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THE PACIFIC FISH BONE REFERENCE COLLECTION AT THE UNIVERSITY OF OTAGO

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INTRODUCTION

Faunal analysis has been an integral component of research at the Department of Anthropology, University of Otago for three decades. Beginning with projects in Foveaux Strait (Higham 1968) and Fiordland (Coutts 1972), and extended in the Wairarapa (Anderson 1973, Leach 1976) and Chathams (Smith 1976, Sutton 1979), a systematic approach to the identification of archaeological fauna was developed, enabling both general reconstructions of prehistoric subsistence patterns and more detailed analyses of specific faunal components. Fundamental to this approach has been the compilation of a comprehensive archaeozoological reference collection, ensuring accuracy and consistency of identifications, and permitting the development of techniques for estimation of size, age, season of death and other characteristics of some species. Since the first items were accessioned in 1967, the archaeozoological reference collection has expanded to include more than 2500 specimens, covering all the major genera and most of the common species of mammals, birds, fish and shellfish found in New Zealand archaeological sites, many of those from the Pacific, and some from South East Asia.

Fish remains have been a central component of the collection since its inception. There are now more than 500 specimens of this class, most represented by full skeletons, but some less complete as the methods initially developed for fish identification relied on a restricted set of cranial bones (Anderson 1973, Leach 1976). For some years the collection contained significant numbers of tropical Pacific, as well as New Zealand fish (Leach 1986), but most of the former were transferred to the National Museum in 1988. This paper describes the objectives, strategies and procedures involved in rebuilding and substantially expanding this component of the collection. This project is part of an ongoing reference collections development programme within the University of Otago Archaeological Laboratories designed to expand their coverage, improve their utility and ensure that they remain a significant tool for archaeological research.

OBJECTIVES

Rebuilding the Pacific fish bone reference collection has been underway for the past 5 years. The initial objective was to provide reference material for the identification of archaeological assemblages from field projects in the tropical Pacific, particularly the Cook Islands. The Pacific archaeological program at the University of Otago has expanded over the past few years with new staff members and new projects established in the Cook Islands, Niue, the Marshall Islands, the Pitcairn Group, French Polynesia, Hawaii, Norfolk Island, and the Solomon Islands. It has become clear that the present collection should be augmented with additional specimens to facilitate the different research goals of each project.

Whereas the initial collection was adequate for family-level identifications on the basis of a small number of "diagnostic" bones, we now know that it is necessary to consider all the elements for increasing identifications at the family, genus and species levels (Colley 1990). The collection also needs to accommodate a wider range of research questions beyond taxonomic identification such as size of fish represented in prehistoric middens and seasonality, the latter issue a difficult problem to address within tropical regions.

Taphonomic issues and food processing behaviour are also topics of increasing importance in Pacific subsistence studies. The collection is increasingly used by students and outside researchers which has required the development of a protocol for the laboratory processing of archaeological material. This paper provides a summary of the present state of the collection and outlines the projected short and long term goals for future development. We also discuss the procedures used in the development and management of the collection, and the protocols used in the laboratory analysis of archaeological collections.

COLLECTION STRATEGY

The reference collections have been assembled using a number of different procedures with an initial emphasis on opportunistic collection strategies. During the first stages of collection, fish specimens were gathered opportunistically by the authors during periods of fieldwork in the tropical Pacific. One of the most important strategies has been through the participation in local fishing activities. We have been involved in offshore pelagic fishing and in a variety of inshore fishing sorties in reef and lagoon environments using both traditional and contemporary Western equipment. In addition to obtaining reference specimens, information on fish catches were recorded including counts and metrical data on any specimens which were added to the collection.

Another strategy employed in augmenting the reference collections was the purchase of specimens from local markets. Shops in Hawaii and the Marshall Islands provided the opportunity to target specific species and to increase the size ranges of selected taxa. On Niue, there is a small but well organised fishing industry specialising in offshore trolling and deep water benthic fishing to supply the domestic market. A range of pelagic fish were purchased there, as well as a variety of deep water fish including several genera of large lutjanids which are extremely difficult to come by in many parts of the Pacific. On occasion it was possible to finance the recreational scuba-diving community on Rarotonga to collect fish outside the reef at depths of around 15 - 30 m. This has enabled the collection of species that are not normally caught using contemporary practices, but which may well be represented in prehistoric middens.

