An Emotional Prehistory

A scientifically driven generated art approach to removing anthropomorphism and artistic interpretation from prehistoric visualisations

By Dean Cameron Reynolds

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Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Abstract

Documentary is often perceived as an *authoritative* voice of experts and scientists exploring a topic for our benefit. The audience responding to the *authoritative* tone believe the content to be based on fact, represented correctly, unbiased and free of entertainment based constructs such as a scripted narrative, anthropomorphism of animals and inanimate objects, emotional dialogue, mood manipulating music and unrealistic behaviours. However, documentaries do display these entertainment-orientated constructs and in so doing misrepresent reality to the detriment of the trusting audience. This is particularly evident in documentaries dealing with visualising prehistoric life, as every movement, behaviour and aspect of its physiology is designed and constructed for the audience and not simply filmed from the wild. In spite of the continuing improvement in visualisation technologies which represent the extinct creatures in a more photorealistic manner, the artificial constructs by filmmakers such as anthropomorphism, scripted actions and emotive content wilfully lead the film from being documentary to being entertainment. Instead of educating an audience, they can mislead and damage an audience's perceptions of the past.

These additions or distortions of evidence are unnecessary, as more than a century of research has shown that prehistoric life was varied and fascinating.

Photorealistic visualisations of these prehistoric animals that is evidence based can be enthralling to viewers whilst not showing a distorted emotionally manipulating narrative driven version.

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1. Introduction

It is the thesis of this review that technological improvements in animation and cinematic technologies have led to improved documentary visualisations.
Animated visualisations of extinct creatures have reached a level of photographic realism through technical innovations which filmmakers and documentary producers have utilised in their films.

Scientific discoveries that have been made over the course of the last two centuries have continued to improve our understanding of extinct creatures, their behaviour and world. Although scientific understanding of these creatures as well as the advancements in how to technically visualise them have improved, this has not resulted in more accurate depictions as entertainment oriented decision making often leads to inaccurate depictions of prehistoric creatures.

These inaccurate depictions anthropomorphise prehistoric life, suggest emotional motivations for natural acts such as predation, and overlay a moral schema which damages the understanding of these creatures in the eyes of the public.
The result is convincing visualisations which have the illusion of scientific credibility but which actually reinforce unscientific ideas and mislead rather than educate.

Wildlife documentary is an example of a popular documentary genre which does not feature designed creatures susceptible to anthropomorphism and artistic influences.

This popularity perhaps suggests that a prehistoric visualisation done in the style of wildlife documentary without anthropomorphism and artistic influences could still be popular to the public.

1.1 Background

This research stems from a lifelong passion for prehistoric life, museum experiences and creature modelling.

At age four I was fascinated with seeing dinosaur visualisations in museums, and then rushing home to make them out of clay.

At thirty-four I am exactly the same, only some of my clay is digital now which means I can make them move as well.

Unfortunately a lifetime of being fascinated and collecting research on the creatures of the past makes one aware that some visualisations are more fantastic than authentic.

Some of these inaccurate visualisations occur in documentary films, which the public perceive as a trustworthy source of knowledge.

Research on prehistoric animals and their environments paints an increasingly clear picture of past epochs, and indicates that these worlds and animals are fascinating enough to be presented as scientific findings indicate, and still be captivating to the public.

1.2 Research Questions

The primary research question which drives this project is ***"Can Anthropomorphism and Artistic Interpretation be removed from 3D animated prehistoric visualisations and still be captivating to the public?"***

This question can be best broken down into the following series of smaller questions:

- What is anthropomorphism and why is it employed as a filmmaking tool?
- What is the history of animated prehistoric visualisations?
- Are animated prehistoric visualisations prone to anthropomorphism and other unscientific influences?
- Do wildlife documentary filmmakers employ anthropomorphism or other narrative tools that may misrepresent nature?
- Can industry standard 3D software recreate photorealistic creatures from New Zealand's past based purely on scientific evidence?
- Would these scientifically derived visualisations be useful as a means of educating the public about prehistoric life?

1.3 Significance of Research Conducted

Humanity has an enduring fascination with the past and the fascinating creatures which existed therein.

Every year scientific papers are published by researchers studying prehistoric life which give an increasingly clear image of prehistoric ecosystems and the way which these changing epochs shaped the world we live in currently.

This research not only identifies extinct life which was diverse and in many cases remarkably different from current creatures, but also gives context to our own species' rise and place amongst the order of life on our planet.

Understanding the trials of life, its evolution to survive in the face of changing adversity, and comprehending that extinction is a reality and survival not a certainty is an educating and humbling experience for a species such as ours.

The rise of complex life on our planet is a heritage which our entire species shares, and so becomes an important unifying concept to a species divided by cultural, religious and historical differences.

Since the public exhibitions of fossils, skeletons and sculptures of extinct animals in the late 19th century the public has held a strong fascination with prehistoric life.

Prehistoric visualisations in the moving image have been popular and enduring subject matter since the early days of cinema. From the early days of animation which produced *Gertie the Dinosaur* to the modern cinema blockbusters like *Jurassic World* filmmakers and animators have found moving prehistoric visualisations to be popular subject matter.

This has extended into documentary film as well, with animated prehistoric visualisations making a frequent appearance as an effective means of communicating information about the prehistoric world.

In spite of the increasing scientific evidence many visualisations in cinema and documentary filmmaking misrepresent prehistoric life in order to make the subject matter more dramatic and exciting.

The public have a strong fascination with contemporary living animals, and the popularity of wildlife filmmaking, wildlife photography and documentaries dealing with animals send a strong message that prehistoric visualisations could be as captivating without the misrepresentation of evidence and trappings of constructs such as drama and anthropomorphism.

Considering that this would educate the public about the reality of the shared heritage of life on our planet, the investigation into whether a scientifically driven animated visualisation of prehistoric life could be realistic and yet still useful as an educational medium warrants further investigation.

New Zealand prehistoric life from the Late Cretaceous period has not been visualised in a photorealistic animated manner to this date.

Whilst this has been accomplished with creatures such as the Moa by Media Design School students this technology has yet to be implemented with ancient extinct reptiles from New Zealand.

On numerous occasions I have encountered adults and children in New Zealand who are unaware that New Zealand had prehistoric reptiles and dinosaurs, but when asking these same individuals if they were aware of American species such as the *Triceratops* or *Tyrannosaurus Rex* all of them were aware of those species.

The opportunity to be the first to visualise the remarkable creatures of ancient New Zealand and in so doing educate the New Zealand public about their own heritage using modern technology definitely warrants further research.

The strongly positive reaction from New Zealand palaeontologists (such as the researchers at GNS Science in Wellington who are a Crown Institute and hold the national fossil collection) is a strong indication that the visualisation of New Zealand's remarkable extinct creatures is due to be researched.

1.4 Summary of Contributions to Existing Knowledge

This project represents several contributions to existing knowledge.

Firstly it is the first time in which animated photorealistic visualisations of these two extinct marine species have been attempted. These visualisations have not been driven by aesthetic choices, but have been based on evidence from researchers and use comparative extinct and living creatures to recreate an objective visualisation.

Working with New Zealand palaeontologists, scanned fossil data, published scientific research and research from modern comparative creatures has allowed for a visualisation based on a methodology of transparent evidence-based conclusions.

More contributions to existing knowledge stem from the fact that this is the first time recent palaeontological discoveries have been incorporated into an animated visualisation which dramatically change the way experts believe marine reptiles known as mosasaurs looked and moved.

A remarkable fossil of a mosasaur was discovered in 2011 in Jordan which amazingly had an imprint of the soft flesh of its body. This astonished researchers as it showed mosasaurs had lobed tails similar to a sharks, and dispelled previous ideas that they had straight tails like a crocodile. This allowed for my visualisation to be the first animated photorealistic depiction of a mosasaur to incorporate this physical detail.

The lobed tail discovery also changed the way researchers believe the mosasaurs moved and allowed for another new contribution to existing knowledge.

Instead of swimming like a crocodile with a straight tail, experts believe they swam like a shark which has a very similar tail. This allowed for the animation of the visualisation conducted to be the first which matched the swimming patterns of recorded footage of not only sharks, but also of crocodiles in order to give the palaeontologists visual comparisons of the two different swimming styles.

Another contribution to existing knowledge stems from recent fossil discoveries which have been implemented into the visualisation.

The coloration and patterning of long extinct creatures such as dinosaurs has long been speculative due to the absence of evidence. This has changed in recent years as microscopic studies of the strata in which some fossils have been found has shown that fossilised melanin patterns still exist. This has provided evidence that marine reptiles such as the mosasaurs exhibited colouration known as countershading, which is a common feature among marine creatures today in which the upper surfaces of an animal are darker than the white lower surfaces. Newly published research specifically discussing this feature in Late Cretaceous marine reptiles (including the mosasaurs) has been incorporated into the mosasaur visualisation giving the first opportunity for this evidence to be included in a visualisation of this marine species.

A further contribution to existing knowledge comes from the development of a new technique which for the first time actually took images of the scales of mosasaurs and used it to directly sculpt and texture the surface of the 3D model to create scale details.
This meant a further removal of the influence of the digital artist as the scales of an actual mosasaur were being used to create the scales on the digital model.

1.5 Thesis Structure

The thesis contains six sections, Literature Review, Methodology, Results, Discussion, Conclusion and References. These six sections are broken down into the following subsections:

1.5.1 Literature Review

This section explores specific iconic prehistoric visualisations in the history of the moving image, their accuracy and examples of anthropomorphism, sensationalism and overdramatised depictions as well as the impact of improving technology on the visualisations.

Pioneering prehistoric visualisations in cinema and their treatment of the animals are analysed and cover visualisations through the following eras:

- The first stop motion and hand drawn animated visualisations in the early part of the 20^{th} century during the period in which stop motion and hand drawn animation processes were invented.
- Hollywood depictions of prehistoric life in film during the stop motion monster film eras of the 1930s and 1950s.
- Prehistoric visualisations in hand drawn animations of the 1940's Disney era upward to the Don Bluth era of the 1980s.
- The impact of computer generated imagery on prehistoric animal depictions in cinema from the 1993's *Jurassic Park* up until *Jurassic World* (2015).

Animated visualisations are then analysed in a documentary that covers:

- The integration of modern animation technologies in documentaries.
- Artificial documentary constructions.
- Theory regarding documentary and wildlife filmmaking and anthropomorphism in wildlife and documentary film.
- Documentary visualisations that contain animated prehistoric creatures related to New Zealand species are then evaluated in terms of accuracy, anthropomorphism and sensationalised content.

The final section of the literature review contains relevant scientific research in order to complete a scientifically accurate visualisation of selected New Zealand prehistoric life. This covers:

- Published research from palaeontologists covering New Zealand's prehistoric life
- Published research from international researchers of closely related international species.
- Visualisations from credited paleoartists.
- Data collected from modern comparative species
- Data collected from research trips to scientific institutions, museums and aquariums.
- Data collected from my personal fossil collection.

1.5.2 Methodology

The methodology lays out the process of constructing a visualisation that is not driven by aesthetic or artistic interpretations, but rather is focussed on using scientific evidence and published peer reviewed data to create a scientifically accurate prehistoric visualisation.

1.5.3 Results

The results section examines the implementation of the methodology in the project, and covers the creature selection process, creature concept development, modelling and texturing of the creatures, animation of the creatures, the cinematography and finally the editing of the animated clips.

1.5.4 Discussion

In this section a critical analysis of the work takes place, with reflections from the creator and from scientific specialists.

Feedback from institutions that are formally engaged with transmitting the scientific reality of prehistoric creatures to the public are analysed as a determination of the effectiveness of the overall project.

Positive and negative aspects of the work are discussed, and recommendations made for improvements of the process for future prehistoric visualisation projects.

1.5.5 Conclusion

The conclusion reflects upon the impact of artistic and aesthetic driven motivations on prehistoric visualisations, and the merits and shortfalls of a scientifically driven approach to reconstructions.

1.5.6 References

Bibliography of references formatted in the Chicago formatting style.

2. Literature Review

2.1 Anthropomorphism as a Documentary Construct

Anthropomorphism, or the projection of human attributes on nonhuman objects or animals, may seem avoidable in the nature and prehistoric documentary filmmaking process, but as Elliot (2001) concludes that since the subject matter is being created by humans for human cultures means that it is inescapable.[1]

He goes on to say that the moving image and photographic signs are by nature anthropomorphic, due to the relationship between sign, object and interpretant. Elliot (2001) states that not only does this apply to all documentary film, but also to the scientific papers documentaries base their information on, making the construct of anthropomorphism unavoidable.

This inescapable nature is interesting to note in context of anthropomorphism as being considered an emotional tool, a form of manipulation open to biases best avoided by serious documentary filmmakers who would like to claim an air of respectability.[2][3]

[1] Elliot, "Signs of Anthropomorphism."
[2] Horak, "Wildlife Documentaries."
[3] Porter, "Engaging the Animal in the Moving Image."

This consideration shows that documentary filmmakers are aware that anthropomorphism is inaccurate and misleading but may be tempted to use this device regardless as a tactic to engage the viewer. Being conscious of the inescapable danger of anthropomorphic contamination should raise the vigilance in spotting and removing anthropomorphism; it should not be accepted and ignored as an inherent risk.

As Porter (2006) notes viewers can become emotionally attached to characters and animals, sympathising with their losses and fearing for their safety during sequences of peril.
This spectator engagement with nonhuman animal characters can often lead to misconstrued communication, unrealistic and artificial human cultural constructs being projected onto subject matter leading to incorrect understandings of scientific material, historical events and thereby posing a danger of misleading the viewer.[4]
This directly relates to the subject of prehistoric visualisations as these artificial human constructs can be projected onto the behaviours of prehistoric creatures.

Without a living example of a creature to study and compare behaviours to, documentary filmmakers are more likely to attempt to engage the viewer with the visualised creatures by purposefully connecting our cultural behaviours to speculative visualised behaviours.
Whilst potentially effective as a communication strategy, viewers can develop an incorrect understanding of prehistoric creatures when their behaviours are interpreted through human cultural and emotional constructs.

Overlaying important fundamental archetypes such as family based constructs, strong emotional motivations, aspirations and sentimentality serves to humanise these creatures to

[4] Ibid.

create a bond with a human audience, but in so doing misleads the audience into believing that there are sentimental and personal forces at work in Nature which do not exist.

If the public wish to understand our link to nature and our relationship to the natural past which created us, it is critical that filmmakers strive for an accurate understanding by the viewer of the natural world past and present.

As Horak (2006) notes viewers perceive documentary as an example of fact, an expansion of human vision.

An extension of the physical body of the viewer through the barriers of space and time.[5] As such viewers believe and trust in that iconic nature of that experience[6] which can lead to situations where the viewer may believe a particular aspect to be fact when it is conjecture or artistic liberty.

This is a particular concern when considering the subjective and inherently anthropomorphic nature of documentary[7] and the potential for biases toward human culture as noted by Elliot (2001).

Horak goes on to note that the anthropomorphic nature of documentaries explains the use of particular narrative conventions derived from human culture.[8]

[5] Horak, "Wildlife Documentaries."
[6] Ibid.
[7] Elliot, "Signs of Anthropomorphism."
[8] Horak, "Wildlife Documentaries."

2.2 Pioneering Prehistoric Visualisations in Cinema

2.2.1 1900 – 1980

Gertie the Dinosaur (1914) by pioneering animator and cartoonist Winsor McCay is one of the first animated films ever produced and features a prehistoric visualisation of a dinosaur[9]. After the success of an earlier work of McCay's, the 1912 film *How a Mosquito Operates*, he chose for his next film a prehistoric visualisation.

He chose an extinct creature to challenge a common understanding of the inability to glimpse the past. He felt it was possible to see what people accepted was never to be seen, with the innovative use of new paper animation technologies[10].

Elliot (2001) notes it is iconic, not only because it is the first animated visualisation of a dinosaur, but also because it strongly favours anthropomorphism over a realistic approach to entertain the audience[11].

McCay promoted his film as an educational work, but in the execution took strongly to a vaudeville style intended to amuse and entertain[12].

Along with the comedy showmanship from vaudeville he also adopted some traits of a Barnum and Bailey circus show. Where, as a ringmaster with a whip, he commanded the beast to in front of a paying audience seeking an entertaining spectacle.

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[9] Baker, "Early Incarnations."
[10] Elliot, "Signs of Anthropomorphism."
[11] Ibid.
[12] Ibid.

The film also pioneered a narrative that has been incorporated into many documentary films in which the earlier part of the film takes place in a natural history museum examining the skeleton of a dinosaur before moving onto the visualisations[13].

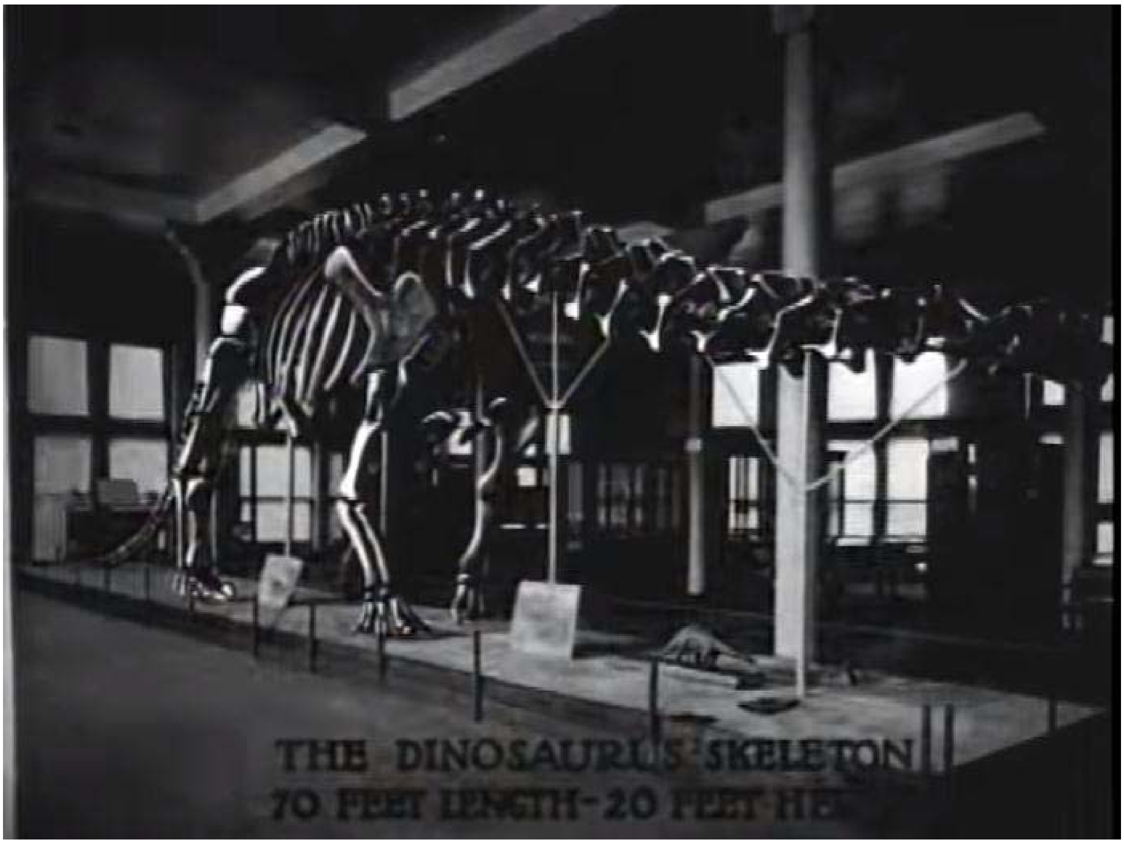

Figure 1 - A still from Gertie the Dinosaur *(1914) showing a mislabelled* Apatosaurus *skeleton.*[14]

The segment showing the visit to the museum and the skeleton of the Brontosaurus raises an example of an opportunity to educate the public, which was ignored.

As seen in the image itself the museum had information on placards below the skeleton, and even a small sculpture showing a life reconstruction.

In spite of this, and the visible evidence in the frame, McCay presented incorrect information on the lettering on the film, labelling the *Brontosaurus* skeleton as "The Dinosaurus

[13] Nathan and Crafton, "The Making and Re-Making of Winsor McCay's Gertie (1914)."
[14] McCay, *Gertie the Dinosaur (1914) - World's 1st Keyframe Animation Cartoon - Winsor McCay*.

Skeleton" with dimensions below it. For a filmmaker who intended to create an educational film his opportunity here was wasted. He had seen the correct information but had presented information that was not only oversimplified but also incorrect in spelling. He should have labelled it a dinosaur skeleton instead of a dinosaurus skeleton.

An interesting technical innovation demonstrated in this work is the way in which McCay broke the fourth wall by incorporating himself into the film as an animated character existing alongside and interacting with the dinosaur in the latter parts of the film. The circus-like atmosphere of McCay, with a ringmasters whip giving Gertie commands to obey, strongly identifies it with Barnum and Bailey circus acts where audiences went to see lion tamers giving commands to wild animals in the same spectacular manner.

In the article *Early Incarnations: Gertie the Dinosaur* Chris Baker discusses how *Gertie the Dinosaur* (1914)[15] was a technically revolutionary film and the first animated prehistoric visualisation[16] and pioneered many animation and special effects techniques in film.
Many pioneering visual effects are demonstrated in this film, such as the interaction of a living actor with an animated character, the substitution of the actor with an animated double and breaking the fourth wall with the actor.[17]

Baker goes on to discuss more subtle innovative animation techniques which gave the prehistoric visualisation more believability, such as a simulated muscle system beneath the

[15] Nathan and Crafton, "The Making and Re-Making of Winsor McCay's Gertie (1914)."
[16] "Dinos - My First Love Love Them or Loathe Them, Hollywood Can't Ignore Them. Edward Power Remembers His Boyhood Obsession with Dinosaurs and Looks Back Fondly at the Classic Dino Movies, Gertie the Dinosaur, King Kong and Jurassic Park."
[17] Baker, "Early Incarnations."

skin[18] her stomach becoming distended when drinking prodigious amounts of water[19] and objects receding into the distance when thrown with force[20].

However David L Nathan and Donald Crafton in their article chronicling the original creation and restoration of *Gertie the Dinosaur* reflect on many aspects of the film that are very scientifically inaccurate, for example that Gertie is not a single species but an amalgamation of many unspecified ones[21], behaves not as a large reptile but more as a "curious puppy"[22], obeys instructions from McCay to perform circus animal tricks[23], co-exists with creatures of other epochs such as the *Mastodon*[24], and performs impossible tasks such as drinking a lake dry[25].

Figure 2 - Gertie interacts with a species which would only exist 60 million years after her extinction.[26]

[18] Ibid.
[19] Ibid.
[20] Ibid.
[21] Nathan and Crafton, "The Making and Re-Making of Winsor McCay's Gertie (1914)."
[22] Ibid.
[23] Ibid.
[24] Baker, "Early Incarnations."
[25] Ibid.
[26] McCay, *Gertie the Dinosaur (1914) - World's 1st Keyframe Animation Cartoon - Winsor McCay*.

McCay would have known the mastodon never co-existed with dinosaurs, but again the temptation to entertain overrode the desire to educate.

