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Marine Collections at the Museum of New Zealand: Contents, Care and Continuing Improvement

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Abstract The Museum of New Zealand Te Papa Tongarewa occupies two major buildings, with one, the Museum Resource Centre, being the main collection repository. Te Papa holds an unusually wide variety of national treasures in natural history, art, history and Pacific, and Maori collections. The natural history collections include terrestrial, freshwater and marine taxa, the marine groups comprising algae, seabirds and mammals as well as fish and the majority of marine invertebrate phyla. Major portions of the collections are maintained separately in both wet and dry storage, employing a range of containers in a variety of cabinets, racks and shelving systems. Knowledge of collection maintenance has developed greatly over the last 25 years with optimum environmental factors well known and appropriate storage materials being adopted. Recently, other challenges to best storage practice have emerged including workplace health and safety regulations, more exacting freighting requirements and higher quality storage containers. Consequently, the management of collections has become more professional; technical assistance has increased, information and courses specialising in collection care have become available and Te Papa has employed preventive and materials conservators. Recent initiatives to improve the long term care of Te Papa's natural history collections include extensive testing and upgrading of liquid preservatives, wet storage facility renovations and adoption of Risk Assessment surveys of natural history collections.

Key words: Museum of New Zealand, Te Papa, natural history collections, collection maintenance, collection management, risk assessment, risk management.

Introduction

New Zealand's national museum, with the new name Museum of New Zealand Te Papa Tongarewa (Te Papa) and a new institutional structure, opened its doors to the public in 1998. Te Papa arose from the National Museum of New Zealand and National Art Gallery, two separate institutions amalgamated under one administration (in 1992), and was designed to provide exhibitions in a single building and develop and care for its collections and carry out research, in common. Consequently, Te Papa holds an unusually wide variety of national treasures, in art, history and Pacific, and Maori collections, as well as natural history collections.

Conceived and Government funded as a national museum with a similar role to other, older national institutions such as the British Museum, the New Zealand institution and its collections are of much longer standing than the advent of Te Papa may suggest. Its earliest origins, set firmly in the natural history of New Zealand, were as the New Zealand Geological Survey and Colonial Museum, established in 1865. That institution subsequently underwent a number of changes in form and name before becoming the present one—the National Art Gallery opened in 1936.

The collections Te Papa holds are presently administered under four Directorates; Natural Environment, Art, Maori, and History and Pacific. Te Papa occupies two major buildings, the Cable Street Building on the waterfront of New Zealand's capital Wellington, and a Museum Resource Centre elsewhere in the city. All exhibitions and other public activities occur in the Cable Street Building while part of it, and the entire Resource Centre, are used to store collections and for back-of-house activities including administration, collections management, conservation and research.

Besides holding type specimens of named species, Te Papa's natural history collections, like those of similar institutions in other countries, include many specimens representing the local and regional diversity of plants and animals. The collecting of rare as well as more common species from different localities continues steadily and natural history collections typically become large. Their safe and secure storage becomes challenging both physically and financially. In this paper, characteristics of Te Papa's marine collections are briefly described along with information on storage systems and materials employed for long term storage. Some of the current projects to improve collection care are also outlined and it is hoped that this account will be of some interest to others who care for natural history collections.

Content and Care

Te Papa's natural history collections include terrestrial, freshwater and marine taxa, the marine groups comprising algae, seabirds, mammals, fish, molluscs, crustaceans, cnidarians, echinoderms, bryozoans, polychaetes, sponges, and several other, minor invertebrate phyla. The marine collections are international, but focus mainly within the New Zealand Exclusive Economic Zone, the fourth largest EEZ in the world.

The natural environment collections of Te Papa are currently managed by a permanent staff of 23 (Director, Curators, Collection Managers and Technicians) as well as at least three contract technicians at any one time. The content of the collections is rather broader than this number of staff might suggest due in some part to the presence of a significant herbarium in addition to the wide range of terrestrial and aquatic fauna. Major portions of the collections are maintained separately in both wet and dry storage, employing a range of containers in a variety of cabinets, racks and shelving systems.

