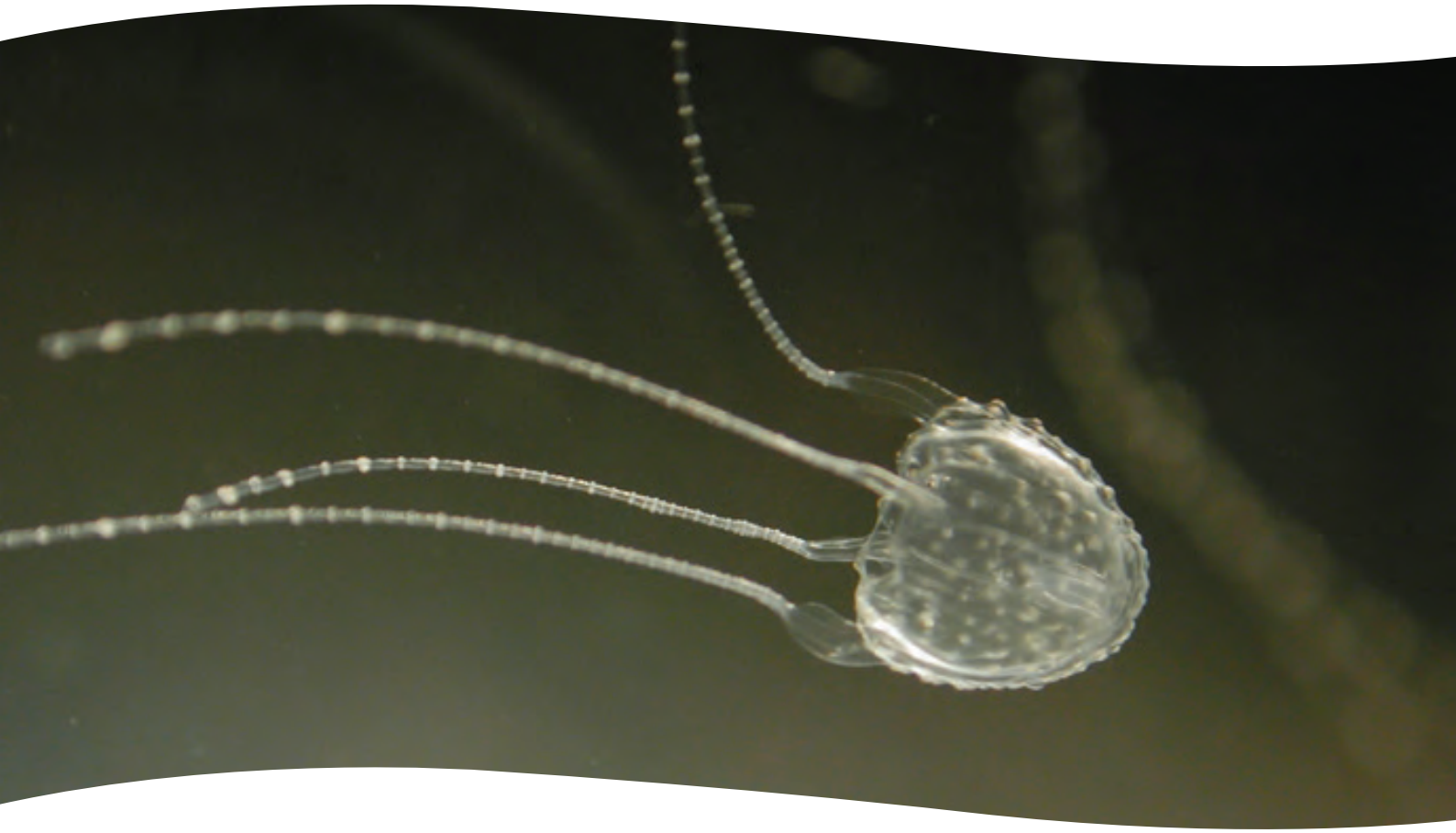
Tropical Water Quality Hub

National Environmental Science Programme

Final Report

Establishing a research framework for future NESP investment into better understanding of the presence of Box-Jellyfishes (Irukandji) and risks in the Great Barrier Reef

Michael Kingsford, Kylie Pitt, Lyndon Llewellyn, Mark O'Callaghan, Jamie Seymour and Anthony Richardson



Australian Government

Australian Institute of Marine Science

Project 3.6: Establishing a research framework for future NESP investment into better understanding of the presence of Box-Jellyfishes (Irukandji) and risks in the Great Barrier Reef

Investigators: Michael Kingsford[1], Kylie Pitt[2], Lyndon Llewellyn[3], Mark O'Callaghan[1]

Co-contributors: Jamie Seymour[4] and Anthony Richardson[5]

[1] College of Marine and Environmental Sciences, James Cook University, Townsville

[2] School of Environment, Griffith University, Gold Coast

[3] Australian Institute of Marine Science, Townsville

[4] Australian Institute for Tropical Health and Medicine, James Cook University, Cairns

[5] CSIRO Oceans and Atmosphere Flagship, Ecosciences Precinct, Brisbane

Supported by the Australian Government's
National Environmental Science Programme
Project 3.6: Establishing a research framework for future NESP investment into better understanding of the presence of box-jellyfishes (Irukandji) and risks in the Great Barrier Reef

This report should be cited as:
Kingsford, M.J., K. Pitt, L. Llewellyn, M.D. O'Callaghan, J. Seymour and A. Richardson. (2016) Project 3.6: Establishing a research framework for future NESP investment into better understanding of the presence of box-jellyfishes (Irukandji) and risks in the Great Barrier Reef. Report to the National Environmental Science Programme. Reef and Rainforest Research Centre Limited, Cairns (56pp.).

Published by the Reef and Rainforest Research Centre on behalf of the Australian Government's National Environmental Science Programme (NESP) Tropical Water Quality (TWQ) Hub.

The Tropical Water Quality Hub is part of the Australian Government's National Environmental Science Programme and is administered by the Reef and Rainforest Research Centre Limited (RRRC). The NESP TWQ Hub addresses water quality and coastal management in the World Heritage listed Great Barrier Reef, its catchments and other tropical waters, through the generation and transfer of world-class research and shared knowledge.

Cover photographs: *Carukia barnesi* (Image credit J. Seymour JCU); Group Photo (Image credit B. Robertson RRRC).

This report is available for download from the NESP Tropical Water Quality Hub website:
http://www.nesptropical.edu.au

CONTENTS

Acronyms ii
Acknowledgements iii
1.0 Executive Summary 1
2.0 Introduction 2
2.1 Intent of the project and workshop 2
2.2 Alignment of the project with management plans of stakeholders 3
3.0 Workshop background and outcomes 4
3.1 Invitation for submissions 4
3.2 Schedule for the workshop 4
3.3 Workshop outcomes 5
3.4 Gaps in our knowledge 5
3.4.1 Knowledge of biology and ecology 5
3.4.2 Reducing risk – prediction, prevention and treatment 5
3.4.3 Existing data 6
3.5 Key performance indicators 6
3.5.1 KPI Formal meetings 6
3.5.2 KPI Indigenous engagement 6
4.0 Recommendations for future NESP TWQ Hub investment 8
5.0 References 9
Appendix 1: Stakeholders invited to the workshop 11
Appendix 2: Stakeholders that attended the workshop 13
Appendix 3: Submissions from stakeholders 14
Appendix 4: Notes on workshop presentations 31
Appendix 5: Workshop group summaries 40

ACRONYMS

AIMS..... Australian Institute of Marine Science
AITHM ..... Australian Institute for Tropical Health and Medicine
AMPTO..... Association of Marine Park Tour Operators
ARC..... Australian Research Council
AVRU..... Australian Venom Research Unit
ARC CoE..... Australian Research Council Centre of Excellence
CSIRO ..... Commonwealth Scientific and Industrial Research Organisation
DOE..... Department of the Environment
FNQ..... Far North Queensland
GBR..... Great Barrier Reef
GBRMPA..... Great Barrier Reef Marine Park Authority
JCU..... James Cook University
NAILSMA..... North Australian Indigenous Land and Sea Management Alliance
NESP..... National Environmental Science Programme
QTIC..... Queensland Tourism Industry Council
RFDS..... Royal Flying Doctor Service
RRRC ..... Reef and Rainforest Research Centre Limited
SLSA ..... Surf Life Saving Australia
SLSQ..... Surf Life Saving Queensland
TFC..... Tourism Forecasting Committee
TSRA..... Torres Strait Regional Authority
TTNQ..... Tourism Tropical North Queensland
TUMRA..... Traditional Use of Marine Resource Agreements
TWQ ..... Tropical Water Quality
UQ ..... University of Queensland

ACKNOWLEDGEMENTS

We would like to thank all of the stakeholders who participated in the workshop and those who provided submissions. A number of students and personnel helped at the workshop as volunteers, we thank the following: Jodie Schlaefer, Christopher Mooney and Shelley Templeman. We thank JCU for providing the venue for the workshop and the staff of the Cairns Institute for their assistance especially Jennifer McHugh. Further thanks to Lisa-ann Gershwin, Boyd Robertson and Jamie Seymour for the use of their images. This project was funded by the Federal Initiative NESP and we thank RRRC, especially Julie Carmody, for their support.

