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Author(s): Townsend, A. & Carter, J.

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Making a life-size model of a *Rhizostoma pulmo* (Barrel Jellyfish) for the Amgueddfa Cymru – National Museum Wales marine displays

Annette Townsend* & Julian Carter

Department of Collection Services,
Amgueddfa Cymru – National Museum of Wales,
Cathays Park, Cardiff CF10 3NP

*Corresponding author: Annette.townsend@museumwales.ac.uk

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Abstract

Rhizostoma pulmo, commonly known as the barrel jellyfish, is a large enigmatic jellyfish commonly found off the southern and western shores of Britain. It has a thick domed bell of variable colour from whitish to blue, which can be up to 90cm in diameter, with four pairs of oral arms. It frequently comes to the attention of the public as it can end up washed onto beaches in large numbers. The marine gallery at AC-NMW contains specimens and objects which represent both the work of the museum scientists and the habitats and species from the local Welsh environment. In 2012 the Department of Natural Sciences chose to commission a life size model of the *Rhizostoma pulmo* to include in the marine displays. This paper documents the materials and techniques used to create the life-size replica jellyfish and also the practicalities faced in the preservation of real jellyfish specimens.

Keywords: Displays; Scientific models; Jellyfish; Fluid preservation; Moulding; Casting

Introduction

During 2010/11 the National Museum Cardiff closed all of its West Wing galleries to replace the roof and to develop new contemporary art gallery spaces. The works extensively affected one of the Natural History spaces below due to the removal of a main staircase. This provided the opportunity for the Natural History team to redevelop a section of the displays in this area. As the affected gallery already housed key display specimens such as the humpbacked whale skeleton and the leatherback turtle, it was decided to further develop the display to celebrate marine biodiversity. The redevelopment needed to take best advantage of the gallery's height, so the decision was made to use large impressive hanging specimens or models that would help capture the beauty and wonder of the marine world. Some sort of large jellyfish model was proposed since jellyfish are an important part of the biodiversity and ecology of the marine environment found around the coasts of Wales.

Rhizostoma pulmo was chosen as it is one of the largest jellyfish, a familiar visitor, and because of the impact it would make in the gallery. Jellyfish are also one of the reasons seasonal visitors such as the leatherback turtle and sunfish visit our Western shores as they follow and feed upon the jellyfish populations. Thus the proposed model would link well with the AC-NMW leatherback turtle specimen which was already on display in the gallery.

Preserving shape, colours and texture can be very difficult with many biological specimens. Initially the preservation of natural history material was only possible with dry inert materials such as horn, bone, skin, shells, corals, or robust insects (Reid, 1994). It was not until the development of the use of fluid preservation techniques that it became possible to preserve moist, soft biological material, such as specimens of jellyfish.

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The preservation challenges of real specimens

The history of modern fluid preservation effectively dates back to 1644 when Croone presented to the Royal Society two whole puppies preserved in the 'spirit of wine' (Birch, 1756-57). Since this time the general principle of using some form of alcohol solution as a preservative has not fundamentally changed, although during the 20th century the use of formaldehyde started to become widespread (Simmons, 2014).

Today fluid preserved biological museum specimens are prepared broadly in two ways;

- Fixation: The arrest of post mortem changes to stabilize biological tissue and prevent autolysis.
- Preservation: The long-term method used to store and protect the specimen.

Fixation and preservation can be distinctly separate processes e.g. a specimen may be chemically fixed in formaldehyde, and then stored in an ethanol solution for its long-term preservation. The two processes can also be the same e.g. a specimen may be fixed and preserved in an ethanol solution. The choice of process will depend on the type of specimen and the methods that will be used to study it. The long term aim is to preserve, as best we can, the chemical structure and morphology of a specimen.

