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A Jomon Shellmound Database

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Archaeology in Japan has made rapid progress in the last twenty years, and thousands of archaeological sites are excavated each year, mainly as a consequence of large and widespread land development projects. Until now the flow of new archaeological information has been managed efficiently by the government, but clearly, if it continues to be generated in an increasingly large volume, it will soon become unmanageable. However, this mass of new information can be compiled in the form of a computerized database, and a Jomon shellmound database was developed as a pilot project using the existing records of Jomon shellmounds [SAKAZUME 1959].
This paper describes the process of building up a database, the use of that database as an information retrieval system, and some statistical analyses using data extracted from it. In the analyses, the frequency of shellmounds was tabulated by region and temporal phases. The change of shellmound frequency generally coincides with that of other sites; large in quantity in eastern Japan and in the Middle phase. However, the decline of shellmounds in the Final phase in the Kanto region was catastrophic. Kanto had the largest number of shellmounds (as well as other Jomon sites) and was the most densely populated region during the preceeding period. Conventionally, this phenomenon has been explained by a degenerating environment, but such a drastic depopulation might be better explained by other more devastating factors, such as epidemics, commonly observed when a society is overwhelmed by an alien culture, as occurred with the American Indians or the Australian aborigines. [Computerized Database, Depopulation, Epidemic, Jomon].

INTRODUCTION

We have seen in Japan a marked increase in the number of reported finds of buried cultural properties (Table 1). According to the Center for Archaeological Operations, the number of reports published annually on archaeological finds is increasing each year, with the average in recent years at 800–1000 per year [C. A. O. 1976].[1] Since these numbers represent only reported finds, one must assume that

1) The Center for Archaeological Operations of the Nara Cultural Properties Research Institute was established in 1974. Its major functions are: a) research on buried cultural properties, b) sponsorship of training programs on the investigation and preservation of buried cultural properties, c) providing assistance and guidance to local groups and related organizations, and, d) collection and distribution nationwide of information on buried cultural properties. Recently the institute has begun development of a computerized information system.

Table 1. Reported finds of archaeological sites

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978
Finds	1129	1275	1715	2066	2309	2825	3886	5685	7083

[C.A.O. 1979]

many more archaeological sites remain unknown or have been destroyed. The volume of site reports represents for archaeology an "information deluge" similar to that which has already occurred in the natural sciences, leading to an unmanageable situation for researchers and scholars.

That is, owing to the huge amount of material produced, it is impossible for scholars to obtain all the information necessary for their research. In some cases, scholars are unable even to know of the existence of certain information; and not knowing what kind of research is going on is a real handicap in proceeding with serious scholarship.

It was with these perceptions that we began our project, in 1978, to develop a database on the Jomon shellmounds.[2] Shellmounds are really prehistoric garbage heaps containing bones and shells discarded by people of the Jomon period, 2000–8000 years ago. By investigating the remains unearthed from these mounds, as well as their distribution, archaeologists are able to surmise various aspects of the food gathering and consumption of the Jomon people. By introducing computer techniques into these investigations, and thereby offering a way of organizing the huge amount of information that is being (or could be) accumulated, we hope to help develop a new trend in archaeological research.

JOMON SHELLMOUND DATABASE CREATION

The creation of any database requires considerable money, manpower, and organization. Moreover, the process of gathering primary data is very time-consuming. Since databases are generally created with only limited resources and manpower, it is particularly important to consider carefully the efficiency factor in gathering primary data. This factor was the most important issue for us in proceeding with our project. As a source for primary data, the shellmounds offered many advantages, considering the constraints under which we were working. These advantages were:

1. There was already an excellent, well-organized source work on the shellmound sites, by Nakao Sakazume [1959, 1969]. The data may be slightly out-of-date by today's standards, but no compilation of shellmound information has been carried out since then. Thus, we utilized his work as a basic source of this database, and named it the Sakazume File;

2) The project has been running for two years under a Grant-in-Aid for Scientific Research from the Ministry of Education, Science, and Culture.

2. The number of sites which are examined in the Sakazume File is relatively small (2000 to 3000 in all), and these data are therefore handy as a pilot project for a future, more comprehensive Jomon database;
3. These sites are spread throughout the country; and
4. Excavated artifacts from these sites are both plentiful and diverse.

