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SEASONALITY FROM FISH REMAINS

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Butts (1979) has advised caution when applying modern catch statistics to the method Leach (1976: Appendix 28; 1979) has devised for establishing season of occupation from the remains of fish in middens. I agree that the modern figures are unsatisfactory, and some of the difficulties will be considered below. However, Leach's method is also open to the more fundamental objection, that the manipulations he proposes to apply to the data produce unreliable results no matter how good the data. This paper is written to offer an approach that seems to be more appropriate.

A test of the Leach method

In Leach's approach the probability that a site was occupied in any month of the year is found by: (a) establishing a set of monthly "capture probabilities" for the species recovered from the site; (b) multiplying these by the respective site frequencies of the species; and (c) totalling and scaling the results to produce monthly "occupation probabilities".

Leach proposed two methods of assessing capture probabilities. In one, here called "Method A", the catch of a species in a month is first divided by the total catch of all species in that month. This proportion is then divided by the total of the twelve monthly proportions to produce the capture probability for that month. In "Method B" the capture probabilities are the proportions of the total catch of the species that are caught each month. Leach (1979: 112) says that Method B would be better if more fisheries data was available, but that he has to settle for Method A.

Assume that two species have the monthly catch-rates (units of, say, "fish/day'):

	J	F	M	A	M	J	J	A	S	O	N	D
Species I	8	10	12	14	12	10	8	6	4	2	4	6
Species II	11	12	13	14	13	12	11	10	9	8	9	10

In this test both methods of assessing capture probabilities will be applied, and the results for the two hypothetical species are:

Method A

	J	F	M	A	M	J	J	A	S	O	N	D	Row total
species I	.088	.095	.101	.105	.101	.095	.088	.078	.065	.042	.065	.078	1.001
species II	.080	.076	.072	.069	.072	.076	.080	.087	.095	.110	.095	.087	0.999
Method B													
species I	.083	.104	.125	.145	.125	.104	.083	.063	.042	.021	.042	.063	1.000
species II	.083	.091	.098	.106	.098	.091	.083	.076	.068	.061	.068	.076	0.999

If a site was occupied in October, and the inhabitants did one day's fishing, they would catch 2 fish of species I and 8 of species II. But when these numbers are fed into the mincer, the "occupation probabilities" that emerge are:

	J	F	M	A	M	J	J	A	S	O	N	D	
Method A	8.16	7.98	7.78	7.62	7.78	7.98	8.16	8.53	8.91	9.65	8.91	8.53	99.99
Method B	8.31	9.37	10.31	11.42	10.31	9.37	8.31	7.35	6.29	5.31	6.29	7.35	99.99

Method A therefore produces a pattern of occupation probabilities that is almost perfectly flat, suggesting year-round occupation, while Method B produces a set of probabilities slightly more diverse than those at the Washpool (Leach, 1979: 123), but including the result that October is actually the least likely month of occupation. Leach never explains the model on which his procedure is based, but one premise seems to be that the pattern of seasonal availability of a species of fish is a reliable guide to the season of the year that prehistoric people would have chosen to fish for that species. Of course that is the whole basis of presence/absence seasonal dating but it is generally less reliable for fluctuating abundance data and certainly seasonality inferences cannot be added together in the same simple way.

Say that a site contains two species with peak abundance in summer and winter respectively. Leach's approach is to assume that the animals of the summer abundant species were probably taken in summer, and the winter abundant species in winter, and the two together therefore tend to suggest year-round occupation. That need not be the case; the method is specifically addressed to species present all year round, so a mixture of the two could have been obtained at any time of year. The relative frequencies of the two species may be a guide to the likely season of capture, but Leach's monthly statistic "occupation probability" is not helpful here.

When a traditional measure of sampling probability is applied to the hypothetical situation described above the contrast is clear. Figure 1 compares the results of Leach's methods with those produced by the binomial probability function (Mode, 1966: eq. 8.1).

