CLINIC the environmental health clinic+lab

ECHOLOGY making sense of data

Presents...

MUSSELCHOIR

Natural Intelligency for Water Quality Sensoring in Urban Habitats

Brief prepared by Carbon Arts

19 April, 2013

About this Brief

This document provides an overview of plans for the implementation of the Mussel Choir public artwork for the benefit of key stakeholders and project partners. As requested by the Project Reference Group, it covers: technical and design options, milestones and time frames for delivery of the work, operations and maintenance guidelines, programming options and a marketing plan.

This is a working document for the purposes of sharing progress to date in terms of the detailed design and delivery plans for the work and for identifying opportunities for working collaboratively to ensure a successful installation, ongoing programming and maintenance. This document will continue to be developed up to and during the project development LAB in late June 2013 with a final version submitted late July, at which stage contracting for delivery can commence. Comments and feedback are requested of invited stakeholders and potential partners by 30 April to the project manager **jodi@carbonarts.org.**

These comments will be discussed at a Project Reference Group meeting on 2 May, with a view to feeding into the planning and development of the work up to the end of July.

Authors and Contributors:

Natalie Jeremijenko, xClinic, New York University
Jodi Newcombe, Carbon Arts
Javier Candeira, Monash University
Steve Marshall, CAPIM, University of Melbourne

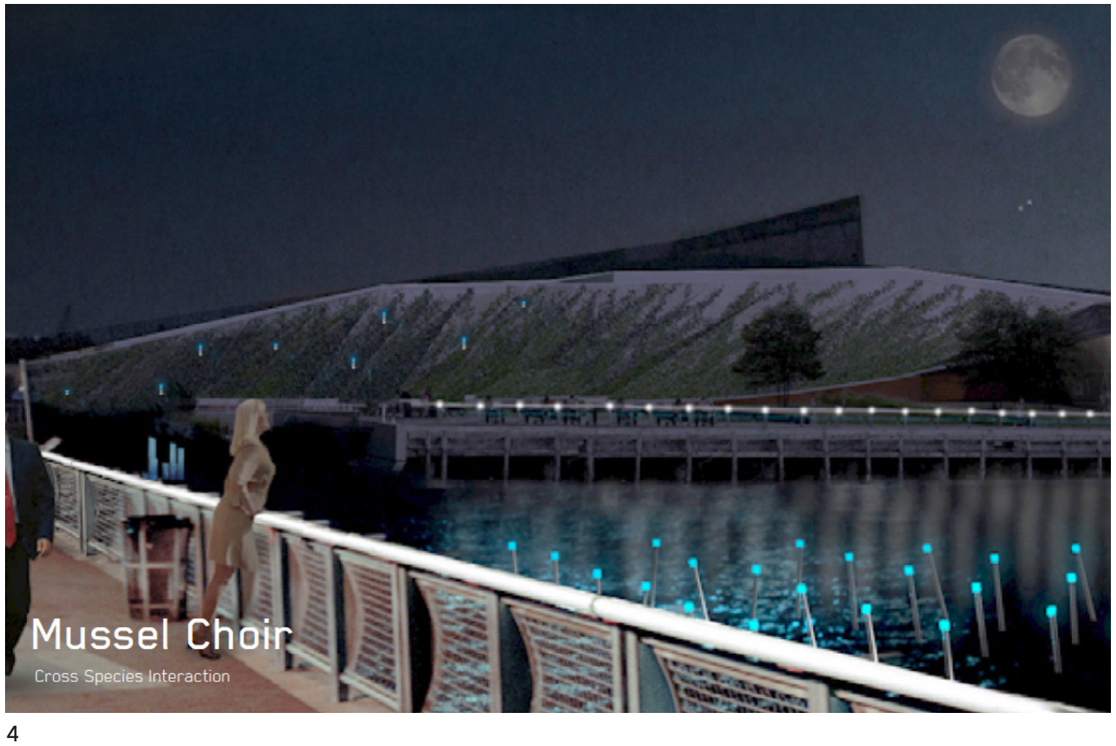
Table of Contents

Overview

Melbourne Mussel Choir is a bio-sensing public artwork planned for Victoria Harbour in Melbourne's Docklands that aims to engage the public on water quality and urban ecology. Consisting of a real, live colony of mussels, of a species native to the area, the artwork monitors the water filtration activities of these organisms and converts this data into song.

Passersby can listen to the mussel choir in situ. They can also interact with the work through social media channels, by attending regular performances or through potentially one or more off-site listening stations.

Melbourne Mussel Choir is due for launch in early 2014, in conjunction with the completion of the Victoria Harbour development (and therefore subject to any delays in delivery of the overall site). The lifespan for the work is 10 years.



Mussel Choir + Amphibious Architecture mock-up for New York City

Mussel Choir Vision

The complex systems design challenge we face in the 21st century is to synthesize a desirable urban future – with urban design that integrates biodiversity, that leverages technology for social and environmental change, and that addresses the crisis of agency: the question of "what to do". In the face of ecological crisis.

The Mussel Choir offers a hopeful song, demonstrating active remediation and therefore challenging the traditional view of sustainability through a collaboration with non-human organisms that are more effective at sustainably and inexpensively improving water quality than any comparable human technology.

In the face of ecological crisis, the Mussel Choir offers a hopeful song.

Natalie Jeremijenko, installing Mussel Choir pilot in Venice

The Artist

Mussel Choir is the work of Australian, artist Natalie Jeremijenko, currently Associate Professor in Visual Arts at New York University and Director of the Environmental Health Clinic and Lab (xClinic).

Jeremijenko is a 1999 Rockefeller fellow, a TED Global fellow, and has shown her work widely including at the Whitney Museum of American Art, MoMA, the Noguchi Museum and MASSMoCA.

In the tradition of institutional critique, Jememijenko's xClinic treats health as an environmental issue, using participatory public experiments that are often playful but nonetheless produce measurable environmental health improvements.

Echology: Making Sense of Data

Mussel Choir is the winning proposal selected as part of the Echology: Making Sense of Data initiative.

Echology seeks to encourage and create data driven public artworks that drive meaningful engagement with issues surrounding sustainability, climate change and resource use at a local level. The initiative was developed by the Australian Network for Art and Technology (ANAT) and Carbon Arts in partnership with developer, Lend Lease. Melbourne is the first site of an Echology commission, with Sydney and Brisbane to follow.

ECHOLOGY
making sense of data

Echology: Making Sense of Data

Imagine living alongside an artwork that reflects the choices you and your local communities are making towards achieving a sustainable future.... an artwork that lives and breathes, that encourages change.

Presented by the Australian Network of Art & Technology (ANAT) and Carbon Arts, ECHOLOGY: making sense of data brings together Australia's leading artists, a world leader in urban development and local communities to create data-driven public artworks that encourage meaningful engagement with issues surrounding sustainability, climate change and resource use at a local level.

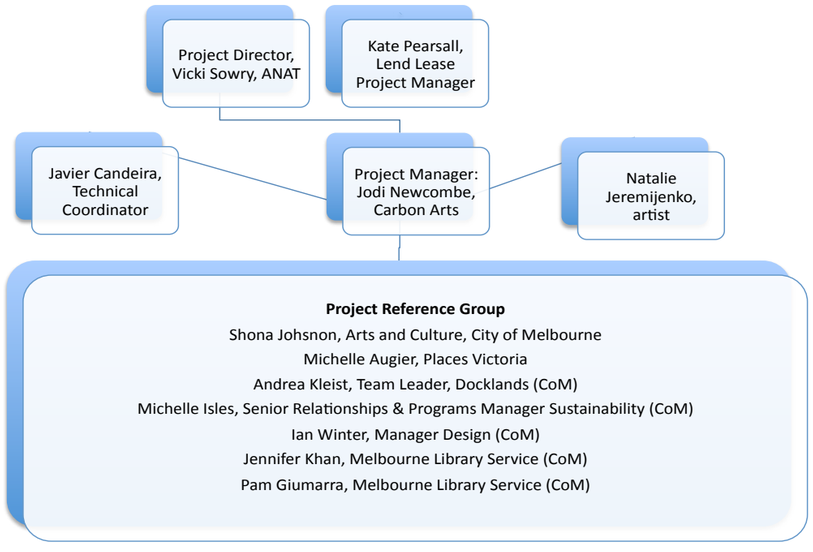
It is a three stage project, supported by a mix of government and private sector partnership, that will culminate in the production of three new, significant public art works at Lend Lease sites in Sydney, Melbourne and Brisbane. In the first stage of the project, seminars were held in three state capitals to introduce Australian artists to the rapidly developing field of data-driven arts practice. An open call for ideas for the three sites was announced in June 2012 with winners declared in August 2012. The first of these winners, Mussel Choir by artist Natalie Jeremijenko is the first to enter production.

