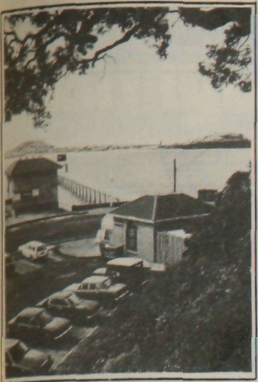


Orakei Aquarium — an innovation in engineering

By Ian Mellsop, MIPENZ

The use of innovative techniques to almost halve costs enabled my partner, Kelly Tarlton and I to realise his dream of building an aquarium at Orakei. Constructed in huge sewerage tanks under Auckland's harbourside Tamaki Drive, Kelly Tarlton's Underwater World has proved an outstanding attraction since it opened on January 25, 1985.

The aquarium is designed to recreate the world the diver sees on a typical Hauraki Gulf volcanic reef. Spectators move through this world inside a clear acrylic covered tube set in a trench in the base of the aquarium. They travel on a conveyor belt, stepping on and off to watch colourful fish life around and above them.

Kelly Tarlton, who died last April, aged 47, not long after welcoming the 100,000th visitor to the aquarium was a world renowned diver with an impressive list of achievements in the underwater sphere. An early interest in mountaineering at the expense of his schooling at Christchurch Boys' High School gave way to his great love in life, diving. Within six months he held the New Zealand record of 112 ft depth for a free dive.

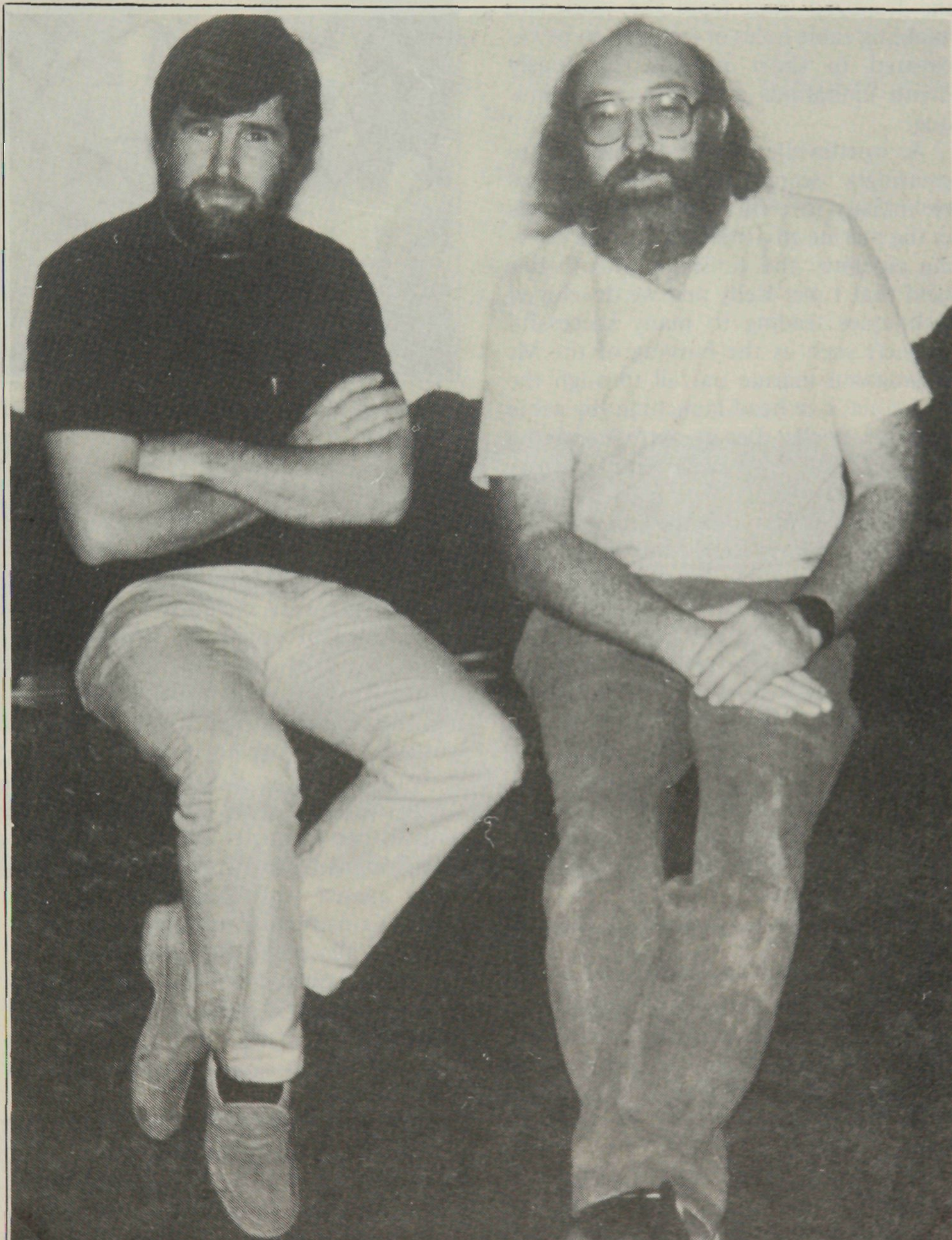
He developed his skills as a diver, photographer and innovator while working as a Post Office technician. With the help of his father, Ewart, a retired indentured engineer, he designed and built many devices which were the forerunners of diving equipment used today, such as the buoyancy compensator.

