cebra
Centre of Excellence for Biosecurity Risk Analysis

MESSAGE FROM THE DIRECTOR

The world continues to battle COVID-19. The mechanics of this virus are just the same as any invasive species: incursion, establishment, spread, modelling, policy, management (or mismanagement) and consequences. COVID-19 has reached nearly every corner in the world. This international spread has thrown a spotlight on just how connected we are, with the virus finding copious footholds and vectors for transmission. The feared and anticipated second waves (and in some cases, third waves) are taking hold, or threatening.

Decision-makers and advisory bodies have developed a variety of management approaches to deal with COVID. Many countries have adopted eradication or containment strategies, while others have taken a more hands-off approach. Some of these approaches have played out with deadly consequences, highlighting the importance of management based on solid scientific principles.

Here in Australia, Victoria adopted a strict stage four lockdown in response to a second wave of infections. At its peak, Victoria was identifying many hundreds of new cases per day. For months, the majority of us spent most of our days at home. Notwithstanding the economic, mental and social wellbeing costs of a lockdown, the approach achieved its goal: there have been no new COVID cases diagnosed in Victoria for more than a month.

For Victoria, relying on the science worked, but the science is not always unequivocal. However, most sources agree that wearing masks, maintaining hygiene, social distancing, efficient testing and strong contact tracing all help to lower risks and contain the spread.

At CEBRA, we have been doing our bit in the fight against COVID-19 by continuing to work from home. We've made great progress on several interesting projects, two of which are featured in this newsletter. This includes Dr Susie Hester's work on CEBRA project 190804: *Re-evaluating management of established pests including the European wasp, Vespula germanica, using biocontrol agents*. Susie's research found that there is likely to be significant benefit in implementing a classical biological control program to deal with European wasps.

Also featured is Nathaniel Bloomfield's work on CEBRA project 190801: *Automated image analysis for identifying biofouling risk on vessels.* This is an exciting project involving the use of neural networks and crowd sourcing analysis.

I'd like to also highlight the excellent work that Professor Tom Kompas, Dr Aaron Dodd, Professor Natalie Stoeckl and Dr John Baumgartner have done on valuing Australia's biosecurity system. Our research valued Australia's biosecurity system at $314 billion. This figure represents the amount that Australia would stand to lose over fifty years if we switched to a 'do nothing' approach. Equivalently, for each dollar invested by the Australian Government in biosecurity, there is an average return of $30.

This year, several of our researchers have also contributed to COVID-related discussion and research. This includes Dr Chris Baker, whom we welcomed to CEBRA earlier in the year. As an applied mathematician with an interest in invasive species, Chris is an excellent addition to our team. Read more about Chris in this newsletter.

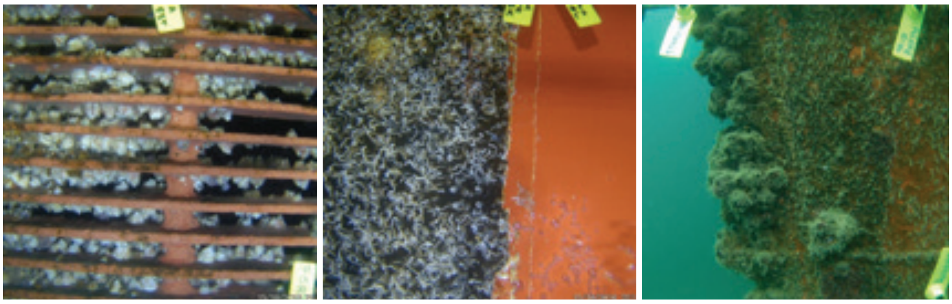
I wish all our staff, stakeholders and readers all the best for the festive season ahead. Let us hope that next year is a little more business as usual!

Andrew Robinson
Managing Director,
Centre of Excellence for Biosecurity Risk Analysis

IN THIS EDITION

Automating the assessment of biofouling in images to improve our management of marine biosecurity risks

Nathaniel Bloomfield



Examples of biofouling observed on vessels.