Because of the opportunistic nature of these strategies fish collected in the past few years were those most frequently caught in the local catchment areas, usually the villages in which we were resident. Fortuitously, these fish also happened to be the most commonly represented in archaeological assemblages. In the Cook Islands, Niue, the Pitcairn Group, Hawaii, and the Marshall Islands where much of the initial collection took place, this included a range of inshore specimens especially serranids, labrids, lutjanids, scarids, lethrinids, holocentrids, carangids and acanthurids as well as some of the larger pelagics in the family Scombridae. However, by the end of 1995, the opportunistic gathering strategies were producing fewer new genera and a more directed and targeted approach became necessary to provide specimens representing families less frequently found in the archaeological assemblages. To this end, each field project carried out by the authors included a small budget and time allocation specifically for the collection and processing of fish.

At this point most of the major families are represented by at least one genus but there is an urgent need to increase the number of genera represented per family and to assemble additional examples of each species. In addition, multiple specimens of key genera are needed for addressing the variation of size ranges across growth cycles and sexual dimorphism. There are still a large number of target specimens either missing or under-represented in the collection. Consequently, field collection strategies have taken on a more directed approach. This requires a greater commitment of resources than under the previous opportunistic collection regimes. It is no longer possible to treat the collection of fish specimens as a secondary component to existing research programmes. Instead, specific research oriented collection projects need to be designed and funded.

PROCESSING OF SPECIMENS

Fish reference material is processed in the field or in the Otago laboratory

depending on the practicality of getting the specimens from the field to the lab. There is some advantage in processing the skeletal remains in the Otago laboratories but this is only possible when working with collections made in the Cook Islands or Niue, from where the importation of frozen fish is allowed. If freezing facilities are available, field measurements are recorded (see below), the fish are thoroughly cleaned and are then frozen until they can be airfreighted back to New Zealand. Flight times are short so it is usually possible to wrap the frozen fish in towels, pack them in a styrofoam container and bring them in as luggage. The difficulty of transporting larger specimens or of field processing them has meant that many of the larger fish are only represented by mouth bones. For example, at present we have no complete skeletons of large tuna, sailfish or swordfish.
Where processing takes place in the field, the fish are deflensed in a three stage process. The first processing of the fish usually involves simmering it in water to remove the larger chunks of flesh. In stage two, additional flesh is removed either through bacterial action where the specimen is placed in a container of water and allowed to sit in the sun for several days, or by exposing the skeleton for a week or so to ants and flies in a controlled environment. The bones must be clean and odour free before transport back to New Zealand and this can be achieved by repeated boiling of the bone in fresh water or with the addition of small amounts of ammonia based bleaches (Janola) or hydrogen peroxide (H20). Final cleaning and soaking takes place in the Otago laboratories. We have also collected fish bones during our meals by carefully eating the flesh from individuals that were cooked in an earth oven, roasted or boiled. The resulting bones were placed in coconut leaf baskets and hung in trees where flies finished the cleaning process.

If the fish are processed in the laboratory, the most effective method is to lightly boil them in water, and then remove the flesh by hand (Wheeler and Jones 1989). The bones are then further treated, as in the field, by simmering in a very light solution of bleach or hydrogen peroxide. This is a labour intensive system and time and budgetary constraints often mean that, unless the exercise can be accommodated within a student research project, other methods are necessary. The Otago laboratories currently maintain a dermestid beetle colony which provides an effective method of defleshing. Flesh is first removed with a scalpel or knife and the carcass put into a tank of dermestids. The colony is kept at a constant temperature of about 35° C. Daily monitoring is required to keep the flesh moist so as to promote dermestid growth and after three or four days the bones can be removed to a tank of water which is kept in the temperature controlled colony room, and bacterial action removes the remaining flesh. This is a messy and odorous approach and has the disadvantage of disarticulating the skeleton making siding more difficult. With the smaller specimens a great deal of care is required in removing the bones from the remaining sludge in the water

troughs and this task must be done carefully by hand.