Plants: the herbarium holds an estimated 250,000 specimens of algae and seed and cryptogrammic plants of which the algae make up 27,000 lots. The entire collection is stored in the Cable Street building (the only natural history collection that is) in purpose built facilities, well designed for long term storage. A special feature of the collection is a publicly accessible garden of native plants, developed as a coastal forest biotope and of increasing educational and conservation value as the trees and other plants grow and mature. The algal collection includes more than 800 species and over 200 primary types and is the best identified and curated, and probably the largest, in the country. In addition to endemic species, Te Papa holds voucher collections from research projects that document the spread of introduced algal species. 22 species such as *Codium fragile* spp. *tomentosoides* are considered naturalised in New Zealand. Te Papa's botanical collections are cared for by two Curators and two technicians plus ancillary staff. Algae are now maintained only on a part-time basis although the collection is regularly added to.

Most algae are stored on acid-free herbarium sheets (Fig. 1) shelved in acid-free boxes on shelves with specialised cabinets built for the largest specimens. A small number are stored in

Fig. 1. A specimen of the red seaweed *Porphyra* sp. attached to an acid-free herbarium sheet. *Porphyra* spp. (called karengo in Maori; Nori in Japanese) is regarded as a food source, world wide. (Photo: Museum of New Zealand Te Papa Tongarewa)

Fig. 2. 20 litre pails used to preserve fish (and some marine invertebrates), stored on steel pallet racks. (Photo: W. R. Webber)

liquid preservative and a number are dried specifically for molecular research.

Fish: the collection of fish is much the largest and most important in the country and includes over 285,000 specimens (in 41,000 lots) including more than 150 primary types. Over 1,200 species of fish are recognised in the collection with a new species identified every three weeks. The collection grows rapidly in response to the recent development of an extensive fishing industry both in and beyond the EEZ, which has given urgency to the need to identify and define the fish fauna of the region. The collection of intertidal and shallow water triple fins is of particular interest with a high level of endemism resulting from New Zealand's geographical isolation over the past 70 million years. A curator and collection manager actively build, maintain and research the fish collection.

The size range of fishes brings challenges to long term storage—besides storage in 27,000 jars fish specimens are kept in over 1,000 20L pails (Fig. 2) and 130 stainless steel tanks (Fig. 3). Although the development of stainless steel tanks has not been problem free, they have allowed efficient storage of large fish, even sharks, and proved ideal for large invertebrate specimens as well, such as giant squid (see below).

Birds: The bird collection at Te Papa includes, naturally enough, the iconic birds of New Zealand such as kiwi as well as an extensive collection of fossil and subfossil bird bones of extinct species (45,000 specimens) including moa, wrens and rails. The collection of extant birds (25,000) includes 13,000 seabirds of which 1,100 are albatrosses and 7,000 petrels with the re-

Fig. 3. Two medium sized (200 litre) stainless steel storage tanks set in a wooden frame to minimize space use while allowing access to both. (Photo: W. R. Webber)

mainder being 1,500 each of penguins, shags, gulls and terns. Among them, albatrosses and petrels have shown the greatest growth in recent years. The bird collections are managed by two curators, one assigned to bones and the other to the collection of extant birds, and a technician.

Bird specimens are stored dry in purpose-designed cabinets as skins, mounts, wings, nests and eggs, as skeletons in cardboard boxes, and as organs in liquid preservative. Because of their size, albatrosses pose their own problems for storage. Most are represented by wings, for which cabinets with 1.5 m wide drawers have been developed, with one-off crates built to accommodate taxidermied specimens (Fig. 4)—exhibits of well mounted albatrosses, birds that are seldom seen by the public, have proved very popular.

Marine Mammals: While Te Papa holds a collection of just 2,000 marine mammal specimens this includes the world's largest collection of beaked whales (230 specimens). Fur seals are also well represented. The collection focuses on the New Zealand region, including Antarctica, but includes some foreign material. A major source of specimens in the collection is whale strandings. Moving dead whales or parts of them from stranding sites, which can be anywhere in New Zealand, to Te Papa is facilitated by a well organised network of people who report stranded animals and assist in their preparation and transport to the Museum. The collection and care of marine mammals is carried out by a collection manager.