His first underwater camera was made using a pressure cooker. He also built one of the first acrylic viewing panels in an aquarium consisting of a steel tank with a three foot square hole cut in the side and a sheet of quarter inch thick acrylic sealed over the hole. The device was used successfully for a display at the Christchurch show.

Most of this equipment was built in the home workshop he shared with his father who still contributes to the aquarium from his home workshop in Papatoetoe.

Kelly continued to develop devices during the next two decades to help him locate, excavate and salvage lost wrecks throughout the world. Most of the salvaged pieces are on display at his shipwreck museum in Paihia.

His principal invention was the adaptation of his jet boat for underwater excavation so that it became a large volume highly mobile pump. The Hamilton jet unit, at 200,000 gallons per hour for a 200mm unit driven by 220



The author, Ian Mellsop (left) with the late Kelly Tarlton on a rock pool in the aquarium.

HP, is unmatched by conventional civil engineering equipment. When this pump was attached to hand-held underwater venturis canvas hoses it could shift hundreds of cubic metres of sand/silt per day, leaving behind the heavier metal objects (eg gold). This was a significant improvement over air lifts which tended to suck up everything and thus lose coins etc forever. A further development was in attaching blasting nozzles to the jet unit to direct the blast from the jet so that it physically hoses the sea floor. This is especially effective where there is current flow which immediately removes the fluidized sand from the work site enabling cable holes or trenches to be excavated in short periods. Obviously depth limitations apply to this technique.