1.0 EXECUTIVE SUMMARY

The intent of this project was to conduct a workshop with key researchers and stakeholders to establish the future research framework for NESP investment into better understanding of box-jellyfishes presence and risk in the Great Barrier Reef. This was to include, defining the scope of work required to: identify how species of Irukandji and stingers respond to changing water quality conditions, make predictions of box-jellyfishes presence based on environmental conditions, determine ecological impacts and recommend innovative management options. We proposed to engage with stakeholders to discuss stakeholder concerns, determine the scientific information already available, determine research gaps to be filled and develop a framework to guide future NESP research to meet end-user needs.

Stakeholders to be involved included - the scientific community, AMPTO, Queensland Tourism Industry Council, SLSQ, Traditional Owners, Queensland Health, GBRMPA and Local Government representatives.

We spent over a month of the project identifying key stakeholders and urging them to contribute to workshop that was held 20-21st August 2015. In total we approached 50 people and related organisations; 31 persons were listed to attend and 38 arrived as some parties recruited additional contributors. Engagement by all attendees was strong and all played a role in defining the scope of work required to fill research gaps.

Initial findings were forwarded to the NESP Tropical Water Quality Hub so that the identified priorities could be considered with respect to funding in round two. Following the workshop we had more consultation with indigenous communities, especially the Yirrganydji community about the active engagement of Indigenous Rangers and the development of a longer term Research Partnership Agreement.

We have also had heavy engagement with stakeholders to develop a NESP (2) application that aimed to focus on: (1) building a jellyfish database; (2) developing a forecast model to reduce the risk of stings; (3) test those models – including the use of Rangers; (4) providing on-beach quick ID of jellyfish using digital cameras; (5) delivering more accurate forecast of stings to stakeholders.

2.0 INTRODUCTION

The purpose of this project was to conduct a facilitated workshop with researchers and stakeholders to establish a framework for future NESP investment into better understanding of the presence of Box-Jellyfishes (Irukandji) and risks in the Great Barrier Reef.

2.1 Intent of the project and workshop

Prior to funding into further research on box jellyfishes, it was considered essential that the stakeholders and researchers set an agreed research agenda that would deliver strategic information needed to allow progress in determining the risks of: envenomation by box jellyfishes in different water conditions and 'real life' solutions to stakeholders to mitigate against the risks. Without an agreed research framework, well intended research work will occur in isolation and struggle to achieve end-user acceptance.

Our intent, therefore, was to provide a coordinated research framework that would guide the timing and extent of future research investment into box-jellyfish management in the GBR. We anticipated that some of the ideas offered at the workshop would be considered to be innovative management options.

Strategic investment of NESP research funds in box-jellyfish management was intended to progress the current debate towards a solution focus within the commitment of the Australian and State Government to address issues concerning *key species* and the decline in *water quality decline* in the GBR.

Stakeholders who were consulted included: the scientific community, AMPTO, Queensland Tourism Industry Council, SLSQ, Traditional Owners, Queensland Health, GBRMPA, Local Government representatives. A full list of those invited is provided in Appendix 1 and the list of those who attended is provided in Appendix 2.

It was particularly important that indigenous communities would have an opportunity to play an active role in setting the research agenda at the workshop. This report largely focuses on the outcomes from the workshop that was held at JCU in Cairns (Cairns Institute building).

EXPERTISE OF THE INVESTIGATORS

James Cook University has the capability, experience and network to lead the facilitated workshop to establish the research agenda. Pitt, Kingsford and Llewellyn comprise a strong, multidisciplinary team that unites expertise across three of the six research organisations (Griffith University, JCU, AIMS) involved in the TWQ Hub. Pitt and Kingsford are experts in the ecology of jellyfish, have co-authored 8 publications and have been joint investigators on an ARC Linkage project on interactions between jellyfish and nutrients. Pitt has undertaken multiple experiments on polyps of jellyfish, including Irukandji and is maintaining a lab population of the animals. Kingsford has expertise in cubozoan jellyfish, including chemical analyses of tissues. Llewellyn is a marine biologist with expertise in analytical biochemistry and will provide specific support for chemical analyses of pesticides. Llewellyn and Kingsford are currently collaborating to develop a real-time camera-based monitoring system for cubozoan jellyfish.

2.2 Alignment of the project with management plans of stakeholders

Research outcomes on box jellyfishes that increase knowledge, reduce risk and help to develop effective management options align with the intent of stakeholder strategies as follows:

Association of Marine Park Tourist Operators (AMPTO): The project aligns with major themes of the 20-year plan of Tourism Queensland (*Destination*): Build strong partnerships > Engage the community to make tourism everybody's business > Inform decision-making with data, research, intelligence and insights (www.destq.com.au). Our collaboration with AMPTO, therefore, will work towards our common goal of reducing risk to users utilising GBR waters.

Great Barrier Reef Marine Park Authority (GBRMPA): What are the population dynamics, distribution and behaviour of Irukandji and box jellyfish?" is identified as a 'key science question' (BscQ33) in GBRMPA's Science Strategy and Information Needs 2014-2019.

BOX JELLYFISHES

Box jellyfishes include 'stingers' (*Chironex fleckeri*) and 10 known species of 'Irukandji' jellyfishes.
Image – Irukandji jellyfish
Size of bell ~ 2 cm wide
Carukia barnesi
(Image L. Gershwin)

Surf Life Saving Queensland (SLSQ): The current project aligns with a key strategy in SLSQ's Strategic Plan 2015-20 (SLSQ 2015): (1.1) Reduce drowning and aquatic deaths > Apply effective methods developed through research and expert partnerships; strengthen our partnerships with like water safety practitioners and increase awareness. Based on a recent workshop we conducted, SLSQ wants to protect swimmers by obtaining accurate estimates of risk, reliable IDs of high-threat species, and a robust database that can be used to identify trends that would help to manage beaches.

Queensland Government: The Far North Queensland Regional Plan 2009–2031 outlined an agreed government position on the future of FNQ (Queensland Government 2009). The plan recognises the importance of climate change and the effect of economic, environmental, tourism, social and cultural values and functions of the region's natural resources. These need to be valued and managed to achieve ecological sustainability and resilience to climate change. This would infer the continued requirement of jellyfish research to ensure sustainable development of the coastal area to attract new business enterprises, new residents and tourists. Careful management of the coast is required to ensure the region's coastline continues to contribute to the livelihoods and lifestyles of residents and visitors, and to ensure its most valued elements are protected and conserved.

The strategic plan for Mandingalbay Yidinji Country (2009) prepared by the Mandingalbay Yidinji Aboriginal Corporation includes caring for all animals as their responsibility to their country. This includes continuing jellyfish research to understand their ecology and biology as they are an important food source for turtle populations.
(http://www.djunbunji.com.au/files/8713/2219/6853/Mandingalbay_Plan.pdf).

3.0 WORKSHOP BACKGROUND AND OUTCOMES

3.1 Invitation for submissions

Prior to the workshop stakeholders were invited to make submissions, where they were asked to list key issues. Specifically, and with respect to box jellyfishes (i.e. stingers and Irukandji) stakeholders were asked to provide the following as dot-points.

1. Your concerns (Please rank from most important to lesser importance; you may decide to give some items equal rank).
2. How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank).

All unedited submissions are provided in Appendix 3.

3.2 Schedule for the workshop

Time	**Item**
Day One - Thursday, August 20th, 2015	
11:00- 11:10	Indigenous Welcome (Gavin Singleton)
11:10- 12:00	Background on NESP and intentions of project – Mike Kingsford, Sheridan Morris (RRRC), Damien Burrows (Hub Director)
12:00- 12:30	A brief statement of attendee affiliations and interest in the workshop
12:30- 13:15	Lunch
13:15- 14:00	Box jellyfishes – background on box jellyfishes (Mike Kingsford)
14:00- 15:00	Stakeholder statements/submissions
15:00- 15:20	Afternoon tea
15:20- 17:00	Statements on the science
17:10-18:30	Social event
Day two - Friday, August 21st 2015	
09:00-10:30	Progress from day one Statements on the science (continued) Group discussions
10:30- 10:50	Morning tea
10:50- 12:15	Group discussions and summaries
12:15- 13:00	Lunch
13:00- 14:00	Wrap up and action plan

Notes on individual contributions from stakeholders in the schedule are provided in Appendix 4.

3.3 Workshop outcomes

Key outcomes and recommended focus for future research were enabled during general discussions and then distilled within three workgroups to prioritise research needs (the raw comments from each group and the prioritisation by stakeholder is provided in Appendix 5) and in doing so identify the gaps in our knowledge and the needs for innovative management. The results of group discussion were then presented to the whole group to identify what were considered to be the top priorities that related to the NESP Hub for water quality.