Though McCay may have originally intended for his film to have an educational purpose, ultimately he strongly engineered the film to use tried and tested vaudeville techniques to thrill and entertain an audience.

His desire to show people something alive from the past ultimately came second best to his desire for effective showmanship. Whilst the film is undoubtedly entertaining, it does not give an accurate depiction of this creature or even a specific species. When critiqued on its merits as a prehistoric visualisation it does more harm to confuse the public than educate them.

Winsor McCay was by no means alone in this. Only one year later pioneering stop motion animator Willis O'Brien completed his short film *The Dinosaur and the Missing Link – A Prehistoric Tragedy* (1915)[27].

The film is very similar to *Gertie the Dinosaur* in how the past is misrepresented, and an emphasis is placed on entertainment over education. As the title suggests, there is a mix of species that would never have occurred simultaneously: early man and hominid co-existing with a dinosaur from at least 65 million years previous. The plot is human centred, with anthropomorphised prehistoric creatures, particularly the hominid ape-man, a mischievous character who went by the name "Wild Willie".

[27] Willis O'Brien, *Willis H O'Brien's THE DINOSAUR AND THE MISSING LINK - A Prehistoric Tragedy (1915)*.

Figure 3 - "Wild Willie" the ape-man nibbles on a dinosaur tail in this still from film The Dinosaur and the Missing Link – A Prehistoric Tragedy *(1915)*[28].

In fairness to both McCay and O'Brien, neither had ever claimed to be passionate educators, but rather entertainers or artists.

The emphasis placed on entertainment is entirely understandable when considering the financial risk of gambling on an early technology such as animation, and the drive to secure an entertaining and profitable film in order to fund the next project would have been an overriding concern to both men.

Regardless, the opportunity to entertain *and* educate was there and not seized upon.

[28] Ibid.

The development of stop-motion animation enabled Willis O'Brien to improve the quality of his animations, utilising this technique in later films such as *The Ghost of Slumber Mountain* (1918), *The Lost World* (1925) and *King Kong* (1933).

All of these films feature animated visualisations of prehistoric life which are designed to be impressive spectacles of entertainment rather than scientifically accurate. In spite of this O'Brien did in fact do his research and presented many actual species. In the 1933 adventure film *King Kong*[29], several visualisations of various types of prehistoric creatures are featured from dinosaurs such as *Stegosaurus* and *Elasmosaurus*, to the flying reptile *Pteranodon*. These presentations, though archaic, do not suffer from the trappings of anthropomorphism. The dinosaurs behave very much as the scientists of the time believed they did. Gone was the dancing for treats approach McCay used in Gertie a decade earlier[30].

The success of O'Brien's later films due largely to the spectacle of animated beasts is encouraging as proof that prehistoric creatures could behave as animals, and not have to suffer the anthropomorphism which was dominating classical animation.

The very successful implementation of stop motion animation in prehistoric visualisations in *King Kong* inspired later iconic animators such as Ray Harryhausen to utilise it for films such as 1953's *The Beast From 20,000 Fathoms*[31] which was part of the popular wave of "creature features" of the 1950s, and features a large fictional prehistoric reptile causing widespread destruction in the United States.

[29] "Dinos - My First Love Love Them or Loathe Them, Hollywood Can't Ignore Them. Edward Power Remembers His Boyhood Obsession with Dinosaurs and Looks Back Fondly at the Classic Dino Movies, Gertie the Dinosaur, King Kong and Jurassic Park."
[30] Ibid.
[31] Hayes, "Harryhausen Marvels at Ascendancy of F/x."

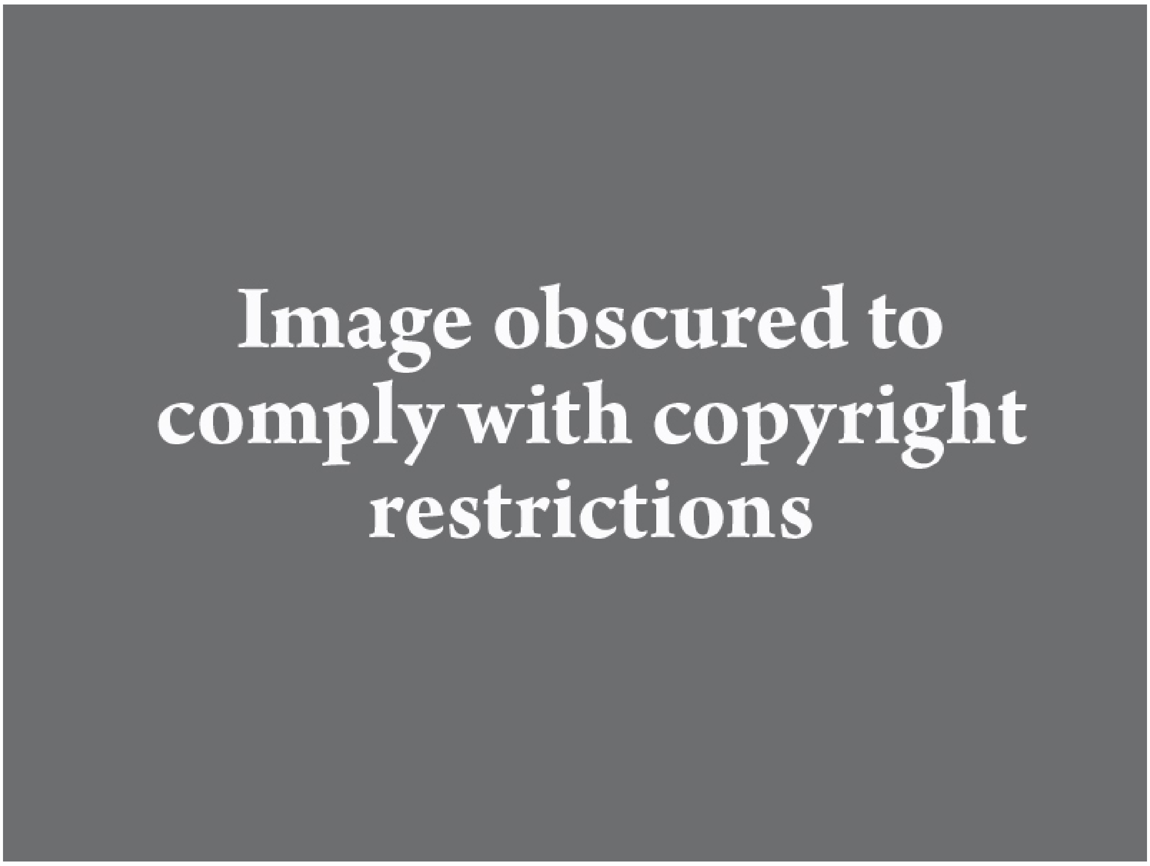

Figure 4 - Ray Harryhausen designed and animated the creature from Beast From 20,000 Fathoms *(1953)*[32]

Harryhausen was strongly influenced by O'Brien's work, and took a similar approach of animating creatures in a realistic manner, even if the creatures themselves were outlandish. These principles gave the creatures a believability, and allowed them to be superimposed opposite live action characters without them standing out as obviously unrealistic[33].

Traditional hand drawn animation also made steady improvements over the intervening decades since *Gertie the Dinosaur*, as is evident in the much lauded 1940 Walt Disney production *Fantasia*[34], which contained a sequence dealing with the rise of life, age of reptiles and final extinction of the dinosaurs.

[32] Harryhausen, "Beast From 20,000 Fathoms."
[33] Hayes, "Harryhausen Marvels at Ascendancy of F/x."
[34] "Fantasia, Review."

To this day it stands as an astounding cinematic sequence and notably brave in confronting a conservative and creationist-orientated 1940's America.

There was no 'Garden of Eden' in Disney's vision of the past, where life was created in a violent cauldron of earth's titanic forces. The diversity of life faced adversity.

The sequence itself faced adversity from creationists, who promised to make trouble if an earlier version had been made, which was to show the evolution of man and discovery of fire.[35]

Disney was determined to be as scientifically accurate as possible, and so asked some of the leading scientific specialists in their field to work closely with the animation team.

Palaeontologists Roy Chapman Andrews and Barnum Brown, biologist Julian Huxley and astronomer Edwin Hubble[36] acted as consultants and advisors, along with support from the American Museum of Natural History[37].

The animators studied the movements of actual reptiles that were brought into the film studio such as a herd of iguanas and a baby alligator.[38]

The result is a dramatic piece which derives tension, spectacle, and emotion through a closer depiction of reality than one driven by anthropomorphism.

The creatures moved with a realistic pacing and weight, and in some instances were so well researched and implemented that to this day their locomotion would still be counted as an accurate representation. The ostrich like *Struthiomimus* (the name incidentally means ostrich mimic) is animated so well that when the same species was shown in *Jurassic Park*

53 years later they moved in exactly the same way.

[35] Culhane, *Walt Disney's Fantasia*.
[36] Ibid.
[37] Ibid.
[38] Ibid.

Although Fantasia can be applauded for this admirably executed work there are a few instances were totally unrealistic anthropomorphism does rear its ugly head and unfortunately does detract from the strongly accurate approach.

Figure 5 - In Fantasia *(1940) some species such as* Struthiomimus *(left) are portrayed excellently. Unfortunately the* Tyrannosaurus rex *(right) is portrayed as a demonic monster.*[39]

The *Tyrannosaurus rex* is given the monster treatment, portrayed as an evil ravenous murderer from which there is no escape. The *T-rex* is given totally unrealistic glowing red eyes, and a bright red glowing mouth filled with teeth, which it never shuts.
It was definitely a design decision to portray it as a villain, an unnecessary approach since it is a natural predatory species merely performing its function in the ecosystem.
Another conscious design decision was to have the *T-rex* arrive during a terrifying lightning storm, an old cinematic cliché generally reserved for the most evil of villains. Needless to say that is an obvious artistic approach and entirely unrealistic, which makes its frequent use interesting. It is as if the audience must feel the villain's evil nature is so strongly, it is echoed in the forces of nature around them. It is interesting to note that the *Tyrannosaurus rex* in

[39] Disney, "Fantasia Struthiomimus."

1993's *Jurassic Park* would also make a dramatic first appearance during an identical lightning storm.

2.2.2 1980 – Present

Land Before Time was an animated hit in 1988 and was executive-produced by George Lucas in collaboration with Steven Spielberg, Kathleen Kennedy and Frank Marshall.[40]
It tells the story of five young dinosaurs of varying species who work together as friends to journey to a land of plenty. The five main characters of the film are anthropomorphised dinosaurs, and are a *Brontosaurus* named Littlefoot, Cera the *Triceratops*, Ducky the *Saurolophus*, Petrie the *Pteranodon* and Spike the *Stegosaurus*.[41]
The film was designed from the outset as an animated adventure for the whole family, with an emphasis on children. Using anthropomorphism intentionally along with other aspects such the dinosaurs talking and having human personalities, and characters who face peril but ultimately have a happy ending and learn life lessons on the way.
As a family orientated adventure it wouldn't be appropriate to criticise its use of anthropomorphism since this is the style of the genre.
If anything the film, by being a hit and amassing a large audience, did much to inspire interest in dinosaurs for small children. Though a children's fantasy the dinosaurs were faithfully designed after actual species and it no doubt helped some children to learn the different species by which character it represented.

[40] *The Land Before Time by Lucasfilm*.
[41] "The Land Before Time | Universal Pictures Entertainment Portal | Trailers, Bonus Features, Cast Photos, and More."

The fact that the names of the anthropomorphised characters were a shortened derivatives of the species name no doubt would also have aided younger viewers in retaining information about the creatures.

As mentioned before the film was a great hit, creating a franchise that extended to no less than thirteen direct to video sequels, a range of merchandise and a 2007 television series.[42]

Image obscured to comply with copyright restrictions

Figure 6 - The five main characters of Land Before Time *(1988) which became a multi-million dollar franchise.*

In a similar vein to *Fantasia* the *Tyrannosaurus rex* is portrayed as a monster, and in the beginning of the film kills the mother of the title character. The dinosaur characters refer to the carnivorous dinosaurs as a "Sharptooth" and although anthropomorphised do actually deal with aspects such as one species preying on another.

[42] Ibid.

For a movie intentionally aimed at small children the film makers could be commended for tackling the cycle of life and death, predation and subjects such as a failing ecosystem.

The 1993 blockbuster *Jurassic Park*[43] made use of puppets and 3D computer generated dinosaurs for its visualisations,

Carol Cling reflects on how the special effects have completely overwhelmed the characters and story of *Jurassic Park* (1993)[44]. Cling describes *Jurassic Park* as a film adaptation of the Michael Crichton novel of the same name in which eccentric billionaire funds the bioengineering of dinosaurs as a theme park attraction that breaks down causing chaos[45]. When discussing the special effects Cling states that the film features extensive special effects sequences in which the ingeniously realised dinosaurs emerge as the movie's true stars[46]. Jay Stone in a review article on *Jurassic Park* discusses many aspects of the anthropomorphism of the prehistoric visualisations, crediting the dinosaurs as the protagonists of the film and reflecting on how they were anthropomorphised and given personalities[47] such as the ailing *Triceratops* and the *Tyrannosaurus rex* which according to special effects pioneer Stan Winston "acted its ass off"[48]. Digital special effects companies such as Industrial Light and Magic, and Digital Domain worked closely with the actors to make the interactions between cast and dinosaurs as immersive and dynamic as possible[49] whilst animatronic puppeteers under supervision of Stan Winston offered physical interaction possibilities[50]. Whilst the prehistoric visualisations are landmark and revolutionary,

[43] Stone, "Jurassic Park Special Effects Revolutionary; Spielberg Classic out in 3D Friday," April 4, 2013.
[44] Cling, "Special Effects Overwhelm `Jurassic Park' Story."
[45] Ibid.
[46] Ibid.
[47] Stone, "Jurassic Park Special Effects Revolutionary; Spielberg Classic out in 3D Friday," April 4, 2013.
[48] Ibid.
[49] Ibid.
[50] Ibid.

unfortunately some critics regard the special effects as covering a weak tale[51], or widely dismissed as celluloid froth[52]. Frank Scheck in a review article titled *Dinosaurs Alive* documents an American Museum of Natural History video exhibition, and does mention some of the scientific inaccuracies due to the contemporary understanding of the creatures, such as the *Velociraptors* not having feathers which more recent evidence suggests was the case[53].

Further criticism of the prehistoric visualisation of the *Velociraptor* was mentioned in the article by Renee Clary and James Wandersee titled *DINOVIZ Exploring the History and Nature of Science Through the Progression of Dinosaur Visualisation* where they note that although the dinosaurs look lifelike, new research indicates that they were not nearly as large as portrayed in the movie *Jurassic Park* and that that they were covered in feathers[54]. Their article also is of interest as they discuss how prehistoric visualisations are often produced concurrently with scientific research, and therefore become a visual history of our understanding of the prehistoric world.

It is worthy of noting at this point that the criticism from the scientific community objected to the representation of aspects of some of the creatures, but not the behaviour. Whilst the creatures may not have looked accurate they behaved in an accurate manner, meaning the anthropomorphism if present was kept low key enough to not be an overriding concern. This can be seen in some points in the film, such as the sequence in which the *Velociraptors* hunt the children in the kitchen.

[51] Cling, "Special Effects Overwhelm `Jurassic Park' Story."
[52] "Dinos - My First Love Love Them or Loathe Them, Hollywood Can't Ignore Them. Edward Power Remembers His Boyhood Obsession with Dinosaurs and Looks Back Fondly at the Classic Dino Movies, Gertie the Dinosaur, King Kong and Jurassic Park."
[53] Scheck, "Dinosaurs Alive."
[54] Clary and Wandersee, "DINOVIZ."

Steven Spielberg realised that the creatures themselves and their actual behaviour was dramatic and fascinating enough to keep the plot moving.

So when the *Velociraptors* are stalking the children, the tension is sharp and intense because they are incredibly proficient hunters and therefore difficult to elude and outwit.[55]

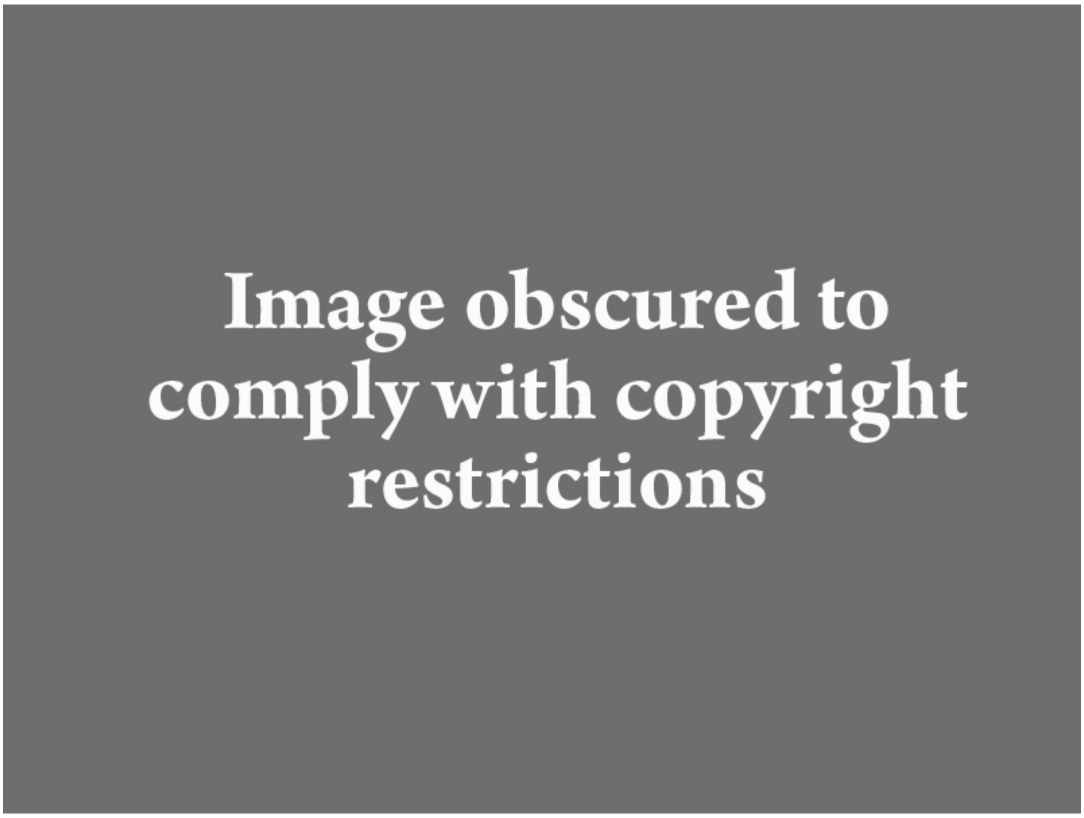

Figure 7 - The Velociraptors *in 1993's* Jurassic Park *stalking the children in the kitchen.*[56][57]

The film can be commended for showcasing them as animals out of their time and place, although there are some instances of overdramatic sensationalism.

One such occurrence is the dramatic thunderstorm announcing the arrival of the T-rex in a similar vein to the arrival of the *T-rex* in Fantasia. As if the thunder and lightning wasn't

[55] Stone, "Jurassic Park Special Effects Revolutionary; Spielberg Classic out in 3D Friday," April 4, 2013.
[56] Spielberg, "Jurassic Park."
[57] Stone, "Jurassic Park Special Effects Revolutionary; Spielberg Classic out in 3D Friday," April 4, 2013.

enough to clearly label the *T-rex* as a threat it is also accompanied by the now iconic shot of ripples in a glass of water as the footsteps boom out of the torrential rain.

The suspenseful entrance is then broken with a violent shock as the mutilated limb of a goat falls on the sunroof of the tour vehicle. Whilst the film may not be anthropomorphising the dinosaurs as human characters, there certainly does seem to be an agenda to portray the *Tyrannosaurus rex* here as a monster.[58]

By 2000 technology had moved on from the puppetry and CGI animated mix that had produced the dinosaurs of *Jurassic Park*.

Computer generated imagery and 3D animation had now allowed for photorealistic characters that could be integrated seamlessly into real filmed locations[59].

Disney had bandied around the idea of producing a feature length dinosaur themed family adventure, a project that culminated in the film *Dinosaur* (2000)[60].

The film shares many similarities with *Land Before Time*, with a small group of friendly prehistoric animals that work together to journey to a promised land[61]. The creatures talk and are anthropomorphic in the way they act, although they are anatomically correct and rendered photo realistically.

The decision to produce a film with animated characters that look entirely realistic in actual filmed locations was met with a negative reception by reviewers.

Renowned film and television critic Roger Ebert found the mix of photorealistic dinosaurs and anthropomorphism to be disconcerting in his review article entitled *Animation in*

[58] Ibid.

[59] "Movie Review."

[60] Ibid.

[61] Writer, "Disney's Dinosaur-Amazing Animation, Ancient Plot."

Dinosaur a sign of wonder to come of Disney's 2000 film *Dinosaur*. Ebert discusses our species determination to project our behaviourisms on other species and laments the amount of effort to construct a realistic illusion, which greater effort is then spent to undermine[62] through unscientific anthropomorphism and entertainment constructions.

Michael Janusonis in *Disney's Dinosaur – Amazing animation, ancient plot* voices similar criticism to Roger Ebert, noting a similar moment of disappointment when the illusion of the photorealistic natural world and creatures in the film *Dinosaur* is ruined when they start speaking, an obvious and unnecessary anthropomorphism. As he notes in the article "*Dinosaur's* prehistoric characters are beautifully believable that is, until they start talking" (Janusonis, 2000)[63].

Conservative Christian audiences were urged not to view the film as it apparently had an undertone of Darwinism[64]. The mix of dinosaur characters which are slowly dying out and small lemur-like primates which were thriving in the changing environment certainly was illustrating the rise of mammals.
A conservative reviewer noted that because the creatures were presented in a photo realistic manner the violence was as a result graphic and not suitable for small children[65].

Technology saw breakthroughs in the field of motion captured performances, which allowed Peter Jackson to utilise these new tools for his remake of *King Kong* in 2005[66].

[62] Ebert, "Animation in Dinosaur Sign of Wonder to Come."
[63] Writer, "Disney's Dinosaur-Amazing Animation, Ancient Plot."
[64] "Movie Review."
[65] Ibid.
[66] "Kong Captures Actor."

Motion capture now allowed for capture of facial acting, which allowed actors such as Andy Serkis the ability to give a more convincing performance as Kong[67].

Serkis and the animation team studied the movements of primates in zoos and with film reference material in order to give a convincing performance of the giant gorilla[68].

Human and gorilla faces are alike enough to allow Serkis to give the intricacies of Kong's facial expressions[69].

Christian Rivers the animation director on King Kong noted "A lot of the similarities are in the face and the eyes"[70] which was a direct result of the success of the facial motion capture innovations.

> "Gorillas have such a similar looking set of eyes and brows, you can look at those expressions and transpose your own interpretation of them."
>
> Christian Rivers, Animation Director[71]

Andy Serkis trained himself to mimic the behaviour of these apes, and so was able to remove the natural anthropomorphism of a human performance, and replace it with more believable ape behaviour. One part of the face that did not work for facial capture was the muzzle, as this is a feature very different in humans. Andy Serkis was required to put on 135 facial motion capture markers, which took over two hours each day[72].

