged e.g. 20-24 years is

$$\int_{20}^{25} B(x)dx = \int_{20}^{25} W(x;t) \int_{o}^{x-a_o} f(x-a)dadx \qquad (5)$$

and since the total number of females aged 20-24 years is $\int_{20}^{25} W(x;t)dx$, the average, or mean, parity for females aged 20-24 years is

$$P_2 = \frac{\int_{20}^{25} W(x;t) \int_{o}^{x-a_o} f(x-a)dadx}{\int_{20}^{25} W(x;t)dx} \qquad (6)$$

If we assume, as Brass did, that the age distribution of females is uniform between the ages of 20 and 25 years, we may write

$$W(x;t) = \Lambda$$

where Λ is a constant, for ages between 20 and 25 years. Denoting the cumulative fertility at age x by F(x), i.e.

$$F(x) = \int_{o}^{x} f(u)du = \int_{a_o}^{x} f(u)du$$

we have from (6) that

$$P_2 = \frac{1}{5} \int_{20}^{25} F(x)dx.$$

In general, assuming a uniform age distribution for females within each five-year age group, we may write

$$P_i = \frac{1}{5} \int_{t_i}^{t_i+5} F(x)dx$$

where $t_i = 10+5i$, for the average parity corresponding to the i:th age group. It will now be seen that the number of deceased children to be reported by women aged 20-24 years is

$$\int_{20}^{25} W(x;t) \int_{o}^{x-a_o} f(x-a)q(a)dadx$$

and that, accordingly,

$$D_2 = \frac{\int_{20}^{25} W(x;t) \int_{o}^{x-a_o} f(x-a)q(a)dadx}{\int_{20}^{25} W(x;t) \int_{o}^{x-a_o} f(x-a)dadx}$$

Since we have assumed $W(x;t) = \Lambda$, we finally obtain

$$D_2 = \frac{\int_{20}^{25} \int_{o}^{x-a_o} f(x-a)q(a)dadx}{\int_{20}^{25} \int_{o}^{x-a_o} f(x-a)dadx}$$

In general, we have

$$D_i = \frac{\int_{t_i}^{t_i+5} \int_{o}^{x-a_o} f(x-a)q(a)dadx}{\int_{t_i}^{t_i+5} \int_{o}^{x-a_o} f(x-a)dadx} \qquad (7)$$

where $t_i = 10+5i$, models the proportion of deceased children to be reported by mothers in the i:th five-year age group. In passing, let us note, once again, that it is the assumption of a piecewise constant density of females that yields (7). Deviations from this assumption will lead to a more complicated expression for the proportion of deceased children (theoretically) reported by women aged [x,x+5[.

Using the mean-value theorem for double integrals, it will be seen that there is an age $\zeta_i = \zeta(f,q,i)$ so that

$$q(\zeta_i) = D_i \qquad (8)$$

It is clear, therefore, that the proportion of deceased children reported e.g. by women aged 20-24 years is equal to the probability of dying before a certain age ζ_2, say. Estimating childhood mortality from proportions of deceased children given by five-year age groups of women, then, is a matter of finding the age ζ_i that corresponds to D_i (see e.g. Hartmann, 1982). It will be noted, however, that ζ_i obviously depends on the fertility of women (f), and the mortality of children (s). Without going into detail, we mention that the Brass multipliers are found from the observed ratios $\hat{P}_i/\hat{P}_{i+1}$, i = 1, 2 e.g. $\hat{P}_2/\hat{P}_3$ (see e.g. Brass 1975, pp. 50-59).