STORAGE

When identifications were being made on the basis of the five mouth parts (maxilla, premaxilla, dentary, articular and quadrate) as well as "special" bones (Leach 1986), we followed the procedure of mounting bones on boards where each board represented a single element. We painted sheets of 1000 x 800 x 12 mm particle boards with a dark matt-green paint which provided a sharp contrast with the bones. Strips of cloth were taped to the back of the boards to facilitate sliding them onto the storage shelves. Left and right elements for each specimen were mounted both face up and face down (requiring two individuals per species), using a reversible latex adhesive. A label placed beside each specimen contained taxonomic information and the accession number. This unique number linked each specimen to the computer database (described below).

1. The use of flat boards stored horizontally on shelves has a great many advantages, especially in allowing the identifier to glance over a range of genera and thus gain much comparative information quickly. However, disadvantages have developed and new storage techniques have had to be devised. The first disadvantage is that the bones can be broken easily. As the reference collection has been integrated more widely into the teaching programme at Otago, more students are using the facility and damage is inevitable. Furthermore, it is often advantageous to handle the reference specimens to examine different landmarks crucial for accurate identifications and this is impossible with mounted specimens. Finally, as we move towards the identification of a larger range of paired and unique elements the area required for storing mounted boards becomes excessive. The new policy is to keep the mounted boards of mouth parts and specials as a primary identification tool but to develop other storage facilities.

Instead of concentrating on five paired bones, the Otago laboratories now aim to provide the facilities to allow identification of all paired bones found in the fish skeleton. To this end, sets of drawers are being constructed with each draw dedicated to one of the paired elements. Each drawer will be divided into compartments for one species such that each compartment will contain at least one set of lefts and rights. Each compartment will be labelled with the taxon and the accession number will be numbered directly on the bone. The collection is designed to work in conjunction with the computerised database so any additional information is unnecessary.

2. At present vertebra are routinely used to identify Elasmobranchii (rays and sharks) and other pelagic fish such as tunas. We believe that vertebra are

potentially important for identifying fish bones to family level. This is especially true for tuna which have very robust vertebra but have fragile mouth bones. In the reference collection vertebra will be strung together in anatomical order and placed in their own storage cabinet with taxonomic and accession information.

3. The first examples of any genera are being placed in the element based collections we described above. However, duplicate specimens of each species are being collected and complete specimens are being boxed and stored separately.

4. Otoliths are vital for genus and species level identifications across a wide range of Pacific taxa (Weisler 1993). Indeed, in New Zealand, otoliths are "frequently found in archaeological sites" (Leach 1989:15) but taxonomic identifications are rarely reported. We are currently expanding our reference material to include more tropical specimens as well as New Zealand taxa collected from throughout the year. Our goal is to assemble baseline data on seasonal growth patterns of otoliths from fish families routinely recovered from New Zealand sites (Leach and Boocock 1993) as well as taxa that should be present in prehistoric middens (based on ecological and modern fish catch data), but have so far gone unidentified.

5. Fish scales should also prove a valuable element for perhaps family level identifications, determining age of death and estimation of live weight (Casteel 1976). Scales are found routinely in archaeological sites throughout the Pacific and their near two-dimensional shape should facilitate computer-aided identification programmes.

DATABASE

A computer database for field entry, laboratory retrieval and as a general research tool has been designed to work with the reference collection. The database was written by Richard Walter in Filemaker Pro ™ and is running in a network version on a Macintosh server in the Otago laboratories. Hosts can log into the server from elsewhere in the laboratories and mini versions of the database can be downloaded onto powerbook computers to be taken into the field, with the data uploaded into the system at a later date. The database is effective, but the system is underpowered and before the database can be opened for general use, a major upgrade in software and network components is urgently required. It is our intention to make some components of the fish bone database available through the World Wide Web and to allow researchers free access to the data through remote (or local) log-ons. Because of the rapid growth in the Otago reference collections, we are now experiencing an urgent need to develop a fast, secure and integrated database system to serve the specialist research needs of the wider scientific

community.

