Seal hairs can help us better understand our own hairs

The kekeno, or Australasian fur seals (*Arctocephalus forsteri*) have hairs in their coats that respond to water by changing shape in a predictable way. These are not the fine soft hairs you might associate with fur, but the thicker guard hairs that stick up above and protect the undercoat. Our own hair (and that of other mammals) also changes shape with humidity and water, but not in a predictable way – often we call the result a “a bad hair day”. Kekeno never have a bad hair day, scientific study of the guard hairs will greatly boost our understanding of water interactions with our own hair, and all mammalian hair.

Who we are and why we care about what we can learn from seal hair?

We are scientists (Duane Harland, Marina Richena from AgResearch in Lincoln NZ, and Yukari Nishita from Kao corporation in Japan) who work on wool and human hair. We are all passionate about nature, have widely travelled in the wild places of Aotearoa/New Zealand and have an affection and respect for kekeno and their environment. We are also passionate about discovery in hair and wool. All mammalian hair has an intricate internal organisation that we don’t fully understand despite many decades of research. The research on seal hairs is fundamental research that will inform us of some principles by which all mammalian hair works. The seal hairs are a model system because, like human and sheep hair, they change shape and mechanical properties in water. In human and sheep single hair fibres water induced changes in shape are hard to pin down to microscopic or nanoscopic structures within the hair because shape changes are a bit random and unpredictable. Like in other seals, kekeno have guard hairs that appear to change shape predictably at points along single hairs. This gives us a rare opportunity to examine the underlying structure of these points along kekeno hairs and what happens when they get wet and change shape. What we learn applies widely across mammals because the level of detail that we are interested in is conserved in all mammals from platypus to tiger.

Fur appearance in wet seals (left) differs from that of dry seals (right). Centre image shows an intermediate stage. The drying process affects individual guard hairs (outer coat hairs), relying on adaptations built into each guard hair. Photos courtesy of William Harland (D. Harland’s son).

In nature the hair changes probably help the kekeno transition from streamlined (but poor insulation) when swimming to better insulated (but poor streamlining) when on land.

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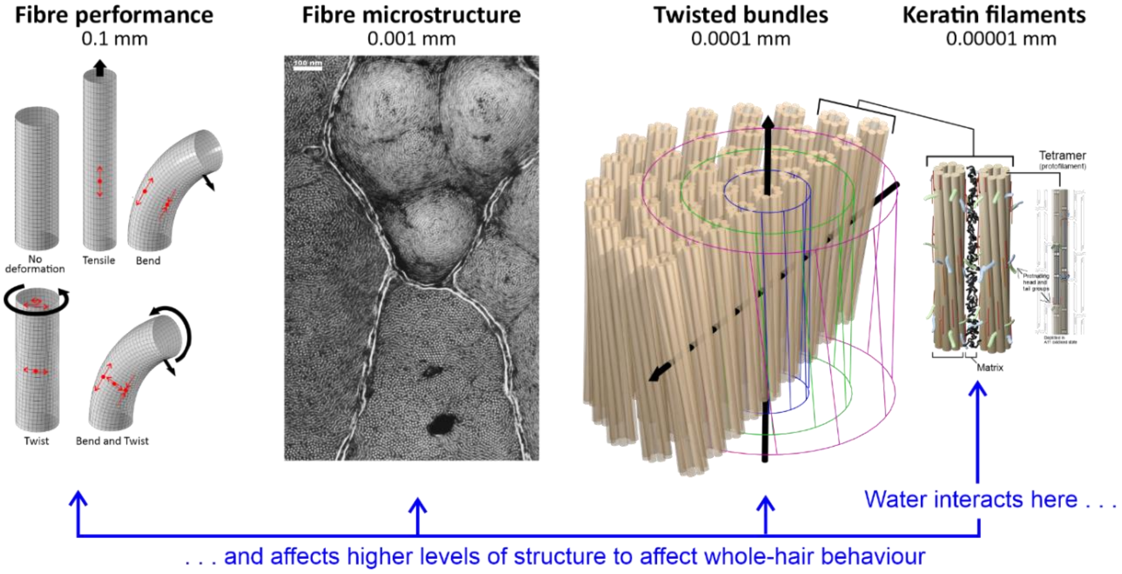