2.2 Modeling the survival function for children

In order to use (4) in a method for estimating childhood mortality it is necessary to model f and q. To this end, we first model q = 1 - s. It has previously been shown that

$$\text{logit } s(x) = a + b \log x \tag{9}$$

where $\text{logit } p = \frac{1}{2} \log \frac{1-p}{p}$ with $0 < p < 1$, and where log is the natural logarithmic function, gives a close fit to empirical childhood mortality experiences (Hartmann, 1980, 1981 and 1982). In terms of the mortality function, (9) becomes

$$q(x; a, b) = \frac{e^{2a} x^{2b}}{1 + e^{2a} x^{2b}} \tag{10}$$

When fitting (9) to a childhood experience at ages x_i, i = 1, ... ,N, one may minimize the sum of squares

$$\sum_{1}^{N} [\text{logit } \hat{s}(x_i) - a - b \log x_i]^2 \tag{11}$$

with respect to a and b. The estimated, or fitted, mortality function then becomes $\hat{q}(x) = q(x; \hat{a}, \hat{b})$ where q is given by (10), $\hat{a}$ and $\hat{b}$ minimize (11) and $\hat{s}(x)$ is the observed survival function. If one fits q(x; a, b) directly to an observed experience $\hat{q}(x)$, then the normal equations become non-linear and (weighted or unweighted) non-linear least squares estimation must be resorted to. For most practical applications it is sufficient to use (11) which gives linear normal equations.

2.3 Modeling the fertility function

There are several possibilities at hand for modeling the fertility function for women. For example, one could use the Hadwiger formula, the Pearson type III frequency function (see e.g. Keyfitz, 1968, pp. 140-169; Luther, 1982, pp. 5-12), the Brass fertility polynomial (see e.g. Retherford, 1979), a third-degree polynomial or B-splines (see e.g. McCutcheon, 1981, pp. 421-438). We have chosen to work with the Pearson type III frequency function because it appears to give a closer fit to recorded fertility than other (simple) density functions. The Hadwiger model, although it often gives a close fit to recorded fertility has too many parameters for our application.

To model the fertility curve, we let

$$g(x; c, k) = \frac{c^k}{\Gamma(k)} x^{k-1} e^{-cx}, x > 0$$

where c and k are parameters. This is also known as a gamma density with parameters c and k. Its mean value and variance are $\mu = k/c$ and $\sigma^2 = k/c^2$, respectively. A convenient approximation is

$$\Gamma(k) = (2\pi/k)^{1/2} k^k \exp(-k + \frac{1}{12k}).$$

When graduating a normalized fertility experience, an earliest age at childbearing a_o is often introduced and $g(x-a_o; c, k)$ is used for fertility at age $x > a_o$. Because $g(x; c, k)$ is virtually zero for ages less than 10 years, for typical fertility values of c and k, it is sufficient to let $a_o = 0$. In our applications, then, we let

$$f(x; c, k) = R\, g(x; c, k) \tag{13}$$

model a fertility function with total fertility rate R (see e.g. Keyfitz and Flieger, 1971, p. 586).

When fitting (12) to data it is often sufficient to use the method of moments whereby $\hat{R} = \hat{T}$, where $\hat{T}$ is the observed total fertility rate, and $\hat{c} = \hat{\mu}/\hat{\sigma}$ and $\hat{k} = \hat{\mu}^2/\hat{\sigma}^2$. Here $\hat{\mu}$ and $\hat{\sigma}^2$ are the estimated mean and variance, respectively, of the observed fertility schedule.

Empirical studies suggest (Hartmann, 1982) that by letting k=18 and by keeping c as a free parameter,

$$f_s(x) = R\, g(x; c, 18) = R \frac{c^{18}}{17!} x^{17} e^{-cx},\ x > 0 \tag{14}$$

gives a simple two-parameter model of the fertility schedule. Another useful model of the fertility schedule is the Brass fertility polynomial (see e.g. Retherford, 1979, pp.15-19)

$$b(x; a_o, C) = C\,(x-a_o)\,(a_o + 33 - x)^2 \tag{15}$$

where a_o is the starting age of the fertility schedule and C a constant that gives the desired total fertility rate. The Brass fertility polynomial (15) has mean age $\mu = a_o + 12.7$ and (fixed) variance $\sigma^2 = 43.6$.