Project Management

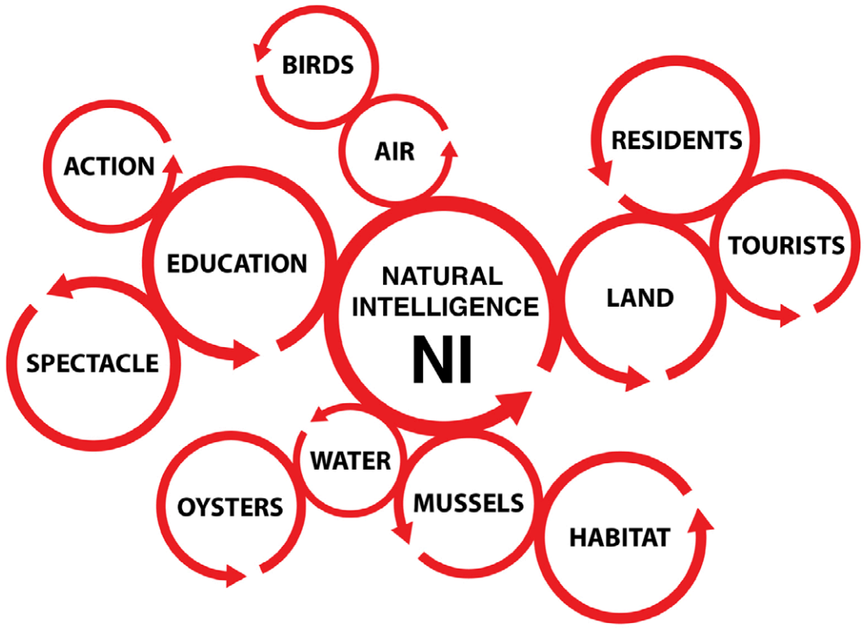
Melbourne Mussel Choir is managed by Jodi Newcombe, the director of Carbon Arts, based in Melbourne. Vicki Sowry, CEO of ANAT, is project director, based in Adelaide. Creative direction is provided by Natalie Jeremijenko with technical assistance from Javier Candeira, who is working locally with Carbon Arts.

The project is funded by Lend Lease. A Project reference group meets regularly to advise on the project's delivery and includes representatives from City of Melbourne and Places Victoria. See organogram for more details.

The Mussel Choir team is assisted by Aspect/Oculus, an organisation tasked with delivering the public realm strategy for Victoria Harbour. Aspect/Oculus is collaborating to ensure a seamless and optimal integration of the artwork into the evolving design at Bourke Dock. The Centre for Aquatic Pollution Identification and Management at Melbourne University will be assisting the team in the delivery and maintenance of the mussel colony.



Mussel Choir Organogram



Jeremijenko's Natural Intelligence framework

Environmental Messaging

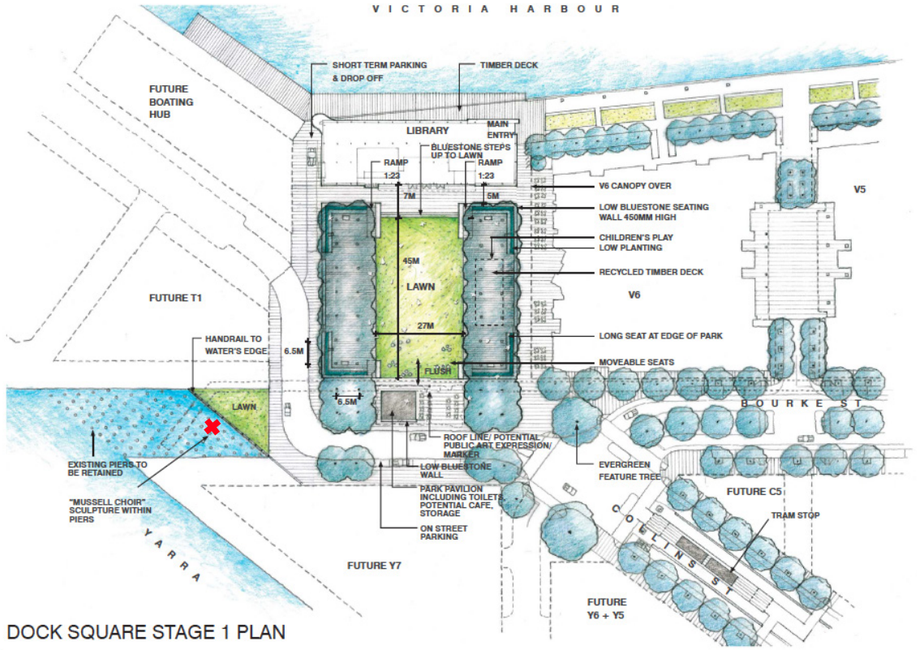
How terrestrial activity affects water quality is not widely understood by the public and yet it has one of the biggest effects on our urban ecosystems. The Mussel Choir provides the opportunity to develop that understanding and playfully encourage the on-going improvement.

Mussel Choir explores the productive intersection of land, air, water and urban systems at the water's edge. It provides an attraction driven by data on the immediate local estuarine water quality. The attraction helps demonstrate the environmental performance of the local urban development and immerses people in visceral experiences of the natural urban phenomena with which they are intimately connected. Mussel Choir seeks to demonstrate that spectacle can build on these natural systems representing them as a radically new entertainment space.

Using biological organisms as sensors has many advantages over traditional dumb or dead sensors celebrated in corporate "smart city" visions. Biological organisms integrate many parameters into a legible data stream – i.e. if the mussels are open-mouthed singing, many people instantly understand that the water quality is decent and biologically meaningful, which is more legible than a data set on water pH, dissolved oxygen, turgidity and what the combination may mean.

On a daily basis over a number of years, local residents and workers will develop an understanding of how the water quality changes over time.

For example, storm water run-off, local weather, and seasons will have evident effects on the Choir's performances.



DOCK SQUARE STAGE 1 PLAN

Location

The Mussel Choir is currently proposed for Bourke Dock in Victoria Harbour, where construction work is expected to expose the original wooden pylons that supported the extension of the dock.

This area provides a unique space for contemplation and is undisturbed by boats or other traffic.

Bourke Dock is an ideal venue for connection to the water's edge that will be assisted by the Mussel Choir artwork.

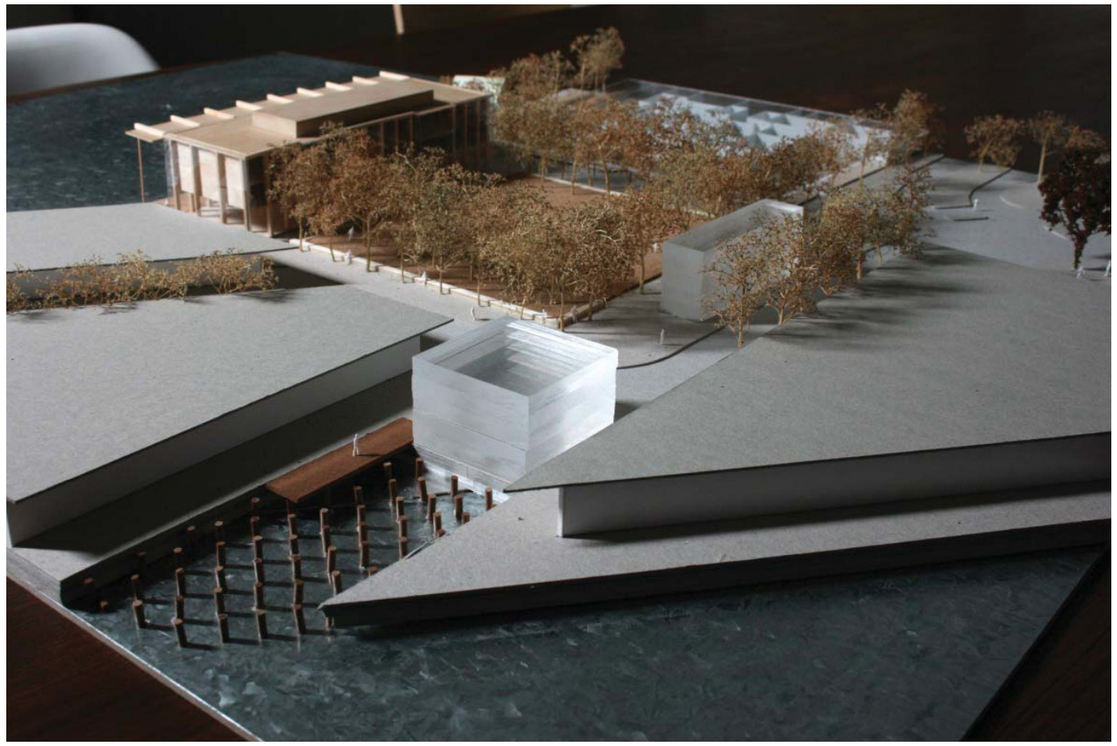
In addition, Bourke Dock faces the Yarra, a flowing body of water, which will offer a dynamic environment for the mussels to communicate.

Eco-Park New York City

Mussel Choir is also being developed by the artist for an 'Eco-Park' at Pier 35 along New York City's East River. The project is part of a larger plan to incorporate the East River waterfront into New York's urban fabric.

Designs for the Mussel Choir at this location are well developed and the Melbourne Mussel Choir benefits from the research already undertaken in New York by the artist and her team.

At this stage it is looking likely that Melbourne Mussel Choir may launch before its NYC cousin. In any case, the twin sites offer interesting opportunities for sharing of mussel songs from two iconic urban river systems.



Model View of Bourke Dock, Courtesy of Aspect | Oculus

More About Mussels

Mussels live much longer than oysters, sometimes reaching the age of several decades or even a century. As water is pumped through the gills inside the mussel to give it oxygen, the gills act as a filter to extract the particles of food out of the water where they are then transported to the mouth and the stomach. One mussel can filter as much as 6-9 litres of water/ hour, removing particulates and pollution, thereby performing an invaluable environmental service.