Marine mammal collections consist primarily of skulls, teeth and other bones, for the most part stored in pallet racks, either in large cardboard 'coffin' boxes or in padded, one-off wooden trays (Fig. 5). A significant number of specimens consist of complete or near complete skeletons and in this respect Te Papa has succeeded in the frequently voiced desire to create visible stor-

Fig. 4. A wandering albatross (Diomedia exulans) mounted for display. The specimen has a 2.8 metre wing span. (Photo: Museum of New Zealand Te Papa Tongarewa)

age—safe storage that can be viewed by the public. Fig. 6 shows the 'X-Ray Room' viewed from the public gallery, a safe store for a significant number of marine mammal specimens, present since the Cable Street Building opened eight years ago.

Molluscs: This collection is also by far the largest and most comprehensive of its kind in New Zealand with several million specimens, 1,079 primary types, and over 3,500 species, of which 1,600 have yet to be described. New Zealand is characterised by its diversity of endemic land snails species, having as many as any other land mass of equivalent size, and our collections are large as a result (60,000 lots). Marine lots predominate, however, with more than 270,000 lots, and specimens range enormously in size and nature from microscopic gastropod species (Fig. 7) to colossal squid (Fig. 8). Despite the size of the collections, the molluscs are managed and researched by a single collection manager.

The great majority of shelled molluscs are stored dry (Fig. 9) while the very extensive collections of squid and octopus are kept in liquid preservative, including large squid in stainless steel tanks.

Fig. 5. Two beaked whale skulls stored in a padded wooden tray. (Photo: W. R. Webber)

Fig. 6. The 'X-Ray Room'—visible storage of marine mammal skeletons as viewed from the public gallery. (Photo: Museum of New Zealand Te Papa Tongarewa)

Crustacea: Te Papa's collection of Crustacea is not large (about 18,000 lots; approximately 100,000 specimens) but has particular strengths in New Zealand decapods (crabs, shrimps and lobsters) with additional material from the Pacific Islands. Other strengths include decapod larvae and harpacticoid copepods of New Zealand. Collections of Antarctic crustaceans, generally non-decapod forms, are currently being developed. The collection holds about 250 primary types. The Crustacea collection is currently cared for and researched by one curator.

Most of the Crustacea are stored in liquid preservative although a small number, mainly decapods, are also preserved dry, including specimens mounted for display.

Echinoderms: in the echinoderms we have a very extensive and well curated collection with no resident specialist or designated staff at all. This important collection resulted from the past employment of echinoderm specialists (two) with responsibility to build the Museum's collection. It has now become one of a number of marine invertebrate groups administered but not currently targeted for collection or actively researched at Te Papa.

One third of the 13,000 lots of sea stars, sea urchins, brittle stars, sea lilies and sea daisies in the collection are stored in liquid preservative; the remaining 8,500 in dry storage (Fig. 10).

Fig. 7. Some of more than 400 undescribed species of tiny molluscs trawled recently from north west of New Zealand at 800 metres depth (size range 1–5 mm). (Photo: Museum of New Zealand Te Papa Tongarewa)

Other marine invertebrate phyla: Care of the remaining collections of polychaete worms, sponges, bryozoans, cnidarians, protozoans and other small marine invertebrate phyla (roughly 6,000 lots) is assigned to the Mollusc and Crustacea sections. Like the echinoderms these collections are ‘inactive’ although specimens collected with other, targeted biota are processed and stored if resources allow, especially those taken in rarely sampled places.