3.4 Gaps in our knowledge

3.4.1 Knowledge of biology and ecology

- The life history of all species of Irukandji.
- The influence of physical factors such as salinity and temperature on influencing abundance and survival of polyp and medusa stages of jellyfishes.
- The influence of related water quality, especially nutrients, pesticides and physical factors such as salinity and temperature on the abundance and survival of polyp and medusa stages of jellyfishes.
- Factors triggering the release of medusa from benthic polyps
- The connectivity of populations in ecological and evolutionary time.
- Scales of movement of box jellyfishes
- Identification of hotspots
- The impact of climate change on biogeography and abundance.

3.4.2 Reducing risk – prediction, prevention and treatment

- Local predictive models of the level of risk for envenomation
- Surveillance of abundance
- Empowering stakeholders to estimate risk to reduce unnecessary closures of beaches

WATER QUALITY AND BOX JELLYFISHES: DOES IT MATTER?

Current information suggests that water quality can affect all life history stages of jellyfishes and specifically box-jellyfishes (this includes the benthic polypoid and medusoid phases) as follows: changes in salinity trigger the release of small jellyfishes and if too low can kill; critical temperatures can affect them and further nutrient levels can influence the food available - that can in turn affect jellyfish survival (Reviews: Gershwin et al 2013; Kingsford & Mooney 2014). Controlled experiments are required to further explore tolerances and triggers.

- Rapid identification of dangerous jellyfish
- An effective ‘alert system’
- Effective communication or risk
- Automated detection systems – image acquisition and identification and molecular detection
- Best practice for the treatment of stings from all species

3.4.3 Existing data

- Access to exiting data on abundance of cubozoans and stings from SLSA, hospitals and researchers
- Indigenous knowledge

3.5 Key performance indicators

3.5.1 KPI Formal meetings

Conduct a two-day Workshop with 38 stakeholders at JCU’s campus in Cairns. This was held on 20-21 August 2015 with key researchers and stakeholders to establish the future research framework for NESP investment into better understanding of box-jellyfishes presence and risk in the Great Barrier Reef. This was to include defining the scope of work required to: identify how species of Irukandji and stingers respond to changing water quality conditions, predictions of box-jellyfishes presence based on environmental conditions, determine ecological impacts, innovative management options.

There was a press release from RRRC immediately after the event and some press coverage before the workshop. Because this project overlapped with NESP (round two) informal discussions were also held with stakeholders for other Irukandji initiatives as follows; AMPTO (Chair, Col McKenzie and Quicksilver Connections), Surf Life Saving Australia and Gavin Singleton of the Yirrganydji.

3.5.2 KPI Indigenous engagement

The groups engaged in the workshop represented ‘country’ from the Lockhart River to Townsville. Other groups were invited to the workshop, but could not attend. Eight individuals from the following groups attended the workshop: Balkanu, Yirrganydji, Yuku Baja Muliku Rangers, Djunbunji Land & Sea Program; indigenous officers from JCU attended (Appendix 2). We are also expanding our engagement with indigenous representatives to include Mapoon Land and Sea Rangers and the Mapoon Aboriginal Shire Council from the Gulf of Carpentaria.

Separate communication and meetings have been held with Gavin Singleton of the Yirrganydji (Cairns to Port Douglas). A Research Partnership Agreement is in progress that

sets out long-term targets to inform and engage the Yirrganydji Saltwater Traditional Owner Group and specifically involve the Indigenous Rangers in the research and access to the databases that results. An important part of this collaboration will centre around the opportunities created by Project 2.2.3 of NESP 2.

4.0 RECOMMENDATIONS FOR FUTURE NESP TWQ HUB INVESTMENT

The following are the top priorities from the workshop for future NESP TWQ Hub investment. Priorities were scored as follows:

A1 - highest relevance to the Hub; A2 - high relevance to the Hub; A3 - important regarding box- jellyfish related issues, but of secondary relevance to the NESP Hub.

- Early warning by forecasting (models), detection (e.g. with jellycams and nets) and accurate identification when jellyfish collected – the information would in turn be fed into a revitalized alert system – 'including app.' development (A1).
- The development of risk models that are backed up by the good husbandry of jellyfish (and their benthic polyps) for experiments on the influence of water quality (A1).
- An integrated warehouse to store data (e.g. SLSA) and data rescue to determine existing data, including what is known from indigenous sources (A2).
- Clinical trials to determine the most effective first aid, species ID for effective treatment and secondary treatments as well as the capturing of clinical data. Needs to feedback in to the alert system (A3).
- Awareness and communication material and media pack (release by issue), and record all relevant data on the *eAtlas* – a NESP initiative (A3).

Project 3.6 has improved stakeholder engagement and helped to strategically focus the NESP investment.

5.0 REFERENCES

Carrette *et al.* (2014). Early life history of *Alatina* cf. *moseri* populations from Australia and Hawaii with implications for taxonomy (Cubozoa: Carybdeida, Alatinidae). PLos ONE 9(1): e84377. doi:10.1371/journal.pone.0084377.

Carrette & Seymour (2013). Long – term analysis of Irukandji stings in Far North Queensland: Diving and Hyperbaric Medicine. 43(1) 9-15.

Carrette, T. J., et al. (2002). Temperature effects on box jellyfish venom: a possible treatment for envenomed patients? Medical Journal of Australia 177(11-12): 654-655.

Courtney *et al.* (2015). Prey capture ecology of the Cubozoan *Carukia barnesi*: *C. barnesi* using tentacles as lures to fish during the day, less active at night. Plos ONE 10(5) e0124256. doi:10.1371/journal.pone.0124256.

Courtney, R. and J. Seymour (2013). Seasonality in Polyps of a Tropical Cubozoan: *Alatina nr mordens*. Plos ONE 8(7) e69369. doi:10.1371/journal.pone.0069369.

Gershwin L., Condie S.A., Mansbridge J.V., Richardson A.J. (2014). Dangerous jellyfish blooms are predictable. J. R. Soc. Interface 11: 20131168. http://dx.doi.org/10.1098/rsif.2013.1168.

Gershwin, L. A., et al. (2013). Biology and Ecology of Irukandji Jellyfish (Cnidaria: Cubozoa). Advances in Marine Biology, Vol 66. M. Lesser. San Diego, Elsevier Academic Press Inc. 66: 1-85.

Gershwin, L. and M. J. Kingsford (2008). Pelagic Cnidaria and Ctenophora. The Great Barrier Reef: Biology, Environment and Management. P. Hutchings, M. Kingsford and O. Hoegh-Guldberg. Collingwood, CSIRO Publishing: 188-198.

Gordon, M. and J. Seymour (2012). Growth, Development and Temporal Variation in the Onset of Six *Chironex fleckeri* Medusae Seasons: A Contribution to Understanding Jellyfish Ecology. Plos One 7(2): 11.

Gordon, M. R. and J. E. Seymour (2009). Quantifying movement of the tropical Australian cubozoan *Chironex fleckeri* using acoustic telemetry. Hydrobiologia 616: 87-97.

Great Barrier Reef Marine Park Authority (2014). Great Barrier Reef Marine Park Authority Science Strategy and Information Needs 2014-2019, GBRMPA, Townsville. P3232p.

Kingsford, M. J. and C. J. Mooney (2014). The Ecology of Box Jellyfishes (Cubozoa). Jellyfish Blooms. K. Pitt and L. CH. Heidelberg, Springer: 267-30.

Kingsford, M. J., et al. (2012). Abundance patterns of cubozoans on and near the Great Barrier Reef. Hydrobiologia 690: 257-268.

Klein, S.G. et al. (2014) Irukandji jellyfish polyps exhibit tolerance to interacting climate change stressors. Global Change Biology 20: 28-37.

Mandingalbay Yidinji Aboriginal Corporation (2009). The strategic plan for Mandingalbay Yidinji Country (26p). Available from http://www.djunbunji.com.au/files/8713/2219/6853/Mandingalbay_Plan.pdf.

Mooney, C. J. and M. J. Kingsford (2012). Sources and movements of *Chironex fleckeri* medusae using statolith elemental chemistry. Hydrobiologia 690: 269-277 DOI 10.1007/s10750-012-1049-5.

Queensland Government (2009). The Far North Queensland Regional Plan 2009–2031 (2009) outlined an agreed government position on the future of FNQ. 188p.

SLSQ (2009) Surf Life Saving Queensland's Strategic Plan 2015-20. Available from http://lifesaving.com.au/

Templeman, M. A. and M. J. Kingsford (2015). Predicting aqueous copper and zinc accumulation in the upside-down jellyfish *Cassiopea maremetens* through the use of biokinetic models. Environ. Monit. Assess 187: 416- DOI 10.1007/s10661-015-4657-5.

Templeman, M. A. and M. J. Kingsford (2012). Variation in soft tissue chemistry among scyphozoan and cubozoan jellyfishes from the Great Barrier Reef, Australia. Hydrobiologia 690: 279-290 DOI 10.1007/s10750-012-1051-y.