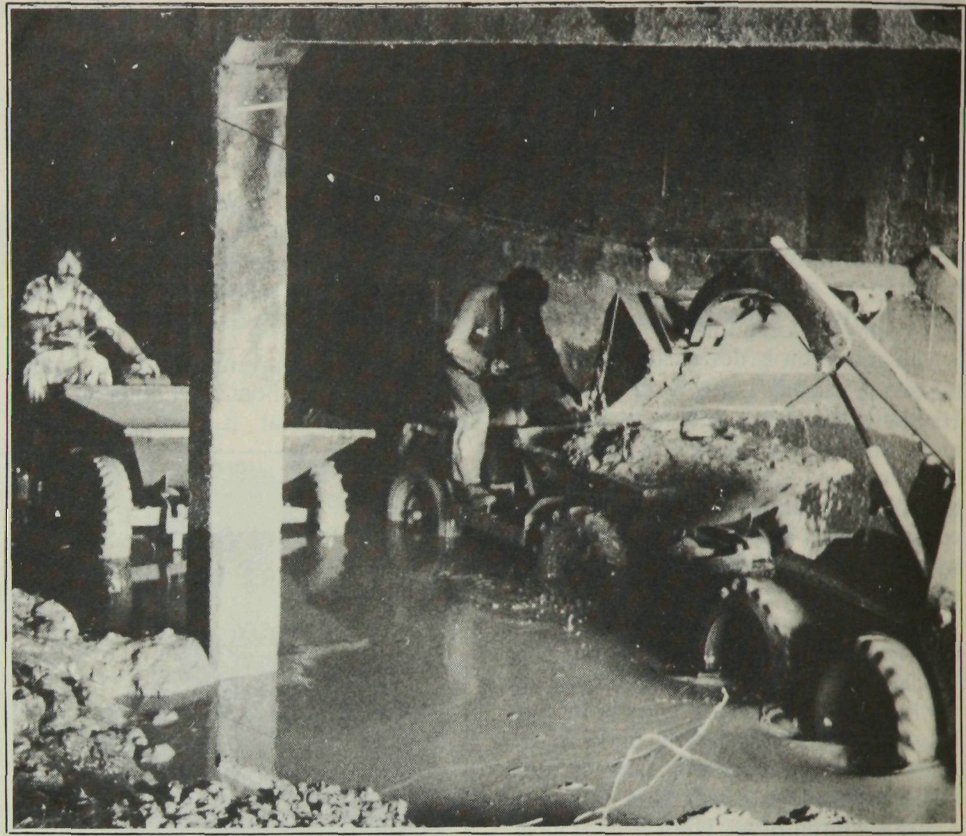
As worthwhile shipwrecks became increasingly scarce Kelly applied this technology to civil engineering projects in the marine environment such as burying pipelines and cables. It was in this field that I met Kelly and we developed techniques leading to many successful projects such as the burying of the Mt Maunganui marine outfall through the surf zone, overhead launching (by cable way) of Snells' Beach outfall and the New Zealand Steel water intake structure.

During this period in the late seventies and early eighties Kelly had been working towards building his own aquarium in the Bay of Islands. He undertook at his own expense several world trips to look at aquariums, including those in Japan. Kelly's approach was to first research the project thoroughly, talk to as many people as possible about the idea and then look freshly at all viewpoints. He found many shipwrecks, not from admiralty charts or newspaper reports, but from talking to survivors or their descendants.

Planning

Armed with knowledge about the state of the art in overseas aquariums, Kelly approached me to convert this dream to reality and share in the ownership of an aquarium to be built in Paihia.

In a story only too familiar to engineers, two years and tens of thousands of dollars later we were hamstrung by local politics, parochialism, apathy and miles of red tape. We then discovered that the Auckland Harbour Board was putting the old valve house by the Orakei wharf up for lease. We realised that if the old sewage holding tanks below it, unused since 1962, were included in the lease, the aquarium could be fitted in the tanks. We applied for the lease and this was secured in June 1983. Within six months planning approvals had been gained. A working model of the aquarium built by Kelly's father proved to be the highlight of the planning hearings. Once financial backing from the Development Finance Corporation had been gained work began on April 2, 1984. Construction took nine months. Bruce Wallace and Partners, consulting engineers, carried out structural design and gave general assistance in technical matters.



Clearing 70 years of accumulated residue from the tanks to allow construction to proceed.