Whilst some of the specific histochemical changes caused by many of the standard methods of preservation have been actively researched in the last 50 years (Steedman, 1976; Pearse, 1980), the overall effect of preservation treatments on biological material is still relatively poorly understood. The development of many of the methods currently used for collection preservation has been a result of trial and error, and pure chance. Fixation and preservation techniques have changed little since their discovery (Reid, 1994; Simmons, 2014), and have not been developed by hard scientific research. Many of our existing methods of preservation have significant drawbacks, as in practise it is not possible to preserve all of the components that form an organism. Fixatives such as formaldehyde form crosslinks across a range of cellular components such as proteins and nucleic acids, a process that causes significant chemical change along with tissue swelling.

Acidity is also a key long term problem with the use of formaldehyde. Alcohols such as ethanol work differently by dehydrating biological tissues which causes tissue shrinkage along with changes to the structural chemistry of proteins, although functional group chemistry remains relatively unchanged. This is a key reason why ethanol can preserve biomolecular data such as DNA (Carter, 2003). Colour loss is a significant issue with both chemical processes. Pigments are either chemically changed or extracted from the specimen. Subsequent colour loss can also occur from oxidative and hydrolytic effects. Attempts have been made to develop techniques to preserve colour, notably the use of the Kaiserling's and Wentwood methods, but none of these methods adequately preserve colour in the long term (see Simmons, 2014 for further information).

Research continues today to attempt to improve on the methods used for fluid preservation. Andries van Dam (2003) proposed a set of criteria for evaluating fluid preservatives. One chemical that has arisen from these investigations is the 'formaldehyde releaser' DMDM-hydantoin as a safer alternative to formaldehyde, and shows good potential for preserving the form, though not the colour, of soft bodied marine animals such as jellyfish. Research also confirms that DMDM-hydantoin chemical action is similar to formaldehyde making it a poor alternative for the preservation of research collections due to the inadequate preservation of components such as DNA (Carter, 2012). Research is ongoing in this field.

Soft-bodied animals such as jellyfish and sea anemones loose much of their shape and colour when preserved in fluid preservatives such as alcohol or formaldehyde, thus museum exhibitions have long tried to capture the life like form and colour of such animals through the use of illustrations and models (Fig 1). In the latter half of the 19th century the German glass-worker and naturalist Leopold Blaschka devised a solution to this problem. Together with his son, Rudolf, he established a successful business supplying glass models, mostly of marine animals, to museums worldwide, and their work is still greatly admired today. Model makers remain important even in today's digital age as a means of linking the real specimen to its size, colour and form in life, or reconstructing animals and plants of the past. Given the challenges in preserving a large jellyfish such as *Rhizostoma Pulmo* in a lifelike state it was felt that a model would better reflect the colour and form of these beautiful creatures. In addition there are many new and historic marine models on display in the AC-NMW galleries,

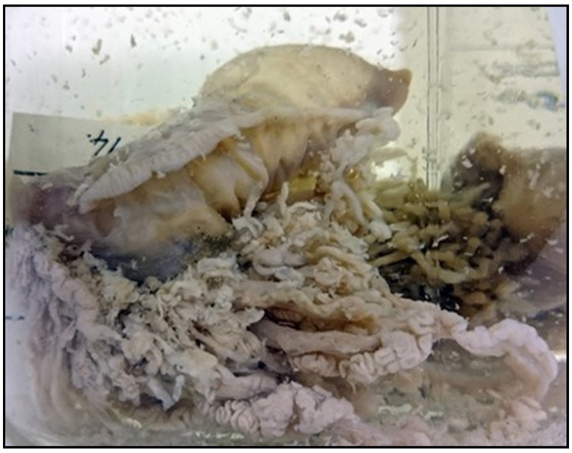

Fig. 1. An example of a formaldehyde preserved specimen of *Physalia physalia* (the Portuguese Man o' war) showing associated loss of colour and overall form.

including examples from the Blaschka collection. A model of *Rhizostoma Pulmo* would be an excellent addition to these displays and would demonstrate the important role 3D modelling still plays in modern natural science displays.

