Managing risk for organised sport in the natural environment: a case study of the development of the *Surf Hazard Rating* model

Gary Kenneth McCoy

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Managing Risk for Organised Sport in the Natural Environment:

A Case Study of the development of the *Surf Hazard Rating* Model

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MSc (Research) (Bond University)

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Doctor of Philosophy

12 August 2019
Thesis Declaration

I certify that the work presented in this thesis is, to the best of my knowledge and belief, original, except as acknowledged in the text, and that the material has not been submitted, either in whole or in part, for a degree at this or any other university.

I acknowledge that I have read and understood the University’s rules, requirements, procedures and policy relating to my higher degree research award and to my thesis. I certify that I have complied with the rules, requirements, procedures and policy of the University (as they may be from time to time).

Name: Gary Kenneth McCoy

Signature: [Signature]

Date: 12 August 2019
Abstract

Participant death or serious injury during sport is notionally rare, and subject to intrinsic and extrinsic factors, including sport type. The management of the risk of injury in modern organised sporting activities is commensurately complex, as entities attempt to satisfy stakeholder needs, together with their own corporate needs and expectations. When sports are conducted in potentially extreme natural environments convening organisations are presumed to prioritise participant safety through the strategic intent of their governance structure and their operational practices. It is expected that their risk-assessment models should reflect this intent by also accounting for extrinsic factors associated with such natural environments to assist in assuaging the concerns of other stakeholders, including the loved ones of the athletes, corporate sponsors, and public donors.

This research takes the form of a case study that provides the supporting evidence for the development of the Surf Hazard Rating (SHR). This real-time model, created by this author, quantifies those extrinsic risk factors associated with participating in organised surf-sports involving the natural environment. The research is contextualised by considering the consequences of comparatively recent drowning deaths in the Australian Surf Lifesaving Championships on the risk-management policies and practices of Surf Life Saving Australia (SLSA).

The study reviews the literature associated with corporate governance and risk-management within the not-for-profit sports sector. A separate review examines wave and surf-zone theories as they apply to the concept of surf hazard-assessment models. The argument is presented that good corporate citizenship requires sports organisations to prioritise the safety of athletes under their control by utilising evidence-based models, which comprehensively assess surf-zone hazards, sufficient to make informed decisions in...
real time. This research presents the evidence supporting the validation of such a model, which quantitatively accounts for the effects of potential observable and measurable surf-zone features.

The analysis draws on a data set from 2118 competitive surfboat races across 47 different Australian beaches between 2013 and 2015. The study employs a Mixed Methods approach with an empirical design in association with SLSA. The model measures incident outcomes against the SHR predictor variable, while examining model convergence using decision maker interviews, surveys and the implantation of the SHR decision framework at a three-day national surf lifesaving competition in 2015.

The research integrates traditional risk-management and governance theory with a growing but less-examined area of sports risk-management involving natural environments. The demonstrated accuracy and reliability of the quantitative model, resulting from the robust research design, could be adapted to future technologies and the risk-management practices of other sports conducted in potentially extreme natural environments.
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Acknowledgements

This dissertation is dedicated to the memories of Robert Gatenby, Saxon Bird, and Matthew Barclay. The results of this research are a testimony to these young men and all athletes who challenge themselves in a natural environment that is exciting, rewarding, and often times unforgiving.

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Finally, I thank Dr Stephen Holden, for his assistance in helping me to establish a rigorous methodology to validate the Surf Hazard Rating model, and my supervisors, Professor Ian Eddie, Associate Professor Michael Charles, and Dr Patrick Gillett, for overseeing and editing this narrative.
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<td>Australian Beach Safety and Management Program</td>
</tr>
<tr>
<td>ACNC</td>
<td>Australian Charities and Not for Profits Commission</td>
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<tr>
<td>AIS</td>
<td>Australian Institute of Sport</td>
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<tr>
<td>ALS</td>
<td>Australian Lifeguard Service – SLSA Subsidiary</td>
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<tr>
<td>AMPAG</td>
<td>Australian Major Performing Arts Group</td>
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<tr>
<td>ANZAC</td>
<td>Australian and New Zealand Army Corps</td>
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<tr>
<td>ASC</td>
<td>Australian Sports Commission</td>
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<td>ASRL</td>
<td>Australian Surf Rowers League</td>
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<tr>
<td>ASX 200</td>
<td>Australian Stock Exchange Top 200 companies</td>
</tr>
<tr>
<td>AUC</td>
<td>Area under the Receiver Operator Characteristic curve</td>
</tr>
<tr>
<td>AUD</td>
<td>Australian Dollar</td>
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<tr>
<td>AWSC</td>
<td>Australian Water Safety Council</td>
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<tr>
<td>BOM</td>
<td>Bureau of Meteorology</td>
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<tr>
<td>CEO</td>
<td>Chief Executive Officer</td>
</tr>
<tr>
<td>CLERP</td>
<td>Australian Corporate Law Economic Reform Program 1999</td>
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<tr>
<td>COSINE</td>
<td>Competitive Organised Sports Involving Natural Environments</td>
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<tr>
<td>FIFA</td>
<td>Fédération Internationale de Football Association</td>
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<tr>
<td>ILF</td>
<td>International Lifeboat Federation</td>
</tr>
<tr>
<td>ILS</td>
<td>International Life Saving Federation</td>
</tr>
<tr>
<td>IOC</td>
<td>International Olympic Committee</td>
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<tr>
<td>IRB</td>
<td>In-shore Rescue Boat</td>
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<tr>
<td>JRB</td>
<td>Jet Rescue Boat</td>
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<tr>
<td>LCM</td>
<td>Landing Craft Mechanised</td>
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<tr>
<td>LCR</td>
<td>Longshore Current Rating</td>
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<tr>
<td>LURCS</td>
<td>Lushine Rip Current Scale</td>
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NFP  Not-for-Profit organisation
NGO  Non-government Organisation
NOAA National Oceanographic and Atmospheric Administration,
OECD Organisation for Economic Co-operation and Development
OHR Other Hazard Rating
PPE Personal Protective Equipment
PwC Price Waterhouse Coopers
QCO Quality Control Officer
RCR Rip Current Rating
RHIB Rigid Hulled Inflatable Boat
RLSS Royal Life Saving Society
RLSSA Royal Life Saving Society of Australia
ROC Receiver Operator Characteristic
SHR Surf Hazard Rating
SLF Surf Lifesaving Foundation
SLS Surf Life Saving
SLSA Surf Life Saving Australia
SLSAA Surf Life Saving Association of Australia
STR Surface Turbulence Rating
TSO Trained Surf Observer
UAS Unmanned Aerial Systems
USA United States of America
WHO World Health Organisation
WHR Wave Height Rating
WPR Wave Period Rating
WTR Wave Type Rating
ZWR Zone Width Rating
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Appendix I  
2012/13 Pilot Study.

Appendix II  

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Trained Surf Observer/Data Collector Information Sheet.

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Appendix VI  
Race-Specific SHR Data Recording Sheet.

Appendix VII  
Author-Presentation: ASRL General Meeting, May 2014.
Chapter 1 Introduction

This research examines the development, by the author, of a quantitative model known as the Surf Hazard Rating (SHR), as a case study in surf-risk assessment. The research investigates this development in the context of corporate governance and risk management within Surf Life Saving Australia (SLSA), a Not-for-Profit (NFP) sporting organisation. An important dimension of SLSA’s governance structure includes its policy response to rare-event surf sports crises, such as serious injury or death. Expectations of corporate behaviour in such circumstances are provided in the literature in terms of board of management responsibilities and performance, corporate legitimacy, transparency and accountability to stakeholder groups (Donaldson & Preston 1995; Freeman 1994; Mitchell, Agle & Wood 1997; Walters & Tacon 2010).

This case study specifically addresses the above issues by developing a real-time risk-management tool to assist surf sports decision makers in association with SLSA. The research adheres to recognised case study protocols as detailed by Yin (2018, pp. 93-105). These protocols include a detailed overview of the case study, by providing the relevant theoretical framework; recognising the nature of the association with SLSA, the case study’s “sponsor” during the study period; specifying the research questions and procedures to acquire the related quantitative and qualitative data, through which the evidence supporting the findings was established; and then finally, the reporting of the case study’s findings, conclusions, and implications.

The governance structure of SLSA, as a NFP, from its formation in 1907 through to 2016, will be examined to provide the context for the changes that have occurred in its risk management policies in recent years. Elements such as its community image (especially as
it pertains to water safety and competition), its organisational and governmental associations and responsibilities, and the regulatory and fundraising environments in which it operates, will be reviewed in order to contextualise the need, formulation, operationalisation, and outcome of the developed model.

Risk-management frameworks, in the context of sporting events become subject to scrutiny during times of crisis, such as competitor injury or death, which threatens the legitimacy of an organisation to function as designed by its board of directors. However, participant death or serious injury during sport is notionally rare (Gabbe et al. 2005), and subject to intrinsic and extrinsic factors, including sport type. The management of participant safety in organised sporting activities, to a level that is reasonably practicable, is commensurately complex, as entities attempt to satisfy stakeholder needs, together with their own corporate needs and expectations. This often necessitates similarly complex solutions and models to mitigate risk to those competing in sporting competitions. When those sports are conducted in potentially extreme natural environments, such as in the surf or in alpine environments, the governance requirements of those organisations therefore need to place a heightened emphasis on comprehensive and efficient risk models. These models should prioritise the safety of athletes, and also assist in assuaging the concerns of other stakeholders, including the loved ones of the athletes, corporate sponsors, and public donors.

Although most Australian sporting groups behave in a not-for-profit manner, there are only 8 from the 95 sporting organisations recognised by the Australian Sports Commission

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1 The natural environment is that domain, which is outside (or independent of) the influence of interference by humans. It includes living and non-living objects, and physical, chemical and biological processes and forces.
(ASC) (Australian Sports Commission 2017a) that are also registered as NFPs with the Australian Charities and Not for Profits Commission (ACNC) (Australian Charities and Not for Profits Commission 2017). These organisations are: Blind Sports Australia, Deaf Sports Australia, Disability Sports Australia, Riding for the Disabled Association of Australia, Special Olympics Australia, Sport Inclusion Australia Incorporated, Transplant Australia, and Surf Life Saving Australia. Surf Life Saving Australia, would appear to be the anomaly among these otherwise disability-oriented organisations. However, as declared within SLSA’s recent annual report (Surf Life Saving Australia, 2018a), its surf risk management strategies aspire to account for all surf participant ability levels. These levels range from the elite competitive surf lifesaver to public surf bathers. This dual registration places added legal responsibilities on those entities to provide regulated, transparent, and accountable governance practices (Anheier 2000, 2006; Brandsen & Pestoff 2006; Hoye et al. 2015; Seibel 1996), “by complying with statutes such as the Corporations Act 2001, and adhering to accounting standards” (Australian Institute of Company Directors 2017b). If the organisation is also an iconic corporate entity, operating a multi-million dollar budget, and entrusted with the maintenance of community services such as health and/or safety, the expectation of the provision of adequate and comprehensive risk-management practices is further compounded, and becomes fundamental to the organisation’s functionality, and indeed long-term viability.

Surf Life Saving Australia (SLSA) is such an iconic Australian not-for-profit and sporting organisation (Surf Life Saving Australia 2007, pp. 1-21). It is not only a major sport-event organiser for surf athletes, but is also acknowledged as Australia’s peak coastal water safety authority (Surf Life Saving Australia 2018c), with an operating 2016 budget over AUD70 million (Surf Life Saving Australia 2016, pp. 75-83). These revenues were received through government grants (12.1%), sponsorship (16.7%), fundraising and
donations (24.6%), commercial revenue (34.5%), contract revenue (5.7%), other revenue (2.1%), interest (0.8%), sale of goods (1.8%), hire of helicopter (0.3%), royalty and trademark revenue (0.3%), and competition entry fees (1%). It has progressed from an amateur-based organisation, formed in 1907, into a trusted, professional, water-safety corporate entity employing professional administrative staff, and using the most advanced and available, rescue techniques and equipment (Surf Life Saving Australia 2018a) to execute its governance directives, with assistance and guidance from its extensive Australia-wide volunteer base.

Advances in operational techniques have accompanied the acquisition of more technology-dependent equipment, such as inshore rescue boats (IRBs), rescue drones, and rescue helicopters. This comes at a cost to the organisation, which, being underwritten by government and corporate sponsorship, and community donations, makes it vulnerable to any threat to its legitimacy, as a not-for-profit coastal authority during times of crisis. That legitimacy has recently been threatened by the deaths, in 2010 and 2012, of two young surf athletes during the organisation’s showcase event, the Australian Surf Lifesaving Championships. The case study at the heart of this research investigates the changes to the safety-based risk management practices of this organisation in the context of its role as an iconic charity and sporting organisation. It also documents the consequent development of a tool that models the propensity for hazardousness of surf-zone phenomena in real time.

1.1 Motivation for the Research

On 19 March 2010, this author was present at Kurrawa Beach, Queensland Australia, when nineteen-year-old Saxon Bird was killed during competition in the Australian Surf Lifesaving Championships. The subsequent coronial inquest (Queensland Office of the
State Coroner 2011) reported that this occurred in surf conditions that were beyond those in which most competitors could expect to compete safely.

This incident was subsequent to the death, some years earlier, of fifteen-year-old Robert Gatenby on 31 March 1996, again during the Australian Surf Lifesaving Championships at Kurrawa Beach. The local press (*Gold Coast Bulletin* 2016) reported that this death occurred during competition that was also in questionably dangerous surf conditions. No coronial inquiry investigated the circumstances leading to this death, and consequently there are few facts available to establish the exact nature of the surf conditions at the time. The only information that sheds light on those prevailing surf conditions was the claim in the same *Gold Coast Bulletin* article that the surf was so powerful that some experienced lifesavers chose not to enter the water. Later, in a media exposé of the culture and management practices of SLSA, the family of Robert Gatenby added that they were not informed by the SLSA hierarchy about the dangers that existed when competition took place in such an ‘extreme sport’ as surf lifesaving, which was ‘likely to result in death’ (*Australian Broadcasting Corporation* 2013).

On 28 March 2012, a similar tragedy occurred when fourteen-year old Matthew Barclay died while competing at the Australian Surf Lifesaving Championships at Kurrawa Beach. Surf conditions were considerably different to those in the Saxon Bird incident, as were the circumstances involved in the accident. The subsequent coronial report (Queensland Office of the State Coroner 2016) indicated that the wave heights were generally one metre smaller, and accompanied by less wind and water-current movement than was the case for Saxon Bird’s death in 2010.

The death of Matt Barclay again focused public attention on the risk-management practices of SLSA officials, and the suitability of conducting lifesaving competitions in
potentially dangerous surf conditions. This most recent death prompted local and national 
media to reflect the community’s serious concerns and distress (Channel 7: "Sunday 
Night" 2012; The Daily Telegraph 2012) in SLSA’s inability to assess safe surf-conditions 
in which all athletes could, and should, compete. The media challenged representatives of 
the SLSA board of directors and its administrators to prove why they were not reckless by 
permitting competition to occur in these dangerous surf conditions. In order to understand 
the decision-making practices of SLSA officials during competition at this time, it is 
necessary to consider the attitude of officials and competitors towards participating in surf 
sports throughout SLSA’s history.

Since the first Australian Surf Life Saving Championships were held in 1915 (Surf Life 
Saving Australia 2015c), there have been many thousands of surf-sport competition-races 
conducted across Australia. Throughout the years before and since the accidents referred to 
avove, many events have been held in surf conditions that were arguably more dangerous 
than the races during those unfortunate competitions in 1996, 2010, and 2012. However, 
there has been only one other death (in 1950) recorded in any lifesaving event since 
competitions commenced in 1907 (Channel 7: "Sunday Night" 2012; Curby 2007, pp. 104- 
9; Surf Life Saving Australia 2007, p. 133). It could be argued that such incidents may be 
classified as ‘rare events’. Nonetheless, all SLSA competitors, being major stakeholders in 
the SLSA organisation, are afforded the right to participate in surf-sport competitions 
where the risk (of death or serious injury) is “as low as reasonably practicable” (Surf Life 
Saving Australia 2015d, p. 10).

To gain insight into the events leading to these deaths, and to work towards preventing 
future serious injury or death, it is necessary to explore the surf-related decision-making 
processes existing within SLSA in the period surrounding the 2010 and 2012 events. In
particular, there is a need to validate the positioning of the *Surf Hazard Rating* (SHR) model, which was developed by this author within the context of this decision-making framework as a risk assessment tool (McCammon & Hägeli 2004; Siegrist Gutscher & Earle 2005; Slovic 2001; Tonkiss & Passey 1999; Uttl, B, Henry & Uttl, J 2008; Uttl, B, McDouall & Mitchell 2012). The process will take the form of a case study of an Australian not-for-profit organisation (SLSA) that conducted surfboat competitions during the 2013/14 and 2014/15 surfing seasons. This case study, which resulted in data being collected by the author, formed part of an Action Research agreement between the author and SLSA (Surf Life Saving Australia 2015d, p. 6). The author considered possible interpretations of the potential for personal bias in the research (Sackett, D 1979) by developing a methodology, consistent with the protocols suggested by Beguería (2006), Yin (2018), and Cook and Campbell (1979). This methodology primarily focused on the analysis of objectively acquired, quantitative data, and supported by the analysis of qualitative input in the form of broad-based comments from data collectors, surf management decision makers, and competitors so as to avoid personal involvement in the data collection process. Thus the action research nature of this study provides opportunity of model validity using multiple research methods.

1.2 The Not-for-Profit Sector

The establishment of the ‘not-for-profit’ (NFP) sector as reported in the literature (Anheier 2006; Lyons 2001; Steane & Christie 2001) is a recent economic development, and an expansion of the traditional two-tier business model involving ‘for-profit’ and government sectors (Hall 2002; Powell & Steinberg 2006). The Australian Charities and Not for Profits Commission defines a NFP as a “charitable entity” that operates within the Australian economy and elsewhere. Its function is “to provide a public benefit” (Australian
Government 2013, Part 2, Division 1, Section 5), but with the expressed purpose of not seeking “profit, personal gain or other benefit of particular people” (Australian Charities and Not-for-profits Commission n.d.-b). Of course, NFPs vary in size, mission, and capability. They contribute to the welfare of people, animals, and the natural environment, particularly in the form of community service associations, charities, and sporting organisations.

In the definitive text on the principles and management of sporting organisations, Hoye et al. (2015) propose that sporting organisations act as not-for-profit organisations by “working[ing] for the benefit of public good” (2015, p. 34). Sporting organisations achieve this by providing an environment that encourages participation in healthy and socially beneficial activities, thereby increasing overall societal wellbeing. They also fill a niche by providing necessary welfare services that are often not accounted for by governments or the private sector. These organisations are often positioned within specific population groups or geographic areas. Some large organisations, such as *Cricket Australia* (Cricket Australia 2018), are registered purely as sporting organisations. Others, such as SLSA, are registered both as a sporting organisation, and as a charity through its fundraising arm - the Surf Lifesaving Foundation (SLF), meaning that donations to this entity are tax deductible (Australian Government 2012a; Surf Life Saving Australia 2017e, pp. 45-7).

Organisations, acting as NFPs, are theorised to be mission-focused at the expense of exhibiting values of market pragmatism and profit maximisation (Steane & Christie 2001, p. 51). The staples of good governance, such as the diversity of director experience, and the mix of professional administrators and volunteers, often reflects the normative value of “doing well while doing good” (Kanter & Summers 1987, p. 154). Within the past twenty years, large NFPs and sporting organisations have modified this normative behaviour in an
attempt to present themselves as modern corporates, thereby maintaining their viability through government funding and corporate sponsorship. Such governance arrangements, it follows, are also intended to instil confidence in their major sporting stakeholders, especially with respect to the appropriate and prudent utilisation of the income provided by these stakeholders, which include government agencies, for-profit corporate donors and the general public (Blowfield & Murray 2014; Matthew 2017; Miettinen 2006; Walters & Tacon 2010).

Advances in technology and the adoption of more business-styled operational practices has accompanied the dramatic expansion of these community service and sporting organisations. In 2018, when the population of Australia was approximately 25 million people (Australian Bureau of Statistics 2018), there were approximately 56,000 registered charities (Australian Charities and Not-for-profits Commission 2017a). Such charities provide various forms of community services, while the Australian Sports Commission (ASC) (Australian Government 2018) records that almost 17 million adults and 3 million children participate in a sport or a physical activity each week. According to the Australian Sports Commission, these adults spend an estimated AUD10 billion annually on those sports or activities.

Community needs and expectations have progressively altered during this period. Changes to the services offered by these entities have also occurred to meet those expectations and to reflect advances in modern technology and associated techniques. These changes to service provisions and associated technologies often substantially increase cost pressures within the entity. Many of these entities have consequently grown from predominately volunteer and limited-sized groupings, utilising simple risk management strategies, into large corporate-styled entities that employ professional staff and develop sophisticated
governance and risk management frameworks that are broadly similar to those used in the for-profit sector or in large government agencies. SLSA can be counted among such corporatised NFP entities.

Before the 1990s, most national and international sports in Australia, such as athletics, cricket, rugby union, and soccer, were predominantly conducted on an amateur basis. They attracted relatively modest viewing audiences, limited media coverage, moderate sponsorship, and used relatively basic sporting and personal protective equipment. Viewing audiences now expect graphic and dynamic sporting coverage. Audience numbers for major sporting events, such as the Olympic Games and the FIFA World Cup (association football, or ‘soccer’), are now often measured in hundreds of millions or billions. These entities are now sometimes responsible for budgets in the order of billions of dollars, and promote competitions using ‘high tech’ performance equipment and broadcasting techniques. Accompanying these advancements, audiences, participants, sponsors, and governments expect similar high standards in the sophisticated application of safety equipment and risk management models used in these activities.

NFPs such as SLSA, which provide multiple and varied service functions, experience escalated pressures as the costs of this technology impacts on the community services and activities that it provides. In the case of SLSA, these costs have significantly affected its sporting arm and its coastal rescue services. Prior to the 1980s, safety and rescue services provided by SLSA for surf lifesaving carnivals and general coastal safety operations relied predominantly on low (financial) cost human resources. The modern authority now provides high cost safety services at carnivals and on patrolled Australian beaches using jet skis, helicopters, technologically advanced communication systems (PwC 2011, Surf Life Saving Australia 2007, 2017a, 2017b, 2018a). These strategic operational costs to provide
safety services are detailed in Sections 3.4 and 3.5. The cost, to a not-for-profit corporate, to provide these functions creates multiple operational and strategic tensions, as administrators, the board of management, and its stakeholders struggle for demonstrable recognition of their rights (Cornforth 2002). Whereas administrators pursue practices consistent with bottom-line, transparent accounting, and commercial interests (Walters & Tacon 2010, p. 570), boards of management strive to achieve the NFP’s mission.

Stakeholders in the organisation expect those same managers to provide activities and/or services that are consistent with the not-for-profit’s mission statement (Blowfield & Murray 2014), referred to as “corporate social responsibility” (Walters & Tacon 2010, p. 566).

Contained within this mix of idealistic and pragmatic attitudes and behaviours reside latent stakeholder, board, and administration tensions (Cornforth 2002) that often only surface in times of crisis (Walters & Tacon 2010). According to Corfield (1998), middle-level management and employees are often subject to a disproportionately higher level of risk-pressure when the benefits of successes are compared with the results of corporate non-performance. This condition is especially exacerbated when entities are exposed to event crises. If those crises involve the death or serious injury to stakeholders while acting in some official capacity, for example as a competitor, critical attention is focused on the adequacy of the risk-management practices that were in place at the time of the incident in question. This may invoke consequent threats to community trust and confidence in the organisation, with resultant threats to the organisation’s sponsorship contracts and governance structure. SLSA represents a clear example of an organisation where these tensions are present. This is particularly the case as the entity so very often relies on the continuing financial support of its major donors, including the general public who, even if
not regular beach goers, will nonetheless contribute to SLSA because of its status as an iconic Australian institution and coastal safety authority.

1.3 Crisis Events – Threats to Corporate Legitimacy

Major sporting organisations and NFPs rely heavily on brand image to sustain and grow their funding sources. Over 67% of all sporting organisations recognised by the Australian Sports Commission are directly funded by the Australian Government (Australian Government 2017c). The Australian Sports Commission, through its high-performance agency known as the Australian Institute of Sport (AIS), represents a highly recognised and trusted Australian brand (Australian Sports Commission 2018a). Many of these organisations, such as Cricket Australia and Surf Life Saving Australia, promote their association with the ASC and AIS to further legitimise their respective sports (Sam 2011), and to exploit external funding sources, including sponsorships and endorsements from the for-profit sector. Conversely, ‘for-profit’ organisations are often keen to be associated with these sports of immense national and international significance (Cornwell et al. 2000, Cunningham, Cornwell & Coote 2009).

In their ‘not-for profit’ roles, both Cricket Australia and Surf Life Saving Australia promote their activities as being inclusive of all Australians. As a result, they contain and support a mix of amateur and professional sports participants. Their respective mission statements include stakeholder-focused aims to engage and grow supporters (fans), volunteers, administration, and players (competitors) (Cricket Australia 2018; Surf Life Saving Australia 2017c). Cricket Australia boasts yearly participant involvement of nearly 1.5 million people, while a 2011 report by Price Waterhouse Coopers (PwC 2011, p. 20) estimated that many of SLSA’s 153,000 volunteers performed 18,507 surf-related rescues in that year, thereby saving the Australian economy over AUD3.4 billion. Surf Life Saving
Australia not only provides coastal-safety-based operations, it also conducts surf sports events to assist its members to hone the skills necessary to perform those rescues. SLSA annually conducts the Australian Surf Life Saving Championships (‘The Aussies’), which is one of Australia’s largest annual participant sporting events. In 2016, SLSA had registered over 7,000 competitors to compete at ‘The Aussies’, which was more than the anticipated 6,600 competitors and managers expected for the 2018 Commonwealth Games on the Gold Coast Australia (Tourism Australia 2018).

There is an expectation that organisation such as Cricket Australia and Surf Life Saving Australia would be significantly impacted by critical events involving competitors, in terms of public trust and confidence, brand legitimacy, and funding. Funding agencies, including governments and corporate sponsors may reasonably expect these NFPs and sports entities to exhibit corporate-style behaviours and values while providing the community benefits and services that are addressed in their mission statements. However, many large-scale corporate sponsors can also indirectly influence change to the governance and risk-management practices of these charitable and/or sporting entities by threatening to reduce, or totally withdraw, their funding agreement(s) (Cornforth 2002; Hearit 2006; Walters & Tacon 2010).

Management decisions are especially influenced by threats to an organisation’s legitimacy and loss of funding during times of crisis. Reaction and policy development, being in the interests of the “categorical imperative” of moral judgement (Gibson 2000, p. 248), often become a more strategic rather than a normative, behaviour. For example, on 27 November 2014, the Australian cricketer Phillip Hughes, died from injuries he received when he was accidently struck in the neck by a cricket ball while batting in a first class cricket match (New South Wales State Coroner’s Court 2016). In the subsequent coronial
inquiry, the coroner recommended that the governing body, Cricket Australia, review the existing Sheffield Shield playing codes (New South Wales State Coroner’s Court 2016), in the interests of competitor safety. The coroner’s recommendation was made with a view to eliminating decision-based anomalies and providing officials with guidelines for consistent interpretation of the laws of the game. This included the wearing of additional protective equipment, and greater control by umpires and captains of the practice of verbal abuse and intimidation known as ‘sledging’. Sledging, as defined by Joseph and Cramer (2011) in the context of the game of cricket, is “the practice whereby players seek to gain an advantage by insulting or verbally intimidating the opposing batter” (2011, p. 237).

The residual impact of the crisis involving the death of Phillip Hughes in 2014 on the reputation and management practices of Cricket Australia is underscored by a recent event, involving the Australian cricket team, while they were playing in a test match against South Africa. Although not involving death or serious injury, the crisis, involving ball tampering, as reported in the media (Halloran 2018), has the potential to cost Cricket Australia over $100 million in immediate loss of sponsorship contracts. The above example demonstrates the possible ramifications that crisis events have on continued funding stability, as focus is placed on the organisational behaviour that precipitated such crises. When crises occur, all facets of an organisation become subject to public scrutiny and comment. This may include its culture, board structure, and operational and risk management practices.

By comparison, SLSA holds a similar institutional legitimacy to Cricket Australia within the Australian psyche in terms of sport participation, but with the added responsibilities of maintaining a charity-perspective, as an iconic guardian of coastal safety. Furthermore, the inherent risks to organised surf lifesaving competition is grounded in the desire by athletes
to challenge themselves primarily against the natural environment, while ostensibly participating in events which develop the necessary skill-sets to perform coastal rescues. This is in contrast to most other competitive sports, where risk-management practices primarily address participant safety in terms of the rules and standards governing competitor-to-competitor interactions and performance, known as ‘internal risk factors’ (Fuller 2007; Fuller & Drawer 2004; Fuller, Junge & Dvorak 2012; Meeuwisse 1991).

Surf lifesavers have been compared to the ANZAC military legend (Surf Life Saving Australia 2007, pp. 1-21) as they rely on their skills to challenge a potentially hostile natural environment – the surf! SLSA surf-sport risk managers address similar internal risk-factors to traditional sports such as cricket, rugby union or Australian Rules football, which include player rules, equipment standards, and personal protective equipment. However, they must also identify and manage those natural hazards (‘external risk factors’) that have the potential to have catastrophic effects on the competitive arena and the competitors under their charge. SLSA, as compared to other extreme-sports organisations, such as The International Freeskiers and Snowboarders Association (International Freeskiers and Snowboarders Association 2018), which only permit competitions involving expert adult participants, are in a unique position for an organisation conducting competitions in the natural environment. SLSA are responsible for both male and female participants, whose ages may vary from 6 to over 80 years, and exhibit a wide variation in abilities. SLSA thus bears the responsibility of mitigating the risks associated with conducting a sport in a natural environment to a level that is as low as

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2 ANZAC stands for the Australian and New Zealand Army Corps, comprised soldiers from these countries who land on the shores of Gallipoli on 25 April 1915 (The Australian Army 2018).
reasonably practicable, all the while maintaining the underlying ethos of the competition –
to conduct competitive events that reflect the required skills of an effective surf lifesaver.

1.4 The Management of Safety-based Risk

Given that both not-for-profit and recognised sporting organisations are directed through
their respective governance charters to mitigate risks to the safety of stakeholders in a
functionally efficient manner, it becomes incumbent upon them to seek, develop, and
apply the most comprehensive, yet parsimonious, and valid safety-based risk models
available (see Section 5.3.1). The commitment to model-adequacy is related to the specific
sporting activity, and the safety-based risks to, and expectations of, its participant
stakeholders. For example, risk models suitable for a particular sport such as the Summer
Olympic Games track-and-field competition would not adequately account for the risk
factors involved in, say, a Winter Olympic Games Downhill ski race, and vice versa. Risk
models for each of these sports should therefore comprehensively account for those
inherent internal and external risk factors, which are particular to each sport, but in a
manner that provides mobility (McCammon 2005, 2007), being significantly applicable to
multiple geographic locations, and ease-of-use. As a not-for-profit sporting organisation
develops a higher corporate profile, which in this case is the International Olympic
Committee, the responsibility and appearance to uphold the standards of participant safety,
to the highest level, also dramatically increases.

The risk management practices associated with traditional sports such as the Summer or
the Winter Olympic Games, are extended when the sporting event encroaches on the upper
limits of the domain of the natural environment. Participants in these activities, commonly
known as ‘Extreme Sports’, extend the limits of acceptable risk of serious injury when
they engage in events such as the Red Bull Air Race (airplane), Crashed Ice (ice-cross
downhill skating), Cliff Diving World Series (rock diving), Big Wave Surfing, the Yukon Arctic Ultra (motor biking) (Red Bull 2018), or Crankworx World Tour (mountain biking) (Crankworx 2018). Each of these extreme sports challenges various aspects of the natural environment (Bennett et al. 2002; Heike, P 2005). Sports-event organisers, by necessity, have adopted new safety-based risk models, which account for these extended levels of acceptable risk, so that they may continue to present such extreme events to an ever-growing technology-dependent world audience. Extending the argument by Fuller and Drawer (2004) and Fuller, Junge and Dvorak (2012), continuance of sporting activities after related serious injury and/or death, may be threatened by significant negative responses by primary stakeholders. These potential negative responses may include, but are not limited to, threats which are legal, for example through coronial inquests; financial, being impacted by future insurability and cost, or loss of sponsorship; participant support; to participant health and safety concerns. Continuation may also be impacted by associated negative media coverage, which may heighten the abovementioned effects on these primary stakeholders, leading to a review of the entity’s governance structure, as was the case with SLSA after the Saxon Bird death in 2010 (Australian Broadcasting Corporation 2013, Deloitte Touche Tohmatsu 2012, Queensland Office of the State Coroner 2011).

The International Freeskiers and Snowboarders Association (International Freeskiers and Snowboarders Association 2018), for example, is the not-for-profit governing body of extreme alpine or ‘Big Mountain’ skiing and snowboarding events. Being an extreme sport, participant risk of death or serious injury in ‘sanctioned’ events is significantly higher than that tolerated in most traditional sporting events, including Olympic-standard alpine downhill ski racing. Through its mission statement, The International Freeskiers and Snowboarders Association recognises these inherent risks. In addition, with due consideration for those risks involved, the association “sets sanctioning guidelines for
event execution and judging to ensure consistent competitions and represents the needs, interests, and safety of freeride competitors” (International Freeskiers and Snowboarders Association 2018). Although safety is a priority, the management of risk of death and/or serious injury is to a level that is as low as reasonably practicable, given the extreme nature of this sport. Participants who compete in this style of event accept these risks because they seek the extreme challenge offered by this type of sport, together with the increasing rewards of doing so, as the sport becomes more popular to audiences. Unlike many competing surf lifesavers, whose competition ages vary from eight to over eighty, and from age fifteen, require a Surf Rescue Certificate or Surf Bronze Medallion to compete (Surf Life Saving Australia 2017a), these extreme sports participants are adults, with a minimum of expert-level skiing and/or snowboarding ability. They are also exposed to higher levels of risk on account of natural catastrophes such as avalanches than would be expected in traditional sports, such as, athletic track-and-field events, swimming, rugby union, soccer, Australian Rules football, and the like.

1.5 Stakeholder Needs, Values and Expectations

Powell and Steinberg (2006, pp. 54-7), supported by Hall (2010), contend that NFPs emerged in Western economies during the late 1950s and became a recognised and “coherent” sector in the 1970s. NFPs reflect their development from the ‘for-profit’ sector by assuming many similar traits, such as financial transparency and accountability, which were fundamental to the success of these profit-focused entities. However, being composed of volunteers, NFPs often adopted an ideological perspective, when conducting their business. Consequently, Powell and Steinberg (2006) argue that performance of NFPs should be primarily measured in terms of mission achievement, as opposed to profit maximisation.
Freeman (1984) argued that financially stable and socially responsible for-profit corporates can survive by adopting a strategic management approach, which included the recognition and consideration of stakeholder rights and values. Freeman’s interpretation was substantially clarified and formalised into a Stakeholder Theory by Donaldson and Preston (1995). Central to their argument is Freeman’s tenet that a stakeholder is “any group or individual who can affect or is affected by the achievement of the organization’s objectives” (Freeman 1984, p. 46). The scholarly work by Mitchell, Agle and Wood (1997) contributes to the identification and salience of Stakeholder Theory and its relationships with power, legitimacy and urgency. They posit that stakeholders can influence change within the entity by demonstrating their power over the behaviour of that entity, especially in times of crisis. Gibson (2000) later extended the tenets of Stakeholder Theory by arguing that aspects of ‘prudence’, ‘agency’, and ‘deontology’ should also be considered when entities interact with stakeholders in the course of doing their business. These aspects explicate the entity’s responsibilities to some, but not all, stakeholders, all the while providing a means to distinguish between “competing stakeholder claims” (Gibson 2000, p. 245).

Stakeholder Theory is based on the understanding that corporate entities should recognise the wide range of interests that affected parties such as customers, employees, suppliers and the community have on them. Laplume, Sonpar and Litz (2008) reviewed and analysed the available literature critiquing Stakeholder Theory and suggested that there was broad positive support for its tenets throughout the academic literature. The same authors recommended more comprehensive empirical research across a wider range of organisations. Jones, Felps and Bigley (2007) further contributed to the theoretical basis of Stakeholder Theory by describing aspects of organisational culture “consisting of beliefs,
values, and practices” that have assisted in solving problems involving management and stakeholder relationships (2007, p. 137).

Leopkey and Parent (2009) continued the discourse to apply to sporting organisations by examining the utility of a stakeholder approach to large-scale sports-event management. Although initially developed for the ‘for-profit’ corporate sector, the utility approach equally applies to not-for-profits, including sporting organisations, whose size and influence mimics those ‘for-profit’ entities. In the light of the varied dimensions and approaches to Stakeholder Theory referred to in the literature, it is necessary to identify those NFP and sporting organisation stakeholders, who are relevant to this case study (Surf Life Saving 2018a, pp. 8-9).

The major stakeholders, who may affect not-for-profit organised sporting corporates include:

(i) Government departments and agencies, which are lawful entities representing the rights of the community. They provide the legislated regulative frameworks and guidelines in which the entity can implement its fiduciary duties to its stakeholders. Often, these frameworks focus on the financial transparency and accountability of the organisation to function as a legitimate business. They expect the organisation to operate in an ethical and lawful manner, which gives due recognition of the lawful rights of all stakeholders. An example of a relevant agency for the NFP sector is the Australian Charities and Not for Profits Commission (ACNC).

(ii) Relevant national and/or international governing bodies provide ideological, ethical and operational frameworks and guidelines for the standardisation of the rules, equipment, facilities, and risk management (including safety). They are cognisant
of the national/international legislative framework within which the entity functions and its responsibility and ability to meet those requirements. Examples of governing bodies include the Fédération Internationale de Football Association (FIFA), the International Olympic Committee (IOC), Rugby Australia, Cricket Australia, and the Australian Football League (AFL). These governing bodies expect the registered sporting organisation to abide by those standards, as applied to their own jurisdictions, and remain consistent with the national or international codes. They possess the authority to enforce penalties, such as fines and suspensions, for non-compliance to those rules.