2.5 The estimation procedure

The estimation procedure used in this report is one which builds on model proportions of deceased children corresponding to a given mortality function q, and a given fertility function f. The model proportions of surviving, or deceased, children is obtained by inputting relevant functions f and q in (4).

Estimation of f is a delicate matter. Under conditions of stationary mortality and fertility, and assuming that the age pattern of fertility is well modeled by e.g. the gamma density, one may calculate model ratios of mean parities and relate these to the mean of the model density. Using an observed ratio of mean parities e.g. $\hat{P}_1/\hat{P}_2$, one may then infer the corresponding mean value of the underlying fertility function. In the particular case of using (14) one lets $\hat{c} = \hat{c}\ (\hat{P}_1/\hat{P}_2)$. Since the mean parities are independent of R (the total fertility rate), it is now possible to calculate model proportions of surviving, or deceased, children that are similar to the observed ones. The final step in the estimation procedure is then one of adjusting the mortality function $\hat{q}_s = q(x; \hat{a}, \hat{b})$ in (4) so that the model proportions of deceased children become equal, or near equal, to the observed ones. We now turn to a discussion of how this adjustment can be made.

For short age intervals (at least for ages between 0 and 5 years), mortality functions are very nearly proportional. Consequently, one may define a family of mortality functions, relative to a standard mortality function q_s, by letting

$$q = K q_s \qquad (16)$$

where K is a constant. As long as K is close to unity, the generated function q can be perceived as a realistic representation of an empirical mortality function. In passing, notice that this also means that the corresponding model proportions of deceased children emerging from (4) are proportional, i.e, we have

$$H_x = K H_x^s$$

To explain the method, let H_x^s be model proportions of deceased children given by (4) and corresponding to a model fertility schedule f, and a model (standard) mortality function q_s. Let $\hat{H}_x$ be observed proportions of deceased children which are numerically similar to the model proportions H_x^s. Assume further that f has the same mean age as the fertility function underlying the $\hat{H}_x$. To estimate K in (16), we minimize the sum of squares

$$\sum_{1}^{N} [\hat{H}_x - K H_x^s]^2$$

with respect to K. This gives

$$\hat{K} = \sum_x [\hat{H}_x H_x^s] / \sum_x [H_x^s]^2 \qquad (17)$$

where the summation is over relevant ages x. For example, if we were to use the reports from women aged 20, 21, 22, 23 and 24, the summation would be over those ages. The estimated mortality function is then $\hat{q}_t = \hat{K} q_s$. We now turn to numerical illustrations of the method.

2.6 Numerical illustrations

In order to estimate the mean age of the fertility schedule underlying the given child survivorship data, we have regressed P2/P3 on μ for the model parity ratios given in Table A1. These model ratios have been derived from the Brass fertility polynomial and (14). The regression representation is

$$\hat{\mu} = 38.2125 - 23.0989\, \hat{P}_2/\hat{P}_3 \qquad (18)$$

with coefficient of determination $R^2 = 0.840$, and n = 26 model values. The model ratios obtained by means of (14) are slightly different from those obtained from the Brass fertility polynomial. Thus the regression representation (18) reflects a blend of two types of model ratios. We believe that this makes (18) useful for practical estimation of μ. It should be noted, however, that whichever method we use, the estimation of the mean age of the underlying fertility schedule from the ratio of mean parities is error prone. Whereas for various fertility models there is a unique relation between the first moment of the fertility function (here denoted by μ) and the ratios of mean parities, e.g. P2/P3, empirical fertility functions do not have that property.