These factors enabled us to put the data into machine-readable format with relative ease, while at the same time providing a good example for future archaeologically-oriented databases.

In creating a database, one must decide carefully what kind of elements are to be entered into the computer, and in what form. Possibilities include a character format, a numerical format, or a numerically-coded format. Without proper consideration of these choices, the resulting database may be very difficult to use, and it may even become necessary to redo the whole thing. We debated at the outset of our project what elements were necessary, and what would be necessary to add later to incorporate the Sakazume File into the overall database. The following elements were included:

1. Sequential I. D. number;
2. I. D. number of the Sakazume File, which makes it possible to refer to original records whenever necessary, such as checking for recording errors;
3. Location of the sites (Prefecture and city codes of J. I. S.);
4. Site names (Japanese and Chinese characters);
5. Chronological code: The Jomon period is conventionally divided into 6 sub-periods based upon pottery types, each sub-period consisting of about 10 types. The order of these periods correlates well with radiocarbon dates [after KOYAMA 1978]:

Sub-period	Radiocarbon age	Standard deviation
Incipient	11187.5 B.P.	888.2
Initial	8130.0 B.P.	989.1
Early	5157.9 B.P.	369.8
Middle	4350.3 B.P.	389.8
Late	3328.9 B.P.	354.9
Final	2915.6 B.P.	483.4

The Jomon period is followed by the Yayoi [250 B. C.–A. D. 250], Haji [A. D. 250–700], and Historic periods; and

6. Natural remains in shellmounds (species of shell, Arthropoda, Echinoidea, fish, Amphibia, reptile, bird, Mammalia, and others).

These elements are used as keywords for information retrieval, as well as for cross-tabulation through the computer. The machine-readable shellmound data was coverted to a database using IDEAS/77[3] an information retrieval and data management system.

Our database is intended at present for use exclusively by Japanese researchers, so the names of the sites and species are in Japanese alphabets and Chinese characters. In the future, however, we should think of making databases available to researchers throughout the world to ensure mutual understanding of contents through some sort of standardization of period names, as well as in formats for encoding and organizing names of the data elements. Opportunities for the exchange of opinions among those concerned with the subject will therefore be encouraged.

JOMON SUB-PHASE AND SHELLMOUNDS.

The Jomon shellmounds are tabulated from this database by region-period elements (Table 2). More than 80 percent of the sites are found in the eastern half of Honshu, in the Tohoku and Kanto regions. Shellmounds began to be formed in the Tohoku region during the Initial phase, and the number steadily increased until the end of the Jomon period. But in the Kanto region, the curve of increase shows an irregular pattern; sites were first inhabited in the Initial sub-phase, and accumulated rapidly through the Early phase. The number decreased slightly during the Middle phase, but there was a sharp rise in the Late phase. Drastic decrease then occurred in the Final phase. The slight decrease in the number of shellmounds in the Middle phase can be explained in terms of an evolution of settlement pattern or reorganization of the society itself. Shellmounds of the Early phase are generally small and poor in contents, whereas those of the Middle phase are large, often forming a horseshoe-shaped settlement pattern. The shell species in these sites are varied, and the quantity is generally large. Artifacts such as pottery vessels, stone implements, personal

Table 2. Jomon shellmound tabulated by region-period element

Time \ Region	Tohoku	Kanto	Chubu	Kinki	Chugoku	Shikoku	Kyushu
Incipient	0	7	0	0	0	0	0
Initial	9	65	8	1	7	2	5
Early	30	193	12	4	8	0	7
Middle	46	170	14	5	13	0	10
Late	42	301	23	6	29	2	22
Final	45	25	20	3	16	1	9

3) IDEAS/77 is the acronym for "Interactive Database Easy Access System" developed jointly by the University of Tsukuba and the Toshiba Electric Company. The project was begun in 1975, and the program now has over 280,000 steps. This database is now available for use by researchers through the large-scale computer system of the Tsukuba University's Science Information Processing Center and the National Museum of Ethnology.

ornaments, and ritual objects are abundant. Such evidence suggests that small and non-sedentary settlements of the Early phase merged to form large and stable villages in Middle phase times.