Making the model: Research and design

Moulding and casting is a process which is regularly used for many different projects at AC-NMW but the production of such a large translucent object presented entirely new challenges. Annette Townsend, the Department of Biodiversity and Systematic Biology's part time Scientific Artist and Assistant Conservator was commissioned to create the model using in-house funds. Annette had already created several models in the Natural Science galleries, had significant expertise in moulding and casting and a flexible schedule which allowed her to work on site alongside the scientific staff. Unfamiliar casting and laminating materials had to be researched, sourced and tested for performance and compatibility; also cost and health and safety played a major factor in the final choice of product. There seemed to be very little information available online about using clear resins so advice was sought from colleagues in the model making industry and from technical staff at distribution companies.

A selection of resins were ordered and tested along with different fibreglass products to see what results could be achieved. Some companies aided this process by providing small free quantities of their products. Epoxy, polyurethane and polyester resins were all considered in both laminating and casting versions and the advantages and disadvantages of each were noted.

Epoxy

Epoxies are the choice material for many museum conservators when making replicas due to their mechanical properties and resistance to environmental degradation, low shrinkage during cure and ease to work with. They are incredibly versatile so it is easy to find a product to match an application. Some disadvantages are that they can be very expensive, they pose health and safety risks and can yellow significantly over time. Most epoxies are amber in colour and there are very few colourless products available to buy; however a 'Resoltech WWA clear epoxy casting system' was found and tested. Although totally clear in terms of transparency, it initially appeared to be clear in colour when cast in thin sections but then showed a distinct yellow appearance when cast in thicker parts, so it was discounted.

Polyester

Polyester resins are probably the most common type of casting and laminating resins. They are two -component systems in which a pre-polymer resin dissolved in styrene is mixed with a peroxide catalyst. They are inexpensive and versatile, the setting times can be controlled by adding varying amounts of catalyst. Laminating polyesters are combined with fibreglass tissue and matting to create strong thin layups and casting versions can be used alone for thicker sections. The disadvantages are that they shrink considerably, are highly flammable and pose significant health and safety problems. Great care has to be taken in the working environment to deal with the styrene fumes. Polyesters are marketed as water clear rather than crystal clear and sometimes have a green or purplish tinge to them. They also discolour slightly over time. A general purpose clear casting resin was tested with good results, but the product was unpleasant to work with and concerns were raised about using large quantities of polyester in the conservation workspace. Therefore the product was discounted.

Polyurethane

Urethanes are a huge family of resins with a variety of applications. They can be purchased as foam, rigid or flexible formulas. They show very little shrinkage during cure and can set in a matter of minutes if required. Their remarkable flexibility and toughness means that they can be cast in thin sections without the need of fibreglass support. Some polyurethanes are truly crystal clear and do not appear to yellow over time. Polyurethane is a versatile material for the model maker as cured pieces can be reheated and reshaped into new positions. The disadvantages are that they are expensive, have some serious health and safety issues and are incredibly sensitive to moisture. If any moisture is present the polyurethane will froth up so it can be very difficult to obtain bubble free clear casts without the use of a vacuum. 'Poly Optic series 14' was tested with excellent results. The product set quickly and was crystal clear and strong. There were some small bubbles in the cast but it was felt that they would not be visible when the model was hanging in the gallery, therefore the polyurethane was chosen to cast the bell of the jellyfish.

Sculpting and moulding

Sculpting began with the jellyfish bell. A very basic shape was built up using bundles of bubble wrap taped around a large inflated exercise ball (Fig 2—3). This was then covered with chicken wire and coated in a Jesmonite (water based, two component, acrylic polymer/mineral resin system) and jute fabric to make a solid base to work on. It was placed on the base of a wheelie chair so the sculpture could be spun around and worked on evenly (Fig 4). Finally a layer of fine wet modelling clay was applied to the surface and flattened with water and modelling tools to achieve a smooth surface finish. A single piece silicone mould and three piece support casing were chosen for the mould design. This meant that no seem lines would be visible on the jellyfish bell cast from the silicone and the outer casing would be supportive but easy to remove. The modelled clay was kept wet during the process to prevent cracking and a first layer of RTV (room-temperature vulcanizing) silicone rubber (Tinsil 70-25) was applied to the entire surface. Subsequent layers of silicone with a thixotropic additive were brushed on and smoothed down using a touch of