For the full body performance animators used the motion capture data and video as a reference piece[73] since the anatomy of a gorilla differs from human anatomy.

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67 Ibid.
68 Ibid.
69 Ibid.
70 Ibid.
71 Ibid.
72 Ibid.
73 Ibid.

The resulting visualisation was really successful and earned the animation team a Visual Effects Academy Award.

The 2005 remake of King Kong contained an array of prehistoric creatures and dinosaurs. Although these are dinosaurs they technically are not prehistoric visualisations, since these are meant to be surviving descendants that have evolved over the intervening 65 million years[74].

The design team at Weta Workshop designed an array of wildlife to fill the ecosystem of Skull Island. Many of these designs were colourful and featured scientific discoveries that had been since the original 1933 film was made, such as the knowledge that many dinosaurs had feathers[75].

Richard Taylor co-founder and co-director of Weta Workshop in 2009 commented on the fact that the design team had pushed for more diverse colourful options, but were told by Peter Jackson to keep the dinosaurs dull and plain, much like the ones from the original film[76]. Whilst stylistic continuity between the films is understandable it would have been really interesting to have seen the new scientific informed dinosaur choices in the final film. It could have been seen as an opportunity to embrace new findings and in so doing bring more cultural awareness to the findings occurring in palaeontology.

The design team had certainly done much research on prehistoric life and had the completed designs ready to go[77].

The conscious decision was made to echo the scientific understanding of the 1930s and ignore the 75 years of research that had happened in the intervening time.

[74] Weta Workshop, *The World of Kong*.
[75] Ibid.
[76] Reynolds, Richard Taylor.
[77] Weta Workshop, *The World of Kong*.

It was a deliberate single decision that favoured aesthetics over cultural understanding of scientific findings.

The film shied away from anthropomorphism in how the dinosaurs behaved. They were presented as having a range of behaviours many of which were realistic.
However the large *Venatosaurus rex* did not act realistically. In one of the longest sequences on Skull Island three *V-rex* dinosaurs fight with Kong over the character of Ann Darrow.

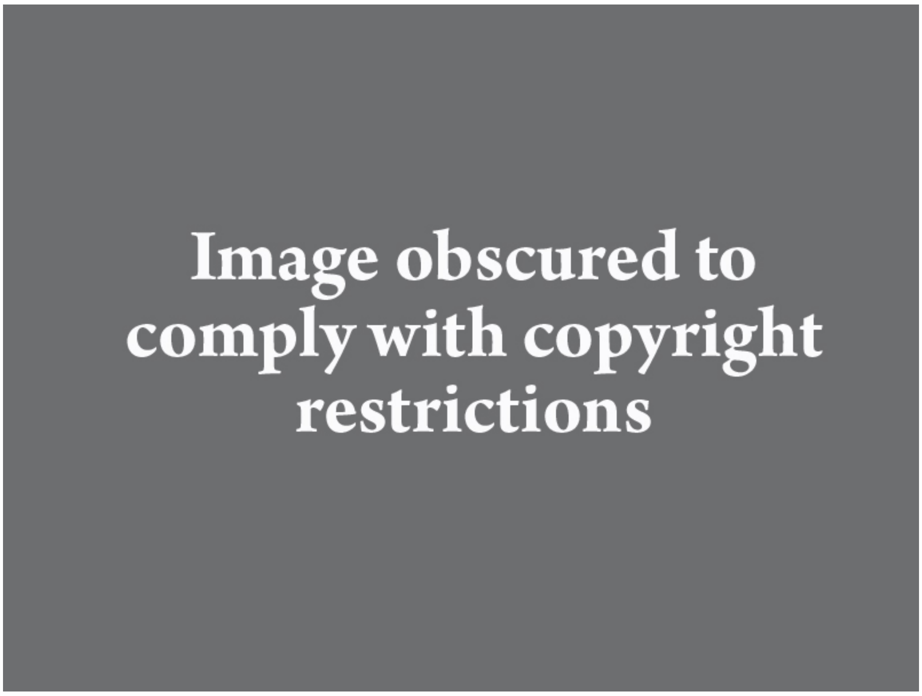

Figure 8 - In a scene from King Kong *(2005) a* V-rex *fights with Kong over the character Ann Darrow (Naomi Watts)*[78]

The behaviour of the large V-rex dinosaurs is unrealistic. When one first spots Ann it is eating another dinosaur and has already half swallowed it. The moment the dinosaur spots Ann though it begins to pursue her to eat her. In doing so it drops a tonne of meat to pursue the fifty-five kilograms of her. It is another case of a dinosaur being misrepresented as an

[78] Jackson, "King Kong (2005)."

insatiable killing machine. Large predatory dinosaurs were not monsters; they ate when hungry and fought to defend territory. The way they are portrayed in *King Kong* as monsters that pursue to kill and not to eat cheapens them and makes their behaviour unrealistic and illogical.

If Jackson had instead treated them as hungry predators the chase would have been written a little differently but the believability of the creatures as real animals with real motivations would have been easier.

Jurassic World[79] a 2015 blockbuster instalment of the *Jurassic Park* franchise drew much ire from the palaeontology community for upholding disproven and out-dated scientific theories about the prehistoric life featured, with palaeontologists such as Thomas R. Holtz of the University of Maryland complaining that whilst it was ground breaking for the original *Jurassic Park* to bring research of the 1980s to the audiences of the 1990s, the 2015 film has now made the decision to ignore more recent findings and once again bring the research of the 1980s to 2010s viewers[80].

One of the main examples being the fact that scientists have learned that dinosaurs even back to the earlier times had plumage of all styles and patterns, from long fully developed feathers to decorative plumes, wattles and insulating tufts.[81]

Regardless of this and to keep to the same stylistic continuity of the original film the dinosaurs are shown to be essentially bald, with either scaly reptilian skin or rough wrinkled elephantine style hides.[82]

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[79] Trevorrow, *Jurassic World*.
[80] Qiu, Vergano, and 2014, "'Jurassic World' Dinosaurs Stuck in the 1980s, Experts Grumble."
[81] Ibid.
[82] Ibid.

Whilst this is neatly explained away in the film by one of the characters representing a scientist as being a design aesthetic to please the park visitors'[83] preconceived notions of what these creatures should look like, it does represent a lost opportunity to a film franchise which in its original instalment was celebrated as pioneering dynamic visualisations of dinosaurs which captured the public's attention[84].

Other intentional deviations from current scientific understanding concern the *Velociraptors* being too large and holding an incorrect hand posture, whilst the marine mosasaur featured is far too large to ever have been real, and has been compared to a Boeing 747 in scale[85] whereas the actual creature would have been far smaller and sleeker. The mosasaur also featured a frill, which was an idea abandoned more than a decade ago[86] by the scientific community and would have been evident to the films creature designers as an outmoded concept.

These deviations from scientific findings could be accounted for by the park scientist's explanation of how these creatures are designed as a living spectacle to please crowds. However it still represents a lost opportunity to tell a story around amazing accurate creatures instead of simply explaining the opportunity away.

Ultimately the decision would have been an aesthetic choice by the producers to keep the dinosaurs on brand. A deliberate decision to adhere to a familiar style from the earlier film that was known to be scientifically incorrect.

This was a very similar decision to one discussed earlier in 2005's *King Kong* where the decision was made to keep the dinosaurs plain, reptilian and thus inaccurate.[87]

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[83] Trevorrow, *Jurassic World*.
[84] Qiu, Vergano, and 2014, "'Jurassic World' Dinosaurs Stuck in the 1980s, Experts Grumble."
[85] Ibid.
[86] Ibid.
[87] Reynolds, Richard Taylor.

2.3 Relevant Documentary Visualisations

2.3.1 Integration of Modern Animation Technologies in Documentaries

1993's *Jurassic Park* was a major international success and though fictional, heavily influenced the conception of the landmark BBC documentary series *Walking With Dinosaurs* (1999)[88] which was designed to be a fully immersive depiction of various epochs in the age of the dinosaurs.

Tim Haines the creator of *Walking With Dinosaurs* recalls the origination of the show in his blog titled *The Making of Walking With Dinosaurs*[89].
Haines was working as a TV producer at the BBC and knew they were looking for a new palaeontology based series idea. He suggested utilising the same visualisation technologies that had been demonstrated so successfully in *Jurassic Park*.[90]
This would feature a mix of animated creatures for full-motion shots and puppeteer operated heads and claws. This economic use of 3D animation allowed the production crew to produce the footage needed quicker and at a more reasonable price.
Haines vision was for a documentary series was one where the experience was immersive as well as spectacular and informative[91].

As Haines notes he was faced with a dilemma with regards to affordable special effects. *Jurassic Park* was made on a feature film budget and had nine minutes of dinosaurs in it[92].

[88] Scott and White, "Unnatural History?"
[89] Haines, "Walking with Dinosaurs - The Making Of."
[90] Ibid.
[91] Ibid.
[92] Ibid.

The project he was hoping to develop needed three hours of footage in order to produce six thirty minute episodes[93].

With the help of visual effects expert Mike Milne economic and creative decisions were made which made the endeavour affordable[94]. Due to the limited budget and high cost of photorealistic animation many of the close ups would be filmed puppeteers with animatronic heads, claws and even hatching baby animals.

Non-animated objects would be created as physical objects, so skulls, carcasses and shells would be made as props that would cut down the cost of compositing many objects into the hours of footage.

This mix of practical effects and 3D animation would utilise the best of both worlds and allow for the immersive prehistoric experience Haines had intended for[95].

Improvements in computer generated animation made later productions such as *Walking With Beasts* (2001)[96] and *Walking With Monsters* (2005)[97] possible without the use of puppetry for the close-ups of the creature's faces or hands.

The popularity of the series in conjunction with the rise of stereoscopic 3D cinema releases culminated in the 2013 film *Walking With Dinosaurs 3D*[98] as well as made for television stereoscopic 3D documentaries such as National Geographic's 1997 film *Sea Monsters A Prehistoric Adventure*[99].

[93] Ibid.
[94] Ibid.
[95] Ibid.
[96] Scott and White, "Unnatural History?"
[97] Ibid.
[98] Bousé, "Bring 'Em Back… Alive?"
[99] Anonymous, "E&S to Distribute National Geographic's Sea Monsters."

2.3.2 Artificial Documentary Constructions

Dingwall and Aldridge in *Television wildlife programming as a source of popular scientific information: a case study of evolution* point out that wildlife television documentary is a problematic genre due to its situation between entertainment and education.[100]

They note that strong social forces such as the continuing popular and political support for Intelligent Design Creationism impacts the dissemination of amoral evolutionary perspectives to the public.[101]
By bowing to the "pressures of a strong narrative"[102] the production often distances itself from standpoints that directly oppose creationism and "may even implicitly endorse them".[103]

Dingwall and Aldridge note that in the medium of television broadcasting wildlife television is surprisingly often regarded as "primarily a storytelling form"[104] which since its earliest days had to compete with high-budget entertainment focussed cinema and as a result "adopted the same narrative forms"[105].
They note that the domestic market in the United States "continued to demand drama, suspense and happy endings"[106] including "plenty of warmth and jeopardy"[107].

2.3.3 Critiques of Documentary Visualisations

[100] Dingwall and Aldridge, "Television Wildlife Programming as a Source of Popular Scientific Information."
[101] Ibid.
[102] Ibid.
[103] Ibid.
[104] Ibid.
[105] Ibid.
[106] Ibid.
[107] Ibid.

Karen D. Scott and Anne M. White in *Unnatural history? Deconstructing the Walking with Dinosaurs Phenomenon* address many of the pitfalls associated with producing a television series based on prehistoric visualisations. With regards to the critical reception from the scientific community they state that with BBC's release of *Walking with Dinosaurs* (1999)[108] effort was made to ensure scientific accuracy by consulting with seven palaeontologists and more than 100 other academic researchers in various fields[109][110]. The show was a huge success, becoming the most watched science program in British television history[111]. Unfortunately aspects such as conjecture and the anthropomorphism of the dinosaurs by giving them human names, emotions and motivations resulted in criticism, such as from Oxford University's Dr Paul Barrett who was one of the specialists consulted for the show who described it as a "lost opportunity" and a "dinosaur soap opera"[112].

Dr Derek Bousé in his work *Bring 'em Back…Alive? The BBC's Walking with Dinosaurs brings extinct species back to life – or something like it* addresses how even the producers of *Walking with Dinosaurs* acknowledged is speculative aspects, with Tim Haines admitting that in many cases they had pursued a course of "informed speculations" (Bousé, 2000) and Mike Milne confessing that they had to some extent generalised from contemporary animals[113].

Scientific criticism of prehistoric visualisation is discussed by Andrew Watson in an article he wrote for *Science* titled *TV Dinosaur Team Treads Tricky Mammalian Terrain* about the follow on series BBC produced *Walking with Beasts* (2001)[114] where in spite of a clearer

108 Scott and White, "Unnatural History?"
109 Ibid.
110 *The Making of Walking with Dinosaurs in HQ Part 1 - BBC.*
111 Scott and White, "Unnatural History?"
112 Ibid.
113 Bousé, "Bring 'Em Back... Alive?"
114 Watson, "TV Dinosaur Team Treads Tricky Mammalian Terrain."

fossil record[115] scientists remained uncomfortable about behavioural conjecture. An example of this is paleoanthropologist Leslie Aiello of University College London who was a consultant to the show and admitted she was uncomfortable with the shows tendency to drift into "paleofantasy" (Watson, 2001).

As discussed by Karen Moltenbrey in *Computer Graphics World* a more intentional exercise in paleofantasy or docu-fiction was evident in the 2006 ITV production *Prehistoric Park*[116] where a fictitious contemporary theme park is constructed and a theme park ranger travels through time to collect animals at various stages of earth's history. The depictions of prehistoric creatures were produced by the same company that did *Walking with Dinosaurs*[117], so suffered from the same shortcomings as mentioned above mixed with the entirely fictional human/dinosaur interactions and time travel[118].

(Dingwall) Examples of these considerations can be seen in wildlife television and documentaries featuring animated prehistoric visualisations such as the National Geographic film *Sea Monsters: A Prehistoric Adventure* (2007)[119] in which the focus of the documentary, a marine reptile known as *Dolichorhynchops* is anthropomorphised as the title character "Dolly" and goes through all the aforementioned trials and tribulations of drama, suspense, jeopardy and eventually a happy ending.[120] The young female *Dolichorhynchops* is addressed in affectionate colloquial terms[121] and portrayed in unscientific and non-reptilian behaviours displaying a playful nature[122] and goes through the dramatic build-up of peril when she firstly

[115] Ibid.
[116] Moltenbrey, "Dinosaur Dynamics."
[117] Ibid.
[118] Ibid.
[119] Macleod Phillips, *Sea Monsters: A Prehistoric Adventure*.
[120] Ibid.
[121] Ibid.
[122] Ibid.

loses her mother to a shark attack[123] and then her brother later on to a *Tylosaurus* attack.[124] The family friendly nature of wildlife television which Dingwall and Aldridge note as being ever present[125] in these documentaries is displayed in *Sea Monsters: A Prehistoric Adventure* (2007) by the sterilised nature in which the deaths of the brother and mother *Dolichorhynchops* are depicted: both are shown to be killed in silhouette at a distance and the unrealistically small amount of blood fades quickly and is coloured to be black rather than red.[126]

In the same manner as a cinema fiction, music plays a large part in setting the mood of the various sequences, with suspenseful music building tension as a predator approaches[127], fast paced action music during a chase and wistful dreamy music when exploring the magical underwater realm.[128]

The documentary features a drawn out happy ending[129] where the anthropomorphised "Dolly" not only lives to die peacefully in old age[130], but also has multitudes of offspring of her own which carry on her legacy[131] and fulfil her biological aspirations[132]. This message is an example of the narrative bowing to the considerations of family friendly "fairy-tale endings"[133] mentioned by Dingwall and Aldridge, and gives a false message of continuation and completeness of not only this individual creature's life but a false representation to the audience of the continuation of her species. This ultimately proves not only misleading but self-defeating since her entire species is ultimately doomed to extinction.

[123] Ibid.
[124] Ibid.
[125] Dingwall and Aldridge, "Television Wildlife Programming as a Source of Popular Scientific Information."
[126] Macleod Phillips, *Sea Monsters: A Prehistoric Adventure*.
[127] Ibid.
[128] Ibid.
[129] Ibid.
[130] Ibid.
[131] Ibid.
[132] Ibid.
[133] Dingwall and Aldridge, "Television Wildlife Programming as a Source of Popular Scientific Information."

Considering that palaeontologists develop a description of species such as *Dolichorhynchops* from multiple fossils or parts of fossils, the decision to focus on the life-cycle of a single individual leading to its happy ending as noted by Dingwall and Aldridge[134] is a misleading anthropomorphised construct. Events from various fossils (such as the shark tooth found in the *Dolichorhynchops* flipper in *Sea Monsters: A Prehistoric Adventure*[135]) are presented as occurring to one individual[136] and results in a blend of fact and fiction which Watson (2001) labelled "paleofantasy"[137].

The fictitious entertainment driven narratives described by Dingwall and Aldridge (2006)[138] recurs as a formula in the documentary series *Walking With Dinosaurs* (1999)[139] in the third episode *Cruel Sea*[140] which in the same fashion as *Sea Monsters: A Prehistoric Adventure*[141] traces the life of a single personified individual female marine reptile, in this instance a female *Opthalmosaurus*[142]. The formulaic depiction follows the storytelling narrative identified by Dingwall and Aldridge (2006)[143] and utilises the noted "drama, suspense and happy endings" (Dingwall and Aldridge, 2006) to the same effect. The newly born female *Opthalmosaurus* faces threats from the ever-present predators who are clearly cast as villains, before herself completing the character arc by ultimately giving birth to her own generation of offspring[144]. As in *Sea Monsters: A Prehistoric Adventure* the optimistic climax or "happy ending" is misleading, as the species is ultimately doomed to extinction. The decision by both series to anthropomorphise an individual and see that they live to fulfil their biological need

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134 Ibid.
135 Macleod Phillips, *Sea Monsters: A Prehistoric Adventure*.
136 Ibid.
137 Watson, "TV Dinosaur Team Treads Tricky Mammalian Terrain."
138 Dingwall and Aldridge, "Television Wildlife Programming as a Source of Popular Scientific Information."
139 Haines, *Walking with Dinosaurs*.
140 Ibid.
141 Macleod Phillips, *Sea Monsters: A Prehistoric Adventure*.
142 Haines, *Walking with Dinosaurs*.
143 Dingwall and Aldridge, "Television Wildlife Programming as a Source of Popular Scientific Information."
144 Haines, *Walking with Dinosaurs*.

to successfully procreate instead of dying unexpectedly through predation gives the audience the unrealistic impression of nature that so long as you are a "good" animal you will survive to see your happy ending.

In the same episode a large predator (*Liopleurodon*)[145] which through sensationalist terminology like "monster" and dramatic music is typecast as the villain ultimately experiences a fictional narrative style "comeuppance" by ultimately meeting a grim death expiring in the sun after being washed up after a storm[146]. This neatly parallels the grim fate experienced by the typecast villain *Tylosaurus* in *Sea Monsters: A Prehistoric Adventure* that has its neck broken during a territorial dispute with another tylosaurus[147] and sinks drowning being circled by sharks[148]. Not only is the audience seeing the unrealistic sensationalist demonization[149][150] of natural predators, but in the tradition of fictional narratives[151] the villains fail to kill the hero and meet an untimely end themselves.[152][153]

It is interesting to note that the typecast villain of this piece

Mega Beasts – T-Rex of the Deep (2010) is a documentary which features predominantly the *Tylosaurus*, which due to it being a close relative of the genera *Taniwhasaurus*, makes it exceedingly valuable as documentary treatment research material for any documentary style project on New Zealand's prehistoric sea reptiles.

The film begins the process of needlessly dramatic unscientific sensationalism in its very title: *Mega Beasts – T-Rex of the Deep*. The titles statement drawing a relationship between T-Rex's status as an apex land predator and *Tylosaurus'* apex marine predator status is a fair

145 Ibid.
146 Ibid.
147 Macleod Phillips, *Sea Monsters: A Prehistoric Adventure*.
148 Ibid.
149 Haines, *Walking with Dinosaurs*.
150 Macleod Phillips, *Sea Monsters: A Prehistoric Adventure*.
151 Dingwall and Aldridge, "Television Wildlife Programming as a Source of Popular Scientific Information."
152 Haines, *Walking with Dinosaurs*.
153 Macleod Phillips, *Sea Monsters: A Prehistoric Adventure*.

point, although it is also made for dramatic effect and to draw interest to the documentary from the general public as *Tyrannosaurus rex* is a very popular dinosaur and has a wide fan base and familiarity to the public. The first part of the title, "Mega Beasts" is far more problematic in its sensationalism. Describing a creature as a beast is unscientific, and harks back to times of far lesser understanding of the important role large predators carried in ecosystems. The term has many negative connotations: it was used in the Bible to describe an apocalyptic demonic entity which would be instrumental in the end of the world in the Book of Revelation, and was also used as a synonym for Satan when describing the mark of the beast which would be carried by the unsaved. Culturally the connotations were not flattering either. It was most commonly used as a term in agriculture to describe cattle, usually of a bovine nature. These were creatures seen as large and useful, but not intelligent or dynamic resulting in phrases such as "beast of burden" which is certainly not complimentary. In a more modern context it has continuing negative connotations, ranging from Disney's naming of the hulking monstrous character Beast in *Beauty and the Beast* (1991) to the Peter Benchley novel (and later miniseries) *The Beast*, a thriller in which a very unscientifically portrayed giant squid terrorises a seaside community. Peter Benchley is no stranger to unscientific demonisations of natural predators, as he earlier penned the bestseller *Jaws*, which did much damage to the reputation of sharks in the mind of the general public. Describing *Tylosaurus* as a "Mega Beast", although in some sense correct in that it is a large animal, is needlessly sensationalist and pushes the concept of this dynamic prehistoric creature more into the realms of penny-dreadfuls and Barnum and Bailey circus attractions.

This overdramatic sensationalism becomes obvious only 26 seconds into the documentary where the prehistoric oceans are described by the narrator as "cauldrons of violence", a really journalistic unscientific and overly emotional way of describing an active, healthy marine ecosystem where predation frequently occurs.

The narrator carries on this vein of demonization where after an introduction showing animations of these prehistoric marine reptiles and a short clip of a palaeontologist we are shown a series of images of metalworkers working in a machine workshop with angle grinders grinding down the steel teeth of a life-size animatronic steel dinosaur skull. To these images he declares "Now a monster is resurrected inside a laboratory", a direct connection to Mary Shelley's *Frankenstein* and immediately intentionally cheapening the attempt of the researchers to gain a deeper understanding of the biting mechanics of this creature by drawing a parallel to the world of horror novels and films where "monsters" are created in labs. The use of the term "monster" to describe this prehistoric animal is demonising enough, but using the term "resurrected" which in some contexts has an occultist ritualistic connotation certainly warrants the question of whether or not this can even be considered as a documentary, as enlightenment and the dissemination of knowledge seems to be coming second best to sensationalism and over-dramatisation.