The Late phase is considered to be the peak of the maritime adaptation during the Jomon period, and many large shellmounds are known in the Kanto region. Besides such great settlements, many small-size shellmounds of single temporal components (yielding only the Late phase pottery types) are also reported. However, we should recall that this phase is followed by the Final phase, when very few shellmounds accumulated. The difference in numbers of shellmounds suggests a complete destruction of the marine adaptation of the society during the Final phase. A large proportion of the human population seems simply to have disappeared from the region, and one of the causes of such drastic change involved environmental factors.

The climate improved steadily after the end of late glaciation. Temperatures kept rising until about 6000 B.P. (during the Hypsithermal) and pollen analyses show that coniferous forests yielded to more resource-abundant *Quercus* forests in many parts of Japan. The number of sites also showed a great increase in the Early phase. There was also a rise in sea-level during the Hypsithermal. In the Kanto region, which has a large, low-lying plain, the landscape was probably modified by extensive marine-ingression. Many of the Early phase shellmounds are known to have been located on the shores of this bay, which penetrated deep into the present Kanto plain. Temperature declined after the Hypsithermal and regression of the sea started, but the Jomon marine-adapted society in the Kanto region continued to flourish. This was probably due to a positive response by the inhabitants to the deteriorating coastal environment.

The Late Jomon phase seems to have been a critical period in which the people failed to meet the challenge of environmental change.

CLUSTER ANALYSIS

Characteristics of Cluster

The Sakazume File provides qualitative data summarizing various molluscan species excavated from each shellmound. Based on the premise that shell species are characteristic of shellmounds, it is possible to treat the file quantitatively by utilizing binominal presence (1) or absence (0) values.

The geographical distribution of shell species is determined by physical ecological factors, such as water temperature, degree of salinity, bed conditions, and other parameters, including depth and type of niche [Matsushima and Oshima 1974]. Obviously, the species that can be collected in a certain environment are, in considerable measure, predetermined by the nature of the environment itself. A complete list of species that inhabited any one environment cannot be made since only those species exploited as food were collected. But it is possible to infer the natural habitat of shell species in a certain area from excavated species. Such inference is based on the premise that the sequential process of "collect—eat—discard" existed exclusively

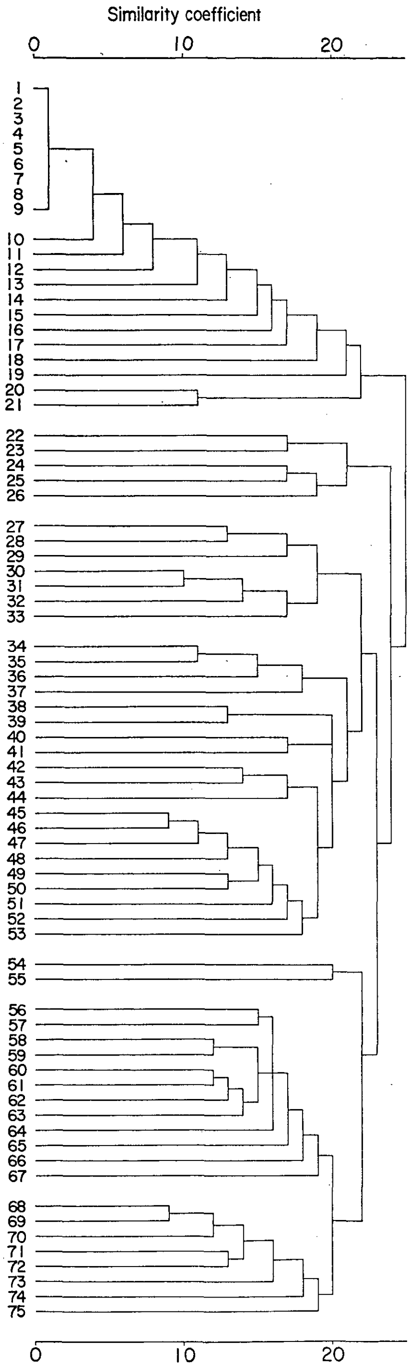

Fig. 1. Dendrogram of late Jomon shellmound clusters.

in the area or economic territory of the shell-midden society. Single component shell-mounds of the Late Jomon phase in the Kanto region provide data useful for such an analysis.