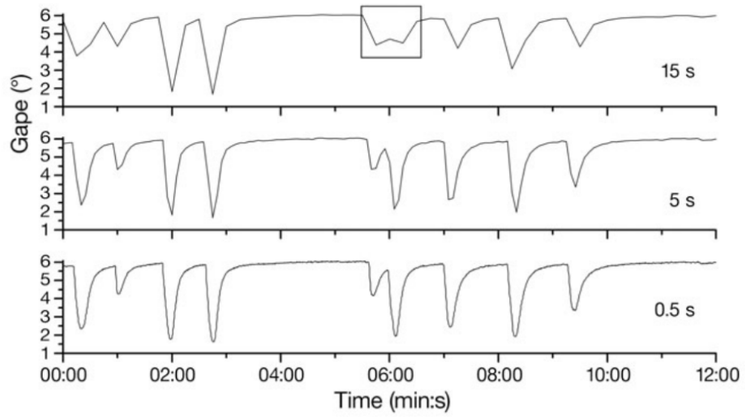
Mussels are a natural part of temperate Australian marine and estuarine ecosystems. The blue mussel (Mytilus galloprovincialis) is farmed in all southern states including New South Wales, Victoria, Tasmania, South Australia and Western Australia. While it shares the same scientific name as the blue mussel from southern Europe, it is native to Australia and has been found in ancient Aboriginal middens.

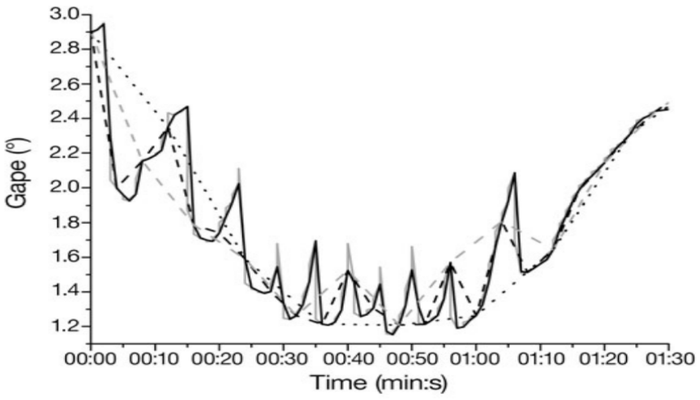
In the 1980s the Victorian State Government phased out the environmentally damaging practice of dredging blue mussels and encouraged the development of mussel aquaculture. In Victoria, mussel farming is a stated "beneficial use" under State Environmental Protection Policies. The environmental effects of mussel farming in Port Phillip Bay have been negligible after a period of 15 years (McKinnon et al. 2003). Therefore there is no major concern arising from the risks of mussels escaping, surviving or establishing feral populations.

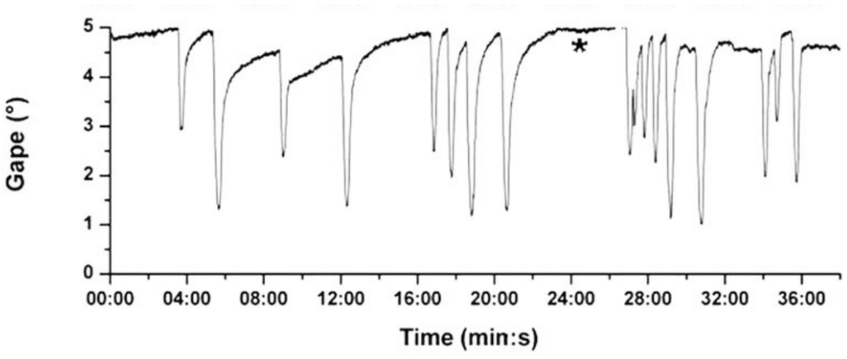
Mussel Behaviour

There are several research groups contributing to our understanding of mussel behaviour and the team is actively summarising these contributions into the behavioural model, or mussel 'bot' that is being built. The artist expects to publish a paper on this work shortly in the Journal of Disruptive Science and Technology; and related papers in other peer-reviewed contexts.

Research shows how the behaviour of mussels can be very well characterised by an envelope of CHIGA (changes in gape angle per sec) and that each mussel has its own behaviour characteristic of that individual. Given that these mussels have a (human) lifespan of approximately 80-90 years, and that, selection pressure is based largely on feeding and avoidance behaviour with respect to the site specific conditions, this project can illustrate the "synthetic evolution" of organisms adapting to anthropocentric conditions.







Technical and Design Options

Mussel Choir at Bourke Dock

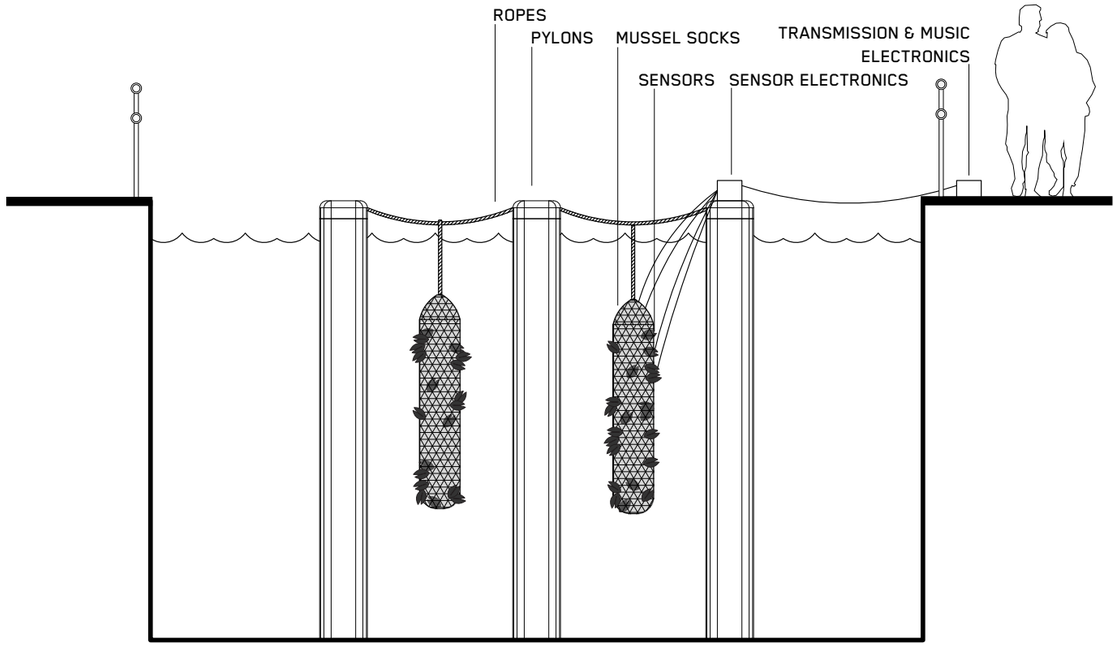
Initially the artwork was proposed to be sited in the water in front of the new Docklands Library. For a variety of reasons, the team has selected Bourke Dock as the preferred location. These include:

- The pedestrian activity that Mussel Choir will bring to Bourke Dock, which doesn't otherwise have a particular draw card, thereby increasing connections and movement across precinct;
- Bourke Dock public realm design has not been finalised offering an opportunity to collaborate with Aspect | Oculus to integrate shoreline features with the Mussel Choir, such as railings, seating, stairs and vegetation;
- The Yarra is flowing on this side of Victoria Harbour, which offers a superior water quality and more dynamic set of parameters to feed the Mussel Choir song; and
- Space for experiencing the Mussel Choir; a destination and place of reflection, rather than a thoroughfare.

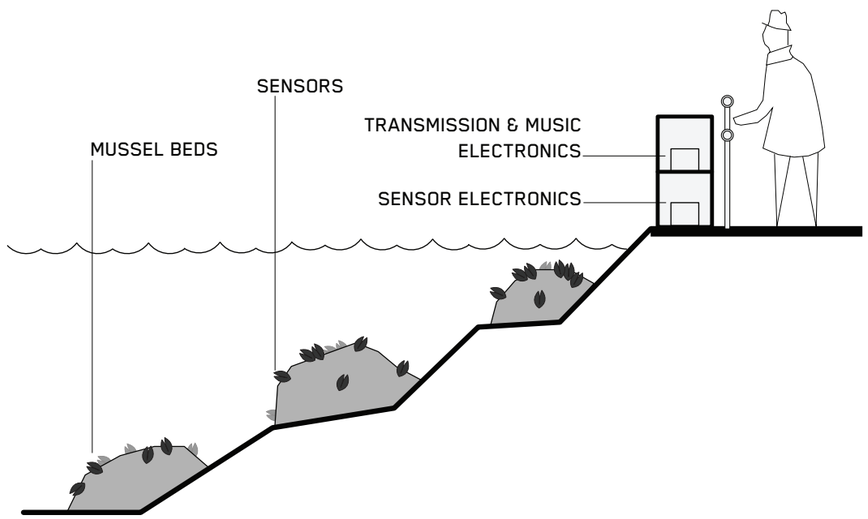
The revealing of the pier infrastructure at Bourke Dock is in progress at the writing of this document, and a number of unknowns prevent the Mussel Choir team from finalising designs for the site until the site parameters are known. However, it is likely that the Mussel Choir will take one of two possible installation formats.

Design A shows the preferred option for installation, whereby the existing pylons provide the infrastructure for hanging mussel socks, the well-established means for mussel farming. This option is preferred as it utilises the existing structure and also facilitates maintenance, as socks can be lifted out of the water from a boat with relative ease. However, there is still uncertainty regarding whether the pylons exist and in what state they will be.