This sequence goes hand in hand with some noticeable production techniques which set it apart in style from documentaries such as the *Walking With Dinosaurs #3 Cruel Sea* which is the exceedingly rapid editing at 00.52 (four consecutive shots each are no longer than half a second) but also usage of filming techniques such as shaky hand held camera and rapid blurring zoom cuts all set to a pumping techno soundtrack which make the production seem far more like an episode of *CSI: Miami*. This style continues with the titles, done in 3D in which the transition is again a fast blurring zoom accompanied to a "whooshing" sound effect. This sensationalist style is continued in the location text which also adopts a *CSI* styled effect as the location is "typed" onto the screen with an intentionally rough looking old typewriter font although the sound effect accompanying it isn't one of a typewriter, but the sound effect of streaming satellite data.

In the documentary there is an interesting indication of where some of the less than scientific terminology may be coming from. In an interview with Mike Triebold, who is the President of Triebold Palaeontology, he makes the following statement: “This guy weighed eight tonnes, he could easily swallow a full grown human male whole, just like a tater-tot”. This is an interesting realisation for my research and represents somewhat of a paradigm shift. So far I have concluded that the sensationalist and unscientific language has come from the documentary filmmakers, and was a dumbing down of the scientific viewpoint, but in this instance we have the president of a palaeontology institute describing a prehistoric creature as a “guy” and comparing its impressive biting and swallowing abilities to us eating “tater-tots” an American potato snack. This brings an interesting new concept to the research I have so far gathered, perhaps the perceived journalistic language does not only come from documentary filmmakers but also from researchers who are used to interacting with the general public and describing facts in a manner relatable to the audience.

Shortly after the above noted instance the narrator goes on to make a particularly bold journalistic statement, in which he says “Researchers studying mosasaurs realise nothing on Earth could have stopped them”. This is a problematic statement for two reasons: Firstly it is untrue, many things could have stopped the mosasaurs such as the reduction of their food source due to an ecological collapse, disease or being preyed on themselves by another emerging apex predator. Secondly the statement is troubling because the mosasaurs didn’t need “stopping”. They were a perfectly natural species occupying an important role in an ecosystem and the statement is as untrue, alarmist and shocking as if a researcher declared: “Nothing can stop Great White sharks!”

The narrator continues to use overly dramatic and unscientific terminology when describing them as “sea-monsters” who come in “two lethal varieties” all to heavy metal music whilst CSI styled sudden zoom fades and overexposure fades occur. The narrator goes on to describe them as "relentless killers" again an incorrect and sensationalist demonising since this perfectly natural apex predator killed to satisfy hunger, not in a relentless fashion.

After an advertisement break the journalistic sensationalism reaches new levels of fantasy when we see a dramatisation with actors of a fishing vessel pulling up a catch that seems unusually heavy before bringing it to the surface and seeing their lobster pots being snatched away by a huge animated mosasaur. The terrified fishermen yell to the captain to change course and speed away, whilst an aerial shot shows the mosasaur circling the fishing boat, all to heavy metal music. At the end the narrator explains how we as humans are lucky to have missed out on co-existing with the mosasaur, but it was illustrated with such similarities with scenes out of the film *Jaws* that this section certainly had far more in common with the Hollywood tradition of monster films than with serious documentary filmmaking.

2.4 Relevant Scientific Research

Initial investigation centred on conducting research into the field of precisely what creatures existed in New Zealand's past in order to be able to choose one (or more) which would give the New Zealand public a balanced taster of their prehistoric world. In order to effectively convey a snapshot into the past the decision was made to focus on selecting a specific era and not to show creatures from different eras as this would be an artificial and perhaps misleading combination of creatures for the viewer.

John A Long, curator of Vertebrate Palaeontology at the Western Australian Museum, gives an overview of the prehistoric life found in New Zealand in his book *Dinosaurs of Australia and New Zealand and Other Animals of the Mesozoic Era* (1998). Long clearly indicates that whilst fossil remains of terrestrial dinosaurs remain scant, there is an abundance of well-preserved marine fossils from the Late Cretaceous (Long 1998)[154]. The Late Cretaceous New Zealand marine fauna he covers includes the marine turtles from the group Protostegidae, large marine predators from the Mosasaur family, which in New Zealand's fossil record are represented by *Mosasaurus mokoroa, Moanasaurus mangahouangae, Prognathodon waiparensis, Tylosaurus haumuriensis, Taniwhasaurus oweni* and a smaller mosasaur *Rikisaurus tehoensis* (Long 1998)[155]. The descriptions were accompanied by paleontological drawings which would prove useful, particularly a skull fossil comparison between the mosasaurs listed above (Long 1998, pg. 163).

Among the elasmosaurs, which were long necked marine reptiles fossils of *Mauisaurus haasti* and *Tuarangisaurus keysi*, whilst amongst another group of long necked marine reptiles, the plesiosaurs were several indeterminate species (Long 1998). The final group of marine reptiles from the Late Cretaceous mentioned by Long (1998) were scant remains from an indeterminate genus tentatively described as belonging to the group ichthyosaurs.

Land dwelling dinosaurs did exist in New Zealand, but as mentioned above their remains are exceedingly rare, generally represented by a single fragment of bone, sometimes not enough to identify a particular species but enough to identify their order and suborder. These remains include parts from the large carnivorous theropods, the large long necked sauropods, the squat armoured ankylosaurs, the ostrich like ornithopods (possibly *Dryosaurus*) and remains from the flying group of reptiles known as the pterosaurs (possibly *Anhanguera*)(Long 1998)[156].

Dixon (2007) echoes the findings of Long (1998) in *The Complete Illustrated Encyclopaedia of Dinosaurs & Prehistoric Creatures* whilst also providing prehistoric visualisations by

[154] Long, *Dinosaurs of Australia and New Zealand and Other Animals of the Mesozoic Era*.
[155] Ibid.
[156] Ibid.

credited paleo-artists for the pterosaur *Anhanguera* (Dixon 2007 pg. 239), *Tylosaurus* (Dixon 2007 pg. 284), *Taniwhasaurus* (Dixon 2007 pg. 286), and *Prognathodon* (Dixon 2007 pg. 287).

From these sources it was clear that the majority of the preserved vertebrate fossil material showcasing a diversity of creatures in New Zealand's past were to be found in the period known as the Late Cretaceous (Long 1998) (Dixon 2007), which was a period extending from 89.3 million years ago (mya) until the mass extinction event which brought to a close the rule of the dinosaurs 65 mya (Dixon 2007). It was also clear that the best examples of preserved remains were of marine reptiles, particularly the large predatory mosasaurs (Long 1998). This prompted the decision to focus the visualisations on the marine environment of New Zealand during the Late Cretaceous period.

Further research into non-vertebrate fossil remains of New Zealand in this period led to *A Photographic Guide to Fossils of New Zealand,* an authoritative work illustrating fossils commonly found in New Zealand and authored by palaeontologists working for the Crown Research Institute *GNS Science* based in Lower Hutt, Wellington (Campbell 2013). GNS Science holds the National Palaeontology Collection and maintains the New Zealand Fossil Record file. The authors of the book are all specialists in the field of palaeontology. Hamish Campbell is a palaeontologist, author of scientific papers and is a science communicator for Te Papa (Campbell 2013). The other authors Alan Beu, James Crampton, and Liz Kennedy are palaeontologists, whilst Marianna Terezow is a senior palaeontology technician (Campbell 2013).

A Photographic Guide to Fossils of New Zealand covers commonly found fossils with their identification features and essential geological information. Specifically regarding the Cretaceous period the book details many invertebrate species which would have been part of the ecosystem in which the marine reptiles listed above would have lived and in some cases preyed upon (Campbell 2013).

The book shows photographs of fossils from the GNS Science collection including extinct creatures from the cephalopod family such as the squid like belemnites, and the ammonite, an extinct creature closely related to the cuttlefish which had a coiled shell (Campbell 2013). Ammonites existed from the early Devonian (419 mya) until the mass extinction event at the end of the Cretaceous (65 mya) and through this time had over 10,000 diverse forms[157]. Fossil ammonites are commonly found on every continent and thus have become an index fossil, a way palaeontologists can measure the age of a rock in which it was found (Campbell 2013). Ammonites were a common food source for many marine reptiles such as the ones found in New Zealand, and in fact some mosasaurs such as *Prognathodon* which was found by Joan Wiffen had special cone shaped teeth specifically designed to crush their shells (Campbell 2013, Long 1998, Dixon 2007). As a commonly encountered prey creature from New Zealand's Cretaceous represented by many different fossil remains the decision was made to choose an ammonite as one of the creatures for the visualisations.

Holding the National Palaeontology Collection meant that GNS Science held the original fossils discovered by pioneering New Zealand palaeontologist Joan Wiffen and her husband. Working in locations such as the North Island Mangahouanga Stream site Wiffen discovered many of the fossils mentioned previously, such as the ancient turtle *Protostega*, mosasaurs such as *Prognathodon*, plesiosaurs, *Tuarangisaurus*, as well as land dwelling dinosaurs such as the carnivorous theropod, a pterosaur, the armoured ankylosaur, and the vertebra bone of a titanosaur (Long 1998). As a scientific institute in possession of such an incredibly important

[157] "Ammonite Fossils."

fossil collection GNS Science became an important resource for information that I needed to pursue.

I contacted one of the authors of the book, palaeontologist James Crampton and discussed my project. He expressed interest and invited me down to visit the GNS Science institute in Wellington to do a presentation to the researchers and scientists there. I found the GNS Science team to be exceedingly friendly and helpful, and was able to see some of the original fossils in the collection discovered by Joan Wiffen. Two of the GNS team who co-authored the book *A Photographic Guide to Fossils of New Zealand* were particularly helpful in answering questions and directing me to information, James Crampton and the senior palaeontology technician Marianna Terezow who directed me to valuable online resources on the GNS Science website: the National Paleontological Collection (NPC) Database[158] and the online 3D Fossil Scan Gallery[159] which has 3D scanned examples of fossils such as the ammonite which can be downloaded and viewed in 3D. Marianna also very kindly allowed me to have a 3D medical CT scan of the jaw and teeth of *Tuarangisaurus*.

At this stage of my research I began to narrow down a short list of animals as candidates to show a range of diverse prehistoric lifeforms to the New Zealand public. These creatures all existed in the Late Cretaceous New Zealand marine and coastal environment, occupied different roles in the ecosystem and showcased distinctiveness in body forms that would be of more interest to the public.

The list comprised of five animals: a mosasaur, a pterosaur, a turtle, an ammonite and a common bony fish. The inclusion of the common bony fish was specifically to be able to

[158] "National Paleontological Collection Database."
[159] "NZ Fossils in 3D / Gallery / Fossils / Science Topics / Learning / Home - GNS Science."

demonstrate feeding animations as the pterosaur, mosasaur and ammonite would feed off them.

The decision on which specific pterosaur and turtle was made for me as only one set of remains had been found of each species (Long 1998).

Joan Wiffen describes her discovery of the fossilised plates of turtle shell in the *New Zealand Journal of Geology and Geophysics* journal article *The first Late Cretaceous turtles from New Zealand* and discusses the close similarity in the preserved plates to those of the ancient turtle family Protostegidae (Wiffen 1981)[160]. Thus the extreme closeness of the find made the ancient Late Cretaceous turtle *Protostega* the only possible conclusion, as Joan Wiffen herself states in her scientific description in the conclusion "it seems probable the New Zealand bones represent a small species of Protostegidae, that survived in the Late Cretaceous of the Southwest Pacific"[161] (Wiffen 1981).

Joan Wiffen discusses her find of the first ever flying reptile or pterosaur fossil remains in the journal article *First pterosaur from New Zealand*[162] as well as in the journal article *A Late Cretaceous polar dinosaur fauna from New Zealand*[163] and confirms the pterosaur remains as coming from the Upper Cretaceous and found in marine sediments, indicating it was a coastal species and therefore part of the ecosystem of the other species mentioned earlier (Wiffen 1988).

Whilst on the research trip to GNS Science in Wellington I was able to see this original fossil remain first hand. Long (1998) discusses the piece and suggests it is most likely from the

[160] Wiffen, "The First Late Cretaceous Turtles from New Zealand."
[161] Ibid.
[162] Wiffen, "First Pterosaur from New Zealand."
[163] Molnar and Wiffen, "A Late Cretaceous Polar Dinosaur Fauna from New Zealand."

family Anhangueridae. The flying reptile *Anhanguera* had a four metre wingspan lived along the coast, using its keel like bill to catch fish.

Pterosaur bones have been found numerous times in the stomach of fossil mosasaurs which shows that pterosaurs themselves were prey to large marine reptiles. Anhanguera has been found in other parts of the Southern Hemisphere, such as Australia and Brazil.[164]

Anhanguera fossils from Brazil have been found unusually uncompressed due to the nature of the deposit which allows for a very clear understanding of the anatomy of this reptile. As a result the morphology of *Anhanguera* is well understood and documented, even to the point of fossil casts of its entire skeleton being available for purchase online.[165]

Thus fortuitously the only choice of pterosaur was one that had a large amount of photographic reference, which would aid in the 3D reconstruction.

Michael J Everhart is one of the world's leading experts on the marine fauna of the Late Cretaceous[166].

In his book *Oceans of Kansas: A Natural History of the Western Interior Sea* (2005) he traces the history of the large inland sea that in the Late Cretaceous covered much of the interior of the United States[167].

This shallow ancient sea was rich in diverse life and as the sea receded over time the current area where the prehistoric sea used to be has become famous for the abundance of well-

164 "National Paleontological Collection Database."
165 "Anhanguera Skeleton and Skull Cast Replica Fossils Pterodactyloid Pterosaur."
166 Everhart, *Oceans of Kansas: A Natural History of the Western Interior Sea*.
167 Ibid.

preserved fossils which has greatly elevated the understanding of the ecosystems of the time as well as the lifestyles of the creatures that lived there.

This directly concerns the marine life of the Cretaceous in New Zealand because many of the creatures found by Wiffen and other New Zealand palaeontologists have also been found in the Badlands of Kansas and other areas where the large central sea used to exist[168].

Mosasaurs, the large predatory marine reptiles which lived at the end of the Cretaceous have been found worldwide[169] and were an apex predator filling the role which larger shark species, porpoises and Orca whales fill today.

They were an important part of the marine eco-systems of the time as well as being a successful grouping judging by the global spread of some species.

Prognathodon is an example of one of these successful global species discovered in locations as diverse as Belgium, Israel, New Zealand and the United States[170].

Joan Wiffen discovered the New Zealand fossils of *Prognathodon*, and whilst not complete there was enough material to conclusively identify it as part of this species.

This is an important example for any project with a focus on New Zealand prehistoric life. Not every fossil found is a complete preserved skeleton. So being able to connect a local find to an international species and thereby learn more about it by studying the fossil finds gives a vast array of information that the local fossil may not have yielded.

168 Long, *Dinosaurs of Australia and New Zealand and Other Animals of the Mesozoic Era*.
169 Dixon, *The Complete Illustrated Encyclopedia of Dinosaurs & Prehistoric Creatures*.
170 Ibid.

The benefit of being able to reconstruct a creature found in New Zealand by utilising an international array of specialists and evidence not only benefits the local public and scientists interested in the prehistoric world.

It also opens the possibility of international studies and projects that have the potential to connect the public of various countries under a shared prehistoric heritage.

A project visualising the creatures from the past would be remiss to not build on a repertoire of knowledge built globally. As a result collecting data from international discoveries would be an important factor when recreating New Zealand's prehistoric heritage.

An international discovery, which had a direct impact on the understanding of mosasaurs and thus New Zealand's marine reptiles, occurred in Jordan in 2008[171].

The discovery was monumental in the wealth of preserved information which changed scientific understanding of how mosasaurs looked *and* moved, thus making all previous visualisations of mosasaurs incorrect[172].

The fossil was of a Cretaceous *Prognathodon* which died approximately 72 million years ago.

What made this fossil ground-breaking and unique was the fact that it was the first one found which had the outline of its soft tissue preserved showing an unexpected shark like tail instead of a straight eel-like tail which had been the widely held scientific view for over 200 years[173].

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171 Lee, 10, and 2013, "Shark-like Tails Sped Ancient Sea Monsters Through Oceans."

172 Ibid.

173 Ibid.

Vertebrate palaeontologists Michael Polcyn at Southern Methodist University in Dallas, Texas and Johan Lindgren at Lund University in Sweden discussed the impact of the finding in a 2013 *National Geographic* article[174].

The vertebrate palaeontologists marvelled at the outstanding level of preservation, which even showed the outline of scales and the direction of the stiffening fibres.

The closest living relatives of mosasaurs today are the monitor lizards. As a result for over two centuries the scientific understanding of mosasaur tails was that they were like the tail of a modern monitor lizard or saltwater crocodile and thus swam like a lizard or crocodile.

The discovery of the fossil mosasaur with the imprint of the shark like tail changed the view of these creatures as slow swimmers and suggested a far more dynamic and active high speed hunter which swam far more like a shark running down its prey.

All previous visualisations before 2008 had demonstrated the straight lizard like tail and slow swimming style. This remarkable fossil opened a new chapter in the understanding of mosasaurs and gave the opportunity of any visualisation made of these creatures to not only show the newly discovered shark like tail but the fast swimming style as well.

Johan Lindgren authored a journal article in *Nature* describing fascinating evidence that strongly suggests the colouring of marine reptiles[175].

The colouring of dinosaurs and prehistoric life has long been a point of fascination to the scientific community and the general public as it had long been accepted that there was no way to tell what colour dinosaurs were as most of the fossils were skeletal in nature.

[174] Ibid.

[175] Lindgren et al., "Skin Pigmentation Provides Evidence of Convergent Melanism in Extinct Marine Reptiles."

Some dinosaur fossils discovered did have fossilised skin imprints, and some dinosaurs which had lain in hot environments such as arid deserts had become mummified before being fossilised. These fossilised dinosaur mummies still had the impression of scales and wrinkly reptilian skin, but had assumed the colour of the mineralising rock.

Previously dark patches around the fossil were assumed to be fossilised bacteria, but as understanding of organic chemistry improved scientists realised that they were remnants of the animals own colours. The pigment melanin was exceedingly stable during the fossilisation process, and was able to give strong evidence as to the light and dark areas of the creature in life[176].

The results clearly showed that for the marine reptiles studied they all displayed a patterning whereby they were darker on top, and lighter underneath.

This phenomena is common in marine creatures and is called countershading. It allows the creature to blend in to the dark water when seen from above, and when seen from below blends into the lighter surface above.

Data collected from mosasaurs, ancient turtles and ichthyosaurs (a type of swimming reptile that resembled a dolphin) all showed the adaptation of darker colouring on the upper surface, indicating a strong trend across creatures of this period[177].

The ability to use this new data in a visualisation alongside the other recent findings which change the scientific viewpoint of how these creatures looked and behaved would be an important point of difference from previous visualisations.

[176] Ibid.
[177] Ibid.

The new information available on mosasaurs, which had not been previously implemented in visualisations, made the group a candidate for any project wishing to display current knowledge.

As Long (1998) states many of the species found in New Zealand were also found in other locations worldwide. *Tylosaurus* is a species from Kansas known from many complete skeletons and is so similar to the New Zealand species *Taniwhasaurus* that initially when *Taniwhasaurus* was first discovered it was classified as a form of *Tylosaurus*[178].

The fact that mosasaurs' closest living relatives are todays monitor lizards made studying the anatomy of monitor lizards a priority since they are the closes representation of mosasaurs in life[179].

Tylosaurus has not only been found complete as a skeleton, but also had been found with remarkably well-preserved fossilised skin. This showed the skin to be covered in a prominent pattern of regular scales, much like the monitor lizard of today.

[178] Long, *Dinosaurs of Australia and New Zealand and Other Animals of the Mesozoic Era*.
[179] Everhart, *Oceans of Kansas: A Natural History of the Western Interior Sea*.

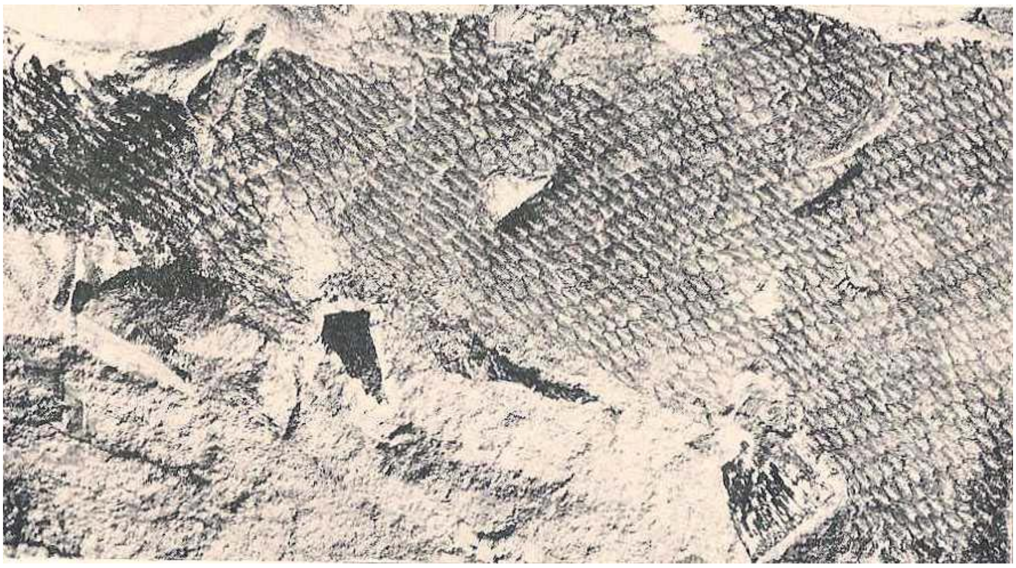

Figure 9 - Well preserved fossil scales of Tylosaurus *give a clear indication of how the skin would have looked in life*[180]

Lindgren (2014) also shows in his article on marine reptile skin from the Cretaceous in *Nature* that studies of the preserved skin of ancient turtles show a predictably strong connection to living turtles. Lindgren notes that some current living turtles are descendants from turtles of this period.

For example the leatherback turtle is represented by living species as well as prehistoric species[181]. This would make studying the anatomy and reptilian skin of modern turtles that have a prehistoric relative important for any visualisation project.

As a result high-resolution photographic data on the scales, colouring and patterns on relevant reptiles such as monitor lizards, turtles, crocodiles and tortoises would be an important research asset to a visualisation.

Professional animal photographer Paul Starosta in his 2004 book *Reptiles* documents hundreds of reptiles relevant to the study of mosasaurs and ancient turtles[182].

180 Kansas, *Scales of Tylosaurus Proriger (KUVP-1075)*.
181 Lindgren et al., "Skin Pigmentation Provides Evidence of Convergent Melanism in Extinct Marine Reptiles."
182 Moncuit, Daoues, and Starosta, *Reptiles*.

His high-resolution photographs capture many surface details important not only when painting the textures on the 3D creatures, but also serves as a useful guide when rendering. Seeing which areas are dull or highly reflective for example and then adjusting settings in the renderer to reflect that research is only possible with good reference photographs.
The photographs also give indication of areas that would not be preserved as fossils, such as the structure, pattern and colour of reptilian eyes, gum, tongue and other soft tissue areas.