(iii) Corporate sponsors and partners often contribute to the stakeholder mix through motivations of corporate citizenship, self-interest, and/or strategic benefit. They exploit their association with the NFP, through endorsements and service provision, to leverage community approval, possible tax advantages, and in anticipation of increased returns to their shareholders. They often implicitly exert a high level of influence through financial assistance to the sporting organisation, which may be fundamental to its viability. In return, these stakeholders expect the NFP and its representatives to behave in an ethical, moral, safe, and legal manner, which indirectly brings credit or advantage to themselves. They also expect the NFP to conduct its activities, reflective of the standards of the governing body, in an environment, which assures the safety of participants to a level that is reasonably practicable. For example, The Coca-Cola Company (Coca-Cola 2018) has been a major sponsor of the Olympic Games since 1928. Haas and Healey (2016) report in their book, Doping in Sport and the Law, that its association with the Olympic movement enhances the Coca-Cola image. The Coca-Cola Company
embraces the Olympic ideals of the spirit of fair play and the pursuit of excellence in sport, with an expectation of drug-free Olympic competition.

(iv) The Community, including the general public, individual or group participants, and friends and family of participants, are generally the recipients or beneficiaries of the NFP’s products, activities, or services. They have a very high expectation that those activities or services, such as surf lifesaving, are conducted in an environment where the competitor is afforded the highest standards of safety, given the nature of the activity that is involved. In a sporting context, they expect that the rules, equipment, and competing environments meet the standards of the national or governing body, and are in line with government regulations. They expect competition to occur on a safe arena where fair play between competitors is standard. These sports arenas may also occur in the natural environment, such as the surf zone or alpine snow backcountry, which inherently possess separate extraordinary competitor-challenges. They expect the entity to apply modern, appropriate, and comprehensive risk management practices. Given the diverse nature of sport, the variation in risk levels could be exceedingly large. These stakeholders expect that the risk-management practices be appropriate to their sport, and should identify internal and external risk factors, and provide mitigation strategies to overcome those risks to a level that is reasonably practicable and so ensure the safety of all (Fuller, Junge & Dvorak 2012).

(v) Volunteers act as agents of the NFP when interacting with community beneficiaries, such as surf-sports participants. They often perform the role of officials and managers of risk. They are expected to adhere to and enforce the rules and standards of the controlling governing body in an unambiguous and objective
manner. In the case of sporting organisations, this is for the benefit and safety of participants at all levels of ability, gender and age. Volunteers expect the NFP or sporting organisation, with which they are associated, to provide up-to-date, accurate, and clear, regulation and risk-management policies. They expect to be able to perform their duties in an efficient and diligent manner using policies, which are comprehensive, inclusive of participant concerns and needs, especially safety.

(vi) Coaches and/or educators provide expert advice and knowledge to volunteer and professional stakeholders, who represent the organisation. They, too, may act in a voluntary or professional capacity, depending on the sophistication and financial resources of the relevant NFP or sporting organisation. They expect that the organisation, in return, should provide them with the most recent and comprehensive regulations and management policies, in order to maintain a fair and safe participant environment. This enables them to clearly impart their knowledge and advice in a safe and effective manner, which adds value to the organisation. They also expect the organisation to adhere consistently to those policies for the benefit of all stakeholders. For example, SLSA, together with its various sub-entities, employs coaches and educators to train athletes and voluntary lifesavers to apply lifesaving skills and abilities efficiently to competition and patrolling duties.

(vii) The media provide an opportunity for the community to access information about an organisation and its activities. It can act as supportive agents of the organisation, individual, or group, by reporting only positive aspects of the entity’s activities or achievements. Yet the media can also function as an unbiased community agent, by
presenting an impartial, accurate, and transparent account of those same activities or practices. Thus, the media is capable of acting as a powerful force to assist or hinder the progress of a NFP or sporting organisation, in its association with stakeholders, by strenuously or emotively reporting the relevant facts and issues. As a consequence, their expectations could be many-fold and tempered by biases, including their own self-interest. The influence of the media, in questioning SLSA’s governance practices, risk management policies, and legitimacy to be considered as a coastal safety authority, is detailed in Sections 3.9 and 3.10 of this case study.

(viii) Suppliers, who provide the commercial resources and/or services to the entity so that the entity may function as intended. The roles of suppliers, like many groups within this list, often overlap with groups of other stakeholders mentioned herein, through their interaction with the organisation. For example, as referred to in section (iii) above, a company such as The Coca-Cola Company may supply beverages at an event on a quasi-commercial basis while contributing to, and benefiting from its sponsorship of the NFP in other areas.

(ix) Administrative staff are employed by the organisation to execute safely, efficiently and effectively the policies derived by the governing body for the benefit of the organisation. In return, they expect to work in a safe and healthy environment, and be financially recompensed for their services.

Gibson (2000), in his treatise on ‘the Moral Basis for Stakeholder Theory’, argues that the distinction should be made between these stakeholder types, based on their primary or secondary influence on the organisation. According to Gibson (2000, p. 245), ‘primary’
stakeholders comprise those “who have a formal, official, or contractual relationship” with the organisation, while all others should be regarded as secondary stakeholders.

Many of the abovementioned groups would therefore be classified as primary stakeholders. For example, SLSA conducts the *Australian Surf Lifesaving Championships* each year at a designated Australian surfing beach. It has contractual arrangements with government agencies (local councils), corporate sponsors (through endorsements), and competitors via their membership with this association. It directly seeks the assistance of volunteers, coaches, educators, and administrative staff to conduct these events. However, not all of the ‘stakes’ held by these groups or individuals are equal. Differing stakeholders such as sponsors, competitors, officials, and the media all have differing rights, needs, and values, as has been referred to above. Risk management becomes confounded, conflicted, and sometimes critical, when the priorities of these stakeholders become confused. Ideally, regard for competitor safety should be prioritised. Based on evidence presented in Sections 3.7 and 3.8, this was clearly not the case when amateur surf athletes Saxon Bird and Matthew Barclay were killed during officially sanctioned SLSA-managed competitions in 2010 and 2012.

### 1.6 Crisis Events - Stakeholder Influence on Corporate Entities

Jones, Felps and Bigley (2007) argue that organisations may adopt a variety of different beliefs, values and practices as they resolve the threats from critical events involving their stakeholders. Their responses may be tempered by inter-relational cultures including “agency, corporate egoist, instrumentalist, moralist, and altruist” (2007, p. 137). Indeed, many for-profit and NFP corporates exhibit a continuum of these and other behaviours in their associations with stakeholders. Their own corporate interests may be limited by a process of stakeholder prioritisation, which is dependent upon the ‘affect’ (Freeman, 1984)
or the “power” or “influence” (Mitchell, Agle & Wood 1997, p. 854) that primary
and/secondary stakeholders exert over the organisation, together with the urgency of the
stakeholder’s claim on the entity. These prioritisations could still be consistent with a
normative approach, as is argued by Donaldson and Preston (1995). It is only in times of
crisis that primary stakeholders fully realise their potential for influence (Walters & Tacon
2010).

Influence often occurs because of, and in partnership with the media, which may or may
not have complementary, value-based, agendas. The media, as a secondary stakeholder,
provides the catalyst/agency/medium by which maximum influence for reform can be
advocated, as occurred with the crises involving the aforementioned cricketing (ABC News
2016, BBC Sport 2016, India Today 2018) and surf lifesaving (Australian Broadcasting
Corporation 2013) organisations during their times of crisis. The subsequent coronial
inquests became the instruments by which change was forced upon those organisations.
The inquests recognised that athletes require a safer competing environment, reflective of
their intrinsic culture, abilities, values, and the perceived challenges of their sport (New
South Wales State Coroner’s Court 2016, Queensland Office of the State Coroner 2011,
2016). The coroners in each case acted as legal agents when recording their findings and
recommendations, which is consistent with expected community standards and values. The
media also acted as a less formal community agent by expressing those concerns for the
existing cultural standards and risk management practices of the organisation, which may
have contributed to those deaths, often in more emotive presentations. For example, in
reporting the second death in surf lifesaving competition within a two year period, an
article titled “Matt Barclay torn from young rescuer's hands” expressed community
outrage by stating “Put killer Kurrawa Beach off-limits, community says” (Meyn and
Lulham 2015). Similar reports occurred earlier in the *Courier Mail* (Stoltz, & Pierce 2012) and the *Gold Coast Bulletin* (2016).

### 1.7 The Need for Valid Risk-Management Models

As can be seen from the above discussion, coronial inquests and intense community interest are common outcomes when an event crisis results in the death or serious injury of a primary stakeholder. When this also involves a significant not-for-profit and/or sporting organisation, such as Cricket Australia or Surf Life Saving Australia, it is often accompanied by intense media coverage, as stakeholders wrestle with the consequences of the tragic events. Such has been the outcomes of the recent deaths to the Australian cricketer and the surf lifesavers mentioned above. Often the heightened scrutiny envelops the operations of the whole organisation, including its governance and risk-management practices. The consequences for an organisation can be legal, long-term, and substantial, thus placing focus on the entity’s culture and its legitimacy to function.

Research by Deegan, Rankin and Voght (2000) and Deegan (2002) suggest that organisations react to this extra stakeholder scrutiny, in an attempt to maintain corporate legitimacy and viability, by increasing the level of voluntary public disclosures and reports. They may do this in pursuit of corporate strategic benefit rather than for normative validity. For example, the responses by Cricket Australia and Surf Life Saving Australia to their separate corporate crises was to undertake rigorous reviews of their competition risk-management policies prior to the tabling of the respective coronial findings. By preempting the coronial request to review their risk management policies, they were perceived by the community as acting responsibly and being pro-active in their attempts to mitigate risk, thus reducing the threat to their corporate legitimacy and satisfying sponsor concerns.
A prime requisite of good corporate citizenship when applied to sporting organisations managing sports events is the prioritisation of participant safety. It is incumbent upon the organisation to optimise its opportunity to adopt the most parsimonious risk-management model available. In order to provide ease of transition into existing protocols, it would be preferable that such a risk model complements existing rules and practices as determined through its governance policies. Safety-based risk models should be objective in nature and design in order to reduce the chance of “human malfunction” (Rasmussen 1982, p. 325), or human error. Rasmussen draws distinction in errors resulting from “skill-, rule-, and knowledge-based performance” (1982, p. 11). Research by McCammon and Hägeli (2007) examines these skill-, rule-, and knowledge-based approaches as they apply to avalanche risk-models for backcountry skiers. In their paper “An evaluation of rule-based decision tools for travel in avalanche terrain”, in which the researchers attempt to develop a slope-scale avalanche prediction model, they suggest that there is a growing interest in the application of rule-based “quantitative algorithms for assessing avalanche danger” because these models and strategies offer significant advantages “for making complex decisions in high consequence settings” (2007, p. 194). Such is the case when lifesavers are regularly called upon to assess the dangers, which may exist in prevailing surf conditions in surf-sport events and which may lead to serious injury or death. Model development should also be mindful of the process of systematic analysis using modern multivariate techniques and access to truly representative data samples (Booysen 2002; Nardo, Saisana, Saltelli, Tarantola, et al. 2005; Tabachnick & Fidell 2014).

For the Cricket Australia crisis, the outcome involved a review of the rules governing the delivery of a series of fast short-pitched cricket-ball deliveries known as ‘bouncers’, as well as the introduction of more technically advanced protective equipment for the neck and head. A similar outcome resulted from the crisis involving the death of the surf athlete
Saxon Bird in 2010, which was reinforced through the proceedings of the subsequent Matthew Barclay inquest. The surf-hazard assessment models that were available to decision makers at the times of these tragedies were found to be deficient, especially given that they were incapable of accurately and objectively determining the risk levels of prevailing surf conditions (Queensland Office of the State Coroner 2011, 2016).

In the light of these issues and challenges to the corporate legitimacy of NFPs in the arena of sporting governance, this research will demonstrate that existing surf risk models are founded on unclear and statistically weak analytical methods that rely on non-representative data samples. As a result, it can be argued that SLSA now has the obligation, as a responsible sporting and water-safety corporate citizen, to adopt an evidence-based model, particularly if the organisation is to retain its iconic and hard-earned position of community trust and confidence, and long-term viability. The risk model employed should therefore be capable of providing SLSA’s decision makers with a real-time tool that is able to objectively, accurately, comprehensively, and easily assess potential surf hazards when sporting events take place in the surf.

This case study traces the development of such a tool, known as the Surf Hazard Rating (SHR) model, in partnership with SLSA, using data prospectively collected from surfboat competitions during the 2013/14 and 2014/15 Australian surfing seasons. The research statistically models craft incidents in surfboat events against observable and measurable surf zone characteristics that prevailed at the time. Surfboat competition events are an appropriate measurement vehicle in this instance because they demonstrate a wide variety of incident types, competitor abilities, are not gender-specific, and provide the opportunity for the collection of a large, randomly-based sample. An appropriate quantitative surf hazard risk model is developed in this study by considering, in Section 5.4, the research
aim to ‘validate and evaluate the theoretical construct of the Surf Hazard Rating model as a real-time risk-management tool for surf lifesaving competitions’ through three research questions, which address issues of model validity, ease-of-use, and real-time practicability.

1.8 Chapter Summary and Thesis Overview

This chapter has provided an overview of the research areas involved in this study and the sequence in which the evidence to support the research argument will be presented. It indicates the circumstances that provided the motivation for this author to seek a better hazard-assessment model than was currently available, and contextualises the development of the Surf Hazard Rating (SHR) model within the Australian sporting and not-for-profit sectors. This chapter also provides a preview of the nature of this research and its methodology, which employs an Action Research design in partnership with SLSA, to seek risk-management solutions for entities that organise events in extreme natural environments.

The following chapter will review the governance and sports risk-management literature as it applies to general Stakeholder Theory, with specific reference to the policy frameworks, the operations, stakeholder pressures, and the responsibilities, as they might apply to a NFP and/or sporting organisation such as SLSA. Chapter 3 will provide an historical review of the surf lifesaving movement within Australia since 1907, and the tragic events of 1996, 2010, and 2012 that led to the strategic need for SLSA to seek better, and evidence-based, risk models to manage future surf lifesaving events. The argument is made in a further literature review in Chapter 4 of wave and surf-zone theories that a surf-hazard-assessment model should be developed that adopts an alternative ‘effect-based’ risk model approach as opposed to those found in existing ‘process-based’ models. Chapter 5 supports the argument for the validation of the SHR model by detailing the study’s
research design, while Chapter 6 follows with supporting evidence, comprising data \((n = 2118)\) collected from 47 separate beaches across Australia between December 2013 and April 2015. The analysis of these data adopt a Mixed-Methods approach, which quantitatively assesses model ‘goodness-of-fit’ against external regressors, all the while utilising stakeholder surveys to converge towards a parsimonious real-time model. The appropriateness of the model as an efficient tool to assess surf hazardousness is supported by a detailed account of the model’s operationalisation in real-time decision making at a major surf lifesaving event in 2015. This research study is completed with a conclusion and implications chapter that draws all of the elements presented throughout this research together to substantiate the arguments presented herein.
Chapter 2  Governance and Risk Management in NFPs and Sporting Organisations

2.1  Introduction

This chapter will consider scholarly contributions to the theory of governance in the context of not-for-profit organisations, such as Surf Life Saving Australia (SLSA), that provide health, social and sporting community benefits. It will also examine the influence that stakeholders have on governance practices, which affect their risk management responsibilities. This chapter will also examine the concept of risk as it applies to the risk management of sporting events involving natural environments, where mitigation may necessitate event-cancellation and/or venue-transfer.

2.2  The Not-for-Profit Sector

As presented in Chapter 1, the ‘not-for-profit’ (NFP), is recognised as a large and diverse group of entities contributing to community welfare. The Australian Charities and Not-for-profits Commission (ACNC) hold that this contribution is in the form of services and activities including health, education, social services, sport and recreation, the arts and culture, the environment, religious practices, animal welfare, and human rights (Australian Charities and Not-for-profits Commission 2019; Australian Government 2012b). A not-for-profit entity functions as a charity group, whose mission is to provide public benefit, without seeking profit or the personal gain of its members. Anheier (2000, p. 2) provides a similar assessment of the characteristics of the general NFP, which include being organised, private, non-profit-distributing, self-governing, and voluntary. Hoye et al. (2015, p. 34), in their text on Sports Management: Principles and Applications, perceive
many sporting organisations as NFPs, in the sense that they remain separate from the state, do not return profits to their owners, are self-governing, are formally incorporated, and contain a significant proportion of volunteer human resources. Hoye et al. (2015) argue that sporting organisations act as not-for-profit organisations in contributing to the ‘public good’ by providing an infrastructure that encourages participation in activities that promote health and social wellbeing.

Not-for-profit organisations, including sporting organisations, make a significant contribution to the Australian community in terms of the social and economic benefit they provide to their stakeholders. In Australia, there are approximately 600,000 not-for-profit groups, which include health, social service, and sporting associations. Of these, as at December 2017, nearly 56,000 are registered with the ACNC, and have a combined annual revenue of over AUD142.8 billion (Australian Charities and Not for Profits Commission 2017). The economic value of this social benefit provided by NFPs to the Australian economy is demonstrated in the following two examples. A 2011 independent report by Pricewaterhouse Coopers (PwC), entitled ‘What is the economic benefit of Surf Life Saving’, assessed SLSA’s total economic value to the Australian economy in terms of savings, for coastal drowning and injury prevention, to be AUD3.6 billion per year (PwC 2011). It concluded (2011, p. 6) that: “Under either [accounting model] scenario, the benefits of Surf Life Saving far outweigh the costs, further demonstrating SLSA’s unique and significant value to the Australian community and economy”. As a second example, the Australian Sports Commission (ASC), as the regulator of Australian sport, reported in 2018 that over 17 million Australian adults, and 3 million Australian children, participated in organised sporting activities within Australia, with an annual spend of AUD10 billion (Australian Government 2018).
The establishment of the not-for-profit sector, as reported in the literature (Anheier 2006; Lyons 2001; Steane & Christie 2001), is a recent development, and an expansion of the two-tier business-model approach involving the traditional ‘for-profit’ and government sectors in modern economies (Hall 2002; Powell & Steinberg 2006). Hall (2010), whose views are supported by Powell and Steinberg (2006), contends that NFPs (as distinct from non-government organisations or NGOs) emerged in the late 1950s and became a recognised and coherent sector in the 1970s, particularly in the United States of America (USA). According to a review of the Australian Charity Sector before World War II on the ACNC website, NFPs in Australia consisted mainly of “religious institutions working towards relieving poverty and suffering” (Australian Charities and Not-for-profits Commission 2019). Two exceptions to this general statement were the Royal Lifesaving Society, Australia (Royal Life Saving Society - Australia 2018), which was formed in New South Wales in 1894 (Museums Victoria 2018), and Surf Lifesaving Australia (Surf Life Saving Australia 2015c), which was formed in 1907 (Surf Life Saving Australia 2007). Both organisations have continued to provide community-based water safety services since that time within Australia. However, like their USA counterparts, the NFP sector in Australia also underwent a similar transformation post World War II (Goodwin & Phillips 2015).

A review of the literature indicates that there are a limited number of scholarly studies involving NFP governance requirements, stakeholder scope and development, and performance measures within the Australian context (Adams & Simnett 2011; Moxham 2014; Steane & Christie 2001). Moxham’s (2014) review of the literature, from a database of 110 journals, found that the body of works, which examined NFP performance-measurement system-design, was often fragmented and published in a range of public sector, third sector, and management journals. The author, however, discerned three key
drivers of NFP performance, they being “accountability, legitimacy and improvement of efficiency” (Moxham 2014, p. 707). There is also limited scholarly input into the management of sporting organisations as a specific sub-group of NFPs (Fuller & Drawer 2004; Hoye & Cuskelly 2007; Stewart & Smith 2000; Dowling, Leopkey & Smith 2018). In particular, Hoye has been a strong advocate for further research into sports governance and its regulatory environment (Hoye 2003; Hoye & Cuskelly 2007; Hoye, Nicholson & Houlihan 2010), the contribution of volunteers to sport development (Cuskelly, Hoye & Auld 2006), and the capacity of sport to create substantial social capital (Hoye & Nicholson 2008).

In order to provide an Australian context to a later discussion (Section 2.3) on the role of governance within the NFP sector in Australia, it is necessary to review those attributes Australian Government agencies consider to be reflective of NFP ideals. Within Australia NFPs take many forms, ranging from small self-help groups providing specific and localised benefits to stakeholders, through to large-scale professionally run organisations with multiple sub entities, and which may also operate in an overseas capacity. These organisations must conform to the Commonwealth Charities Act 2012 (Australian Government 2013) with a stated purpose to include at least one of the following elements (Australian Charities and Not-for-profits Commission n.d.-a):

(i) advancing health;
(ii) advancing education;
(iii) advancing social or public welfare;
(iv) advancing religion; advancing culture;
(v) promoting reconciliation, mutual respect and tolerance between groups of individuals that are in Australia;
(vi) promoting or protecting human rights;
(vii) advancing the security or safety of Australia or the Australian public;
(viii) preventing or relieving the suffering of animals; advancing the natural environment;
(ix) promoting or opposing a change to any matter established by law, policy or practice in the Commonwealth, a state, a territory or another country, (where that change furthers or opposes one or more of the purposes above);
(x) or other similar purposes ‘beneficial to the general public’ (a general category).

Not-for-profit organisations therefore provide a vital function within the Australian community by contributing to the maintenance of the health and wellbeing of its citizens. As will be demonstrated in the next section, corporate governance is the process by which these organisations systematically, and efficiently, manage the complex interplay of their regulatory, legal, and stakeholder responsibilities (Hoye 2003; Stoker 1998).

2.3 NFP Governance

In his often-cited paper ‘Governance as Theory: five propositions’, Stoker (1998) proposed that governance theory, in the modern context, extends the original notion of the ability and capacity of governments to make decisions and enforce them to a condition of “ordered rule and collective action” (1998, p. 17). The author supported Rosenau’s (1992) tenet that this condition encompasses modern judgements, which include an entity’s capacity to cope with external challenges and prevent conflicts among its stakeholders. Stoker posited that there are many different governing styles, and that the boundaries between and within the public and private sectors is often varied and blurred.
Other authors’ interpretations of organisational governance also support this view. For example, Brandsen and Pestoff (2006) and Kiel and Nicholson (2003) propose that governance of any organisation may be defined in many forms, depending on the purpose of the organisation. The literature reflects this variance, often again from the perspective of ‘for-profit’ organisations rather than for not-for-profits. Huse (2005) supported the argument of Monks and Minow (2004) that any definition of corporate governance is biased, and that “corporate governance definitions and board accountability are influenced by the stakes and power of various actors” (Huse 2005, p. 69). Tricker (1994; 2015, p. 4) suggests that corporate governance is about the way power is exercised over corporate entities”, while Bevir (2012, p. 1) defines it as “all of [the] processes of governing, whether undertaken by a government, market or network, whether over a family, tribe, formal or informal organization or territory and whether through the laws, norms, power or language”. In the sports organisation context, Henry & Lee (2004) provide seven guiding principles of good governance, which envelop those similar traits, and which are identified in the NFP literature. Those principles are: transparency, accountability, democracy, responsibility, equity, effectiveness, and efficiency. Accounting for these variants of governance definition, this study includes direction from the ACNC and the Australian Institute of Company Directors (Australian Institute of Company Directors 2017b), to design a hazard-assessment model that remains consistent with the stated purpose of the governance of SLSA to act as a charity within the Australian NFP sector (Surf Life Saving Australia 2019).

According to the Australian Institute of Company Directors document on ‘Good Governance: Principles and Guidance for not-for-profit Organisations’, governance is a framework within which an organisation’s internal and external authority is exercised and maintained (Australian Institute of Company Directors 2017b). The entity’s management
board forms the central core to this functionality. The guidance document further advises that a governing board “plays an important role in setting the vision, purpose and strategies of the organisation” (2017a, p. 22), and assists that organisation to understand and adapt its direction or plans appropriately. Governance within the Australian NFP sector conforms to this same corporate definitional framework. Governance of NFPs therefore deals with the autonomy and capacity to provide a framework for understanding the changing processes, values, and needs of these organisations.

The Australian Institute of Company Directors, through its website (Australian Institute of Company Directors 2017b), asserts that corporate governance in the Australian not-for-profit sector encompasses, amongst other things, “the rules, relationships, policies, systems, and processes that establishes the entity’s legitimacy to function”. The ACNC provides guidance for NFP governance standards, which includes purpose, accountability to its stakeholders, compliance with Australian Law, the suitability and duties of responsible persons, who act on behalf of these organisations. A further guidance principle, which is of particular interest to this research, is the responsibility of governing boards to form and execute suitable stakeholder-focussed risk-management practices, for example, during sporting events.

2.4 The Development of NFPs as Third Sector Corporates

Governance standards of NFPs, including their organisational business models and practices, display strong underpinnings of ‘for-profit’ board and executive structures. However, unlike their for-profit counterparts, they attempt to maintain missions of community benefit, similar to social-, or welfare-based public agencies (Anheier 2000; Brandsen & Pestoff 2006; Kramer 1981). NFPs therefore, could be considered as a ‘third sector’, which is separate to for-profit entities and government agencies. Kanter and
Summers (1987) suggest that a dilemma exists because of the problematic nature of NFP goal-specification, by trying to manage healthy financial returns while moving to achieve the goals aspired to in their mission statements. Overarching the emergence of the not-for-profits sector is the recognition of the joint roles of NFP entities to provide financial transparency and accountability, as well as those values associated with volunteerism and community benefit, all of which underpin the tenets of modern Stakeholder Theory (Friedman, A & Miles 2006; Gibson 2000; Mitchell, Agle & Wood 1997; Ribeiro Soriano et al. 2011; Walters & Tacon 2010). Seibel (1996) contends that a competition exists between the day-today ‘for-profit’ corporate ethos of bottom-line profit maximisation, financial management, and the achievement of a charity’s established purpose, and that this provides fertile ground for “successful failure” (1996, p. 1015). This might occur when a NFP maintains its legitimacy within society, without the absolute necessity to achieve the stated goals of its mission statement. Seibel (1996, p. 1015) suggests that management’s “rent-seeking” attitude of dependence on sponsor funding might enhance this position. This study will explore this position in the context of SLSA’s responses to several crisis events during surf lifesaving competitions.

2.5 NFP Board Composition and Structure

Steane and Christie’s (2001) research extended American research by Kang and Cnaan (1995) into the social and welfare service industries in Australia, especially benevolent groups and health care organisations. Their work pre-dates the formation of the Australian Charities and Not-for-profits Commission Act 2012 (Australian Charities and Not-for-Profits Commission 2013a), but is nonetheless insightful and instructive in terms of corporate governance development within Australia. In particular, the analysis of surveys from 1,400 directors, representing 118 Australian NFP boards, revealed many similarities
between the ‘not-for-profit’ and ‘for-profit’ sectors, regarding their approaches to governance. They suggested that NFP isomorphic behaviours, including mimicking and coercion, stem from the legislation that was initially imposed on the ‘for-profit’ sector, from which most ‘non-for-profits’ gained their initial and ongoing direction in governance structure. However, they concluded that several distinctive governance elements existed, in which NFPs displayed a “dissonant” behaviour (Steane & Christie 2001, p. 55) compared to ‘for-profit’ corporates. These NFP behaviours revealed a mix of issues, which effected the prioritisation of operation and policy. These distinctions often displayed a greater stakeholder-like approach to governance. They included:

(i) NFP board members were primarily concerned with their fiduciary and due diligence responsibilities, including transparency and accountability. The NFP boards addressed this need, by encouraging greater diversity in the backgrounds and associated skills of their directors, compared with the for-profit sector.

(ii) Non-executive directors of NFPs positively affected performance on account of their independence, monitoring ability and influence over executive management. However, they did not specify how they measured performance. Research by Moxham (2014) concluded that, although the purpose of performance measurement was as a guide to the effectiveness of decision making by management, the demarcation line between the two was often blurred, owing to the complexities and variance in measuring methodologies. Supporting research by Kiel and Nicholson (2003) found there was insufficient consistent evidence to conclude that a significant relationship existed between board composition and performance. There exists a lack of detailed research
about performance measures of NFPs in general and especially NFPs in Australia.

(iii) Not-for-profits were more concerned with ideology and values than the for-profit sector, especially by explicitly favouring structures and decision-making processes that are “expressive” rather than “instrumental”. Mission, at the expense of market-place pragmatism, often drove the NFP business culture. Steane and Christie reported (2001, p. 49) that this was interpreted in various forms by other authors as ‘commitment’ (Judge & Zeithaml 1992a, 1992b) and ‘power’ (Tricker 1994), which was legitimately derived from the organisation’s membership. The concept of volunteerism played a significant role in the development of this culture within the organisation. Saj and Verity (2014, p. 1) describe this intermix as the “plurality of values and ideological perspectives”.

Not-for-profits were more involved in day-to-day operational management, although strategic issues maintained a high importance.

(iv) Not-for-profit boards were more diverse in terms of member interests, skill sets, and ability to lobby for funding. Positions on governing boards prized sector-loyalty as an essential quality. The organisation’s functionality and operations management also benefitted from the impact of non-executive directors. Steane and Christie (2001, p. 51) reported that this position was supported by research by Ezzamel and Watson (1993), Pearce and Zahra (1992) and Byrd and Hickman (1992). It would appear that NFP boards present a more representative but less streamlined structure than their ‘for-profit’ equivalents.

(v) NFP boards were, in general, twice as large as their for-profit-counterparts. Kiel and Nicholson’s (2003) research estimated corporate board size to be 6.6
members compared with Steane and Christie’s average of 12, which suggests that this number is sample-dependent.

(vi) When NFPs adopted more corporate-like practices, which were more closely linked to ‘market environments’, the appropriate use of resources to meet mission outcomes, were constrained by the financial concerns with raising funds and meeting capital flow benchmarks during the course of the year (Steane & Christie 2001, p. 51). They did not expand on the consequences of this constraint. Kiel and Nicholson (2003, p. 194) argue, however, that resource dependence theory suggests “greater opportunity exists for more links and access to resources” is provided by a larger and perhaps more diverse board composition.

(vii) Female CEOs and directors formed a higher proportion of NFP board membership than in the ‘for-profits’ sector. Their research found that NFP boards contained approximately 40% female directors and 43% female CEOs. By comparison, recent data from the Australian Government Workplace Gender Equality Agency (Australian Government 2017f) stated that, with regard to the for-profit sector in Australia, females held 14.2% of chair positions, 15.4% of CEO positions and 23.6% of directorships. These figures were reflected in the data from the Australian Institute of Company Directors (Australian Institute of Company Directors 2017b), which show that, as at 13 April 2018, the percentage of women on ASX 200 boards was now over 30%, and represented 52% of new board appointments in the first quarter of 2018.

Steane and Christie’s (2001) research linked the above distinctions to the effectiveness of NFP activity and the overall importance of ‘values’ in strategic decision making compared
to ‘for-profit’ groups. These authors also noted the increasing regulatory framework within which NFPs operated. This was part of a global trend, which was reflected in OECD documents (Organisation for Economic Co-operation and Development 1997, 1999). The authors cited several legislative Acts from 1997 to 2000 as a demonstration of the increase in stakeholder power within the aged and health care industries, with this power being placed more in the hands of the recipient of the care or service rather than the provider. This was also indicative of the growing trend of stakeholder power and governance regulation within NFPs in Australia.

Included in the move towards greater regulation is the increasing emphasis on adversarial contract-based agreements, replacing informal, and cooperatively negotiated, agreements between parties. Muetzelfeldt (1998) also observed that the introduction of compulsory contracting had affected the previously informal decision making practices of NFPs within Australia. Both the studies of Stone, Bigelow and Crittenden (1999) and Muetzelfeldt (1998) noted that this increased the overall effectiveness of the strategically-focused skill-sets of NFP boards to communicate with governments and other potential sponsors in a more acceptable corporate style. This was supported by Considine, O’Sullivan and Nguyen (2014), whose research into NFP employment-service agencies found similar trends in board professionalism and development along with diversity of board-member skill sets. The Australian Corporate Law Economic Reform Program 1999 (CLERP) (Australian Government 1999) formalised the preferred regulatory structure for conducting business within Australia. The establishment of the Australian Charities and not-for-profits Act 2012 (Australian Government 2012a) formalised this process to address the needs of the NFP sector directly. The related 2013 Chantlink Report (Australian Charities and Not-for-profits Commission 2013b) concluded that the efficient and ethical management of
resources by the board and its executive, as well as its transparency of use of its resources, were desirable major drivers of community trust.

An example of the pressures, which affect the efficient, ethical, and transparent governance of NFPs, can be seen in the consequences for SLSA following the deaths of the aforementioned young lifesavers in 2010 and 2012. An independent report was commissioned by SLSA in 2012 (Deloitte Touche Tohmatsu 2012) to ostensibly review SLSA’s commercial operations and revenue raising activities. The report was commissioned in response to criticism resulting from the Saxon Bird death in 2010. It concluded that SLSA’s “governance model was not working” (Deloitte Touche Tohmatsu 2012, p. 12). The report elaborated by stating that day-to-day operations did not always support SLSA’s mission statement. It needed to better manage risk of death or serious injury, act strategically, and make decisions to remain operationally efficient. It recommended forty-three separate changes to SLSA’s governance structure. Many of these recommended changes involved traditional corporate elements of financial accountability, transparency, and board composition, in order to change the culture within SLSA, which had contributed to inadequate communication, mistrust, lack of collaboration, low morale and reduced fund-raising capacity. The recommendations included greater independence of directors and, important to this research, improvement of communication of strategic priorities and the establishment of a “detailed risk-management plan” (2012, p. 15). SLSA commenced the implementation of all Deloitte recommendations in 2013, in its attempt to retain community trust and confidence in their organisation.

2.5.1 Responsiveness of Boards

The ACNC Act 2012 formalised not-for-profit organisational responsibilities by requiring registered charities to comply with a series of structured governance practices, and in
particular, financial accountability. The 2012 Act’s aim was to provide a regulatory system that promoted good governance and, in so doing, maintained, protected, and enhanced “public trust and confidence in the [Australian] not-for-profit sector” (Australian Government 2012a, p. 2). This was a stakeholder-based approach. In its guidance document for board members Governance for Good (Australian Charities and Not-for profits Commission 2013), the Commission not only encouraged good governance practices but also specified those stakeholders to which these practices should be directed. It stated that (2013a, p. 13):

*There is ‘good governance’ when charities have practices and procedures in place that help them to do their work effectively and openly, and when the roles and responsibilities of people in the charity are clearly understood. This includes the particular roles of board members and the roles of staff, volunteers, and members.*

Of the limited available scholarly works into the NFP sector in Australia, research by Radbourne (2003) provides some insight into the function of Australian not-for-profit boards. Her research into the Australian Major Performing Arts Group (AMPAG) found that innovation in product development and artistic excellence, which formed the core values of its mission, had become secondary drivers of good governance. They had been replaced by a focus on strong management systems and rigorous financial reporting, which were in response to requirements set by governments and funding agencies. The author acknowledged research by other scholars into arts boards throughout the world and contended that many reported characteristics and activities were unique to this particular not-for-profit grouping. It could be argued, however, that these characteristics are common to most large NFPs, including SLSA. Two characteristics that the author’s research did highlight, and which are relevant to this research were the sensitivity to the needs of
community participants (Thorn 1990), and the tension in relationships between volunteer board members and professional staff (Fishel 1993; Jones, Felps & Bigley 2007). The author summarised the research by stating that not-for-profit arts organisations stake their reputation on the board’s “capacity to manage its finances, stakeholders and its mission” (Radbourne 2003, p. 215).

Brandsen and Pestoff (2006) offered a somewhat different position regarding third-sector roles of boards-of-governors and management, particularly as they relate to welfare services in Europe. They posited that much of the scholarly discussion of the role of management in the NFP sector was motivated at least as much by ideology as by fact. In an attempt to approach a more unified understanding of the role of NFP boards-of-governors, they called for a “comprehensive empirical understanding of what happens when the third sector is drawn into public service provision” (Brandsen & Pestoff 2006, p. 494). Research by Cornforth (2001, 2002) into UK-based charity-boards also found mixed support for the normative behaviours related to board effectiveness. He reasoned (2001) that the effectiveness of board governance relied on the commitment of board members’ time, skill, and experience to perform their role, and the clear definition of those roles and responsibilities. He also concluded that administrators should support the common vision expressed by the board, and how it can be achieved, and finally, that the board should undertake a process of regular review of operational procedures by management.

However, the complexity of management responsibilities becomes evident as the boundaries between market, state, and the NFP sector become “blur[red]” (Nicholls & Murdock 2011, p. 3). This is especially noticeable as not-for-profits increasingly outsource servicing contracts and provide other ‘for-profit’-styled services in return. Brandsen and Pestoff (2006) argue that this blurring of boundaries leads to a difficulty in measuring
board performance and organisational efficiency. Some NFPs have developed characteristics that had drifted closer to state-run agencies in terms of formalisation (institutionalism), and dependence on government funding, while others had developed characteristics of ‘for-profit’ corporates, by attempting to maximise revenue without the complementary need for profit maximisation. Brandsen and Pestoff (2006) identify the need to develop coping mechanisms and deal with the myriad of “tensions” (2006, p. 499) confronting all providers of public services on account of numerous isomorphic and decoupling pressures. These pressures are induced through an atmosphere of accountability, balancing multiple organizational objectives and the need to differentiate and integrate their services within the norms and bounds of the society in which they operate in an attempt to retain legitimacy and, often, government funding. Indeed, in a review of its revenue and reputation status, SLSA’s 2008-09 Annual Report recognised these pressure by stating that the increased costs associated with the running of its voluntary arm during the economic climate at the time, had affected its overall annual performance (Surf Life Saving Australia 2009b, p. 32).

The tragic deaths of two young lifesavers in competitions in 2010 and 2012 provided a catalyst that brought to the surface many of the pre-existing tensions between SLSA policy decisions, operational practices, and volunteer concerns. These crisis events precipitated the coronial inquests (Queensland Office of the State Coroner 2011, 2016), independent reports on governance practices (Deloitte Touche Tohmatsu 2012), and media coverage (Channel 7: "Sunday Night" 2012; Guilliatt 2017; Owens & Barrett 2010; Ruehl 2013; The Daily Telegraph 2012), all of which challenged community trust and confidence in SLSA’s water-safety risk-management practices, and ultimately, even the legitimacy of the entity in its current governance state (see Section 3.9).
2.6 NFP Trustworthiness and Confidence

Furneaux and Wymer (2015) compiled a comprehensive study on the findings of the ACNC commissioned Chantlink Report (Australian Charities and Not-for-profits Commission 2013c). The Chantlink Report was an ACNC commissioned investigation into public trust and confidence associated with the governance structure of Australian charities. This study included a detailed analysis of the key drivers of trust using the definitional approach of Mayer, Davis and Schoorman (1995). This approach regarded trust as a moderator and mediator of the antecedents (of trust) and outcomes (of trust) as they relate to corporate human interrelationships. Furneaux and Wymer (2015) found that accountability and reputation were key determinants of public trust in charities and had practical operational implications. The Furneaux and Wymer (2015) model also indicated that trust had a modest influence on giving and volunteerism. These outcomes are key elements affecting the longevity, efficiency, and performance of NFPs in general, and the operations of SLSA in particular.