Design B shows an alternative installation design, which could be pursued if there is insufficient pylon infrastructure. It consists of a constructed ramp upon which portable mussel beds would be installed.



A. BOURKE DOCK



B. BOURKE DOCK or OTHER LOCATION

Variations to Options A and B are:

- Design A variation: rafts replace pylons as the structure to which mussel socks are hung (adapted from commercial raft systems). Rafts are anchored to the floor of the estuary with chains.

- Design B variation: a constructed landscape of some kind will mediate the experience at the foreshore, instead of a railing.

The following will also need to be resolved once more information is available:

- The culvert, which directs storm water away from the precinct, is located at Bourke Dock. The extent of the culvert will be reviewed once the deck has been demolished.

- Design features of the publicly accessible area around Bourke Dock are not yet finalised and will impact on the nature of the interface with Mussel Choir. For example, if hoardings are going to be a feature of the site, due to ongoing construction, these can be integrated with the work as interpretive displays and/or opportunities for listening stations.

- Possibilities for a softer edge to the water mediated with aquatic plants or some other gradual introduction and approach to the water are still being explored and will impact upon the options being explored for experiencing the Mussel Choir.

The Mussel Choir also exists in virtual space online (see Data Management System) and therefore can potentially be experienced anywhere. The Library presents an ideal venue for off site experience of the Mussel Choir, given its focus on digital learning and its proximity to the site (see Programming, Education and User Experience).

Listening to the Choir

Listening stations don't necessarily need to be on the waterline. A remote listening station can read mussel data from the cloud back end and generate and play music anywhere there is an Internet connection. However, we plan to have the first listening station draw data from the mussels directly, in situ.

A number of different listening stations are being explored for the Mussel Choir in situ. The preferred choice will depend on the public realm design that is developed in response to ongoing engineering and excavation of the site. The options are:

- Stairs or steps descending into the water: This would allow speakers to be embedded in the stairs facing towards the water so that people can position themselves to listen, but that the sound directs outwards rather than flooding the whole area with sound. In this way, sitting on the stairs would provide the "place to listen" as if in an amphitheater, where the stage is the water.

- Floating rafts: Speakers embedded in the rafts would provide disembodied voices from a stage could be a nice displacement of the actual mussels. This has the advantage of suggesting and doubling as an actual performance stage that could have a light show and fog effects to "rock out" the periodic mussel concerts (See Mussel Choir performances below).

- Bone Conduction: (seating or railing) the artist has been exploring bone conduction interfaces in her research. Listening stations could take the form of a 'sonified railing' whereby listeners place their elbows on the railing and with their fingers in their ears the sound travels through their bones. Alternatively, bone conduction listening can take the form of chairs whereby the conduction point is a headrest directing the audio signal through the skull. This method is most appropriate if wind and other ambient sound is expected to disturb an ambient listening experience.

- Hoardings: If hoardings are surrounding the site due to ongoing building works adjacent to Bourke Dock, this could provide opportunities for speakers to be situated around the site in the hoardings, creating a wind protected, intimate listening space.

Depending on the type of listening station, it can also afford other types of interactions with the mussels:

- Library: the library mussel listening stations could be part of either the educational program or the performances and entertainment program. To be determined with stakeholders.

- Possible listening 'stations' could be instrumented through the library desks or tables (audible by putting head to tables)

- Possible use of amphitheatre in Library for concerts

- Outdoor busker's: a temporary portable busking station with a small patch panel and mixing table, for artists and musicians to perform concerts with the mussels. Busking performances could also occur at Dock Square or outside the Library.

- Pool hydrophones: temporary or permanent installations in pools around Victoria let bathers enjoy the Mussel Choir song about water quality and conservation.

Establishing a Mussel Colony

Using standard mussel-farming techniques, we will establish a population of mussels of around 5,000 individuals. However, this population size is scalable and only a handful, say 20 will actually be instrumented (see below). The larger the colony size the larger the environmental benefits.

The two systems being explored for creation of a colony are a rope or 'sock' system and mussel bed establishment on an artificial sloping 'floor' under the water. The former is the preferred option as it is common in mussel farming and lower cost.

The mussels prefer living in the littoral zone, rather than benthic, and therefore the former system, where the ropes are suspended from the surface, will mean part of the mussel colony will be viewable from the surface. It also means the depth of the water isn't an issue.

The project team will be commissioning the Melbourne University's Centre for Aquatic Pollution Identification and Management (CAPIM) to become an expert partner on the delivery of Mussel Choir .

The scope of works to be provided by CAPIM consists of: a baseline survey and

risk assessment, a plan for the establishment of the mussel colony, and a strategy for the maintenance of the colony over a ten year period.

CAPIM will assess the suitability of the chosen site for mussel establishment, provide the project with a supply of mussel spat, and provide expert scientific advice on the interpretation of environmental data.

CAPIM will also deploy novel remote sensory technology to independently monitor water quality to help place the mussel choir data outputs within the context of local environmental quality.

Timing: Spat will be available in summer (TBC). Adults are available immediately. Begin end of April and provide results by mid-June.

CAPIM's Methodology

CAPIM propose the baseline study be conducted in three modes:

1.Conducting a survey to determine the density, locality and species of mussels within the Yarra River at Docklands.
2. Deploying a small number of mussel colony in the Yarra Estuary and
3. By conducting a literature review.

CAPIM propose the survey will be conducted in the following manner:

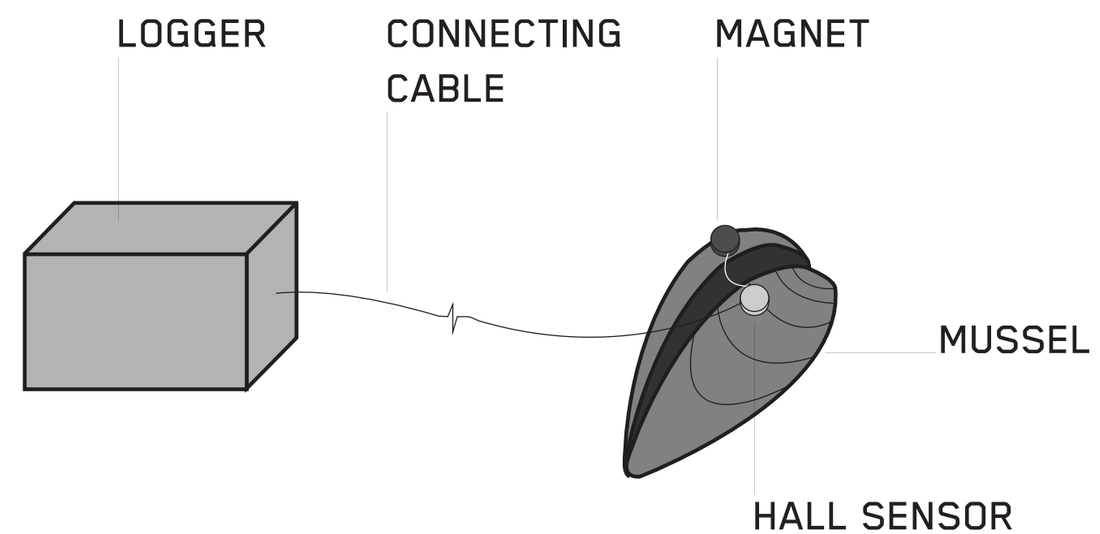
- SCUBA survey dive conducted at pylons to determine abundance and extent of mussels conducted over a single day. This survey will complete the following:
- Survey a parallel transect along the wharf edge at each pylon at the edge of the wharf and examine one pylon back from edge
- Collect individuals to confirm species. Likely to be Mytilus edulis planulatus
- Measure several individuals to confirm age
- Photograph mussel colonies that have been surveyed, to assess densities and community (pest / diversity of other species and fouling)
- Calculate densities of mussels on pylons
- In addition, a risk assessment will be conducted by:
- Conducting a water quality literature review, including data mining the Yarra River at Docklands for the concentration of heavy metals and turbidity, for example.
- Conduct a literature review on the mussel species found and determine the known chemical tolerances of the species
- Compare known locations of the mussel species and compare the water chemistry within the Docklands
- Deploy 5 x 1m mussel adults/juveniles/spat of rope into the docklands region and monitor their health and viability over a 8 week period
- Requires gluing (adults) to rope or having spat attached to rope
- Requires a successful application submitted to Department of Industries and Port of Melbourne for the implanting of aquaculture species and Port of Melbourne for the use of space.
- The hatchery can provide spat and adults. The spat are 1mm at attachment. 10-15mm at 3-6 months and 60-90mm at 18months.

Mussel Choir pilot at Venice Architecture Biennale 2012

Instrumenting the Mussels

Using a proven technique involving a hall effect sensor and a rare earth magnet attached to each shell of the mussel, it is possible to detect changes in the gape of its shell over time and subsequently extrapolate its response to local water conditions in situ.

An array of these mussel-sensors will be incorporated into the mussel colony, and the choir will be generated by a computer program driven by the collected data.



EcoPark Mussel Choir
Mussel Sensors

Open Data and COSM

The raw real-time data will also be made available via Cosm.com, a publishing platform for sensor data (see Box), so that artists and academic researchers can benefit from and learn from the Choir.

The data will be under a Creative Commons license enforcing public sharing of all derived work, so the public also benefits from downstream use of our data. People can download data from Cosm about the Mussels' behaviour and do what they like with it, musical compositions, data visualisations, and so on. They can then upload their results to Soundcloud, Vimeo, Github, Youtube, or Cosm itself.