Seasonal occupation: a simulation

An alternative approach is clearly called for, and for simple two species situations like the hypothetical example the binomial theorem is a sensible choice. The formula can also be extended to any number of species, but the arithmetic involved becomes much more troublesome as the number of species is increased. The approach I prefer is to simulate the outcome of different seasons of exploitation of the local environment, and then compare the results with the make-up of the archaeological sample recovered, using the chi-square statistic to find reasonable matches. Say the season of occupation just covers a sequential series of months, so that there are 12 possible beginnings and 12 possible ends, and therefore 144 different possible seasons of occupation (remembering that 12 of these are all for the whole year, i.e. beginning of January to end of December, beginning of February to end of January, etc. and so are identical).

It is likely that the prehistoric people would have adjusted the length of time they spent fishing in a month according to the rate at which fish were caught. This means that it is necessary to give weightings to the catch rates in the different months, and three fishing 'strategies' are suggested:

1. The time put into fishing remains constant during each month of occupation;
2. The total number of fish taken each month remains constant;
3. The time spent fishing is proportional to the hourly catch rate; e.g. if the catch rate doubles, the time spent fishing doubles. Of these strategy 3 seems intuitively much more likely to have operated in prehistory.

If suitable catch statistics are available it is now only a matter of simple book-keeping to work out what the set of cumulative catches for the different species would be for each of the possible 'seasons', and for each fishing 'strategy'. These patterns of predicted species frequencies can be compared with the frequencies actually found. Using the chi-square statistic the likelihood that the archaeological sample could

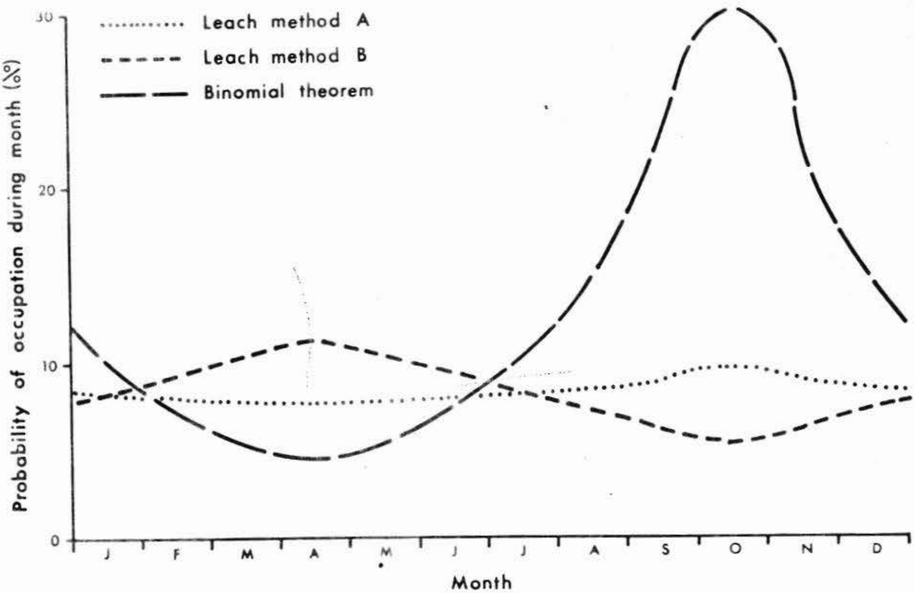

Figure 1. Monthly probabilities.

have arisen as a result of sampling of each of the hypothetical populations can be measured, and the results presented in a form to help with interpretation.

A computer programme 'SEASONAL' that performs these tasks has been written (Nichol, 1978: Appendix 1). To use this programme it is necessary to have catch rates in the form of the numbers of animals of each species that would be caught in each month of the year. This raises the important question of the value of modern catch statistics, and it is worth considering some the sources of Leach's (1979) capture probabilities before attempting an analysis.