Similarly in order to accurately visualise ammonites, research would have to be conducted into their closest living relatives, which are the cuttlefish of today[183].
Photographic reference images were collected for not only cuttlefish, but for other cephalopods such as squid species, octopi and the nautilus species.
Photographic reference works such as Norbert Wu's 1994 *Splendors of the Seas*[184] as well as Branch's 2008 *Two Oceans: A guide to the marine life of southern Africa*[185]. Between them these works document in photographs over 2,500 species giving valuable reference for cephalopods as well as the rendering of marine environments.
Whilst this research covers modern cephalopods well data had to be collected for the many various forms of fossilised ammonite shells.
Books such as *A Photographic Guide to Fossils of New Zealand* (2013) by Campbell, *Fossils* (2013) by Palmer, *Discover Dorset: Fossils* (1999) by Edmonds and *Jurassic Coast: A Walk Through Time* all featured detailed photographs on ammonite fossils and structures[186][187][188][189].

[183] Campbell et al., *A Photographic Guide to Fossils of New Zealand*.
[184] Wu, *Splendors of the Seas: The Photographs of Norbert Wu*.
[185] Branch et al., *Two Oceans: A Guide to the Marine Life of Southern Africa*.
[186] Campbell et al., *A Photographic Guide to Fossils of New Zealand*.
[187] Palmer, *Fossils*.
[188] Edmonds;, *Discover Dorset Fossils by Richard Edmonds*.
[189] BRUNSDEN, *The Official Guide to the Jurassic Coast*.

As previously mentioned Lindgren (2014) published research in *Nature* which concluded marine reptiles of the Cretaceous displayed the common phenomena known as countershading, where the upper part of an animal is darker than the much lighter surfaces underneath[190].

Whilst the previously mentioned marine life photographic books are also beneficial when studying countershading, it would be important to study the countershading of larger marine predators which today occupy the same ecological niche as the one which mosasaurs did. To this end collecting reference material on the marine colouration of creatures such as large sharks, porpoises and toothed whales became important.

Peschak and Scholl's 2007 book *South Africa's Great White Shark* contained high-resolution photographs of the great white shark in its natural environment and gave clear indication of the prominent countershading on the shark[191]. Due to the photographs being taken from a diving cage the good visual reference is obtained of how a large predator looks underwater. This is useful when lighting and rendering the creature as noting and implementing details such as the underwater colour and flickering sunlight effects.

Details such as the underwater visibility and how far you can see certain colours on the shark before it becomes a silhouette are also useful details to note for realistic compositing of the 3D creature of this size into a virtual scene.

Carwardine (2002) in his book *Whales, Dolphins and Porpoises* gives clear visual reference for countershading in porpoises and toothed whales as his book details and features illustrations of every species of whale, dolphin and porpoise[192].

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[190] Lindgren et al., "Skin Pigmentation Provides Evidence of Convergent Melanism in Extinct Marine Reptiles."
[191] Peschak and Scholl, *South Africa's Great White Shark*.
[192] Carwardine and Camm, *Whales, Dolphins and Porpoises*.

As previously mentioned some of these species occupy the modern ecological niche that mosasaurs did in times past. The vast majority of the hundreds of various species of marine mammal in his book display countershading to some degree and coincide perfectly with the notes made on marine reptile countershading by Lindgren (2014)[193].

Just as our oceans today the Late Cretaceous marine environment naturally contained many thousands of fish species, many of which were important as a food source to the marine reptiles and ammonites.

Long (2010) in his book *The Rise of Fishes: 500 Million Years of Evolution* gives a detailed account of the evolution of all fish species[194]. With regards to species which would have inhabited the seas of the Cretaceous in the South Pacific the book gives details of not only species, but images of fossils and sketches of the creatures in life.

Flindersichthys denmeadi was a species of the Cretaceous in the Pacific, which would have been a staple food source of marine predators such as mosasaurs, and its descendants are still an important food source in the Pacific to predators such as sharks, orca and marlin.

Paleoartists are artists who work with palaeontologists in order to create visualisations with an emphasis on scientific accuracy[195].

Their work is created for museum displays and for publication in scientific papers and journals. Whilst not animated and therefore less likely to feature anthropomorphism it is important to research the work of paleoartists in order to see how scientific understanding is reflected in their work; specifically artworks featuring marine reptiles of the Cretaceous such as mosasaurs, and ammonites and prehistoric squid.

[193] Lindgren et al., "Skin Pigmentation Provides Evidence of Convergent Melanism in Extinct Marine Reptiles."
[194] Long, *The Rise of Fishes*.
[195] White, *Dinosaur Art: The World's Greatest Paleoart*.

Paleoartists often are from scientific backgrounds themselves, occasionally are palaeontologists, or have had veterinarian experience, and as a result have long experience understanding the anatomy of contemporary and prehistoric animals. This along with the fact that palaeontologists guide the visualisation as it is created means that their artwork becomes an important reference material in itself. By comparing visualisations of a specific dinosaur from different paleoartists it is possible to see anatomical details that palaeontologists agree on. It is also possible to understand soft tissue structures like musculature through the visual implementation of their anatomical knowledge.

Steve White in his 2012 book *Dinosaur Art: The World's Greatest Paleoart* has collected work from the world's leading paleoartists, and features work by artists such as Robert Nicholls and Douglas Henderson, both of which create visualisations of marine reptiles such as mosasaurs[196].

[196] Ibid.

Figure 10 - Robert Nicholls is a paleoartist who specialises in marine reptile visualisations[197][198].

Similarly the 2005 BBC book by Tim Haines *The Complete Guide to Prehistoric Life* features 3D visualisations of hundreds of prehistoric creatures[199].

Haines was the producer who created the concept of the *Walking With Dinosaurs* franchise and the book features visualisations of many relevant creatures, such as the different species of marine reptiles, ammonites, ancient squid, cretaceous fish and pterosaurs.

Whilst this holds obvious reference value as prehistoric visualisations, it also affords an opportunity to judge high-resolution still images of the 3D models used in four different BBC series'. Being able to look closely at the 3D models, to study the geometry and the textures and how well the creature has been composited into the environment not only sets a benchmark to be able to strive toward but also is educational to see how they have executed the challenge of visualising prehistoric creatures at an industry level.

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197 Nicholls, *The-Leviathan*.
198 White, *Dinosaur Art: The World's Greatest Paleoart*.
199 Haines and Chambers, *The Complete Guide to Prehistoric Life*.

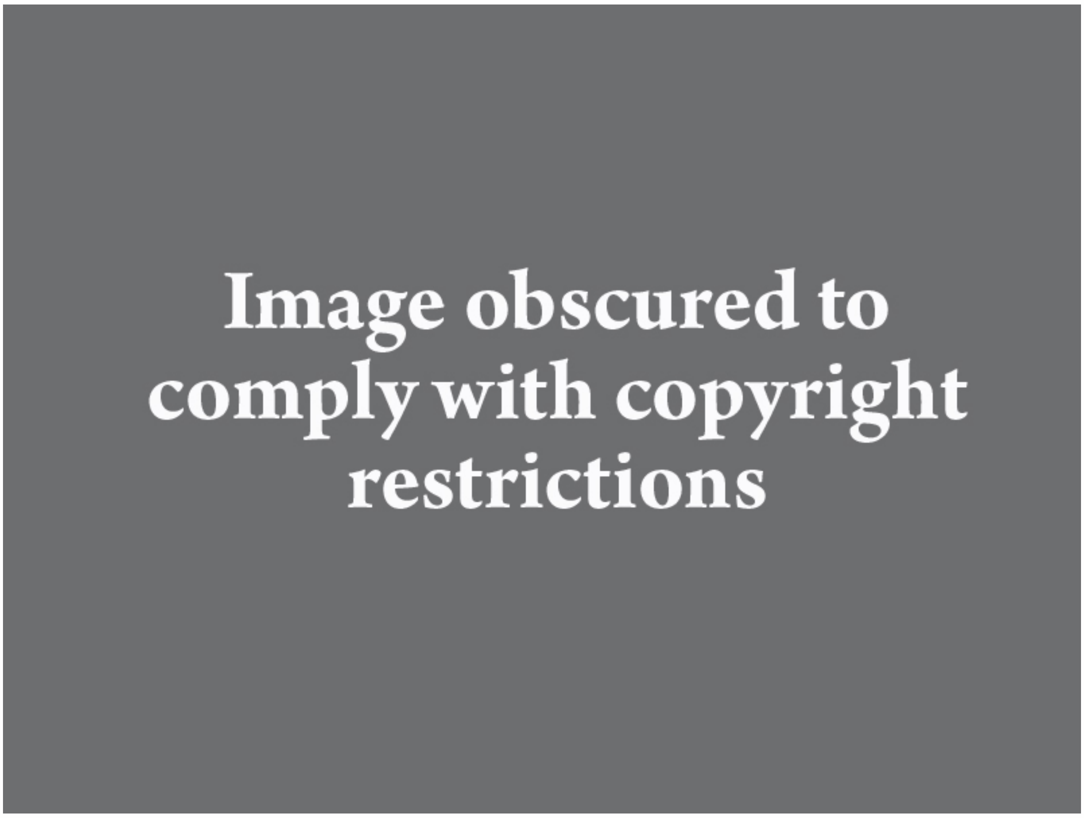

Figure 11 - A scene from Walking With Dinosaurs *gives information of not only how the creature was visualised but also to what quality the visual effects were taken*[200].

2.5 Research Trips

Auckland War Memorial Museum houses an Origins section that contains many fossils and casts of fossils related to New Zealand's prehistoric past[201].

As one would expect of a local museum it focuses on New Zealand palaeontology and fossils and is a good starting point for an investigation into the subject matter. The museum holds many original fossils and casts of fossils which directly concern a project visualising New Zealand marine life.

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[200] Haines, *Walking with Dinosaurs*.

[201] Hira and Museum, "Auckland War Memorial Museum."

Fossils of many various ammonites ranging in size from a few centimetres across to nearly half a metre are represented, as well as well as other ancient squid-like creatures such as the orthocones and belemnites which are good reference for visualising an ammonite.

The museum houses a collection of fossil marine reptile remains and has several examples of mosasaur skulls, but also skulls of the longer necked elasmosaurs that were found by Joan Wiffen[202].

Being able to photograph life size skulls from different angles is useful reference when constructing a 3D model of an object.

The museum also makes the same strong connection which the scientific literature does regarding the relationship between the Cretaceous in New Zealand and that of the Great Inland Sea which existed in central North America by displaying fully complete skeletons of American mosasaurs and pterosaurs.

Figure 12 - The Auckland War Memorial Museum houses many relevant fossils and casts such as this skull of a mosasaur found in Mangahouanga Stream, Hawkes Bay[203]

[202] Long, *Dinosaurs of Australia and New Zealand and Other Animals of the Mesozoic Era*.

[203] "Skull of Mosasaur, Mangahouanga Stream, Hawkes Bay, on Display, Auckland Museum, November 2008."

Doctor Matt Rayner who is Head Curator of the vertebrate collection at Auckland Museum expressed strong interest in an animated visualisation as a means of connecting New Zealanders and visitors to the museum with the fascinating creatures of New Zealand's past.

Kelly Tarlton's Sea Life Aquarium[204] is home to many marine creatures relevant to a project set in the Late Cretaceous.

Not only does it have living cephalopods to observe such as the Pacific octopi, but also has an opportunity to closely observe the skin texture, anatomy and tentacles of the preserved giant squid carcass that they have on display. As previously mentioned ammonites are closely related to modern cuttlefish and squid, so being able to observe the details of a creature such as a giant squid so closely is valuable research for the 3D modelling and digital sculpting of the skin details.

Photographic and video reference was obtained of the squid and octopi. The Pacific octopus on display afforded opportunities to gather not only photographs showing how an underwater cephalopod should be rendered, but also video showing how they breathe using the siphon.

[204] "Kelly Tarlton's SEA LIFE Aquarium, Auckland | Cheapest Tickets | Official Site."

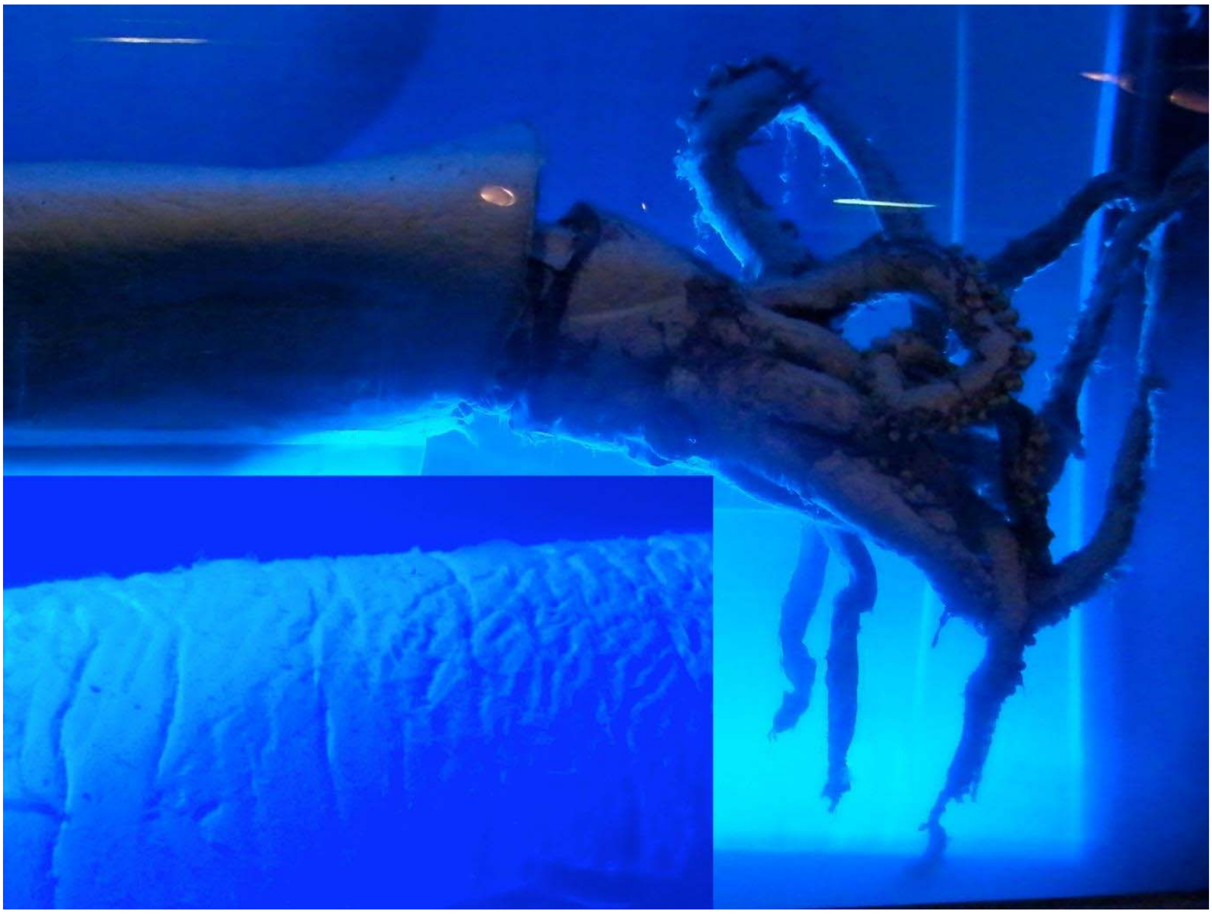

Figure 13 - The preserved giant squid carcass at Kelly Tarlton's Sea Life Aquarium yields much information on how to model the skin and tentacles of a cephalopod[205].

Sharks have existed for 420 million years[206] and many species existed in New Zealand's waters during the Late Cretaceous[207]. Therefore when researching creatures present during this era it is logical to observe the living descendants. Kelly Tarlton's *Sea Life Aquarium* has a collection of many different shark species as well as rays which are close relatives. Photographs of shark skin textures and video reference of the movement of sharks was gathered from the underwater glass tunnel that houses many shark species.

[205] Australia, *A Giant Squid (Architeuthis Spp) Carcass on Display at Kelly Tarlton's Underwater World, Orakei, Auckland, New Zealand.*
[206] Long, *The Rise of Fishes*.
[207] Campbell et al., *A Photographic Guide to Fossils of New Zealand*.

This is also beneficial when noting the recent scientific findings indicating the shark like tail of mosasaurs and the new theory that mosasaurs swam more like sharks than lizards or crocodiles.

2.6 Personal Fossil Collection

Aside from collecting scientific literature and photographic reference material of fossils and contemporary animals, another reference avenue at the disposal of the project is my personal fossil collection.
In the collection is fossil material directly relevant to the project, being Late Cretaceous mosasaur teeth as well as a collection of ammonites from varying epochs.

Being able to closely study the structure and surface of the teeth of actual mosasaurs gives much information when 3D modelling the surface structures, dimensions and even reflective properties, as the mineralized enamel on the teeth still retains its sheen.

The ammonites range in size from smaller examples two centimetres across from the Late Cretaceous in Morocco, to the largest example from Italy measuring ten centimetres across. Two of the ammonite shells are sectioned, which gives direct and clear information on the internal chambered structure, whilst the rest of the fossilised shells have the complete outer structures, giving important reference when modelling the details of the spirals, the striations on the surface and the differences between the more weathered older centre of the spiral versus the younger outermost chambers which were created in the last part of the ammonites life.

Figure 14 - Some of the ammonites from my personal fossil collection which give details on the internal structure on the sectioned side and external structures on the opposite side.

3 Methodology

The methodology used to investigate the research question is a mixed-methods approach, more specifically an implementation of pragmatic qualitative research.
The study also features specific customised approaches, such as action research, and the more specific art methodology of generative art.

Tjark Ihmels and Julia Riedel in *"The Methodology of Generative Art"* describe the generative art methodology as "*the rigorous application of predefined principles of action for* *the intentional exclusion of, or substitution for, individual aesthetical decisions that sets in motion the generation of new artistic content out of material provided for that purpose."*[208]

This generative art methodology is central to this research project as the aesthetical decisions critiqued in performance driven anthropomorphised prehistoric visualisations are substituted by conclusions from scientific data to generate the artistic content.

Data collection is also implemented in this qualitative research approach to build a broad thematic overview of the cultural constructions which impact prehistoric visualisations in cinema and documentary in order to arrive at a more complete understanding of the motive drives to add anthropomorphism to a prehistoric visualisation. In order to make the study specific and culturally relevant to a New Zealand context, only cinematic and television examples from English speaking Western nations will be analysed.
Whilst one specific still image of paleoartists work is discussed, the majority of studied works specifically focus on animated examples of prehistoric depictions in order to connect it directly to the research question.

In order to understand the phenomena of anthropomorphism being a detractor to scientific evidence in animated visualisations, a collection of commentary by scientific specialists would be analysed of various visualisations that have differing levels of inaccuracy and sentiment driven storytelling.
Comparison between scientific data directly related to the ancient marine reptiles of New Zealand, and depictions of similarly related species in animated visualisations are also made to investigate scientific accuracy of these representations.

[208] Tjark Ihmels, "The Methodology of Generative Art."

In order to ensure a lack of anthropomorphic influence in this work it was critical that every decision that was made was to be driven by evidence, not creative or aesthetic decisions as discussed in the aforementioned generative art methodology.

Thus every aspect of these creatures, from body form, surface textures, colourisation and finally animation of their behaviours had to be based on information from palaeontologists, published peer reviewed research or from studying data of the closest living relatives alive today of these species.

The aim would be to generate art, in this case prehistoric visualisations, which would not be driven by individual aesthetical decisions.

Artistic additions, sentimentality, anthropomorphism and confusing or potentially misinforming trappings would be absent. This would let the visualisation demonstrate that imagery of prehistoric creatures derived from scientific data are what interests the public, not the unscientific additions added by producers of entertainment.

In order to establish the validity of the results an unstructured interview process or feedback loop was initiated with individuals specifically employed in New Zealand in the fields of scientific communication to the general public, such as museum staff, or official scientific communicators working in a New Zealand paleontological context.

These specialists were selected due to their professional experience, which bridges the disciplines of scientific research of palaeontology, as well as communicating scientific data to the New Zealand public.

This makes their feedback directly applicable to the central research question.

A feedback loop was also initiated with New Zealand palaeontologists, in order to validate the scientific accuracy of the prehistoric visualisations presented.

The following sections discuss the process of developing these prehistoric visualisations from New Zealand's past based on this evidence with no aspects of anthropomorphism or aesthetic decision making to detract from scientific data and thus misinform the viewer.

4 Results

Utilising the methodology outlined above of scientific evidence driven decision making as a form of generative art designed to replace aesthetic and performance driven decisions required a large amount of scientific evidence to inform every aspect of the modelling, texturing, animating and compositing of the creatures covered in the project.

4.1 Creature Selection Process

The process began with the selection of the creatures to represent.
The largest amount of fossil material found in New Zealand consisted of remains of marine organisms, primarily invertebrates such as molluscs, corals, brachiopods, sea urchins, plant fossils and finally fossils of vertebrates[209].

This clearly established that the focus of a project that represents prehistoric New Zealand would take place in a marine setting and would need to include examples of invertebrates and vertebrates.

[209] Ibid.

Invertebrates such as snails, ammonites, bivalves etc. have a long history in the geology of New Zealand, and are the oldest fossils discovered so far. The oldest fossils were found in Cambrian deposits from 542 million years ago, and remained a consistent feature of the fossil record until modern times where most invertebrates such as mussels, oysters, squid and snails still have living descendants. Since the public are aware of modern living descendants, it would be more educational to showcase a form of invertebrate that has not survived into the present age, and would therefore be unlikely to be mistaken for a modern equivalent.

Trilobites and the squid like ammonites and belemnites are the more prominent fossil invertebrates that have no living descendants and therefore would make good candidates to showcase as an example of New Zealand's extinct marine life.

The decision of which to choose would now fall down to which of them co-existed with vertebrates that are well represented in New Zealand's fossil record.

Fossil trilobites are found in New Zealand from the Cambrian era (542 mya) where the only vertebrate remains are teeth from primitive eel like creatures known as conodonts. Since the only known fossils of conodonts are teeth, it makes a prehistoric visualisation of the entire fish's body extremely difficult.
Trilobites are also found during the Ordovician period (488 mya), but no known vertebrate fossils are known from this era in New Zealand's fossil record.
The Devonian period (416 mya) and Permian period (299 mya) sees an identical situation to the previously mentioned Cambrian period, where trilobites co-existed with the eel like

conodonts. The conodont fossils from this era are rare and are of only teeth, making the reconstruction of these creatures problematic.

Thus whilst trilobites existed for 200 million years in New Zealand's fossil record, the only fossil evidence of vertebrate life are scant remains of primitive eels which would have very little evidence for reconstructions.

Ammonite fossils on the other hand are found to have co-existed with vertebrates in the New Zealand fossil record.

Ammonites and nautiloid fossils are frequently found during the Triassic, Jurassic and Cretaceous eras coinciding with all the major prehistoric marine reptile and scant land dinosaur remains.