Example I

In our first example, we use data from the 1976 Western Samoa population census. In this census, the proportions of deceased children were tabulated by single-year ages for more detailed analysis. The observed proportions are given in Table A2. This table also gives model proportions of deceased children corresponding to a model fertility schedule given by (13) with a mean age of $\hat{\mu} = 29.6$ and a variance of $\hat{\sigma}^2 = 47.1$. The model mortality function is given by (10) with a = -1.6420 and b = 0.1106 (estimated from VSSS data). The model proportions of deceased children are constructed so as to be close to the observed ones. Estimating K in (16) by means of (17) for the ages 20, ... , 29, gives $\hat{K} = 1.0442$. The model mortality function and the estimated mortality function are given in Table A3. Notice that it is part of the method that it is guessed that (10) with the above-mentioned parameters gives a first approximation to the mortality function we wish to estimate. We then make use of the fact that (16), when introduced into (4), makes the model proportions of deceased children proportional to the observed ones. The proportionality factor in (16) is then estimated from the model proportions of deceased children and the observed proportions of deceased children by means of (17).

It is an essential part of the method that the selected model proportions of deceased children have been generated by a fertility function which is as similar in terms of location and shape to the one underlying the observed proportions of deceased children. In the case of the Samoan data, the fertility function used to generate the model proportions of deceased children has been estimated from VSSS data.

If we only make use of $\hat{D}_2 = 0.0414$ and $D_2 = 0.0401$, we obtain $\hat{K} = 0.0414/0.0401 = 1.0324$. Based on previous experiences and theoretical elaborations (Hartmann, 1982b), we do not recommend that $\hat{D}_1$ be used for estimation of q. (The observed proportion of deceased children reported by women aged 15-19 is very sensitive to the age-pattern of mortality.)

In the Pacific where, by and large, the level of infant and childhood mortality is close to that of level 20 in the West Model Life Tables (Coale and Demeny, 1966), Table A4 may be used as a standard table for estimation. This table gives model proportions of deceased children by single-year ages of women corresponding to the mortality function (both sexes) at West level 20 and model fertility schedules given by (14). We now illustrate the use of this table.

Example II

For Kosrae 1980, we note that $\hat{P}_2/\hat{P}_3 = 0.4048$ and that $\hat{D}_2 = 0.0588$ (see Table 5). Using (18) for estimation of the mean age of the fertility schedule underlying the reported proportions of deceased children, we get $\hat{\mu} = 28.9 \approx 29.0$. Using Table A4, this gives $\hat{K} = 0.0588/0.0515 = 1.1417$. The estimated mortality function now becomes $\hat{q}(x) = 1.1417$ $q(x;-1.5055, 0.0757)$ with q given by (10).

Table A1.-Model ratios of mean parities generated by the gamma density and the Brass fertility polynomial

Value of parameter c	Mean age of fertility schedule μ	Variance of fertility schedule σ^2	P_1/P_2	P_2/P_3
Gamma density with k = 18				
0.7296	24.7	33.8	0.2166	0.5237
0.7151	25.2	35.2	0.2085	0.5055
0.7012	25.7	36.6	0.2008	0.4877
0.6878	26.2	38.1	0.1932	0.4710
0.6749	26.7	39.5	0.1865	0.4549
0.6625	27.2	41.0	0.1797	0.4396
0.6505	27.7	42.5	0.1734	0.4248
0.6390	28.2	44.1	0.1678	0.4110
0.6278	28.7	45.7	0.1622	0.3976
0.6171	29.2	47.3	0.1572	0.3849
0.6067	29.7	48.9	0.1520	0.3730
0.5966	30.2	50.6	0.1475	0.3613
0.5869	30.7	52.3	0.1430	0.3503
Brass fertility polynomial				
Value of a_o				
11.8	25.0	43.6	0.3705	0.6044
12.3	25.5		0.3415	0.5850
12.8	26.0		0.3115	0.5649
13.3	25.5		0.2806	0.5439
13.8	27.0		0.2491	0.5221
14.3	27.5		0.2172	0.4993
14.8	28.0		0.1855	0.4757
15.3	28.5		0.1550	0.4510
15.8	29.0		0.1263	0.4252
16.3	29.5		0.0996	0.3984
16.8	30.0		0.0752	0.3705
17.3	30.5		0.0540	0.3594
17.8	31.0	43.6	0.0357	0.3221