Invasive species in our coastal environments can be incredibly damaging. Northern Pacific seastar (Asterias amurensis) is a prime example, having been introduced to Tasmania from Japan through ballast water exchange. Ballast water is water that is taken on by ships in one port, and then discharged at another when they load cargo. Northern Pacific seastar is an apex benthic predator, meaning it is the top predator on the ocean's floor. Since the 1980s, when it was first introduced, it has devastated Tasmania's coastal ecosystems and spread to other parts of Australia.

Another major pathway for invasive marine organisms to reach our shores is biofouling. Biofouling is the accumulation of organisms on solid surfaces immersed in water, particularly on the hulls of vessels. There is growing interest within Australia and overseas to more closely manage the biosecurity risk presented by this pathway. New Zealand is currently leading the world in biofouling management. In 2018, New Zealand's government implemented a clean-hull standard that set mandatory requirements for vessels to manage biofouling. The management activities available to vessel owners include the use of antifoulant coatings – which delay the process of biofouling accumulation – and cleaning a vessel's hull while it is still in the water.

However, the only way to determine if a vessel's management strategy is effective is to do an in-water inspection. Currently, these require specialist dive teams to capture footage of the underwater hull. Analysing this data is expensive and time consuming, and the ship cannot undertake other activities while divers are in the water, as it would pose an occupational health and safety risk.

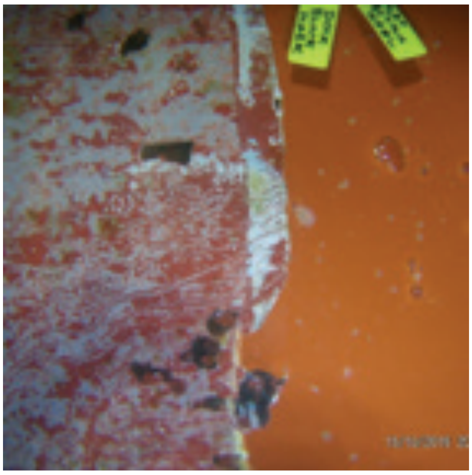
CEBRA project 190801 aimed to develop a method to assist or automate the assessment of footage from in-water inspections for biofouling, with the intent that this could be used with data collected from ROVs (remotely operated underwater vehicles) or automated drones to allow in-water inspections to be conducted much more easily.

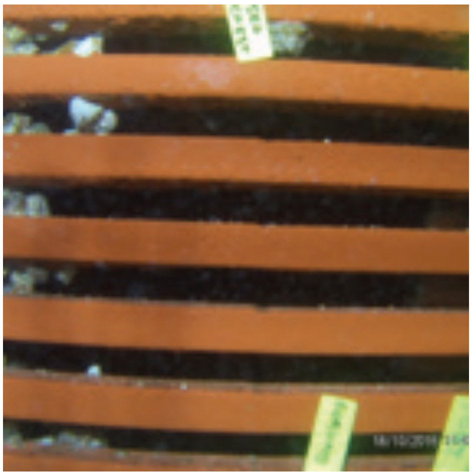
For this task, we explored the use of deep convolutional neural networks. This approach has achieved widespread success in the field of automated image recognition over the past decade. One notable application has been the successful automation of analysis of camera trap imagery for wild animals, even when tasked with identifying several different animal species.

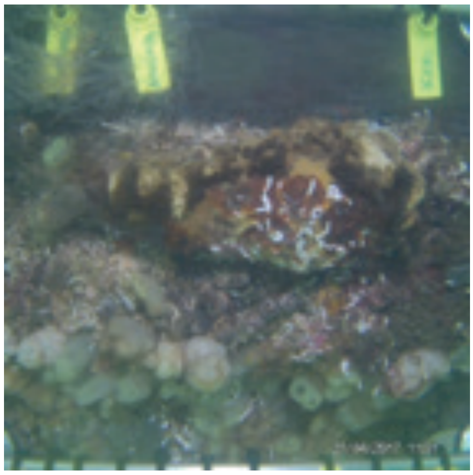
The first step of 190801 was to assemble a dataset of underwater vessel imagery, gathered from surveys conducted by the Department of Agriculture, Water and the Environment, the Ministry for Primary Industries and the California State Lands Commission. Then, we needed to manually grade these images in a way that we could teach to a neural network. There were over 10,000 images to grade, so we looked to online crowd-sourcing platforms (such as Amazon Mechanical Turk) to achieve this.