Of the 299 species (some identified only at the family level), 16 species are important as key characteristics for clustering shell-mounds. There are three kinds of freshwater shell: marsh snail (*Semisulcospira bensoni*), mud snail (Viviparidae), and *Corbicula*. The rest of the shells are from marine water organisms whose habitats are shallow water in the bay environment. Clusters of certain shell species are useful in determining specific locations within the bay environment. *Umbonium* (*Suchium*) *moniliferum*, *Babilonia japonica*, *Mya* (*arenomya*) *arenaria oonogai*, and *Dosinia* (*Phacosma*) *japonica* prefer a sandy bed in the central part of the bay, whereas clams such as *Tegillarca granosa*, *Scapharca subcrenata*, and *Cyclina siensis* live in muddy beds in the same location. A group of species such as *Mactra veneriformis*, *Tapes* (*Amygdala*) *philipprarum*, *Neverita* (*Glossaulax*) *didyma*, and Corbiculidae are found in the inner bay on a muddy sand bed [MATSUSHIMA and OSHIMA 1974].

Cluster analysis divided the Late Jomon shellmounds in the Kanto region into 8 groups (Fig. 1):

Group 1 (Sites 1 to 9): Yields only freshwater *corbicula* (*Corbicula japonica*).

Group 2 (Sites 10 to 21): Brackish water *Corbicula* (*Corbicula* [*Corbiculina*] *leana*) and Oyster (*Crassostrea gigas*) are the dominant species.

Group 3 (Sites 22 to 26): This group is characterized by freshwater species, although more marine species are exploited than Group 2.

Group 4 (Sites 27 to 33): Clusters of inner bay species are dominant, but freshwater species as well as terrestrial snails (*Euhadra* spp.) are also important. Such a combination clearly indicates a degrading marine environment owing to marine-regression.

Group 5 (Sites 34 to 53): The most important clusters are of inner and central bay species, considered as a typical type of shellmound during the Late Jomon.

Group 6 (Sites 54 to 55): Sample number is small, and basic composition resembles Groups 7 and 8. This type of site seems to have had access to the open sea coast, yielding types of conch (*Monoplex echo*), and similar species.

Group 7 (Sites 56 to 67): Shell species of the central bay area are dominant and the group shows strong orientation to the marine environment. A wide diversity and large quantity of shells were collected.

Group 8 (Sites 68 to 75): The basic combination of species resembles Group 7 except that fewer species were collected. Also, *Corbicula*, not common to those of Group 7, is known. The existence of *Tegillarca* and *Babylonia* suggests that shellmounds with this cluster were close to areas with muddy beds.

The Groups can be combined to form larger Groups: (1 and 2), 3, (4 and 5), and (6, 7, and 8). Linkages between (1 and 2) and Groups after 3 appear in Fig. 1.

CLUSTER DISTRIBUTION

Figure 2 was prepared by projecting the results of clustered shellmounds onto a map. Most shellmounds are concentrated geographically, as follows:

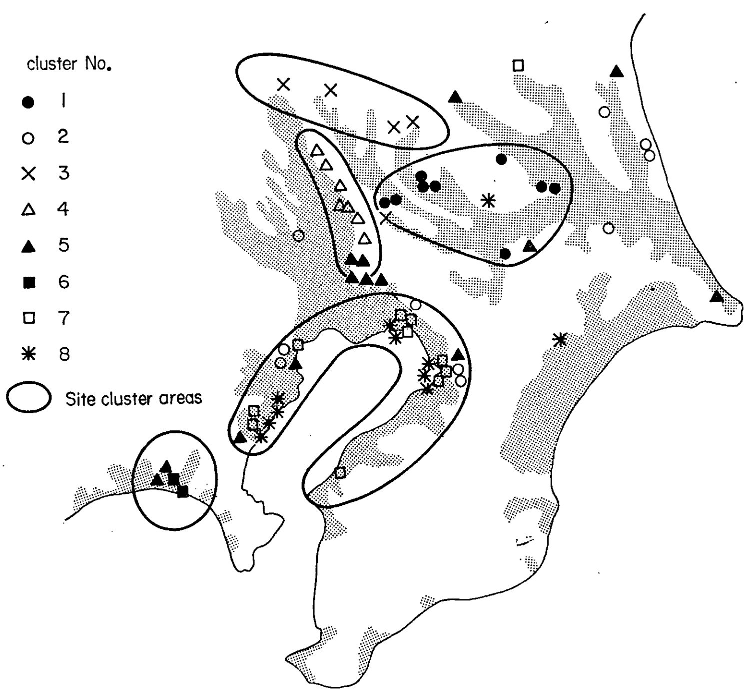

Fig. 2. Late Jomon shellmound cluster areas in Kanto.