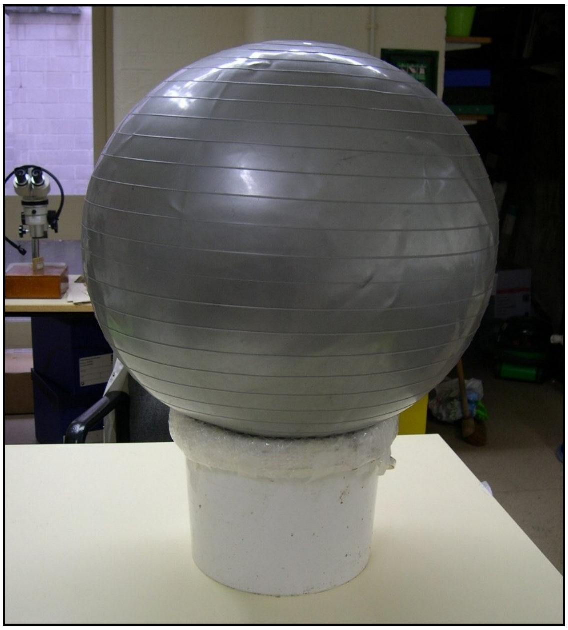

Fig. 2. Inflated exercise ball used as a base shape for the jellyfish bell) (Figure 3: Exercise ball covered with bubble wrap and chicken wire.

washing up liquid. Once completely set, flat walls of wet clay were laid on the surface of the silicone to define the separate areas for the outer support casing, then layers of Jesmonite and jute were built up on top. Once the first section of Jesmonite had set, the clay strips were removed and a separating agent (Maguire's miracle wax no. 8) applied to the seam. This process was repeated until all three sections were complete. Once dry, holes were drilled into the edges of the Jesmonite support case so it could be bolted back together after disassembly. Next the outer case and silicone mould were peeled off and the wet clay sculpture was discarded (Fig 6).

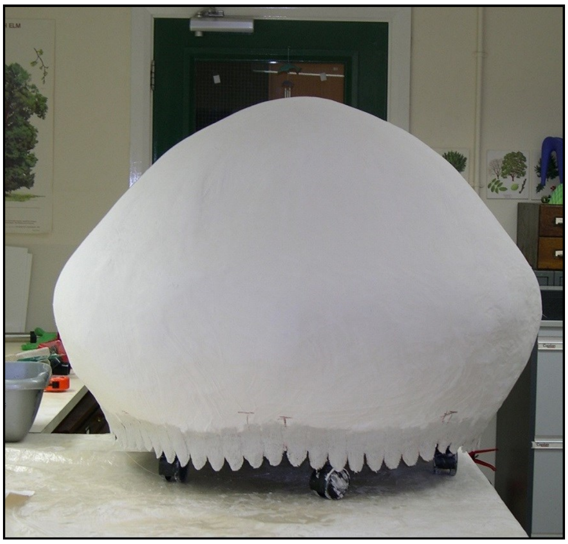

Fig. 4. Jellyfish bell coated with Jesmonite and placed on a wheelie chair for even sculpting.

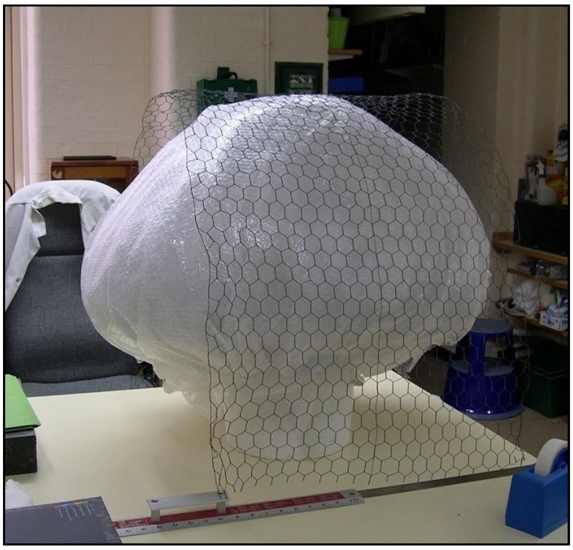

Fig. 3. Exercise ball covered with bubble wrap and chicken wire.