Capture probabilities and fisheries data

Because of the range of fish species found in the Washpool midden Leach has had to draw on a variety of sources for his capture probabilities, and as a result some problems are apparent. For example, the assumption is made that, because nothing is known of the seasonal abundance of the conger eel, then the probability of its capture remains constant through the year. This assumption turns out to be quite controversial when the result of the analysis is that the probability of occupation remains nearly constant, but no other assumption can be any sounder.

More satisfactory are the use of a study of the protohistory of the Wairarapa by Mair (1972) for information on eels; Poata (1919), a Maori fisherman, for marblefish; and Graham (1953), a biologist, for sea perch. Though the figures Leach abstracts from these sources are necessarily arbitrary, they do generally reflect the seasonal abundances of the species in question. Unfortunately, the only figures possible are of the form "X% of the animal of this species caught are caught in month Y" - corresponding to "method B" above - so it is difficult to compare catch rates of the different species.

What is needed is a collection of data for as many species as possible, comparable with the commercial trawling data from which Leach derives his capture probabilities for tarakihi, red cod, kahawai, barracouta, snapper, common mackerel, blue moki, red gurnard, southern dogfish, elephant fish, trevally and ling. Because of the abundance of modern commercial trawling data makes their use very attractive, it is necessary to consider their value in detail. The problems involved are basically that we are dealing with modern, commercial trawling.

Butts (1979) has made the point that modern boats can fish far from the port at which they land their catch. This could produce very serious distortions in seasonal catch-rates. In addition, there is the requirement that, "... If very local sea conditions prohibit deep water line fishing in certain months, then this factor should be taken into account, even though a particular fish may be very abundant over the same period" (Leach, 1979: 110-111). But though "sea conditions ... which hamper modern fishermen also applied to prehistoric people" (ibid: 111-112), it is by no means certain that the reverse applies. A prehistoric fishing canoe - even a large one such as Best (1929:46) describes as holding "thirty men, more or less" - cannot be compared with vessels in use today, including boats of 20 m and more in length, equipped with radar and echo sounders, and powered by diesel engines of hundreds of horsepower (Watkinson and Smith, 1972). This equipment allows modern fishermen in New Zealand to operate virtually year-round, while prehistoric fishing would be markedly restricted during the stormier months of the year. A major bias toward constant monthly capture probabilities must remain. Butts (1979) has already given reasons for doubting the value of commercial returns, but I think that perhaps the most striking demonstration of the dangers involved in the use of commercial data for information on prehistoric subsistance is provided by the case of blue cod, which,

> "... is a highly prized commercial fish ...
>
> Though the fish is still plentiful at the Chatham Islands, the landings there declined to zero in 1967 and 1968, when the total fishing effort was devoted to rock lobstering.
>
> A gradual return to lining for blue cod has taken place since that time with the decline in rock lobster catches. It is noteworthy that the rock lobster vessels at the Chatham Islands, in particular, still fished for blue cod even during the time when no fish were landed. The catch was used exclusively as bait for the more valuable crustaceans."
>
> (Watkinson and Smith, 1972:29-30)

A corollary of Leach's (1979: 116) comment that the almost exclusively line-fishing data on blue cod makes them particularly useful, is that trawling data must be rather doubtful, and there is good reason for this. Trawling especially is subject to important restrictions, and harbours, estuaries, and most large bays are 'closed' areas (Watkinson and Smith, 1972: 11, 13). These areas will have been of enormous importance in prehistoric fishing.

Trawlers are generally used for surface or bottom trawling. Prehistoric fishing methods might not have been any more effective in mid-water, but there are other interesting problems. As Leach (1979:113) says, tarakihi is exclusively demersal in feeding habits, but when trawling is involved the whereabouts of the fish at all times is important:

> "tarakihi spawn in the late summer and autumn. This is when they take on a more regularly demersal behaviour and are caught in greatest quantity."
>
> (Watkinson and Smith, 1972:15)

"The emphasis should be on "catchability" rather than mere presence" (Leach, 1979:110); but it is clear that mere presence is the crucial factor here.