Cosm (formerly Pachube) is an on-line database service allowing developers to connect sensor-derived data (e.g. energy and environment data from objects, devices & buildings) to the Web and to build their own applications based on that data. Cosm manages millions of data points per day from thousands of individuals, organisations & companies around the world. Data can be pushed from the sensor end, or pulled by the Cosm servers every 15 minutes, with the data feeds then made available in multiple formats at no charge. Cosm is built to encourage open digital ecosystems, for example electricity meters, weather stations, building management systems, air quality stations, biosensors and Geiger counters.

Mussel Choir Music

Data from the sensors will be used to generate a song performed by synthesized voices (the Choir) in real time.

The songs will map parameters such as water depth to sound pitch, presence of pollutants to sound timbre, and the rate of the opening and closing of mussel shells to sound tempo, for example. These are being developed for both legibility and musicality. The aim is to clearly represent the qualities of water, rather than to represent water quality as it has been codified for regulatory purposes.
There are two main choral modes: real time "mussel tone" and the data review or mussel performance mode. Playing with the obvious metaphor of mussel tone and muscle tone allows a popularly legible way to think through the relationship of our on health the environmental health.

Playing with the obvious metaphor of mussel tone and muscle tone allows a popularly legible way to think through the relationship of our on health the environmental health.

The real time mussel tones simply maps pitch to mussel depth. As the mussel gape angle changes they arpeggio around a chord. Overlaid on this is the Shepard tone effect -- the auditory illusion achieved by superimposing that a tone is continually ascending or descending in pitch, yet which actually gets no higher or lower. This has been described as a "sonic barber's pole" and the mussel choir uses this to map to tides. i.e. as the tide is incoming, the tones appear to ascend; as tide retreats the tones appear to descend.

The chords will use both functional and modal harmony. Modal harmony allows us to map perceived "brightness" well codified in the modal harmonies to turbidity, or the murkiness of the water (i.e. from Lydian to Locrian). The dissolved organic matter (DOM) and coloured dissolved organic matter (CDOM) are critical parameters that expresses the degree to which light is scattered and absorbed by particles suspended in the water column, which effects the photosynthesizing phytoplankton on which the food network is based. Suspended particulate matter includes clay and silt (e.g suspended sediment), and detritus and organisms (algae and zoo plankton) and is particularly relevant to our own terrestrial activities. These effects are legible to untrained ears.

The team in NYC is experimenting currently with a combination of sampled voices with Shepard toning. The voices grafted onto the mussel will either be human or non-human. Humans whose activities in someway affect water quality will "donate" their voice to a particular mussel--for instance the Lord Mayor's voice. The team is able to extract "voices" of aquatic organisms thanks to the burgeoning field of fish acoustics. The Oyster Toad Fish has a delightful gravelly Nat King Cole voice. The pitch shifting of birds and waterfowl will also be used as sample sources. Transposing the sounds from the fluid regime of air into the fluid regime of water propositional to the Reynolds numbers is not only legible but has generated very beautiful sounds. The birds might act as "backup singers".

Humans whose activities in someway affect water quality will "donate" their voice to a particular mussel--for instance the Lord Mayor's voice.

The performance mode allows us to analyse and review data and to perform comparisons. Using familiar songs, such as Daisy Bell, we can exploit the musicality and melody moving in and out of perceptibility as the water quality varies. Because people are incredibly competent at recognizing musical patterns and because the complexity of water quality is best represented as qualities of water, this effect is very promising. This mode reflects the work to extract meaning and to make sense of what the water quality actually means to these keystone organisms and is developing as the data is forthcoming.

Technical Overview

Roughly, the artwork's digital infrastructure can be divided into three main components:

1) **Mussel site(s):** on the waterline, a mussel site reads the mussels activity, uploads data to a cloud back end, and generates and plays music in situ.

2) **Cloud back-end and social media engagement:** the work also comprises a fair amount of server code, running on different cloud services, performing the following functions:

- Back-end: cosm back-end for data, remote access to mussel site computers.
- Platform management for technical and administrative staff.
- Social media interaction exchanging photographs and pleasantries with Mussel Choir visitors and fans who are also users of Facebook, Twitter,Flickr, Pinterest and Soundcloud.

3) **Web site:** Suggested that this website is part of the Library's website. Suggested functions of this website:

- Information about the work, the artist, etc.
- Information about mussels, about the river, about water quality.
- Live streaming of Mussel audio.
- Concert times and schedules.
- Educational activities around marine biology, electronic art, the work itself.

Requirements: these are the requirements for the two physical access sub-elements of the work:

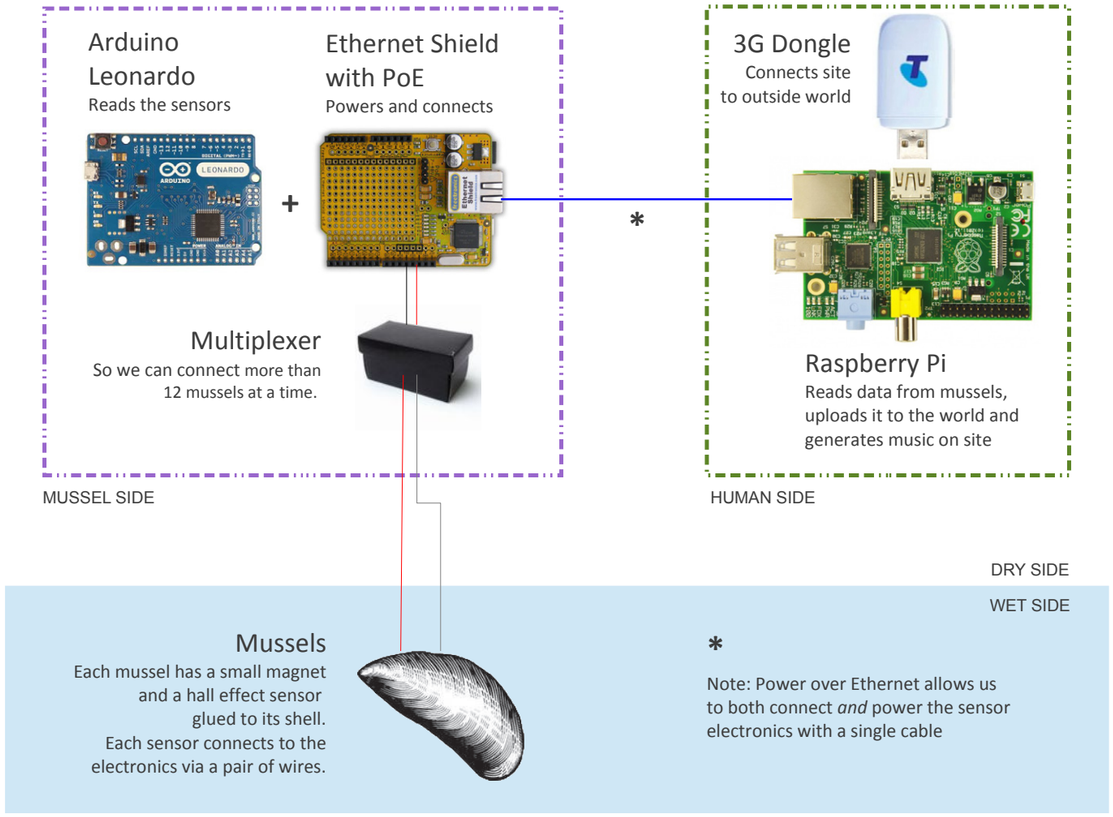
Mussel site(s) requirements:

- Power- these sites are very low power, it is suggested we plug in into the lighting supply.
- Physical audio infrastructure- railings if bone conduction, posts if loudspeakers, etc.
- Equipment boxes like the ones used for housing traffic lights or phone exchanges, only smaller.
- Communications and data- zero requirements from the site. The mussel site communicates over its own 3G wireless connection. (See Mussel Data Flows).

Listening station(s) requirements:

- Power: audio requirements are still quite low power. Extra amplification (not provided by the Mussel Choir project) may require extra power.
- Audio infrastructure: TBD, depending on the type of listening station.
- Communications and data: fixed installations require that the site owner provides an Internet connection.
- Temporary/mobile installations have their own data link via 3G wireless modem.