Fig. 8. The largest specimen of colossal squid (*Mesonychoteuthis hamiltoni*) recorded to date (5.4 metres long) caught south of New Zealand. (Photo: Museum of New Zealand Te Papa Tongarewa)

Fig. 9. Gastropod molluscs are stored in gelatine capsules to avoid acidity and binds disease which are kept in turn in small glass vials. (Photo: W. R. Webber)

Fig. 10. Dry sea urchin (Echinoidea) storage. These specimens were stored in cardboard trays which have since been replaced by better quality containers (see Fig. 12). (Photo: W. R. Webber)

Continuing Improvements

General: In the interests of maintaining collections long term, it is usually the aim of all institutions holding collections to maximise the quality of their care as resources will allow, and Te Papa is no exception. Its natural history collections overall contain approximately 1.4 million lots of which 343,000 are electronically databased. Historically some collections (notably the terrestrial arthropod collection with over 600,000 lots) have not been databased manually or electronically whereas all new lots are entered on an electronic database as an essential part of the acquisition process.

Electronic databasing began in 1994 with an in-house database (Te Kahui) purpose-designed to accommodate all Te Papa's collections. In 2005 the institution changed to KE EMu, a database designed in Australia for museum use and now installed in several museums internationally. Considerable progress has been made with collection backlogs. Priority for databasing backlogs is generally dependant on the level of identification and quality of data, on whether distinct taxonomic groups can be clearly defined, and on the level of research interest in that group. Significant advances in the databasing of existing collections are usually made according to the availability of external funding. Databasing is a priority but must compete with other collection care requirements for resources.

A recent innovation in staff structure has been the assignment of four general technicians to the whole Natural Environment collection rather than to individual collections such as Botany or Birds. Given the uneven representation of staff in different collections, this was seen as a way of making assistance available where priority tasks would not otherwise be done. Some collections do retain technical assistance, but this move has succeeded, in large part because the activities of the general technicians have been carefully managed.

Dry collections: The quality of Te Papa's natural history storage materials and systems is also improved when and where possible. For example, the extensive dry marine invertebrate collections have historically been stored in medium density fibre board cabinets. These are now gradually being replaced with powder coated steal equivalents (Fig. 11), better designed for safe storage and access, and elimination of the acidic vapours given off by fibre board, which cause cumulative damage to specimens. Safer storage and handling, and the reduction of acidic vapours, were also behind a recent project to replace acidic cardboard storage trays without lids (see Fig. 10), with acid-free containers. In late 2004 the bulk (about 5,000 lots) of the dry echinoderm collection was transferred to boxes in a range of appropriate sizes, consisting of an acid-free card base with a clear Mylar lid (Fig. 12). Stored in these boxes echinoderms are no longer in an acidic atmosphere and the clear top allows inspection with reduced handling of brittle specimens. Additional reasoning behind this comparatively expensive change is that, because this is an important but 'inactive' collection, due to the absence of a dedicated echinoderm specialist, this high quality storage will mitigate against its deterioration. The quality and range of sizes of these acid-free boxes has led to their wider use for fragile molluscs, bryozoans and birds eggs.

Wet collections: Te Papa follows traditional techniques for the preservation of animal specimens in liquid preservative with the great majority preserved in dilute ethyl alcohol, some stored in isopropyl alcohol to retain flexibility and avoid the clearing effects of ethanol, and a few others (as well as marine algae), in buffered formaldehyde solution (formalin). A variety of more specialised preservatives, generally based on alcohol or formalin and developed to suit certain ani-

Fig. 11. A new powder coated steel cabinet alongside an older, medium density fibre board cabinet it is designed to replace. The steel cabinets (which hold 40 trays, similar to the fibre board cabinets) are expensive. Complete the replacement of the older cabinets will take time and depend on the financial resources made available, year by year. (Photo: W. R. Webber)

mal or plant groups, are also used (e.g. Steadmans Solution for some plankton; a mixture of glycerol and ethanol used to preserve crustose coralline algae). The optimum types and concentrations of liquid preservatives for animals and plants has become refined and are to be found in manuals or on web sites of some museums such as the Smithsonian Institution site (see References); Te Papa is also in the early stages of compiling a manual of recommended processing and storage methods to suit its own requirements. The advent of molecular analysis as a tool of taxonomy has shown that specimens fixed and stored, short or long term, in isopropyl alcohol and especially formalin cannot be analysed. This has led to a change in approach to sampling specimens, requiring tissue sampling prior to fixation.