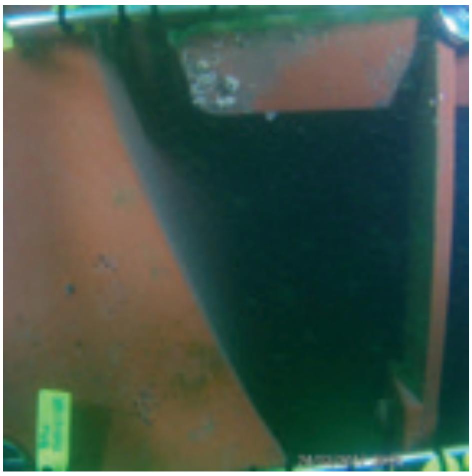
The 'graders' were unlikely to have a background in marine biology, so we also developed a simplified scale to use with three levels – no biofouling present (level 0), a small amount of biofouling present (level 1), and a large amount of biofouling present (level 2). By taking an aggregate of many scores for the same image, we were able to quickly label the whole dataset using crowdsourcing. This method achieved accuracy comparable to a set of three experts from Ramboll New Zealand who have experience working with biofouling grading scales and qualifications in marine biology.

The final step was to then train our neural networks. The resulting neural networks obtained very promising results, giving better than 80% accuracy for identifying clean and heavily fouled images and performing almost as well as our experts. To illustrate the performance of our method, some examples where the network was right and wrong are shown below. In this project we have been able to demonstrate that neural networks can help automate the process of analysing imagery for biofouling. However, there remains a large amount of work to be done to develop this into a method that can be deployed by the department. This includes adapting the method to perform well using video footage taken from ROVs and combining our footage-based biofouling ratings to determine the biosecurity risk of a whole vessel. CEBRA is looking forward to continuing to work with the department on this project, and see this innovation made available to frontline staff working to keep Australia's waters free of further incursions of invasive species.


Level 0 (Network predicted 0)


Level 1 (Network predicted 1)


Level 2 (Network predicted 2)


Level 1 (Network predicted 0)


Level 0 (Network predicted 1)


Level 2 (Network predicted 1)

Project update: is the European wasp a candidate for a renewed biological control program?

Dr Susie Hester

The European wasp *(Vespula germanica)* has been present in Australia for 60 years, and is now well established across south-eastern Australia. Although the negative impacts to horticulture, apiculture, biodiversity and (particularly!) tourism and outdoor social activities are well known and thought to be significant, there is no coordinated control program to reduce impact. Rather, control is undertaken by affected individuals and local councils, who bear any associated costs.

Established pests such as the European wasp are often overlooked as candidates for formal eradication or containment programs because the use of traditional control techniques over very large areas becomes uneconomic. Use of biocontrol agents in this context is usually the only economically feasible management option. However, the approvals process for the release of biocontrol agents typically takes years and requires substantial resources, especially when screening and testing of potential agents is required.

On the plus side, if the biocontrol agent becomes established, ongoing costs are minimal and the benefits carry on for many years into the future. Partly for this reason, along with access to new technologies for surveillance and detection, interest in the control of widespread pests is increasing. A recent re-evaluation of established pests by Australia's National Biosecurity Committee identified a set of widespread pests that might be good candidates for renewed attempts at impact reduction if resources were made available. This includes pests where biological control agents have already been identified and/or released.

The European wasp is one such pest – the parasitoid *Sphecophaga vesparum vesparum* was screened and tested in the late 1980s, and subsequently released in south-eastern Australia between 1989 and 1993. Unfortunately, the parasitoid failed to establish. The poor performance of the agent was thought to be caused by a 'genetic bottleneck' – all releases in Australia (and New Zealand) were derived from a single female parasitoid, something that could be avoided in future releases of the agent.