A similar process was used to sculpt and mould the remaining parts of the jellyfish model. The oral arms required the greatest amount of detail to model. The clay was applied in a thicker layer and covered with plastic sheeting when not being worked to prevent drying and cracking. As four pairs of oral arms were needed, it was decided to create multiple copies from just one mould, so time was spent modelling one piece in detail (Fig 7). The silicone mould was made in two sections this time so that the cast could be created in parts then joined together afterwards (Fig 8). Jute and Jesmonite were again used to make the outer support casing and the modelled clay was discarded once the mould was removed.

Fig. 5. One part silicone mould and three part Jesmonite support case. Holes were drilled into the edges to bolt the sections together.

Fig. 6. The cured single piece silicone mould being peeled off of the wet clay sculpture.

Making the casts

Although the Tinsil 70-25 RTV silicone rubber which was used is perfect for moulding on wet surfaces such as the modelling clay, it is not the best choice for casting clear resins. The alcohol and moisture that remain in the mould can inhibit the cure of the clear resin and leave the surface of the cured cast sticky. An addition cure silicone could have been considered as an alternative moulding material, but the supplier advised against its use in this situation. There are mixed reviews about the performance of addition cure silicones when in contact with wet sculpting clays, so this material was avoided. Therefore there were problems to overcome when casting the clear Polyoptic resin in the Tinsil 70-25 moulds. A colleague from the modelling industry advised that RTV silicone moulds should be baked in an oven to dry them out. The technical team at Mouldlife supplies did not think this would be effective but the decision was made to go ahead and test the method. Unfortunately the jellyfish mould was too large to fit in an oven so a plastic cover was created and the mould was heated manually with a hairdryer (Fig 9). When the mould had been treated, a first layer of the Polyoptic 14 series polyurethane resin was brushed onto the inner surface and left to set. Then further layers of resin were applied along with sheets of fine fibreglass tissue to make the cast very strong and fit for public display. Finally a purple coloured dye was mixed into the resin and painted onto the edges of the jellyfish bell to give a realistic finish. When the resin cast was removed from the mould it had set perfectly with no tackiness to the surface.

Although all health and safety precautions had been taken, an allergic skin reaction was experienced when using the Polyoptic range of resins so it had to be discarded, and an alternative choice was made for the remaining parts of the cast. The polyester clear casting resin had originally been

Fig. 7. Detail of the oral arm sculpted in wet clay.

Fig. 8. The oral arm moulded in pieces with silicone and Jesmonite.

Fig. 9. The completed jellyfish bell mould ready for heating prior to casting with Polyoptic resin.

discounted due the problems posed by styrene fumes in the workplace, but a lab space with an external extraction system was found in a remote part of the museum away from other office areas. Although it was also not crystal clear in colour, its use here was acceptable as jellyfish have natural variations in colour. The polyester was ordered and stored in an external unit away from staff and collections to eliminate risk. Once these measures were in place the clear cast polyester was used along with fibreglass tissue and coloured dyes to cast the oral arms (Fig 10). It proved to be an excellent material and was a far cheaper alternative to the polyurethane. The oral arms were cast in two parts then joined together and the process was

Fig. 11. The completed bell and oral arms painted with acrylic paints.

Fig. 10. Filling the two part silicone moulds of the oral arm with polyester resin.

repeated to produce all of the casts. The cured polyester components were stored for some time in the external unit until the smell of styrene had dissipated.

Building and finishing the model

The National Museum Cardiff building is located in the centre of town with very little in the way of outdoor spaces, so it was easier for the oral arms and lower sections of the jellyfish to be worked on outdoors at a private premises during the summer months. The seam lines were trimmed and the parts laminated together with strips of polyester and fibreglass matting. Once complete, the lower section was returned to the museum lab so the surface details could be added by hand painting and airbrushing with acrylic paints (Fig 11). All remaining parts were finally assembled and fixed with resin and fibreglass, and heavy duty monofilament wires were threaded through laminated hooks and loop holes ready for hanging.