Furneaux and Wymer (2015) concluded that core ethical values and the degree to which a charity was mission-focused and able to provide good stewardship of resources were significant contributors to trustworthiness. In turn, the trustworthiness of a charity affected the level of giving (that is, funds available through sponsors) and the number of volunteers the organisation was able to attract. Their conclusions support the scholarly work on risk-management by Slovic (1993), who argues that major internal or external crises, which present unfavourable reflections of the organisation, heighten public awareness, undermine community trust and confidence in that organisation, and can threaten their funding sources. Although not highly efficient (R-square of 56%), the Furneaux and Wymer (2015)
model does provide low-level correlation of factors, sufficient to claim that activities, reputation, and wastefulness, appear to be the main drivers of trust.

Furneaux and Wymer (2015) also found no significant connection between a charity’s trustworthiness and the degree to which it fulfilled its purported mission obligations. This supports the proposition presented by Seibel, who questioned how resources could continue to be mobilised in favour of permanently failing not-for-profit organisations, that is, “successful failure[s]” (Seibel 1996, p. 1011). A body of scholars, including Anheier (2000, 2006); DiMaggio and Anheier (1990); Kanter and Summers (1987, 1994); Meyer and Zucker (1989); Seibel (1989, 1996), have reasoned that this lack of connectivity could encourage a “placebo arrangement” (Seibel 1996, p. 1022) within the general community. In this instance, the public may willingly accept a NFP’s current position in terms of accountability and efficiency, especially if it maintains a position of institutional legitimacy, because they (i.e., the public) are either unable or unwilling to resolve this position if it is not acceptable to them. Seibel (1996, p. 1016) classifies this public position as “serious cognitive dissonance”. The public retain a convenient intentional ignorance that overrides traditional values of accountability and efficiency – which are the backbone of a modern organisation – because it is easier to maintain the status quo than to advocate change. This asymmetric attitude (Seibel 1989, 1996), together with other “multiple constituencies” (Kanter & Summers 1987, p. 155) lying at the core of management dilemmas regarding performance measurement, may contribute to a charity’s inefficiency or what they define as not-for-profit “hidden failure” (Anheier 2000, p. 13).

Anheier (2000, 2006) also argued that ‘non-profit’ entities were far more complex than similar sized ‘for-profit’ equivalents. They consist of a tensional mix of the for-profit realities of financial accountancy, transparency, and viability, with voluntarist idealism.
Organisational pressures develop because of management’s focus on strategic operational procedures, including financial viability, while governing boards attempt to satisfy stakeholder concerns, as reflected in the entity’s mission statement and its volunteering culture. This is an argument also presented previously by Jones, Felps and Bigley (2007) in their paper on ethical theory and stakeholder-related decision making, which promoted a normative of organisational leadership and culture of managerial “moral stewardship” (2007, p. 146) when addressing the concerns of stakeholders. Anheier (2000) contended that the ‘externalities’ of trust and confidence, which accompanied NFP community service responsibilities, when mixed with self-serving managerial attitudes, made these non-for-profit businesses vulnerable to inefficiencies. These inefficiencies and tensions between management, the board, the entity’s stakeholders, including its volunteer core, could become especially evident in times of event crises. Rerup (2009) suggested that even efficient organisations may overlook these tensional ‘weak cues’, which pre-empt crises, and which may ultimately threaten their business.

However, it is incumbent upon efficient organisations to understand why a crisis has occurred and to respond appropriately and ethically to that crisis by developing strategies to prevent its reoccurrence. Boin and Hart (2003) argue that crisis events and the role of leadership are closely intertwined. In particular, Boin and Hart (2003, p. 544) support the view expressed by Rosenthal, Boin and Comfort (2001) that the public experience crisis events as “episodes of threat and uncertainty”. The same authors also posit that, during these times of distress, the public look to their leaders to “do something” [sc. constructive]. Thus, modern NFP corporates, such as SLSA, in their view, should show leadership by developing constructive and realistic strategies within their risk management frameworks, especially, in this case, as they relate to competitor safety during sanctioned competitions.
Research into the relationships between trust, confidence and volunteerism in the United Kingdom by Tonkiss and Passey (1999) provides insight into the interconnectedness between stakeholder rights, organisational legitimacy and institutionalism, and the purpose of effective NFP risk management practices. They concluded that the shared values of stakeholders comprising a NFP, which relate trust with confidence, were mediated by “institutional and contractual forms” (1999, p. 257). They argued that, although the resources of trust within voluntary organisations are linked to its core (ethical) values, the managers of these organisations are increasingly focused on, and are influenced by, “formal measures designed to promote confidence” (1999, p. 257), which are secured by contract or other regulatory forms. This particularly applies to the management of risk of injury or death. In his paper on Perceived Risk, Trust, and Democracy, Slovic (1993, p. 676) argued that risk management had become politicised and contentious, mainly owing to “the complex mix of scientific, political, legal, institutional and psychological factors”.

Tonkiss and Passey (1999) further argued that notions of trust are based on normative cultural values, which lead to dimensions of legitimacy and unconditionality towards that institution. This is consistent with the arguments presented earlier by Anheier (2000, 2006), and Seibel (1989, 1996). As a consequence, an organisation responds to external pressures by exhibiting isomorphic behaviours, which are designed to maintain and enhance those dimensions, rather than primarily (and normatively) attend to those core values expressed via their mission statement, such as the maintenance of stakeholder safety. The pressures caused by the adherence of a voluntary organisation to a path of achievement of its core ethos or social values may conflict with, and at times become problematic, because of the organisation’s attempt to satisfy the needs of four key constituencies. These include: (i) governments and major sponsors; (ii) the general public; (iii) users of voluntary services; and (iv) businesses. Their work is supported in the
Australian context by the findings contained within the Chantlink Report (Australian Charities and Not-for-profits Commission 2013c). This report concluded (2013c, p. 39) that, in terms of the trust by public stakeholders, financial transparency and accountability were stronger determinants of trust than whether the NFP was continually able to achieve its stated mission. These pressures have been further emphasised in NFP annual reporting since the formation of the ACNC 2012 Act, as is demonstrated hereafter.

Owing to the lack of literature on the performance and behaviours of ‘not-for-profit’ boards within the Australian context, insight and direction for this sector may be attained by considering the relevant scholarly works associated with the ‘for-profit sector’.

According to the arguments presented by Deegan, Rankin and Voght (2000) and Deegan (2002), the numerous annual report disclosures and periodically commissioned independent reports of ‘for-profit’ businesses provide an opportunity for an organisation to legitimise their ongoing existence. These authors suggest that many ‘for-profit’ organisations provide “voluntary annual report disclosures” (2000, p. 101) for a strategic benefit rather than normative validity. Examples are provided where this was evident following major environmental crises such as the Exxon Valdez and Bhopal disasters, the Moura Mine disaster in Queensland, an oil spill caused by the Iron Baron off the coast of Tasmania, and the Kirki oil spill off the coast of Western Australia. In reality, however, they found that it was often unclear whether the voluntary report disclosures by an organisation were an attempt to legitimise its business model and governance practices, or a normative response by managers to provide information to those stakeholders who had a “right-to-know” (Deegan 2002, p. 283). A similar argument could also be put forward regarding report disclosures after crisis events in the ‘not-for-profit’ sector.
In this context, Deegan, Rankin and Voght (2000, pp. 123-4) argue that (for-profit) organisations provide higher levels of incident-related social disclosure after a critical incident than before, that companies facing threats to their legitimacy are more likely to increase disclosure of positive incidents surrounding a major incident (crisis event), and that these disclosures are an attempt to reduce the effects “of events that are perceived to be unfavourable to a corporation’s image” (2000, p. 127). Often, when corporations make major disclosures, they are the result of being shocked into action by “legitimacy threatening events” (2000, p. 127). Shocker and Sethi (1973) argue that the perceived community dissatisfaction in ‘for-profit’ organisations might exist irrespective of the validity of available information. Further, these authors suggest that any breaches in the trust contract would lead to societal perception of an organisation’s lack of legitimacy, which is based on some preconceived notion(s) of good behaviour. Research into Australian gambling corporations by Loh, Deegan and Inglis (2015) supports the argument that social and environmental disclosures are made by corporations in an attempt to legitimise their activities when they come under political scrutiny (2015, p. 3). Hearit (2006) suggests that an apologetic approach may serve the same strategic purpose, while Campbell (2007) argues that corporations act in a socially responsible manner because of the way in which institutions constrain and enable such behaviour. There is sufficient research to suggest that corporations often respond to threats to their legitimacy and viability in a manner that prioritise strategic goals. Whether this is directly transferable to the not-for-profit sector is unclear, owing to a dearth of research in this area. However, there are parallelisms of behaviour observed throughout this case study that could be mapped to those referred to by the above authors.

In this context, the deaths of the three young lifesavers in 1996, 2010 and 2012 provide an example of the critical effect that ethical, transparent and prudent management of NFPs
have on community trust and the implied social contract that an organisation, such as SLSA, has to maintain competitor safety as a first priority during competition. After the death of the third young lifesaver in dangerous surf conditions in 2012, SLSA’s on-beach risk-management practices were severely questioned and criticised by its members, the general public (The Daily Telegraph 2012), and the families of the deceased. Media reports (Australian Broadcasting Corporation 2013; Channel 7: "Sunday Night" 2012) quoted relatives of the previous two lifesavers who were killed in 1996 and 2010. Robert Gatenby’s family said that they had no idea that Robert “faced death” when he competed in the surf on the day of his death in 1996, and that they were not informed by the SLSA hierarchy of the serious dangers that existed that day (Australian Broadcasting Corporation 2013). When interviewed in a report about the death of Matthew Barclay in 2012, the mother of Saxon Bird, who died in 2010, said that she believed that SLSA had “killed” her son (Channel 7: "Sunday Night" 2012). In this same report, entitled Surf Life Saving in Crisis, the reporter challenged a SLSA board member to show why the organisation had not been “reckless” in permitting young lifesavers to compete in unsafe surf conditions. The community focus, which SLSA received as a result of these reports, highlighted the direct threats it was facing to its legitimacy as the peak Australian coastal water safety authority (Surf Life Saving Australia 2017e, p. 8). It is therefore appropriate to seek direction from the literature to help clarify what are acceptable stakeholder needs, values, and rights, and how a good corporate citizen should respond to crisis events affecting these dimensions in terms of changes to the entity’s risk-management objectives and overall corporate performance.
2.7 Stakeholder Rights versus Corporate Legitimacy

Since the mid-1980s, modern corporate boards of governors have adopted a greater stakeholder focus in order to optimise their organisation’s objectives. This is in response to an increasing number of reports of ethical misconduct, and the harmful impact of corporate negligence (Boesso & Kumar 2009; Laplume, Sonpar & Litz 2008), together with a worldwide trend for ‘for-profit’ business practices to be more stakeholder aware. Boesso and Kumar (2009), and Laplume, Sonpar and Litz (2008), recognised that increased focus on stakeholder needs, values, and rights was a response to an increasing number of “takeovers, activism, foreign competition, new industrial relations, worldwide resource market, government reform, supranational agencies” and a “rising consumer movement, increasing environmental concerns and changes in communication technology” (Laplume, Sonpar & Litz 2008, p. 1157). Prior assumptions regarding good corporate governance centred on management’s perceived responsibilities to increase corporate profits (Corfield 1998; Friedman, M 1970; Jensen 2002; Mitchell, Agle & Wood 1997).

Freeman (Freeman 1984, 1994; Freeman & Evan 1990) proposed a pragmatic strategy that urged organisations to be cognisant of stakeholder concerns in order to achieve superior business performance. Freeman’s (1984, p. 46) classical definition regarded stakeholders as “any group or individual who can affect or is affected by the achievement of the organization’s objectives”. Donaldson and Preston (1995) proposed three mutually supportive aspects of Freeman’s stakeholder model to further develop and facilitate a better understanding of the theory. They identified these aspects as “descriptive accuracy, instrumental power, and normative” validity (1995, p. 65). These dimensions form the basis of modern Stakeholder Theory. The latter aspect included the fundamental principle of property rights. This right extends to those stakeholders who, for example, compete in a
sanctioned organised sport, where they have the ethical and moral right (Jones, Felps & Bigley 2007) to expect to compete in a safe and fair environment, which is managed by an informed, responsible organisation.

Several other scholarly works, in chronologic order, contributed to a deeper appreciation of Stakeholder Theory by identifying the types of stakeholders, the power or influence they could exert in their association with the relevant entity, which could threaten the efficiency in doing business, and the times at which this influence could be optimised. Savage et al. (1991) posited that a strategic manager could interpret media exposure of a crisis event, which has the potential to be problematic for one or more of the organisation’s stakeholders, to be a threat to the organisation’s ongoing effectiveness. Gibson (2000) supported the earlier view by Carroll (1993) that distinctions should be made between primary and secondary stakeholders, and that both groups had the potential to help or harm the entity. Walters and Tacon (2010), concurred with the view of Campbell (2007) that, “it was moments of crisis that created the conditions for formal mobilisation” (2010, p. 581) of stakeholder groups. The above scholarly contributions underpin the argument that an entity’s long-term survival is dependent on how it attends to the concerns of its primary and secondary stakeholders, especially when managing either internal or external critical events.

Jones, Felps and Bigley (2007) argue that a variety of beliefs, values and practices may evolve in an organisation owing to the resolution of the problems or threats resulting from some association or critical event involving their stakeholders. They suggest, furthermore, that senior managers can be profoundly influenced by organisational-level factors involving their own self-interest and the tensions, which frequently involve “power and legitimacy” (2007, p. 137). The authors added that organisational response may be
tempered by inter-relational cultures within the organisation itself, and in association with its stakeholders. Many for-profit and NFP corporates exhibit a continuum of these and other behaviours in their associations with stakeholders. These may be based on a process of prioritisation, which depends on the ‘affect’ (Freeman, 1984) or the ‘power’ or ‘influence’ (Mitchell, Agle & Wood 1997, p. 854) that primary and/secondary stakeholders exert over the organisation, and the urgency of the stakeholder’s claim on the firm. These could still be consistent with a normative approach as posited by Donaldson and Preston (1995). Their response, as Freeman suggests, may be more in line with a “Multi Fiduciary Interpretation” (Freeman 1994, p. 410). Jones, Felps and Bigley (2007) and Jensen (2002), however, would suggest that firms gain greater community respect and support by managers acting as moral stewards, building trust, and avoiding treating stakeholders ‘opportunistically’. This approach is consistent with the view of Deegan, Rankin and Voght (2000) regarding corporate disclosures in times of threat.

Boesso and Kumar (2009) provide a rationalisation for similar voluntary disclosure-behaviour in their research into stakeholder prioritisation of for-profit organisations. They provide some evidence to suggest that these engagement/disclosure efforts may have potential limitations on account of “prevalent social values and the need to maintain organization legitimacy” (2009, p. 76). In terms of governance, operations, and the management of risk, this is an evolving process. The developments after and because of a crisis event, such as the death of a lifesaver during a surf sports competition, may precipitate changes to an organisation’s governance structure, and in particular, its risk management framework. In the context of this case study, the management of risk, as it applies to stakeholder needs, values, and rights, deserves further discussion.
2.8 Risk Management

2.8.1 The Concept of Risk

In the context of this research, risk is a construct that expresses the uncertainty of exposure to a potential hazard, which may produce an unfavourable outcome, for example injury or loss of property or wellbeing. Standards Australia (International Organization for Standardization 2009) associates the risk to an organisation with the uncertainty in the achievement of its objectives. This is moderated by the influence of internal and external factors. It suggests that risk management within an entity will improve if it systematically addresses issues such as the need to identify and treat risk threats, improve its stakeholder trust and confidence, establish a reliable basis for decision making and planning, and – important to this research – enhance health and safety performance (International Organization for Standardization 2009, p. iv). Aven and Renn (2009) provide a human context to the concept of risk by asserting that risk is associated with “the uncertainty and severity of the consequences (or outcomes) of an activity with respect to something that humans value” (Aven & Renn 2009, p. 1). They further claim that no matter how entities or stakeholders view or assess risk, in the “objective state of the world, risk exists”.

Aven and Renn (2009) contrast the perception of risk, being a subjective judgement, with the attempt by managers to create an objective evaluation using a systematic process of assessment. In the objective context, risk is often expressed as a function of the consequences of an event and its likelihood of occurrence (Kaplan & Garrick 1981). To reflect back on the subject of this thesis, Short and Weir (2016) define public beach-risk for management purposes, as a function of beach hazards and the number and type of beach users. This functional definition refers to its original introduction through the research by Short and Hogan (1994). In relation to the management of risk associated with
coastal drownings, Michalsen (2003) separated an organisation’s statistical appreciation of risk, often as the probability of financial loss, from an individual’s perception of risk, which relates to the uncertainty surrounding an undesirable event. Boholm and Corvellec (2011) posit that lay people have a cognitive bias in their understanding of risk, which translates into a subjective appreciation of decision outcomes by expert risk managers. The authors argue that risk decisions should be more closely aligned with risk assessment, a view supported by Kahneman, Slovic and Tversky (1982), and Slovic (2000). Boholm and Corvellec (2011) advocate for better public communication of the well-informed choices that risk professionals should make when assessing and mitigating those risks.

Slovic (2001) contributes to the above debate by arguing that risk is more than just the mathematical outcome of the product of probability and consequence. Instead, risk is problem specific. Risk also involves value judgements, which are socially negotiated between experts and stakeholders. He adds that the concept of risk is subjective, which has been devised by humans to help “understand and cope with the dangers and uncertainties in life” (2001, p. 19), and emphasises the importance of institutional, procedural, and societal process in the development of risk-management strategies. These concepts have relevance to this case study, in terms decision making involving environmental risk, and will be recalled in Section 4.5.2.1. In the paper: ‘Perception of Risk Posed by Extreme Events’, Slovic and Weber (2002) examine the differing perceptions of risk-outcomes from extreme event crises, between technical experts and members of the general public, and the effect these have on risk management decisions. They extend their discussion, as it relates to risk assessment and risk management by arguing that, when accounting for potential rare-event crises, experts tend to ‘over-weigh’ possible outcomes of risky choices via objective formulations and the dollar value of outcomes, while the public tend to ‘under-weigh’ them in terms of their potential emotional impact. Slovic posited that
experts viewed the public perception of risk to be based on criteria which were “subjective, often hypothetical, emotional, foolish and irrational” (2001, p. 18). According to this tenet, when a rare event, such as a death in a sporting competition involving the natural environment, does occur, public reaction often appears to be stronger than it would be when considering large statistically predicted loss-of-life events such as with the national road toll or an influenza outbreak. Weiner (1993) suggested that “this separation of reality and perception is pervasive in a technically sophisticated society, and serves to achieve a necessary emotional distance”. As has been previously argued, Deegan et al. (Deegan 2002; Deegan, Rankin & Voght 2000) observed that corporates tend to respond to such crises by increasing favourable disclosures in an attempt to maintain corporate legitimacy.

A crisis event, which threatens an organisation’s legitimacy, will ultimately challenge both the subjective and the objective viewpoints of all stakeholders. This was the case for SLSA as it responded to the young lifesaver deaths, particularly in 2010 and 2012. The challenge for a responsible NFP organisation, such as SLSA, is to create a risk-management model that is cognisant of stakeholder concerns, all the while maintaining compliance with regulation, through its governance charter.

2.8.2 Corporate Governance and Risk Management

In providing guidance for not-for-profit organisations in Australia, the Australian Institute of Company Directors (Australian Institute of Company Directors 2017b) lists risk recognition and management as one of ten principles that promote good governance. It adds that a board can help deliver on its purpose, by putting in place “appropriate system[s] of oversight and internal controls” (2017b, p. 11). It suggests that the number, type, and significance of risks vary from entity to entity. These include risks to staff (e.g., wrongful dismissal or harassment), injury to, or damage caused by volunteers, physical
spaces and equipment, record keeping, accounting practices, and financing (e.g., grant dependency). The guidelines draw attention to the importance of the maintenance of a safe and healthy environment when not-for-profit entities provide services for stakeholders. In reference to SLSA, it is incumbent upon them to provide a safe competitive arena, where participants “try to maximise their outcomes relative to each other” (Jones, Felps & Bigley 2007, p. 140), all the while challenging the surf environment, and where the rights and needs of the entity and the stakeholder are mutually respected and satisfied.

The Australian Institute of Company Directors’ guidelines suggest (2017b, p. 27) that an organisation’s board remain informed of, and monitor, risk management practices, which include:

(i) The identification of risks, especially principal risk;
(ii) The analysis of those risks, including categorisation, probability of occurrence, and consequence;
(iii) The establishment of the organisation’s risk appetite;
(iv) The prioritisation of risks;
(v) The development of a risk register;
(vi) The development and implementation of control strategies.

The guidelines identify risks to the organisation (2017b) in the form of compliance risks, financial risks, governance risks, operational risk involving service delivery, environmental risks, brand risks, and strategic risks, owing to stakeholder behaviour or competition for funding.

By way of comparison, the Australian Sports Commission (Australian Sports Commission 2018b) provides similar guidelines for acceptable governance practice within Australian sporting organisations in relation to risk management. It suggests that poor governance
within an organisation has a number of causes – including the failure to manage risk. It adds that, when present, ineffective management practices such as the failure to manage risk will affect the local organisation, as well as the whole of the Australian sports industry. The Australian Sports Commission, like the Australian Institute of Company Directors, recommends that boards pay careful attention to strategic goals and direction, focus on effective operational practices (including risk management) to ensure that the entity complies with its legal and regulatory obligations, and acts in the best interest of its members.

2.8.3 Risk Management in Sport: a definitional perspective of process

Risk management within an organisation is the process of assessment and control of risk pertinent to the successful operation of that business, which includes organised sport (Fuller & Drawer 2004). For an organisation such as SLSA, which regards itself as “Australia’s peak coastal water safety, drowning prevention and rescue authority” (Surf Life Saving Australia 2017e, p. 8), the ability to identify, prevent and/or mitigate risks associated with dangerous surf conditions, is a core element of its risk management policy. The Australian Sports Commission (2017b), in its advice on the governance of sporting organisations, defines risk management as “the practice of systematically identifying and understanding risks and the processes in place to manage them”. It identifies five dimensions in the process. These are the same dimensions recommended by the Australian Institute of Company Directors (2017b, p. 17) and Standards Australia (International Organization for Standardization 2009).

As illustrated in Figure 2.1 below, these dimensions include: (i) the establishment of the context of the risk; (ii) the identification of risk-types; (iii) the analysis of those risks using
an evidence-based approach; (iv) the evaluation of risk type and severity; and (v) the treatment of the risk threat, including prevention and mitigation.

![Risk Management Process Diagram]

**Figure 2.1 The Risk Management Process**

Source: Australian Sports Commission. Approval given on 28/04/2018

The Australian Sports Commission, the Australian Institute of Company Directors, and Standards Australia strongly recommend that each board of directors regularly monitors and reviews outcomes through each step of the process, and continuously communicates and consults with its stakeholders. Thus, these major Australian and international institutions hold that the risk-management process forms an essential component of responsible governance practice.

The management of risk is fundamental to governance practices across many diverse fields of human endeavour and organisational practice. The recent literature provides extensive
risk-management research in such varied fields as finance (McNeil, Frey & Embrechts 2015; Wolke 2017); supply chain risk (Brindley 2017); terrorism and homeland security (Haines 2015); business operation, compliance and governance (Hopkin 2017; Lam 2014); healthcare (Groves et al. 2016); and human safety (Glendon, Clarke & McKenna 2016). Each of these fields, in the context of their application, adopts a risk-management framework, inclusive of the five dimensions listed above. This case study, involving the development of the *Surf Hazard Rating* model, which quantifies the potential danger of surf-based phenomena, affords opportunity to apply this five-dimensional risk-model approach, with a focus on ‘external’ contributing injury-risk factors (Fuller & Drawer 2004; Meeuwisse 1991), such as surf-zone dynamics. Other studies that provide an understanding of the modelling of injury risk-management frameworks include Van Mechelen, Hlobil and Kemper (1992), Fuller (2007), and Fuller, Junge and Dvorak (2012).

Leopkey and Parent (2009) reported that recent sports risk-management literature has concentrated on crowd management, facility management, spectator and athlete aggression, and hooliganism (2009, p. 351) as they relate to major sporting events such as the Olympic Games and FIFA World Cup. The research by Leopkey and Parent (2009) identified 15 risk categories that event organisers should be cognisant of and plan for, owing to their economic, tourism, and marketing impacts on the organisation and its stakeholders. The categories of risk-issues (Leopkey & Parent 2009, p. 358) include the environment; financial; human resources; infrastructure; interdependence; legacy; media; operations; organising; participation; politics; relationships; sport [administration]; threats; and visibility. Competitor safety and health were only mentioned as a sub-category of operational risk. Leopkey and Parent’s 2009 research suggests that major and influential stakeholder concerns focussed mainly on financial and operational issues such as returns, sponsorship, logistics, crowd behaviour, and security as opposed to a more ethically-based
approach to the prioritisation of competitor safety. An argument posited in this case study, that the non-prioritisation of competitor safety as a primary concern in the risk management process, as noted in the Saxon Bird coronial inquest of 2011 (see Section 3.7), is an irreconcilable practice when competition is conducted in a potentially dangerous natural environment.

2.8.4 The Modern Sports-Injury Risk-Management Model

Fuller, Junge and Dvorak (2012, p. 12) adapted the model proposed by Fuller and Drawer (2004) and Fuller (2007) to create a framework to manage the potential risk of injury in modern sporting events. The model is displayed below as Figure 2.2.

This framework was adopted by the Fédération Internationale de Football Association (FIFA 2009) for implementation by its associated national football (soccer) organisations throughout the world. Central among its themes is the identification of injury risk-factors, the use of evidence-based epidemiologic research into the incidence, severity, and consequence of injury, and the adoption of a systematic approach to the prevention, mitigation, and communication of risks of injury involving participant stakeholders. Fuller et al.’s 2012 risk-management model is also consistent with the risk-management process outlined above and recommended by Standards Australia, the Australian Sports Commission, and the Australian Institute of Company Directors.
Figure 2.2  The Injury Risk Management Model
Source: Fuller, Junge and Dvorak, 2012

Where the Fuller, Junge, and Dvorak model differs from the other three is in its specific focus on the safety and risk of injury to competitors. In defence of their causative-injury model, Fuller, Junge and Dvorak (2012) identify two input risk factors, ‘internal’ (or intrinsic) and ‘external’ (or extrinsic), which were originally defined by Meeuwisse (1991). Internal risk factors are participant-related, and include age, gender, health issues, psychological factors, and sport-specific legalities such as tackling rules, etc., in football. External factors by definition are exogenous. They include facility-related factors such as the competition surface, stadium design, and the availability of medical facilities/personnel, equipment-related factors, and finally, environmental factors such as
the weather and its effect on the competition arena. Hershman (1984) categorised three components that contributed to the prevention of sports injury. They included the “performance demands of the sport, the risk factors, and the individual musculoskeletal” structure (1984, p. 65), which involved reference to the patient’s exercise equipment and program. Hershman (1984, p. 65) added that risk factors could be separated “by combining the epidemiology of injuries for a particular sport and the predisposing conditions” [emphasis added] that may lead to injury”. Meeuwisse (1991) supported these propositions in his identification of external risk factors in particular. He assigned importance to “those factors which have an impact on the athlete while they are playing the sport” Meeuwisse (1991, p. 1).

Fuller and Drawer (2004) detailed the concepts of their original model involving risk factors, risk estimation, risk evaluation (including mitigation and prevention consequences), and risk communication. They extended their approach to include stakeholder risk-input factors such as participant perception, which led to the standardisation of competitor rules and equipment in major world sports such as international football (soccer). Fuller and Drawer (2004) advocated the imperative of determining injury causal factors through evidence-based research, both qualitative and quantitative, with preference for the latter, using a prospective design where possible.

The focus of this case study, involving the development of a surf hazard assessment tool, provides an opportunity to model those ‘predisposing conditions’ referred to by Hershman (1984) in the form of environmental risk factors that may affect the surf participant and lead to injury. The ‘predisposing conditions’ in this study, represent the ‘external’ factors that contribute to the on-beach risk-management process. Unlike the external risk factors referred to by the above scholars, surf sport risk-management is critically impacted by the
levels of danger imposed by the surf environment. The World Congress on Drowning (Bierens 2006) prioritised hazard identification and consequent risk assessment as the first steps in solving the problem of drowning in a variety of environments, including surfing beaches (2006, pp. 84-93). This Congress, like the work of Meeuwisse (1991), Fuller and Drawer (2004), and Fuller, Junge and Dvorak (2012), recognised that the physical environment is one of several internal and external factors, including human behaviour, which affect the drowning outcome. The World Congress on Drowning recommended that international bodies such as the World Health Organisation (WHO), the International Lifesaving Federation (ILS), and the International Lifeboat Federation (ILF) develop guidelines and simple tools to assist in hazard identification, risk assessment, and injury-prevention (Bierens 2006, pp. 85-6). This recommendation, from such an authoritative body, and which represented a comprehensive global agreement of experts, demonstrates the global importance of the need to develop functional water-safety risk-management models. They further recommended that these tools and guidelines should be widely and internationally communicated, based on best practice and rigorous research that is standardised, updated, regulated, and supported by international governing bodies and national governments.

2.9 Chapter Summary

A review of the governance and risk-management literature in this chapter has underscored the relevance of this case study’s aim to develop a quantitative risk-model associated with conducting sporting events that are impacted by natural environmental hazards. The review emphasises the importance, to an entity, of good corporate citizenship with respect to coping with the many conflicts and challenges, both internal and external that are presented during the course of its operations. The review has also demonstrated the dearth
of scholarly works dealing with not-for-profit corporates, particularly those that maintain a high sporting and safety profile, such as Surf Lifesaving Australia.

This review has also highlighted the need to consider stakeholder needs, values, and rights when addressing crisis events, such as deaths in competitive organised sports involving natural environments, which, although they may be initiated externally, quickly refocus community attention on the organisation and its management practices as a whole. Within this context, the direction shown through the literature towards the management of sports-risk, as it applies to competitor safety, is pivotal to this research. This case study seeks the confirmation and validation through the literature of the need to create a quantitative risk-model to assist decision makers manage those external risk-factors, such as surf hazards, in real time. The literature has demonstrated that good corporate governance not only implies satisfactory performance in meeting its organisational responsibilities, but also, in the case of not-for-profit entities, being seen to actively work towards achieving the goals expressed in its mission statement if it is to be regarded as a legitimate corporate citizen.

The purpose of this research is to contribute to the sporting and corporate risk-management literature. This research has pursued a methodology, which encompasses a case study of the management of the sports-risk associated with participating in the surf environment, to develop a surf assessment tool and decision framework. It formulated this method with the assistance and participation of volunteers from Surf Life Saving Australia (SLSA) to help resolve a management crisis following the deaths of young athletes in surf lifesaving competition. It is therefore reasonable and necessary to explore this iconic not-for-profit entity, with the purpose of understanding its origins, its ethos as the pre-eminent coastal water safety authority in Australia, and its standing as a good corporate citizen that
prioritises the safety of its primary stakeholders. The following chapter reviews this organisation’s governance and management structure.
Chapter 3  Surf Life Saving Australia and its Management of Surf-Risk

3.1  Introduction

This chapter reviews the Surf Life Saving Australia (SLSA) organisation, from its formation in 1907, until after the presentation of its comprehensive surf-risk management report in 2015, the Personal Protective Equipment (PPE) Project (Surf Life Saving Australia 2015d), and the tabling of the Matthew Barclay coronial inquest report in 2016. The chapter reviews the history of SLSA, its governance structure and strategic operations, as it evolved from an association of community-minded volunteers, striving to reduce the surf-bather death toll on Sydney beaches, into a professional corporate entity, which is registered as a charity with the Australian Charities and Not-for-Profits Commission (Australian Charities and Not for Profits Commission 2017), and as a sporting organisation with the Australian Sports Commission (Australian Government 2017c). This review examines SLSA’s growing need for funding, as both an authoritative coastal safety, and iconic sporting entity. The chapter examines the tensions that developed within the organisation as it attempted to satisfy its volunteer-based strategic purpose, its pragmatic operations-management priorities as a modern not-for-profit entity, and the achievement of its mission to “to save lives, create great Australians and build better communities” (Surf Life Saving Australia 2017c).

The chapter concludes with an overview of the effect that the deaths of three young lifesavers, Robert Gatenby, Saxon Bird and Matthew Barclay, during surf lifesaving competitions, had on the organisation, in terms of community trust, confidence, and resultant changes to SLSA’s risk-management practices. It is within this context that the
Surf Hazard Rating (SHR), explained in-depth in later chapters, was created and
developed by the author, to provide best-practice, on-beach assessment, of surf hazards for
decision makers.

3.2 The Changing Image of the Surf Lifesaving in Australia

As detailed in SLSA’s review of the surf lifesaving movement in the last 100 years (Surf Life Saving Australia 2007), the organisation was formed as a breakaway association from the British-based Royal Life Saving Society (Royal Life Saving Society - Australia 2018). On 18 October 1907, representatives from Sydney Surf Life Saving clubs, together with members of other interested groups, met with the Royal Life Saving Society to form the Surf Bathing Association of New South Wales (2007, p. 37). These volunteers comprised experienced rescue personnel, regular surfers, and bathers, who were concerned about the rising incidence of drownings on Sydney’s beaches.

In the global conflict-dominated period after 1913 the image presented to the community by these surf lifesavers was one of military-styled discipline, which was reinforced through the publicity they gained from spectacular rescues (Surf Life Saving Australia 2007, pp. 1-21). The surf lifesaving organisation was perceived as an institution where equality, democracy, and volunteerism were seen as something almost akin to the ANZAC legend (Surf Life Saving Australia 2007, p. xiii). Surf lifesavers (and by default, the organisation) were identified as ‘bronzed’ muscular males (predominantly) who not only patrolled the Australian foreshores, keeping the community safe, but also dared to challenge successfully, an almost overwhelming natural force – the surf (Surf Life Saving Australia 2007, p. xiii). In 1922, the association’s name was changed to Surf Life Saving Association of Australia (SLSAA) in response to the growing needs of the bathing public,
the increase in the number of surfing clubs throughout Australia, and the need to position this organisation as a national movement (Surf Life Saving Australia 2007, pp. 51-64).

The name and structure was later changed in 1991 to its present form, Surf Life Saving Australia (SLSA), to reflect its modernised corporate profile, which included compliance with the terms of the New South Wales Charitable Fundraising Act 1991 (New South Wales Government 2017a; Surf Life Saving Australia 2014c). The imagery surrounding this institution epitomised many altruistic Australian values, which were later conveyed succinctly in the prefaces of several published books and annual reports about SLSA, by several Governors General of Australia.

Sir William Deane, (Governor General of Australia 1996-2001), in the book referred to above describing the historical review of the first 100 years of Surf Life Saving in Australia, wrote that surf lifesavers displayed an ethos of “unselfish community service through teamwork, egalitarianism, friendship and disciplined training and competition” and “leadership, initiative and self-reliance” (Surf Life Saving Australia 2007, p. xi).

Later, the Governor General of Australia in 2011, Ms Quentin Bryce, wrote in her foreword to the 2010/11 SLSA Annual Report (Surf Life Saving Australia 2011, p. 2), of the level of esteem within the Australian community with which surf lifesavers were regarded:

> Your red and yellow colours are an icon of professionalism within a longstanding tradition of service; a history that you embody with outstanding effort and dedication.

> As Patron-in-Chief, I respect and admire your enduring commitment to protecting our community. You are shining examples of strength and fortitude.
SLSA has evolved throughout the decades to become “Australia’s peak coastal water safety, drowning prevention, and rescue authority” (Surf Life Saving Australia 2018a, p. 8). In 2017, it was also the nation’s largest volunteer organisation, with over 170,000 members from more than three hundred affiliated surf lifesaving clubs throughout Australia (2018a, p. 8). The emphasis, style, and type of life saving activities, as well as related endeavours and technologies, have dramatically changed throughout the decades. This has occurred in an attempt to keep apace of the ever-changing coastal-safety needs of a growing Australian community (2007, pp. 107-31) that increasingly exploits its coastal resources for commercial and recreational purposes.

The cornerstones of development of this corporate image have been in governance, competition, lifesaving services, and education (Surf Life Saving Australia 2007, p. 70). Within these areas, surf-risk management practices, especially as they relate to governance responsibilities and their effect on major stakeholders, are of considerable importance. This is because they underpin the ethos of the Surf Life Saving (SLS) movement, as reflected in their mission statement, “Surf Life Saving exists to save lives, create great Australians and build better communities” (Surf Life Saving Australia 2017c).

3.3 Governance of SLSA

3.3.1 Early Governance

From its formation in 1907, the governance structure and associated terminologies of SLSAA closely resembled that of the British-based Royal Life Saving Society (RLSS), from which it had originated. For example, like the RLSS, it was governed by a representative ‘Council’ and a ‘Board of Examiners’. It also maintained a number of honorary positions such as “instructor” and “examiner-in-chief” (Surf Life Saving
Australia 2007, p. 50), which were similar in name and responsibilities to those that existed in the Royal Life Saving Society. These structures, however, were tempered by the requirement that office bearers have surf-related qualifications, similar to the Royal Life Saving Society’s Bronze Medallion, Instructors, and Examiners awards. These early office bearers instilled the core characteristics of democracy, transparency, and accountability into the organisation, in an attempt to legitimise competence and standards. Many of these characteristics form essential components of modern ‘for profit’ and ‘not-for-profit’ corporate structures (Australian Charities and Not-for profits Commission 2013, p. 50; Australian Institute of Company Directors 2017b).