Table A2.-Observed proportions of deceased children by single-year ages of women reported in the 1976 Western Samoa population census, and model proportions of deceased children

Age of mother	Model proportions of deceased children	Observed proportions of deceased children*
20	0.0381	0.0425
21	0.0394	0.0430
22	0.0397	0.0394
23	0.0407	0.0376
24	0.0416	0.0451
20-24	0.0401	0.0414
25	0.0433	0.0380
26	0.0446	0.0509
27	0.0456	0.0524
28	0.0464	0.0463
29	0.0475	0.0504
25-29	0.0457	0.0482

* Special tabulation prepared at the Government of Fiji Electronic Data Processing Services in Suva, Fiji. This tabulation has not been published previously.

Table A3.-Model mortality function and estimated mortality function

Age	Model mortality function $q_s(x; -1.6420, 0.1106)$	Estimated mortality function $\hat{q}(x) = 1.0442\, q_s(x; -1.6420, 0.1106)$
0	0.0000	0.0000
1	0.0361	0.0377
2	0.0419	0.0437
3	0.0456	0.0476
4	0.0485	0.0506
5	0.0508	0.0530

Table A4.-Model proportions of deceased children corresponding to West model life table, level 20, and selected mean ages of the fertility schedule*

	Mean age of model fertility schedule				
	25.7	26.7	27.7	28.7	29.7
Age	H_x	H_x	H_x	H_x	H_x
15.5	0.0438	0.0436	0.0434	0.0402	0.0399
16.5	0.0462	0.0460	0.0442	0.0440	0.0438
17.5	0.0478	0.0469	0.0466	0.0464	0.0461
18.5	0.0488	0.0485	0.0482	0.0472	0.0469
19.5	0.0500	0.0494	0.0491	0.0488	0.0485
15-19	0.0473	0.0469	0.0463	0.0453	0.0450
20.5	0.0509	0.0506	0.0502	0.0496	0.0493
21.5	0.0518	0.0514	0.0511	0.0507	0.0504
22.5	0.0529	0.0523	0.0519	0.0515	0.0512
23.5	0.0538	0.0533	0.0529	0.0523	0.0519
24.5	0.0547	0.0541	0.0537	0.0533	0.0529
20-24	0.0528	0.0523	0.0520	0.0515	0.0511
25.5	0.0556	0.0550	0.0545	0.0541	0.0536
26.5	0.0565	0.0559	0.0554	0.0549	0.0544
27.5	0.0574	0.0568	0.0562	0.0557	0.0552
28.5	0.0583	0.0576	0.0570	0.0565	0.0560
29.5	0.0592	0.0585	0.0579	0.0573	0.0568
25-29	0.0574	0.0568	0.0562	0.0557	0.0552

*

This tabulation shows that when childhood mortality is given by West model 20 and when the mean age of the fertility schedule is e.g. $\mu = 25.7$ years, then mothers aged 15-19 report that a proportion of 0.0473 of their ever born children have died. If the mean age of the fertility schedule is 29.7 years, then they would report a proportion of 0.0450 deceased children. By studying the model proportions of deceased children in Table A4, it is clear that even if the proportion of deceased children is a function of both the mortality and the fertility functions, the differences in mean location of the fertility functions have a relatively marginal influence on the proportions of deceased children. In practice, the fertility rates for young women may change markedly from year to year and it is this circumstance that makes it difficult to assess to which extent the proportions of deceased children depend on fertility.