The reference collection has been designed with a view toward flexibility in the expectation that needs and applications will change through time. To accommodate different interests, a wide variety of field and lab data has been collected. In the past notebooks were used in the field and entries then made directly into laptop computers. We are now moving to the use of standard recording sheets in addition to direct digital data entry. Information is grouped into several categories and as far as possible, each field is provided with a range of answers from which to select. The general categories of information collected in the field and entered into the fish bone database are:

1. **Catch data**

Catch data includes various levels of locational information, capture methods and local sea and meteorological conditions at the time of capture.

Location: Both general and specific locational information is required. General locational data includes the date and time of catch, and the island, region and marine zone in which the fish was taken. Specific location information attempts to record the exact position of the fishing spot in reference to a permanent landmark. In addition, the habitat zone within which the fish was caught, the bottom conditions (rocky, coral shelf, muddy bottom) and any other relevant environmental or ecological data are also recorded.

Capture Methods: The fishing technique is recorded, whether it involved traditional or modern fishing practices. Wherever possible the name of the fisher is also recorded along with details of the equipment used, bait (if appropriate), and the fishing party size, content and the social context of the fishing event (eg. subsistence, gift exchange, commercial activity etc).

Local Conditions: Tide and moon conditions at the time the fish was caught, and any other relevant meteorological information is recorded wherever possible.

2. **Specimen Data**

Wet dimensions of the fish are recorded including fork length and standard length (see Fig 1). Taxonomic identification is facilitated by the use of a number of standard texts: Lieske and Myers (1994), Randall *et al.* (1990), Munro (1967), Myers (1989), Gosline and Brock (1960), and Bagnis *et al.* (1972). It is impractical to take many of these reference materials into the field but Lieske and Myers (1994), is inexpensive, it is small, the colour illustrations are excellent and it covers the vast majority of reef and offshore

specimens encountered in the Pacific. Where there is any doubt about identification and where the complete fish can not be brought back to the laboratories, fin and scale counts are obtained. A colour photograph is also taken of each fish. Nomenclature follows Randall *et al.* (1990). Where possible, fish are weighed wet both before and after gutting although it is sometimes impossible to obtain weights since fish are often part-processed before they are collected.

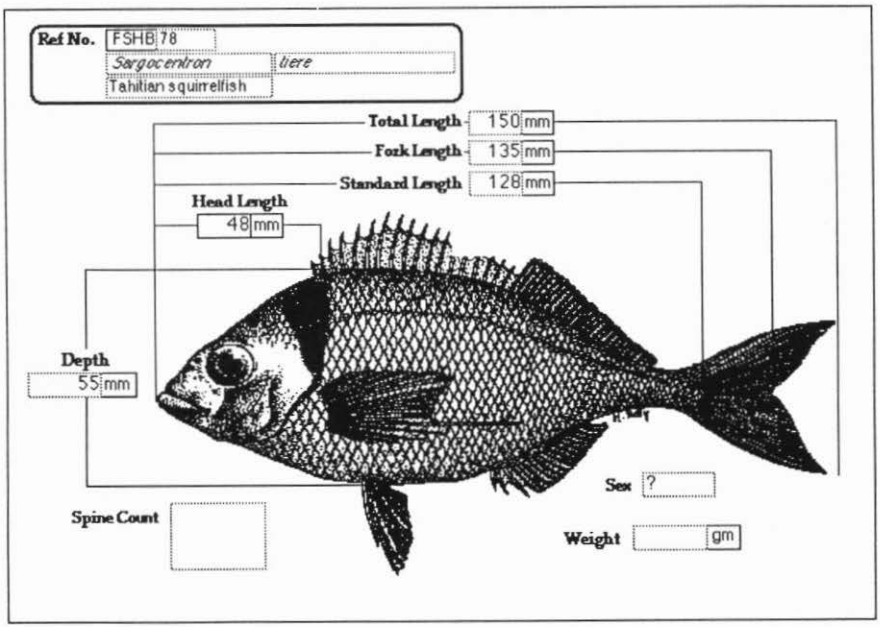

Figure 1. Standard entry screen used for the recording of metric data on each fish specimen in the reference collection. (Note: the fish represented on screen is used to illustrate measurement protocols. It is not necessarily an illustration of the current specimen).