Templeman, M. A. and M. J. Kingsford (2010). Trace element accumulation in *Cassiopea* sp (Scyphozoa) from urban marine environments in Australia. Marine Environmental Research 69(2): 63-72.

APPENDIX 1: STAKEHOLDERS INVITED TO THE WORKSHOP

Surname	First	Institution	E-mail	Affiliation
Barclay	Shaun	TSRA	Shaun.barclay@tsra.gov.au	Government
Becken	Susanne	Griffith University	s.becken@griffith.edu.au	Research Institution
Bellafquih	Robyn	Jabalbina Aboriginal Corporation (Chairperson)	rbellafquih@yahoo.com.au	Indigenous
Blackman	Celestine	Gidarjil TUMRA (Port Curtis Coral Coast)	bjsel11@gmail.com	Indigenous
Blanchard	Russell	SLSQ	rblanchard@lifesaving.com.au	Government
Burrows	Damian	JCU	damien.burrows@jcu.edu.au	Research Institution
Caley	Julian	AIMS	J.Caley@aims.gov.au	Research Institution
Carmody	Julie	RRRC	julie.carmody@rrrc.org.au	RRRC
Carrette	Teresa	JCU	Teresa.carrette@jcu.edu.au	Research Institution
Condie	Scott	CSIRO	Scott.Condie@csiro.au	Research Institution
Corkeron	Michael	Townsville Hospital	Michael_Corkeron@health.qld.gov.au	Government
Courtney	Rob	JCU	robert.courtney@jcu.edu.au	Research Institution
Cowlishaw	Melissa	GBRMPA	mel.cowlishaw@gbrmpa.gov.au	Government
Delaine	Jon	Djunbunji Ltd Land & Sea Program	jon@djunbunji.com.au	Indigenous
Gale	Kevin	Dept. of the Environment - Reef Trust	Kevin.gale@environment.gov.au	Government
George	Melissa	Wulgurukaba Traditional Owner NAILSMA Ltd	Melissa.george@nailsma.org.au	Indigenous
Gordon	Matt	JCU	matthew.gordon@jcu.edu.au	Research Institution
Gschwind	Daniel	QTIC, RRRC, TFC	Daniel.Gschwind@qtic.com.au	NGO
Hale	Larissa	Yuku Baja Muliku Rangers	larissa.hale@balkanu.com.au	Indigenous
Hill	George	Surf Life Saving	ghill@lifesaving.com.au	SLSA
Jones	Chris	GBRMPA	chris.jones@gbrmpa.gov.au	Government
Joyce	Alf	Mamu TUMRA	alfjoyce@bigpond.com	Indigenous
Keating	Graham	QEHP Land & Sea Rangers	Graham.keating@ehp.qld.gov.au	Government
Kingsford	Michael	JCU-ITF	michael.kingsford@jcu.edu.au	Research Institution
Little	Mark	Cairns Base Hospital	angie-mark@bigpond.com	Research Institution-health

Llewellyn	Lyndon	AIMS	L.Llewellyn@aims.gov.au	Research Institution
Lui	Stan	TSRA	Stan.lui@tsra.gov.au	Government
March	Jay	SLSQ	jmarch@lifesaving.com.au	Government
McGrath	Ami	Reef Trust	ami.mcgrath@environment.gov.au	Government
McKenzie	Col	AMPTO	colmckenzie@ampto.com.au	Industry
Mooney	Christopher	JCU	christopher.mooney@my.jcu.edu.au	Research Institution
Morris	Sheriden	RRRC	Sheriden.morris@rrrc.org.au	RRRC
Muir	Bob	Woppaburra TUMRA Steering Committee	woppa1@bigpond.com	Indigenous
Mundraby	Dale	Djunbunji Ltd Land & Sea Program	dale@djunbunji.com.au	Indigenous
O'Callaghan	Mark	JCU	mark.ocallaghan@jcu.edu.au	Research Institution
Penrose	Helen	JCU	Helen.penrose@jcu.edu.au	Research Institution
Pereira	Peter	Cairns Base Hospital	pereirapet@gmail.com	Research Institution-health
Pitt	Kylie	Griffith University	k.pitt@griffith.edu.au	Research Institution
Prestipino	Cheryl	Yintingga Aboriginal Corporation Lama Ranger Service	executive@lamalama.org.au	Indigenous
Reed	Lyn	JCU	lyn.reed@jcu.edu.au	Research Institution
Richardson	Anthony	UQ/CSIRO	a.richardson1@uq.edu.au	Research Institution
Rist	Phil	Girringun Aboriginal Corporation	admin@girringun.com.au	Indigenous
Schlaefer	Jodie	JCU	jodie.schlaefer@my.jcu.edu.au	Research Institution
Seymour	Jamie	JCU	jamie.seymour@jcu.edu.au	Research Institution
Singleton	Gavin	Yirrganydji - Cairns	g_singo1@hotmail.com	Indigenous
Sparks	Colin	SLSQ	csparkes@lifesaving.com.au	SLSQ
Templeman	Shelley	JCU-TropWATER	shelley.templeman@jcu.edu.au	Research Institution
Winkel	Ken	AVRU-UMelb-ITF	kdw@unimelb.edu.au	Research Institution-health
Wolanski	Eric	JCU	eric.wolanski@jcu.edu.au	Research Institution

APPENDIX 2: STAKEHOLDERS THAT ATTENDED THE WORKSHOP

Last name	First name	Organisation
Becken	Susanne	Griffith, Gold Coast
Blanchard	Russell	SLSQ, Townsville
Burrows	Damien	TropWATER, Townsville
Caley	Julian	AIMS, Townsville
Carmody	Julie	RRRC, Cairns
Carrette	Teresa	JCU, Cairns
Condie	Scott	CSIRO, Hobart
Courtney	Rob	JCU, Cairns
Cowlishaw	Mel	GBRMPA, Townsville
Gershwin	Lisa-Ann	Consultant
Gordon	Matt	JCU, Cairns
Hale	Michael	Yuku Baja Muliku
Hore	Russell	Quicksilver, Port Douglas
Jones	Chris	GBRMPA, Townsville
Kingsford	Michael	JCU, Townsville
Llewellyn	Lyndon	AIMS, Townsville
Lui	Stan	RRRC, TSRA
March	Jay	SLSQ, Cairns
Moon	Steve	AMPTO, Cairns
Mooney	Christopher	JCU, Townsville
Morris	Sheriden	RRRC, Cairns
Mundraby	Laurissa	Djunbunji Ltd; Land & Sea Program
O'Callaghan	Mark	JCU, Townsville
Penrose	Helen	Consultant
Pereira	Peter	Cairns Base Hospital
Pereiva	Peter	Dawul Wuru Aboriginal Council
Pitt	Kylie	Griffith, Gold Coast
Prestipino	Cheryl	Yintingga Aboriginal Corporation; Lama Ranger Service
Reed	Lyn	JCU, Townsville
Richardson	Anthony	CSIRO, Brisbane
Robertson	Boyd	RRRC, Cairns
Schlaefer	Jodie	JCU, Townsville
Seymour	Jamie	JCU, Cairns
Singleton	Gavin	Dawul Wuru Aboriginal Council
Singleton	Tarqin	Dawul Wuru Aboriginal Council
Skeene	Michael	Dawul Wuru Aboriginal Council
Last name	**First name**	**Organisation**
Templeman	Shelley	TropWATER, Townsville
Winkel	Ken	Australian Venom Research Unit

A total of 38 people attended the workshop.

APPENDIX 3: SUBMISSIONS FROM STAKEHOLDERS

Professor Susanne Becken (Griffith University)

E-mail contact: s.becken@griffith.edu.au

With respect to box jellyfishes (i.e. stingers and Irukandji) please provide as dot-points:

(1) Your concerns (Please rank from most important to lesser importance; you may decide to give some items equal rank)

- Changing distribution patterns of jellyfish due to global warming
- How predictable are these patterns and how variable are they season-by-season
- How prepared is the tourism industry to deal with jellyfish risks and incidents
- If and how should the tourism industry communicate jellyfish risk to tourists and is there a different need for different market segments?