While dry natural history collections are reasonably well housed we have experienced more serious problems with the housing of collections stored in liquid preservatives ('wet' collections). What follows is a brief account, presented as a 'case study', of a problem which confronted us subsequent to occupying the Museum Resource Centre.

Wet Collection Storage: a Case Study

The Resource Centre was not purpose-built for museum use as the Cable Street Building

Fig. 12. Acid-free boxes in a range of sizes containing echinoderms, which were used to replace acidic cardboard trays (see Fig. 10). (Photo: W. R. Webber)

Fig. 13. The Spirit Collection Area of the Museum Resource Centre. The buildings include wet collection storage, freezers and preparation and research laboratories. (Photo: W. R. Webber)

was. Instead it was built as a public utility building designed to withstand severe earthquakes, which is a priority for collection care in Wellington. The building has also proved suitable in other respects, with manageable spaces and room for growth of Te Papa's extensive dry natural history collections (as well as other, non-natural history objects). However, the space used to house collections in liquid preservatives, the Spirit Collection Area (SCA–Fig. 13), which is separated from the main complex in order to meet City Council safety requirements, has proved less adequate. Soon after occupying the building (in 1999) it became evident that specimens stored in

Table 1. Temperature and humidity ranges in Resource Centre collection storage space measured over one year (July 2002–July 2003). (Table: C. D. Paulin)

Minimum & maximum temperatures | Minimum & maximum humidities

2002–2003 Month	Spirit Collection Area Tory Street					
	Temperature °C			Relative humidity		
	Minimum	Maximum	Average	Minimum	Maximum	Average
July	5.4	15.7	10.8	62.3%	93.8%	82.2%
August	6.2	15.1	11.2	56.9%	89.3%	77.0%
September	7.5	18.0	13.1	50.8%	85.5%	71.9%
October	6.9	18.6	13.7	51.8%	82.3%	67.2%
November	7.7	19.9	14.3	50.4%	86.0%	69.5%
Dec.-mid January	11.7	25.4	18.0	40.9%	89.9%	69.3%
Mid Jan.-end January	12.0	22.4	17.5	49.0%	81.7%	65.4%
February	11.5	23.4	18.2	52.7%	79.6%	67.0%
March	12.0	24.4	18.0	51.8%	89.3%	74.9%
April	8.8	20.8	14.2	63.7%	87.7%	76.2%
May & June	6.2	18.3	13.4	53.2%	92.1%	75.9%
July	4.9	16.8	9.9	57.9%	89.9%	77.6%

alcohol were subject to falling preservative levels and failing lids. Individually or in combination, a concentration of ethyl alcohol below 70% or a ratio of less than two volumes of preservative to one volume of preserved specimen(s) leads to specimen deterioration. Mould was also found on fibre board shelves and storage containers. Temperatures fluctuated and were commonly below the level acceptable for staff to work in for any length of time. As a consequence, a test of temperature and relative humidity levels over a year (four seasons) was initiated in 2002.

Table 1 gives the results of the one year tests and indicates that the range of temperatures experienced was considerable; for the year it ranged over 20.5°C; Summer (December–January) temperatures were close to twice those of Winter with the greatest monthly range 13.7°C over the same two months. While storage temperatures are ideally lower, the recommended temperature for safe storage and to enable work to be carried out is 18°C + or –1° (recommendation by Te Papa Conservation Department). Average monthly temperatures over the year only reached the minimum working level in the four months from December through March.

Relative humidity (RH) fluctuations were also wide; the RH ranged through 52.9% throughout the year (40.9%–93.8%) and the greatest monthly fluctuation was a surprising 49.0%, again during the height of Summer (December–mid January). The recommended RH for wet collection storage is 50% (+ or −5%) but as Table 1 indicates, monthly RH averages were consistently well above this figure. As the range and rapidity of fluctuations indicate, there was no control over RH levels in the facility. The most obvious indicator of excessive humidity was the spread of mould but it is also known that high ambient RH increases the absorption of water by alcohol and, since no containers are considered completely sealed, this absorption was also thought to be lowering alcohol concentration levels in specimen containers.