From its inception, the organisation developed using a bottom-up hierarchical structure, where decisions, originating at the club level, passed through branches and states, to provide direction to the overarching entity. By 1913, the oversight of decision making changed to a more traditional top-down model, which provided more singular control and direction from above, in an attempt to attract new clubs to affiliate. In essence, power and decision making on all aspects of the surf lifesaving movement rested in the hands of one or two individuals, and was overwhelmingly dominated by Surf Life Saving NSW “Head Centre” (2007, p. xvii).

This governance structure remained relatively unchanged through the 1920s until the 1980s, except for the inclusion of a “National Council” in 1949 (2007, p. 51), which comprised two representatives from each foundation club, to oversee all governance matters, as well as several subcommittees. These subcommittees included an Executive Committee, to deal with day-to-day matters, and the Board of Examiners, which was responsible for patrols, lifesaving techniques, examinations, gear, and competitions. The
Board of Examiners was regarded as “the biggest and most powerful of all [sub]committees in the organisation” (Surf Life Saving Australia 2007, p. 68).

As the surf lifesaving movement progressed into the 1980s and 1990s, change to the old governance structure occurred at such a slow pace that it had the potential to “severely reduce surf lifesaving’s effectiveness” (Surf Life Saving Australia 2007, p. 71). Surf Life Saving clubs and branches, being composed of volunteers in honorary positions, resisted the introduction of the professional administration, which eventually had been forced upon the movement in its search for further funding arrangements (Surf Life Saving Australia 2007). Conforming to the requirements of the New South Wales Charitable Fundraising Act 1991 (New South Wales Government 2017a) meant that, along with the new title of SLSA, the organisation restructured the National Council to reflect a more corporate-styled charitable organisation. SLSA’s 1995 Annual Report (2007, p. 71) stated that the organisation consisted of a president, six state presidents, a chief executive officer and five honorary directors of Lifesaving, Competition, Finance, Commercial Development, and Junior Activities.

However, the transition into a modern corporate entity brought with it a common conflict that is evident within many NFP structures (Anheier 2000; Fishel 1993; Jones, Felps & Bigley 2007; Meyer & Zucker 1989; Seibel 1996) – the struggle for power and control between the members (the corporate principals) and their agents (the professional administrators). The members were deeply entrenched in volunteerism and ‘mateship’, arising from club and branch activities. Many (mostly competitors) had a growing understanding of the dangers involved when entering the “wild surf” (Queensland Office of the State Coroner 2011, p. 30). They viewed the organisation in these value-oriented terms. In contrast, the executive administration was pressured through its governing body,
now known as the Australia Council, to meet publishable and marketable outcomes, in order to meet government and potential sponsor requirements. Management viewed the organisation in terms of the protection of its brand, and as an increasingly responsible corporate citizen (Surf Life Saving Australia 2007). By the year 2000, the Australia Council had expanded to a twelve-person governing body, consisting of ten elected honorary officers (directors), six boards, an advisory body, and eleven committees (2007, p. 72). The hierarchy of control continued to follow a top-down approach, originating from a director, through a board, and on to a professional manager and assistant, who executed board directives.

3.3.2 Modern Governance

In 2013, the Australian Federal Government further regulated the Australian not-for-profit sector by establishing the Australian Charities and Not-for-Profits Commission (ACNC). The guidance provided by this government agency assisted SLSA to establish the corporate governance structure, which it presents today, and as displayed Figure 3.1.

SLSA (Australian Business Number: 67449738159), as a not-for-profit organisation, is one of nearly 56,000 charities registered with the Australian Charities and Not-for-Profits Commission (ACNC). Its registration includes being a public benevolent institution, and advancing the security or safety of Australia or the Australian public (see Section 2.2). As a NFP, SLSA has a ‘Limited by Guarantee’ status under the Commonwealth Corporations Act of 2001 (Australian Government 2017d). SLSA is also known as a ‘recognised sporting organisation’ with the Australian Sports Commission (ASC) (Australian Government 2018), and, through the ASC’s associated Australian Institute of Sport, is classified as a ‘pre-eminent body taking responsibility for the development of their sport in Australia’.
As indicated in Figure 3.1 above, the SLSA organisation consists of: The Parent Body (Surf Life Saving Limited); the Surf Life Saving Foundation (SLSF), which is responsible for all fundraising activities; seven State Centres; over 170,000 members from 314 affiliated surf lifesaving clubs; subsidiary companies providing helicopter rescue services; and a professional lifeguarding arm called the Australian Lifeguard Service (ALS). The organisation’s executive management team consists of a CEO, a General Manager of Corporate Services, a General Manager of Capacity and Capability, and a General Manager of Communications and Business Development. Governance responsibilities are controlled through the board chair (SLSA president) and its directors, which comprise the

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3 ALS is SLSA’s Australian Lifeguard Service, which are professional lifeguard services, separate from SLSA’s volunteer patrolling members.
seven presidents from their respective State and Territory organisations. A team of approximately fifty paid assistants and twenty-five committees supports these managers. In short, the executive management team is responsible for executive, financial, lifesaving, education, research, the operation of subsidiary companies, and other operational management functions.

SLSA’s roles and responsibilities focus on local and international community water-safety activities; maintaining a professional relationship with all related government agencies; the maintenance of a corporate styled fund raising enterprise; and the delivery of sponsorship, sufficient to grow the business. Key responsibilities, which are relevant to this case study, include the use of a framework in which all lifesaving activities may be safely conducted; the provision of lifesaving rules, policies and standards supported by evidence-based research; and the responsibility to train and educate its lifesaving members (Surf Life Saving Australia 2017e, pp. 12-20; 2018a, pp. 12-8).

The diversity and number of tasks undertaken by the modern corporate form of SLSA is complex. The multiplicity of these responsibilities encourages different motivations, standards, challenges, and practices within the organisation. In many ways, it can surpass the complexity of managing an equivalent sized ‘for-profit’ company. The SLSA organisation would appear to satisfy many of the criteria, listed in Section 2.2, of a complex not-for-profit organisation (Anheier 2000, p. 7). Indeed, Kanter and Summers (1987, p. 164) would argue that such a complex set of responsibilities may lie at the core of many management dilemmas in not-for-profit organisations such as SLSA.

The existence of these dilemmas was reflected in the Deloitte Touche Tohmatsu report (2012) that was commissioned by SLSA to review its governance structure, and the resignations of SLSA and SLSF Board-member in 2013 (Australian Broadcasting
This report was highly critical of the existing governance structure and culture of SLSA. For example, the report (Deloitte Touche Tohmatsu 2012, p. 21) stated that “The existing [SLSA] governance model is not working”; “…the existing [SLSA] governance model is the main cause of duplication of effort, poor decision making, mistrust, lack of collaboration and low morale within SLSA”; and “There is an urgent need for the [SLSA] movement to establish a robust governance framework that supports its vision…”. Part of that criticism included its attitude towards risk management, of which on-beach risk management processes form a significant component. SLSA promotes its community purpose through its mission statement: “Surf Life Saving exists to save lives” (Surf Life Saving Australia 2017c). The perception that SLSA is not capable of providing safety to its members reflects badly on its capacity to provide that same capability of safety to all stakeholders, including the bathing public. Of particular interest to this research are the water-safety, lifesaving, and evidence-based research requirements referred to above, and the management of “significant business risks”, which are identified in SLSA’s Governance Charter document (Surf Life Saving Australia 2016, p. 62). The latter aspect includes stakeholder risk and its mitigation, particularly involving participation in the surf environment. The importance and relevance of these aspects of good governance for SLSA in particular, as the pre-eminent water safety organisation in Australia, are examined in more detail in later sections of this chapter.

Policy development, risk assessment, and mitigation strategies are managed at an operational level through SLSA’s Lifesaving Management, Lifesaving Management Advisory, and Sport Advisory Committees (Surf Life Saving Australia 2016, pp. 62-70). As presented in Section 2.8.4, according to Fuller and colleagues (Fuller & Drawer 2004; Fuller, Junge & Dvorak 2012), the identification of external risk factors, such as dangerous
prevailing surf conditions, is a critical first step in the sports-injury risk-management process. Subsequent risk control measures include elimination, substitution, isolation, engineering, administration, and finally, the use of personal protective equipment (PPEs). This hierarchy is reflective of the ISO 31 000:2009 standards (International Organization for Standardization 2009) for risk control. The recognition of these risk control measures has been a recent inclusion in SLSA’s surf-sport competition policy, and sports-competition manual updates (Surf Life Saving Australia 2014b, 2015b). This policy was a response initiative by SLSA to the safety-related recommendations of the Saxon Bird inquest (Queensland Office of the State Coroner 2011, p. 34).

3.4 SLSA Strategic Operations and Funding

Before the 1960s, SLSAA’s governance structure focused on the major resource-dependent activities of surf patrolling, rescue and resuscitation training, and limited competition. SLSAA office bearers were still volunteers, with the NSW Head Centre (i.e., the NSW branch) remaining as the dominant influence in the National Council. In this climate of relative volunteerism, SLSAA required, and subsequently attracted limited funding, to maintain its Sydney-centred operation. The first grant of £200 was awarded by the New South Wales state government in 1922 to the NSW branch of Surf Life Saving to promote surf lifesaving methods outside of the Sydney metropolitan area (Surf Life Saving Australia 2007, p. 53). Its first major federal government grant in 1950/51 was £5,000 (2007, p. 65).

During the 1980s, unlike most other Australian not-for-profit organisations, SLSAA remained relatively insulated from those market forces, which would have required them to realign their strategic practices to become more ‘for-profit’ like in order to attract funding. SLSAA’s policies and practices remained focused on its volunteers and beach
safety. This is because it received the majority of its funding from state and federal governments, in return for providing these beach-safety services (Surf Life Saving Australia 2007). Thus, it was able to maintain its legitimacy as a coastal water safety authority, which it had established in the decades before.

Throughout the ensuing decades, SLSAA, and now SLSA, has used the number of rescues, which presumably have prevented death or injury, as a measure of its service-performance, and the justification for its increased reliance on revenue sources to fund the acquisition of new rescue related technologies. For example, during the 1950/51 surfing season, 56% of all beach rescues were performed using the traditional ‘reel and belt’ method (Surf Life Saving Australia 2007, p. 69). By 1980/81, however, this type of less sophisticated and inherently riskier rescue technique had largely been replaced with new technologies. As a result, by the 1980s, only 9% of all rescues were performed using the ‘reel and belt’ technique (2007, p. 69). In 2007, rescues involving these new technologies including ‘In-shore Rescue Boats’ (IRBs), ‘Jet Rescue Boats’ (JRBs), ‘Helicopters’, ‘Rescue Tubes’, and ‘Rescue Boards’, represented the dominant yearly rescue methods with 16%, 5%, 2%, 12% and 21% respectively. Rescues ‘Without gear’, which involved a rescuer without the aid of any technology, remained at approximately 34% of the yearly total. By way of comparison, the number of yearly rescues involving surf skis and surfboats had substantially decreased. In 2007, they only represented 2% and 1% respectively, of the rescues performed in 1980/81 (2007, p. 69).

As rescue and resuscitation methods became more reliant on newer technologies, so too did the demands for more frequent and sophisticated training methods and competitions, thus increasing the necessity to attract higher levels and more diverse sources of funding. By the late 1980s, the number of rescue and resuscitation related awards had grown from
five to fifty-five, and the number of carnival events from twenty-five to more than fifty (2007, pp. 68-9). SLSA was able to increase the size, and diversity, of their revenue stream by charging fees to members for these awards and carnival entries. These changes to SLSA’s strategic focus and fund raising sources were reflected in the increase in the number of full-time managers to assist the state superintendents of its National Council (2007, pp. 68-9) in managing the business of lifesaving and surf sports. As a consequence of these strategic changes, SLSA states (Surf Life Saving Australia 2017e, p. 6) that nearly 11,000 rescues were performed by over 45,000 proficient lifesavers during 1.38 million patrol hours in the 2016/17 surfing season. During this same period, over 6,600 Bronze Medallions were awarded (2017e, p. 110), and its helicopter services registered over 800 missions involving 1,000 flying hours. Similar figures are published in SLSA’s most recent annual report (Surf Life Saving Australia 2018a, p. 6).

The changes to SLSA’s corporate profile, and the subsequent increase in demands for resources to run the organisation, have continued and escalated into the modern era. SLSA’s 2017/18 Annual Report sets out, in detail, its ‘Strategic Plan” (Surf Life Saving Australia 2018a, pp. 11-8), which demonstrates its modern corporate approach to beach safety, lifesaving operations, and competition. The first item of its 2020 Strategic Intent plan, lists the extension of its lifesaving services to match community needs. This plan continues to reflect the past-decades-commitment of its predecessors to community service. Key elements include the use of “evidence-based research” (2018a, p. 12) to maintain a rescue-ready focus with regard to water safety requirements, the enhancement and integration of coastal risk-management systems, and the maintenance of its brand and reputation as the peak Australian coastal safety body.
An integral component of this rescue-ready image continues to include its support for surf lifesaving competitions, which have also grown at a rapid pace. By 2018, the Australian Surf Life Saving Championships (‘The Aussies’) had over 7,000 registered competitors, participating in over 400 separate beach and ocean events (Surf Life Saving Australia 2018b). The scale and composition of competition events had dramatically changed from previous years. As part of its renewed structure, and regulatory requirements of accountability and transparency, SLSA progressively upgraded the detail and coverage of its competition manual. By the time that Saxon Bird was killed in a surf lifesaving competition in 2010, the 33rd edition of its competition manual (Surf Life Saving Australia 2008) had become a comprehensive 260-page regulatory document. It was comprised of fourteen sections, covering competition safety, competition rules, and administrative procedures.

The discussion presented to this point clearly reveals the complex nature of SLSA’s coastal safety and surf sports operations. The organisation is therefore one that Anheier (2000, 2006) may have had in mind when he argued that NFPs are so “sufficiently distinct” from ‘for-profit’ organisations and governments that they “require separate management models and practices” (Anheier 2000, p. 1). SLSA also clearly fits the description of a NFP having a more complex business model than similar sized ‘for-profit’ organisations, and therefore should be regarded as part of a distinct ‘third sector’ (Anheier 2006, p. 4; Brandsen & Pestoff 2006). It is appropriate, here, to view this argument in terms of SLSA’s need to provide the financial resources necessary to service its strategic plan and the associated costs incurred in acquiring those funds. In particular, it is relevant to consider the framework within which SLSA operates as a NFP and sporting organisation. The examination of these issues is relevant in terms of stakeholder trust, operational performance, and the effect these pressures place both directly, and implicitly,
on surf-risk management. This pertains to SLSA’s Key Roles of Governance (Surf Life Saving Australia 2018a, p. 51), its Governance Charter (Surf Life Saving Australia 2018a, pp. 54-5), and its commitment to implement the recommendations of the 2012 Deloitte Review (Deloitte Touche Tohmatsu 2012) into SLSA governance structures (Surf Life Saving Australia 2013b). To contextualise these pressures, and associated constraints, a brief review of SLSA’s funding and subsequent responsibilities in the years surrounding the deaths of three young lifesaving competitors in 1996, 2010, and 2012 follows.

3.5  SLSA Funding and Service Responsibilities

In 2011, the SLSA parent entity was reported in the Courier Mail newspaper (News.com.au 2011) as the number one charity in Australia in terms of fundraising costs over a twelve-month period. It spent 62% of the AUD23.8 million in gross fundraising revenue on administration costs. Media reporting of the level of funding spent on administrative costs provides an insight into community sensitivity towards the accountability of any publicly funded NFP, and SLSA in particular. The corresponding responsibilities of SLSA to its community and membership-stakeholders in return for the receipt of those funds can be viewed through SLSA’s role as a coastal safety authority, the need to provide best-practice surf-risk assessment, and especially at the point of time in question, for surf-sports competition.

SLSA presents itself, via its website and numerous publications, as a “unique not-for-profit charity and community service that exists only through community donations, fundraising, corporate sponsorship and government grants” (Surf Life Saving Australia 2013a, p. 10). In terms of those funding sources, the organisation is not unique. Most of the forty-three registered Australian charities listed in the Courier Mail article (News.com.au 2011) mentioned above, claim similar revenue sources as part of their funding revenue.
According to the financial statements registered with ACNC, SLSA’s 2015/16 annual revenue, as the parent entity, was AUD28.7 million (Australian Charities and Not-for-profits Commission 2017c). Its closest rival in terms of water-safety service-charities, and the main competitor for those funds, is the Royal Life Saving Society of Australia (RLSSA), with a 2015/16 annual income of AUD7.5 million (Australian Charities and Not-for-profits Commission 2017b). The next most financially active water safety charity is AustSwim Ltd. with AUD5.2 million (Australian Charities and Not-for-profits Commission 2016). In terms of funding, SLSA could be regarded as the dominant corporate in the NFP sector in Australia with respect to water safety.

The community service that SLSA offers in response to that funding occupies a niche position in the field of water-related safety. During the period of interest of this study, SLSA regarded itself as “Australia’s major coastal water safety, drowning prevention and rescue authority and the largest volunteer movement of its kind in Australia and the world” (Surf Life Saving Australia 2013a, p. 10). It was a foundation member of the International Life Saving Federation (ILS) (International Life Saving Federation 2002), through which it still maintains contact with other lifesaving nations, and plays a leadership role in developing global lifesaving expertise (Surf Life Saving Australia 2018a).

SLSA is also an important member of the consultative forum, the Australian Water Safety Council (AWSC), which was formed in 1998, and which consists mainly of registered NFPs, including RLSSA and AustSwim, together with other significant Australian water-related, and government agencies (Australian Water Safety Council 2017). The forum provides definitive advice and direction to community groups and governments at all levels, on all Australian water-related matters, as demonstrated through the production and implementation of multiple national water safety plans since its inception. Through this
membership with the AWSC and ILS, Surf Life Saving Australia provides authoritative input into local and international community coastal-risk-management practices, thereby demonstrating its strategic aim to “extend lifesaving coverage to match community needs” (Surf Life Saving Australia 2018a, p. 12).

As a member of the Australian Water Safety Council (AWSC), SLSA has included in all annual reports since 2009 its commitment to lower the ‘per capita coastal drowning rate’ by 50% as part of its 2020 Strategic Management Plan (Surf Life Saving Australia 2017c). This significant objective, which it presents to the community and all levels of government, forms part of SLSA’s headline mission statement: “Surf Life Saving [sic] exists to save lives, create great Australians and build better communities … and we are committed to reducing the coastal drowning rate by 50 per cent by 2020” on its websites (Surf Life Saving Australia 2017c) and other relevant reports (Surf Life Saving Australia 2013a, 2014a, 2015a, 2016, 2017e). However, recent evidence (Sherker, Brighton & Thompson 2012) suggests that the 2020 target is unlikely to be achieved. Possible barriers to the achievement of this target may include inadequate coastal drowning prevention strategies, lifesaving services, and public education (Sherker, Brighton & Thompson 2012); and the existence of governance structural deficiencies (Deloitte Touche Tohmatsu 2012), which may lead to the deployment of less than best practice surf risk management policies. These policies and associated practices may include the sole focus on rip-current drowning prevention strategies at the expense of consideration of other contributing surf hazard factors (see Sections 4.4 and 4.5). This potential inability to meet its headline mission statement presents a dilemma for the SLSA organisation in terms of community trust, confidence, and legitimacy to function as Australia’s peak coastal water-safety authority, as was argued previously.
SLSA’s emphasis on lifesaving in the surf, as its “raison d’être” (Surf Life Saving Australia 2007, p. 53), is a further focal point on which to assess SLSA’s performance in terms of its corporate governance and responsibility to major stakeholders. It also serves as a precursor to a discussion within this study, of the development of a water safety tool, the *Surf Hazard Rating* (McCoy & de Mestre 2014) to manage surf-risk. Decision tools such as the *Surf Hazard Rating* provide objective mechanisms by which risk may be mitigated using a hierarchy of control measures (Safe Work Australia 2011, p. 13; Surf Life Saving Australia 2015d, p. 5) when dealing with surf-related safety. This study demonstrates that there is a clear need for a tool such as the *Surf Hazard Rating*, if SLSA is to maintain its responsibilities to primary stakeholders involved in surf-sports activities.

### 3.6 Safety and Surf Lifesaving Competitions

Beach safety involving the public, or members involved in competition, throughout all periods until the present has been the dominant measure of SLSA’s success. By the 1970s, more than 170,000 lives had been saved, with the number of rescues estimated to average about 12,000 per year (Surf Life Saving Australia 2007, p. xiii; 2017d). In the 33rd edition of their Australian Surf Sport Manual (Surf Life Saving Australia 2008), which was used in the period between 2008 and 2015, SLSA recognised that surf lifesaving competitions provided an essential training ground on which to develop the strength, knowledge, and skill levels necessary to perform rescues, in surf conditions that may be treacherous for members of the general bathing public (Surf Life Saving Australia 2015b, Chapter 1, p. 1). Ever since 1907, when surf lifesaving competitions were first introduced, there has been community acceptance that lives “could best be saved by strong and skilful swimmers” and that the necessary abilities could best be achieved and maintained by encouraging “regular racing” (Surf Life Saving Australia 2007, p. 135). SLSA acknowledged, in this
same 33rd edition of the Australian Surf Sports Manual that officials and organisers conduct these competitions to support and encourage lifesavers to hone the necessary “mental and physical skills” needed to perform patrolling duties and save lives effectively (Surf Life Saving Australia 2008 Chapter 1, p. 1; 2018b).

In order to maintain accountability to other stakeholders and responsibility to its members, the early surf lifesaving association, in 1907, developed the Australian Surf Life Saving Handbook to accompany the introduction of surf patrols and competition on Australian beaches. By 1928, this handbook was regarded as the international textbook on surf lifesaving. The ‘Blue Book’ (Surf Life Saving Australia 2007, p. 51), as it was known, specified the rules and regulations that accompanied patrolling and competition responsibilities. In 2008, SLSA updated the Blue Book specifically for surf lifesaving competition, and renamed it The Australian Surf Sports Manual, hereafter referred to as the Surf Sports Manual. This manual warned potential competitors of the risks that they could encounter when entering into those competitions. The 33rd edition of this Surf Sports Manual stated (Surf Life Saving Australia 2008, p. i):

> Surf lifesaving can be inherently dangerous. Serious accidents can and often do happen, which may result in property damage, physical injury and even death. All members are assumed to have voluntarily read and understood this warning, and accept, and assume the inherent risks in surf lifesaving.

Furthermore, the same Surf Sports Manual specified the precautionary tasks required of the responsible official (‘The Referee’) prior to, and during competition. It stated (2008, p. 1) that:

> The provision of safety management is vital to the conduct of all SLSA competitions.
And,

_The Referee must be satisfied that the safety arrangements provide the necessary safety for competitors prior to the commencement of any event. The Referee must also be satisfied that the surf conditions are satisfactory for competition to proceed. Tests may be undertaken to assist in the assessment process._

These regulations specified officials’ responsibilities that were in place at the time of Saxon Bird’s death in March 2010 and Matt Barclay’s in 2012, during competitions at the Australian Surf Lifesaving Championships. Importantly, the manual did not state that safety was the first priority of carnival officials. In fact, it took the Saxon Bird Coronial inquest to point this out.

### 3.7 The Saxon Bird Coronial Inquest - 2011

The findings of the coronial inquest into the circumstances leading to the death of Saxon Bird in _wild_ surf conditions at Kurrawa Beach, Queensland, Australia, on 19 March 2010 were published on 2 August 2011 (Queensland Office of the State Coroner 2011). The inquest considered how adequately the arrangements and policies of SLSA had ensured the safety of competitors at the championships, the adequacy of rescue attempts, and the need for change in management policy or practice (2011, p. 1).

The state coroner, Mr. Barnes, recognised that SLSA was more than just a sport-based organisation, and that it provided essential public services. The coroner also recognised that lifesavers required surf-related competition to sharpen the skills needed to undertake rescues, often in similar surf conditions to those experienced during the Saxon Bird death. The coroner found that SLSA had put in place appropriate committees (Australian Championships Committee and the Competition – or ‘Organising Committee’) to conduct
a surf carnival of this magnitude. However, the coroner made the point that this was an outcome from the previous death of Robert Gatenby in a surfboat accident in 1996 at Kurrawa Beach (2011, p. 6). The coroner emphasised that the Organising Committee was responsible for the “implementation of safety and contingencies prior to, and during, an event” (2011, p. 6). He also stated that “Neither the [then current Surf Sports] Manual nor any of the safety plans detail how decisions are to be made by the committee”.

As previously recognised, SLSA had operationalised its existing competition regulation protocols at this time through the 33rd edition of its Surf Sports Manual (Surf Life Saving Australia 2008). This procedural manual conferred the power for the Organising Committee to postpone, cancel, or relocate the Australian Surf Lifesaving Championships. It required the evaluation of dangerous surf conditions during competition to be delegated to a responsible person (the ‘Carnival Referee’) or group. It also required this information to be passed on to the Organising Committee, and the Safety and Emergency Services Coordinator, in liaison with the Carnival Referee. The inquest noted that the Carnival Referee had no formal qualifications to make such assessment, and that the coroner was “unaware of the existence of any formal qualifications relevant to the task” (2011, p. 7). The protocols, which were developed during this case study, provide an opportunity to address this formal skill vacuum.

3.7.1 Inquest Findings and Recommendations

The proceedings of the coronial inquest into Saxon Bird’s death recorded discrepancies between swell size, as forecast by the Bureau of Meteorology (BOM) (Australian Federal Government Bureau of Meteorology 2017), and observations and recordings by the relevant carnival officials (Queensland Office of the State Coroner 2011, p. 14). The responsible officials did not discuss these recognised discrepancies in surf-condition
assessments. The senior official’s report sheet was adopted at the carnival without discussion with other officials or participant stakeholders, and without further action. On the days leading up to and including the death of Saxon Bird, accounts were recorded of concerns, by senior competitors and other officials, of the dangerous nature of existing surf conditions. They include (2011, pp. 14-25):

- Assessment and forecasts of the existing dangerous nature of surf conditions, by the ‘Championship Referee’, on the days preceding the tragedy, were “inconsistent with the evidence of other witnesses” and “importantly, it is inconsistent with the Arena Assessment sheets”. These sheets were the official assessments of surf conditions, which were countersigned by both the Championship Referee and the ‘Safety and Emergency Services Co-ordinator’.

- The Championship Referee and the Safety and Emergency Services Co-ordinator, had “limited understanding of the significance of the north-south sweep [alongshore current] present at Kurrawa” on the day that Saxon Bird drowned.

- An official’s log book noted: “Boat area 1 surf conditions too big for U/23 males”.

- Another official noted in his logbook, regarding an under-seventeen male ski-relay race, that “paddlers [were] getting smashed”.

- A separate official stated during proceedings, in reference to the surf conditions at the time: “Events are going to take forever [for competitors] to get around and it’s going to be a long day, and these – there could be possibly that someone here may get injured in these – in these conditions”.

- The supervising superintendant of (Queensland) police said in evidence that “There was a lot of white water, the break was uneven. It was a considerable way out to sea. There were a number of pressure waves brought about by the bank. All in all, yes, it was extreme conditions”.

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• A member of the Organising Committee, who was also the SLSA ‘Director of Surf Sports’, provided evidence. He stated:

*I took it upon myself without consultation with anybody, to walk down to the beach and consult [with] some elite athletes and – and to seek their opinion about what the conditions were like, and what they thought of the conditions – so I had some – I could relay that back to the carnival committee. You know, this is real time information from – from the athletes, and then I walked along.*

• A multiple Australian, World Champion Ironman, and competing elite athlete, significantly stated:

*The waves were too big and powerful to get through. I thought the conditions were at the top end of what we as open competitors should be racing in. I take into account the entire conditions including power/height of waves, the strength of the sweep, rips, wind, and tide level. I thought it was dangerous.*

• The president of a surf lifesaving club, in wide consultation with other members, stated:

*I think the general feeling was that a firm decision to move, suspend or call off the carnival could and should have been made earlier. This can be seen to be easily said in hindsight; however, most people had grave concerns for the event if it stayed at Kurrawa very early in the week.*

• An athlete with 36 years of experience competing in Australian Surf Lifesaving Championships stated, “With all the competitors aware of the rising seas, predicted to be almost 4m by today [19 March], it seems ludicrous officials simply kept delaying a move”.
The coronial comments highlight the differing views between officials and primary competition stakeholders regarding the dangerous nature of the surf conditions that were in existence both before and during the relevant competition. It also provides evidence that SLSA had no objective and systematic, real-time risk management process involving surf-condition assessment during the competition. Furthermore, the existing decision making process did not include input from elite competitors, even though a member of the Organising Committee recognised this input regarding the nature of surf conditions as valuable.

The coronial proceedings recorded that the carnival officials also questioned the motivations behind surfboat crews’ concerns, with the officials saying “What makes you think your forecast is better than ours?” (2011, p. 16). It was suggested by the officials that the reasons for this concern were to gain tactical advantage during the competition rather than a genuine concern about the potential surf danger. The surfboat competition officials appeared to ignore many of the dangerous incidents on the days preceding 19 March. These incidents included numerous collisions, craft damage, and injuries to competitors. In reference to these incidents, an experienced surfboat sweep told the inquiry (2011, p. 20) that:

\[A\ text{ clear majority of a large meeting of surfboat sweeps... [gave a] clear indication that the managers of the surfboat competition had misread not only the conditions, but the preparedness of sweeps to continue to place their crews at such high risk of injury.}\]

The coroner commented that the view by officials to discount the opinions of other experienced competitors “was a fraught perspective from which to make decisions” (2011, p. 29).

When making his final assessments, the coroner noted that:
(i) The death of Saxon Bird was due to drowning, after he had suffered a head injury (p. 27).

(ii) The safety of stakeholders was of paramount importance (pp. 33–4) when conducting sporting events in any surf environment.

(iii) There was no evidence to suggest that SLSA would not have suspended competition if they “had been better informed of the conditions”. However, the coroner recognised that when the surf conditions were unduly dangerous (p. 29), there was an increased “opportunity” for an adverse outcome to occur.

(iv) He did not accept the submission by SLSA that “competitors voluntarily participated and therefore assumed the intrinsic risk” (p. 29), thereby indicating that SLSA still maintained the primary duty of care, since it was the sanctioning body for the events.

(v) An appropriate tool was required that accurately and objectively assessed all contributing surf conditions to related danger. Relevant surf conditions include the power and height of waves, the strength of the sweep, rips, wind, and tidal effects. Indicators of the danger that competitors are exposed to, include the number and type of collisions, loss of craft control, and injuries. This tool should include a process that does not invite officials “to seek to balance competing views” (p. 34).

The coroner made two recommendations relating to the prevention of further death and contribution to public safety (p. 34):

a. Making Safety Paramount, SLSA should:

   Focus on safety in a way that does not invite them to seek to balance competing views as to whether competition should continue. Event officials should be required to suspend competition whenever there is a reasonable basis for concluding there is a risk of serious injury.
b. Continuing the Review of Safety Devices, SLSA should collaborate with safety
designers of lifejackets and helmets,

*with a view to making the wearing of them compulsory once the organisation is*
satisfied they are suitable. Consideration should also be given to the use of helmets by
competitors in surf craft events.

Significant to this study, the coroner declared (2011, p. 30) that:

*When lives are at stake, it is not appropriate to seek to balance competing views or to
seek consensus. Those responsible cannot try and [sic] calculate the average or most
widely held view. The danger posed by wild surf is not capable of precise calibration.*

And,

*officials should favour a wary approach.*

SLSA responded in part to these findings by undertaking several initiatives, including the
Deloitte Touche Tohmatsu (2012) investigation into the organisation’s governance
structure, and eventually, the Personal Protection Equipment (PPE) Project (Surf Life
Saving Australia 2015d), which included the research involving the *Surf Hazard Rating*
(McCoy & de Mestre 2014) undertaken by this author.

According to research by Walters and Tacon (2010, p. 581), “it was moments of crisis that
created the conditions for formal mobilisation” of stakeholder groups. Boin and Hart
(2003) also argued that institutions should demonstrate public leadership in times of crisis,
by reducing stakeholder stress, or else they become the “obvious scapegoats” (2003, p.
544). It was the Saxon Bird death, more than the other two, that created the greatest
mobilisation of affected stakeholders. Together with the findings of the related coronial
inquest, community concerns, as expressed through the media and the independent
governance report by Deloitte Touche Tohmatsu (2012), provided the justification for this
research. The death of Matthew Barclay in 2012, however, provided the initial catalyst for this author and his colleague to create the conceptual *Surf Hazard Rating* model (de Mestre & McCoy 2012), before the research for this thesis commenced, which puts forward the finalised and empirically verified model.

### 3.8 The Matthew Barclay Coronial Inquest - 2016

The findings of the coronial inquest into the death of Matthew Barclay were not tabled until 15 January 2016. As a consequence, within this empirical study the validation of need for a risk-assessment model focuses on the Saxon Bird inquest, dated 2 August 2011. However, there are several elements from the Matthew Barclay inquest findings and conclusions (Queensland Office of the State Coroner 2016, pp. 29-40) that are also relevant to this study. They include:

(i) Death was due to drowning when Matthew was participating in the male under 15-years surfboard race. No definitive conclusion could be made regarding the circumstances that rendered Matthew unconscious. The cause may have been due to a blow from his surfboard. However, there was no direct evidence to prove that such an event was the cause. The coroner, Mr. Ryan, determined that some “catastrophic event” occurred on the outer sandbank that caused Matthew to lose consciousness almost as soon as he was separated from his board. The coroner concluded that this was probably due to the impact of a dumping wave, followed by aspiration of seawater (p. 31). Matthew’s body was carried offshore by water currents and retrieved the next day.

(ii) The fact that surf lifesavers compete in inherently dangerous surf conditions did not relieve SLSA of its duty-of-care obligations under the Work Health and Safety Act
of Queensland (Queensland Government 2011). SLSA was obliged to implement risk control measures to minimise those risks to a level that is “reasonably practicable” (p. 32). It was recognised by the coroner that SLSA was aware of these obligations and was attempting to develop a suitable risk-management framework when this tragedy occurred.

(iii) The assessment of surf-risk that the SLSA Safety and Emergency Services Coordinator received from SLSA’s existing iPad risk-assessment model, which was used at the time, was contributing to the provision of “assessments of variable quality” (p. 33). This model was not intended to usurp the observations and judgements of experienced officials.

(iv) The coroner stated that the Work Health and Safety, Queensland report noted that a person entering the surf environment is subject to inherent risks of serious injury and/or drowning. Any person voluntarily entering such an environment should assume some of that risk (p. 33). However, SLSA must minimise those risks as far as reasonably practicable by implementing administrative controls. These controls would take account of weather, wave and wind conditions, as well as experience and age of competitors, and type of craft used during an event.

(v) The degree of surf turbulence that was present during the event made it impossible to see Matthew as soon as he went below the water surface. It was apparent that he was then swept along underwater by a strong current (p. 36).

(vi) The SLSA Personal Protective Equipment (PPE) Project report (Surf Life Saving Australia 2015d) was presented as evidence that SLSA was in the process of developing primary risk mitigation strategies (p. 37). This included the determination of suitable safety thresholds for competition. The possible use of
personal protection equipment would only apply in “conditions of elevated risk due to surf conditions”, referred to by SLSA as “Heightened Risk” (Surf Life Saving Australia 2015d, p. 21). The coroner complemented SLSA for commencing the implementation of this initiative before the inquest’s findings were handed down.

(vii) The research by this author was specifically mentioned (item 226, p. 39) as contributing research to the development of the PPE project.

(viii) The primary recommendation of the coroner that is relevant to this case study, was that “SLSA must mandate the use of helmets and level 25 lifejackets for all surf craft events (including ski and board races) involving competitors in all age categories up to and including under 17” (p. 40).

3.9 Public Review and Criticism of SLSA Competition Management

A review of the tone of SLSA’s annual report after the death of Saxon Bird contrasted with the sentiment expressed in the media subsequent to that death. The annual report displayed a professional tone, while media reports in the *Sydney Morning Herald* (Murphy & Jensen 2010), the *Australian* newspaper (Owens & Barrett 2010), and later the Australian Broadcasting Corporation’s *Four Corners* program titled ‘The Surf Club’ (Australian Broadcasting Corporation 2013), strongly criticised SLSA’s ability to address stakeholder concerns, and provide a safe sporting environment for competitors. This included its ability to assess in an accurate manner the surf dangers that existed when Saxon Bird was killed. The *Sydney Morning Herald* (Murphy & Jensen 2010) reported a comment by ex-world surfing champion, and long-time surfboat sweep, Bernard (Midget) Farrelly AM 4,  

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4 Bernard (Midget) Farrelly was the first World Surfing Champion (surfboard riding) in 1964 (Warshaw 2005).
which typified the resentment that competitors felt in the days preceding the 2010 tragedy. Mr Farrelly said: “Surfboat sweeps, people of experience, had told organisers it was too dangerous but were ignored for days until the message sank in. Younger competitors had nobody to speak for them and were sent to their fate” (Murphy & Jensen 2010). The *Australian* newspaper article (Owens & Barrett 2010) expressed a similar viewpoint, while the *Four Corners* program challenged SLSA’s existing corporate governance structure, its risk-management framework, and its responsibility to conduct safe surf-related competition.

The *Four Corners* program (Australian Broadcasting Corporation 2013), aired twelve months after the death of Matthew Barclay, and before the related inquest findings were published in 2016. The program reviewed governance issues, especially accountability and transparency, in terms of the fiduciary duties of SLSA managers and officials towards stakeholders, including competitors, parents of the deceased lifesavers Robert Gatenby and Saxon Bird, as well as previous Surf Life Saving Foundation (SLSF) directors. The program firstly reported on the coroner’s findings of the 2011 Saxon Bird inquest, which questioned SLSA’s ability to prioritise competitor safety effectively. The program reported many interviews with lifeguards and competitors, who were world or Australian champions in the surf, and were present on the beach at the time of Saxon Bird’s death, and who argued that the surf conditions on the day were unsuitable for competition.

The *Four Corners* program also reported on the discordance between the directors of the fundraising arm of SLSA, the SLSF, and the directors and executive management of the SLSA governing body. It investigated the resignations of directors from the board of SLSF, which had occurred in 2013. These respected corporate directors, namely Deborah Thomas, Neil Balnaves, Alan Rydge, John Kirby, and Jeremy Charlston, expressed their
collective concern about the “seriously flawed governance [of the SLSA parent body], including lack of transparency”. A separate media report (Ruehl 2013) stated that these directors “were already concerned about pet projects at SLSA that were not in line with the organisation’s strategy”. In contrast, the SLSF directors found “absolutely nothing wrong with the organisation at the beach level” (Australian Broadcasting Corporation 2013). Thomas commented that “the structure of the executive [management] was ineffective”, while Balnaves called for a full disclosure of the content of the 2012 Deloitte Touche Tohmatsu Australia’s review of SLSA’s governance structure (Deloitte Touche Tohmatsu 2012). This included the key areas of revenue raising, structure, strategy, culture, communication, roles and responsibilities, as well as processes, and risk management.