Example III

In the case of Yap, 1987, we demonstrate how the estimation of the underlying mortality function can be fine-tuned so as to take the underlying age-pattern of fertility into account. For graduation of the observed fertility rates (see Table 14, column (5)) the graduating polynomial is

$$p_\phi(x) = -1.051956 + 0.1109\,x - 0.0031026\,x^2 + 0.00026111\,x^3$$

with approximate roots, $a_1 = 14.9562$, $a_2 = 50.0354$ and $a_3 = 53.8664$. As already noted, the mean age for $p_\phi(x)$ is $\hat{\mu} = 29.6$. We use $p_\phi(x)$ to model the fertility function f in (4). To model the mortality function, we use q(x; a, b) with $\hat{a} = -1.5055$ and $\hat{b} = 0.0757$ which gives a continuous representation of the mortality function (both sexes) in West level 20 (see Hartmann, 1980, pp. 36-55).

Starting the numerical integration in (4) at age x = 14.9562, the model proportions of deceased children appear as given in Table A5.

To estimate K in (16), we use (17) for the ages 20, 21, 23, 24 and 25 (we drop age 22 because $\hat{H}_{22} = 0$) and obtain

$$\hat{K} = \sum_x [\hat{H}_x H_x^s] / \sum_x [H_x^s]^2 = 0.014024 / 0.013593 = 1.0317.$$

As in the previous examples, the estimated mortality function becomes $\hat{q}(x) = 1.0317\, q(x;-1.5055, 0.0757)$ with q given by (10).

Table A5.-Model proportions of deceased children corresponding to estimated fertility for Yap 1987

Age x	Cumulated Fertility at age x	Cumulated child deaths at age x	Proportion of deceased children at age x
14.9562	0.00000	0.00000	
15.5	0.00518	0.00018	0.0347
16.5	0.04015	0.00162	0.0403
17.5	0.10498	0.00456	0.0434
18.5	0.19612	0.00896	0.0457
19.5	0.31019	0.01472	0.0475
15-19	0.13132		0.0423
20.5	0.44395	0.02179	0.0491
21.5	0.59434	0.02995	0.0504
22.5	0.75844	0.03916	0.0516
23.5	0.93349	0.04918	0.0527
24.5	1.11690	0.05998	0.0537
20-24	0.76942		0.0515
25.5	1.30621	0.07138	0.0546
26.5	1.49913	0.08330	0.0556
27.5	1.69354	0.09548	0.0564
28.5	1.88746	0.10789	0.0572
29.5	2.07907	0.12040	0.0579
25-29	1.69308		0.0563

2.5 Estimating a life table for Yap around 1987

The estimation of a life table for Yap is necessarily an approximate endeavor. The only practical solution at hand is to take advantage of the estimates of infant and childhood mortality and infer the remaining part of the survival curve from these estimates. With this approach one could select e.g. a West model life table with the corresponding level of infant and childhood mortality. We abandon this approach because, in our view, it would give an estimated life table with a too high life expectancy. Instead, we make use of the Brass logit life table approach (see e.g. Brass, 1971, pp. 69-110). The application of the Brass logit life table method hinges on the selection of a proper standard life table. We have chosen the life table for Western Samoa around 1981-82 as a standard (see Table 2).

The Brass logit life table method makes use of the approximate relation between survival functions $l(x)$ and $l_s(x)$ that

$$\text{logit } l(x) = \upsilon + \omega \text{ logit } l_s(x) \qquad (19)$$

where $l_s(x)$ is referred to as a standard survival function and υ and ω are parameters. For a given standard survival function, (19) generates a family of related survival functions. From a practical point of view, it is best to work with values of ω that are close to unity. The more ω departs from unity, the more the age-pattern of the generated survival function deviates from empirical patterns. For estimates $\hat{\upsilon}$ and $\hat{\omega}$, and by letting

$$\text{logit } \hat{l}(x) = \hat{\upsilon} + \hat{\omega} \text{ logit } l_s(x),$$

the generated survival function is

$$\hat{l}(x) = \frac{1}{1 + \exp(2\hat{\upsilon}) \, [\{1 - l_s(x)\} / l_s(x)]^{\hat{\omega}}}$$

In our application of (19), we let $\omega = 1$ and estimate υ on the basis of the difference between childhood mortality in the standard life table (the life table for Western Samoa 1981-82) and in the estimated mortality function for Yap State 1987 (see bottom of Table 10).