3. Linguistic and ethnological data

Local fish names have been recorded with a view towards potential interests in folk taxonomy or historical and comparative linguistic issues (see for example Walter 1989). In addition, any other linguistic or folk taxonomic information including alternative names, dialectical variations, name derivations, traditional associations or references (including events or persons

associated with the fish name), different names applied to different phases in growth cycles etc have also been recorded.

4. **Laboratory processing**

Details are entered into the database of field storage and processing techniques, laboratory processing including deflensing, which technicians were involved, date and particular preservation treatments used.

5. **Elemental data**

A list of all bones identified and curated from each specimen is recorded using a standard database entry form as in Figure 2. Nomenclature of elements follows Wheeler and Jones (1989).

6. **Archival data**

Accession numbers are assigned and storage locations within the laboratory bays are recorded.

CURRENT PROGRESS

The reference collection of teleost fish currently contains 72 genera in 32 families comprising a total of 234 specimens which have been processed and entered into the database and with at least 100 specimens either frozen, or deflensed but not yet processed (Table 1). This represents 84% of the families reported in a recent summary of 20 Pacific island archaeological assemblages the results of which are stored in the faunal database, Archaeozoology Laboratory, Museum of New Zealand (Leach *et al.* 1994). These 32 families also represent 96% of the family level identifications (Total MNI = 9748) which were made on these collections. On this basis, the collection is now at the stage where we can confidently identify at least 95% of all mouth parts and special bones which pass through the lab, not to mention an increasing number of additional paired bones. (Of course, accuracy of identification is another matter and reflects the expertise of the identifier, as much as the quality of the collection). At present, there is a great deal of outstanding work to be done to process the material we have at hand and the opportunity for a number of interesting and useful student research projects exists. A large number of specimens have been prepared or part-prepared, but have not yet been entered into the database or provided with accession numbers. From these specimens we expect to add to the number of genera and perhaps families represented, but many specimens are duplicates collected for specific research purposes.