Mussel Electronics

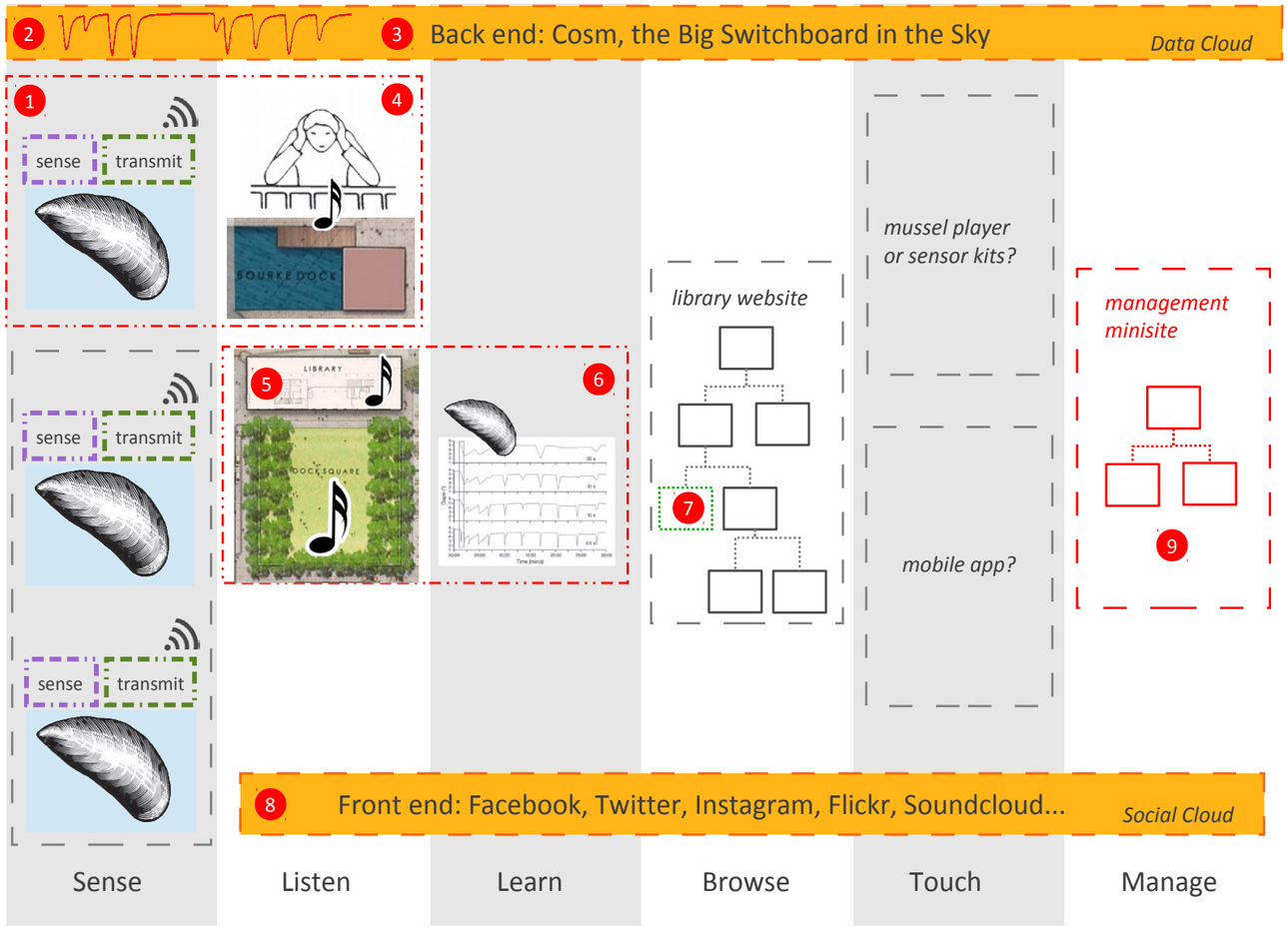


The Mussel Choir site contains two separate sets of electronics. One set senses the mussel behaviour and collects a time sequence that looks a lot like an "electro-mussel-gram". The second bit of electronics has two functions: uploading the mussel data to the cloud, and generating the on-site Mussel Choir song.

Note that the data connection is wireless, so the only wiring the work needs is an electric feed at 220V. The system includes transformers to 5V DC for the electronics. Electric consumption is very low: the electronics barely draw a couple of watts.

Technical And Design Options

Mussel Data Flows



1 The Mussel Choir site contains sensor electronics that detect how the mussels open and close their shells over time.

2 The sensed data is uploaded to Cosm 3 a cloud service for data devices which we will be using as our back end. Other mussel choir sensing sites may exist in Melbourne or somewhere else, and the data would be shared too.

4 The Mussel Choir site also runs a program that turns the mussel data into sound, producing the song of the Mussel Choir. One of the ways this music can be experienced is through a bone conduction system embedded in the site railings: the audience can rest their elbows on the railing, and listen to the Choir by putting their hands on their ears.

5 Anywhere that we want to hear the Mussel Choir, we can put a second bit of electronics like the one generating the song onsite. For instance, inside the Library, or on a portable stage for buskers to play with the mussels in and around Dock Square. These Mussel Choir Players require not only electric power, but also a data connection so they can download the mussel data from Cosm. Inside the Library, this connection can be via wired ethernet, and for the portable stage it can be a 3G modem similar to the one used for data uploading.

6 The library also contains educational displays. Some of them are not electronic, but others reflect the state of the mussels, and visualise the state of the waterways using the mussel data as a proxy for water quality. These also require a small piece of electronics, power and a regular Internet connection.

7 The library's website contains a page for the Mussel Choir, with the timetables and calendars for mussel performances, history of the work, etc. But it's not the main way of interacting online with the work. It's just a brochure about the work. CarbonArts and the Mussel Choir project do not make themselves responsible for this page, but we'll offer advice and technical expertise on how to integrate this page with the mussels' social media presence.

8 The public interacts with the work via social media. The Mussel Choir has a series of social media accounts. The mussels post photos on flickr and pinterest and Instagram, they tweet and update their facebook and G+ pages, upload their music to their soundcloud accounts... and that's also how they interact with the audience; by retweeting tweets about themselves, about the Melbourne harbour, about the waterways.. etc.

9 There is a management site which is private, with two subsections:

A - Hardware management: a dashboard to manage the electronics of the sensing site and the various player instances. This is purely an engineering access to the systems, without consequence for the public.

B - Social media management: a simple interface allowing several people to have shared access to many social media accounts at once. Via this interface we can schedule public tweets, repost photographs and user-submitted mussel choir remixes, manage repeat announcements of scheduled activities, etc. All in the name of the mussels.

This private management site will have extremely low traffic, with only a handful of people having access, so it can be hosted on the smallest of Amazon Web Services instances.

**Mobile app and personal mussel sensing/ listening stations subject to further development on later stages of project*

Programming, Education and Audience Experience

Mussel Choir Performances

Whilst the Mussel Choir is always, in effect, performing music in situ, in real-time, the artist envisages that, through the open data platform, others might be invited to join in and 'jam with the mussels'. The project offers a number of platforms for facilitating additional spectacles as part of the work, such as a mobile busking station for outdoor performances and Library performance venues.

A busking station, described under 'Listening to the Mussels', can be housed in the library and wheeled to Bourke Dock or Dock Square to allow musicians to feed the live mussel data into a performance. Composing with real-time data will appeal to electronic and cross-media musicians, but is by no means limited to them.
While the busking station can be delivered by the project, the programming of concerts would need to be delivered by another party, such as the Library. Some support can be provided in the first year by the project team to build internal capacity and ongoing relationships.
The artist envisages that the performances may include mappings on to contemporary songs, that may be recent hits, or seasonal, such as the Mussel Choir: the Christmas Album. Also, the real-time data from the Choir will be made available via Cosm.com to the general public so that others can propose alternative mappings and choral arrangements.

These performances don't necessarily need to use the data in real-time, they could generate performances that summarise the previous 24 hours, the previous month, or the previous year. Performances could bring in other sets of data that somehow relate to the mussels to tell a bigger story. The variety of environmental and data stories, together with the depth of music culture thriving in Melbourne can provide for rich programmatic content over a period of years.

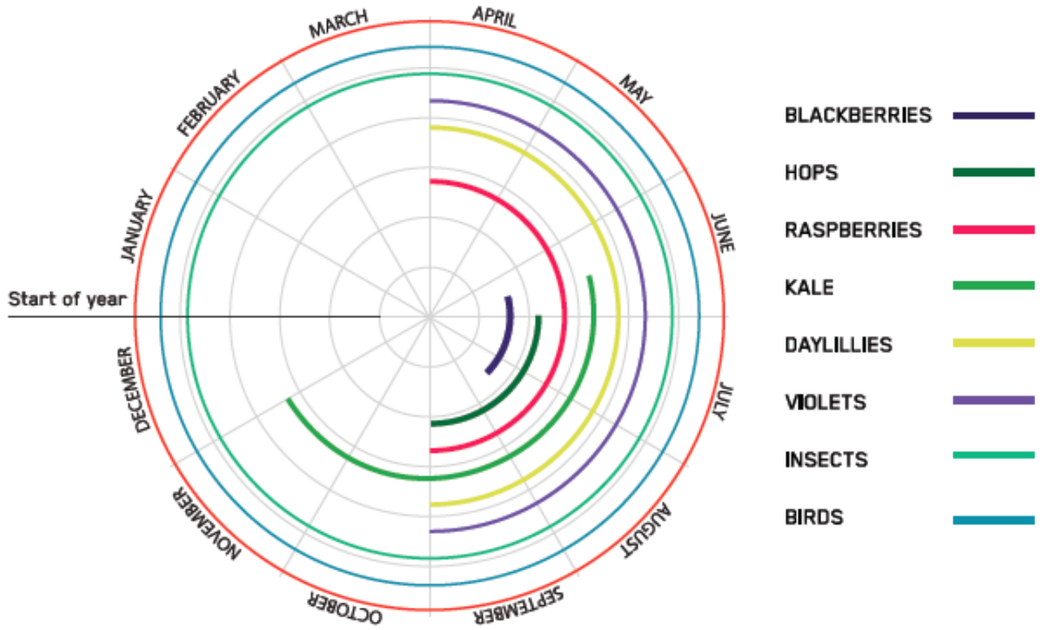
The style of music also lends itself to interesting collaborations/cross-pollinations with organisations such as the Placard / Headphone Music Festival, Electrofringe or even Melbourne Music Week, which could offer satellite events at Dock Square, Bourke Dock or within the Library itself.