During the Triassic ammonites were found with conodont, fish and marine reptile fossils.

During the Jurassic they were found alongside sharks and bony fish. The Jurassic was also the era a single theropod hand bone was discovered near Port Waikato. The theropods were a group of dinosaurs that included large famous predators such as *Tyrannosaurus Rex*, and although conclusive identification from one hand bone is impossible, experts suggest that this fossil could be that of a species closely related to *Allosaurus*, a large carnivore.

During the Cretaceous era much vertebrate marine fossil material was discovered, which covers the vast majority of New Zealand's prehistoric reptile fossils. Discoveries include the ancient turtle *Protostega*, mosasaurs such as *Mosasaurus mokoroa*, *Moanasaurus*, *Prognathodon*, *Tylosaurus*, *Taniwhasaurus* and *Rikisaurus*. The long necked marine reptiles the plesiosaurs were also discovered which included the indeterminate Shag Point plesiosaur, a *pliosaur* discovered in various locales around the South Island, the *elasmosaur Mauisaurus*, and *Tuarangisaurus*[210].

Scant remains of fossil ichthyosaurs from three locations were also found which were tentatively described as *Platypterygius*. Ichthyosaurs were a group of extinct marine reptiles which had undergone drastic evolution to suit their lives in the oceans, and although true reptiles they strongly resembled dolphins.

Land dinosaur remains were discovered in New Zealand, these remains were generally only partial remains of a single bone or two. This was enough to establish a broad type of the creature, but not enough to conclusively pinpoint a specific species. A rib was discovered which is most likely from a long necked land dwelling sauropod that would have been about 10-12 metres long. Ankylosaurs were squat, heavily armoured dinosaurs that had a large club-like tail for self-defence, and were part of the group nodosaurs. Fossil evidence has shown such dinosaurs existed in New Zealand during the Cretaceous, and potentially may have come from the species *Minmi*.

Ornithopods were sleek fast two legged dinosaurs much like the ostriches of today, and fossil evidence has shown these too existed in New Zealand. The remains showed similarities to the species *Dryosaurus* and may have measured approximately 3 metres long.

Pterosaurs were flying reptiles and a partial arm bone found by Joan Wiffen has shown that they too existed in the North Island in the past and probably had a lifestyle similar to large sea birds such as pelicans and albatrosses feeding on fish that they would have scooped up from the surface of the ocean. The remains whilst not conclusive show strong similarities to a species of pterosaur called *Anhanguera*, which had an array of outward pointing teeth to make catching fish easier.

[210] Long, *Dinosaurs of Australia and New Zealand and Other Animals of the Mesozoic Era*.

Thus it can be seen that the vast majority of New Zealand prehistoric vertebrates that are well represented are from the Cretaceous era, and so did not co-exist with trilobites but with ammonites.

This would make the ammonite a more logical choice to model and animate, as it could be shown co-existing with a variety of creatures.

The summary of the creatures from the Cretaceous period in New Zealand also clearly shows that the majority of vertebrate fossils were of marine reptiles known as mosasaurs.
This evidence-based elimination of potential candidates to refine a selection thus results in the pairing of a mosasaur with an ammonite during the Cretaceous.
It is important to note the implementation of the evidence based decision making methodology during this process.
The decision making process to select which mosasaur would be modelled followed a similar strategy to the ammonite selection.

Of the various mosasaur fossils discovered in New Zealand none have been found completely intact, so the decision on which to model hinged on which species had enough remains found internationally to make modelling possible. Many of the mosasaur remains have been found with an intact albeit compressed skull, so whilst that aspect of the creature's physiology could be modelled the rest of its body would have to rely on fossils from overseas that would be more complete.

Fossils of mosasaurs such as *Tylosaurus* and *Prognathodon* have been found in New Zealand as well as in many other parts of the world such as the United States, Europe and the Middle East[211].

The multitude of international fossil remains which have been studied and researched over the decades, and in some instances over a century since their first discovery has led to an in depth understanding of their anatomy, lifestyle and the eco-system which they inhabited.

Some species of New Zealand mosasaur such as *Rikisaurus* and *Moanasaurus* whilst unique to the New Zealand Cretaceous have incomplete remains[212], so whilst in some instances a complete skull and a few vertebrae have been discovered this would not be enough information to model an entire creature.

Tylosaurus and *Prognathodon* were found in New Zealand and as previously mentioned have been found around the world and thus have far more complete anatomical understanding but lack a distinctive New Zealand context.

Thus an ideal candidate of mosasaur would ideally be unique to New Zealand and closely related enough to international species in order to make its reconstruction more evidence based.

This criteria resulted in *Taniwhasaurus* being an extremely strong choice, as it not only is a species which was initially discovered in New Zealand before being discovered in Antarctica and Japan and thus has a strong New Zealand flavour but also is very closely related to *Tylosaurus* which has been discovered internationally and whose anatomy is well understood.

[211] Dixon, *The Complete Illustrated Encyclopaedia of Dinosaurs & Prehistoric Creatures*.
[212] Long, *Dinosaurs of Australia and New Zealand and Other Animals of the Mesozoic Era*.

Taniwhasaurus is so closely related to *Tylosaurus* that when it was initially discovered it was misidentified as a species of *Tylosaurus* before studies concluded that there were enough differences in the fossils to describe it as a new species.
The name *Taniwhasaurus* also signifies itself as uniquely New Zealand, as the creature was named after the Taniwha, a supernatural creature from Maori tradition.
In Maori mythology taniwha were depicted as sea serpents or dragons and lived in rivers, lakes and watery caves. Some were terrifying, with fiery eyes and lashing tails, others were protective. The stories of taniwha were often interwoven with the tales of brave Maori warriors who faced them and defeated them with a mixture of bravery, cunning and courage.[213]

Taniwhasaurus thus became the choice of extinct New Zealand mosasaur to model and animate.

In order to provide a cross-section of creatures for a visualisation, other animals from the Cretaceous had to be included that would compliment the marine environment.

A prey creature had to be considered not only for the mosasaur Taniwhasaurus, but also for the ammonite. Whilst mosasaurs did prey on ammonites themselves, both species also fed on fish which in the Pacific waters of the Cretaceous would have been as full of fish as today. A common species of teleost or bony fish would be the logical choice, as they exist today in a vast array of species. In fact 96% of all fish belong to the group teleosts, also known as the

[213] Taonga, "Taniwha – Te Ara Encyclopaedia of New Zealand."

ray-finned fishes. Since they are the vast majority of all fish it would be logical to include one as a potential prey species.

Flindersichthys denmeadi was a teleost commonly found in the Pacific during the Cretaceous, and its adult size of between 30 centimetres to 1.25 metres[214] meant it was large enough and common enough to be preyed upon by mosasaurs, ammonites and pterosaurs such as *Anhanguera*.

They have living descendants that fall into the group Elopiformes, which contains tarpon, ladyfish and giant herrings. They are a common fish in the Pacific and preyed on by large modern predators that occupy the ecological niche the mosasaurs did.
Today Orca, sharks, marlin and other large apex marine predators hunt these fish much as reptiles preyed them on in the Cretaceous.
In a realistic portrayal of a Cretaceous ecosystem *Flindersichthys* would be a common fish and prey animal in the seas of the Cretaceous and so would be included in a list of animals to model and animate for a project dealing with the Cretaceous creatures of New Zealand.

To represent an ancient marine turtle and pterosaur in the Cretaceous ecosystem of New Zealand required a selection process for the candidates as well.
This selection process was extremely simple since only one of each animal has been found as a fossil.

[214] Bartholomai, "Revision of Flindersichthys Denmeadi Longman 1932, a Marine Teleost from the Lower Cretaceous of the Great Artesian Basin, Queensland."

For the pterosaur *Anhanguera* was selected since this has been the closest match to the arm bone fossil found by Joan Wiffen[215]. *Anhanguera* also lived in South America and particularly well-preserved 3 dimensional skull fossils have been found in Brazil. It was also found in Australia showing the large range of this creature during the Cretaceous[216].

The anatomy of *Anhanguera* is well understood, with complete fossil skeletons held in fossil collections around the world. Skull casts and casts of the entire skeleton are available for purchase online, as well as many photographic studies of the fossils making data for 3D modelling easily accessible and verifiable.

Joan Wiffen also discovered the only known fossils of Cretaceous marine turtle, which consisted of plates from its shell. Though incomplete it was enough to tentatively identify it as being a member of the family Protostegidae. This is not only important as a discovery to New Zealand but indeed the entire world as it still remains the only recorded discovery of this species in the Southern Hemisphere[217].

4.2 Creature Concept Development

Planning for the modelling stage of the project required the collected data to be visualised in a series of concept artworks for the creatures on the list of candidates.

In order to maintain anatomical accuracy, the concept artworks were built up over a photographic image of a fossil of the creature being studied.

This ensured the visualisation displayed accurate proportions and dimensions.

The methodology of ensuring all aspects of the visual representation be based on scientific data is reflected in the notes following each visualisation.

215 Wiffen, “First Pterosaur from New Zealand.”
216 Long, *Dinosaurs of Australia and New Zealand and Other Animals of the Mesozoic Era*.
217 Wiffen, “The First Late Cretaceous Turtles from New Zealand.”

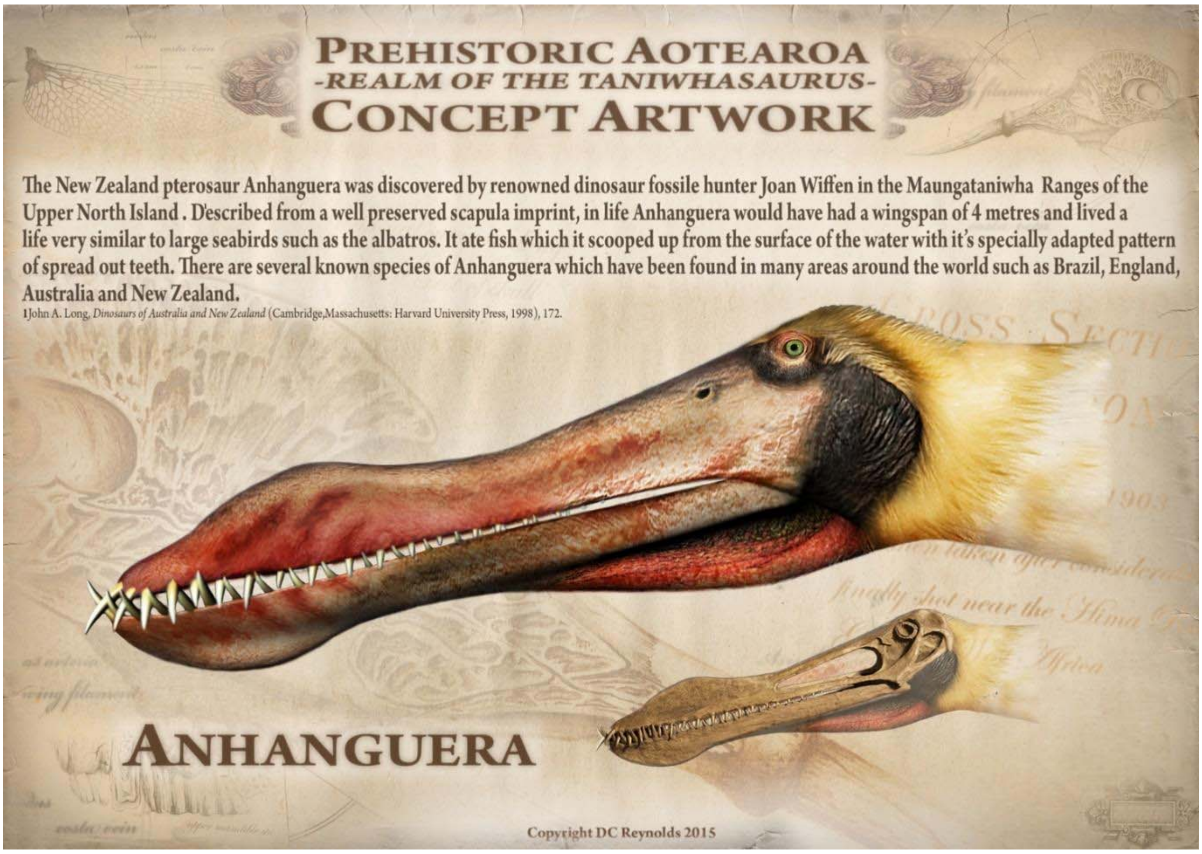

Figure 15 – Concept artwork of Anhanguera

The profile concept art image of *Anhanguera* was built up on top of a side photograph of the skull of a fossil found in Brazil. Fossils of pterosaurs such as *Anhanguera* from this country are well known for having been preserved without compression distorting the shape of the skull. A fossil can become distorted or flattened over the millions of years it lies preserved due to factors such as pressures on the layers of rock or their movement.

Thus discovery of uncompressed fossilised remains such as those found in Brazil are a boon to researchers, as their proportions do not require adjustment to be correct.

Pterosaurs were covered in a layer of fur, and fossils with imprints of hair have been found since 1831.

These hair-like fibres are not the same as those found in mammals, and are called pycnofibers[218]. They are similar to the furry covering of bats and are regarded as an example of convergent evolution. Convergent evolution is when two entirely separate species of creature independently evolve organs, abilities, markings or any other characteristic that serves the same function.

In many of the fossils found the furry covering did not extend down the beak and was much thinner on the surface of the wings. This has been used to advance the theory that pterosaurs may have been warm blooded, as the lack of fur on the wings suggests it did not serve an aerodynamic function but rather to serve thermoregulation[219].

The fossil imprints of hair have yet to provide any direct evidence of coloration. However similarities to modern day birds may provide a clue to how they may have looked. Anhanguera lived along coastlines feeding on fish in a similar lifestyle to pelican or albatross of today. Also like pelican or albatross the furry surface did not extend down the forward part of the head or beak. These similarities of lifestyle and function between modern and prehistoric creatures that serve the same purpose can be considered a form of convergent evolution.

Convergent evolution has been proven in the relationships between the coloration of ancient species and modern species that have evolved to live a similar lifestyle and ecological niche in an ecosystem. An example of this is the evidence of coloration in a Cretaceous mosasaur fossil[220]. This fossil contained an outline of the creature's soft tissue that had been fossilised and under tests showed it contained stable fossilised melanin. Through the studies of which areas had more or less melanin, researchers were able to understand which part of the animal

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[218] Witton, *Pterosaurs: Natural History, Evolution, Anatomy*.
[219] Ibid.
[220] Lindgren et al., "Skin Pigmentation Provides Evidence of Convergent Melanism in Extinct Marine Reptiles."

was darker or lighter. The realised that mosasaurs exhibited a coloration pattern called countershading. This is an exceedingly common coloration in marine fish and mammals, in which the upper surfaces of an animal are dark, whilst the belly and undersides are much lighter, often white.

Sharks exhibit countershading, as do dolphins, porpoises, whales and sea birds such as penguins. It is perhaps not surprising then that mosasaurs, which had lived in the same environment, would also exhibit this same coloration.

This evidence of convergent evolution in coloration of animals, which inhabit the same conditions, and lifestyle of extinct creatures, is an important aspect of these visualisations. In creatures that have been fossilised without the preservation of the soft tissue such as Anhanguera we are able to look at the modern creatures that inhabit the same environment and lifestyle to suggest coloration patterns. Sea birds such as pelican and albatross fit this criteria and the visualisation has been developed with the coloration of these animals as a guide. The patterning of the fur extends down the body but stops at the beak, which has been left hairless as with modern pelican and seabirds such as the albatross and gulls.

In the majority of sea birds such as gulls the bodies are white with occasional grey or dark grey upper wing surfaces. This coloration pattern was implemented in the visualisation.

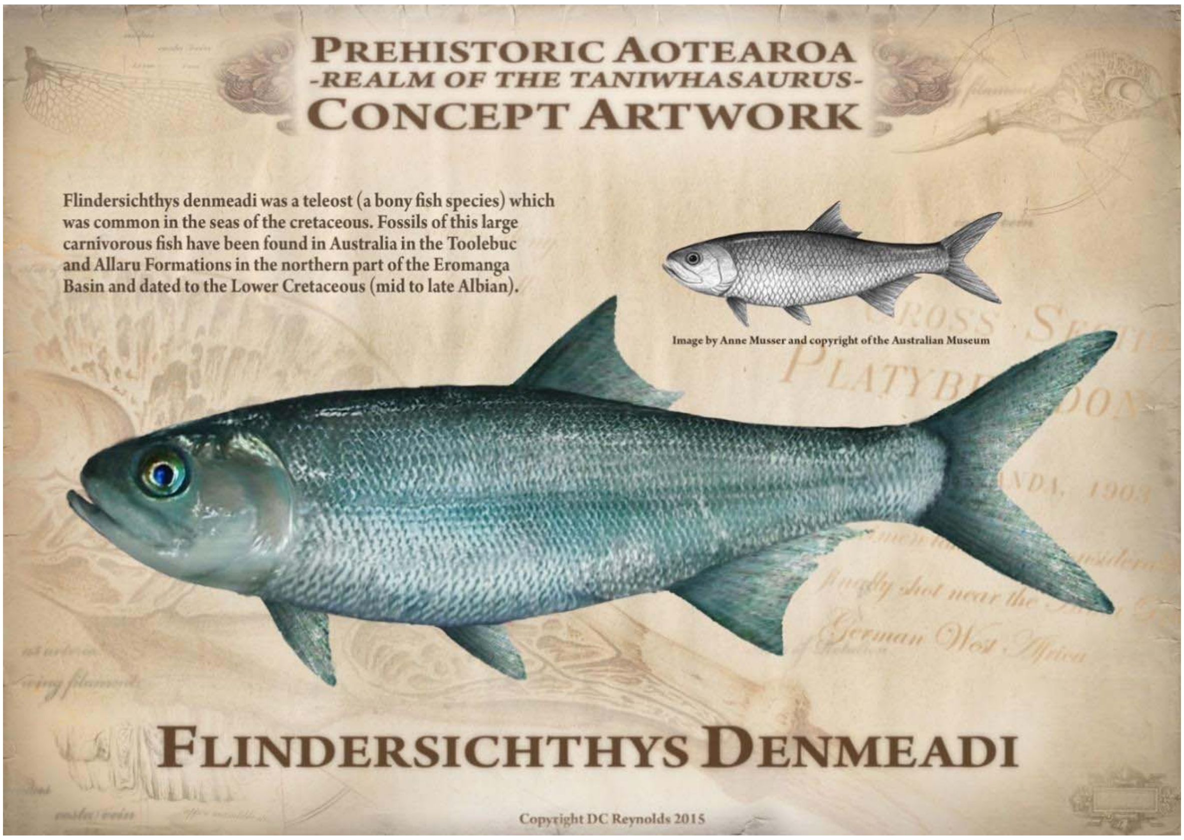

Figure 16 – Concept artwork for Flindersichthys denmeadi

The visualisation for the Cretaceous fish *Flindersichthys denmeadi* was developed using an image by Anne Musser that was published by the Australian Museum. This fish was part of the group Elopiformes and as previously mentioned has close living relatives such as tarpon and ladyfish.

The visualisation was built up using photographs of skin textures of these living descendants.

Figure 17 – Concept artwork for Gunnarites spathi

The visualisation for the Late Cretaceous ammonite *Gunnarites spathi* was developed on top of a photograph of the fossil supplied by GNS Science in Wellington, which holds the National Palaeontology Collection and maintains the New Zealand Fossil Record file.

The proportions of the shell were modelled on those in the photograph, however as there was no soft tissue which survived it, was not possible to follow the same process for the soft-bodied animal.

Other information had to be collected by observing the closest living relatives. Whilst closely resembling the modern living nautilus the ammonite was actually more closely related to today's cuttlefish. The eyes, shape of the tentacles, siphon and patterns were all taken from living Pacific cuttlefish species. The patterning of the shell was taken from the patterning on the Pacific nautilus.

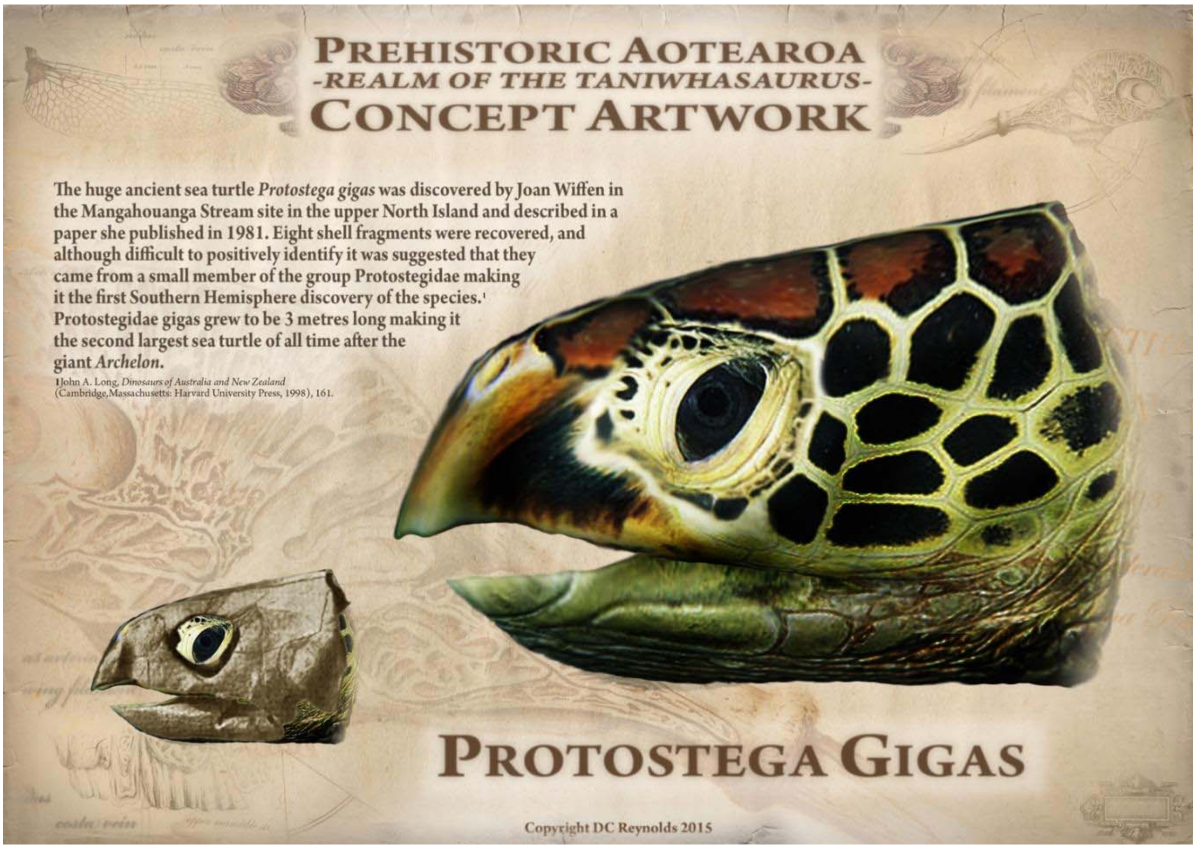

Figure 18 – Concept artwork for Protostega gigas

A side profile photograph of *Protostega gigas* was used in as the basis for this visualisation in order to again make sure the proportions were accurate. More complete fossils from the United States of *Protostega* show that it was an exceedingly large turtle, which was able to grow up to 3 metres long making it the second largest sea turtle of all time after the extinct giant *Archelon*[221].