The temperature and RH fluctuations encountered prior to December 2002 prompted a subsidiary survey of alcohol levels and concentrations which was carried out over December and the first half of January 2003. During those six weeks, 3,800 specimen jars containing specimens across the range of vertebrate and invertebrate specimens stored, were tested. Tested jars were selected at random but only from specimens preserved in ethyl alcohol which is the predominant and most volatile preservative used in the facility. The results of these tests are given in Figs. 14

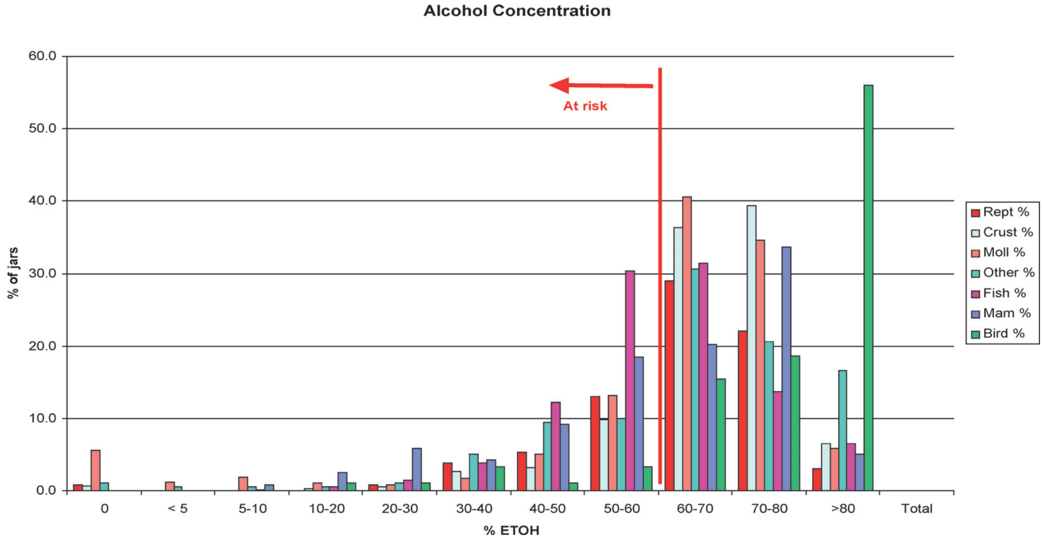

Fig. 14. Ethyl alcohol concentrations in 3,800 jars holding fish and invertebrate specimens. (Rept=Reptiles; Crust=Crustacea; Moll=Molluscs; Mam=Mammals). (Fig.: C. D. Paulin)