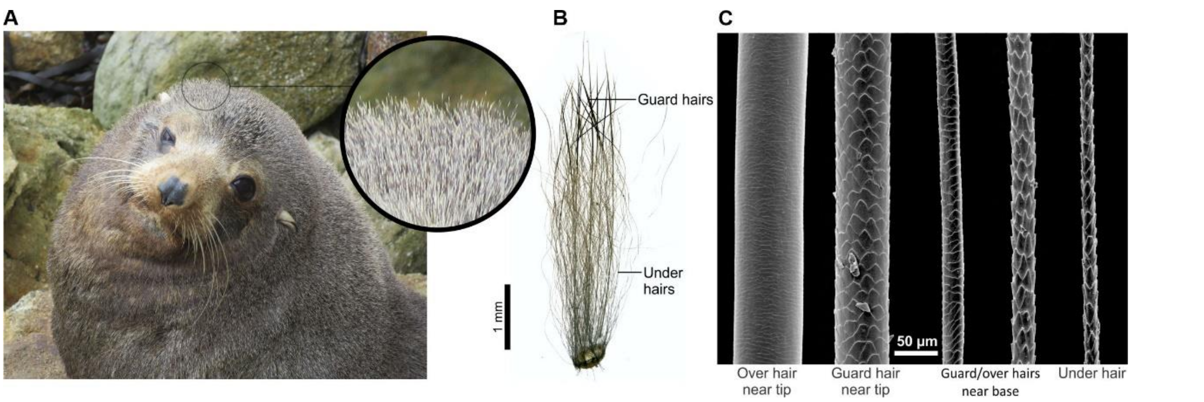
Our interest in what we can learn from the kekeno guard hairs is to help us better understand how water interacts with keratin filaments (at a scale of ~1s of nanometres) and how the effects scale up to filament bundles (100s of nanometres), across the hair structure (micrometres) to affect performance at the level of millimetres in hair from other species. (illustrations from some of our scientific research papers on hair and wool)

What are we going to study?

Parts of kekeno guard hairs always bend or straighten the same way each time with wetting and drying. There are three regions: near the base they bend when wet; in the middle they stay straight, wet and dry; near the tip they bend backwards when wet and forward when dry. Water interactions are only partly understood at a molecular and micro-structural level in mammalian hair. We want to investigate these regions using high-power microscopy and microanalysis methods (including electron microscopy and x-ray microbeam diffraction) to find clues in their microstructure and biochemical organisation associated with specific responses to water. We hope to piece together some of the relationships between molecular interactions with water and nanoscopic structures (bundles of keratin filaments) and how these scale up to affect fibre performance (bending when wet).

What hairs do we want to study and what we do with the hairs?

In common with many mammals, the kekeno coat is composed of fine underhairs that trap air for warmth and this understory of fine hairs is supported by longer and higher-diameter guard hairs that form a protective canopy. We are only interested in guard hairs.



The fibres visible on the surface of the seal (A) are guard hairs. Common in mammals, (B) shows and example from a cat (resulting from a fight). Guard hairs differ in their structure along their length (C) (scanning electron microscopy) (Sources: A, W. Harland, B and C from research publications from our team)

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Our plan is to collect samples in the first half of 2021 from kekeno that have died of natural causes and washed up on the beach, or from scratched off tufts from grooming. This is not an uncommon occurrence in areas where kekeno aggregate and we have previously identified a few locations where we have previously noted dead seals or nest areas – Shag Point (Waitaki district), Tauranga Bay (Buller district), and beaches around Okuru , which is adjacent to the Open Bay Islands (Westland district).

*Sampling will occur from resting locations or deceased individuals. **Left**, depressions in grass meadow (black arrow) left by kekeno resting at Shag Point (Waitaki district). Tufts of fur are sometimes found caught in the grass. **Right**, sub-adult kekeno corpse Cooper's Lagoon beach (Selwyn district) in moderate state of decomposition with tufts of fur peeling off skin (white arrow). (Photos courtesy of D. Harland).*

We only require a few tufts of hair to get enough single guard hairs for the study. The hairs will be washed to remove dirt and grease, and to make them safe to handle (marine mammals can carry some unpleasant bacterial pathogens). Guard hairs will be separated by individually removing them using fine tweezers, possibly under an inspection microscope. Individual hairs may then be used for different analyses. The remaining underhairs will not be used. We can dispose of them or, return to iwi or to the beach.

Guard hairs will be mostly sent for analysis in Japan and the parts of individual hairs that respond predictably to water will be examined using a variety of techniques. The most important of these are:

Transmission electron microscopy which allows us to look at filament structures at a level of nanometres (see the previous illustration, the fibre microstructure image was taken with this technique);

Microbeam x-ray diffraction using a synchrotron electron accelerator that generates highly pure x-rays which we will scan across the regions of the hair to examine how the filament organisation changes at the level of the molecular organisation.

More details are provided in the methodology section of the application. Some of the hairs will be effectively destroyed by these methods, but any hairs not used can be returned to NZ for disposal or return to the beach (our application includes provision for this).

What will we do with the findings of our study?

There is no direct commercial application of our findings. We plan to make the results available publicly through either or both of scientific conferences and technical journals. If there is enough public interest, we may write some news articles.