With respect to the governance behaviour of the SLSA board, Balnaves added, “I mean I’m a director of public companies and have been for a lot of my life. You could not get away with this [SLSA board behaviour]” (Australian Broadcasting Corporation 2013). Balnaves also commented that he doubted whether SLSA would meet the new rules of the soon-to-be-formed charities regulator, the Australian Charities and Not-for-profits Commission (ACNC). Thomas, Balnaves, and other board members believed that change was not happening fast enough, and that the SLSF board was meeting a great deal of resistance in what was deemed as SLSA’s “secret little club” (Australian Broadcasting Corporation 2013). These were serious challenges to the legitimacy of the SLSA governance structure, and forced the SLSA board to undertake immediate initiatives in order to retain its appearance of good corporate governorship and coastal water-safety leadership.
3.10 SLSA’s Response to Community Criticism

Prior to Saxon Bird’s death in 2010, the attitude of SLSA, as expressed in its 2008/09 Annual Report (Surf Life Saving Australia 2009b), highlighted the underlying corporate tone towards its on-beach risk-management practices. It presented achievements such as rescues, saving lives, increasing its ‘volunteer’ membership, being Australian-centred, growing, striving, protecting, performing, nurturing, supporting, and contributing via its front-page statement of “Australia. The home of can do. Can do is what we do.” The tone was vibrant and positive. Importantly, it recognised that it had a duty of care to protect its members “as they carry out their duties” (Surf Life Saving Australia 2009b, p. 21).

After the Saxon Bird incident, SLSA’s 2009/10 Annual Report presented a more strategic and corporatised image. SLSA now claimed that its priority was in “Delivering our peak body responsibilities by establishing, advocating and securing international best practice water safety standards, practices and systems for national beach safety and lifesaving services” (Surf Life Saving Australia 2010, p. 20). They presented corporate-styled strategies of growing business enterprises, increasing sustainable and diversified revenues, and maintaining its peak authority status of ‘owning the beach’. Resource allocation was dependent on performance management within these dimensions. In the section headed “Sport Scorecard” (2010, p. 36), SLSA focused on the achievement of a set of professional sporting standards, which included the improvement of coaching resources targeting performance and development gaps, assisting the International Life Saving Federation (ILS) to grow its sporting capacity, reviewing event schedules to improve participation, focus on elite and talented athletes programs, and maintaining SLSA’s world champion status. The issue of stakeholder safety in lifesaving competitions was not addressed specifically. This assessment was in contrast to that by the Queensland State Coroner of
those same processes that contributed to the death of Saxon Bird in 2010 (Queensland Office of the State Coroner 2011), as detailed above.

Post 2010, as the effects of media, community, coronial criticism and resignations of SLSF directors began to impact on SLSA’s image as a valued coastal-safety authority, its board members responded through several initiatives intended to restore its public credibility (Surf Life Saving Australia 2013a). These included the positioning of a new CEO and the commissioning of an independent report (Deloitte Touche Tohmatsu 2012) into its governance and operational structure (Surf Life Saving Australia 2013a, p. 19). With the appointment in 2013 of a new CEO, SLSA undertook to publish and implement all forty-three recommendations of the Deloitte Touche Tohmatsu report (2012, pp. 30-46). A majority of the recommendations concentrated on the governance structure of SLSA, including accountability, transparency, and communication within the board, and executive. These deficiencies presented as “duplication of effort; low morale; mistrust; lack of collaboration; sub optimal revenue-raising capacity and conflict” (2012, pp. 12-5). Section 6.7 of the Deloitte recommendations dealt with “Process and Risk Management” (2012, p. 43). SLSA acted on all the recommendations of the Deloitte Touche Tohmatsu (2012) report, including risk management, by introducing a directive, focussing on beach risk-management and beach safety as part of its updated SLSA 2020 Strategic Plan. Item ‘A.4’ of that upgraded strategy, was to “Extend lifesaving coverage to meet community needs” (Surf Life Saving Australia 2014a, p. 13). SLSA committed itself to achieving significant developments in risk management of surf sports. This commitment was of particular relevance to this research. The Deloitte Touche Tohmatsu (2012) report, and the actions adopted by SLSA to address the report’s concerns, including the research associated with SLSA’s Personal Protective Equipment (PPE) Project (Surf Life Saving
It is within this atmosphere of membership, community, and board criticism that this research involving the development of the *Surf Hazard Rating* (SHR) was undertaken. In April 2014, the author met with SLSA hierarchy to discuss the inclusion of the SHR model in its soon-to-be-updated beach risk-management strategies. At this meeting, it was agreed that the research the author commenced in 2012 (McCoy & de Mestre 2014), would be used as a pilot project to trial the *Surf Hazard Rating* as a risk-assessment tool specifically for surfboat competition (Surf Life Saving Australia Capability and Capacity 2014, p. 4). SLSA expected that, if the pilot project, The Surfboat Hazard Rating Pilot Project (Surf Life Saving Australia 2015d, Appendix 8), was successful, the model could have multiple future applications in SLSA competitions. As the first step, the SHR model would be used to establish a threshold value, at which to mandate the wearing of safety helmets in surfboat competitions. The updated reprinting of the SLSA 2016 Surf Sports Manual (35th edition), included the *Surf Hazard Rating* as the preferred method of on-beach risk-assessment of prevailing surf conditions for future surf lifesaving surfboat competitions (Surf Life Saving Australia 2017a, pp. 1_3 and 5_1 - 5_2 Section 1.4 and 5.1 f).

**3.11 Chapter Summary**

Using any of the accepted measurement standards referred to in this chapter, SLSA is a substantial Australian corporate in the not-for-profit sector. The public reporting of member and community concerns regarding its ability to conduct surf-sports events in an environment, where safety is paramount, has underscored SLSA’s governance responsibility to its stakeholders, and the impact that incidents such as the deaths of the
three young lifesavers, have on its corporate image, management-transparency, and accountability.

Governance in the ‘for profit’ and ‘not-for-profit’ sectors encompasses the rules, relationships, policies, systems, and processes that establish an entity’s legitimacy to function. SLSA like many NFPs maintains a complex managerial structure of bottom-line financial accountability and transparency juxtaposed with an ethos of ‘volunteerism’. Its performance is measured by its ability to continually achieve its mission statement and maintain public trust. Jones, Felps and Bigley (2007) and (Jensen 2002) argue that corporations gain greater public respect and support by building trust and not treating stakeholders opportunistically. Crises within the SLSA organisation in recent years have placed these dimensions under intense public scrutiny.

The deaths of Saxon Bird in 2010 and Matthew Barclay in 2012, while competing in Australian Surf Lifesaving Championships, concentrated public and coronial focus on SLSA’s governance structures and risk-management practices. These events exposed SLSA’s vulnerability to external criticisms, especially its primary responsibility to prevent serious injury to volunteer lifesavers when competing in potentially dangerous surf conditions. The coroner, in each inquest, noted the high level of subjectivity and variability in risk-assessment of surf conditions involved in both incidents. The legal and societal ramifications for this iconic Australian institution resulting from the deaths of these two boys encapsulate the motivation for the research involving the present case study.

This chapter has reviewed how SLSA reacted to the criticisms, coronial inquests, and threats to its legitimacy by commissioning independent reviews of its governance practices (including risk management), which provided the opportunity for the development of the Surf Hazard Rating model. With this review of SLSA and the impacts of the coronial
inquiries into the deaths of competitors in SLSA events, it is now appropriate to review the literature associated with similar surf-zone risk models. This is required in order to establish the relevance of the *Surf Hazard Rating* as a real-time, rule-based risk-management tool within that body of literature.
Chapter 4 Wave and Surf-zone Risk Models

4.1 Introduction

A review of the literature in the previous chapter highlighted the governance and stakeholder imperative for risk assessment within a not-for-profit sporting organisation such as SLSA. In light of the extensive community and coronial criticism of SLSA’s governance and risk management practices since 2010, there is an acute need to address these issues by considering a new, more accurate, and robust model that assesses hazards in the surf zone in real time.

This chapter explores the theories associated with early and recent wave and surf-risk models. It examines their suitability as an operational tool, which could assist on-beach decision makers to comprehensively, and accurately assess dangerous surf conditions in real time. The chapter will review these models in terms of their internal and external validity, and the robustness of the methodology, including accuracy of the data used to develop these models.

4.2 Early Ocean Wave Models

Mathematicians have analysed and documented the theories involving complex ocean-wave formations since the late 1600s. Sir Isaac Newton made an attempt to explain water-waves in his book *Philosophiae Naturalis Principia Mathematica* (1687). Newton derived his original water-wave equation by assuming that water particles travelled in a straight line, even though he had observed wave particles travelling in circular patterns. He subsequently provided several caveats to his approximation equation that related to deep-water wave frequency. Other noted scholars such as Daniel Bernoulli (1738), Leonhard
Euler (1757), Pierre-Simon Laplace (1776), Louis Lagrange (1781, 1786), and Augustin-Louis Cauchy (1816) attempted similar explanations for shallow water wave-particle movement with limited success. The scholarly work by Craik (2004, pp. 1-18) summarised the numerous wave theories, which were presented by these foremost mathematicians of their time, and who provided the grounding theories of modern coastal engineering and environmental-mathematics modelling. These theories include Airy Wave Theory (Airy 1845), which mainly focused on tidal phenomenon; Stokes’ Wave Theory (Stokes 1880), which approximated non-linear wave motion (Shand, Peirson & Cox 2007), as it applied to intermediate and deep water waves; and Solitary Wave Theory, which was defined in the seminal works by Joseph Boussinesq (1871, 1872). In 1876, Rayleigh derived an improved approximate solution of the Boussinesq equations, and in so doing retained the dispersive and nonlinearity components of water particles at the front and behind the wave (Craik 2004, p. 18). Collectively, these major contributions to wave literature provide the basis of wave-particle theory leading into the middle of the twentieth century.

4.3 Developments in Modern Wave Theory

Modern wave theory, although based on the works of the aforementioned classical scholars and mathematicians, relies heavily on studies from the 1940s onwards. Authors of these studies include Michael S. Longuet-Higgins, Walter Munk, and Komar and Gaughan. The theories developed by these authors extended ocean-wave theory to apply to wave-energy dissipation in the surf zone. The surf zone is defined as “the area of water lying between the shore and the surf line, characterized by white foamy water produced by breaking waves” (Oxford University Press 2018) or “the region where in coming waves break and eventually run up the foreshore of the beach if one is present” (Miller 1987, p. 92). For example, Longuet-Higgins (Longuet-Higgins 1953; Longuet-Higgins & Cokelet 1976;
Longuet-Higgins (1970) detailed previously undefined equations for particle-energy transference of steep surface waves in the breaker zone. His work infused the theoretical with his own observations to describe the effects of ocean waves on climate, inshore sediment, and water transport.

4.3.1 Contributions of Walter Munk to Modern Wave Theory

The esteemed oceanographer, Walter Munk (1917-2019), from the Scripps Institute of Oceanography in San Diego, USA (Nature International Journal of Science 2019; Scripps Institute of Oceanography 2017, 2019), has recently been described as the “Einstein of the Oceans” (Galbraith 2015). Munk pioneered research that related wind motion and ocean circulation (Munk 1950). His work provides the foundation theory that is associated with modern global wave-casting services, as will be detailed later in this chapter. These services provide essential wave information for coastal engineers, scientists, environmentalists, and recreationalists. Munk placed greater importance on observation and practical experimentation above the overuse of computer simulations when modelling the ocean’s movements. The San Diego-Tribune quoted Munk as saying: “I think this [computer overuse] comes at the expense of making direct observations of what happens in the oceans” (Robbins 2016). The New York Times similarly reported Munk saying “And I’m a little worried about so many people doing computer experiments and losing their ability, the American leadership, in measurements at sea” (Galbraith 2015). These comments demonstrate Munk’s strong belief that robust modelling occurs only after close personal observation of the processes and effects involved in the natural environment.

Solitary Wave Theory was based on ocean-wave formations, which were assumed to have no boundary conditions in the direction of wave travel. Munk, in contrast, observed that surf-zone bottom-friction had an effect on the breaker-wave height. He argued that “waves
may be expected to break in water of [approximate] depth of 1.28 times the breaker height” (Munk 1949, p. 389). This relationship, known as ‘the wave breaking criterion’ (Komar & Gaughan 1973), is an heuristic that is still applied today by coastal engineers, coastal scientists, and marine and coastal wave-forecasters. The wave-breaking criterion is the ratio of depth of water to height of wave at the point of wave-breaking. According to Solitary Wave Theory (Munk 1949, p. 377), its use is conditional upon assumptions such as constancy of wave period, conservation of energy, and applicable to waves breaking “behind a sand bar in water of increasing depth”, and not to waves “generated in shallow water \( \frac{h}{L_0} < 0.5 \)” (1949, p. 390). The ratio \( \frac{h}{L_0} < 0.5 \) measures the relative depth according to Stokes’ Theory (1949, p. 377), which compares water depth \( h \) to wave length \( L_0 \).

Munk approached the observation of potential inshore surf risks in terms of processes and similar physics-based variables. In collaboration with his mentor, Harald Sverdup (Sverdrup & Munk 1947), Munk applied his original wave theory to sea and swell-prediction models using wind effects. The basis of this theory was utilised by the Allied Forces, under the command of General Dwight Eisenhower in 1944, to predict surf zone conditions prior to the landing of troops on the beaches at Normandy, France on D-Day (1947, p. 1). A report in the San Diego Tribune quoted Munk as he recounted the motivation for his milestone research, and the events leading to the development of his surf zone model involving breaker-wave heights (Robbins 2016):

*We went down to South Carolina [in 1942] to watch the practice exercise. They were using LCVPs [landing craft vehicle personnel]. Whenever the LCVPs turned into the breakers — and the waves got above about five feet — the boats would broach and turn parallel to shore. Waves would break into them. People would get hurt. They*
called it a day and said we’ll continue the practice landing when things calm down a little.

I thought that a catastrophe was about to happen. The only way to do something was to learn to predict waves, then pick two good days for a landing. That had not been done. There had never been a wave-prediction attempt.

The wave theory was grounded upon mathematical formulations using wave height as the most significant predictor-variable in this relationship. He believed that other contributing surf-condition factors such as wave type, wave period, surf zone width, and water movement relevant to the beach, both laterally (alongshore or longshore), and perpendicularly (shore-normal), were more easily accounted for by the wave-height variable. The model did not specifically address the construct of danger, although Munk did refer to the potential outcome of LCVP rollover events as ‘catastrophic’. Munk had observed the apparent surf-risk to this specific craft-type and had created a model that was relevant to the task, that being the potential reduction of LCVP incidents when wave heights exceeded a particular height. His analysis focused on an area immediately beyond the outermost breaking wave in the surf zone, where the breaker water-depth was greatest. This zone contained the greatest danger for participants, who were relevant to his study. He noted that the outer edge of the surf zone “is usually the most critical from the point of view of bringing landing craft ashore” (1949, p. 376).

Sverdup and Munk also defined the concept of Significant Waves as “waves having average height and period of the one-third highest waves” (1947, p. 1). The universal standard for measuring wave height now defines Significant Wave Height as “the average wave height, from trough to crest, of the highest one-third of the waves” (Australian Government Bureau of Meteorology 2012). The concept of Significant Wave Height has
global application throughout the coastal science and engineering, and marine forecasting communities. Major world weather forecasting agencies such as the United States of America, Department of Commerce’s, National Oceanographic and Atmospheric Administration, commonly known as NOAA (U.S. Department of Commerce 1970), and the Australian Bureau of Meteorology, commonly known as BOM (Australian Government Bureau of Meteorology 2017a), report swell size in terms of Significant Wave Height. Surf-forecast websites such as Coastalwatch (COASTALCOMS Pty Ltd 2015; Coastalwatch 2018), Magic Seaweed (Magic Seaweed 2014), Willy Weather (Willy Weather 2018), and Surfer Today (Surfer Today 2007) publish daily wave forecasts also using the Significant Wave Height. These forecasts are then utilised by surfers, and professional surf managers such as lifeguards and surf-event managers, to estimate the hazards within the surf environment (Surf Life Saving Australia 1990b, 2009a). Moreover, the concept of Significant Wave Height is extensively referenced throughout the coastal-management literature. For example, as will be demonstrated in a later section of this chapter, morphodynamic beach states and hazard research by Wright, Short and Hogan (Short & Hogan 1994; Wright & Short 1984), use the definition of Significant Wave Height as a primary risk-model predictor-variable.

During his interview with the San Diego Tribune in 2016, Munk commented that, until his work in 1942, there had been no attempt to make predictions of wave behaviour within the surf zone. A major reason for this lag was the mathematical difficulty in accounting for the complexity of interactions and variables that are present within this zone. In his 1949 paper, he addressed the difficulty in developing a set of wave equations that accurately reflected observed phenomena in the natural environment through the following comment (Munk 1949, p. 396):
The observations, which have been introduced to test the solitary wave theory, exhibit such a large degree of scatter that it is not possible to speak of confirmation in the sense in which physical laws can be checked in the laboratory. The overall impression is, however, that the solitary wave theory provides a useful tool for the study of various surf phenomena. To obtain reliable observations of some of the features here described is exceedingly difficult. In the field, extreme variability in the wave train itself is likely to obscure meaningful relationships.

These comments are still relevant to modern coastal research and application. For example, Mann (2003) argues that observational studies are often the only practicable method of studying various complex phenomena, especially in cases where randomised controlled trials are unethical, or involve ‘rare events’, such as those involving serious injury or death. Munk’s seminal research was founded upon observation, not only of surf-condition processes, but also of the inshore risk-effects those conditions had on troop landing craft.\(^5\) His oceanographic contributions have been many-fold and widespread, especially in the application of Solitary Wave Theory to inshore surf-dynamics, and the use of the Significant Wave Height as a universal standard of ocean and nearshore wave-height measurement.

4.3.2 Wave Fields and Wind Generation Effects

In their comprehensive review of the wave modelling literature in the ensuing years, Cavaleri et al. (2007) summarised the difficulties associated with capturing the practical elements of deep and shallow water interactions using existing wave theory. They

\(^5\) Munk used ‘Trained Observers’\(^5\) to record wave heights from a fixed point at sea (Australian Government Bureau of Meteorology 2012). Section 5.5.2 (iii) a. details the use of Trained Surf Observers in this case study, in acknowledgement of Munk’s and other authors’ belief in the importance of observation in the development of a theory of the surf-zone dynamic.
reinforced Munk’s appreciation of the nexus between theory and application. The complexity of the interactions of variables defining modern wave theory is still largely undefined in the surf zone. Battjes and Janssen also noted that the examination of energy equations in the surf-zone were usually abandoned because the breaker wave-energy dissipation process is so “little understood” (Battjes & Janssen 1978, p. 570). Falnes (2007) has similar reservations when examining the diversity of theoretical models that were applied to the harvesting of wave-energy from the sea. The authors (Cavaleri et al. 2007) conclude that consensus within the literature is that an accurate and comprehensive model of wave-energy dissipation within the surf zone has yet to be formulated because of the complexity of the breaking process within the whole of the surf zone.

Cavaleri et al. (2007) classified the physical processes inherent in wave modelling to be wind generation; wave propagation; non-linear interactions in deep water; white-capping dissipation; non-linear interactions in shallow water; and dissipation at the sea bottom. They reviewed currently accepted wave models, which predominantly focussed on Significant Wave Height, period and direction, and surface wind-fields, as input variables. The same authors noted that wave peaks and extreme conditions, such as rogue waves, were frequently not well accounted for by wave equations. Wave models accounted for good ‘average’ results but lacked accuracy in predicting extreme conditions. The position was supported by authors such as Dysthe, Krogstad and Müller (2008) and Kharif and Pelinovsky (2003), who argued that the height of rogue waves, and their probability of occurrence, could be explained using second-order wave theory. However, it was unclear whether the exceptions they observed represented measurement error or statistical flukes. Cavaleri et al. (2007) suggested that the theory appeared sound, providing it was applied within the “usual range of conditions” (2007, p. 656). The Australian Bureau of Meteorology provides similar advice. It cautions that maximum wave heights could be up
to twice the size of the Significant Wave Height, and occur approximately three times per
day (Australian Government Bureau of Meteorology 2012), or roughly 1 in every 3,000
wave occurrences.

Cavaleri et al. (2007) concluded that wind generation and its influence on the propagation
of waves is an extremely complex process that is also not well understood outside the
normal range of application. The authors posited that a single ‘best’ solution had yet to be
determined because of modelling uncertainty. Cavaleri et al. (2007, pp. 661-2) also
asserted that the formulation of the physical interactions between wind and waves, which
are recognised by the presence of “white-capping”, was “the least known process”, and
that existing models could not “routinely evaluate the exact result” of wind-wave
interactions.

In their review of scholarly opinions of wave spectral energy dissipation, Cavaleri et al.
(2007) concluded that the main hypotheses only examined pre-breaking or post-breaking
wave fields. They asserted that none of the models dealt with the wave breaking dynamic,
and that all of the hypotheses “lacked experimental validation or support” (2007, p. 657).
This reflects the view by Galvin that “no theory of those tested, satisfied the dynamic free
boundary condition exactly” (Galvin 1971, p. 418), and that any agreement of results
between the breaking of oscillatory waves and solitary waves was “fortuitous” (Galvin
1971, p. 450). Cavaleri et al. (2007) recommended greater awareness of observation in the
process of modelling surface breaking waves. They recognised that “the integrated
characteristics of the surface are not always purely indicative of the bottom dissipation
process” (2007, p. 658), and that the water surface in the surf zone is also affected by wind
generation. Finally, in recognition of the complexity of variable-interactions in the surf

environment, they noted that a completely accurate wave model should reflect the wind and wave dynamic because this is “how nature works” (2007, p. 662).

4.3.3 Breaker Wave Height models

An earlier investigation of the wave-breaking phenomenon within the surf zone, not cited by Cavaleri et al. (2007), but relevant to modern Australian surf-forecasting models, such as Coastalwatch (Coastalwatch 2018), was undertaken by Komar and Gaughan (1973). They developed a new term, the Wave Breaking Criterion (Komar & Gaughan 1973, p. 405), which provides an approximation of the water depth at which a wave will break as it enters the surf zone. The term is defined by the equation: \( \gamma_b = \frac{H_b}{h_b} \), where \( H_b \) is the breaker wave-height and \( h_b \) is the breaker wave-depth. Having an approximate value of 0.78, it is the inverse ratio of that quoted above by Munk (1949, p. 389). Laboratory studies by Komar and Gaughan have indicated that this value varied with beach slope (1973, p. 407). Galvin (1971, p. 413) supported this position in part, when he stated that “slope determines the extent of nonlinear changes in wave shape”. Using the definition for the Wave Breaking Criterion and Airy Wave Theory (Longuet-Higgins & Stewart 1964; Longuet-Higgins 1970), Komar and Gaughan (1973) demonstrated that the energy flux exhibited by the wave-dynamic in the surf-zone is explained through the breaker wave equation: \( H_b = \frac{kg^{1/5}(TH_{\infty}^2)^{2/5}}{2} \), where \( H_{\infty} \) is the deep-water wave height, \( T \) is the wave period, \( g \) is acceleration due to gravity, and \( k \) is approximately 0.39.

Research by Caldwell (2005) used the Komar and Gaughan (1973) breaker-wave equation to compare the breaker-wave height, using data from nearshore wave buoys, to actual surf observations along the north shore of Oahu, Hawaii. He concluded that the daily surf-height observations, provided primarily by the lifeguards, were “imperative for safety,
coastal planning and engineering applications” (2005, p. 1128). The differences in observed and calculated results were not only consistent in time but also indicated that the magnitude of the error-difference was between 10% and 15%. He concluded that the subjective evaluations by experts such as lifeguards, with long-term experience in wave estimations, had only a small error-differential to that predicted by (average) wave modelling programs such as WAVEWATCH III (Tolman 2008). However, real-time estimates of wave height were much more difficult to ascertain because the instantaneous characteristics of the ocean-wave models were “highly variable” (Caldwell 2005, p. 1129).

Caldwell and Aucan (2007) extended the work by Caldwell (2005) and argued that the complex transformations involved in the conversion of offshore data into accurate breaker wave-height predictions in the surf zone contributed to the uncertainty of validation of “explicit surf height estimates” (2007, p. 1238). They further argued that typical wave models such as SWAN (Booij, Ris & Holthuijsen 1999) and WAVEWATCH III, which are currently used by NOAA in Hawaii, provided high quality estimates of wave fields in the major global oceans and seas. However, there was little understanding of how this data could be transformed into explicit operational (instantaneous) surf-height estimates. Their research presented an empirical method for estimating breaker-wave heights, which was based on visual surf observations by experts and Significant Wave Height data measured at nearshore deep-water buoy collection points.

Using existing Airy Wave Theory and equations developed by Komar and Gaughan (1973), Caldwell and Aucan (2007) derived an empirical estimate of surf height ($H_{surf}$) based on offshore Significant Wave Height and the dominant, or average, wave period, as recorded by offshore buoy recording stations. The values $H_{1/3}$ and $H_{1/10}$ were the average of the $1/3$ and $1/10$ highest observed waves respectively, and approximated the lower and
upper range-limits of the daily swell heights (Caldwell & Aucan 2007, p. 1239). Caldwell (2005, p. 1129) argued that the task was to account for a wider range of observable wave heights using “a value roughly equivalent to the average of the one-tenth highest waves”. Caldwell and Aucan (2007) extended the notation to include the value of $H_{1/100}$, which represented the observed average of higher sets of waves. The model proposed by Caldwell and Aucan extends the traditional Significant Wave Height concept by Sverdrup and Munk (1947) to include lower and mid-range averages. The study concluded that visual observations of wave heights were the “best means of verifying” surf forecasts, which were “vital for safety, property protection, and planning of coastal activities” (2007, p. 1237). This was also supported in research by Perlin (1984) and Plant and Griggs (1992).

However, Caldwell and Aucan (2007), as with previous authors, focused again on using wave heights to describe the mechanics of the physical processes within the surf dynamic, as distinct from using the ‘effects’ that such features have on the level of danger inherent in the dynamic. The authors also based their findings predominantly on historical records. Nonetheless, the research produced a reliable empirical predictor of breaker wave-height based on offshore buoy readings. The research focused on large swell events where the wave period was of 10 seconds to 20 seconds duration, which provided trough-to-crest wave sizes in the proximity of 5 metres to 15 metres. The research by Caldwell and Aucan supports the data collection process using suitably trained ‘experts’ for nearshore coastal risk management modelling.

4.3.4 The Contribution of Surfing (Surfboard Riding) Research

Scarfe, Healy and Rennie (2009) examined the wave-theory literature as it relates to recreational surfing (surfboard riding) in coastal management practices. They explored
research-based surfing publications to present an alternative viewpoint of important surf characteristics and physical processes, which were not well represented in the traditional oceanographic literature, but which were important to surfing communities. For example, they noted that wind-wave interactions had been investigated from an oceanographic perspective, but not from the effects that these interactions had on the creation of acceptable or challenging surfable wave formations. They reported on breaking wave-height, wave peel angle, wave-breaking intensity, and wave-section length. They commented that, except for breaking wave-height, all other terms were under-reported in the literature.

The authors also supported Battalio (1994) by asserting that although surfers sometimes adopted a different measuring metric for wave heights to that of oceanographers, both still utilised Sverdrup and Munk’s Significant Wave Height definition (Sverdrup & Munk 1947). This suggests that most coastal scientists and local surf communities assess wave height from an ‘average’, rather than ‘maximum’ height perspective. Scarfe, Healy and Rennie (2009) also attempted to rank surfing wave parameters to surfer skill levels. They recognised the moderating effect that participant competency plays when measuring surf-zone interactions and outcomes.

The discourse above demonstrates that multiple stakeholders rely on Significant Wave Height measurements for numerous predictive applications, and have applicability to these groups in an average sense. This is because the interaction of waves, wind, and bathymetry is a complex physical process, and generally approximated by averages in both spatial and time dimensions. When these complex interactions occur in real time, the consequent singular, nett outcomes, affecting exposed surf participants, can be catastrophic, as demonstrated in the previous chapter, with the death of three young lifesavers in 1996,
2010, and 2012. Soomere (2014, p. 5) supports this viewpoint by noting that “It is not uncommon that the risks associated with wave-based or wave-driven coastal hazards is severely underestimated”, by surf participants.

4.4 Rip Current Models – Theory and Practice

Scholarly studies have also attempted to provide theory and create models to describe and predict other aspects of nearshore phenomena. Widespread research on rip currents, beach morphology, and related risk forecast and management models are strongly evident in the literature. The research uses the rip-current dynamic, acting as a proxy for all-of-surf hazards, to develop prediction models and risk-management strategies within the near-shore environment. It is argued in this section, that this approach however achieves varied success, owing to the complexity of the physical rip-current modelling process, the structural limitations of retrospective data analysis using rip-current rescues, and the inability of this methodology to account for other hazards and injury types within the surf zone.

4.4.1 Rip and Longshore Current Definitions

Early research by (Shepard 1936), which was followed by Shepard, Emery and La Fond (1941), Shepard (1949), and McKenzie (1958), provide early definitional descriptions of rip currents as the major form of surf-zone drainage. These nearshore phenomena are mainly responsible for the outward flow of water and sediment transfer (Talbot & Bate 1987). This drainage restores the balance of water build-up (known as ‘wave set-up’), that is generated by breaking waves in the surf zone (Lascody 1998). Voulgaris, Kumar and Warner (2011, p. 89) described two possible resultant wave-induced systems: an alongshore current, which is generated by incident waves approaching the shore at a
relatively large oblique angle, and a cell-circulation system, which is generated by a small wave-incident angle. These two systems either singularly or in combination are responsible for the generation of rip currents.

Following Shepard’s (1949) approach, the Glossary of Meteorology (Huschke 1959, p. 484) defined a rip current as: “a strong water-surface current of short duration flowing seaward from the shore”. This definition has been widely accepted in the literature since its appearance in the 1959 publication. MacMahon, Thornton and Reniers (2006, p. 191) clarified the directional seaward movement of water, by defining a rip current as the “approximately shore-normal, seaward-directed jets that originate within the surf zone”. Laterally moving currents were associated with the water flow originating at the site of the breaking wave into the surf zone, before it was transferred back out to sea via the rip current. The lateral water flow is defined as alongshore (longshore) current (Dillery & Knapp 1970; Hunter, Clifton & Phillips 1979; MacMahon et al. 2011; Swart & Fleming 1980; Talbot & Bate 1987). These alongshore feeder-currents converge into the rip current flow, referred to by Voulgaris, Kumar and Warner (2011, p. 11) as “the rip neck”. The literature,\(^6\) acknowledges that longshore, or alongshore, currents travel approximately parallel to the shoreline, while rip currents travel in a shore-normal, seaward direction. These definitions will be assumed throughout this study.

Despite its importance, coastal studies continue to overlook the distinction between outward and lateral current flows when examining rip-current rescue data. For example, Scott et al. (2014, p. 198) define rip currents as “strong, narrow seaward-flowing currents in the surf zone”. Defining rip currents as ‘seaward flowing’ rather than ‘shore-normal-

\(^6\) Bowen 1969; Brander, Cowell & Short 2001; Lascody 1998; Leatherman & Fletemeyer 2011; Short 1999; Short & Hogan 1994; Wright & Short 1984.
flowing’, introduces the opportunity for confusion, and loss of accuracy of historically recorded rescue data. It is posited that this encourages model-variable confounding, and consequent development of sub-optimal risk-management strategies, which are reliant upon such definitions.

4.4.2 Rip Current and Surf Rescue Research

Worldwide, rip currents have been documented as the single most hazardous surf characteristic that that leads to drowning.\(^7\) For example, in a survey of several hundred Australian beaches between 1989 and 1992, Short and Hogan (1994, p. 197) found that 89% of rescues occurred in rips. In a similar study of rescue data and lifeguard rip-current observations, in Southwest England between 2005 and 2007, Scott, Russell, Masselink, Wooler, et al. (2009), found that “68% of all recorded incidents (individuals rescued) where due to rip currents” (2009, p. 4251). Leatherman and Fletemeyer (2011, p. 1) reported that, annually, “rip currents account for 80% of rescues” in the United States, which supports research by MacMahan, Thornton and Reniers (2006). Brighton et al. (2013) report that a review of SLSA’s lifesaving database, called SurfGuard (Surf Life Saving Australia 2015e), found that, between 2004 and 2011, “rip currents were related to 44% of all beach-related drowning deaths and were involved in 57.4% of reported major rescues” (2013, p. 1069). It is therefore recognised, that the rip current is a substantial surf-zone hazard, and warrants consideration as a significant variable in any surf hazard model.

This viewpoint regarding rip currents, must be tempered, however, by the recent statement

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by McCarroll et al. (2014, p. 145) that “contemporary rip current safety information is often idealise[d]”, and demonstrates variance with real-world application.

Recent research (Reinhart & Pfaff 2016; Short & Weir 2016) confirms the focussed discourse and analysis on rip-current and rescue-related studies, at the expense of the investigation of other possible contributing factors (Morgan & Ozanne-Smith 2012, 2015). Many risk-management strategies, which predominantly focus on this hazard, may consequently be sub-optimal. Nonetheless, as demonstrated in the conclusions of Reinhart and Pfaff (2016, p. 3), analysis using rip-currents and rip-rescue data “will help lead to improved local rip current forecasting techniques and enhance the services provided to emergency managers, lifeguards, and beach communities”.

Surf survival advice, which is provided by coastal water-safety organisations such as SLSA, has presented differing strategies, thereby reflecting the changes in understanding of rip-current flow-behaviour throughout the past decades (Bradstreet et al. 2014; Gallop et al. 2016; MacMahan et al. 2010; McCarroll et al. 2014; McCarroll et al. 2015; Shaw et al. 2014; Van Leeuwen et al. 2016). Survival/escape strategies have varied from swimming diagonally to an outward flowing current, swimming parallel to the beach (‘alongshore’), through to treading water and waiting for the rip current to dissipate (Bradstreet et al. 2014, pp. 87-9). Miloshis and Stephenson (2011), for example, report that certain strategies, such as swimming parallel to the beach (2011, p. 823), could hinder escape from rip currents if the wrong direction was chosen. McCarroll et al. (2014) endorsed

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8 There is sufficient, though limited evidence in the literature, to indicate that other surf-zone phenomena also contribute to the total level of hazardousness within the surf-zone environment (Austin et al. 2010; Caldwell & Aucan 2007; de Mestre & McCoy 2012; Dusek & Seim 2012; Erby, Heard & O’Loughlin 2010; MacMahan et al. 2011; McCoy & de Mestre 2014; Scott et al. 2007). For example, the Saxon Bird coronial inquest reported that hazardous surf factors included “the power/height of waves, the strength of the sweep, rips, wind and tide level” (Queensland Office of the State Coroner 2011, p. 19).
floating (i.e., ‘doing nothing’) as the most appropriate rip current escape strategy. They suggest that previous traditional swim strategies, which included swimming parallel to the beach as an escape strategy, were based on a ‘shore-normal’ understanding of rip current flow, which was not sufficiently comprehensive of existing surf-current flow dynamics.

Based on the research by McCarroll et al. (2014), Van Leeuwen et al. (2016) also argue that existing rip current safety information is often idealistic, with potentially different implications for real-world rip escape strategies (Van Leeuwen et al. 2016, p. 145). Their rip current experiments, using hydrodynamic and morphodynamic approaches found varied “action failure” (2016, p. 145), when using common escape strategies such as, stay afloat, and swim parallel to beach, under certain beach conditions. Van Leeuwen et al. concluded (2016, p. 163) that a “Swim Onshore” strategy was “generally viable, contrary to conventional safety advice”. The ‘Swim Onshore’ strategy was classified by McCarroll et al. (2014, p. 1835) as swimming towards the shore with the waves, so that a person could reach the safety of the shoreline, especially in rip currents that exhibited a circular flow pattern. Van Leeuwen et al. (2016, p. 163) concluded that “Floating has been a poor strategy, with 70% of escape attempts failing”. A consistent strategy, which has been present in all survival advice, has been to stay calm and not panic (Bradstreet et al. 2014, p. 87). It appears that, to date, there remains no consistency in surf risk-management, especially as it relates to rip current escape strategies and rip-rescue data.

4.4.3 Research Design of Surf Risk Models

As indicated above, the predominating focus of coastal management literature involves research based on rip-current rescues. This is generally of a retrospective design, which can be susceptible to inherent systematic errors. The following sections review aspects of
such research, which may be prone to errors, and provides opportunity to consider an alternative surf-zone research design.

4.4.3.1 Recall Bias and Retrospective Data

Bias in research occurs when data is collected and analysed in a manner that can lead to a “systematic distortion of statistical results due to a factor not allowed for in their derivation” (Smith & Noble 2014, p. 100). The analysis of historical records in isolation, for example, can introduce opportunity for measurement error involving recall bias. Recall bias tends to occur when subjects are asked to recall past events or are exposed to some unfamiliar condition (Coughlin 1990; Sackett, D 1979; Weinstock et al. 1991). Hassan (2006, p. 1) defined recall bias as “the deviation of results from the truth” in the collection of information. He added that the recall of information depended entirely on memory, and that this can often be imperfect, and thereby unreliable. The resultant appearance of systematic errors, were a major threat to a study’s validity, as they distorted the correlations between variables. He added that recall bias was highly likely to be evident in studies using reported (i.e. retrospective) data if the condition being investigated was of a significant event (2006, p. 2). Sports injury research by Junge and Dvorak (2000) found that incident recall-time affected recall accuracy. They recorded that even severe injuries were sometimes not reported in some retrospective sports-injury studies. Furthermore, they found that prospective epidemiological studies provide more reliable data than retrospective studies. This argument finds support in the research into an avalanche predictive model as it relates to retrospectively acquired rescue data.