Performances need not be limited to the audio, as the data will offer possibility for rich visual interpretation as well. Arts spaces or external/ internal screens within the Library can also be host to invited Mussel Choir creatives in the community.

The mussels will become rock stars.

Educational Opportunities

Example of a Phenological diagram for urban agriculture, courtesy of the artist



Natural Intelligence (NI) is a paradigm, employed by the artist, that couples feedback from natural systems into social systems for ongoing interpretation and information. Mussel Choir uses NI to locate and display the information within the community for whom it is most relevant, thus putting the information in the hands of those who can take actions informed by it. Learning is at the centre of the artwork, particularly learning that leads to agency and stewardship of the local environment.

With Docklands Library

The proximity of Mussel Choir to the new Docklands Library, together with the focus of the library on digital learning, point to opportunities for connecting the sites through a range of educational activation strategies.

Discussions to date have touched on the following:

- The opportunity to tell the evolving natural history of Victoria Harbor through the Mussel Choir at Bourke Dock with interpretative materials in situ and at the Library;
- The opportunity to use the Mussel Choir as a platform for novel digital and technology learning through the Library's planned Maker or 'Hacker' Space (with themes like bio-sensing, data representation and sonification);
- The potential for a physical Kiosk or designated space in the Library, such as in the children's educational space on the ground floor, dedicated to Mussel Choir and associated educational activities around;
- Associated with the Kiosk, a 'Fingerprint

of the Bay' - Vinyl print on a glass wall or window, which shows a phenological diagram of local river ecology that can be added to with people's observations (like a whiteboard), and replaced as the ecology shifts. (See artist's example diagram for urban agriculture);
- Listening 'stations' embedded in Library furniture, such as tables, that operate according to the same principles as bone conduction.
- Activities along the foreshore, such as a 'Tug O War' whereby residents install new mussel ropes around the Docklands to grow the mussel ecology

The educational content might include some or all of the following:

- Natural history of Victoria Harbor and European influences on mussel colonies, including conflicting priorities, e.g. between boat owners and mussels.
- Seasonal educational programming reflecting the mussel life-cycle, e.g. spawning events.
- Culinary and nutritional history of mussels, including Aboriginal diets and the sacred nature of middens and global mussel recipes.
- Innovation in the electronics and biology of bio-sensing and its scientific uses.
- Issues and challenges related to water quality monitoring and water sensitive urban design, as employed throughout the precinct.
- Ecological services of mussel colonies - storm water retention, water filtering, etc
- Transversal educational programming on physical computing, computer programming, data visualisation and sonification. Examples:
  - how to build something like the mussel choir itself,
  - how to plot and analyse the mussel data
  - how to build a robotic mussel that gapes in sync with the real mussels

A partnership with the Library is therefore highly desirable. The section on the 'Data management' system illustrates how the Library's website can host information about the Mussel Choir.

The project has budgeted for initial programming support for the Mussel Choir in the Library for the first year, with a view to developing ongoing capacity and sustainable funding for the life of the project.

With Melbourne Water

Preliminary discussions have taken place with Melbourne Water about partnering with Mussel Choir. Melbourne Water's education program would be a potential candidate for integrating messages about storm water management and management of waterways to school children enrolled in the program. The Mussel Choir team will pursue these conversations in the lead-up to the project LAB planned in June.

Marketing Strategy

The marketing strategy for the year until the launch is outlined here. Beyond the launch, marketing will be automated to a large extent through the social media system, described below or carried forward as part of ongoing programming (see Programming, Education and Audience Experience).

In line with the project's milestones there are six main stages or milestones around which the marketing strategy can be built:

Dec 2012: Project announcement
June 2013: Development LAB
Aug-Dec 2013: Build Phase – tracking progress
Jan-Feb 2014: Launch of completed work
Feb-Dec 2104: First year of programming

Platforms for available for marketing are:

- Carbon Arts website, Facebook and Twitter
- ANAT website
- Library or City of Melbourne website
- Public talks and events
- Media: online and print (arts + culture, urban planning + architecture, science, general interest)
- Conferences, festivals and symposia
- Publications (academic)
- Other

Strategic initiatives and partnerships for marketing include:

- Aligning with Lend Lease and CoM marketing teams around the delivery, launch and activation of Victoria Harbour and the Library to provide content about the Mussel Choir.
- Leveraging presentation events such as conferences and festivals, like Knowledge Week Melbourne, to garner press.
- Seeking out diverse presentation publication opportunities across Science,Culture, Sustainability and Urban Design.

Materials to develop:

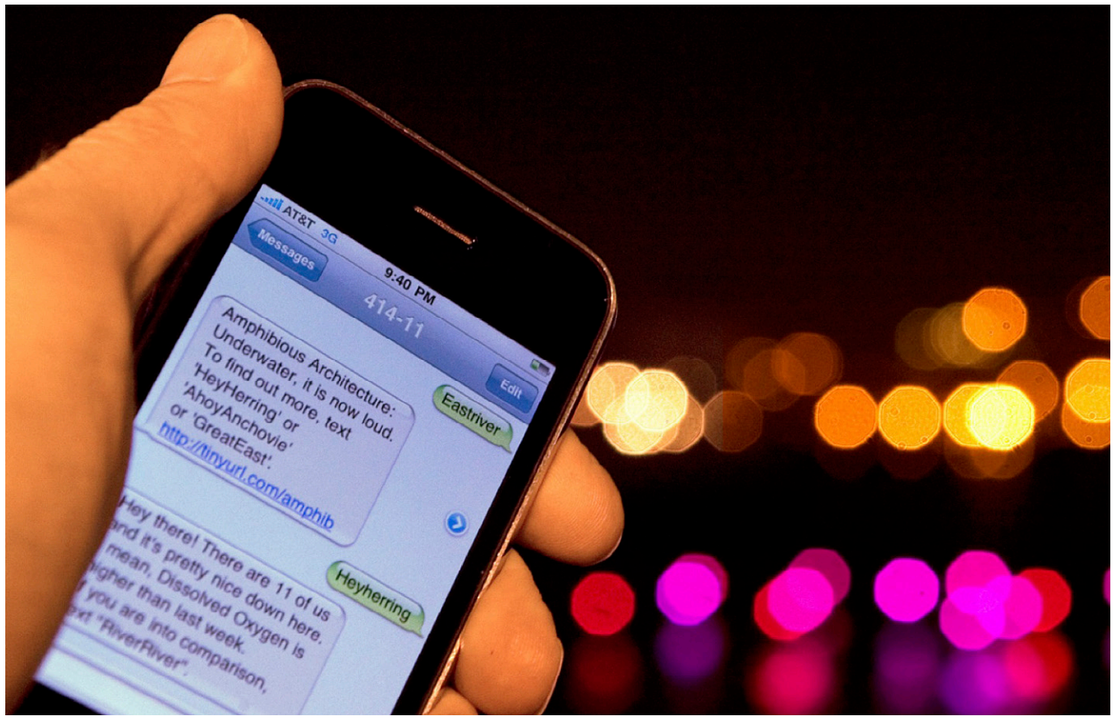
- Mussel Choir prospectus, for example, the Overview section of this document, to be downloadable from the project partner's websites and available to send to media, the public and stakeholders.
- Mussel Choir FAQs for media partners.
- Draft Press releases for different milestones, such as Mussel Choir LAB, Mussel Choir facebook and twitter account launch, Launch of Mussel Choir and programming.

Marketing Activities Completed or in Train

Date	Type Of Marketing	Detail	Web
Dec 13-ongoing	e-newsletter	Carbon Arts announcement about the project, the LAB, the build and the launch	www.carbonarts.org/news/
Jan 13 - ongoing	Website	Carbon Arts project page	www.carbonarts.org
Jan 13 - ongoing	Website page	ANAT Project page	www.anat.org.au/echology/echology-mussel-choir/
May 13	Conference presentation	Balance-Unbalance	www.balance-unbalance2013.org/
May 13	Media	Article about Balance-Unbalance + Mussel Choir	
June 13	Public Talk	Vivid Festival of Ideas	www.vividsydney.com/
June 13	Conference presentation	International Symposium of Electronic Arts	www.isea2013.org/
June 13	Blog	ANAT blog about the LAB	TBD
June 13	Social Media (CA, ANAT)	LAB images, progress, videos, uploaded to FB, Twitter to track progress and build excitement	Various
Nov-Dec 13	Event	Melbourne Knowledge Week – Mussel Choir event	www.melbourne.vic.gov.au/knowledge

Mussel Choir Social Media

Amphibious Architecture, Natalie Jeremjienko



Social media is a key aspect of the work and its ability to reach large audiences and well as be accessible to residents at all times for ongoing checking in and monitoring of the mussel environment.

Social media strategies through Facebook/ Twitter include:

- The mussels have their own voice, a "bot" or program that tweets in their name.
- The mussels also retweet interesting information on water quality, on Docklands life.

People can befriend the mussels and get their updates on:

- Activity calendar for the mussels, for Mussel Choir related happenings in Melbourne.
- Cool things other people are doing with the mussels (pics, music, even recipes).
- Retweets from the artist and from Melburnians that "the mussels like".
- The mussels may befriend you back, favourite your Instagram pics, your pinterest pins.
- The mussels also point to people doing interesting things with their data through Cosm.