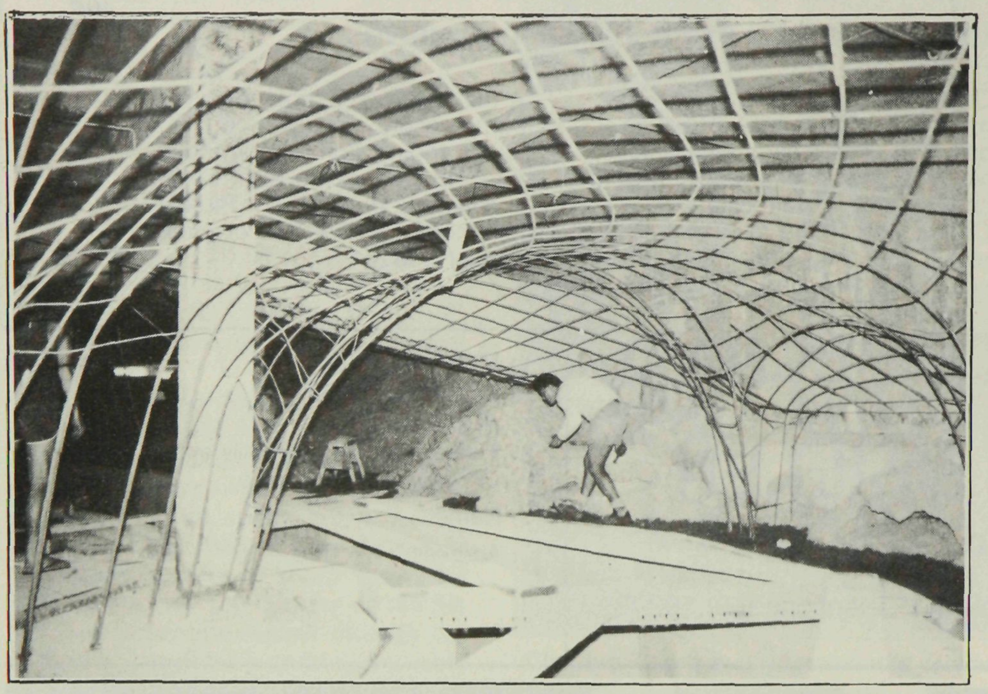
Civil works

Innovative use of jet boats was needed once again to move the waist-deep harbour silts and other residues that had accumulated in the tanks which were open to the tidal flood. The jet boat fluidized the silts which were then removed with each ebb tide in suspension — imagine a 200,000 GPH 8 inch diameter fire hose delivering at 100 PSI.

During the five hours at the bottom of the tidal range a bobcat stockpiled the heavier materials clear of the construction site. Full breathing gear had to be used as carbon monoxide was a continual hazard. This whole operation was mounted 24 hours a day with six hourly shifts. A tremendous amount of slogging handwork characterised the rest of the construction work. However, innovation was important once again in the construction of the conveyor trench which was below low water spring tide level.

The existing floor slab was rock bolted to the underlying sandstone of the Waitemata group to compensate for uplift and construction of the conveyor trench. Difficulties to be coped with during the trench's construction included running sand, silt, 250 mm of old concrete and the Waitemata sandstone, all below low water spring tide level. The tide came in relentlessly every 12 hours, head room was restricted and complaints about noise and fumes came from associated tradesmen such as electricians and finishing carpenters. In essence this was a tunnelling contract.

We devised a system of cut off walls using 10 MPa concrete and a mini digger to excavate 300 metre wide trenches to the sandstone at depths up to two metres. The fluidized silt was retained in the trench in the same manner that bentonite is used in drilling with the concrete placed from one end displacing the silt as pouring progressed. With both walls complete, the mid-bund was excavated.



The ferro-cement cave under construction showing the conveyor trench beneath before the acrylic was installed.

A view inside the tank showing the ferro cement rocks being made.

The acrylic tunnel

Kelly's original concept was an inverted wine glass where people climbed down the stem on a stairway and stood in the inverted bowl to watch the fish. This proved too daunting. Instead an acrylic tunnel in the manner of an aquarium in Orlando, Florida, was decided upon but one 10 years in advance of it in technology.