(2) How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank)

- Mapping of jellyfish distributions in the future
- Communication of jellyfish risk
- Integration in risk management plans

Russell Blanchard and Jay March (SLSQ)

E-mail contact: rblanchard@lifesaving.com.au;jaymarch@lifesaving.com.au

With respect to box jellyfishes (i.e. stingers and Irukandji) please provide as dot-points:

(1) Your concerns (Please rank from most important to lesser importance; you may decide to give some items equal rank)

- Irukandji identification
- Major stings out of hours - accordingly there is no record and information should be passed on to life guard services for potential closures and sting related databases

(2) How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank)

- Better ID charts for cubozoans capable of bringing on Irukandji Syndrome.
- An improved Smartphone technology available to lifeguards for instant response from researchers
- Communication chain from emergency departments to Life Guard Services

Dr Julian Caley and Dr Lyndon Llewellyn (AIMS)

E-mail contact: j.caley@aims.gov.au; l.llewellyn@aims.gov.au

With respect to box jellyfishes (i.e. stingers and Irukandji) please provide as dot-points:

(1) Your concerns (Please rank from most important to lesser importance; you may decide to give some items equal rank)

- Lack of adequate data for building appropriate spatially and temporally explicit risk models
- Lack of risk based decision tools for adequately managing stinger risks
- Improved health management following stings

(2) How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank)

- Investment in data rescue, facilitation of better data collection, and appropriate curation and access to these data
- Increased surveillance of jellyfishes and associated environmental conditions
- Better pre- and post-sting decision support and associated risk management

Dr Mel Cowlishaw (GBRMPA)

E-mail contact: mel.cowlishaw@gbrmpa.gov.au

With respect to box jellyfishes (i.e. stingers and Irukandji) please provide as dot-points:

(1) Your concerns (please rank from most important to lesser importance; you may decide to give some items equal rank)

- Inability to pre-empt with specific detail when box jellyfish will appear at sites frequented by recreational users of the Marine Park.
- Lack of an antivenin that can be administered quickly for all box jellyfish envenomations, including use in remote locations. For example, having the antivenin in a state that can be carried on tourism boats, at surf clubs and administered by persons other than paramedics and doctors.
- Inability to predict future migration of box jellyfish in response to climate change pressures.
- Inability for a member of the general public to readily identify species, i.e. multiple species may be caught in a stinger drag, some may not be dangerous and sites may not need to be closed to recreational use.
- Can box jellyfish be used as bio indicators?

(2) How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank)

- Spatial ecology
- Toxicology, including prehospital care

Dr Scott Condie and Dr Anthony Richardson (CSIRO)

E-mail contact: scott.condie@csiro.au

With respect to box jellyfishes (i.e. stingers and Irukandji) please provide as dot-points:

(1) Your concerns (Please rank from most important to lesser importance; you may decide to give some items equal rank)

- While nets have been very effective in reducing the incidence of *Chironex* stings, management of Irukandji has been mainly limited to use of stinger suites in some circumstances and reactive closure of beaches in response to local monitoring or stings. There is an immediate need for risk prediction based on environmental conditions to inform a range of potential prevention strategies.
- While risk prediction can be progressed on the basis of available empirical sting data, we have very limited understanding of the seasonal distributions and lifecycles of Irukandji species.

(2) How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank)

- Develop a sting-risk prediction system with an initial focus on high incidence regions. This should include design of a delivery system in collaboration with major stakeholders such as AMPTO, SLSQ and indigenous groups.
- Undertake targeted sampling of Irukandji, co-occurring species and water properties; and modelling of oceanographic processes; aimed at testing and refining the predictive model as well as improving our underlying knowledge of Irukandji ecology.
- Develop molecular identification capabilities for Irukandji as a step towards automated detection systems.

Jon DeLaine (Djunbunji Land & Sea Program, East Trinity)

E-mail contact: jon@djunbunji.com.au

With respect to box jellyfishes (i.e. stingers and Irukandji) please provide as dot-points:

(1) Your concerns (Please rank from most important to lesser importance; you may decide to give some items equal rank)

- Continued existence and protection of box jellyfishes as an important marine resource, especially as a food item for sea turtle species within the Mandingal Bay Yidinji Sea Country. 60%
- Monitoring the impact of dredging / increased water pollution from industrial and port development along the Great Barrier Reef coast. 40%

(2) How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank)

- Investment into population assessments (baseline data on numbers and range)
- Investment into exploring the impacts of dredging/port developments on jellyfish
- Investment into exploring the impacts of water quality/temperature on jellyfish
- Investment into first aid and medical treatment of stings (to humans)

Dr Lisa-ann Gershwin (CSIRO, and Australian Marine Stinger Advisory Services)

E-mail contact: lisa.gershwin@stingeradvisor.com; lisa-ann.gershwin@csiro.au

With respect to box jellyfishes (i.e. stingers and Irukandji) please provide as dot-points:

(1) Your concerns (Please rank from most important to lesser importance; you may decide to give some items equal rank)

a. Prediction
b. Prevention
c. Treatment

- Also, I do not believe that in the current climate of extremely limited funding, *Chironex* ranks on a par with Irukandji. *Chironex* is well managed with the Uninet enclosures and the educational value that they offer, and has been since 1982. Therefore, I think that funding at this time should concentrate on saving lives and livelihoods with respect to Irukandji.
- Also, accurate identification of species, specimens, and stings, which in many ways overarches each of the three concerns listed above. All three depend on accurate identification, yet it is one of the most frequently overlooked aspects of good science and proper management.

(2) How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank)

- Assuming a primary outcome is safety of people and industry, priority should be given to projects that directly address the canonical Prediction-Prevention-Treatment, e.g., the forecasting system.
- Funding should tick multiple primary boxes where possible, e.g.,
    a. the forecasting system should help inform field projects,
    b. field projects should be designed to progress the forecasting system,
    c. Database development to open access underlies most other projects now and in future.
- NESP investment should be used as seed money to attract other funding, e.g., from federal, state, local, industrial, and crowd schemes, from all conceivable sources, in order to maximise the pool available to as many research projects as possible.

Professor Michael Kingsford (JCU)

E-mail contact: michael.kingsford@jcu.edu.au

With respect to box jellyfishes (i.e. stingers and Irukandji) please provide as dot-points:

(1) Your concerns (Please rank from most important to lesser importance; you may decide to give some items equal rank)

- We need to empower stakeholders to manage risk through reliable information on the presence and abundance of box jellyfishes;
- There is a lack of automation in the detection of box jellyfishes and within the time frames required by stakeholders;
- Reduce risk though a better understanding of the relationships between water quality (i.e. salinity, temperature, nutrient levels and insecticides) and the abundance and location of box jellies;
- There is lack of experimental evidence on the influence of water quality on the medusoid and polypoid phase of jellyfishes this is required for more advanced modelling on levels of risk to stakeholders;
- A great deal more needs to be learned on the behaviour of box jellyfishes in relation to water quality and currents before models can be considered accurate.

(2) How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank)

- Improve detection in realistic time frames through the deployment of 'stingercams' and 'Irukandjicams' that would allow for rapid detection at local scales (e.g. near a resort of community). This would require further development of systems (especially for Irukandji), and jellyfish identification software for further automate rapid detection and measures of risk to stakeholders;
- Experimentally determine the influence of water quality on different life history stages of box jellyfishes;
- Obtain a greater understanding of the distribution and behaviour of box jellyfishes for the development of more accurate models;
- Engage primary stakeholders in the research.

Dr Mark Little (Cairns Hospital/James Cook University)

E-mail contact: Angie-mark@bigpond.com

With respect to box jellyfishes (i.e. stingers and Irukandji) please provide as dot-points:

(1) Your concerns (Please rank from most important to lesser importance; you may decide to give some items equal rank)

- Effective treatment of Chironex, Irukandji and other jellyfish stings
- Lack of adequate first aid
- Uncertainty around the venom, its action and potential antidotes
- Lack of prediction of when stings are more likely

(2) How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank)

- Effective first aid treatment(s) and definitive treatments
- Better understanding of the venoms, action and potential antidotes
- Better understanding of the biology of the jellyfish

Col McKenzie (AMPTO)

E-mail contact: col@gempearl.com.au

With respect to box jellyfishes (i.e. stingers and Irukandji) please provide as dot-points:

(1) Your concerns (Please rank from most important to lesser importance; you may decide to give some items equal rank)

- Develop an early warning / predictive tool to provide marine tourism and regional councils with timely advanced warning of likely high risk periods. My preferred option would be the CSIRO methodology.
- Develop the computer recognition of various jelly fish to supplement the early warning tool.
- Establish the range of Irukandji and the reasons for its rapid spread south.

(2) How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank)

- Field trial the CSIRO model to ground truth it.
- Establish a number of underwater videos on tourism pontoons and jetties to enable recognition of the various jelly fish.
- Establish the southern boundary of the Irukandji

Dr Christopher Mooney (JCU)

E-mail contact: christopher.mooney@my.jcu.edu.au

With respect to box jellyfishes (i.e. stingers and Irukandji) please provide as dot-points:

(1) Your concerns (Please rank from most important to lesser importance; you may decide to give some items equal rank)

- We need reliable information on the presence and abundance of dangerous box jellyfishes for risk management;
- This information needs to be made readily available and understandable to stakeholders and the public;
- Robust and reliable automated box jellyfish detection systems need development;
- A better understanding of box jellyfish/ Irukandji ecology and behaviour is required in order to produce advanced models for predicting levels of risk for stakeholders.
-

(2) How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank)

- Engage stakeholders in the research;
- Further develop and deploy automated 'stingercams' for rapid detection of box jellyfishes/ Irukandji in realistic time frames. Do so in required locations (i.e. high risk or high use areas) as suggested by both stakeholders and research teams;
- Experimentally determine the influence of water quality/ parameters on different life history stages of box jellyfish species identified as high risk species (i.e. *Chironex fleckeri*, Irukandji species). This will assist in the development of more accurate models for forecasting the presence and abundance of box jellyfishes.