Of the specimens which have been entered into the collection, most have

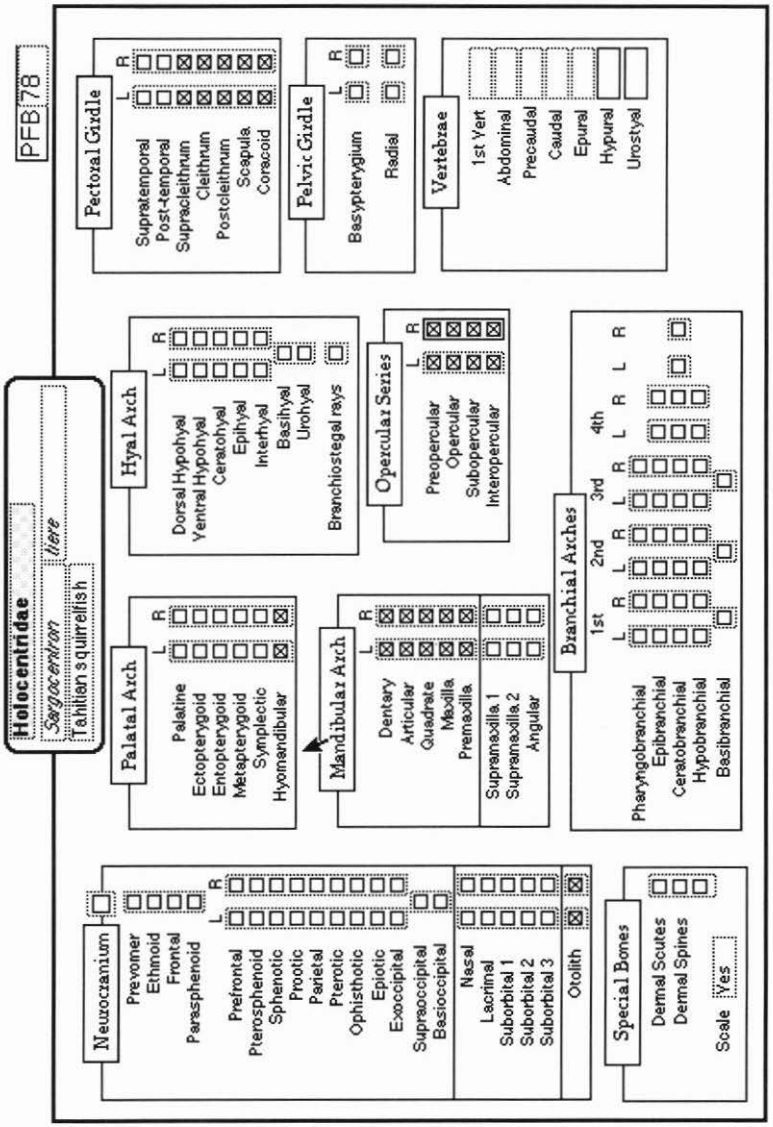

Figure 2. Standard entry screen for the recording of element data on each fish specimen in the reference collection. Additional bones such as the fused mouth plates in scarids or diodonts are entered on a similar screen.

Figure 2. Standard entry screen for the recording of element data on each fish specimen in the reference collection. Additional bones such as the fused mouth plates in scarids or diodonts are entered on a similar screen.

only had mouth parts and special bones removed and mounted. The remaining paired bones now need to be removed, labelled and placed into the new cabinets which are now being constructed.

CONCLUSIONS

The University of Otago reference collections have been building during the past thirty years and it is now vital that we take a more directed approach to systematic acquisition of new taxa as well as multiple individuals representing growth stages collected during all seasons. Although this latter point has not as yet proven vital in the tropical Pacific it is especially important in temperate regions.

We are exploring further computer applications for storing data and new protocols for analysing archaeological collections. The database can store colour digital images of fish but the current system is too overloaded to fully exploit this option; however, images of some fish are stored for test purposes. When we upgrade the hardware we intend to include digital images of all fish for reference purposes, and we have ordered several commercial CD ROMS containing images of tropical Pacific fish. We are currently developing a digital image storage and retrieval system for the analysis of otoliths and fish scales based on a key.

The University of Otago has fieldwork planned for the Solomons and Marshall Islands this year (see Current Fieldwork this issue) and one objective of these projects will be the systematic collecting of reference specimens. We are developing collaborative activities with the Marine Sciences Department, University of Otago to run concurrent field projects to our mutual benefit. We hope to involve more graduate students in this work.

In this article we have discussed the Pacific and New Zealand fish bone reference collection. We are also developing and revitalising old Pacific collections of marine shellfish, echinoderms, crustacea, marine mammals, birds, landsnails, wood charcoal, phytoliths, and lithic source rock.

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TABLE 1. Fish specimens currently accessioned in the Otago Archaeology Laboratory, Pacific Fishbone Collection

FAMILY	GENUS
Acanthuridae	Acanthurus
	Ctenochaetus
	Naso
Anguillidae	Anguilla
Balistidae	Rhinecanthus
	Sufflamen
Belonidae	Platybelone
Bothidae	Bothus
Caesionidae	Caesio
Carangidae	Carangoides
	Caranx
	Decapterus
	Elagatis
	Selar
	Seriola
	Pomacanthus
Chanidae	Chanos
Cirrhitidae	Cirrhitus
Congridae	Conger
Coryphaenidae	Coryphaena
Diodontidae	Diodon
Exocoetidae	Cypselurus
	Exocoetus
Gempylidae	Promethichthys
Holocentridae	Adioryx
	Holocentrus
	Myripristis
	Neoniphon
	Sargocentron
Kuhliidae	Kuhlia
Kyphosidae	Kyphosus
Labridae	Cheilinus
	Thalassoma
Lethrinidae	Gnathodentex
	Gymnocranius
	Lethrinus
	Monotaxis
Lutjanidae	Aphareus
	Aprion
Monocanthidae	Cantherines
Mugilidae	Mugil
Mullidae	Mulloides
	Mulloidichthys
	Parupeneus
	Upeneus
Muraenidae	Gymnothorax
Pempheridae	Pempheris
Polynemidae	Polydactylus
Pomacentridae	Abudefduf
Priacanthidae	Priacanthus
Scaridae	Calotomus
	Scarus
Scombridae	Acanthocybium
	Euthynnus
	Gymnosarda
	Katsuwonus
	Neothunnus
	Thunnus
Scorpaenidae	Synaceia
Serranidae	Anyperodon
	Cephalapholis
	Epinephelus
	Plectropoma
	Variola
Siganidae	Siganus