In order to take full advantage of the two childhood survival functions, we have fitted (10) by means of (11) to the two childhood experiences. This gives two continuous representations of the survival functions. These are $l_s(x) = 1 - q(x; -1.5604, 0.0852)$ for the standard survival function and $\hat{l}(x) = 1 - q(x; -1.4888, 0.0760)$. Notice that $l_s(x)$ is a continuous representation of the childhood experience for Western Samoa 1981-82, and that $\hat{l}(x)$ is a continuous representation of childhood mortality for Yap in 1987. To estimate υ, we let

$$\hat{\upsilon} = (1/5) \sum_{x=1}^{5} [\text{logit } \hat{l}(x) - \text{logit } l_s(x)]$$

The estimation of υ is illustrated in Table A6.

Table A6.-Continuous representations of the survival functions for the ages 1,2,3,4 and 5 for Western Samoa 1981-82 and Yap 1987

Age	$l_s(x)$ Samoa	$l(x)$ Yap	logit $l_s(x)$	logit $l(x)$	logit $l(x)$ - logit $l_s(x)$
0	1.0000	1.0000			
1	0.9577	0.9516	-1.5599	-1.4893	0.0706
2	0.9527	0.9464	-1.5014	-1.4356	0.0658
3	0.9495	0.9432	-1.4670	-1.4049	0.0621
4	0.9471	0.9409	-1.4425	-1.3838	0.0587
5	0.9451	0.9390	-1.4229	-1.3670	0.0559

Mean logit difference: 0.0626

To estimate a life table for Yap, we let

$$\hat{1}_x = 0.0626 + \text{logit } l_s(x)$$

where $l_s(x)$ is the survival function (for both sexes) for Western Samoa during 1981-82. The resulting life table is shown in Table 11.

3.0 ESTIMATING FERTILITY FROM DATA ON BIRTHS DURING THE YEAR BEFORE THE CENSUS

Estimating age-specific fertility rates from returns on the number of children born during the year before the census would be a relatively simple matter if the returns were correct. The only problem that arises is that the women, on average, were half a year younger when they gave birth. The displacement of half a year is immaterial in a small population where the estimated rates have large variances. In populations where the reporting of births (in the census) is affected by recall errors, omissions, misunderstandings between the canvassers and the respondents, etc., the age-specific fertility rates estimated from the census returns will, most likely, give a too low total fertility rate. Furthermore, the age-pattern of the estimated fertility schedule may deviate significantly from the true age-pattern of fertility.

In order to make use of census retúrns concerning the number of children born during the year before the census, the reporting must be fairly accurate. Given that underreporting is the same in all the age groups, the normalized schedule can be used for estimation of age-specific fertility rates from the reported mean parities in the census. This approach, of course, assumes that fertility and mortality are near stationary. Since there is no society for which fertility remains constant over a ten or fifteen year period, it is not very realistic to make such an assumption. Nevertheless, upgrading the fertility rates obtained from the data on births during the year before the census on the basis of the reported census mean parities, at least in some situations, is a better approach than to merely accept the rates as they are. Moreover, if the changes in level of fertility during the past ten or fifteen years have been modest, then the upgrading provided by the census mean parities may be quite reasonable.