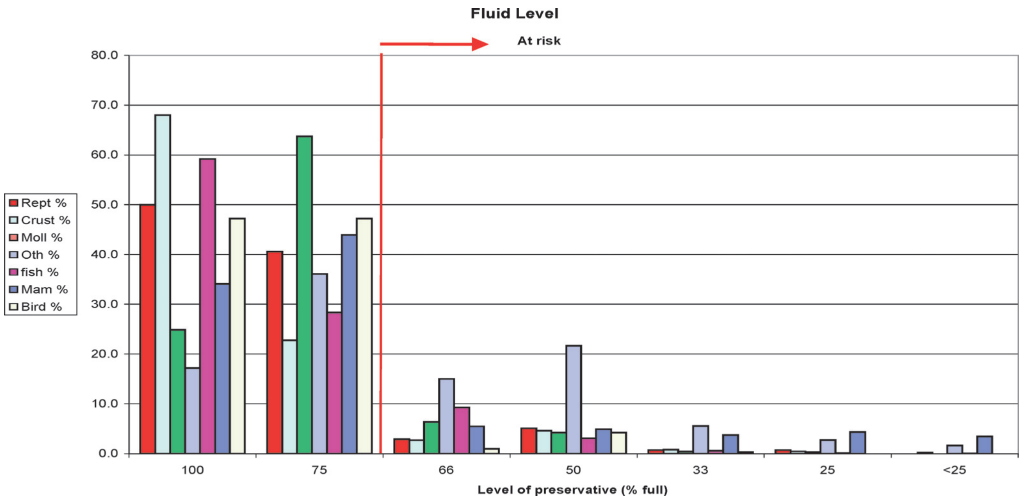

Fig. 15. Ethyl alcohol fluid levels in 3,800 jars holding fish and invertebrate specimens. (Rept=Reptiles; Crus=Crustacea; Moll=Molluscs; Mam=Mammals). (Fig.: C. D. Paulin)

and 15.

Fig. 14 indicates the percentage of jars in each taxon (7 including 'other') against their alcohol concentrations. Jars to the left of the red line indicate that one quarter of the collection in ethyl alcohol was at risk with concentrations below 60% (70% is the standard minimum). It was also estimated that alcohol concentrations decreased over the duration of the survey by 1.2% (six weeks, over which facility temperatures varied by 13.7 °C; RH by 40%).

Fig. 15 gives the measurements of alcohol levels (fullness) in jars (note, fullness was used as an indicator of evaporation, not as a measure of the volume of preservative relative to the volume of the specimen, which is a separate, important issue addressed in a later risk assessment survey).

Those to the right of the red line indicate that 10% of the jar collection was at risk with fluid levels less than 60% of the volume of containers.

The first response to these findings was development of a programme to systematically test and correct preservative concentrations and preservative levels in all wet storage containers in the collections. This is no small undertaking and will take more than three years to complete from commencement in later 2003, using contract staff hired for the purpose.

Clearly, a number of variables contributed to the test results including the types of jars used and the age of preserved specimens, since tests of this kind had not been carried out previously. It is probable that lowered preservative concentrations have also resulted from incomplete stepping from fixation to preservation, or no stepping at all. In this situation, the water content of incompletely fixed specimens, or specimens soaked in lower concentrations of preservative, equalises with the long term preservative at a lower concentration. Even so, prior to moving into this facility, good curation methods and collection management had been applied consistently to all the wet collections. We were therefore confident that the results of the 2002–2003 tests could be fairly attributed to the environmental conditions encountered in the Resource Centre. Consequently the tests were important in getting a better appreciation of the state of collections and rates of change, and served another important role as well; armed with these results we were better able to convince the Museum Board that improvements were urgently required. Sufficient finances have now been allocated to upgrade the liquid preservative storage building to reduce the effects of external temperature and RH fluctuations on the internal environment of the facility. Renovations will take place early in 2006 with temperature and RH controls being installed along with the addition of better quality storage systems and greater room for collection expansion than was previously available.

Risk Management

Given the case study summarised above and its successful results, the repetition of such tests at intervals of say, five years, or when similar problems set in again, would help eliminate the deterioration of collections in preservative. With an unlimited budget this may well be all that is necessary but few, if any institutions have such resources, including Te Papa. Such a reactive approach, also risks delay, inadequate funding when it is required, and may even be overlooked due to changes in staff or restructuring.

With limited resources and the many different requirements of building, maintaining and improving collections, a system to identify priorities that will facilitate the best use being made of these resources, is clearly desirable. Such a system would also assist in anticipating problems and preventing their development (the purpose of preventive conservation). It would also enable the timely planning of measures to improve collection care, and the accumulation of data to support applications for funding to carry out these measures. This may be better achieved through taking a risk management approach to collections and their care.

Risk assessment is a tool of industry, especially insurance companies, which has been adapted to improve preventive conservation in museums and developed as an approach to collection management. Risk management (of which risk assessment is an essential part), was developed by the Canadian Museum of Nature (CMN) to improve the management of its collections. It has been successful to the point that numerous natural history museums have now taken it on, among them the National Museum of Natural History (Smithsonian Institution) which has recently committed itself to applying risk management to all 32 million lots in its natural history collections

Fig. 16. Dr Rob Waller (Canadian Museum of Nature) taking a workshop with Te Papa Natural Environment staff on Risk Management. (Photo: W. R. Webber)

(Rob Waller, personal communication).