Associate Professor Kylie Pitt (Griffith University)

E-mail contact: K.Pitt@griffith.edu.au

With respect to box jellyfishes (i.e. stingers and Irukandji) please provide as dot-points:

(1) Your concerns (Please rank from most important to lesser importance; you may decide to give some items equal rank)

- How climate change (particularly warming & acidification) and water quality (e.g. nutrients, pollutants such as pesticides) may affect the population dynamics (i.e. patterns of distribution & abundance) of cubozoans, including whether populations may be expanding their range south.
- There is very limited robust data on patterns of distribution & abundance (but see Kingsford et al 2012). Sting data is very problematic for inferring patterns of distribution and abundance unless concurrent data on human behaviour is available.
- Models of population dynamics, possible range expansions and warning systems should be developed based on robust data of distribution & abundance and experimental data on effects of climate change and water quality.
- The taxonomy is confused – robust techniques (i.e. that utilise molecular and morphological techniques) need to be used to assess species diversity.

(2) How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank)

- Given that polyps and some medusae can be maintained in captivity we should use rigorous experimental approaches to test the effects of water quality and climate stressors on cubozoan demographics and physiology.
- We need to develop automated systems for monitoring cubozoan populations, such as camera systems, gene probes etc.
- We need to develop models using a combination of experimental data on the effects of climate and pollution stressors and field-based observations of patterns of distribution and abundance to assess whether populations are expanding their range south and, potentially, develop more robust systems for beach-users and tourist operators.
- We need to use molecular, as well as morphological, approaches to improve taxonomy.

Russell Hore (Quicksilver Connections)

E-mail contact: bios@quicksilver-cruises.com

(1) Your concerns (Please rank from most important to lesser importance; you may decide to give some items equal rank)

With respect to box jellyfishes (i.e. stingers and Irukandji) please provide as dot-points:

- Offshore treatment protocol for Irukandji Sting – too much confusion, with vinegar/no vinegar, Ambo's still using $MgSO_4$, hot water, etc.
- What's out there? We still don't have a great understanding of the Irukandji Sting species, so very difficult to move on from there. More basic biology/taxonomy
- Continued education – as there's been no deaths in the last few years, public awareness has dropped away. A significant program needs to be undertaken.
- Central communication point for local stings – to make other marine operators aware of local stings in real time. It happened for a while a few years ago, but dropped away. Maybe AMPTO driven??
- Predictability – important, but not essential (most operators are aware of seasonal signs, such as light northerlies, hot days with no rain for previous 7 days, etc.)

(2) How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank)

- Treatment protocol
- Biology
- Taxonomy

Associate Professor Jamie Seymour (JCU and AITHM)

E-mail contact: jamie.seymour@jcu.edu.au

With respect to box jellyfish (i.e. stingers and Irukandji) please provide as dot-points:

(1) Your concerns (Please rank from most important to lesser importance; you may decide to give some items equal rank)

- Husbandry of cubozoans
- Seasonality of cubozoans
- Distribution of cubozoans
- Thermal tolerance of cubozoans

(2) How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank)

- Not entirely sure what this means. I would like to see funds put towards research that allows us to get a far better handle on the general ecology of these species.

Gavin Singleton (Dawul Wuru Aboriginal Corporation, Yirrganydji Traditional Owner)

E-mail contact: info@dawulwuru.com.au

With respect to box jellyfishes (i.e. stingers and Irukandji) please provide as dot-points:

(1) Your concerns (Please rank from most important to lesser importance; you may decide to give some items equal rank)

- Providing opportunities for Traditional owners to participate in and undertake research activities;
- To value the time and effort of Traditional owner participation in research;
- Recognising Traditional owners as primary stakeholders, guardians and caretakers of their traditional land and sea country estates;

(2) How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank)

- Research Partnership Agreement with Yirrganydji Traditional owners to demonstrate mutual respect and trust as well as promoting an ethical and culturally appropriate approach in research;
- Capacity building opportunities for Yirrganydji rangers/members in jellyfish research and monitoring activities;
- Employment opportunities (i.e. time and labour) for Yirrganydji rangers/members to undertake;:
- Jellyfish sample collection for lab research;
- Monitoring activities at agreed locations, particularly within the Cairns to Port Douglas region, North Queensland;
- Education and awareness activities to promote the prevention and treatment of jellyfish stings;
- The research project to be implemented in accordance with both the Convention on Biological Diversity - Nagoya Protocol and the NERP Tropical Ecosystems Hub – Indigenous Engagement Strategy

Dr Shelley Templeman (TropWATER and JCU)

E-mail contact: Shelley.Templeman@jcu.edu.au

With respect to box jellyfishes (i.e. stingers and Irukandji) please provide as dot-points:

(1) Your concerns (Please rank from most important to lesser importance; you may decide to give some items equal rank)

- Lack of understanding into the ecology to better enable jellyfish management for successful human health, economic and environmental outcomes;
- How urbanisation and other human activities are influencing cubozoan jellyfish populations ;
- How important the polyp life stage is to medusal population structures (population persistence);
- How increasing climate variability is affecting and/or changing jellyfish populations and dispersal;

(2) How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank)

- Assessment of the potential for urban structures to create additional jellyfish habitat;
- Investigations into the effects of changing water temperature, salinity and other variables on polyp metamorphosis to medusae, as a potential opportunity to determine when medusae may begin to appear;
- Initiatives to identify the presence of polyps in areas adjacent to high levels of human activities e.g. popular swimming beaches, marinas, etc.

Dr Ken Winkel (AVRU, Department of Pharmacology, University of Melbourne)

E-mail contact: kdw@unimelb.edu.au

With respect to box jellyfishes (i.e. stingers and Irukandji) please provide as dot-points:

(1) Your concerns (Please rank from most important to lesser importance; you may decide to give some items equal rank)

- Limited understanding of knowledge, attitudes and beliefs regarding these stings and their prevention [with respect to tourist operators, visitors, locals and health professionals]
- Limited understanding of the ecological determinants of stinger 'blooms', leading to limited tools for predictive recommendations for optimal sting prevention strategies
- Limited understanding of the determinants of variation in the severity of sting outcomes (esp. Irukandji syndrome) from mild local sting to life-threatening systemic effects
- No antivenom (specific antidote)
- Hard to separate the ranking as these issues are all important

(2) How you would like to see a NESP investment spent to maximise the value of outcomes? (Please rank from most important to least important; you may decide to give some items equal rank)

- NESP needs to develop a strategy to address all of these issues in collaboration with the stakeholders as they are interlinked. Ideally funds would be co-invested with resources from stakeholders and related parties to augment NESP resources.

APPENDIX 4: NOTES ON WORKSHOP PRESENTATIONS

Background on NESP and intentions of project

Damien Burrows – NESP Hub leader/ TropWATER

- Hub has 6 yrs. of funding
- Focus is on water quality (e.g. catchment runoff)
    - Water quality parameters stretched
    - YES to nutrient run-off, sedimentation*
    - NO to ocean acidification
    - PRIORITIES include estuary repair, dugongs, turtles
- HIGH PRIORITY FOCUS – **End user engagement, solutions orientated**
- 10 day window for funding – fewer but larger projects (integrated) preferable

Background on box jellyfishes

Michael Kingsford - Box jellyfishes Project Leader/ JCU

Talk on box jellyfishes – knowledge of cubozoan life history, patterns of distribution and freshwater runoff was described as well as the potential influence of runoff on jellyfishes.

- Discussion points:
    - Sampling bias – patchiness in distributions (J Seymour)
    - Spatial/ temporal variations unequivocal
    - Need to validate sting data
    - Can use all information in modelling designs, + requirement for purposed sampling designs (J Caley)
    - Location of hotspots/ possible sources – Horseshoe Bay (R Blanchard)
    - There is very little information from local indigenous communities in some places (R Hore)
    - Because of percolation of FW post plumes – there is still potential for FW impacts long after actual event (L Llewellyn)
    - Stories from indigenous population (G Singleton) – heard of:
        - breeding cycle of jellyfish in flood season triggered by FW
        - Weakening of SE winds = NO swimming, better off swimming in creeks at those times
        - Yarrabah community – if conditions good for jellyfish, parents check water prior to family entry (Larissa– Djunbunji Ltd)
        - Indigenous groups use different names for each jellyfish spp. (C Prestipino, H Penrose)

Stakeholder statements/ submissions:

Jay March – SLSQ

SLSQ has > 25 yrs. beach data for NQ with known hotspots for *Chironex* and *Carukia*.