If we assume that fertility and mortality have changed very little during the past ten to fifteen years, the mean parity reported by women aged 25-29 can be used to upgrade the age-specific fertility rates derived from the returns on childbirth during the year before the census. Let us denote these rates by $\hat{f}(x)$. We assume that the estimated rates $\hat{f}(x)$ are proportional to the true, but unknown, rates $f(x)$, i.e.

$$\hat{f}(x) = \kappa f(x) \qquad (19)$$

where κ is an unknown constant. Letting $\hat{P}_3$ denote the observed mean parity for women in the age group [25,30[, we have, at least in an approximate sense, that

$$\hat{P}_3 = \kappa \int_0^{27.5} \hat{f}(x)\,dx = R \int_0^{27.5} g(x;\hat{c},\hat{k})\,dx$$

where g is given by (12) and where c and k have been estimated from the moments of $\hat{f}(x)$. It then follows that estimates of R and κ are given by

$$\hat{R} = \hat{P}_3 / \int_0^{27.5} g(x;\hat{c},\hat{k})\,dx \qquad (20)$$

and that

$$\hat{\kappa} = \hat{P}_3 / \int_0^{27.5} \hat{f}(x)\,dx, \qquad (21)$$

respectively.

We now illustrate how the assumption (19) can be used for estimation of age-specific fertility rates that agree with the reported mean parity at ages [25,30[. The data on births during the year before the census are given in Table 14. Because the number of women obviously is very small, we have graduated the observed rates by means of a third-degree polynomial. For convenience, we denote the graduated rates in Table 14 (column 5) by $\hat{f}(x)$. Letting

$$T_i = \sum (x + 2.5)^i \hat{f}(x)$$

the estimated mean value and variance of the graduated rates become

$$\hat{\mu} = T_1/T_0$$

and

$$\hat{\sigma}^2 = T_2/T_0 - (T_1/T_0)^2.$$

The graduated rates (Table 14, col. 5) now give, $\hat{\mu} = 29.5$ and $\hat{\sigma}^2 = 55.0$. In other words, we have a schedule with relatively high mean age and variance. But this is also what we would expect. For estimation of c and k in (12), we have $\hat{c} = \hat{\mu}/\hat{s}^2$ and $\hat{k} = \hat{\mu}^2/\hat{\sigma}^2$ with $\hat{\mu} = 29.5$ and $\hat{\sigma}^2 = 55.0$. This gives $\hat{c} = 0.5364$ and $\hat{k} = 15.8$ whereby numerical integration yields $\int_{10}^{27.5} g(x;\hat{c},\hat{k}) = 0.4262$.

If the age-pattern of fertility is well modeled by a gamma density, then women (in the absence of mortality) have produced about 42.62 percent of their children by age 27.5. The mean parity reported by women aged [25,30[was $\hat{P}_3 = 2.2512$. From (20) we obtain that $\hat{R} = 2.2512/0.4262 = 5.2820$. From (21) we obtain $\hat{\kappa} = 5.2820/4.0540 = 1.3029$. Based on this result (and assuming near stationary mortality and fertility), it would appear that there was 30 percent underreporting of births in the census.

If instead of making use of the gamma density to infer the value of the fertility integral up to age 27.5, we make use of $p_{\phi}(x)$, the results are

$$\int_{14.9562}^{27.5} p_{\phi}(x) = 1.69354$$

and

$$\int_{14.9562}^{50.0354} p_{\phi}(x) = 4.01373.$$

This means that women (in the absence of mortality) with that age-pattern of fertility have produced a proportion of 1.69354/4.01373 = 0.42194 of their fertility at age 27.5. The estimated total fertility rate becomes $\hat{R} = 2.2512/0.42194 = 5.3354$. The constant for upgrading the observed rates (given stationary mortality and fertility) becomes $\hat{\kappa} = 5.3354 / 4.0540 = 1.3161$. These results are in very good agreement with the ones given by the Brass P_i/F_i method which has been illustrated in the main text of the report.

With this method, the crude birth rate in 1987 is estimated as CBR = 1.3029 X 300/10,139 = 38.5 per 1,000 because 300 births were reported and the total population was 10,139. As noted in the main report, we believe this estimate to be too high. It does not agree very well with the population aged 0 enumerated in the census which was 310 children pointing to a crude birth rate of about 31 per 1,000 population. Our final estimate of the crude birth rate, as will be recalled, is 32 per 1,000 population.

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