Display

The finished model remained in storage until a slot became available for it to be hung in the gallery. During this time a safety assessment was carried out. The weight of the model was estimated, then sturdy lines of monofilament, crimps and hooks were attached (Fig 12). The fixings were tested by hanging the model from the ceiling hooks in the collection stores on long lines just above a cushioned surface.

The model was then moved up to the gallery, strapped to a plywood board and carefully moved up and into position on scissor lifts with the help of the gallery technicians (Fig 13). The hooks were attached to the ceiling fixings and finally the scissor lifts were lowered leaving the jellyfish model hanging in place (Fig 14).

Discussion

On reopening the 'Life in the Sea' the new *Rhizostoma pulmo* model made an immediate impression

Fig. 12. Attaching monofilament lines, and fixings to the model.

Fig. 13. Installing the model in the gallery.

on visitors to the museum: a group of primary school children who were visiting seemed particularly fascinated by the display. They stopped for a long time to discuss the object with their teacher and to find out more information from the surrounding specimens and text panels. The model allowed them to experience the size and scale of the *Rhizostoma pulmo* jellyfish in relation to the other specimens in the gallery such as the leatherback turtle. This is something that could not have been conveyed successfully to the same extent through the use of other media, such as video and photography.

It is important to use models to illustrate collections that cannot easily be displayed or which are altered in colour and shape from their original life-like state when preserved. At AC-NMW the combination of models and real specimens has been used effectively in the galleries to illustrate scientific stories and research that would otherwise be difficult to communicate. Models can also be seen as works of art in their own right. Visitors are captivated by the craftsmanship in historic models such as the Blaschkas, and large models such as *Rhizostomza pulmo* create a huge impact in a gallery space. The display of these models can attract new non specialist audiences to scientific displays. At this stage only qualitative data from personnel communications with visiting groups and comments recorded by visitors via the web or the comments book is available to support this. However more quantitative evaluation is being plan for the natural science galleries as a whole as AC-NMW begins to plan for

Fig. 14. The completed model hanging up in the 'Life in the Sea' gallery at National Museum Cardiff.

the future redevelopment of the Natural History part of the museum.

The making of the large jellyfish model has highlighted the importance of networking and keeping up to date with the latest techniques and materials. When good relationships are built with suppliers and peers, advice can be sought and solutions to problems can be found. This process has also shown the significance of sharing knowledge on the use and adaptation of materials, to create novel solutions with others in the field, so that our successes can be built upon.

Acknowledgments

Esben Horn at 10TONS for specialist advice on model making techniques and materials. Website http://10tons.dk/). Vicky Purewal AC-NMW and Jorge Garcia AC-NMW volunteer for practical assistance in making the model. Louise Mumford AC-NMW for kindly sharing lab spaces where the model was constructed. Ben Evans BGS and the AC-NMW technical team for assisting with the hanging and installation of the model. Thank you also to the reviewers for their comments on this paper.

Suppliers and materials

Industrial plasters, 63 Nether St, Bromham, Chippenham, Wiltshire SN15 2DP
Tel: 01380 850616
<u>Modelling clay 1150:</u>
http://www.industrialplasters.com/prod/clay/modelling-clay-1150
<u>Clear casting polyester resin:</u>
http://www.industrialplasters.com/prod/resin/clear-casting-resin

Resoltech Advanced Technology Resins, 35, Impasse Emeri, ZI Les Jalassières, 13510 EGUILLES, FRANCE.
Tel: +33 (0)4 42 95 01 95, Fax: +33 (0)4 42 95 01 98
<u>WWA clear epoxy casting system:</u>
http://www.resoltech.com/markets.php?id_mot=152

Mouldlife Ltd, Miro House Western Way, West, Bury St Edmunds, Suffolk IP33 3SP
Tel: +44(0) 1638 750679
<u>Poly optic 14 series polyurethane casting resin:</u>
http://www.mouldlife.net/polyurethane-clear-casting-systems-32-c.asp
<u>TinSil 70 Series RTV Silicone Rubber:</u>
http://www.mouldlife.net/tinsil-7025-1129-p.asp

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