SLSQ Resources:

- Marine Stinger Risk Management Guidelines
- Marine Stinger Netting Log – *data is readily available*
- Local knowledge based on the time of year and conditions (e.g. wind direction)
- *Beach Safe* Website/ council website

ISSUES:

- Positive ID of specimens – required for management of beach closures for public safety. Would like more tools such as J Seymour GoPro set up.
- Confirmation of positive Irukandji Syndrome from Qld Health – i.e. better communication pathways between Medics and SLSQ
- Pressure from tourism groups

Questions to SLSQ from public:

- About presence of crocodiles
- Presence of Jellyfish
- TREATMENT for jellyfish stings

Priorities for funding:

- Identification tools
- Stinger education

Discussion points:

- Can incorporate expert knowledge into models (J Caley)
- What about potential for genetic barcoding? (J Caley)

Steve Moon – AMPTO

- Pontoon/ small vessel operators have limited options for closing areas to tourists
- Looking for a forecasting system – incorporating modelling into predictions for industry use; i.e. which species are present, and will they interfere with day to day operations?
- AMPTO is very keen to collaborate with research efforts
    - Have the capacity for 'spare berths' on reef trips free of charge for research personnel, up to 10d trips
- Want to use Condie's model
- Have a large investment into marketing GBR
- Industry wants to know boundaries of dangerous spp. ranges – i.e. range extension debate and public perceptions of this
- Tourism surveys have jellyfish as #2 on lists of concerns of visitors to GBR (after environmental damage to reef at #1)

- Industry would like possibility of underwater videos for real-time detection of jellyfishes + recognition software.

Discussion points:

- Lycra suits – different operators have own protocols for suggested/compulsory wear
- Species recognition, need to know what we're dealing with (R Hore)
- *Irukandji Cam* – could help with reducing risk, silhouette recognition would be used (Kingsford)

Gavin Singleton – Yirrganydji/ Irukandji people

- How can Indigenous personnel get involved?
- Can see capacity building opportunities:
    - Involvement in lab, sampling, employment collaborations with rangers
- NB: heard of use of plants for sting treatment (Indigenous Knowledge*)
- Traditional owners can get involved in sampling of remote locations
- Ranger scheme: federal and state funded for both land and sea activities; highly variable infrastructure; capacity for vessels in some locations + piggybacking with other programs

Larissa Hale – Djunbunji

- Community is keen on jellyfish and assisting in data collection
- Heavy focus on turtles
- Would like to see more community engagement

Cheryl Prestipino – Yintingga Aboriginal Corporation/ Lama Ranger Service

- Cape York - Has 12 rangers
- High intensity of on water work – potential for sampling/ monitoring services
- How will changes with jellyfish (as a food source) affect turtle populations?

Stan Lui – RRRC, TSRA/ Senior Project Manager

- Looking for indigenous capacity building through consultation with communities
- Working on Country plans – FOCUS ON END-USER, i.e. training etc.

Helen Penrose – Consultant

- Focus on water quality
- Ranger groups have high intensity of on water time around Cape York
- Is of high relevance with connectivity between different animals

Susanne Becken – Griffith Tourism Research Unit

1. Risk perceptions and Risk Management
    i. Integrating tourism into emergency management
2. Tourist experience
    i. Warning signage, risk communication
    ii. Balance of satisfaction, comfort and safety
    iii. Jellyfish uniqueness – potential for Jellyfish tourism
3. Need to look at water quality more broadly:
    i. Tourism's impact on water quality, and management
    ii. Take a Ridge – to – Reef outlook

Lyndon Llewellyn – AIMS

- Stinger Management Tools: data source → data treatment → data users and consumers
- AIMS Capabilities: *SeaSim* simulation environments etc.
- Need to take a 'WHOLE – OF – RISK' approach:
    - Risk is not static in time/ place
    - Risk assessment tools: risk of getting stung, learning models
    - Risk mitigation: monitoring/ prediction tools
    - Risk response: medical intervention - Telehealth
    - Pipeline of independent solutions – not just a single solution
    - Risks are different for different locations
- Stinger cams
- Telemedicine – within reach NOW!
- Apps – need user engagement, sustainability and Apps that are platform dependent

Julian Caley – AIMS

- Primary objective – risk management at a national scale through use of predictive models and risk management tools.
- NQ Managing Stinger Risk:
    - Data collection and rescue: SLSQ data → local data centre → Australian Ocean Data Network
    - Predictive models: NB: many information layers!!
- Project collaborators:
    - Research providers: AIMS Quantitative Unit, AIMS data Centre, School of Mathematics and Statistics (QUT), ARC CoE Mathematics and Statistics Frontiers
    - Stakeholder end-users: SLSA, SLSQ, AMPTO
- Useful data – the level of utility really depends on question!

Scott Condie – CSIRO

- Risk forecasting with Sting Database (+ wind)
- Used Cairns hotspot for CONNIE modelling, it was found that stings from Irukandji followed a drop in SE winds (Gershwin *et al.* 2014).
- *eReefs*: water parameter modelling from a Palm Passage Mooring at 70m depth
- New work to add more parameters to get closer to 100% sting avoidance

Lisa-Ann Gershwin – Consultant

- Developing an open – access database.
- Presentation on the publication Gershwin *et al.* (2013) Biology and Ecology of Irukandji Jellyfish (Cnidaria: Cubozoa)
- Possible priorities:
    - Refinement of predictions
    - Geographic expansion of predictions
    - Ecological sampling design to contribute to predictions
    - Near-real-time generation and delivery of forecasts
    - Open-access database to support Irukandji research

Michael Kingsford – Capability of the Reef and Ocean Ecology Lab, JCU

We have had a major role in determining the state of knowledge of Cubozoans (Kingsford & Mooney 2014).

My group has:

- Identified that data available on the distribution and abundance of cubozoans is very poor; my group has contributed to improving that situation (Kingsford *et al.* 2012);
- Critically assessed the model that the polyps of stingers are all based in estuaries by using the chemistry of tiny hard structures found in jellyfish (statoliths) to determine waters of origin (Mooney & Kingsford 2012; Mooney and Kingsford – in review Mar. Biol.;
- Used the shape of statoliths to distinguish families of envenoming jellyfishes and even species (Mooney & Kingsford in review PLoS One);
- Used jellyfish to determine water quality with respect to metals (see Templeman below), we have also examined jellyfish to determine the effects of insecticides on them – work is yet to be done on cubozoans;
- Collaborated with SLSQ to determine the relationships between riverine runoff and the abundance of cubozoans (Kingsford *et al.* 2012);
- Collaborated with Eric Wolanski to integrate data on the ecology and movements of jellyfishes with oceanographic data to make predictions on the connectivity of individual among local populations;
- Collaborated with AIMS and LIONS (Australia) to design a Stinger Cam (Llewellyn, O'Callaghan, Kingsford et al. in review Limnol. Oceanog. Methods);
- Provide solutions for stakeholder engagement – including stinger cam and Irukandji cam.

Kylie Pitt – Griffith University

- There is limited experimental evidence for DRIVERS of cubozoan populations
    - Limited number of species in culture
    - Culturing problems
- Current research:
    - Response to climate change stressors – i.e. temperature, acidity, UVB
    - Water quality influences on jellyfish
- Presentation on Klein *et al.* (2014) Irukandji jellyfish polyps exhibit tolerance to interacting climate change stressors
- Griffith Research Capabilities:
    - New portable gas system: can mix combinations of Nitrogen, Oxygen and Carbon dioxide to create different climate change scenarios.
    - Mimicking diurnal variation in pH
- Klein *et al.* (in review; *Env. Poll.*): interactions of herbicides and salinity on *Cassiopea* medusae; mimicking a heavy rainfall event
- Griffith contributions:
    - Can experimentally compare responses of cubozoans to physical and chemical stressors and water quality stressors.
    - Construct models to predict range expansions to SE Qld.
- Discussion points:
    - Query studies on *Morbakka* as higher priority for SE Qld (L Gershwin)
    - Query phenotypic plasticity (J Caley)

Jamie Seymour – Tropical Australian Stinger Research Unit (TASRU)

- Husbandry:
    - Need to focus on polyps + adults
    - Have *Malo* sp., *Alatina alata*, and *Carukia barnesi* polyps in culture
    - NB: Carrette *et al.* (2014) Early life history of *Alatina* cf. *moseri* populations from Australia and Hawaii with implications for taxonomy (Cubozoa: Carybdeida, Alatinidae)
    - Notes on *C. barnesi* polyps: polyp can metamorphose more than once, NO creeping polyp, buds off swimming polyps
    - There is a difference in food quality in juveniles vs. adults because of an ontogenetic change in prey preference
- Presentation on Courtney *et al.* (2015) Prey capture ecology of the Cubozoan *Carukia barnesi*: *C. barnesi* using tentacles as lures to fish during the day, less active at night
- Presentation on Courtney & Seymour (2013) Seasonality in polyps of a tropical cubozoan – *Alatina* nr *mordens*: interactive effects of temperature and salinity on polyps and metamorphosis