Group 1: This group is distributed in areas with various swamps and small lakes spreading along the present Tone River. The single component of excavated species, *Corbicula*, is thought to indicate formation of these swamps and lakes by sea regression.

Group 3: This group is distributed along the maximum sea ingression coastal line of 7,500 to 5,000 B.P. [ENDO 1979], which is thought to have been far inland from the coastline of the Late Jomon phase. However, the component of species of fresh-brackish-marine water types indicates the existence of a complex environment within the economic territory.

Group 4: Distributed along the east coast of the Old Tokyo Bay. Similar components of species excavated from shellmounds in this group reflect a deeper coast line. It appears that the old coastline was further inland than suggested by Esaka [1975]. The range of species from terrestrial snails to inner bay types indicates exploitation over an extensive area.

Group 6: These shellmounds are isolated from other groups in the area facing Sagami Bay (open sea).

Groups 7 and 8: These two groups have similar distributions along a belt close to the present Tokyo Bay and are thought to have maintained quite high productivity in a marine environment owing to a stable coastline, regardless of regression.

Groups 2 and 5: These groups do not have a distinct geographical concentration. Their dispersion can be attributed to the existence of separated but similar niches which produced a certain combination of species on a large scale in the Kanto region during the Late Jomon. Their records show an uninterrupted exploitation of coastal resources, regardless of complicated environmental change caused by sea regression. Shellmounds utilizing auxiliary freshwater species (sometimes intensively), are categorized in groups 1, 2, 3, 5, and 8, and were numerous during the Late Jomon phase in the Kanto region. This is thought to have resulted from a deteriorating coastal environment caused by sea regression. Shell species which had been utilized as one of the main food resources declined drastically in importance owing to further sea regression.

DEPOPULATION IN THE FINAL JOMON PHASE: A Problem in the Kanto Region

The number of the Jomon sites known today is close to 30,000, less than 3 percent of which are shellmounds. Shellmound sites, therefore, were probably left by specialized groups adapted to the marine environment. These environments, exploited by shellmidden Jomon society, are thought to have been degraded by both sea regression and an increasingly colder climate after the Early Jomon phase.

The majority of the shellmounds have single components. The remainder have two or more temporal components and are interpreted as stable sedentary sites used continuously for a long duration. Single component sites are generally small in scale and were probably short-term camp sites. In the Late Jomon phase of the Kanto region, single component sites increased sharply (162 sites–54 % of the total shellmounds of the phase). But there are no such sites in the Final phase. The camp sites may show the extra effort of food gathering, and the density may correlate strongly with population pressure. In the Kanto region during the Late phase, therefore, population pressure was strong, but it is not evident at all in the Final phase. This phenomenon occurred only in the Kanto region. The number of shellmounds in Tohoku increased, in Chubu it was stable, and in western Japan the decline was slight (Table 3).

It is noteworthy, also, that the absolute number of shellmounds in the Kanto region continued to increase from the Initial to the Late Jomon phase, though a slight decline appears in the Middle phase. The number reached a maximum in the Late phase, then declined drastically in the Final phase to a mere 8 percent of the previous Late phase total. Furthermore, information about shellmounds categorized in the Final phase is "generally vague, and their location is limited to large scale sites of the previous Late Jomon phase, with poor artifacts and features in humus layer" [GOTO 1970: 99–100].

Numerical change of inland sites other than shellmounds in the Kanto area resembles that of shellmounds in the Initial and Early phase. But unlike the shellmound sites, the number increased markedly in the Middle phase and declined in the Late Jomon. The inverse fluctuation of shellmound and inland sites in the Middle and the Late phase seems to reflect a complicated mode of adaptation toward both marine and inland environments during times of climatic change. However, the decline in inland sites in the Final phase coincides with the decline in shellmounds.