Fossilised stomach remains of Protostega have shown that it ate shellfish, whilst it itself fell prey to mosasaurs and sharks.

The reconstruction was created with modern sea turtle photographic textures, ensuring the patterning and scale colours were all true to actual sea turtles.

[221] Dixon, *The Complete Illustrated Encyclopaedia of Dinosaurs & Prehistoric Creatures*.

Figure 19 – Concept artwork for Taniwhasaurus

The reconstruction of *Taniwhasaurus* was built on a photo of a fossilised skull. Taniwhasaurus was closely related to the mosasaurs *Tylosaurus* and *Hainosaurus*. Preserved mosasaur skin has been found fossilised and this has indicated that these marine reptiles had scaly skin similar to their closest living relatives today, which are monitor lizards.

Using images of the preserved skin scales as well as the information regarding the countershading being established from fossilised melanin it was possible to reconstruct *Taniwhasaurus* from photographic textures.

The interior of the mouth was created using the photographic textures from actual monitor lizard and Komodo dragon reptile mouths to ensure the correct flesh tones and texture.

4.3 Modelling and Texturing *Taniwhasaurus*

The initial low poly modelling was done in *Autodesk Maya 2015* utilising the modelling toolkit, specifically the quad-draw tool.

Both creatures were modelled over imported images of skeletal remains, fossils and profile images of reconstructed anatomical drawings. For *Taniwhasaurus* it was possible to utilise the newly discovered fossil evidence that showed mosasaurs had downward pointing shark like tails and not straight tails like crocodiles[222].

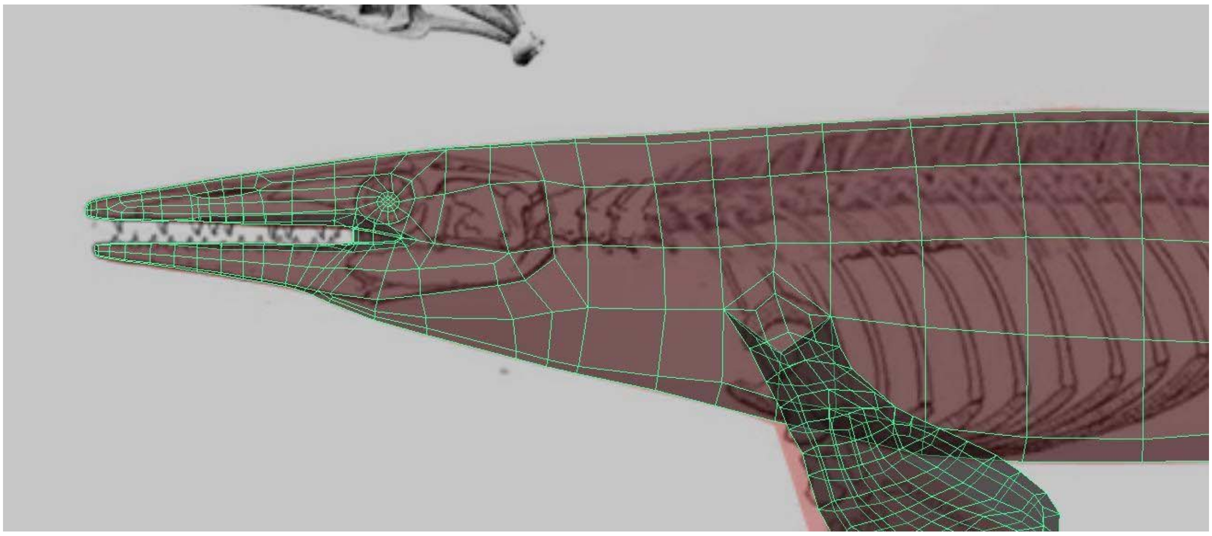

Figure 20 - Image showing the low-poly initial modelling stages for Taniwhasaurus *which were done in Autodesk Maya utilising the quad-draw tool.*

The UV-unwrapping of the mesh was done in Maya before the 3D object was exported to *Autodesk Mudbox 2014* for digital sculpting.

Both creatures were modelled world-scale, which meant that each creature was modelled to the size it was in reality.

[222] Lee, 10, and 2013, "Shark-like Tails Sped Ancient Sea Monsters Through Oceans."

For *Taniwhasaurus* the soft tissue sculpting was aided by studying a sculpture of the close relative *Tylosaurus* which was created under the supervision of palaeontologists at the Carnegie Museum of Natural History. This sculpture illustrated the musculature of the animal as well as areas of loose skin.

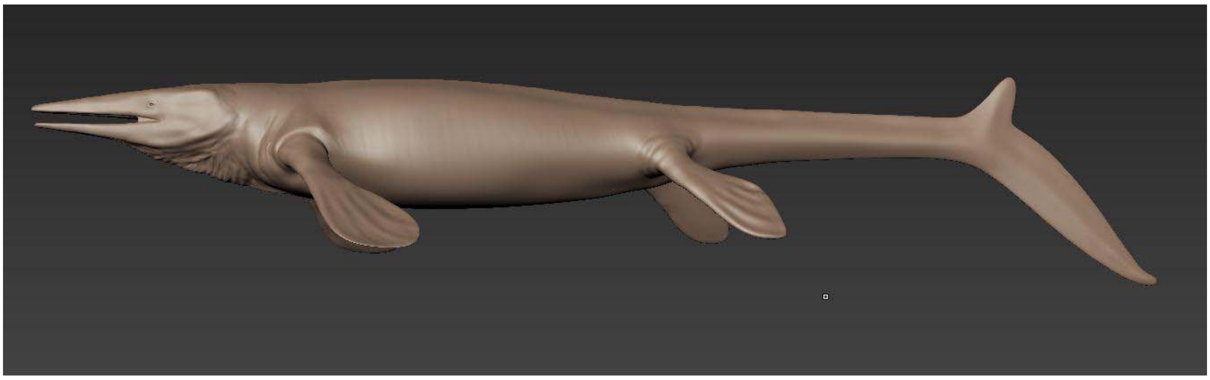

Figure 21 - The soft bodied tissue sculpting was done in Autodesk Mudbox using a sculpture of the anatomy of the close relative Tylosaurus.

The loose skin details such as the wrinkles under the lower jaw were taken from the modern living relatives of Taniwhasaurus the monitor lizards and komodo dragons.
Using the photograph of the preserved scales of a *Tylosaurus proriger* found in the United States[223] it was possible to create a sculpting stamp that would directly transfer the information from the photograph to create the 3D texture of the scales on the 3D model. This meant there was no artistic interpretation to the scales, they were not designed but were actual scales from a close relative of *Taniwhasaurus*.

[223] Kansas, *Scales of Tylosaurus Proriger (KUVP-1075)*.

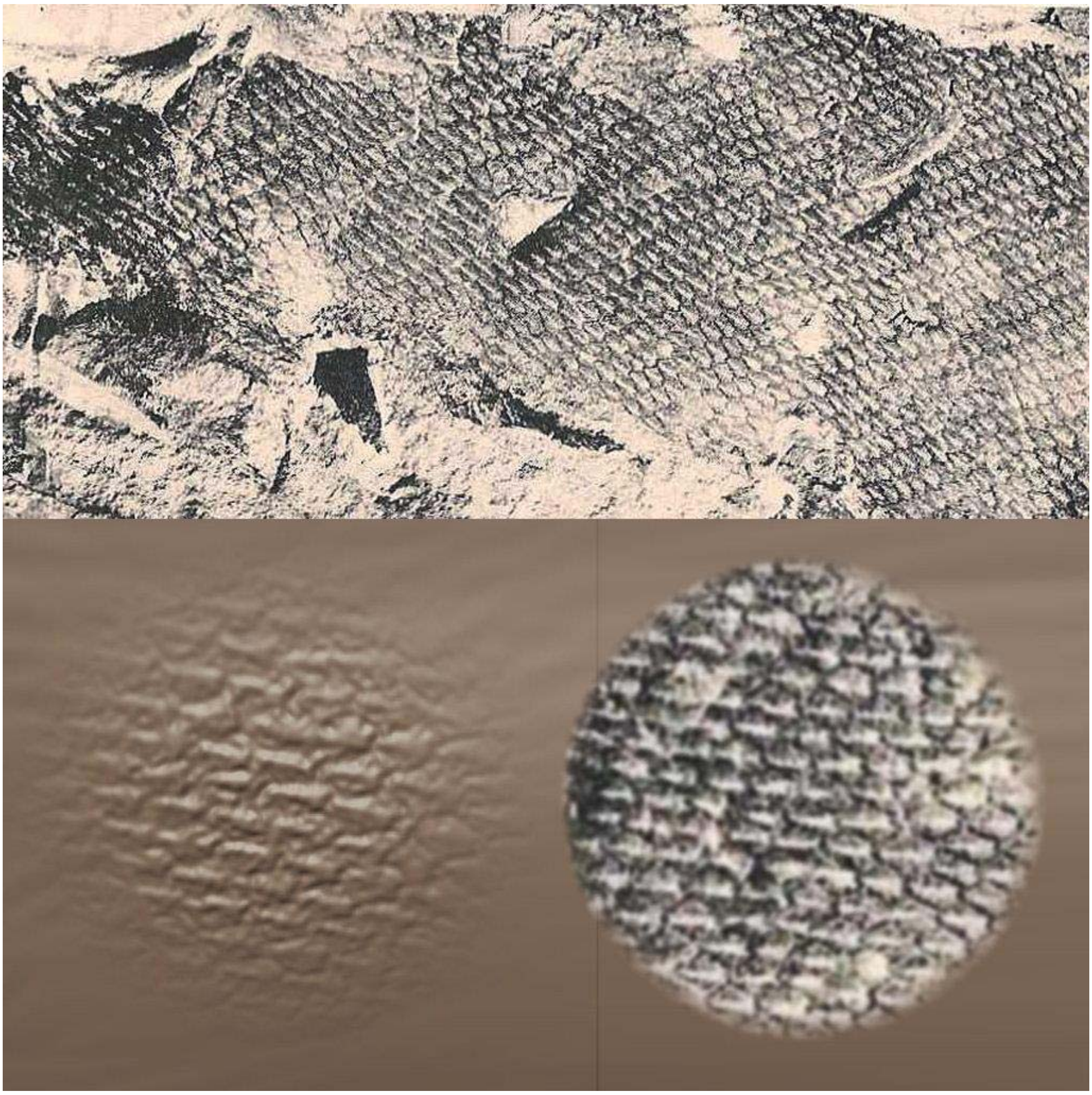

Figure 22 - Image showing the preserved scales of Tylosaurus proriger *and the result of the photograph being used to sculpt the surface of the 3D model.*

As far as research for the project could ascertain, this is the first instance of fossil scales being used in a 3D program to physically sculpt the surface to create the same features the creature would have had in life 65 million years ago.

Taniwhasaurus was then taken into the 3D painting program *Mari* (2015) and was painted using layers of photographic textures.

To keep to the methodology of scientifically driven decisions versus aesthetic design choices, all the photographic textures came from subjects directly related to *Taniwhasaurus.*

Figure 23 - Taniwhasaurus *during the texturing stage, the texture maps and secondary maps were painted from photographic textures in the 3D painting program Mari (2015) edition.*

Photographs of preserved *Tylosaurus proriger*[224] scales were imported and used to create the correct scale patterning, as well as the 3D rendering maps such as the specular reflect, specular roughness, subsurface scattering and specular wetness maps. The displacement maps were also produced in Mari, and consisted of the broad displacement map and fine displacement map. These were for raising and lowering the surface of the 3D model when rendering and to create the very fine surface textures such as wrinkles and scratches respectively.

Taniwhasaurus' surface was laid out over 12 UV tiles, each with the resolution of 2K resulting in very high-resolution detail possible in the renders. The renders were achieved with the renderer *Arnold* in *Maya*, which is known for exceedingly quick renders of high-resolution objects.

[224] Ibid.

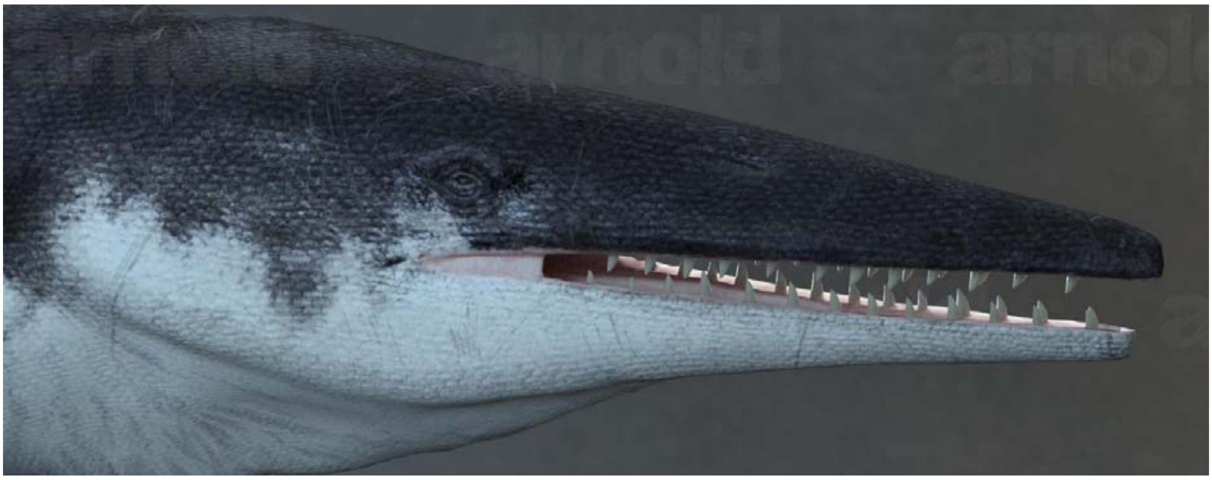

Figure 24 – Countershading illustrated on Taniwhasaurus

The coloration called countershading where the upper part of an animal is darker than the much lighter underside was based on the scientific research published by Johan Lindgren in *Nature*.

His paper showed that fossilised melanin in the skin imprints of fossils showed clearly that marine reptiles such as the mosasaur, ancient turtles and ichthyosaurs had strong countershading, being predominantly black on the upper surfaces and white underneath.[225]

He notes that situation is echoed in other species which evolved at different times, and is thus an example of convergent melanism. Convergent evolution is where two animals from a different background evolve similar traits to occupy a role in an ecosystem.

Melanism is a process by which an animal develops darker areas.

So convergent melanism would describe two independently evolving creatures resulting in the same darker skin surfaces.

Dolphins, porpoises and whales are mammals that evolved to live in water and also predominantly display countershading as well. This would make it an example of convergent

[225] Lindgren et al., "Skin Pigmentation Provides Evidence of Convergent Melanism in Extinct Marine Reptiles."

melanism since they have evolved a similar coloration to the now extinct and unrelated marine mosasaurs.

Both the above examples would have evolved long after fish and sharks, some of the oldest known vertebrates which would have been displaying countershading throughout the 500 million years fish and sharks have existed on our planet.

Convergent melanism has proven to time and time again develop countershading in creatures that are entirely unrelated by time or lineage.

It is interesting then to note that this could predict how extra-terrestrial animals may look in marine environments, since all they would need is a sun above, dark water below and predators which hunt by sight to trigger the process of convergent evolution resulting in countershading.

Photographic weathering studies of the teeth of animals that occupy the same niche in modern eco-systems were studied. So the teeth of dolphins, toothed whales and porpoises were studied as well as the teeth of the closest living relative: the monitor lizard.

When rendering tests were undertaken the teeth were adjusted to have the same reflective properties and translucence of teeth in the above mentioned photographs.

Although not showcased in the short animation, the digital model of Taniwhasaurus has the smaller inner upper jaw which was unique to mosasaurs such as this. This smaller inner upper jaw moved food down the animal’s throat after biting on it with the larger main set of jaws.

The actual photographic skin textures of the pink soft tissue inside the mouth and around the lips as well as inside the throat are taken from high resolution photographs of the closest living relative to the Taniwhasaurus, the monitor lizard and Komodo dragon.

Luckily like crocodiles these large reptiles like to bathe in the sun with their mouths open meaning that a large amount of high-resolution photographs could be found as reference.

To understand the way the flesh of the mouth would absorb light, photographs were studied of large marine mammals like dolphins and toothed whales.

Orca and dolphin are also photographed at close quarters often at places such as Sea-World where they are trained to rest their heads on the pool edge and open their mouths for the cameras. This again allowed for a large amount of high-resolution photographs to be collected and the rendering settings on the 3D model to be adjusted to allow for the same amount of wetness and translucence.

The same process of observation and implementation followed for digitally lighting and compositing the marine reptile into the underwater footage.

Underwater photographs and video of sharks during close encounters with cage divers showed how an animal the size of Taniwhasaurus would underwater in the Pacific Ocean at varying depths.

The small particles in sea water mean that (depending on the local, ocean, depth and light conditions) an animal in water will disappear into the blue underwater haze or, when closer, the part of the animal that is closer to you will be seen clearly while the furthest part will start to fade into the deep blue background water.

This was observed closely with footage of sharks the same size as Taniwhasaurus, and the same faint distance induced low visibility was achieved on the 3D model during compositing.

Also in this footage was observed light ripples (known as caustics) which were rippling over the creatures back, and this was replicated on the 3D model in shots were the lower depth and better lighting conditions meant these light ripples would have been evident.

4.4 Modelling and texturing *Gunnarites spathi*

As was the case with *Taniwhasaurus* the initial low poly modelling was done in *Autodesk Maya 2015* utilising the modelling toolkit, specifically the quad-draw tool.
Scan data was made available of a nautiloid shell from the Idaho Virtualization Laboratory, a museum department specialising in 3D scanning, as well as the 3D pdf file from GNS Science in Wellington which has some examples of ammonites which have been 3D scanned and been made available to the public.
This in conjunction with close observation of the fossils in my collection allowed me to plan for the 3D modelling stage in order to correctly represent the spiralling geometry of the shell.
It also became apparent that the soft-bodied part of the creature had a very different structure to the shell, and so could be modelled after the initial shell modelling stage.
Using a side profile image of *Gunnarites spathi* the correct proportions and dimensions were modelled in, as well as more subtle details such as the more corroded older centre-point of the spiral in comparison to younger more crisply detailed exterior of the spiral.
Using a Vernier callipers it was possible to measure the differences in height of the peaks and troughs on the fossil shells which aided the accuracy of the 3D modelling.
Corrosion and build-up of rock sediments on the exterior of some of the fossil shells meant it was important to look at well preserved high resolution images or examples of shells that had been preserved with a good undamaged exterior.

The soft part of the creature was modelled after data was collected on cuttlefish and squid. The ammonite is extinct, and the closest living relatives are in fact cuttlefish and not the nautilus, which is another living cephalopod with an exterior shell.

While a Pacific nautilus shell was used from my collection to examine the shell details such as lustre and striations for the modelling of the 3D shell, observation of Pacific species cuttlefish was used to model the body and tentacles.

Figure 25 - Comparison of the photograph of the fossil and the overlaid 3D model as it was when first brought into Mudbox.

Initially the concept art and early 3D model of the ammonite featured a hood, which is an anatomical detail of the living nautilus, but when it was discovered the closest living relatives are in fact cuttlefish that do not feature a hood, it was decided to remove the detail to keep to scientific accuracy.

Details such as the eyes, siphon, tentacle shape, sucker arrangement and size were all taken from examples of actual Pacific cuttlefish.

When the 3D model was taken into *Mari* to be textured, high-resolution photographs of Pacific cuttlefish were painted onto the model to keep to the accuracy of the scientific information.

Skin patterns were taken from actual living cuttlefish, and were applied to the same areas on the cuttlefish model so that the tiny dots of skin pigment, or chromatophores, would have the correct patterning and density.

The camouflage patterning for the shell was derived from a combination of nautilus shell camouflage and the very similar striped brown camouflage found on the back of some cuttlefish species.

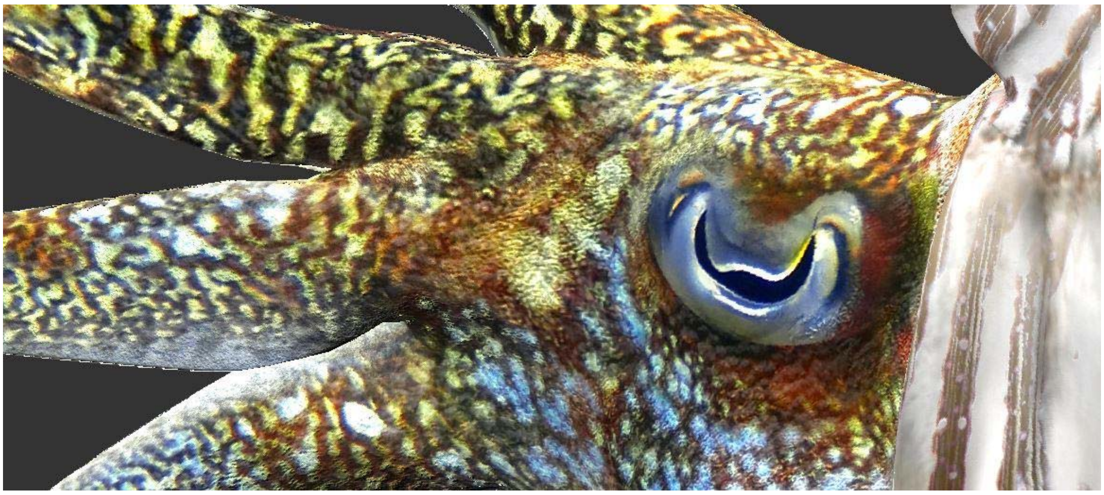

Figure 26 - Viewport render in Mari showing the painting of the high resolution texture.

The secondary maps, which help the render, give fine details like wrinkles, sheen, lustre and translucency were also created in *Mari* at this time.

These maps were then exported to *Maya* and rendered with the *Arnold* Renderer plugin.

High resolution photographic close-ups of cuttlefish in their natural habitat were studied to observe what details could be seen. Wrinkles, subsurface scattering, and translucency were adjusted to reflect the data gathered from these photographs.

Figure 27 - The 3D model of Gunnarites spathi *shown in Maya and rendered with Arnold.*

4.5 Animating *Taniwhasaurus*

Information regarding the swimming locomotion of mosasaurs was obtained through research into scientific literature on mosasaurs and their habits, particularly *Oceans of Kansas* by Cretaceous marine reptile expert Michael J. Everhart.

Newly published scientific research that revealed a new understanding of how mosasaurs swam was also researched. These new findings were published in *Nature* and described how a fossil was found with an outline of a shark-like tail.

Originally palaeontologists thought mosasaurs had straight tails like crocodiles and lizards, but now they understand the tail was actually sickle shaped like a sharks.[226]

This changed how researchers think they swam. Instead of older theories that it swam like a salt water crocodile or monitor lizard, they now think it may have been faster and more agile in the water and swam like a shark.