Uttl and colleagues (Uttl, Henry & Uttl, 2008; Uttl, McDouall & Mitchell 2012; Uttl & Uttl 2009), supporting research undertaken by Gauthier (2010), highlighted the inherent inaccuracies that could be introduced in retrospective injury-related studies. They analysed
the research by McCammon and Hägeli (McCammon 2002; McCammon & Hägeli 2004, 2005, 2007) into avalanche causal-factors as they related to US avalanche accidents between 1972 and 2004, when developing the avalanche decision-support tool known as the ‘Avaluator’ (Haegeli et al. 2006), for backcountry skiers. Uttl, B, McDouall & Mitchell (2012, p. 841) argued that missing data involved in the retrospective research by McCammon and Hägeli, which related human-effected avalanche incidents to environmental causal-factors, was “inappropriately” treated as “missing at random”.

They argued that the possible missing data might not be missing-at-random but instead, be indicative of causal-factor-absence, owing to eyewitness “failure to report absence of conditions and behaviors” (Uttl, B, McDouall & Mitchell 2012, p. 841). They reported that data was not available when avalanches occurred but no injury eventuated. They posited that eyewitnesses were far more likely to report the presence of environmental factors than their non-presence. This argument supports the position regarding recall bias, as expressed above by Sackett, D (1979), Coughlin (1990), Weinstock et al. (1991), and Hassan (2006). Uttl et al. argued that consequent correlations and findings based on this inaccuracy were therefore likely to be skewed. The report by Uttl, McDouall and Mitchell (2012, p. 843) further argued that meaningful prevention models should be supported only when complete datasets were analysed. A similar argument can be put when surf-risk models become dependent on historical data involving surf-related injuries. The influence of historical data on surf-related modelling is explored in the following sections.

4.4.3.2 Domains of Influence on Surf-incident Data Analysis

Studies by Scott et al. (2007), Brighton (2012), Brighton et al. (2013), Mitchell, Brighton and Sherker (2013), Sherker et al. (2008), Sherker, Brighton and Thompson (2012), Bradstreet et al. (2014) and Brander and MacMahan (2011) consistently reference
historical incident-databases, such as SLSA’s *SurfGuard* (Surf Life Saving Australia 2017c), to establish a relationship between rip currents, drowning, and surf-related injuries. However, surf-zone risk-management, based solely on these rip-based studies, cannot account for the injuries that led to the deaths of the three young lifesavers in 1996, 2010, and 2012. Robert Gatenby’s 1996 death was linked to a collision of surfboats (McElroy 2016). As stated previously, Saxon Bird’s death was related to a surf ski collision (Section 3.7.1 (i)), and Matthew Barclay died after being rendered unconscious by the effects of a dumping wave on a shallow sandbank (Section 3.8 (i)). A review of these records shows that all three deaths occurred during surf lifesaving competition, where experts rated the overall surf conditions as dangerous, and the deaths were not solely due to exposure to a single factor, such as rip currents.

Research by Scott et al. (2007) analysed rip-rescue incidents as they related to beach morphology. They also related the causes of these rescues (2007, p. 2) to lifeguard-determined factors, including rip currents, offshore winds, strong winds, bed return flow, plunging waves, heavy surf, sandbars, surging waves and tidal cut-off. The lifeguards also recorded the presence of these natural-environmental factors after a rescue-incident had occurred. The authors state that “Some of these [natural] environmental causes occur in conjunction with rip currents …. suggesting risk to the beach user is often compounded with a combination of these hazards” (2007, p. 3). Although the authors noted the presence of other surf-zone phenomena, they remained focused on the rip current as the main rescue-incident causal factor, especially as it was morphodynamically linked to beach type. They concluded that a high risk of rip development was associated with reflective low-tide terrace and rip, and intermediate low-tide bar and rip morphologies. Furthermore, they concluded that these morphologies were not as predictable as in “previous studies by Short (1994)” (2007, p. 6). Significantly, the lifeguards in their study, did not record the severity
of any contributing environmental factor, only its presence when a rescue incident occurred. These lifeguards also did not record the presence or absence of these factors against periods when no rescues occurred. Opportunity therefore exists for misinterpretation of data, similar to that discussed above, in this study and others, which adopt a similar methodology.

Scott et al. (2007) also implied that rip currents were ‘the cause’ of rescue incidents within their study, when they reported (2007, p. 1) that rip currents “were responsible for 71% of all recorded incidents”. Their later study on rip rescues (Scott, Russell, Masselink, Wooler, et al. 2009) continued to assume this causal inference, as did research by Brander and MacMahan (2011); Brander and Short (2000); and Dalrymple et al. (2011). Holland (1986, p. 945) argues that “correlation does not imply causation”, since causality separates significant contributing factors in a strict chronologic sequence. Holland (1986) explains causality as linking the response variable (i.e., the dependent variable) to causal variable(s) “at some specific time or within a specific time period”. Applying the general argument for causality, as presented by Tabachnick and Fidell (2014, p. 158 & 291), an apparently strong relationship between variables, for example, the relationship between rip currents and rescues, “could stem from many sources, including the influence of other, currently unmeasured variables”. Applying the assertion of Tabachnick and Fidell (2014) to the determination that rip currents as the predominant ‘cause’ of rip current rescues requires noting the change to the number of rescues while manipulating the rip current variable, and ‘controlling’ for all other independent variables. The research by Scott et al. (2007), and the other authors mentioned above, do not control for these other independent variables when measuring rescues solely against rip currents, especially in their use of retrospective studies. Thus, it is misleading to state or imply by absence of reporting or research of other
factors, that rip currents solely cause rip current rescues, and to base risk-management strategies solely on this surf-zone variable.

In certain circumstances, rip (shore-normal) currents can be a causative variable of drowning, which would logically necessitate a rescue event. However, there may be other significant factors that contribute individually, or in combination with rip currents, to the impact on a surf rescue and/or serious-injury incident. Other significant surf characteristics including breaking waves (size, type, and period), width of surf zone, surface turbulence, longshore currents, and other environmental factors, may also contribute to the rescue incident. Even an overall lack of visibility (Avramidis, Butterly & Llewellyn 2009, p. 3; Scott et al. 2007, p. 2) may also be a contributing factor of surf-related incidents, injury, and death, when the surf participant and/or the lifesaver is not able to see the inherent danger prevailing in the surf zone. Rip currents may, in some cases, act only as the final repository in the surf-zone, where a person’s body is located and/or rescued, after the actual drowning-related incident has occurred. Merely associating rip currents to rescue data, in itself, does not prove causality, unless the time-sequence can be proved. For example, Matthew Barclay’s body was recovered the day after his death, some distance from the site of the incident. It was carried to this repository by the longshore, and rip currents that were present throughout the episode (Queensland Office of the State Coroner 2016, p. 31 item 181). These currents were not the cause of the drowning episode, as previously argued, even though they formed part of the overall drowning incident.

4.4.3.3 Causes of Coastal Drownings

Hooper and Hockings (2011, p. 399) reaffirmed the first World Congress on Drowning’s (World Heath Organisation 2002) definition of drowning as “The process of experiencing respiratory impairment from submersion/immersion in liquid”. The process normally
begins with the patient being under water. This is followed by breath-holding, panic, swallowing of water, aspiration, laryngospasm and, finally, unconsciousness. The process is not linearly sequential. However, many of these dimensions are present at some stage in the drowning process. Thus, for example, panic and breath holding, may occur before emersion or again thereafter. Hooper and Hockings (2011) list the major contributing factors to drowning in open water as currents, rips, waves, and cold-water temperatures. Their list is not necessarily complete, although they do separate rip currents from other surf-zone currents.

An epidemiological study by Lindholm and Steensberg (2000, p. 29) of drownings and near-drownings in Denmark in 1995 supported the view on the obscurity of the drowning process in their comment that “Little is known of the overall pattern of water immersion incidents and cases of near-drowning”. Their research provides a medical perspective to the argument that drowning may be caused by multiple factors besides rip currents alone. Hooper and Hockings (2011) emphasised the contribution that panic, breath holding, and water swallowing play in the drowning process. Avramidis, Butterly and Llewellyn (2009) support the viewpoint that the drowning process involves a greater number and type of contributing environmental input risk factors other than rip currents alone, a view which is also supported by Scott et al. (2007). These contributory factors need not necessarily be ‘natural’ environmental factors, such as is the case when injury occurs when a participant collides with an out-of-control craft or flotsam. Nonetheless, the literature persistently focuses on research that relates drownings to rip currents.\(^9\)

In recent years various researchers, in association with SLSA, have undertaken retrospective epidemiological reviews of coastal drownings using the SLSA *SurfGuard* database (Surf Life Saving Australia 2015e). Among them is the work of Sherker, Brighton and Thompson (2012), who concluded that 42% of all drowning deaths involved rip currents. However, they did not account for other possible surf-zone factors that may have contributed to this percentage. They also did not make a detailed account of the factors that contributed to the remaining 58% of drowning deaths. Specifically, no definitional distinction was made between rip currents and alongshore currents as contributing hazard factors.

Based on their findings, Sherker, Brighton and Thompson (2012, p. 134) proposed that the Australian Water Safety Strategy 2008-2011 aspirational coastal drowning death rate target of 0.27 per 100,000 population (Australian Water Safety Council 2008, p. 7) would not be achieved by 2020. This rate is the 50% aspirational target, which is included in SLSA’s mission statement on its website (Surf Life Saving Australia 2017c). The SLSA National Coastal Safety Report 2017 (Surf Life Saving Australia 2017b, p. 34) states that the coastal drowning death rate in 2017 was 0.44 per 100,000 population. Significantly, the trend of this death rate continues to be monotonically increasing, which indicates that the proposition by Sherker, Brighton and Thompson (2012), that is, that the coastal drowning death rate will not reach the desired 50% target by 2020, appears most likely. The authors recommended an intensified education program, which focusses on rip currents, to improve public safety and surf risk-management. SLSA continually promote this rip current theme in their annual reports and public campaigns (Surf Life Saving Australia 2010, 2011, 2012a, 2013a, 2014a, 2015a, 2016, 2017e), with little attention being paid to other contributing surf-factors to overall hazardousness. This remains a dilemma for SLSA’s ongoing risk-management policy and practice.
Brighton et al. (2013) acknowledged that the rescue/drowning statistics recorded in databases such as *SurfGuard* were not accurate, owing to “logistical difficulties” (2013, 1069), which included definitional and operational recoding inconsistencies. These affected “reliable estimates of rip current drowning deaths” (2013, p. 1069). They stated that volunteer lifesavers simply logged data into *SurfGuard* as a rescue “without information given relating to the actual cause, so the amount of total rescues directly related to rip currents is impossible to ascertain” (2013, p. 1073). They also compared evidence, which was often anecdotally compiled and reported by Sherker et al. (2008) and Brander and MacMahan (2011), with evidence compiled during their study. The authors concluded that these prior studies relating the number of rescues due to rip currents was “largely speculative” (2013, p. 1073), effectively acknowledging the potential for measurement error. It could be argued that risk-management policies and practices, which are based on these speculative figures, could lack significant and robust supporting evidence.

Referring to overseas research by Gensini and Ashley (2010), Brighton et al. (2013) also drew attention to the inappropriate use of retrospective data in the prediction of accurate drowning statistics. Brighton et al. suggested (2013, p. 1070) that this might affect policy, funding, and education decisions. A review of the above major rip current, predominantly retrospective research, within and outside Australia, provides support for this position. Furthermore, as demonstrated above, research designs, which predominantly focus on historical rip-current rescue data, provide structural opportunity for incorrect analysis and interpretation.
4.4.3.4 Other Surf-related Injury Types

Although drowning is recognised as the major contributor to surf-related deaths, there are other injury and incident types that also need to be accounted for in the surf environment. Many injuries incurred while surfboard riding, for example, have the potential for a serious outcome. A collision with one’s own, or another craft, may be fatal if it results in damage to vital organs. Research by Nathanson, Haynes and Galanis (2002) involving the causes of surfing injuries from a surfer-reported survey with a sample size of 1,348 found that 55% of these injuries resulted from contact with one’s own craft; 12% from contact with another craft; and 17% from contact with the sea floor. Lacerations (42%), contusions (13%), sprains (12%), and fractures (8%) accounted for the majority of injury outcomes (2002, p. 155). Consistent with the results of this study is the observation by SLSA in its 2015 PPE report regarding other injury types experienced in the surf zone. SLSA reported that “it should be noted that the risk of collision, exhaustion, spinal injury, and shallow water blackout are increased exponentially during hazardous surf conditions” (Surf Life Saving Australia 2015d, p. 15). In the same report, SLSA also acknowledge the presence of other causal factors in drowning aside from rip currents, while justifying their new approach to the use of personal protection equipment in heightened risk surf conditions. SLSA specifically reported on the 2014 drowning death of a US lifeguard, who was hit by a large wave and failed to resurface (2015d, p. 33). This was a very similar circumstance to that involving the drowning of Matthew Barclay, as previously cited.

Further examples of the impact of adverse surf conditions on the incidence of other injury types besides drowning include the following accounts. In the days before the death of Saxon Bird, several competitors were taken to hospital as a precautionary measure to assess spinal injuries, which had been incurred during competition (Queensland Office of...
the State Coroner 2011, p. 16). A UK study by Hay, Barton and Sulkin (2009) reported that a significant proportion of surfing injuries presented to Cornwall District Hospital as a result of surfing incidents consisted of fractures to upper and lower limbs, sprains to neck and back, and shoulder dislocations. They recommended education and the wearing of headwear as a preventative measure against these types of injuries. The risk of injury by a variety of dangerous hazards, applies to recreational surfers, public bathers, and surf lifesaving competitors alike. This viewpoint is supported by Weir and Sherker (2012) from SLSA.

In its Guidelines for Safe Recreational Water Environments, the World Health Organisation (2003, p. 6) state that “Drowning and spinal injury are severe health outcomes of great concern to public health”. Recent Australian newspaper articles have also reported on surf-related spinal injuries and deaths occurring between 2010 and 2017. They include the deaths on Gold Coast beaches of surfers from spinal injuries (Australian Broadcasting Corporation 2016; Gold Coast Bulletin 2017), and the high number of neck and spinal injuries reported on the Gold Coast between 2010 and 2018 (Branco 2016; Ramsey 2018), the Sunshine Coast (Sunshine Coast Daily 2016), and in Sydney (Bloor 2017). These media reports provide evidence of community concern with other injury types besides drowning. The injuries resulted from participant interaction with varying surf conditions on different days, at different beaches, and with varying levels of perceived danger. According to SLSA’s Beachsafe website (Surf Life Saving Australia 1990b) and the Coastsafe website (Surf Life Saving Australia 2009a), these incidents occurred on beaches with different beach morphologies and levels of perceived danger (for further information on morphologic beach states, see Section 4.5).
These media reports widen the debate, not only on the categorisation of major injury types occurring within the surf environment, but also on the external factors that contribute to those injuries. They may also shift the conversation away from being ‘drowning-only’ and ‘rip-only’ focused to become more comprehensive of the surf environment and participant types. Such a debate would have the effect of also shifting the focus of risk-management strategies and policy, to be more inclusive of the prevention of other injury types. These reports provide further evidence for the need for a different approach to surf-zone risk-management.

4.4.4 Modern Rip Current Models

Several rip current models have been proposed since the early 1990s to predict the occurrence and severity of the rip-current phenomenon as a proxy for predicting the risk of drowning. These authors have focused their investigations on rip-current prediction, and beach safety. However, their models make no distinction between current flows, normal or parallel to the shoreline, suggesting methodologic weakness, as discussed previously.

Lushine (1991) developed a rip current forecasting model, which is used by the United States’ National Weather Service (National Oceanographic and Atmospheric Administration 1970). The original LURCS model, which was an acronym for LUshine Rip Current Scale, correlated rip currents and associated fatalities against wind speed and direction, and tidal behaviour (1991, p. 14). The model quantified the threat of drowning owing to rip-current presence via a three-point scale. However, the model did not include wave height as a variable because the study indicated that rip currents were also present “in the absence of swells” (1991, p. 14), and because it was determined that wave height

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was directly related to wind speed. The model was based on historical rip-rescue incident data, which had been collected on the Florida’s South East coast, in the United States, between 1979 and 1988. The collection time-period ranged from 3 hours to 33 days after a rip-present episode, which could last from one to 36 days. The model showed good medium-term predictability, although the possibility of model signal-weakness was acknowledged because the data was only collected when “a drowning or rescue occurred” (1991, p. 19). This comment echoes the caution by multiple authors, as discussed in Sections 4.4.3.1 and 4.4.3.2, of the need for predictive model development to assure against the occurrence of variable confounding. The study by Lushine (1991) also recognised that model generalisability had not been proved because all historical data had only been collected in a limited coastal-beach region.

Research by Lascody (1998), using the LURCS model, found a strong relationship between ocean swell-height and period, and rip-current formation. The model was again based on historical data, collected between 1986 and 1996 from the East Central Coast of Florida. Engle et al. (2002) further modified the LURCS model to include wave-directionality (incidence). Using lifeguard observational data from the same East Central Florida region, the Engle (2002) study found a strong relationship between rip-current formation and shore-normal wave-incidence. Another study by Schrader (2004) evaluated the LURCS model using rip current data from Volusia County and the Florida Panhandle. Schrader found good model signal detection, and was able to predict rip current events on a majority of days containing rescues, and non-rip events on days without rescues. However, he noted that data from the Florida Panhandle showed a reduced accuracy under similar conditions to that from Volusia County. He posited that surf conditions at different locations had their “own range of key parameters” and that the existing model variables
“could not be used accurately to predict the rip-current threat in different locales” (2004, pp. xi-xii).

These studies indicate that rip-current, ocean-based wave height and direction, wind speed and direction, and tidal variables do not completely account for rip current rescues. It also demonstrates that the various forms of the LURCS model have spatial deficiencies. These deficiencies lead to a limited understanding of the comprehensive nature of the surf-dynamic and its effect on potential surf-zone injuries and drownings. Several later studies support this argument. Gensini and Ashley (2010), for example, linked rip-related fatalities to other meteorological conditions, and found that most deaths occurred when onshore winds were prevalent. Gensini and Ashley (2010) also argued that these deficiencies and limited understandings led to the implementation of sub-optimal risk-management strategies, owing to the lack of holistic appreciation and insufficient research into other contributing phenomena. Research by Lee et al. (2013), involving beaches in South Korea, reported that the LURCS-related models are subject to spatial variants, while Kumar and Prasad’s 2014 study of beaches in Southeast India stressed that “local conditions dictate rip current occurrence”, and that these (LURCS) rip-current models “needed to be locally calibrated” (2014, p. 314). These studies raise doubts regarding the generalisability of the LURCS model.

Recent research by Reinhart and Pfaff (2016) built on a previous study by Dusek and Seim (2013) to enhance the development of a probablist rip-current LURCS-related forecast model. Reinhart and Pfaff (2016, p. 4) argued that earlier versions of the LURCS model, which had taken into account factors such as wave height, wave incidence, wind speed and direction, and tidal variations, had signalled many “false alarms”, owing to application of the model over too large a surf zone area. Reinhart and Pfaff (2016, p. 4) posited that
earlier models placed too high an emphasis on wind speed and direction, without sufficient attention to “local wave characteristics”. The Reinhart and Pfaff (2016) study analysed observation-based data, which was collected from lifeguards along a single long-beach in North Carolina, USA from 2000 to 2004. The study concluded, that for this beach, wave height and direction were the most significant factors influencing rip-current activity (2016, p. 15). The authors recognised that whole-of-beach models were likely to be unrepresentative of localised rip current threats due to high variation in “shoreline orientation” to wave direction (2016, p. 2). This suggested that whole-of-beach models may require additional fine tuning of localised surf zone and beach morphology in order to gain greater accuracy. They acknowledged that many factors such as water level data, how tides modulated rip-current activity, local bathymetry, and coast-line orientations all have the potential to affect rip-current activity, but these factors were not investigated in their study.

In summary, the rip current models, which have been reviewed above, continue to focus research on rip currents as a proxy for overall surf-zone-hazard identification and forecasting. All models restricted data collection to a single beach or beach-region, indicating lack of model generalisability. These models tend to forecast whole-of-beach, rather than localised rip-current activity, over at least a day-to-day timeframe. Furthermore, because only rip-current-incident data was used as a validator against a limited number of surf zone phenomena, a comprehensive real time surf hazard model involving other injury types, such as spinal and neck injuries, as referred to earlier in this chapter, is yet to explain such occurrences.
4.5 A Morphodynamic Approach to Beach Hazard Identification

Major nearshore research along the Australian coastline has been undertaken by Short since 1979. In association with colleagues, his studies in coastal morphodynamics, in Australia and abroad, comprise over 160 scholarly works and have garnered 6,600 citations, predominantly involving beach states and coastal risk management. The 2002 World Congress on Drowning Prevention, which was convened in collaboration with the International Life Saving Federation (Bierens 2006, p. xii), and with the support of the World Health Organisation (2006, p. xi), recognised Short’s significant contribution to coastal-science research, by recommending that his beach-risk-management model, known as the Beach Hazard Rating, be regarded “as a basis for developing a worldwide standard for the evaluation of hazard presented at beaches and for developing appropriate drowning prevention strategies” (Bierens 2006, p. 139).

Short separately,11 and in collaboration with significant authors,12 progressively classified beach types throughout Australia. This research contributed to the development in 1990, of the Australian Beach Safety and Management Program, commonly known as ABSAMP (Surf Life Saving Australia 1990a), which was based on this morphodynamic approach to beach hazard assessment, and will be discussed later in this chapter. Research by Short and colleagues, which is significant to this case study, include the following.

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12 Including Wright (Short & Wright 1981, 1984; Wright & Short 1984; Wright et al. 1987; Wright, Short & Green 1985); Hogan (Short & Hogan 1994; Short, Williamson & Hogan 1993); Masselink (Scott et al. 2007; Short & Masselink 1999); Brander (Brander, Cowell & Short 2001; Brander & Short 2000, 2001; Short & Brander 1999); and others (Short & Aagaard 1993; Short & Hesp 1982; Short & Trenaman 1992; Thom & Short 2006); and recently Weir (Short & Weir 2016).
4.5.1 Wright and Short

Seminal amongst Short’s scholarly works is the research in association with Wright (Wright & Short 1984) that investigated the morphodynamic variability of the surf zone. This study was based on field studies, predominantly on seven coastal beaches in New South Wales, and one beach from each of the states of Victoria, South Australia and Western Australia between 1979 and 1982. Wright and Short noted that surf conditions were dramatically different, both temporally and spatially, and involved dimensions of depositional morphology and hydrodynamic behaviour. They classified six “modal, or most recurrent” (1984, p. 94) beach states (or structures), ranging from a dissipative beach state through several intermediate states, and on to a reflective beach state. The beach states depended on morphodynamic features, including tidal flows, seabed topography, and variations in potential wave-fields and environmental conditions (1984, p. 106). The study acknowledged that predicting beach-state changes was complex, and that little confidence could be found in laboratory experiments attempting to simplify this process.

A dimensionless parameter, $\Omega$, was defined as being a function of average breaker-wave-height, wave-period, and sediment fall velocity variables (1984, p. 108). This parameter was used to identify thresholds for each beach state, which were moderated by temporal variability. The authors identified a variety of rip-current and alongshore-current formations, which depended on beach state. For example, they concluded that for a given average breaker height, the strongest rips and feeder currents were associated with “intermediate transverse bar and rip topographies” (1984, p. 93).

The authors concluded that “over the long term a given beach will tend exhibit a modal or most frequently recurrent state which depends on the environment” (1984, p. 106). The 1984 study formed the genesis of later research by Short over ensuing decades, which
focused on coastal dynamics using this morphological approach. His studies on beach states and consequent rip-current hazard-development, provided a benchmark-approach to surf zone investigations and risk management in Australia, and abroad.

4.5.2 Short and Hogan (1994)

In their research into risk management practices of rip currents and beach hazards, Short and Hogan (1994) used the Wright and Short (1984) beach model to create a Beach Safety Rating for wave-dominated beaches (1994, p. 202). This rating applied to the “entire beach system” (1994, p. 205). The model was amended in 1996 by Short to accommodate for wind effects (Short 1996a), and expanded in that same year to include tide-modified, and tide-dominated beaches (1996b). For a given beach, the rating was combined with the level of public beach usage to determine a whole-of-beach risk level. The authors identified four dimensions associated with beach usage. They included that: any beach was a recreational and tourist resource; ocean beaches and their surf zones were “inherently hazardous” (1994, p. 197); public risk would increase as public usage increased; and, finally, that responses to this risk would involve a rescue authority in some capacity. They found that beach hazards had been traditionally associated with damage to structures, property and the environment, with little attention paid to the risk of injury to surf participants. Rip currents, being “generally considered the most hazardous part of the surf zone” (1994, p. 198), formed the central role in the identification and management of surf-zone hazards. Their review of historical records found that 89% of rescues on the beaches within their study occurred in rips, with 70% being at low tide (1994, p. 202). The analysis of rip-rescue data did not distinguish between shore-normal and alongshore current flows.

Short and Hogan (1994) also identified other physical beach characteristics, such as water depth, breaking wave height and direction, tidal state, beach slope, and sediment grain
size; and localised hazards such as reefs, rocks and offshore wind, which contributed to the complex dynamic associated with the surf environment. Significantly, they did not mention the effects of wave type, wave period, surface turbulence, surf zone width, or surf craft, on the risk of injury within this zone. The surf environment contains multiple characteristics, which often interact and lead to injury. Many surf-related processes, such as wave fields, wind effects, rip and alongshore-current flows, and beach bathymetry, are difficult to model because of the complexity of the variables involved in the physical processes of formation, and the sophistication of the technology required to collect significant samples. The complexity of variable-interaction is evident in the literature in terms of conflict in model explanation (Cavaleri et al. 2007), or in published results, as demonstrated in the following example.

Short and Hogan (1994, p. 204) claimed that their experiments indicated that “actual wave height” had “no apparent impact” on rip-current velocity, whereas research by MacMahan, Thornton and Reniers (2006, p. 206) provide evidence for the opposite conclusion, stating that “rip current velocities increased with increasing wave height and decreasing water depth”. Yet these surf-zone phenomena play an integral role in surf-related injuries, as previously argued. Modal or average, process-driven models can be useful for medium and long-term coastal risk-management, as is recognised in the literature (Cervantes et al. 2015; Hartmann, Daniel 2006; Hartmann, D, Pick & Segal 2009; Sherker et al. 2008; Short & Hogan 1994; Sutherland, Peet & Soulsby 2004). However, the temporal and spatial variation of these models does not provide sufficient accuracy to predict the risk of injury in real time at a particular area on the beach, as is required for the suitable management of multiple surf lifesaving events, such as during the Australian Surf Lifesaving Championships.
4.5.2.1 The Need for a Surf Hazard Model: the Expert versus Public Perception

Short and Hogan (1994) observed that the availability of quantifiable surf hazard models had “lagged far behind their impact on the bathing public”. In the development of their Beach Safety Rating, which involved wave height and beach state, they made comment on factors, which may contribute to an ‘accident’ (that is, surf-related injury). The authors, in support of their morphodynamic and rip-current approach to beach risk-management, suggested that terms, which were frequently used by the media to describe surf zone hazards, were “catchy and alarmist” (1994, p. 198), rather than objectively describing the underlying scientific process. They suggested that terms such as “freak waves, collapsing sand bars, undertows and the like…. may have little relevance to the actual circumstances that contributed to the accident” (1994, p. 198).

In contrast, the 2012 scholarly work by Leatherman argues that the general public interpret potentially dangerous surf-zone processes that they do not understand, in more emotive, and less scientific or objective terms, but which nonetheless are still important to consider. This emotive and less scientific, opinion and terminology, is often conveyed in the reporting of surf-related incidents by the media. This divergence in the perception of risk between experts and the general public, has previously been argued (Section 2.8.1), and supported by Slovic (2001), Slovic and Weber (2002), and Boholm and Corvellec (2011). Leatherman (2012) provides evidence of this divergence of opinion, by considering the varying interpretations of current flows within the surf zone. He suggests (2012, p. iv) that the general public use terms such as ‘undertow’, and ‘riptide’ to emotively express their safety concerns for these little-understood surf-zone currents, but which, for them, better reflect “their real-life experiences at surf beaches” (2012, p. iii). Using a similar approach, the term ‘freak wave[s]’, which Short and Hogan (1994) also classified as an alarmist
term, could be interpreted as an emotive term, used by the public to classify a ‘rogue wave’ (Cavaleri et al. 2007), as discussed above (Section 4.3.2). For the public, a rogue wave is the wave that they do not expect, and has potentially dangerous implications. In contrast, the expert perceives this type of wave-event in terms of probability of outcome, such as $H_{1/100}$ (Caldwell & Aucan 2007), or a one in 3,000 wave-event (Australian Government Bureau of Meteorology 2012).

Leatherman (2012) further adds that coastal professionals have attempted to remove from the public discourse, reference to emotive terms, such as those mentioned above, “with little to no success” (2012, p. iv), and that such attempts have “led to some beachgoers to discount important information on surf zone dynamics provided by coastal scientists” (2012, p. iv). The critical point of the argument is that the fears and concerns of the public, as primary stakeholders, regarding these risks must be considered and acted upon by responsible coastal water-safety authorities such as SLSA, if they are to retain legitimacy, community trust, and confidence. With respect to the evidence provided by Short and Hogan (1994) and Leatherman (2012), it would be reasonable to expect that an efficient surf hazard model should convey to the public, and in particular for this research study involving surf lifesaving competitors, the dangers associated with the whole-of-surf-environment in a manner that is both scientifically rigorous and easily interpreted.

4.5.2.2 The Beach Hazard Rating

Short and Hogan’s Beach Safety Rating (1994, p. 198), which later became the Beach Hazard Rating (Short 1999, p. 299), is a model based on six morphological beach states (see Figure 4.1 below). These ratings range from a low safety rating of 2 for a ‘Reflective’ beach state, up to a low safety rating of 4 for a modal ‘Dissipative’ state. All values are able to be modified by considering the ‘prevailing’ wave height and beach state “on the
day” (1994, p. 199), to arrive at a ‘prevailing safety rating’ for each beach, which could be as high as 10. Their analysis comprised the application of the results from previous studies (Short & Hogan 1990), which related beach states with historical rescue statistics, and rip occurrences on 721 coastal beaches in NSW.

Figure 4.1 The Beach Hazard Rating Model
Source: Short & Weir 2016, p. 57

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Reference was made to an unpublished study by Power (1992), which “was able to quantitatively identify the beach characteristics and their thresholds that place particular bather groups at risk (e.g., increasing water depth, current velocity and wave height)” (Short & Hogan 1994, p. 199). However, the study by Power (1992) could not be sourced and is therefore unavailable for verification.
Short and Hogan (1994) reviewed, on average, 25 aerial photographs on each beach over a 63-year period. This data was summarised to give a “mean and standard deviation” (1994, p. 199) measure of the beach state over this whole period. The authors also referred to other data sources including wave height, local hazard identification and recordings by lifesavers, and a “modal wave height for each beach using wave rider data” (1994, p. 199). Wave Rider buoys (New South Wales Government 2017b) record nearshore ocean wave information, including the Significant Wave Height (see Section 4.3.1), at seven sites along the entire 1,720km NSW coastline (1994, p. 199). This data takes the form of a wave height ‘average’ that summarises wave height over large nearshore ocean zones. They stated that this information was combined with local hazards and the “modal beach state” (1994, p. 199) to determine a safety rating for each beach.

Critical to the determination of this beach safety rating, is the apparent inconsistency of the use of the data-summary terms for ‘average’ (or mean), and ‘modal’ (or mode), to describe each beach state and wave height, and the confusion that it causes in the understanding of the model. This inconsistency persists in Short’s 1999 research on Beach Hazards and Safety (Short 1999), where he states that “each beach could be rated for its average or modal conditions” (1999, pp. 299-300). Short defines the modal hazard rating as a function of beach type and modal wave height, and the prevailing hazard rating, as a function of beach type, prevailing wave height, and local and regional hazards, depending on “day-to-day prevailing conditions” (1999, p. 299). It is rational to imply that prevailing ratings referred to day-to-day variance of the longer-term (average or modal) rating values.

Sutherland, Peet and Soulsby (2004), in their evaluation of numeric coastal morphological models, dismiss the contribution of the mode as an unnecessary measure of reliability and bias, preferring instead the mean (average) or median. They state that the mode is “not worth considering” (2004, p. 918).
Short and Hogan (1994) argued that, based on their research, coastal authorities could utilise a model such as the Beach Hazard Rating to permit “proactive beach management practices” (1994, p. 207), and “in coastal policy to mitigate against contributing to or increasing public beach risk” (1994, p. 209), thereby assisting in the process of allocation of resources where needed. Given the uncertainty in definitional precision, and the limited number of predictor variables, it could be argued that Short’s beach safety ratings could more easily be applied to medium to long-term forecasting models, compared with real time, site-specific surf hazard prediction.

4.5.3 Short and Weir

Short and Weir (2016) presented research on beach types, hazards and risk assessment in the text, *The Science of Lifeguarding* (Tipton & Wooler 2016). The authors re-affirmed the significance of studies from previous decades by Short and colleagues, as detailed above, which rated surf zone hazards predominantly from a wave-height and beach-state perspective. They identified active beach hazard variables as breaking waves, wave set-up and set-down, surf zone currents, and especially rip and tidal currents; water temperature and pollution; and biological hazards (2016, p. 55). They argued that some active hazards, such as rip currents, were able to be identified, mapped, and measured accurately by experienced observers, whereas other ‘passive’ variables, such as water depth, troughs and sandbars, were “difficult to see let alone predict” (Short & Weir 2016, p. 53).

Short and Weir (2016, p. 58) also re-affirmed that Short’s Beach Hazard Rating model, was the most effective hazard assessment system for Australian beaches, and had been adopted by the 2002 World Congress on Drowning, as a world standard for risk model development. Short’s Beach Hazard Rating model (2016, p. 57), displayed above as Figure 4.1, provides a guide to a beach’s relative safety in association with its physical
Short and Weir (2016) continued to present definitional inconsistencies and confusion, evident in Short’s previous studies, by interchanging the use of mode and average when referring to Short’s Beach Hazard Rating. They refer to the “modal beach hazard rating” as being “associated with a beach state during typical (or modal) wave conditions” (2016, p. 56). At the conclusion of their discourse on this hazard model, they then refer to the “modal hazard rating” being used to rate all Australian beaches “under their average conditions” (2016, p. 56). Later, in the subtext to Figure 4.1 above, they refer to the use of the “average wave height” to determine the “average hazard rating” (Short & Weir 2016, p. 57). Despite this definitional inconsistency, the Short’s Beach Hazard Rating is recognised as an essential component of any beach risk-management evaluation (Bierens 2006, p. 139).

Short and Weir (2016) provide further evidence of the value of Short’s Beach Hazard Rating model by referring to its inclusion in the Australian Beach Safety and Management Program (ABSAMP) database (Surf Life Saving Australia 1990a), which aims to assess the nature and level of hazards on “all Australian beaches under average conditions” (Short & Weir 2016, p. 56). The ABSAMP database provides information on more than 11,000 Australian open-coast beaches. ABSAMP was developed by Short in partnership with SLSA (Surf Life Saving Australia 1990a), and the Australian Government (Australian Government 2017b; Masselink & Short 1993). The database comprises beach location, including its physical characteristics, access, facilities, and usage. It also advises beach-
users of the number of rescues, physical and biological hazards, and level of public risk under various wave, tide and weather conditions that could be expected at each beach on a daily basis (Surf Life Saving Australia 1990a). Authoritive groups use this database to provide marine and coastal information via websites throughout Australia. These sites include: Geoscience Australia (Australian Government 2017a, 2017e), which provides comprehensive scientific information regarding Australia’s coasts and estuaries, seabed mapping and Antarctica; Beachsafe (Surf Life Saving Australia 1990b), which provides coastal safety information for the general public; and Coastsafe (Surf Life Saving Australia 2009a), which has been adapted to service professional lifeguards, lifesavers and tourist operators. The SLSA websites primarily emphasise the importance of rip current awareness above all other surf related features. As mentioned in Section 3.8, an iPad surf-risk-assessment model (Surf Life Saving Australia 2012b), which was based on the Short’s research, was used by SLSA decision makers at the Australian Surf Lifesaving Championships in 2012, when Matthew Barclay was killed (Queensland Office of the State Coroner 2016, pp. 24, 33).

Through websites and smartphone applications such as Geoscience Australia, Beachsafe, and Coastsafe, ABSAMP, which is underpinned by Short’s Beach Hazard Rating model, remains the most effective Australian database for medium to long-term coastal risk-management, based on ‘average or modal’ morphodynamic conditions.

4.6 Chapter Summary

This chapter has reviewed the development of inshore risk models, from their origins in ocean wave theory, including Airy Wave Theory, Stokes’ Theory, and Solitary Wave Theory, through to modern rip-current-focussed models, applying breaker-wave equations based on Significant Wave Height. The reviewed literature has highlighted the complexity
of the wind-wave interface, especially as it relates to this study, for the surf zone.

According to Cavaleri et al. (2007, p. 661), existing models cannot “routinely evaluate the exact result” of wind-wave interactions, providing opportunity to investigate other models as they relate to the coastal shallow water environment.

Recent surf-risk management research has focussed on rip currents as a proxy for all-of-beach hazards. This is because these phenomena dominate worldwide surf-rescue and drowning statistics. Lushine’s rip current predictive model, which was developed in association with the United States’ National Weather Service (National Oceanographic and Atmospheric Administration 1970) using retrospective rip-rescue data, is physical-process-based, and capable of forecasting rip-current occurrence on a medium to long-term time scale, with limited spatial generalisability. Furthermore, it has been demonstrated that rip-current rescue strategies, which focus on rip-current modelling, are often contradictory, owing to definitional and data analysis weaknesses, and form only part of a comprehensive surf-risk-management framework.

A review of the research by Short and colleagues support the view that Short’s Beach Hazard Rating model, which also uses rip-current rescue statistics to model beach danger against average wave height and morphodynamic beach types, is suitable for predictive purposes on a daily or longer timeframe. The model, which is endorsed by the World Health Organisation (Bierens 2006, p. 139), underpins SLSA’s ABSAMP surf hazard database and surf-risk-management practices for surf lifesaving carnivals throughout Australia. However, the model contains inconsistencies when referring to the modal and/or average wave height, and prevailing-condition-variables. Like the Lushine model, it does not sufficiently explain all surf-injury incidents as they relate to all-of-surf-zone phenomena in real time. The theory underpinning Short’s model was also used to assess
surf conditions when Matthew Barclay died during competing in the Australian Surf Lifesaving Championships in 2012.