Shellmounds in the Tohoku region reached their maximum distribution in the Middle Jomon. The number declined slightly at the Late phase and increased again at the Final phase. The fluctuation, however, is small and the number seems to have been quite stable throughout the whole Jomon period. Fluctuation of general sites, on the other hand, shows the same development as that of the Kanto region, but the decline in the Final phase is much more moderate than in the Kanto region (Fig. 3).

There is a similar mode of change in numbers of shellmound sites during the Jomon period in the region from Chubu to Kyushu. The typical mode is a gradual

Table 3. Number of single time component shellmounds, tabulated by region and period

Time \ Region	Tohoku	Kanto	Chubu	Kinki	Chugoku	Shikoku	Kyushu
Initial	4	32	6	1	2	2	0
Early	7	138	4	2	1	0	1
Middle	13	58	7	0	1	0	5
Late	17	166	7	1	8	2	16
Final	21	0	7	1	2	1	8
Total	62	394	31	5	14	5	30

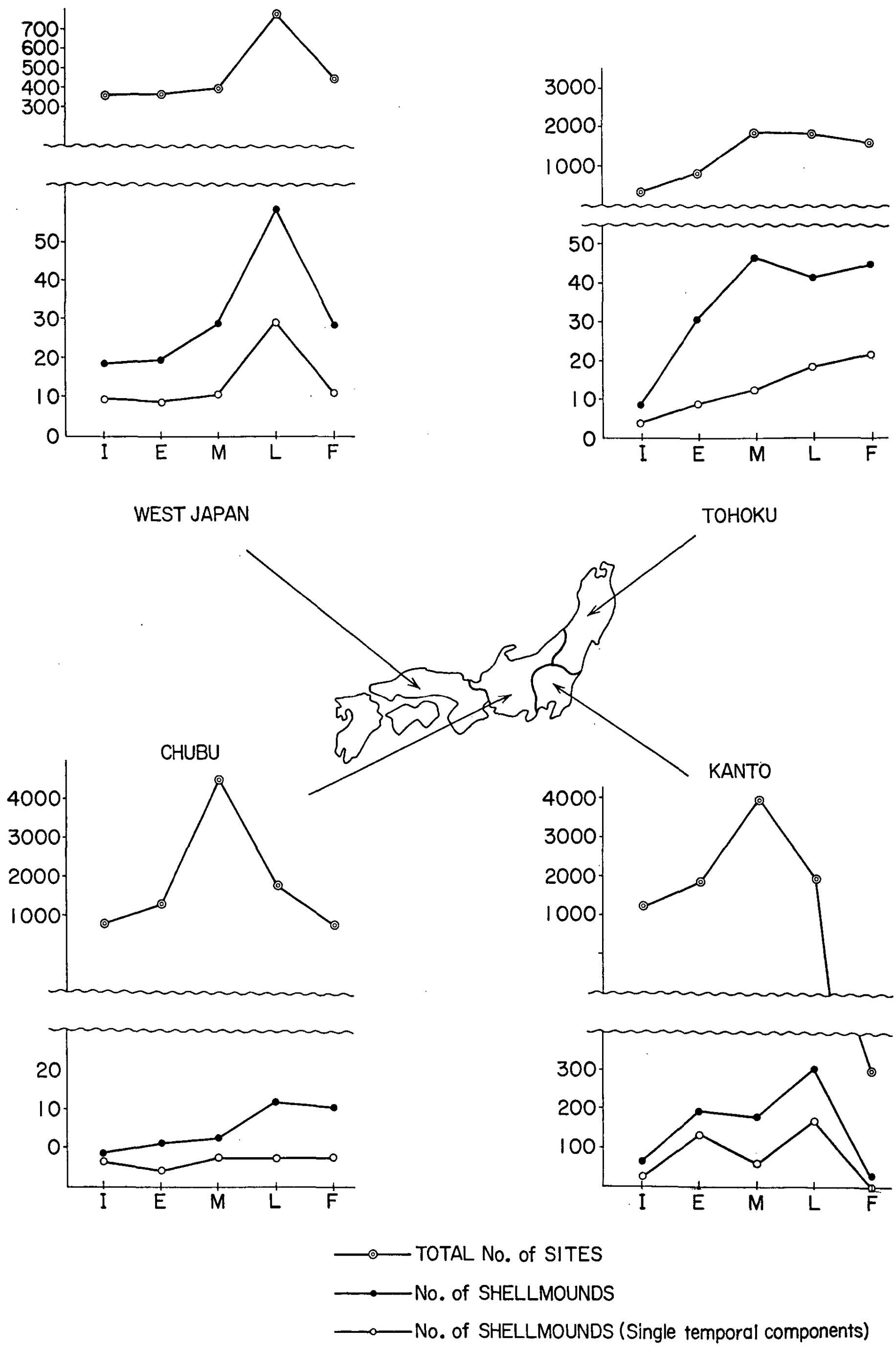

Fig. 3. Change of Jomon site numbers according to temporal phase by region. Note: I=Initial, E=Early, M=Middle, L=Late, F=Final