Evaluation, Research and Development

The innovative and cross-disciplinary nature of Mussel Choir means it is excellent platform for research, both from a scientific and technological perspective as well as from a social and cultural perspective. The project has the potential to be studied for its contribution to four main areas of research:

- Scientific: Mussel ecology and pollution management in the Docklands
- Technological: Instrumentation and remote biological sensing technology
- Urban design: Contribution of eco-public art to the delivery of greener communities
- Arts and Culture: Innovation in cross-platform public arts design and delivery

Science and Technology

Melbourne University's Centre for Aquatic Pollution Identification and Management (CAPIM) will be delivering services to the Mussel Choir project in terms of baseline ecological assessment, installation of a mussel colony and ongoing maintenance, as described earlier.

A joint funding bid is being explored to allow CAPIM to receive grant funding from DBI (Victorian Department of Business and Industry) and their Technology Development Voucher program. The bid will assist in augmenting the ability of Mussel Choir to contribute to scientific research in river pollution management and communication, combining Mussel Choir's sensing abilities with those being developed by CAPIM.

From the Mussel Choir Draft DBI proposal: The project will leverage existing investment in several water quality monitoring systems: the Autonomous Live Animal Response Monitor (ALARM), and the Mussel Choir. ALARM and the Mussel Choir are biological early-warning systems, providing real-time measurement of water quality by detecting aquatic animals' responses to pollutants; the ALARM sensor uses remote video monitoring of aquatic invertebrates' behaviour patterns, while the Mussel Choir uses magnetic sensors to detect mussel valve movements – and by extension, water quality. The project will combine the networked database infrastructure of the ALARM biosensors with the live data of the Mussel Choir and make both datastreams available to a synchronised online database. These components will be complemented by underwater microphones to record the stridulations of aquatic insects, and GPS sensors attached to freshwater turtles.

Urban Design and Green Star Communities

Mussel Choir may also contribute to the attainment of a ratings star under the pilot 'Green Star Communities' scheme of the Green Buildings Council of Australia. Lend Lease is looking to participate in this scheme through the Victoria Harbour development and the opportunity for the artwork to contribute to the award of a star in the category of 'Sustainability Education Facilities' is being explored.

Under the ratings tool, Sustainability Education Facilities are described as 'physical facilities that are provided for community and industry use. These facilities should provide information about the sustainability initiatives of the development.'

In addition to education, two other categories under the ratings tool to be explored are:

- liveability: which includes activities that contribute to place-making and site activation; and
- environment: which might consider the contribution that the mussel choir makes towards water quality and storm water management either directly or indirectly.

Arts and Culture

The Echology: Making Sense of Data Project is committed to evaluating all of the public art commissions that are delivered by the project. ANAT will apply its established evaluation process to measure the artistic and procedural outcomes of ECHOLOGY, from both a quantitative and qualitative standpoint. The process includes the completion of customised questionnaires by participants, as well as one-on-one interviews with project stakeholders. ANAT uses evaluation feedback to critically inform and model future programming, as well as to identify important emerging issues.

The artist also has a keen interest in evaluating the project's delivery against her vision:

> *"Once the Choir is operational, people will begin to develop understanding for how community actions, of individuals, collectives and institutions, affect water quality both positively and negatively. We will be able to develop experiments and proposals for improving the local water quality, and will be able to demonstrate conclusively whether or not they had an effect by listening to how the music changes." - Natalie Jeremijenko*

QUT's Creative Industries is a partner in the evaluation of the project, which involves the PhD candidature of Jodi Newcombe, from Carbon Arts, who will be examining the project against its aims, in the context of similar efforts around the world to affect social and environmental change through public art initiatives.

Operations and Maintenance

The Mussel Choir systems are designed for resilience: they are robust, redundant, resources are easily replaceable, and both hardware and software are documented so maintenance actions are repeatable.

Robustness

- The mussel sensors are covered in marine epoxy. The high performance epoxy has been used in applications by subcontractors, McDermott lighting, have demonstrate 30 years of continual performance in marine buoy lighting.
- The electronics are housed in standard weatherized casings like the ones you see housing traffic lights timers, for instance. Again we rely on well tested off-the shelf system.
- The maintenance mini site is a standard web application on a cloud platform, and is designed to work as an appliance: in case of problems, it can be rebooted remotely by accessing the cloud provider via a username/password.

Redundancy

- The Mussel Choir can operate even with 50% of the originally instrumented mussels. This allows us to replace missing sensors only once a year.
- The song generating software can keep making music based on existing data and predicted moving averages in the event of catastrophic failure. However, death, destruction or sensor failure is salient information that is part of the audible information. If the mussels die for instance, this is important to render. If the sensor fails we can disambiguate this from an unchanging gape angle. Similarly if the connection is corroded, or broken this will change the data we receive such that diagnosing an issue will not be difficult. In any case loss of any of the electronic components, or maintenance is part of the story presented to the public.

Reporting

- The Mussel Choir electronics not only upload data on the mussels, but also on the condition of the systems. The mussel side sensors include a temperature/ humidity sensor for the electronics itself.
- The maintenance mini site sends a daily report on the condition of all systems. Alerts will also be sent in case of serious malfunction.

Remoteability

- The Mussel Choir electronics can be remotely accessed from any Internet connection, so many kind of problems like required reboots or software updating can be solved without requiring site trips.

Replaceability

- Mussel Choir electronics are cheap enough that replacement parts can be bought prior to inauguration of the piece, and kept nearby for fast repairs if needed. They are also standard enough that new parts will
- Mussel habitat design is modular, and if required, new socks with mussels can also be sourced cheaply and locally using mussel cultivation resources. The experience of mussel farmers internationally is that mussels require the least attention and maintenance of any form of aquaculture or cultivation.

Repeatability

- All Mussel Choir hardware and software is documented with diagrams and instruction manuals so maintenance can be performed by any technician with skill in the following areas:
- Physical computing: Arduino, raspberry pi
- Platforms: Unix/Linux, Amazon Web Services (Languages: Arduino C, Python)

There are at least 15 academic postprograms in Australia that graduates students annually that are competent in the software and hardware involved. The development strategy ensure that there are many qualified candidates for ongoing maintenance recruited and familiarized with the installation in the course of it design development and deployment.

Maintenance Schedule

We foresee the need for a quarterly inspection of the mussel beds, with some replacement of missing or defective sensors as required. We are currently in the process of installing two prototype "mussel beds" which will be in operation past the opening of the work in 2014, and which will better inform us of the half-life of the sensor electronics in the given environment.

Plans for ongoing maintenance/ monitoring of mussel beds:

- 2 person SCUBA (or pulling up from a boat) to monitor colony for health/number of viable adults and the potential impact from marine fouling / pest settlement / mussels from the 'wild'. Examination of the electronics equipment at the same time
- Quarterly at 1 day per quarter and 4 days in the initial year
- Pulling up colony once a year and de-fouling mussel rope and electronics equipment
- Duration will be dependent on the number of mussels per rope, number of ropes, and the length of rope.
- If the density is 500/m may need a boat with a lifting device.

Partnerships and Sponsorship

The Reference Group consists of key stakeholders in the Mussel Choir – Lend Lease, City of Melbourne (the Library, Sustainability as well as Arts and Culture) and Places Victoria. Providing a tighter definition around the nature of these partnerships is the top priority for ensuring the success of the work.

The following lists all the partnerships are being pursued to leverage the potential of the artwork to reach a broad audience and reach its aims for generating awareness and action on the environment through citizen engagement.

Some of these partnerships might offer in-kind support, others may offer advice, and others may offer funding for joint activities, or joint funding for shared activities might be sought.

With the Docklands Library

A broad range of options for co-programming and curating with Library have been presented here. We welcome the opportunity to look at the options in more detail with the Library and develop a plan for ongoing partnership and support for these activities. The LAB offers an excellent chance to focus through a workshop between staff and the Mussel Choir team.

With Melbourne Water

Mussel Choir is seeking a partnership with Melbourne Water to assist with the environmental messaging of the work, ensuring the connections made are in line with Melbourne Water's research, communication and educational campaigns. Their education program has been identified as the best fit, and we will be pursuing these discussions further in the lead up to the LAB.

With Port of Melbourne Authority

Port of Melbourne Authority is the agency responsible for water quality management in the Docklands where Mussel Choir will be sited.

A meeting is being sought to discuss how the Mussel Choir team might collaborate with Port of Melbourne to better understand the context in which Mussel Choir is set, as well as discuss an exchange of data and knowledge to improve the environmental performance and messaging of the work.

With CAPIM

Partnership with CAPIM has been progressed and will take the form of payment for services in the first instance, progressing towards a research partnership should funding applications, outlined above, be successful.

With Green Buildings Council of Australia

Looking at the ways in which Mussel Choir can assist the development in the attainment of green stars within the Green Star Communities ratings tool may require a closer working relationship between GBCA to look at this area of innovation.

With Waterwatch Victoria

Waterwatch are operating in the Docklands and will be invited to participate in the LAB to explore opportunities for engaging the community at Mussel Choir through their ongoing initiatives.

With Kids Teaching Kids

Mentioned early on in the project as a potentially interested party for bringing children to the Mussel Choir and associated activities in the Library, this organization has yet to be approached.

With Optus

A sponsorship deal will be sought with Optus to cover, at the very least, the broadband connection to the Mussel Choir over the 10 year period.

With community

The team is interested in working with the right partners to create 'Friends of the Melbourne Mussel Choir', a membership organisation akin to 'Friends of the Melbourne Symphony Orchestra', that provides ongoing financial support and a fan base to support programming.