Initial negotiations with a Japanese manufacturer left us with a quote of three-quarters of our entire budget, an impossible situation. To retain the dream intact we fell back on "do it yourself". After much talk and research, Kelly and Tony Crang from Bruce Wallace and Partners, travelled to a likely supplier in Germany. We took the plunge and ordered $250,000 worth of acrylic — 62 sheets, four metres by two metres and 70 millimetres thick. We built an oven out of 4″ x 2″ timber, batts and other local materials, installed a heater, built the mound and bent the sheets, all properly annealed and stress tested. The extremely complex techniques and process we used were developed only after considerable research and experimentation. The final cost was less than a third of the Japanese quotation. During this time telexes arrived from Japan saying that it was impossible for us to bend our own acrylic without their expert advice.

Penstock construction techniques for going around the corners at first prompted us to have horizontal corners from spun concrete pipes expoxied together in a lobster back formation. When detailed costing showed that acrylic was nearly as cheap we chose flexible jointed acrylic segmented corners which enabled fuller viewing of the aquarium. We developed a unique jointing detail for joining bent acrylic sheets to each other and to the concrete sill. Again this was developed because of excessive quotes from overseas experts. The aquarium had no leaks on filling or later, a unique experience in aquarium construction.

Kiwi ingenuity was put to work on the acrylic sheets. We used airlift work tables, vacuum lifters, a converted magnetometer to record oven temperatures, adapted skilsaws, routers and planers for working the acrylic, a converted bobcat for the tube installations and even an upside down traffic cone as a grout pouring funnel. Application and selection of the right and compatible epoxies were of the utmost importance.

Mechanical works

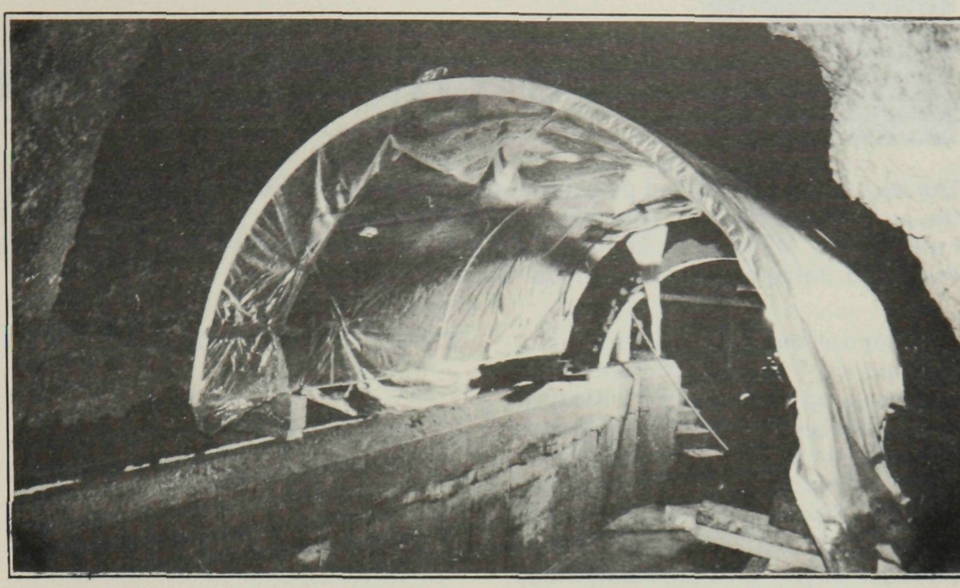
Filtering and pumping were also designed from a "fresh look" approach. Pressure filters were rejected because of cost and inefficiency. Trickle sand filters with low head propeller pumps have proved ideal. We have four identical submersible pumps each able to be replaced in under an hour. The sand filter design is similar to many local authority water treatment plants and is unique only in the cleaning machine, a "creepy crawly" machine, not unlike a swimming pool vacuum cleaner. This machine, which is now being perfected, actually fluidizes the filter sands and pumps the finer particles to waste. An artificial wave machine consisting of a counter balanced tilting door was developed by Kelly and his father. This gives viewers the sensation of surf waves on entering the acrylic tubes.