It is therefore justifiable, from an all-of-surf-zone, as opposed to a rip-current perspective, to seek an alternative risk-management model, which more comprehensively models the surf-zone dynamic in real time, as it relates to multiple incident and injury types. This author proposes such a model, called the Surf Hazard Rating (SHR). The research, on which this model is based, utilises an observational framework to develop a model, in the tradition of the research undertaken by Walter Munk. It employs, primarily, seven measurable surf characteristics to quantify their hazardous ‘effect’, rather than using the inherent physical ‘processes’ associated with those characteristics, as proxies to explain surf danger.

The empirical study investigates the development of the SHR model, using prospectively acquired incident-data to validate the model, to describe the danger associated with the complexity of surf-variable relationships in real time. The author argues that this methodology achieves greater model parsimony, when summarising all-of-surf danger, than models based on historic rip-rescue and/or morphologic beach-state data as discussed above. The SHR model accomplishes this by accounting for all previously cited models’ variables, as well as by extending the summary of the surf-zone dynamic, by including several other difficult-to-model surf-zone phenomena, particularly in terms of the construct of their ‘dangerous effect’ on surf participants in real time. This study will demonstrate that the SHR model has already provided an objective and quantifiable tool, which SLSA on-beach risk managers have applied to make decisions regarding competitor surf-safety within five to ten minute timeframes, as opposed to the longer-term models herein.
reviewed. A discussion of the methodology involved in the development of this model is
detailed in the following chapter.
Chapter 5  Research Design

5.1  Overview

This chapter details the particular methods employed to develop and test the Surf Hazard Rating (SHR) model as a tool to assist surf-risk managers make decisions in real time. The chapter introduces the original conceptual model, and the variations to this model, which were based on a 2012/13 Pilot Study (Appendix I). The chapter provides a theoretical discussion of the SHR variables, which were developed during the research’s main empirical study period from 2013 to 2015. It presents the process by which information was collected to assess the model’s validity and evaluation, as Phases I, II, and III (see Figure 5.2 below). These phases comprise the collection of surfboat-competition\textsuperscript{14} incident-data, carnival officials’ opinions of the dangerous nature of surf conditions during those competitions, and a real-time application of the model by SLSA managers to identify and mitigate surf-risk. The research design includes those participants, tools, material, and

\textsuperscript{14} A surfboat is a craft of approximate dimensions 7.9m by 6.9m. It is constructed mainly of foam-sandwiched fibreglass. The crew consists of four rowers and one ‘sweep’ who is also the captain of the craft.

![Figure 5.1 A Typical Surfboat during Competition](image)

Source: The Author
Theoretical SHR Model


Phase I: Model Validation (2013/14)
- Race-Specific SHR versus Incidents
- Overall Carnival-Referees’ Opinions

Phase II: Model Evaluation (2014/15)
- Prevailing SHR versus Incidents
- Overall Carnival-Referees’ Opinions

Phase III: Model Operationalisation (2014/15)
- Real-time SHR model Implementation

Results and Discussion (Chapter 6)

Figure 5.2  Research Methodology Flowchart
This case study utilises a mixed methods approach to validate the efficacy of the *Surf Hazard Rating* model. The research predominantly draws on the analysis of quantitative data, and is supported by qualitative input continually recorded throughout the data collection process. The methodology includes those protocols and methods, recognised by scholarly works, such as Yin (2018), Cook & Campbell (1979), and DeWalt & DeWalt (2011), as essential aspects of case study research, and noted in the introduction to Chapter 1. The evidence supporting this claim is further documented in the extensive publication titled “SLSA Personal Protective Equipment (PPE) Project” (Surf Life Saving Australia 2015d). The detailed report by this author contained within Appendices 8 and 9 of the aforementioned document, attests to adherence to these protocols and methods throughout the data collection process from 2013 to 2015. Phase III of the research methodology describes the results of the implantation of the model as a decision-making tool in real time. The reference to the SLSA PPE report (Surf Life Saving Australia 2015d, Appendix 9, pp. 46-53,) details the transcribed field notes and personal observations recorded during this phase of the research.

Specifically, the research design acquired the necessary evidence, drawn from those sources defined by Yin (2018, pp. 113-26) as (i) Documentation; (ii) Archival Records; (iii) Interviews; (iv) Direct Observation; (v) Participant Observation; and (vi) Physical Artefacts. As detailed in Section 5.5.3 of this study, quantitative data was collected by independent, trained personnel, by tabulation of surfboat incidents, and calculation of a relevant *Surf Hazard Rating*. The qualitative data was acquired by the author through interviews and the recording of field notes and personal observations.
5.2 Towards the *Surf Hazard Rating* Model

The rip-current-related prediction and beach-hazard-rating models previously reviewed, including the LURCS model (Lushine 1991) and the Beach Hazard Rating model (Short & Hogan 1994), variously explain surf danger in terms of coastal physical ‘processes’. These models purport to measure outcomes mostly on an average-daily or longer-time-period basis – or as Short argues – also on a modal basis over these time frames (Short & Weir 2016, p. 56). The variables used to model these coastal processes include: wave height and direction; wind speed and direction; tidal variations; and beach morphologies. In contrast, the *Surf Hazard Rating* is posited to determine the construct of surf-danger in terms of an ‘effect-based’ composite index. This is achieved by using easily observable and measurable surf-zone features in real time, which are defined as Surf Hazard Descriptors (Surf Life Saving Australia 2015d, pp. 40-2, Appendix 8).

5.2.1 The Conceptual Competition Surf Safety Index Model

The initial theorised composite model developed before the thesis research began, called the *Competition Surf Safety Index* (de Mestre & McCoy 2012), quantified the theorised interaction between observable and measurable surf zone hazards, and surf participant competency. Pryor and Capra (Health and Safety Professionals Alliance 2012, p. 2) posit that a hazard is the source of risk, which is context- and circumstance-dependent, and, as previously described in Section 2.8.1, is associated with the uncertainty of human injury or ill-health (International Organization for Standardization 2009). The hazard component of the conceptual Competition Surf Safety Index, hereafter known as the Conceptual *Surf Hazard Rating*, which was used prior to this research study, initially modelled the level of surf-zone hazardousness using the variables of wave height, zone length, surface...
turbulence, littoral drift, a rocks and rip rating, and a beach-to-swell orientation rating (de Mestre & McCoy 2012, pp. 55-6).

During the surfing season 2012/13, the author conducted a pilot study with the assistance of SLSA (Appendix I) to determine the suitability of the theorised Conceptual Surf Hazard Rating to assess participant safety in surf lifesaving surfboat, surfboard, and surf-ski competitions. It used a heterogeneous sample of the target population for surf lifesaving competitions. The pilot study collected data from nineteen SLSA carnivals in Southeast Queensland and metropolitan Sydney, Australia, between January and April 2013 (see Table 5.1 below). It used a Mixed-Methods design to triangulate a richer explanation of the complexity of surf-zone factors that potentially affect participant-danger during competition. This comprised stakeholder interviews (face-to-face and by telephone), focus-group feedback, on-beach competitor and carnival-referee surveys, and quantitative model assessment using surfboat (‘Boat’), board, and ski (‘Craft’) incidents.

## Table 5.1 Summary of 2012/13 Pilot Study Carnival Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Venue</th>
<th>Categories</th>
<th>SHR Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/1/13</td>
<td>Palm Beach (NSW)</td>
<td>Craft</td>
<td>13-15</td>
</tr>
<tr>
<td>5/1/13</td>
<td>Palm Beach (NSW)</td>
<td>Boat</td>
<td>17</td>
</tr>
<tr>
<td>12/1/13</td>
<td>Tugun (Qld)</td>
<td>Boat</td>
<td>9-12</td>
</tr>
<tr>
<td>12/1/13</td>
<td>Broadbeach (Qld)</td>
<td>Craft</td>
<td>9-10</td>
</tr>
<tr>
<td>12/1/13</td>
<td>Wanda (NSW)</td>
<td>Craft</td>
<td>9-11</td>
</tr>
<tr>
<td>19/1/13</td>
<td>Coolum (Qld)</td>
<td>Boat</td>
<td>10-11</td>
</tr>
<tr>
<td>19/1/13</td>
<td>Manly (NSW)</td>
<td>Craft</td>
<td>6-7</td>
</tr>
<tr>
<td>26/1/13</td>
<td>Freshwater (NSW)</td>
<td>Craft</td>
<td>11-13</td>
</tr>
<tr>
<td>2/2/13</td>
<td>Coogee (NSW)</td>
<td>Craft</td>
<td>12</td>
</tr>
<tr>
<td>16/2/13</td>
<td>Wanda (NSW)</td>
<td>Craft</td>
<td>8-11</td>
</tr>
<tr>
<td>9/3/13</td>
<td>North Kirra (Qld)</td>
<td>Craft</td>
<td>16-17</td>
</tr>
<tr>
<td>22/3/13</td>
<td>Mooloolaba (Qld)</td>
<td>Craft</td>
<td>6</td>
</tr>
<tr>
<td>22/3/13</td>
<td>Maroochydore (Qld)</td>
<td>Boat</td>
<td>12-16</td>
</tr>
<tr>
<td>23/3/13</td>
<td>Maroochydore (Qld)</td>
<td>Boat</td>
<td>12-14</td>
</tr>
<tr>
<td>15/4/13</td>
<td>North Kirra (Qld)</td>
<td>Boat</td>
<td>15-17</td>
</tr>
<tr>
<td>16/4/13</td>
<td>North Kirra (Qld)</td>
<td>Boat</td>
<td>10</td>
</tr>
<tr>
<td>16/4/13</td>
<td>North Kirra (Qld)</td>
<td>Craft</td>
<td>9</td>
</tr>
<tr>
<td>17/4/13</td>
<td>North Kirra (Qld)</td>
<td>Craft</td>
<td>7-9</td>
</tr>
<tr>
<td>18/4/13</td>
<td>North Kirra (Qld)</td>
<td>Craft</td>
<td>6-8</td>
</tr>
</tbody>
</table>
The pilot study explored competitor and decision maker (i.e., carnival referees) perceptions of surf danger as measured against corresponding Conceptual Surf Hazard Rating values, which were calculated by this author using the original model, and based on observed prevailing surf phenomena. A focus group, consisting of elite surf lifesaving competitors, coaches, carnival officials, and senior executives from SLSA, State Surf Lifesaving organisations from around Australia, and the Australian Surf Rowers League\textsuperscript{15} (ASRL), reviewed the pilot study results. They provided final input on, and refinement to, variable selection, definition, and relative scale levels. Based on this input, a report of findings of the Surf Safety Index Pilot Study was presented to SLSA in July 2013 (Appendix I).

This author undertook the current empirical research study, based on this pilot study, with the assistance of SLSA, between 2013 and 2015. The research focussed on the development of a model, which summarises whole-of-surf danger in real time, and is hereafter called the Surf Hazard Rating (SHR). This current empirical research study, which is described in this chapter as Phases I, II, and III, was conducted in partnership with SLSA and the Australian Surf Rowers League (ASRL). The research during 2013/14 (Phase I) was undertaken as a project known as the Surf Hazard Rating and Surf Helmet (Surf Boats) Project, and in 2014/15 (Phases II and III), as a project known as the Surfboat Hazard Rating Trial 2015 (Surf Life Saving Australia 2015d, Appendices 8 and 9). Validation of this updated SHR model underpins the central theme of this current empirical research, using a case study involving SLSA surfboat competitions as an appropriate research vehicle. An explanation of the theorised variables comprising the SHR, which are used in this current empirical research, is detailed in the following section.

\textsuperscript{15} The Australian Surf Rowers League (2018) is recognised by SLSA as the association that represents all surfboat rowers and promotes surfboat-rowing competition in Australia and overseas.
A summary of this SHR model is presented in the publication of McCoy and de Mestre (2014).

5.2.2 The Theorised *Surf Hazard Rating* Variables

The following section provides the rationale for the creation of a construct of the dangerous effects of measurable natural environmental factors on surf participants, based on the findings of the abovementioned pilot study and focus-group feedback. This construct of surf danger is modelled as a composite index, known as the *Surf Hazard Rating* (SHR). In articulating the “theoretical concepts and their interactions”, this rationale satisfies the first of three necessary steps to determine construct validity (Clark & Watson 1995, p. 310). The articulation of “making clear what something is”, comprises the initial step in the theory of scientific proof of construct validity called the “nomological net” by Cronbach and Meehl (1955, p. 12). Put simply, construct validity tests the degree to which the construct actually measures what it is supposed to be measuring. For this empirical research study, this means testing the degree to which the *Surf Hazard Rating* model, as a construct, measures the dangerous effect of prevailing surf-zone conditions at a designated beach in real time.

To assess validity, it is necessary to determine definitional suitability of the SHR as a composite index, which accounts for all aspects of the construct of surf danger. A composite index is a convenient research model, which adequately accounts for the singular and interactive contributions of a variable within a complex structure (Nardo, Saisana, Saltelli, Tarantola, et al. 2005). The *Surf Hazard Rating* (SHR) is posited to be such a composite index given that it summarises the dangerous effects of complex physical interactions and coastal processes within the surf zone. Composite indices relate latent variables/constructs to their constituent multiple indicators to create operational tools for
decision makers in such diverse fields as finance, economics, medicine, sociology, and environmental research domains. Examples of indices used in these fields include the Air Quality Index (United States Environmental Protection Agency 2016); the Socio-Economic Indexes for Areas (Pink 2011); the Ultraviolet Radiation Index (Allinson et al. 2012; Koepke et al. 1998); the Forest Fire Danger Rating System (Tian et al. 2005); the Coastal Vulnerability Index (Thieler & Hammar-Klose 1999); the SF-36 Physical & Mental Health Summary Scales (Ware & Kosinski 2001); and the Perceived Control of Internal States Scale (Pallant 2000).

In a similar manner, the construct of surf danger, as related to multiple surf phenomena is theorised to be modelled using the following variables, which are defined and further described in Appendix II (TSO Training Manual\(^{16}\)), and McCoy and de Mestre (2014).

(i) Wave Height Rating (WHR)

<table>
<thead>
<tr>
<th>Wave Height (metres)</th>
<th>General Description</th>
<th>WHR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Knee High</td>
<td>0</td>
</tr>
<tr>
<td>Up to 0.5</td>
<td>Waist High</td>
<td>1</td>
</tr>
<tr>
<td>Up to 1.0</td>
<td>Head High</td>
<td>2</td>
</tr>
<tr>
<td>Up to 1.5</td>
<td>Overhead</td>
<td>3</td>
</tr>
<tr>
<td>Up to 2.0</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Up to 2.5</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Up to 3.0</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Up to 3.5</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Up to 4.0</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Up to 4.5</td>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>

The Wave Height Rating (WHR) scale is a measure of the danger associated with breaker-wave heights. The wave height is the vertical difference between the maximum and minimum water-surface elevations in front of the breaking-wave-position during the passage of one complete wave-cycle (Galvin 1971). The wave height, in association with the wave type (see below), is used as a proxy in this model to describe the dangerous effect of the energy produced by the wave at its position of breaking. The ordinal scale is a non-unitised measure of the danger associated with the inherent energy contained in waves of

---
\(^{16}\) TSO - Trained Surf Observer: see the definition below and the TSO Training Manual (Appendix II).
varying heights. It is not an expression of this energy using physical formulations and standard units of measure such as ‘Joules’ (Australian Government Department of Industry Innovation and Science 2018). Consistent with the research by Caldwell and Aucan (2007) into the accuracy of breaker-wave height estimation by experts, scale values of the WHR increase in 0.5-metre increments.

Based on the mean energy dissipation in random breaking wave fields in the shoaling process, Battjes and Janssen (1978, p. 576) reported that the wave energy, at point of breaking, is proportional to the square of the wave height. This is supported by Lekshmi and Sannasiraj (2007) in their studies of the correlation between breaking waves and energy dissipation. Part of this energy is released during the actual breaking process (2007, p. 307). The remaining energy dissipation occurs as the wave bore moves towards the shoreline, which, when crossing a sandbank, defines the white-water surf zone. However, as described in the previous chapter, the level of danger associated with this energy dissipation in the surf zone is neither described adequately, nor modelled in the literature (Cavaleri et al. 2007), even though attempts by authors such as Munk (1949) and Komar and Gaughan (1973) have formulated approximations for the physical-energy-dissipation process. The danger associated with the residual wave-energy after the wave-breaking process is measured in the SHR model by the zone-width and cross-wave variables, as described later. In the range of observation of wave-heights during this case study (0 to 4.5 metres), the danger associated with the non-linear increase in kinetic energy at the position of breaking, is accounted for by one-unit increments of the WHR scale for wave heights below 3 metres and thereafter by two units, up to 4.5 metres.
(ii) Wave Type Rating (WTR)

<table>
<thead>
<tr>
<th>Wave Type</th>
<th>Surging</th>
<th>Spilling</th>
<th>Plunging</th>
<th>Plunging with Back-Blasting</th>
</tr>
</thead>
<tbody>
<tr>
<td>WTR</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

The breaker wave-type, being a function of water depth (Komar & Gaughan 1973; Munk 1949), represents those surging, spilling and plunging wave shapes, previously described by Battjes (1974, p. 469). Lekshmi and Sannasiraj (2007, p. 307) investigated the relationship between the energy lost by breaking waves and wave type. They reported that ‘plunging’ waves lose up to 25% of their initial energy store at the position of breaking, whereas ‘spilling’ waves lose less than 10% of their stored energy. The WTR scale-values reflect this variation in potential danger to a surf participant, which is associated with a particular wave type. An additional wave type and scale, called ‘Plunging with Back-Blasting’ (McCoy & de Mestre 2014, p. 124), was created by this author, following a personal conversation with surfing legend Mr Bernard ‘Midget’ Farrelly AM in 2013 (B Farrelly 2013, pers. Comm., 21 July). It accounts for the added danger associated with extreme-type plunging waves in very shallow water. The phenomenon can be identified by water and often bottom sediment being projected upwards and backwards through the breaking-wave structure. In this model, ‘Plunging with Back-Blasting’ represents the most dangerous wave type at the position of breaking.

(iii) Wave Period Rating (WPR)

<table>
<thead>
<tr>
<th>Average Time Between Waves</th>
<th>Long Period (&gt; 14 secs)</th>
<th>Moderate Period (9 -14 secs)</th>
<th>Short Period (6 -8 Secs)</th>
<th>Extremely Short Period (&lt; 6 Secs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WPR</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

The time between breaking waves in the surf zone also presents as a potential danger because it affects the potential for recovery of a surf participant between waves. If the period is short, the participant has little time to recover from the effects of the previous
wave before the next wave interacts with them. This presents as a potential for danger to surf lifesaving competitors, when using a craft or when swimming, as well as the general bathing public. For example, consider a surf-event participant being destabilised on their surf craft, or ingesting a mouthful of water, which may have occurred as the result of an interaction with a breaking/broken wave, surface chop or other hazard. If the wave period is relatively short, that person may not have sufficient time to recover before the next wave interacts with them. In these circumstances, the shorter wave period may present as a greater danger to them, leading to a more serious surf incident or even drowning. The scale values are inversely related to time-period, thus reflecting increasing danger as wave period decreases.

The Wave Period Rating is theorised to capture only the unique variance in danger owing to the time between breaking waves. For example, if wave height remains constant at, say, two metres, then two-metre waves with shorter wave periods are theorised in the model to be more dangerous than two-metre waves with longer time-periods. Since longer period waves are generally associated with larger wave heights (Caldwell 2005; Caldwell & Aucan 2007; Cavaleri et al. 2007; Longuet-Higgins 1983), the potential danger to a participant in surf involving large waves is accounted for through this model by the unique variance in other variables such as the Wave Height Rating.

(iv) Zone Width Rating (ZWR)

<table>
<thead>
<tr>
<th>Zone Width (metres)</th>
<th>0</th>
<th>Up to 20</th>
<th>Up to 40</th>
<th>Up to 60</th>
<th>Up to 80</th>
<th>Up to 100</th>
<th>Up to 120</th>
<th>Up to 140</th>
<th>Up to 160</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZWR</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>

The surf-zone width represents the total lineal distance of the white water measured in a shore-normal direction (Nairn, Roelvink & Southgate 1990) within the defined area of observation. This zone is the area of final energy dissipation of the wave bore as it travels
shoreward (Lin & Liu 1998, p. 251). The width of this surf zone affects the stability and exposure of a surf participant to incoming waves and other potentially dangerous surf zone features. It can present as a danger, depending on the presence and severity of those other surf features. In addition, the wider the surf zone, the more difficult is the task of surveillance and rescue. For example, a shoreward moving wave bore, which creates the white water in the surf zone, may project water or uncontrolled surf craft or flotsam into the path of a surf participant. The ZWR variable increases by one unit for every twenty metres of surf zone width. Twenty-metre increments are relatively easy to estimate by experts, especially using heuristics such as demonstrated in the Trained Surf Observer Training Manual, also known as the TSO Training Manual (Appendix II).

(v) **Surface Turbulence Rating (STR)**

<table>
<thead>
<tr>
<th>Water Surface</th>
<th>No Chop (Glassy)</th>
<th>Light Chop (5-11kts)</th>
<th>Moderate Chop (12-21kts)</th>
<th>Excessive Chop (22-27kts)</th>
<th>Extreme Chop (&gt;27kts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STR</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Cross Waves +1 or +2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The amount of surface turbulence within the surf zone is the chop and cross-wave effect of the complex wind and wave energy-transfer process (Cavaleri et al. 2007), and this can affect participant stability within the surf zone. This condition can lead to danger if the participant is disorientated, or ingests mouthfuls of water, or may cause participants to lose control of their craft. The wind-effect has been adapted by this author from the Beaufort scale, and is the more significant component of the STR scale. The thirteen-value Beaufort scale (Australian Government Bureau of Meteorology 2018) was amended by this author to account for the wind-effect on the surf-zone surface within a range where surf participants were observed to compete. The amended scale commences at levels

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17 Commander Francis Beaufort devised the Beaufort scale in 1805 to assess the effect of the force of wind on sailing craft at sea. In 1874, an adapted scale was adopted by the International Meteorological Committee to identify 13 sea states and land phenomena, which depended on wind velocity.
designated in the Beaufort scale as ‘calm’ or ‘light winds’, and relies predominantly on the introduction and development of white-capping features up to approximately gale-force wind-strengths of 34 to 40 knots. The cross-wave component, however, accounts for reflected secondary waves from rips, sandbanks, shorelines, and solid structures including rocks. Vulnerability and danger to a participant in the surf-zone increases as wind strength and/or cross-wave size increases, as represented by this factor. This is because it results in a greater disturbance of the water surface.

(vi) Longshore Drift Rating (LDR)

<table>
<thead>
<tr>
<th>Latitudinal Movement</th>
<th>No Drag</th>
<th>Low Drag</th>
<th>Moderate Drag</th>
<th>Strong Drag</th>
<th>Very Strong Drag</th>
</tr>
</thead>
<tbody>
<tr>
<td>20m person-drift –time</td>
<td>0</td>
<td>&gt; 40secs</td>
<td>20 to 40 secs</td>
<td>13 to 19 secs</td>
<td>&lt;13 secs</td>
</tr>
<tr>
<td>LDR</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

In their review of research on rip-current physics, MacMahan, Thornton and Reniers (2006) provided evidence from scholarly works, including Short and Hogan (1994), that rip-current velocities generally ranged between 0 (no movement) and 1.5m/s. They noted that Short (1999) estimated the velocity of ‘Mega’ rip currents to be in excess of 2m/s, although there had been no “in situ field measurements” to verify this assertion (2006, p. 191). Previous arguments presented in Chapter 4 indicate that there is limited research that distinguishes between longshore drift and rip currents. The rationale for both longshore and rip current scales (LDR and RCR respectively) draws on the studies by Short and Hogan (1994), and MacMahan, Thornton and Reniers (2006) to provide estimations for the observed velocities of both longshore and rip currents at coastal beaches within Australia.

Longshore drift results from water movement generated by oblique-wave incidence and rip feeder-currents (Dillery & Knapp 1970; Voulgaris, Kumar & Warner 2011). As previously described, these currents may be a major risk to surf-participant safety and rescue if either
participant and/or rescuer does not adequately account for the direction and strength of this surf-zone phenomenon. Measurements associated with this scale are based on person-floating/drifting and swimming speeds in the surf. For example, one criterion for a suitable surf-swimming standard is that of a SLSA Bronze Medallion candidate being able to swim 400 metres in under 9 minutes (Surf Life Saving Australia 2018d). When referring to the LDR scale above, this SLSA Bronze Medallion criterion indicates a relative speed of the water movement of approximately 0.75m/s. This water movement represents a ‘Moderate Drag’ longshore current, with a scale value of 2. It also indicates a standard of competency required to swim against such a current safely and therefore the potential danger for the surf participant if such a swimming standard is not achievable.

(vii) Rip Current Rating (RCR)

<table>
<thead>
<tr>
<th>Longitudinal Movement</th>
<th>No Rips</th>
<th>Mild Rips</th>
<th>Mild to Strong Rips</th>
<th>Strong Rips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average person can:</td>
<td>Swim against</td>
<td>ONLY walk (waist deep) against</td>
<td>NOT even walk (waist deep) against</td>
<td></td>
</tr>
<tr>
<td>RCR</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

As previously described, rip currents are shore-normal current flows (MacMahan, Thornton & Reniers 2006). This scale is more difficult to measure accurately using simple observational methods, but is approximated using an average person’s ability to move against the current flow while swimming, or walking in waist deep water. The scale used to account for this dimension of surf danger imposed on a surf participant is similar to that used by the LURCS model (Lushine 1991, p. 18). This phenomenon has been recognised in the previous chapter as being a major worldwide surf-zone-hazard. A rip current can affect both experienced and inexperienced competitors when this feature is present in a competition arena. An outward flowing rip current can hinder a competitor’s ability to control their movement when attempting to traverse a region near the position of wave-breaking, either ‘going out’ or ‘coming in’ through the surf zone. This critical position is
where the rip current interacts with the wave at the point of breaking. An interaction of lower, yet still significant, intensity occurs when the rip current interacts with a wave bore, cross-waves, or surface chop. Rip currents also hinder patient recovery, as described in the Saxon Bird and Matthew Barclay inquests (Queensland Office of the State Coroner 2011, 2016).

(viii) Other Hazard Rating (OHR)

Other Hazards are those that occur infrequently in the surf zone, but still contribute to overall hazardousness when they are present. Other Hazards include man-made or natural obstructions, including rocks and surf craft, and visibility. For example, visibility occasionally affects both participants and rescuers, who as a consequence, may not be able to see other existing surf zone hazards (Avramidis, Butterly & Llewellyn 2009; Scott et al. 2007). Rescuers have the added disadvantage of not being able to see a person in distress in such circumstances. A further example of a hazard in this category is an out-of-control surf craft, which becomes flotsam, and a danger to participants in the surf zone. This hazard was a significant contributor to the deaths of Robert Gatenby in 1996, and Saxon Bird in 2010, as stated earlier. The presence of any feature in this category is accounted for by the addition of one unit for each hazard occurrence, as defined in Appendix II. For example, one unit would be added to the OHR scale for each out-of-control craft within the surf zone.

(ix) Surf Hazard Rating (SHR)

The overall dangerous effect of the above eight surf-zone-hazards, is summarised by the Surf Hazard Rating (SHR). When considered as a construct, this index reflects the aggregated tendency towards danger of participant-exposure to the above singular and
interacting surf-zone phenomena, without the need to explain fully the underlying physical processes through formulation. The selected value of each of the constituent-variables (WHR, WTR, WPR, ZWR, STR, LDR, RCR, and OHR) corresponds to the most dangerous condition of that surf phenomenon recorded during the observation time-period, and is chosen to maintain an optimum margin of error and safety. The SHR non-unitised scale therefore becomes a summary of the combination of the most dangerous whole-of-surf conditions observed over any specified time-period in a designated surf-zone area.

Although coastal-science research by such authors as Short and Hogan (1994, p. 197), and Short and Weir (2016, p. 56) refer to surf danger, and the presentation of a beach hazard rating, they present no evidence that this research has comprehensively, and statistically, modelled overall surf-danger against contributing surf-zone variables using a robust methodology.

5.3 Model Validity

Winter (2000, p. 1) argues that understanding the ‘truth’ about a model is central to theorising its validity, and that it is “inescapably grounded in the processes and intentions of particular research methodologies and projects”. As stated in Chapter 1, the purpose of this study is to establish model ‘truth’, or convergence towards model reality, by suitably explaining the dangerous effects of observable surf zone features in real time. Clark and Watson (1995, p. 310), in support of Cronbach and Meehl (1955), argue that, once theoretical concepts and interrelations have been identified, it becomes necessary to devise a means by which the model construct(s) can be measured and tested. This viewpoint is more recently emphasised in the research by Booysen (2002, p. 118), DeVellis (2016, p. 8), and in the OECD’s *Handbook on Constructing Composite Indicators* by Nardo, Saisana, Saltelli, Tarantola, et al. (2005, p. 15).
Beguería (2006, p. 315) argues that any risk-management model involving natural hazards must, as a “fundamental step” to gaining confidence in the model’s accuracy and predictive power, compare predictions with a “real-world dataset”.18 By establishing model confidence in the SHR through the validation process, an opportunity is created for the effective implementation of on-beach risk-management practices by end-user decision makers. Therefore, having defined the model in the previous section, the validity of the construct of inherent surf danger requires testing to measure values of the theoretical model against data, which reflects perceptions of danger and observable surf zone phenomena, in accordance with the above-cited literature. The case study utilises an empirical research design in the form a Mixed-Methods approach. This enables comparison of stakeholder perceptions of danger, with the quantitative determination of the SHR, as the hypothesised measure for surf danger, against surf lifesaving competition-incident-data, being an external validator.

5.3.1 The Theorised Model

The theorised construct of surf-zone danger models the *Surf Hazard Rating* (SHR) as a latent variable against eight predictor-variables, or core dimensions, as defined by McCoy and de Mestre (2014), and further in Section 5.2.3. The equation modelling this relationship is given by:

\[
SHR = WHR + WTR + WPR + ZWR + STR + LDR + RCR + OHR \quad \ldots \ldots \quad (1)
\]

The hypothesised model is aggregative rather than additive (Pennoni, Tarantola & Latvala 2006) in the sense that equation (1) includes possible interactive input-factors acting as independent predictor variables. This variable relationship has been established through

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18 Cronbach and Meehl (1955) classified this as ‘predictive validity’.
the judicious investigation and rationalisation of scales via the ad hoc processes associated with the 2012/13 Pilot Study, as previously mentioned. The scales, WHR, WTR, WPR, ZWR, STR, LDR, RCR, and OHR, account for the theorised singular phenomena and complex interactions within the surf zone. The criterion variable (SHR) describes their theorised combinational dangerous effect on participants within the surf zone.

As an example of the theorised interpretation of the model using equation (1) above, consider a SHR value of, say, 14. This SHR value is the construct for the total-danger presented by a given combination of the relevant observed surf phenomena, and as reflected by their relevant predictor-variable values. As the surf dynamic changes, so too does the theorised combination of these surf phenomena change. This would be expressed through equation (1) as a combinational change to the relevant predictor variables. However, it is posited that, if this new combination of predictor-variable values also aggregates to 14, the overall level of observable surf danger remains unchanged. Therefore, the same level of danger can be explained through the model for multiple combinations of surf-zone phenomena. Greater potential surf danger, which is reflected in larger SHR values, occurs when the surf-condition changes are such that the nett change in all of the relevant predictor-variable values is greater than zero. Using the example above, a SHR value of 15 is therefore argued in an ordinal sense, to be a reflection of more potential surf-zone danger than a SHR value of 14. Further details and examples of this functionality are found in the Trained Surf Observer Training Manual (Appendix II).

The Path Diagram below (Figure 5.3) summarises the theorised effect that observable surf-zone variables have on overall surf hazardousness (SHR) in a causative sense (Bollen & Diamantopoulos 2017).
Figure 5.3  The *Surf Hazard Rating* (SHR) - General Path Model

The above path model describes the relationship between the latent variable (SHR), which is an aggregated sum of eight subscales, and its effect on the manifest variables of participant surveys, surf-zone incidents, and officials’ comments. The directional straight lines represent the theorised unique contribution (or effect) of each surf-hazard-descriptor variable to the composite index (SHR), which in turn affects the manifest variables. The curved lines represent theorised possible shared variance (covariance) between surf-hazard-descriptor variables. For diagrammatic simplicity, only potentially significant covariances are indicated.

As an example of shared variance, consider the initial danger posed by the energy expelled at the position of wave-breaking, which has been previously demonstrated to be a function of wave height (Komar & Gaughan 1973; Munk 1949). The remaining energy in the system is theorised in this study to dissipate through other surf-zone phenomena such as wave type, wave period, surf zone width, surface turbulence (cross-waves), longshore
currents, and rip currents. Each of these other variables may share some common variance in the model with the wave height variable (and possibly each other). The above path model theorises that the unique contribution of the wave-height variable to overall surf-zone danger cannot be over-inflated by its relationship with other variables in the energy-dissipation process. This, however, should not be confused with an interaction effect of, for example, the wave height in combination with a particular wave type, which is theorised in the model as ‘WHR + WTR’. A resultant model, after analysis, may account for the variance by statistically extracting the covariance between the Wave Height Rating variable and other theorised variables in the model using multivariate techniques (Nardo, Saisana, Saltelli, Tarantola, et al. 2005; Tabachnick & Fidell 2014).

This process could similarly be applied to the unique variances and co-variances of all Surf-Hazard-Descriptor variables within the model. Explanation of model-variance is dependent on the level to which the unique-effects and interaction-effects can be accounted for parsimoniously. As recommended by Tabachnick & Fidell (2014), a priority in quantitative model building is to seek the most “parsimonious model with as few parameters as possible” (2014 p. 774), by maintaining optimum model explanation while limiting the effects of confounding and covariance. Statistically accounting for the significance of some model factors (i.e., ‘variables’) may introduce unwarranted variable extraction, due to the statistical process itself, which may be contradicted by a theoretical justification for that variable’s inclusion. This potential conflict will be discussed in Sections 5.6, 7.4, and 7.5 regarding limitations of the study. However, it has already been demonstrated by authors such as MacMahan, Thornton and Reniers (2006) and Cavaleri et al. (2007) that it is difficult to explain the complex surf-zone interactions in existing process-based models. The proposed SHR model must therefore demonstrate an acceptable level of statistical rigour while remaining reflective of those aspects of the observed surf-
zone phenomena in the theorised model, as defined above. The purpose of this study is to develop a model that more closely converges towards a ‘truth[ful]’ model reality as posited by Clark and Watson (1995, p. 310). The design of this study must account for the presence/non-presence of the theorised variables and their potential interactions to a level, which is ethically, statistically, and reasonably practicable. Continuing ethics approval has been granted via the original 2012/13 Pilot Study (Bond University Ethics Committee 2012 approval number RO 1561).

5.4 The Aim of the Study

To validate and evaluate the theoretical construct of the Surf Hazard Rating model as a real-time risk-management tool for surf lifesaving competitions.

To achieve model validity and evaluation (Beguería 2006), the following research questions are investigated.

5.4.1 The Research Questions

(i) Research Question One:

To what extent is the theorised Surf Hazard Rating a valid model that summarises surf-zone-danger in real-time in terms of accuracy and reliability?

(ii) Research Question Two:

To what extent does the theorised Surf Hazard Rating model provide an operationally efficient risk-assessment tool for surf lifesaving competitions throughout Australia, in terms of its generalisability (mobility), and ease-of-use?

(iii) Research Question Three:
To what extent does the theorised *Surf Hazard Rating* decision framework contribute to real-time surf-sports risk-management practices?

In this context, given the limitations of the research (see Section 5.6), the *Surf Hazard Rating* model is theorised to quantify the level of surf hazardousness, which presents as an external environmental risk factor (Fuller & Drawer 2004; Fuller, Junge & Dvorak 2012, Meeuwisse 1991) to surf-zone sports participants.

5.4.2 The Impact of the 2012/13 Pilot Study on the Empirical Research Design

Model validity requires the measuring instrument to be both reliable and accurate (Blunch 2008). When measuring construct validity, predictor variables (or ‘indicators’) may act in a traditional sense, as a reflection of the underlying latent condition (Antony et al. 1998; DeVellis 2016; McNally 1995; Spector 1992), or in a formative sense, being a contributing cause of the latent condition (Bollen & Diamantopoulos 2017; Bollen & Lennox 1991; Coltman et al. 2008; Diamantopoulos & Winklhofer 2001). However, Bollen and Lennox (1991) further argue that, to consider indicators in isolation (i.e., endogenously) leads to a model that is “statistically underidentified” (1991, p. 312), and requires measurement against the “consequences” of the model (i.e., exogenous variables) to acquire validity. Irrespective of the theoretical position in considering the *Surf Hazard Rating* model in terms of formative or reflective indicators (i.e., predictor variables), it requires validation using exogenous variables, such as competitor surveys, officials’ comments, and/or surf-zone incidents. Beguería (2006) and Winter (2000) further argue that the predictive power of a model involving natural hazards and latent variables is enhanced by empirical studies using quantitative data. The current empirical research study is posited to achieve model validity using the triangulation of quantitative and qualitative measurements of possible consequences. This empirical study focusses on the analysis of data generated from
possible exogenous variables, including race-specific surf-zone incidents, and surveys of carnival officials and surf competitors.

The 2012/13 Pilot Study (Appendix I), used surf-zone incidents, competitor surveys, and officials’ comments, which provided space for open ended responses, as potential sources of information, to validate the Conceptual Surf Hazard Rating model. The quantitative data, which is of a limited sample size, comprising SHR calculations, and race-specific incidents, was relatively easy to collect during the pilot study.\textsuperscript{19} Winter (2000) argues that this (quantitative) form of data collection is the most appropriate design to obtain external validity, and therefore, in this case, provides the potential for the development of an accurate and robust measure of surf danger to surf participants, in terms of risk of death or serious injury.