In August, 2004 Te Papa invited Dr Rob Waller, Chief Conservator at the CMN and a major contributor to the development of risk management in museums, to conduct a two day workshop on assessment and management of risks to the Museum's natural history collections (Fig. 16). Using a manual prepared for Te Papa (Waller, 1995) and applying its methods to Te Papa's collections, natural history staff (including the institution's preventive and materials conservators) undertook a series of group exercises in assessing risks followed by analysis, evaluation and suggestions as to how the perceived risks might be mitigated.

Risk management of museum collections involves a number of steps using numerous, carefully defined criteria and calculations and is too complex to describe (see Waller, 1994, 1995, 1999, 2002, 2003 for details with examples). However, a simplified outline, without definitions of terminology, is given here, based on the above papers by Waller and Te Papa's own wet collection risk assessment report (Whittaker, 2004). Four steps in the process are identified:

Identifying risks: Fundamental to implementing risk management of collections is the identification of all risks to the collection. A list of agents of deterioration (i.e. physical forces, fire, criminals, water, pests, contaminants, light and UV radiation, incorrect temperature, incorrect relative humidity, and dissociation), developed by the CMN for its own collections, covers all the possible risks to collections. All ten agents do not necessarily apply in each situation. Each of these risks can be refined as three different types of risks depending on the frequency of occurrence and severity of effect on the collections, i.e. whether they are a) rare and catastrophic, b) sporadic and severe or c) constant and mild/gradual (these are termed 'generic risks').

Magnitude of the risks: Once the risks are identified the magnitude of each risk is assessed.

'All risks..... have a magnitude that is the product of probability [or extent] and severity' (Waller, 1995). Calculation of the magnitude of risk addresses four parameters: the Fraction Susceptible (FS) i.e. that proportion of the collection vulnerable to a particular risk; Loss in Value (LV) i.e. the maximum possible reduction in utility; Probability (P) i.e. the estimated chance of the occurrence of an event of a given severity within a 100 year period; and Extent (E) i.e. the measure at which a specific risk will result in Loss of Value to the Fraction Susceptible of a collection within a 100 year period.

Mitigation strategies: With the magnitude of risks calculated, either from measurements, or estimation in cases where measurements are not available, possible mitigation strategies (preventive conservation measures) can be identified. In considering risk mitigation possibilities a matrix of five methods of control (avoid, block, detect, respond, recover) are set against eight levels of control (location, site, building, room, cabinet/shelf, object, policy, procedure). The result of filling out the matrix is a checklist of strategies to be considered for the control of each risk (Whittaker, 2004).

Cost/benefit evaluation: At this point, suitable information for calculating the cost versus benefit of mitigation strategies is available.

Following the workshop on assessment and management of risks, a risk assessment was carried out on wet collections at the Museum Resource Centre (Whittaker, 2004). This assessment undertook all the four steps in the process outlined above. The information and recommendations resulting from the assessment have since been used to inform the planning stage of the 2006 refurbishment of the wet collections facility.

To be of greatest benefit in prioritising the use of Te Papa's Natural Environment resources, it is quite clear that risk assessments of all of its collections will be required. Such assessments of the dry collections are now underway.

Conclusions

This account of the marine collections of Te Papa is far from comprehensive. The brief overview of the collections indicates that the Museum's natural history collections overall are of modest size compared to equivalent institutions in other countries. At the same time, collections of some taxa are exceptionally large, and each collection is uniquely representative of New Zealand's biota. Perhaps the most urgent need in this respect is the enhancement of marine invertebrate collections; the least known biota in the region but becoming increasingly vulnerable to human intervention and damage.

The discussion of collection care problems and solutions, has provided only selected examples of the kinds of changes and improvements being undertaken in the Natural Environment Directorate of Te Papa. Risk management is playing an increasingly important role in the way collections are managed at the Museum which is rationalising the use of resources allowing development of collections of animals and plants that are in need of greater attention.

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