All mechanical works, the ventilation system, sewerage pumps, pipe systems and raw water pick-up system were developed by us as the project developed. We used local materials and called on expert advice where appropriate. A key element was the unbounded enthusiasm which pervaded the whole project.

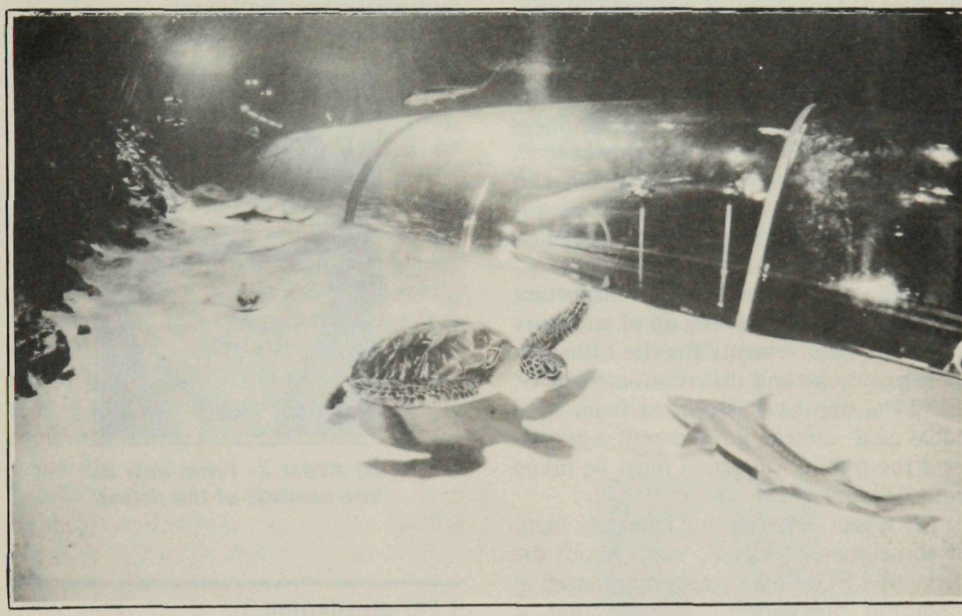
Fish environment

Replicas of typical seascape are needed to create an underwater journey. This is also important for fish health. We engaged John Griffiths, a plasterer and diver, and set about designing our own seascape based on a typical Hauraki Gulf volcanic reef. The rocks were constructed in ferrocement and designed to disguise the structural and mechanical workings, provide accommodation for the animals, and to look attractive. The result is more a work of art than engineering. Experimentation in finishing techniques and colouring were important features.

No seascape is complete without seaweed and this presented problems. In order to stop algae growth aquariums need to be artificially lit which ruled out real seaweed. Artificial seaweed was available from overseas but at $US50 a foot this was beyond our budget. Plastic suppliers were approached and plastic sheets were donated from one source.



The first acrylic sheet being positioned in a cave with the protective cover in place.



Inside the completed fish tank showing a fish's view of the acrylic tube.

Ewart Tarlton designed and built a crinkle machine to make the leaves. The stems were moulded and the product put together and installed for a fraction of the cost.

Costs crucial

Building the Orakei aquarium for about half the cost of approaching the project in the conventional manner, was crucial. Any tourist venture has severe limitations on its upper cost geared to the projected number of visitors. Only by adopting the innovative techniques displayed in the aquarium was construction made possible.

These techniques were, in the main, the result of combining experience, management skills, financial control, engineering, construction and experimentation, at one level in the hands of very few people, who were totally committed to the project. They were available all the time, prepared to try unproven ways and able to make instant decisions without restraints or the need to refer to absent boards or committees.

A common saying between Kelly and myself when striving for completion on time and within budget was: "Get out of bed early and kick backsides." □