Modern commercial trawling data does indeed represent a huge sample, but from the point of view of the study of prehistoric fishing it is also a sample biased in many ways, so it can hardly be relied on to provide an accurate picture.

It seems that all the available data is unsuitable, and more acceptable date will have to be specially collected by any prehistorian intending to make seasonality deductions from fish species in archaeological sites in New Zealand. However, as other archaeologists may be better equipped, it is proposed to demonstrate the approach described above using line-fishing data from a few species.

Fisheries data on the ten most important commercial species in New Zealand has been tabulated by Ritchie, Saul and O'Sullivan (1975). This data comprises the weights of fish caught by each of the important methods, and the number of boat days required for that capture, for each month of 1969 and 1970, by each of 24 'sea areas', Palliser Bay falling in area 8.

Six of the top ten species are represented in Level 1 of the Washpool midden (Leach, 1979: Table 3). With minimum numbers in parentheses, these are: snapper (6), tarakihi (49), trevally (2), gurnard (5), hapuku (4), and blue cod (9). To combine the figures from the two Januaries, Februaries, etc., I added the numbers of hundredweights of fish caught, and divided by the total number of boat-days expended (though note that a boat-day is a rather variable quantity). By this method, the catches of these species in hundredweights per boat-day are as set out in Table 1.

To convert these figures into numbers of fish per boat day, allowance has to be made for the relative sizes of the different species. As an approximation, the individuals of a species are taken to have a weight proportional to the third power of half the maximum length attained by the species. Values for these maxima are provided by Doogue and Moreland (1973): snapper 30 inches, tarakihi 24 inches, trevally 30 inches, red gurnard 24 inches, blue cod 26 inches, and hapuku 48 inches.

The computer program performing this analysis breaks down if catch rates are zero, as happens in some months in the case of trevally, presumably due to rounding error, so a minimum catch of 1 animal per boat-day is set. To keep the ratios with this figure high, all other results are multiplied by the constant factor 10^7, to produce the final figures listed in Table 2.

OCCUPATION FROM BEGINNING OF	TILL END OF DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
JAN	1.16	92.73	27.13	31.26	49.88	49.39	48.38	43.19	41.93	37.05	2.32	2.58
FEB	1.02	1.16	20.17	26.83	49.71	49.25	48.21	42.77	41.48	36.45	2.07	2.33
MAR	0.96	1.09	1.16	48.98	71.93	58.99	55.09	47.59	45.61	39.11	1.84	2.14
APR	0.90	1.03	1.08	1.16	78.69	60.13	55.58	47.50	45.41	38.62	1.65	1.97
MAY	0.58	0.68	0.66	0.70	1.16	48.61	46.97	38.03	36.60	30.28	0.69	1.05
JUN	0.57	0.64	0.48	0.46	0.71	1.16	44.50	27.90	27.78	21.30	0.27	0.57
JUL	0.83	0.84	0.54	0.46	0.51	0.85	1.16	41.06	55.14	58.48	0.67	0.71
AUG	0.81	0.82	0.52	0.44	0.49	0.84	1.15	1.16	73.22	65.85	0.67	0.68
SEP	0.83	0.81	0.50	0.40	0.40	0.72	1.02	1.03	1.16	64.58	0.91	0.68
OCT	0.85	0.80	0.47	0.37	0.33	0.64	0.94	0.95	1.07	1.16	1.22	0.70
NOV	1.42	1.61	0.87	0.83	1.86	3.34	4.32	4.27	4.55	4.66	1.16	104.87
DEC	1.13	1.07	0.37	0.32	1.36	3.02	4.11	4.05	4.36	4.46	0.94	1.16

TABLE 3. SEASONAL results for three species, strategy 3.

Results

When the computer program SEASONAL was run using this data the lowest chi-square value resulting was 41.11, which occurred in each strategy for the month of December alone. With five degrees of freedom this is significant beyond the 0.1% level.