The focus of CEBRA project 190804: *Re-evaluating management of established pests including the European wasp,* Vespula germanica, *using biocontrol agents* was to investigate the economic feasibility of a renewed European wasp management program using *S.v. vesparum*. Whether such a program is worthwhile pursuing depends on the size of the benefits to industry, community and the environment from a reduction in European wasp abundance compared to the costs of the biological control program. Benefits and costs were explored using a decision analysis model, which incorporated (1) the population dynamics of the wasp and biocontrol agent, (2) the avoided damages to nature conservation, public land, households and primary industries (including pollination, apiculture, horticulture) from reduced wasp populations, and (3) the costs associated with importing, rearing and releasing the biocontrol agent.

Four plausible biological control scenarios based on different assumptions related to agent growth, mortality and effectiveness were chosen for analysis. In all cases simulated, the introduction of the control agent reduced damages, and the benefits of management outweighed the costs. The research also found that if European wasps continue to spread across Australia without a formal management program, damage will be significant, with more than half due to the damage that wasps cause to the use of public places for recreational and sporting activities. Specific results will be released once the final report is reviewed and endorsed.

While the economics of controlling European wasp using the biological control *S. v. vesparum* looks promising, additional scientific research is required to refine key parameter values before a formal recommendation to introduce a biocontrol program can be made. The modelling approach presented in CEBRA 190804 could be transferred to other pest–biocontrol agent scenarios. In some cases, this would require modifications to the population dynamics model and the process of calculating damages.

This research was led by Professor Oscar Cacho (UNE), with CEBRA's Susie Hester managing the project and providing research support, and Associate Professor Peter Tait (Lincoln University) undertaking the non-market valuation. The research benefited greatly from expertise in classical biological control provided by Dr Rae Kwong and Greg Lefoe (Agriculture Victoria Research, Department of Jobs, Precincts & Regions), expertise in CLIMEX provided by Darren Kriticos (CSIRO) and those who attended the two project workshops.

This project is a great example of research where economics and science are combined in the design of decision tools. This ensures robust and unbiased analysis with the given state of knowledge, where uncertainty is explicitly acknowledged.

Researcher profile: Dr Chris Baker

Chris Baker has a long connection with the University of Melbourne. After graduating with a science degree (majoring in applied mathematics), he went on to complete a Masters of Science in mathematics and statistics. In 2017, he obtained a PhD on optimal strategies for invasive species removal, also at the University of Melbourne.

As an applied mathematician, Chris has worked on a variety of topics across several institutions. After finishing his PhD, he went to Pennsylvania State University and worked on models for managing antimicrobial resistance. Chris was also awarded the 2016 John Stocker Fellowship, allowing him to undertake a project at the University of Queensland, joint with CSIRO. After this, he lectured in applied mathematics and statistics at the Queensland University of Technology.

In 2020, he returned to the University of Melbourne and took up a joint position across CEBRA and the School of Mathematics and Statistics. His role focuses on invasive species management and building collaborations with the Peter Doherty Institute for Infection and Immunity, looking at the overlaps between ecology and epidemiology to see how decision science can be better used to inform epidemic management.

Given the current pandemic, Chris's research has temporarily shifted focus. 'This year, my work ended up getting somewhat overtaken by COVID,' Chris says. Together with the Papua New Guinean government and the World Health Organization, Chris worked on COVID-19 forecasts on nine pacific island countries, most recently French Polynesia.

Chris has also been assisting the Australian government with COVID preparedness and response activities. 'Another big piece of work I did this year was around optimising the COVID testing strategy in Australia.' For his work, Chris was awarded a Faculty of Medicine, Dentistry and Health Sciences Award for Excellence in Engagement–Partnerships Award.

In his spare time, Chris is a keen rock climber and former swing dance champion. 'I have a bunch of Australian national titles and we won at the USA national championships one year.'

Check out Chris 'lindy-hopping' here.