increase from the Earliest to a peak in the Late phase, followed by a slight decline in the Final phase. Thus, in the Final phase, the contrast in severity of decline between Kanto and other regions becomes most apparent.

The decreasing site density and population in the Final phase can be explained in terms of climatic deterioration and population migration [HARUNARI 1979]. Climate during the Jomon period reached an optimum in the Early phase, followed by a gradual fall in temperature [KURAHASHI 1974]. Environmental deterioration caused by the climatic decline forced people to migrate to other regions in search of new food resources [TSUKADA 1974]. Various regions of migration can be proposed, although just broadly. Movement to Tohoku from Kanto, for instance, has been inferred from comparative typological analysis of pottery.

But did migration really occur in the Final Jomon phase? As far as the Kanto region is concerned, migration within the region can be verified by the evidence of large numbers of single component shellmounds and the concentrations of shellmounds in the area corresponding to present-day Chiba Prefecture, known for its long coast line (Table 4). There is no doubt that site numbers in eastern Japan declined after the Late Jomon phase, and furthermore, because of the scale, decline in the Final phase shows some abnormal factor of decreasing population.

Is it possible to conclude that decreasing site density in the Kanto region in the Final Jomon phase resulted from population migration to areas outside the Kanto plain? Statistical verification of the inference is quite difficult. Regional analysis of shellmound numbers in the Final Jomon indicates a decline in shellmounds, except in the Tohoku region. But because population increase in Tohoku shows no abrupt change that would imply large-scale migration from other regions, the increase should be considered as intrinsic. It can also be objected that the slight increase in the Tohoku region is a result of the shorter calculation of the Final phase compared to other Jomon phases; this can be denied by radiocarbon evidence that shows no duration difference, at least between the Late and Final phase of the region. With respect to the decline of site numbers—really a decline of population itself—in and around the Kanto region in the Final Jomon, it seems rather difficult to escape the conclusion

Table 4. Change of single time component shellmounds in the Kanto Region (by present Prefecture)

Pref. \ Time	Early	Middle	Late
Ibaraki	93	23	23
Gunma	1	0	0
Saitama	20	6	5
Chiba	27	17	27
Tokyo	10	2	1
Kanagawa	17	7	12

that a great catastrophy occurred, comparable in scale to the decimation of the American Indians in the early half of the nineteenth century.

The Jomon population of the Kanto and the Chubu mountain region seems to have increased constantly while the environment was favorable. Carrying capacity reached its peak by the Middle Jomon, but the climatic decline after this peak ultimately led to the severe population loss among Jomon societies. This process can be inferred as follows: lower temperatures affect fauna of mountain areas first; declining productivity of the environment forces the Jomon people to exploit the surrounding environment excessively; consequently, the deterioration is hastened; nutritional input per capita declines accordingly, eventually causing widespread malnutrition. The population, therefore, declines or at best remains constant.

It is quite obvious that a major cultural input had reached Kyushu from the continent at some point in the later half of the Jomon period. It seems reasonable to infer that infection spread from the continent causing epidemics (like cases of smallpox and measles among the American Indians). This, in turn, occurred prior to introduction of new production forms (i.e., agriculture) which eventually caused a population increase. This newly introduced culture is generally thought to have spread along coastal areas first. Shellmound decline on a large-scale throughout Japan during the Final Jomon therefore seems to reflect the route of diffusion of some epidemic infection. The areas most seriously damaged by this epidemic must have been the densely populated Kanto and Chubu mountain regions, both in a chronic state of malnutrition at the time. The Tohoku region, on the other hand, is thought to have suffered less damage than the above mentioned regions owing to sufficient carrying capacity.

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