It is easy to see why the model fits so badly; it is due to the unsuitable catch statistics used. For example, in the fisheries data snapper never represents less than the 15.5% of the total catch that occurs in October. However, 6 of the total of 75 fish of the six species in the midden are snapper, or 8%. Similarly blue cod and hapuku are always too numerous in the modern fisheries. This is not unexpected, as snapper, blue cod and hapuku are all highly prized commercially, and fishermen make a special effort to catch them in large quantities.

At least partly as a result of including these three species trevally appears to be too common in the midden. When only trevally, tarakihi and red gurnard are considered, however, each of these can be accomodated by the model at some time of the year, so it was worth trying just these species in SEASONAL.

An interesting result is that year-round occupation using strategy 3 produces a chi-square value of 1.16. With two degrees of freedom the probability of chi-square exceeding this value is greater than 0.5 (Mode, 1966: Table G), so the test provides no evidence against year-round occupation. However, the overall pattern produced suggests that an occupation in summer is generally more likely. The full set of chi-square results for three species and strategy 3 produced by SEASONAL is set out in Table 3.

Discussion and conclusions

The data used in the above demonstration was from modern commercial line fishing, which at least is not trawling. Some features of modern commercial data may be less pronounced here too; lining is a much more modest approach to fishing, and equipment reflects this (Watkinson and smith, 1972). As well, the much smaller catches will make it less likely that the less popular species will be discarded. It was therefore hoped

	J	F	M	A	M	J	J	A	S	O	N	D
Snapper	.350	.645	.745	.472	.301	.418	.598	.384	1.107	.646	.714	.631
Tarakihi	.042	.092	.043	.070	.101	.084	.087	.062	.104	.736	.182	.649
Trevally	-	.045	.031	.050	.050	.036	-	-	-	.036	-	.024
Red gurnard	.061	.044	.045	.122	.116	.091	.017	.054	.040	.049	.063	.053
Blue cod	.444	.478	.488	.394	.340	.339	.413	.719	.702	.635	.531	.526
Hapuku	2.137	1.850	1.668	1.625	1.858	3.669	4.214	2.135	4.005	4.054	2.745	2.462

TABLE 1. Species catches in cwt/boat.day.

	J	F	M	A	M	J	J	A	S	O	N	D
Snapper	1037	1910	2207	1398	892	1238	1771	1137	3279	1913	2194	1869
Tarakihi	243	532	249	405	584	486	503	359	602	4259	1053	3755
Trevally	(1)	133	92	148	148	107	(1)	(1)	(1)	107	(1)	71
Gurnard	353	254	260	706	671	527	98	312	231	284	365	308
Blue cod	2020	2175	2221	1793	1547	1542	1880	3272	3195	2890	2872	2394
Hapuku	1545	1338	1207	1175	1344	2654	3048	1544	2897	2933	1986	1781

TABLE 2. Relative sp ecies catches in fish/boat. day.

that a demonstration using this data need not have been entirely arbitrary. Unfortunately, difficulties were immediately apparent when looking at the outcome of the analysis for six species, so it is questionable if the three species retained in the second analysis could be any more reliable. As a result, Leach's suggestion that Washpool was occupied throughout the year cannot be disproved. However, the presence in the site of species only available in summer and others only available in winter (Leach, 1979:125) does not represent a useful confirmation of the value of his method of analysis, nor does it really establish that year-round occupation did occur. Where presence/absence species are involved, fleeting exploitation of the local marine environment could leave an unmistakable trace in the archaeological record, and a more useful objective is to measure the importance of fishing over the year.

The model proposed here attempts to do that. This model is necessarily crude. Many of the assumptions on which the model is based have been made just because the arithmetical manipulations required are thereby made simpler, and some of the problems involved, and possible modifications, have been discussed elsewhere (Nichol, 1978: 16-25). Nevertheless, though crude, the model was good enough to detect very quickly the unsatisfactory nature of the modern catch statistics. At the moment, therefore, progress on seasonal dating from fish remains in New Zealand sites seems to depend on the collection of more satisfactory data on seasonal catch-rates, rather than on improvements to the simulation model proposed.

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