- Thermal physiology of three cubozoans: optimal temperatures: *C. barnesi* (~26°C), *C. fleckeri* (~37°C), *C. bronzie* (~36°C)
- Presentation on Gordon & Seymour (2012) Growth, development and temporal variation in the onset of six *Chironex fleckeri* medusae seasons: a contribution to understanding jellyfish ecology
- NB: **photoperiod** main driver for metamorphosis?
- Venom dynamics:
    - Periera & Seymour (2013) *In vitro* effects on human heart and skeletal cells of the venom from two cubozoans, *Chironex fleckeri* and *Carukia barnesi*: ontogenetic changes in venom proteins + bell vs. tentacles.
    - Welfare *et al.* (2015) An in-vitro examination of the effect of vinegar on discharged nematocysts of *Chironex fleckeri*
- Genetics:
    - Coughlan *et al.* (2006) Isolation and characterisation of seven polymorphic microsatellite loci in the box jellyfish (*Chironex fleckeri*, Cubozoa, Cnidaria): there is high fluctuation in genetic diversity
- Sampling:
    - The group has been doing highly localised sampling for measured abundance of box jellyfishes
- Need to know: general biology of animals

Ken Winkel – (AVRU)

- Focus: improvement of care to envenomed patients through the study of creatures, venoms, and those affected by them; long term interests of Australia and Indo-Pacific.
- Irukandji = highest persistent problem for hospitalisations
- research + education and engagement
- AVRU Collaborations (selection):
    - Divers Alert Network*
    - Diane Brinkman – biomedical side of venom
    - Australian Institute of Health and Welfare
    - CSIRO Indigenous Engagement Team*
- AVRU Indigenous engagement:
    - Maningrida Project, Arnhem Land – indigenous. Rangers – education
    - ARC Indigenous Discovery project (high success rate)
- Opportunities to work with SE Asia; complimentary problems with stingers
- NB: Treatment for box jellyfish stings – **CPR** should be main focus!
- In-vitro methods: heart tissue + venoms
- Cubozoan venoms lead to excessive sympathetic nervous system response
    - I have contributed to collections for host response to the venom of different jellyfishes

- NB: *THE VENOM PATROL* – education material
- First Aid Apps
- Arnhem Land collaborations : Key is for Education and community awareness

Teresa Carrette – JCU/ TASRU

IRUKANDJI

- Global issue of Irukandji Syndrome
- Presentation on Carrette & Seymour (2013) Long – term analysis of Irukandji stings in Far North Queensland:
    - Length of Irukandji stinger season increased from 15d (1961) to 151d (2002)
    - Patients presenting with more symptoms = more severe syndrome
    - NB: 74% of Irukandji patients only presented with 1 – 2 symptoms
    - Mean detected Troponin levels in patients significantly higher for reef locations
    - Suggest increasing the spectrum of Irukandji Syndrome definition
    - Variation in a person's physiology may vary the sting experienced
- There is Venom variation within a species both geographically and seasonally
- Current knowledge:
    - Have risk assessments for different regions, i.e. outer reef vs. near-shore
    - Have polyp culture
    - Have reliable sampling locations

Matt Gordon – JCU/ TASRU

Chironex fleckeri

- Presentation on Gordon & Seymour (2012) Growth, development and temporal variation in the onset of six *Chironex fleckeri* medusae seasons: a contribution to understanding jellyfish ecology and Gordon & Seymour (2009) Quantifying movement of the tropical Australian cubozoan *Chironex fleckeri* using acoustic telemetry
- Acoustic tracking:
    - Need to match question to method of tracking
    - Automated tracking for four days found repeated patterns of movement up and down the grid with small patches of position holding
    - Can be used for modelling of movements

Shelley Templeman – TropWATER/ JCU

Jellyfish as Bioindicators and Biomonitors (Templeman & Kingsford 2010; 2012; 2015)

- Different life stages have different tolerance limits of stressors
- Habitat – Coastal Development:
- Infrastructure is offering increased polyp habitat, possibly without natural predators associated with mangrove ecology?

Discussion points:

- What substratums do polyps prefer? (L Llewellyn)
- Have found differences between scyphozoan and cubozoan polyps: scypho's will outcompete cubo's – scypho's settle on top surface, cubo's on under surface (J Seymour).

Some Stakeholder Feedback

- Traditional Owners interested in early warning and a detection system, collecting traditional knowledge and capacity building (G Singleton)
- AMPTO – satisfied that everything needed has come up as part of workshop (S Moon)
- SLSQ – happy to provide support and keen for improved and easy ID of species (R Blanchard)
- GBRMPA – happy with workshop – variable levels of priority
  - -early warning system,
  - ID packages – accepts/suggests priorities more of a flow chart , i.e. need one for the other etc. (C Jones)

HOTWATER VS VINEGEAR

There was a debate on the best First Aid treatment for stings.

The effectiveness of hot water and vinegar for the treatment of jellyfish stings is under review. The Australian Resuscitation Council is committed to revisiting the guidelines.

The present protocol is to use vinegar for the treatment of cubozoan stings.

APPENDIX 5: WORKSHOP GROUP SUMMARIES

The rank importance of each item by group is indicated.

Group 1 (Chaired by Susanne Becken)

Item #	Need	Tasks	End user output	Support	Rank
1	Integrated data warehouse to compile all relevant information in one database (e.g. helps understand idiosyncrasies versus generalizable findings)	AIMS/CSIRO might lead. Describe what data warehouse would look like. Data quality description Collect indigenous knowledge. Include socio-economic info. Include data from real time warning.	Improved patient care; Improved understanding of distribution; Triggers (environmental variables).	Data custodians	1
2	Treatment that is most effective, readily available and easy to administer (store on a vessel)	Clinical trials to test different treatments. End users put forward solutions that work for them (practically). Indigenous knowledge.	Agreed treatment and readily available product. Clear definition of boundaries.	Queensland Health; SLSA; AMPTO; ARC; RFDS;	1
3	More information on lifecycles – investigating polyps (what is the preferred substratum for polyps and what are the triggers for budding, and triggering metamorphosis)	Increase number of species in culture (indigenous rangers, tourism operators)	Modelled coastal map of box jellyfish distribution	Research organisations with various stakeholders	2
4	Increase awareness and provide information to match the needs of visitors and beach users (i.e. public)	Collect on current level of knowledge by market segment and protective behaviours by different groups. Communication and media management. Social media (twitter) analysis.	Communication material. Agreed media pack. Education resources.	Tourism organisations and operators; SLSA; Indigenous communities	3
5	A functional alert system	Revitalise past system. End user driven to develop a system that works for their needs. Refine existing tools.	Functioning warning system.	AMPTO; SLSA; TTNQ; Health Service/ Ambulances	5

Group 2 (Chaired by Julian Caley)

Item #	Need	Description	Support (Rank)
1	Improved capture of medical data	Reporting of incident outcomes/intervention etc. leading to the creation of tools for medicos and tourist operators, fishers.	AMPTO (2) Traditional owners (1) Science providers (1, 2, or 3) Regulators (2)
2	Better intervention tools post sting (instant response)	Leading to the creation of tools for medicos and tourist operators, fishers. Including anti-venom	AMPTO (2) Traditional owners (1) Science providers (1,2 or 3) Regulators (2)
3	Informative packs for tourist education	Educational material about biology, risks, and mitigation of risks	AMPTO (4) Traditional owners (4) Science providers (4) Regulators (4)
4	Better early warning systems	Risk models Reporting (including WQ)	AMPTO (1) Traditional owners (1) Science providers (1) Regulators (1)
5	Rescue of historical data on sting-related events and ecology	Digitization, Apps, distributed publicly available data	AMPTO (1) Traditional owners (1) Science providers (1) Regulators (1)
6	Taxonomy	Better (more accurate ID but taxonomic naming not needed). Field going ID guides Barcodes	AMPTO (3) Traditional owners (3) Science providers (3) Regulators (3)
7	Early wins?		SLSQ data App development Jelly cam

Group 3 (Chaired by Jamie Seymour)

ND = no data

Item #	Need	Description	Support	Rank
1	Quick identification services for stakeholders	Quick ID	ND	1-2
2	Early warning App	Good for pontoons, not now	ND	5
3	Confirmation of envenoming events	From hospital – require accurate data	ND	1
4	Improved relationship between traditional owners and Scientists and better acquisition of traditional owner knowledge	Acquire knowledge	ND	1-2
5	Identify communities capacity and willingness to be involved	Especially traditional owner	ND	2-3
6	Improved education/awareness (community language)	Include with 3	ND	1-2
7	Manipulative experiments	Determine the physical tolerances of polyps and medusae	ND	1
8	Modelling movements of medusa to determine connections between populations		ND	2-3
9	Knowledge of population dynamics, species diversity and overseas collaborations, (e.g., PNG Thailand)	Research and improved connections between countries	ND	3-4
10	Determine the influence of coastal development on the expansion of habitat for polyps	Survey structures for polyps	ND	3-4
11	Husbandry of jelly to improve knowledge of life history and for experiments	Polyps and medusae Sort out food source	ND	1
12	Improved knowledge for best practice First Aid		ND	1-2
13	Improved treatments to be applied by clinicians	(e.g. antivenoms and treatments for hypertension)	ND	4-5

Reef & Rainforest
RESEARCH CENTRE

www.nesptropical.edu.au