I obtained footage of crocodiles swimming and large sharks swimming and carefully copied the poses from the footage onto the 3D model.

In this way the timing of the swim cycle as well as the rhythm and secondary actions would be exactly like the actual animal.

[226] Lee, 10, and 2013, "Shark-like Tails Sped Ancient Sea Monsters Through Oceans."

Figure 28 - Timing and poses taken from crocodile footage resulted in a serpentine ripple extending down the body.

Both versions of the swim-cycle were then edited together so a comparison could be made. The video shows footage of a crocodile or shark side by side the *Taniwhasaurus* as they swim, so frame-by-frame the authenticity of the movement can be inspected.

Finally the shark-like swimming mosasaur animation was played alongside the crocodile-like swimming version so a comparison could be made.

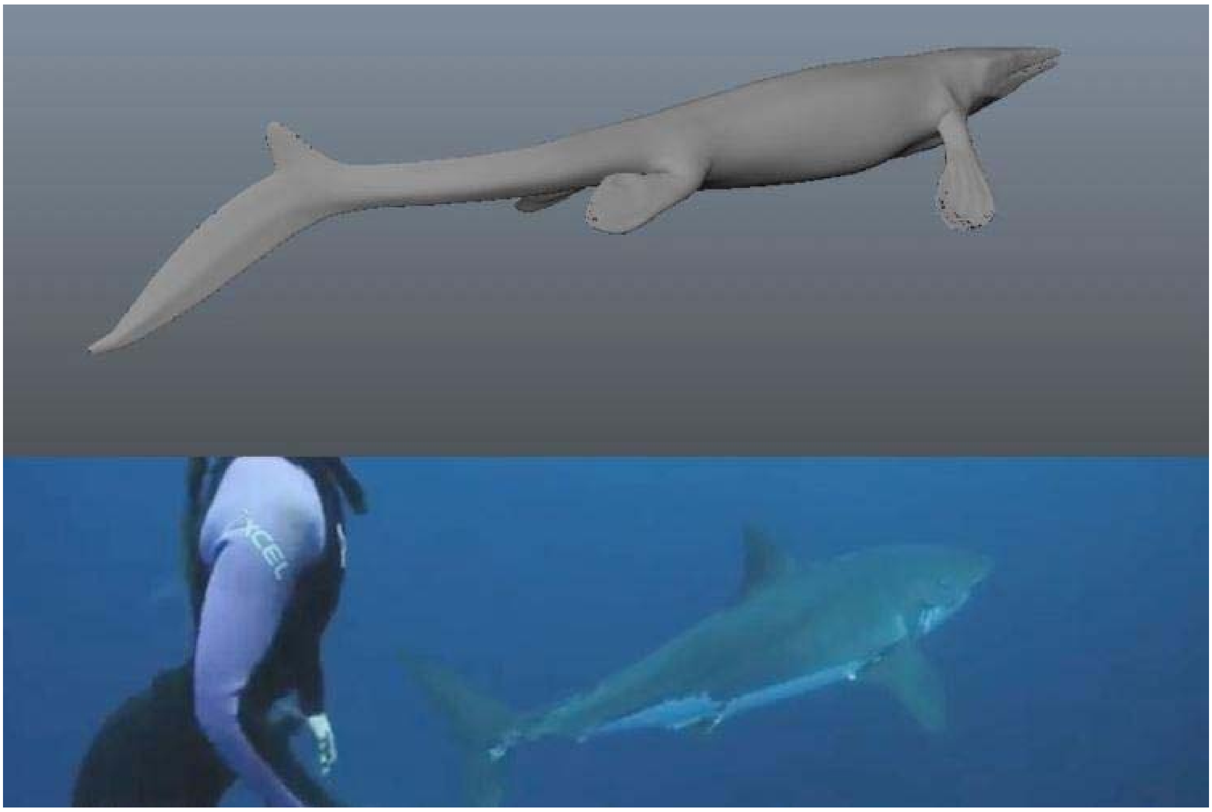

Figure 29 - The swim-cycle animated from the shark reference footage.

This edited comparison video was then uploaded and shown to palaeontologists to give their feedback.

The video is online at Vimeo and can be viewed here in its entirety for digital viewers of this document with internet access: https://vimeo.com/155336392

The response from James Crampton at GNS Science was to echo agreement with researchers who feel that a more shark like swimming locomotion was more likely.

The shark researched swim cycle was adopted, and the secondary movements on the tail and flipper were refined to give the correct drag and deformation in the water.

4.6 Animating *Gunnarites spathi*

Gunnarites spathi was animated with reference from the closest living descendants, which are cuttlefish. As the modelling of the soft tissue areas of the ammonite was based on reference to the anatomy of cuttlefish it followed to use footage of the same creatures for the animation.

Reference footage of Pacific cuttlefish[227] was collected and the poses and movements timed out in the footage.

This timing then was mimicked in the animation to ensure authentic movements directed by evidence rather than an aesthetic performance.

The siphon was animated to the timing and distortion of an actual cuttlefish observed in footage.

The secondary animation such as the drag on the ends of the tentacles when moving was also based on video reference.

The timing of the eye-movements and the range in which they swivel was likewise based on collected video reference. Cuttlefish like most cephalopods have excellent eyesight, they use their vision to detect prey and evade danger.

As can be expected from a creature that relies on eyesight, its eyes move around fairly frequently to focus on new objects it is investigating.

[227] Miki Velja, *King of Camouflage - Cuttlefish (Documentary)*.

Figure 30 - The animation of the soft tissue areas of the ammonite was copied from video reference of cuttlefish species.[228]

The locomotion of the ammonite was derived from using reference from both the cuttlefish and the nautilus.

The cuttlefish when wanting to escape danger uses a jet of water from its siphon to move quickly backwards and away from danger.

When the cuttlefish darts away backwards it moves in a straight line as its body is streamlined. The ammonite has a large shell that has a much higher profile than the cuttlefish. When the Pacific nautilus swims along it bobs or rocks back and forth in a rhythmic manner due to the shell profile resisting forward motion in the water. As the ammonite also had a shell with a high profile the rocking motion of swimming through the water was adopted from the Pacific nautilus.

[228] Ibid.

Figure 31 - Timing and range of motion for the swimming locomotion of the ammonite was taken from the Pacific nautilus.

4.7 Cinematography and editing

Video elements such as the surface of the ocean as seen from underwater were obtained from stock footage suppliers.

The duration of the shots and the cinematography was replicated from documentary footage. The ammonite *Gunnarites spathi* and mosasaur *Taniwhasaurus* obviously do not still exist to see documentary footage of, but there are modern relatives and creatures which occupy their roles in ecosystems to see video footage of.

The cinematography and shot duration of the ammonite shots were based on documentary footage of cuttlefish. This documentary footage is most frequently shot at close quarters, as the cuttlefish is fairly small and so the camera needs to be closer to it to record a satisfactory visual for the documentary.

This means there is less water between the camera and the animal, so the cuttlefish is seen clearly with its colours less filtered by the blue water.

Also since it is a smaller creature it does not fade into the blue water background as a larger marine animal would.

The cuttlefish is mostly seen in shallower coastal waters, and this is reflected then in the ammonite footage. Because the water is shallower it more frequently features the ocean floor at the bottom of the footage, unlike deep open ocean footage that fades to dark blue when looking down.

Figure 32 - Shot duration, cinematography and composition were all taken from video reference of cuttlefish.

Caustics were observed in different shots of cuttlefish, but were absent in just as many others. The smaller size of the animal meant its upper surface area was not large enough to see a complex pattern of caustic light ripples.

The observed evidence was implemented and the ripples were not visible in some shots and were more prominent in others.

The finished animation was rendered in the renderer *Arnold* for *Maya*, and was then composited into the underwater footage using *Adobe After Effects*.

Some post production animation was added to increase the realism of the shots and make it more like the observed cuttlefish footage.

This included caustics on some coral and subtle light rays added filtering through the water. These effects were created in *Adobe After Effects*, as well as small particles drifting in the water that were observed in the reference footage.

Figure 33 - The deeper water environments had a far more intense blue, and none of the sea floor was visible.

For the shots that featured *Taniwhasaurus* video reference was collected of sharks swimming past cameras. Sharks such as the Great White are the same size, have the same countershading coloration and occupy the same role in the ecosystem.

The shark footage was often from cage diving experiences, and so offered clear video reference for the shots with the mosasaur *Taniwhasaurus*.

The deeper water environment meant none of the sea floor was visible, and it faded into a solid dark blue layer as the camera looked down.

Particles were visible in some of the shots, and this was also added to the footage of *Taniwhasaurus* along with light rays.

The large size of sharks meant that they would often appear more obscured and faded when at a distance in the water. As they swam closer the closest parts of their bodies to the viewer would fade into view and become clearer, whilst areas that were further away such as the tail would still be more faded.

This was also implemented into the shots with the mosasaur to give the correct level of opacity to the water as the reptile swam toward the digital camera. Light rays were also represented in some shots, but due to the deeper nature of the water in the reference footage in some shots the rays were absent and in others quite faded.

An infographic panel was also included for each of the creatures; this panel gave basic information such as size in comparison to an adult human, name of the animal and how long ago it lived.

This panel was designed to give limited but relevant information, and was included to demonstrate the video as a museum exhibition video that would play alongside a fossil exhibit.

The nature of museum video exhibits is that they will play looped and so frequently do not have audio as repeating audio is more distracting in a public space than repeating silent footage.

Some museum exhibits do have screens with supplied headsets but due to the health implications this is not always supplied.

The design of the footage as an experience precluded the need for a narrator that was another factor when considering the addition of audio. Audio effects were added, but not music. The sound effects were ambient and reflective of what we as humans would be able to hear in the setting.

For the surface of the water, ambient marine water splashes were used, whilst the underwater shots featured muffled underwater rumbling. These sound effects were obtained from suppliers of stock audio effects and were credited for their contributions.

5 Discussion

When evaluating the results it is important to reflect on the initial research question that prompted the investigation.

The initial research question which was "Can anthropomorphism and artistic interpretation be removed from 3D animated prehistoric visualisations and still be captivated to the public?" is answered from the results in the following discussion.

The results indicated that a generative art methodology that relied on scientific evidence instead of aesthetic and performance driven decision making to create a prehistoric visualisation is possible.

However this is directly dependent on the amount of scientific evidence available for the creature that is the subject of the visualisation.

Thus anthropomorphism and aesthetic decision making considerations do not need to be the driving force behind a prehistoric visualisation, as long as there is enough credible scientific evidence to direct the process.

Using the reception and critical feedback from museum staff, palaeontologists and scientific communicators outlined in the methodology as a tool to evaluate whether scientifically derived visualisations could be used to educate the public the following results were observed.

All the scientific institutions that have seen the animated clip and rendered stills have reacted favourably, with one of the palaeontologists from GNS Science in Wellington describing it as "fantastic"[229] and asking for use of the visuals in a presentation for an upcoming expedition.

Auckland Museum gave praise to the work and asked for permission to display it in two different venues.

Notably one of the Auckland Museum science communicators was very enthusiastic about incorporating the animation into a presentation that the Museum puts on for school tours. This was to specifically illustrate what a mosasaur looked like in life, and was to compliment an existing part of their show that was showing a mosasaur skull to discuss ancient New Zealand.

Having an Auckland Museum science communicator enthusiastically volunteer the idea of using the animation as a way to quickly communicate the reality of these animals to the public certainly validated that a more scientific approach did not mean less fascinating. Anthropomorphism was totally unnecessary to communicate these animals to the public. There was no need for strong emotionally charged constructs such as dramatic music and characterization of animals to keep attention.

The other way the Auckland Museum planned to display the footage was by incorporating it into a renovation of the prehistory exhibit to be shown alongside fossils and casts of fossils of creatures that lived in New Zealand during the Late Cretaceous.

This was for the same reason to communicate quickly what these animals looked like in life. Apart from still illustrations of these animals there was no moving imagery in the display area showing how they would have looked and moved.

[229] Crampton, "Ancient New Zealand Animation."

The fact that many visitors are international, and that the video does not rely on dialogue to explain the imagery means that it can be understood by visitors from any nation as a visualisation of an extinct animal.

The current exhibit does have a looped video on display, but there is no audio for the video.

Looped repetitive audio can be distracting in a museum space, so the fact that the animation is not reliant on audio to connect with the audience is a positive factor.

The video makes use of silhouettes of the human body and human hand to indicate scale next to the creature, which are the icons most frequently used to indicate scale in books of dinosaurs[230][231].

This communicates scale quickly to people of all cultures without the use of language.

The project did present many challenges, which presented opportunities for innovation.

Firstly would be the underestimated amount of time it takes to research and model an extinct animal accurately.

Even modelling an animal with photorealistic textures that exists today can take several months.

In the television series *Game of Thrones* it takes a team of ten different visual effects specialists six months to do a single shot that features a dragon[232].

These shots are rarely longer than ten seconds so the fact that two minutes of animation was completed in eighteen months of production by a single 3D artist shows that the rate of production is promising for a project such as this.

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[230] Dixon, *The Complete Illustrated Encyclopaedia of Dinosaurs & Prehistoric Creatures*.
[231] Haines and Chambers, *The Complete Guide to Prehistoric Life*.
[232] "See What It Takes to Make a Dragon on 'Game of Thrones.'"

There would be an extremely interesting array of creatures which could be presented if more time allowed, and hopefully in the future opportunities for more 3D artists to visualise prehistoric creatures from New Zealand and other parts of the Pacific will present themselves. If this project could be undergone again less time would be spent on visualising extra creatures that there was no time to model and animate.
This time could have been better implemented as time spent on animation or the written aspect of the project.

From the research conducted into the findings of New Zealand palaeontologists it is clear New Zealand has had a fascinating past, and the fossils of creatures found and studied by dedicated researchers is astounding.

The strongly positive reception from the agencies representing a scientific methodology warrants further research into response from the public.
The fact that more New Zealand children are aware of *Tyrannosaurus Rex* and not their own equally amazing *Taniwhasaurus* represents an opportunity to use current cutting edge industry technology to visualise these amazing animals for all New Zealanders.

Another consideration to any project dealing with visualisations of prehistoric creatures is the level of detail the anatomy of the creature needs.
Very quickly in the early stages of the project two important factors were raised which represented a realisation of the realities of such a project.
Firstly what level of detail the anatomy of a creature has to be modelled to in order to be considered accurate.

Secondly how reliable can a visualisation be considered when reconstructing parts of a creature which were not preserved and which has no living descendants.

The level of detail of the anatomy of a creature is dependent on the final outcome.

For a television documentary and cinema, the creature must be modelled and textured as accurately as possible to stand up to close-ups seen in films or documentaries.

This generally means only what is visible is modelled, so much of the interior anatomy such as the creatures skeleton and musculature is not modelled.

For a creature with clearly defined muscle structures a visual effects team may need to model in some parts of the skeleton and some muscle systems so the exterior of the skin.

For *Taniwhasaurus* and the ammonite *Gunnarites* muscle systems were not needed as they are not clearly defined enough in video of the modern ancestors or equivalents.

This suits the outcome of screen usage, and the rendered animation and stills can be used by professional palaeontologists in presentations for example or as illustrations in published research.

Had the creatures been modelled with a skeleton, and the muscle systems been modelled as accurately as possible it would have represented an opportunity for researchers to study the detailed range of movement and potential locomotion and speed capabilities.

This would have taken far longer, and this approach would have would have needed significant input in terms of anatomical research.

As enthusiastic and helpful as I have found the researchers at GNS Science and Auckland Museum it was clear that these individuals were busy people who had their own projects to work on each day.

A prehistoric visualisation done to the level of anatomical detail mentioned above would need a significant time investment from a researcher with many years of anatomical experience on these creatures.

The scientific benefit of having a 3D model done to this level may suit researchers but would be overkill for a documentary related product designed to capture the attention of the public. Does this mean the exterior only animation version is less realistic or accurate than the highly detailed anatomical model? The exterior of both may look the same, so the film only model may not necessarily be less accurate but it certainly would hold far less information.

Looking further into the spectrum of how detailed a digital model can be shows that there is always a way a model could be more detailed and so more accurate.

As mentioned several times during this work, fossils have been recovered which have soft tissue outlines preserved, that under a microscope revealed fossilised melanin particles. Research into these particle patterns has yielded evidence about the coloration of marine reptiles. Whilst this information was incorporated into the project it raises questions of how much more detailed the digital model could conceivably be made.

If the melanin particles that are fossilised could be studied then the potential is there to scan these microscopic fossils to determine their make-up and density.

Building a 3D model up from a microscopic and cellular level would be an enormous undertaking depending on the complexity of the lifeform.

A large animal would have many trillions of cells, and so a digital model of even a contemporary creature to that level of detail may be well beyond the timeframe of a project, or indeed beyond the lifetime of the researchers.

Initially the goal was to model and animate these creatures based on evidence to make the most accurate representation of these creatures so far created. This has been accomplished, but in doing so this has raised the question to what level must a model be created to be described as accurate?

Another realisation which became evident was how reliable can a visualisation be considered when reconstructing parts of a creature which were not preserved and which has no living descendants.

As the modelling and texturing of the creatures was underway it was apparent that even though each decision could be made on evidence rather than an aesthetic or performance, that still meant these answers from the scientific community were occasionally vague enough to allow for much room of interpretation.

An example would be the ammonite *Gunnarites spathi.*

Ammonites do not have any living descendants. All ammonites went extinct and the closest living relatives are the cuttlefish of today. So whilst the evidence states cuttlefish are the closest living relative, there are a massive variety of different species of cuttlefish so which one should be used for reference becomes a choice with no clear answer.

For this project the decision was made to use a species of Pacific cuttlefish that is about the same size and lived in a similar environment to the ammonite of the past.

This decision did result in detail down to the chromatophores, the specific dots of colour in a cuttlefish's skin to be accurate for their size and location on the creature.

Whilst the decision to use cuttlefish skin was based on evidence, there is simply no way of knowing how accurate or inaccurate that choice may have been.

With the hundreds of various cuttlefish and squid camouflage patterns and markings there is simply no way to gauge which one was accurate for the creature in life.

A lot of the details taken from cuttlefish such as the length of tentacles, sucker patterns, eye-size, skin texture etc. are impossible to determine whether or not they are correct or not. Basing a reconstruction on as much evidence as is available is certainly possible, but trying to judge a creature's accuracy in life when none of them will ever be seen by human eyes is not possible.

Even if a prehistoric visualisation happened to be entirely accurate, we currently would have no way of ever knowing it.

The crux of this project seemed ultimately to not be about pursuing perfect accuracy, but being vigilant against inaccuracy.

None of us have power over what we do not know, but being rigorous in research and determined to not misrepresent what we do know was the lesson learnt during the project.

The criticisms of anthropomorphism, drama and unrealistic emotional narrative discussed when evaluating prehistoric visualisations in films and television were not a criticism of lack of knowledge, but a criticism of knowledge that was ignored or not implemented.

An example would be the *Velociraptors* in *Jurassic Park.* In the first film the visualisations were applauded for showing dinosaurs to be intelligent, swift and dynamic.

By the time the later films had been made evidence had been uncovered which showed that these animals were almost certainly covered with a thick plumage of feathers.

Though the scientific evidence was there a conscious decision was made to keep them featherless to keep with the design aesthetic of the earlier films, and to tie in to what viewers were more accustomed to seeing.

This specific choice of aestheticism over accuracy is an example of an instance where it was not lack of knowledge, but knowledge that was wilfully ignored.

In a different area of the same discussion we find the Disney film *Dinosaurs*, which featured stunning integration of filmed environments with photorealistic visual effects and photorealistic dinosaurs. The dinosaurs spoke however, and this anthropomorphism was distracting to viewers who found themselves being lost in this seamless world… until the dinosaurs spoke.

This decision did not make the animals more believable or realistic, only more entertaining. Accuracy may be sometimes elusive, but ignoring what evidence there is to misrepresent the past intentionally is a very different situation.

Criticising entertainment for showcasing unbelievable instances is harsh considering the fact that much entertainment has leaps of fantasy. However the documentaries which drift into the world of entertainment by anthropomorphising animated dinosaurs such as *Walking with Dinosaurs, Walking with Beasts, Walking with Monsters, Sea Monsters a Prehistoric Adventure* and *Megabeasts: T-rex of the Deep* all feature entertainment driven constructs such as anthropomorphism, emotive narration and structured storylines not seen in nature. These constructs do not make the creatures more impressive or endearing, they only make them less realistic to what these remarkable animals were.

6 Conclusion

A closer working relationship between science communicators and prehistoric visualisers will result in visualisations which are more accurate, and rely less on aesthetic driven decision making or entertainment constructs such as anthropomorphism.

A generative art approach where scientific data replaces aesthetic decision-making is possible, but does depend on the amount of information available to a specific species.

Considering that peer reviewed published scientific data from palaeontologists is available online and in back catalogues of scientific journals a thorough and rigorous research process is critical to result in a visualisation which has scientific credibility.

There has always been strong public interest in seeing the creatures of the past on screen or television, and as a result prehistoric animals have made fairly regular appearances over the last 100 years of the moving image.

As special effects and animation technologies have improved over time the visualisations have improved also, and are capable of animated photorealistic creatures.

Whilst the visuals have become more realistic the storytelling tradition of anthropomorphising creatures means that many visualisations are extremely unrealistic.

In a film or television show designed for entertainment purposes this has proven to be an effective storytelling addition.

Unfortunately these extremely unrealistic anthropomorphised visualisations also occur with regularity in media such as documentary film.

Wildlife and documentary films are looked at by the public as an authoritative voice of researchers and scientists and so have an opportunity to educate.

The viewers responding to the authoritative tone believe the information presented to be based on scientific evidence and free of bias or misrepresentation.

The general public expect documentary films to be free of entertainment-based constructs such as a scripted narrative, anthropomorphism, emotional dialogue and unrealistic behaviours.

Unfortunately documentary films often use entertainment orientated constructs and so misrepresent reality to the audience.

This is notable in documentaries featuring visualisations of extinct wildlife since every aspect of anatomy and behaviour is constructed and not simply filmed from the wild.

Artificial constructs by filmmakers such as anthropomorphism, scripted actions and emotive content driven by an artificial narrative has featured in many prominent prehistoric visualisations.

Despite the continuing improvement in visualisation technologies that represent the extinct creatures in a more photorealistic manner, the narrative and direction leads the film from being documentary to being entertainment.

Instead of informing the general public, they misrepresent animals of the past and damage the audience's perceptions of what these creatures actually were.

Through more than two centuries of fossil finds and research, scientists have collected a vast amount of data on prehistoric ecosystems and the animals that used to inhabit them.

Each year more discoveries are published which gives a clearer image of the past, and the evidence is clear that prehistoric creatures were as fascinating and dynamic as animals today. These incredible animals do not need the addition of character or human emotions to intrigue the viewers. Artificial motivations and anthropomorphism is unnecessary as the public already finds prehistoric creatures to be mesmerizing.

Photorealistic visualisations of these animals can be enthralling whilst not straying from evidence based conclusions in prehistoric visualisations.

Scientific communicators and professionals involved in the fields of communicating scientific data to the public see the benefits of prehistoric visualisations that educate rather than misinform the public.

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