However, the pilot study demonstrated that model generalisability was dependent upon a larger and more varied sample of events and beach types. The collection of a sufficiently large sample to obtain significant model validity was highly resource-dependent. A reliable assessment of model performance required the author to accrue the relevant data during the study period (2013 to 2015) from as many as 47 different beaches across the breadth of Australia. The 2012/13 Pilot Study found that the most viable method of data acquisition, in terms of study duration and breadth of data, required a partnership with an organisation such as SLSA, which could provide access to the necessary funding and expert personnel. The inclusion of trained expert personnel to collect data (under supervision), facilitated the completion of this research within the required time-period. The current empirical research study therefore has adopted a methodology whereby expert surf-risk practitioners, having been suitably trained by this author (see Appendix II), would

\textsuperscript{19} Collected by the author and his assistant.
assist in the collection of the SHR and competition-incident data across a broad range of coastal beach-types around Australia.

The pilot study also provided a qualitative assessment of model validity using carnival decision-maker surveys. The data was easily collected from carnival officials after a carnival had finished, and therefore provides an alternative data source to investigate potential model convergence. However, the 2012/13 Pilot Study indicated that data collection of surf-condition assessment from active carnival officials was difficult to obtain while they were performing their official duties. This forewarned of future difficulties in collecting Race-Specific SHR and competition incident data from these participants. As a consequence, the current empirical research study only uses surveys of post-carnival referee opinions of the dangerous nature of surf conditions to correlate against SHR values, which were recorded by other independent data collectors, to confirm model validity. This qualitative approach is explained in Section 5.5.2.

Finally, the 2012/13 Pilot Study found difficulty in controlling the variance in the data obtained using the subjective input from competitor surveys before or after they had competed. Several causes of this lack of control included ethical considerations, such as the inclusion of weak and/or underage competitors in an event, as well as the cognitive and heuristic biases exhibited by surveyed competitors (McCammon 2002; Slovic & Weber 2002). Results of the pilot study found that pre-race surveys of competitors were not allowed by carnival officials, and these competitors had difficulty in objectifying their post-race evaluation of the inherent surf danger. Their comments appeared to be affected by their race-specific performance and/or social threat biases (Slovic 2000; Stango & Zinman 2006; Wieser, McTeague & Keil 2011). As a consequence, competitor surveys are not included in the current empirical research methodology because of the difficulty in
controlling competitors’ motivations to compete and respond objectively when assessing surf-condition dangers.

Therefore, using input from the 2012/13 Pilot Study, the current empirical research study collected SHR and competition race-incident data as the primary source of model validation. Carnival referee opinion-surveys were utilised to demonstrate the extent to which outcomes obtained from the quantitative analysis of the SHR surfboat incident data was confirmed by risk-manager assessment of those same surf conditions. Finally, the rigour of the SHR model was tested to determine its effectiveness and ease-of-use when applied as a real-time operational tool by carnival officials during actual competition.

5.5 The Research Method

5.5.1 The Approach

Based on the findings and conclusions of the 2012/13 Pilot Study, a vehicle by which the relevant data could be acquired for this empirical research relied on a close association with an organisation such as SLSA. The study is therefore one of an ‘Action Research’ design, which Reason and Bradbury (2001, p. 1) define as “bringing [sic] together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people”. There was a multidimensional need to associate with SLSA in order to conduct this research, as explained hereafter.

Partnership with SLSA provided the opportunity to address the research aim and research questions associated with a major Australian charity and sporting organisation. The research association also provided access to the financial and human resources, and depth and breadth of data, which was necessary for rigorous analysis of the SHR model. The author was able to guard against perceived biases owing to his own personal experiences
during this time by employing trained personnel in the data collection process and recording their process-related comments. The partnership also met a practical need of the SLSA organisation in developing a real-time operational risk-management tool, which, as an aspirational goal of not-for-profit organisations within Australia, would “advance social or public welfare” (Australian Charities and Not-for-profits Commission n.d.-a). The arrangement with SLSA took the form of a project (Surf Life Saving Australia 2015d) to quantify heightened risk within the surf-zone, and by so doing, provided an opportunity to calculate a threshold-value for the mandatory wearing of Personal Protective Equipment, in the form of safety helmets (Appendix III). The author gained access to experts in surf-condition assessment and risk-management, an extensive source of real-time incident data on multiple Australian beaches, approval to collect data at the Australian Surf Lifesaving Championship carnivals in 2014 and 2015, and the opportunity to design and implement a suitable risk-management framework in real time.

The partnership with SLSA did, however, limit the collection of data only to competitive surf lifesaving surfboat events, with the aim of developing a SHR Threshold-value20 for these competitors, which could later be applied to all SLSA water-competition events. Yet, far from being a restriction to the validation of the SHR model, this policy requirement provided an opportunity to accumulate more diverse evidence. This evidence assisted in the triangulation of methods to test the rigour of the theorised risk-model (Fuller 2007; Fuller & Drawer 2004; Fuller, Junge & Dvorak 2012). The research arrangement afforded the opportunity to apply the model in real-time, as a tool to assist decision makers during a major surf lifesaving competition. It thereby assisted in the verification of the effectiveness

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20 The SHR Threshold-value was defined as the level of danger exhibited by the prevailing surf-zone conditions, above which there exists a heightened risk of injury, necessitating the mandatory wearing of safety helmets in surfboat competition (Appendix III).
of the model to assist risk-managers make decisions, consistent with the Australian Hierarchy of Risk Control Measures (Safe Work Australia 2012). Therefore, this research greatly benefitted from the association with SLSA by enabling its reporting as a case study, albeit for the purpose of this thesis research for surfboat competitions only.

The empirical research design, which consisted primarily of the collection and analysis of quantitative data, relates observed competition surfboat incidents to calculated values of the Surf Hazard Rating. The incidents, as defined below, were observed during a regular surfboat race of approximate duration of four minutes. The number of incidents involving any surfboat either ‘going out’ through the surf zone or ‘coming in’ was recorded (see below). The SHR value was determined using the scale-values of the Surf Hazard Descriptors as defined in Appendix II and discussed above, and which experts recorded through observation. In the 2013/14 season, incident numbers for each surfboat race were correlated against the surf conditions, which were observed during that particular race, and defined as the Race-Specific SHR.21 The results from the analysis of this data tested the accuracy and reliability of the SHR model, which was then independently confirmed by supporting comments from carnival officials, regarding those same surf conditions (SLSA Personal Protective Equipment (PPE) Project, 2015d pp. 43-6, Appendix 8). This model also utilised the 2013/14 data to determine a theoretical threshold-value, which decision makers could use as an objective criterion of surf-danger to mandate the wearing of safety helmets, consistent with the partnership agreement.

In the 2014/15 season, the partnership arrangement required the race-incident data to be correlated against a longer-time-period SHR value (i.e., not Race-Specific), and was

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21 The Race-Specific SHR is the aggregated sum of each observable surf hazard descriptor-value, during each race.
defined as the *Prevailing* SHR.22 Human-resource availability constraints during the 2014/15 research period restricted the collection of data, which was predominantly undertaken by this author only. However, this process was much simpler than in the previous season because the SHR was now only recalculated when necessary, and not (as previously) calculated during the ‘going out’ and ‘coming in’ phases of each race. *Prevailing* SHR readings were calculated in a manner and time period that reflected the anticipated carnival risk-management practices of officials on the day, and were performed at times that, in general, were independent of the timing of specific races. Readings were recorded by independent data collectors, using the definitions for each of the *Surf Hazard Rating* variables on a continuing and objective basis throughout the period of observation and data collection. For this research, significant changes to surf conditions were deemed to have occurred when a change to any of the SHR variables was recorded, leading to a change in the *Prevailing* SHR. This data was later also analysed to evaluate the model’s efficacy as a management tool, including the positioning of a threshold-value (see Sections 6.3.3 and 6.4), where safety helmets were mandated to be worn during surfboat competitions. Qualitative data, in the form of collecting referees’ comments, particularly during the 2014/15 season (SLSA Personal Protective Equipment (PPE) Project, 2015d pp. 43-6, Appendix 8), provided triangulation of evidence for out-of-sample testing of the model as an effective risk-management tool.

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22 The *Prevailing* SHR is the aggregated sum of each observable surf hazard descriptor-value, measured over a 20 to 30 minute time-period, and continuously monitored. See the TSO Training Manual (Appendix II) for a more detailed explanation.
5.5.2 Research Participants

The participants in the study were composed of competitors, decision makers (carnival officials), Trained Surf Observers (TSOs), and data collectors, with the TSOs requiring specific training by the author. The study’s participants were categorised into four groups, comprising:

(i) Surfboat Competitors: All Surfboat crews were members of an affiliated surf lifesaving club and had satisfied eligibility requirements under Section 2.2.1 of the SLSA Australian Surf Sports Manual, 34th edition (Surf Life Saving Australia 2008). All competitions were conducted using surfboats, which satisfied the craft specifications of the same 34th edition of the Australian Surf Sports Manual. Surfboat competitions comprised the categories of male Under 19 Years, Under 23 Years, Reserve, Open, and Masters events; and female Under 23 Years, Open, and Masters events. These categories fully represented the population of surfboat competitors. Data was recorded during the observation period of competition for any surf-related surfboat incident.

(ii) SLSA Carnival Referees: These officials were responsible to SLSA for all operational and risk-management practices when conducting a surfboat carnival. Carnival referees were appointed by SLSA, and conducted carnival events in accordance with the rules and guidelines of Section 13 of the Australian Surf Sports Manual, 34th edition (Surf Life Saving Australia 2008). The referees made risk-management decisions based on SLSA protocols and concern for the overall safety of all competitors. Data was collected from these participants using post-carnival semi-structured interviews. Many carnival referees also became Trained Surf Observers (see later) as the study continued.
During the 2014/15 study period, when the SHR surf assessment system was being trialled, carnival referees commenced making risk-management decisions while also noting the value of the *Prevailing SHR*.

(iii) Data Collectors: As explained above, a conclusion from the 2012/13 Pilot Study was that, given the research study’s timeframe and financial constraints, the most viable method of collecting the necessary SHR and competition-incident data required the assistance of trained expert personnel. It became incumbent upon this author to develop a method by which these personnel would be trained to a level of expertise sufficient to record accurately the necessary SHR and race-incident data. This was achieved by the author creating a training manual, known as the Trained Surf Observer (or TSO) Training Manual (Appendix II), and conducting workshops (see below), to upskill suitably qualified personnel.

These data collectors consisted of:

a. Trained Surf Observers (TSOs). These participants were recruited, where possible, from the ASRL community, which included voluntary officials, past and active competitors and coaches. They were holders of a SLSA Surf Bronze Medallion (Surf Life Saving Australia 2018d), with a minimum of ten-years of experience in being able to accurately ‘read-the-surf’. This means that they could already identify and assess many of the standard surf-zone features that have been defined using the SHR model as Surf Hazard Descriptors (Appendix II). Their experience could be the result of involvement as a general surfboard rider, patrol member, lifeguard, and/or competitor. At the conclusion of suitable training (see Section 5.5.2.1
below), these personnel were able to collect unbiased *Surf Hazard Ratings* and incident data under the control of an independent supervisor, defined as a Quality Control Officer (see below). To assure data quality, TSO data-collection responsibilities were detailed in the Trained Surf Observer/Data Collector Information Sheet (Appendix IV). Their responsibilities included the completion of the *Prevailing SHR Report Sheet* (Surf Life Saving Australia 2015d, p. 45, Appendix 8), and the TSO Event Report Sheet and/or the *Race-Specific SHR Data Sheet* 23 (Appendix II).

b. Quality Control Officers (QCOs): These participants consisted of the author and his assistant, as well as post-graduate university-level coastal research assistants from the University of New South Wales (UNSW) and Melbourne University. They were certified TSOs, who provided supervision, instruction, and assistance where necessary to the TSO data-collectors, thereby ensuring quality control and unbiased data collection. All QCOs were trained by this author and possessed post-graduate research qualifications. They independently calculated SHR values at the same time as TSOs, thus enabling the testing of inter-rater reliability, and provided feedback regarding ease-of-use of the model by TSOs to measure the SHR components in real time. Their responsibilities are detailed in the Research Assistant/Quality Control Officer Information Sheet (Appendix V). These included the distribution of the material required by TSOs to collect

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23 In the current empirical research, a ‘race’ is defined as a single contest between surfboats over a course of approximately 400 metres, and of approximately four minutes duration. The partnership-arrangement with SLSA required that this contest be classified as an ‘event’. As a consequence, the current empirical research refers to ‘Race-’ specific terminology for ease of understanding, whereas the SLSA projects mentioned in the Appendices refers to ‘Event-’ specific information.
carnival data, organisation of TSO attendance, positioning on the beach, assurance of the unbiased recording of SHR and incident data, assessment of the data collection process, and assurance of data security, which included the secure return of data sheets to this author.

5.5.2.1 Training Manual and Training Workshops

Potential TSOs were trained by the author to assess surf conditions competently and objectively using the theorised definitions of the SHR model. They were also instructed on how to collect surfboat incident-data at designated surfboat carnivals throughout the research period of 2013/14 and 2014/15 surfboat competition seasons.

TSOs were trained by means of participation in a TSO Training Workshop, and competency was determined using a practical examination. After completion of the workshop, participants were classified as Provisional TSOs. They were then required to practice the calculation of SHR values on any beach for several weeks prior to competency-certification, which was conducted via a practical on-beach exam. The certification exam comprised one unassisted calculation of the Prevailing SHR by the TSO candidate at a designated beach, when supervised by this author, and where the author calculated the Prevailing SHR to be equal to or greater than 12. For the

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24 Each workshop participant received a copy of the TSO Training Manual (Appendix II), which contained all of the information presented by this author during the workshop. The TSO Training Manual detailed the definition of each of the SHR variables, known as Surf Hazard Descriptors, as well as how these surf features could be identified, measured, and recorded against the appropriate SHR scale-value. The manual also contained a Trained Surf Observer/ Data Collector Information Sheet (Appendix IV). This outlined TSO future responsibilities for obtaining unbiased data samples, tutorial examples and exercises, which reinforced how a SHR value was able to be calculated for varying surf conditions, and a copy of the Beaufort wind scale, which describes wind effects at sea and on the land. Participants retained the TSO Training Manual for future reference and as a source of data collection material after they left the TSO Training Workshop.
purposes of the validation process, certification was granted if the TSO’s SHR was
within one unit of that calculated simultaneously by this author.

TSO Training Workshops were conducted at Torquay (Victoria), Mona Vale (New
South Wales), and Broadbeach (Queensland) between 6 December 2013 and 11
January 2014, and Maroochydore (Queensland), South Maroubra and Newport (New
South Wales), Anglesea and Jan Juc (Victoria), and South Port Noarlunga (South
Australia) between 11 October 2014 and 31 January 2015. In total, there were 68
participants in the workshops, and 34 received certification as TSOs. Workshop
attendees remained at the Provisional level unless certified by examination, as
explained above. They were not permitted to record SHR values for data collection
purposes.

The TSO Training Workshops were only presented by this author, and consisted of a
four-hour intensive class, broken into presentation and definition of the Surf Hazard
Descriptor scales, data collection requirements, a classroom session involving
theoretical examples of multiple surf-condition scenarios, and a practical session at the
beach shore-line. These sessions were detailed in separate sections of the TSO Training
Manual (Appendix II). Although participants were only required to have ten years of
experience in making surf-related assessments as referees or coaches to attend the
workshop, most had over forty years of active surf-beach experience. Therefore,
workshops adopted a forum-styled approach, with this author providing guidance as to
how the scales could be calculated, and how the data-collection process was to be
implemented. These TSOs, with an estimated total of over 2,500 years of surf-related
experience, provided an ongoing peer critique of the surf-assessment process using the
SHR model. Their active on-beach experience included making surf-risk decisions,
either for themselves, or in an official capacity on behalf of SLSA, and involving large groups of surf participants. The workshops acquired research legitimacy, as the author was able to record feedback from these experts as it related to the adequacy of the proposed study’s model definitions, and processes.

5.5.3 Data Collection

All of the data collected for this study conformed to the definitions previously described. TSO and QCO training programs, reference to the TSO Training Manual, and the guidance to TSOs and QCOs through their respective information sheets, provided the structure for consistency and integrity of the data-collection process during the study.

Data security was maintained by the requirement for TSOs and QCOs to return all data-collection reports to this author, via secure mail or in person, as soon as possible after the completion of any carnival. Mindful of the research by Caldwell (2005), Caldwell and Aucan (2007), and Scarfe, Healy and Rennie (2009), observational measurements for all Surf Hazard Descriptor values were collected on the shoreline, adjacent to the race-starter’s tower, which was just behind the competitors’ starting line, and mid-centre of the arena. Venue selection during the competition period was randomised, depending only on the availability of suitably trained data-collectors. Initial data collection often commenced at surf lifesaving carnivals where the surf conditions were relatively calm. This facilitated data-collectors gaining further experience in the collection process, where few incidents occurred.

Independence in the collection of SHR and surfboat incident data was maintained by employing separate collectors for each process. These data collectors were located at different areas in the competition arena. SHR data collectors were located at the shore
edge. Incident data collectors were located at a high vantage point at the back of the carnival area. QCOs, being experienced research-based personnel, were responsible for overall data quality during their respective data collection periods. Overall assurance of standardisation of collection method and quality was assured by periodic on-beach supervision or post-collection review by this author, through semi-formal telephone interviews and review of post-carnival comments by TSOs and QCOs.

The classification of surfboat incident-types, were derived from the 2012/13 Pilot Study. Definitional support was obtained through the forum-based TSO Training Workshops, before the commencement of data collection for this study. The recorded incident-types included (Surf Life Saving Australia 2015d, pp. 45-6, Appendix 8):

(i) *Boat Broaching* (‘Slewing’);
(ii) *Boat Back-shooting/Nose-diving*;
(iii) *Boat Swamping*;
(iv) *Boat Overturning*;
(v) *Boat Collisions (minor or major)*;
(vi) *Competitor Injuries (minor or major)*;
(vii) *Carnival cancellation*.

Surfboat-related incidents were recorded for each race, giving equal weight to each incident-type, as there was no scale available to measure the severity of these incidents. The incidents were separately categorised as ‘going out’ or ‘coming in’ through the surf zone. The incident data sheet (Surf Life Saving Australia 2015d, p. 45, Appendix 8) recorded the type of incident, the number of surfboats involved in each incident, and the effect of each incident on the crew. For example, in a five-boat race when coming in, three surfboats may broach, one of which may have been swamped, but no injuries occurred.
Surfboat incident data was collected separately from SHR data, using different collectors, as noted earlier. SHR data was collected by TSOs, while incident data was collected using other carnival officials. These other officials were already collecting this incident data for SLSA, as part of SLSA’s own ongoing monitoring program.

Quantitative data collection consisted firstly of a calculation of the *Prevailing* SHR at the commencement of the carnival by a certified TSO, and periodically throughout the data collection process. The data was collected from surfboat incidents as they related to either the *Prevailing* or *Race-Specific* SHR-values (see prior definitional footnotes 20 and 21, and later). The collection of data was divided into two time-periods, corresponding to the 2013/14 and 2014/15 competitive surfboat seasons. This provided the opportunity to a) collect the necessary data to validate, b) evaluate the SHR model and the suitability of the positioning of a safety helmet surf-threshold value for SLSA, and c) test of the model’s efficacy in real time.

Qualitative data was acquired through interviews with referees and recordings of field note observations. The author conducted post-carnival interviews of referees, which followed a consistent line of enquiry to assess their opinions of the level of surf danger present during their management of the surf carnival. Often, the stream of questions followed a more fluid, as opposed to a rigid structure (Rubin, HJ, and Rubin, IS 2011), owing to the limitations involved in this management process (see Section 5.6). The comments from referee surveys provided opportunities for open ended responses (Weiss, RS 1994). Documentation (Surf Life Saving 2015d, Appendices A and B) evidenced personal observations during the design and implementation process (DeWalt, KM and DeWalt, B 2011) and also through field note observations of the implantation of the SHR model, as a
real time risk management tool (Surf Life Saving Australia 2015d, pp. 46-53, Appendix 9), during Phase III of this research (see Section 6.4).

5.5.3.1 Phase I – Model Validation

The purpose of the data collection in Phase I (2013/14) was to validate the model according to the requirements of Research Question One (Section 5.4.1). In partnership with SLSA and ASRL, the data collection process also facilitated the determination of a theoretical SHR threshold-value of surf danger in order to mandate the wearing of safety helmets in surfboat competitions. This phase focussed on the collection of Race-Specific SHR and incident data. The data was collected in the first phase, commencing on 5 January 2014 at Anglesea, Victoria through to 16 March 2014 at Ocean Grove, Victoria. A table of all carnivals at which data was collected during this time-period is shown in Table 5.2 below. The table includes the date, the carnival venue, and the number of races from which data was collected.

Table 5.2 Phase I Carnival Venues

<table>
<thead>
<tr>
<th>Date</th>
<th>Beach</th>
<th>No. of Races</th>
<th>Date</th>
<th>Beach</th>
<th>No. of Races</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/01/2014</td>
<td>Anglesea (Vic)</td>
<td>25</td>
<td>08/02/2014</td>
<td>Stockton (NSW)</td>
<td>6</td>
</tr>
<tr>
<td>11/01/2014</td>
<td>Tugun (Qld)</td>
<td>32</td>
<td>09/02/2014</td>
<td>Stockton (NSW)</td>
<td>18</td>
</tr>
<tr>
<td>12/01/2014</td>
<td>Collaroy (NSW)</td>
<td>29</td>
<td>15/02/2014</td>
<td>Tallebudgerra (Qld)</td>
<td>32</td>
</tr>
<tr>
<td>12/01/2014</td>
<td>Jan Juc (Vic)</td>
<td>27</td>
<td>01/03/2014</td>
<td>Mooloolaba (Qld)</td>
<td>44</td>
</tr>
<tr>
<td>18/01/2014</td>
<td>Coolum (Qld)</td>
<td>24</td>
<td>02/03/2014</td>
<td>Fairhaven (Vic)</td>
<td>9</td>
</tr>
<tr>
<td>18/01/2014</td>
<td>Queenscliff (NSW)</td>
<td>32</td>
<td>07/03/2014</td>
<td>North Kirra (Qld)</td>
<td>17</td>
</tr>
<tr>
<td>25/01/2014</td>
<td>Manly (NSW)</td>
<td>31</td>
<td>08/03/2014</td>
<td>North Kirra (Qld)</td>
<td>40</td>
</tr>
<tr>
<td>26/01/2014</td>
<td>Nth Steyne (NSW)</td>
<td>20</td>
<td>09/03/2014</td>
<td>North Kirra (Qld)</td>
<td>28</td>
</tr>
<tr>
<td>27/01/2014</td>
<td>Freshwater (NSW)</td>
<td>35</td>
<td>15/03/2014</td>
<td>Broadbeach (Qld)</td>
<td>1</td>
</tr>
<tr>
<td>01/02/2014</td>
<td>Broadbeach (QLD)</td>
<td>13</td>
<td>15/03/2014</td>
<td>Ocean Grove (Vic)</td>
<td>22</td>
</tr>
<tr>
<td>02/02/2014</td>
<td>Point Leo (Vic)</td>
<td>20</td>
<td>16/03/2014</td>
<td>Ocean Grove (Vic)</td>
<td>17</td>
</tr>
</tbody>
</table>

The first carnival at which data was able to be collected during this first phase commenced on 5 January 2014 because the first TSO Training Workshop was not undertaken until 6
December 2013 for logistical reasons. As described above, TSOs generally required about one month’s practice in rating conditions using the Surf Hazard Descriptor-values before they were sufficiently capable (as determined through examination by the author) of accurately collecting this data at surf carnivals, albeit still under the supervision of the author. Owing to the late commencement of training, data collection was delayed until suitable personnel were certified to collect the necessary data competently.

A condition of the data collection process, as set out in the Trained Surf Observer/Data Collector Information Sheet (Appendix IV), was that data collectors could not participate in any other carnival-related activity, such as acting as an official, manager, or competitor during these occasions. This condition, separate from those mentioned and accounted for during the training process contributed to the assurance of collection objectivity and accuracy. All data was collected through observation in real time. Data collectors were required to remain sufficiently spatially-separated from carnival decision makers to avoid outside influences and vice versa. TSOs were also required to calculate a Prevailing SHR before the commencement of the Race-Specific data collection process, to establish a datum level of surf danger. However, time limitations and human-resource scarcity restricted the number of times this longer time-period rating could be calculated during the carnival. Priority was given to the more time-sensitive Race-Specific SHR, which could be calculated within a one to two minute time period, as in Phase I, as it directly related to surfboat incidents also within this shorter time-period.

Race-Specific SHR data was collected by TSOs using a standard data-recording sheet (Appendix VI). Separate TSOs collected the Race-Specific SHR data (‘going out’ and ‘coming in’) to those personnel (not necessarily TSOs) who collected the Race-Specific Incident-data ‘going out’ and ‘coming in’ for every race in the carnival, assuring against
selection bias. The process, being under the supervision of QCOs, who independently determined their own Race-Specific SHR, was therefore able to control for the independence of data collection. However, data collectors were encouraged to co-ordinate their efforts so that all available information was recorded over a very short time-period. For example, each surfboat race took approximately four minutes to complete. Data was required to be recorded ‘going out’ and ‘coming in’ through the surf-zone, for each race. This comprised, on average, the first minute and the last minute of a four-minute race. The middle two-minute-period involved crews rowing beyond the surf break to a turning buoy and then returning. As found in the 2012/13 Pilot Study, when the surf became more difficult to negotiate, surfboat incidents (see Sections 6.2.3 to 6.2.6) ‘going out’ could occur simultaneously with those from faster surfboats ‘coming in’ during the same race, thereby leading to multiple incidents in the same arena.

No attempt was made to separate the severity of most incident types, as no suitably defined objective measures were available. However, surfboat collisions and competitor injuries are sub-categorised as ‘major’ or ‘minor’ according to the definitions in Appendices 8 and 9 in the SLSA Personal Protective Equipment (PPE) Project (Surf Life Saving Australia 2015d), as objective measures were available and directly reflected damage to person or craft. Data recorders were easily able to ascertain whether a competitor or craft was able to continue to participate in competition or not.

The research design required the author to conduct quasi interviews with carnival referees, in the sense that they were “unstructured” (Weiss, 1994, pp. 207-8) yet seeking clarification of “explicit” (Cook & Campbell 1979, p. 56) threats to internal validity, and in the form of semi-formal post-carnival verbal and telephone interviews, within one day of the carnival. Responses were sought to assess general referee concerns with inherent
surf dangers when managing the whole carnival. Referees were asked the question:

“Overall, how much concern about the surf conditions and its effect on competitors did you have when you refereed the surfboat carnival at (beach/venue) on (date)?” (Surf Life Saving Australia 2015d, p. 11, Appendix 8). Responses were categorised using a five-point Likert scale, using a design consistent with questionnaire survey research (Saris & Gallhofer, 2007) as shown below in Table 5.3. Referees possess the authority, through SLSA, to implement the protocols contained in the SLSA Australian Surf Sports Manual, 34th (and 35th) editions (Surf Life Saving Australia 2008, 2015b), to conduct or cancel a surf lifesaving carnival when they deem surf conditions to be sufficiently dangerous.

### Table 5.3 Possible Referee Responses

<table>
<thead>
<tr>
<th>Likert Scale Number</th>
<th>Referee Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I was not concerned at all when I conducted the competition in these surf conditions</td>
</tr>
<tr>
<td></td>
<td>I was satisfied that I could conduct the competition in these surf conditions</td>
</tr>
<tr>
<td>2</td>
<td>I had some concern if/when I conducted the competition in these conditions</td>
</tr>
<tr>
<td>3</td>
<td>I was very concerned if/when I conducted the competition in these surf conditions</td>
</tr>
<tr>
<td>4</td>
<td>I was extremely concerned if/when I conducted the competition in these surf conditions</td>
</tr>
</tbody>
</table>

It is possible for the same referee to provide the same survey response, as other referees, and adopt different risk mitigation measures to them. For example, a referee could be extremely concerned about the dangerous nature of prevailing surf conditions, equating to a survey scale response equivalent to 5, and continue to conduct the carnival by taking extreme mitigation measures. The referee could also subsequently decide to cancel the carnival. Referee surf-risk mitigation measures include:

(i) Stern warnings by Carnival Referees to Sweeps to:
a. Consider their (i.e., the sweeps’) own competency in the existing surf conditions.

b. Consider the competency of each crewmember.

c. Act sensibly (i.e., with caution) if continuing to compete.

d. Not take unnecessary risks25 ‘going out’ and ‘coming in’ through the surf zone.

(ii) Continually halting racing if conditions deteriorated to reinforce that extra care and vigilance needed to be taken by all crews.

(iii) Encouragement to members of the Carnival Surfboat Panel,26 known as the ‘Boat Panel’, to advise less-experienced crews to take greater caution, or to consider withdrawing from the competition if surf conditions appear too hazardous.

(iv) Reducing the per-race number of surfboats competing.

(v) Leaving vacant lanes to separate crews or eliminate obstructions, such as shallow sandbanks, dangerous rip currents, outflow pipes, etc.

(vi) Delaying the race-start until large sets of waves had passed.

(vii) Extending the per-race time limit.

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25 An unnecessary risk is a subjective assessment of risk as viewed by different stakeholders, including carnival officials and competitors. In general, it is regarded as a risk factor that may endanger the safety of the crew. For example, attempting to breech the breaker-zone without due consideration of the ability of the crew could potentially endanger the safety of the crew if the breech is not successful.

26 The Carnival Surfboat Panel consisted of three to five experienced surfboat Sweeps who were nominated at a pre-carnival briefing by their peers, according to the protocols in the SLSA Australian Surf Sports Manual, 34th and 35th editions (Surf Life Saving Australia 2008, 2015b).
(viii) Progressively cancelling various competitor categories (e.g., Under 19 years Male, Under 23 years Female, Masters, etc.) as surf conditions deteriorated.

This author presented the results of the analysis of the 2013/14 surfboat incident data to the Annual General Meeting of the ASRL in May 2014 (Appendix VII). This meeting, and subsequent feedback, provide further expert input into the definitional accuracy and suitability of the SHR model as a reliable operational risk-management tool. Based on this meeting and ongoing consultation between the author, SLSA, and the Australian Surf Rowers League, this association presented its recommendations to SLSA for the implementation of the SHR as a risk-management tool (Surf Life Saving Australia 2015d, pp. 37-8, Appendix 8), to be used in a trial throughout the upcoming 2014/15 surfboat competition season (2015d, Appendix 9).

5.5.3.2 Phase II – Model Evaluation.

In the second phase, data was collected to evaluate the model as a risk-management tool and its forecasting performance (using out-of-sample data, albeit using the *Prevailing* SHR instead of the *Race-Specific* SHR). A necessary requirement of the partnership agreement with SLSA and ASRL to acquire the data was that the incident-data in the 2014/15 season was to be recorded against the *Prevailing* SHR only. This was necessary because of human resource constraints, and the need to mimic actual referee decision timeframes. The criteria needed to assess this aspect of the process include the effectiveness of the referee decision process (2015d, p. 39, Appendix 9), the efficacy of the positioning of the SHR threshold-value relative to competitor incidents, and the overall effectiveness of the SHR model to assist referees to mitigate surf-risk objectively in real time, while being mindful of stakeholder safety. This phase therefore focussed on the collection of the longer time-
framed *Prevailing* SHR and the *Race-Specific* Incident data, as well as referee surveys (2015d, p. 43, Appendix 9), and post-season TSO surveys (2015d, p. 42, Appendix 9).

In Phase II, data was collected from 25 October 2014 at Lancelin (Western Australia), through to 19 April 2015 at Tugun (Queensland). A table of all carnivals at which data was collected during this time is shown in Table 5.4 below. The table includes the date, the carnival venue, and the number of races from which data was collected.

<table>
<thead>
<tr>
<th>Date</th>
<th>Venue</th>
<th>No. of Races</th>
<th>Date</th>
<th>Venue</th>
<th>No. of Races</th>
</tr>
</thead>
<tbody>
<tr>
<td>25/10/14</td>
<td>Lancelin (WA)</td>
<td>15</td>
<td>24/1/15</td>
<td>Nth Steyne (NSW)</td>
<td>34</td>
</tr>
<tr>
<td>8/11/14</td>
<td>Surfers Paradise (Qld)</td>
<td>69</td>
<td>25/1/15</td>
<td>Esperance (WA)</td>
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</tr>
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<td>9/11/14</td>
<td>Surfers Paradise (Qld)</td>
<td>16</td>
<td>26/1/15</td>
<td>Freshwater (NSW)</td>
<td>49</td>
</tr>
<tr>
<td>9/11/14</td>
<td>Terrigal (NSW)</td>
<td>35</td>
<td>30/1/15</td>
<td>North Narrabeen (NSW)</td>
<td>Cancelled*</td>
</tr>
<tr>
<td>16/11/14</td>
<td>Trigg (WA)</td>
<td>16</td>
<td>8/2/15</td>
<td>Mooloolaba (Qld)</td>
<td>30</td>
</tr>
<tr>
<td>22/11/14</td>
<td>Mollymook (NSW)</td>
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<td>14/2/15</td>
<td>South Maroubra (NSW)</td>
<td>Cancelled*</td>
</tr>
<tr>
<td>22/11/14</td>
<td>Newport (NSW)</td>
<td>30</td>
<td>20/2/15</td>
<td>Shellharbour (NSW)</td>
<td>Cancelled*</td>
</tr>
<tr>
<td>23/11/14</td>
<td>Stockton (NSW)</td>
<td>39</td>
<td>20/2/15</td>
<td>Warilla (NSW)</td>
<td>70</td>
</tr>
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<td>29/11/14</td>
<td>Coffs Harbour (NSW)</td>
<td>60</td>
<td>21/2/15</td>
<td>Shellharbour (NSW)</td>
<td>Cancelled*</td>
</tr>
<tr>
<td>30/11/14</td>
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<td>25</td>
<td>21/2/15</td>
<td>Warilla (NSW)</td>
<td>92</td>
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<td>30/11/14</td>
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<td>22/2/15</td>
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<td>45</td>
</tr>
<tr>
<td>6/12/14</td>
<td>Warriewood (NSW)</td>
<td>47</td>
<td>28/2/15</td>
<td>Tallebudgerra (Qld)</td>
<td>42</td>
</tr>
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<td>7/12/14</td>
<td>Broadbeach (Qld)</td>
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<td>8/3/15</td>
<td>Sorrento (WA)</td>
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<td>14/12/14</td>
<td>Maroochydore (Qld)</td>
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<td>15/3/15</td>
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<td>21/3/15</td>
<td>Scarborough (WA)</td>
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<td>22/3/15</td>
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<td>28/3/15</td>
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<td>Elouera (NSW)</td>
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<tr>
<td>4/1/15</td>
<td>Anglesea (NSW)</td>
<td>34</td>
<td>16/4/15</td>
<td>Tugun (Qld)</td>
<td>84</td>
</tr>
<tr>
<td>10/1/15</td>
<td>Tugun (Qld)</td>
<td>46</td>
<td>17/4/15</td>
<td>Tugun (Qld)</td>
<td>97</td>
</tr>
<tr>
<td>11/1/15</td>
<td>Fairhaven (Vic)</td>
<td>12</td>
<td>18/4/15</td>
<td>Tugun (Qld)</td>
<td>73</td>
</tr>
<tr>
<td>18/1/15</td>
<td>Swansea (NSW)</td>
<td>35</td>
<td>19/4/15</td>
<td>Tugun (Qld)</td>
<td>37</td>
</tr>
<tr>
<td>24/1/15</td>
<td>Coolum (Qld)</td>
<td>Cancelled*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Carnival cancellation or transference to another venue because of dangerous surf conditions (see details later).*
The Phase II sampling process, using the *Prevailing* SHR instead of the *Race-Specific* SHR, enabled the collection of data with greater variance in number and type of beach venues and surf conditions. This resulted in improved research-partner operational efficiencies compared with Phase I. Data in the first phase comprised information on 515 individual races from 22 separate carnivals at 16 individual beaches, while Phase II data collected information on 1,603 individual races from 47 separate carnivals at 35 individual beaches, 22 of which were different to those sampled in Phase I. Besides confirming model forecasting ability, this design also enhanced the test of model mobility at a wider range of venues, especially as it increased the opportunity for decision maker and stakeholder feedback.

The *Prevailing* SHR versus the *Race-Specific* Incident data was analysed to assess suitability of the SHR model as a decision-making tool, an example of which included the positioning of a Threshold-value to mandate the wearing of safety helmets. The post-carnival and post-season surveys used a five-point Likert scale to record decision maker and stakeholder assessments of the SHR-based risk management process.

*Prevailing* SHR data was predominantly collected by the author or his assistant acting as Monitors,27 and using the Monitor’s *Prevailing Surf Hazard Rating* Report Sheet (2015d, p. 35, Appendix 9). Similar to Phase I, the process requires the initial calculation of a *Prevailing* SHR twenty minutes prior to the commencement of a surf carnival. A calculation is then required approximately every hour thereafter, or when surf-conditions changed significantly as defined in the TSO Training Manual. Information regarding surfboat incidents for each race was collected using the same method as that used in Phase II.

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27 Monitors performed a similar role as Quality Control Officers (QCOs) in Phase I, by collecting their own *Prevailing* SHR data, supporting and advising incident data-captors, maintaining data quality assurance, as well as monitoring and recording referee decisions and stakeholder responses.
I, by TSO-certified carnival officials using the Basic Incident Report sheet (2015d, pp. 36-8, Appendix 9).

Carnival officials’ and other stakeholders’ survey-data was collected using a separate Monitor’s Report Sheet (2015d, p. 34, Appendix 9) during the carnival to assess the effectiveness of the proposed SHR decision framework. This process is outlined in the SHR Decision Flowchart (2015d, pp. 39-41, Appendix 9). It involved the calculation of a *Prevailing SHR*, by a TSO-certified carnival referee, before the commencement of the carnival. The decision process then required a discourse on surf conditions at a meeting between the carnival referee and the Boat Panel. The meeting was required to reach consensus about the level of danger in the existing surf conditions, as assessed independently by the referee and the Boat Panel using existing SLSA protocols, or request a review of those conditions via a recalculation of the SHR. At this point, the referee was then required to explain their assessment of surf conditions to the Boat Panel, using the Surf Hazard Descriptor-scales as a checklist of observed significant surf hazards. If consensus was established between both groups, as to an acceptable level of risk in which to compete, the carnival may continue, with the referee implementing the appropriate risk mitigation measures (see Section 5.6.3). If consensus is not reached between both groups, as to an acceptable level of risk in which to compete, the referee may conduct the carnival in accordance with the guidelines and protocols of the Australian Surf Sports Manual (Surf Life Saving Australia 2015b), which may include cancelling the carnival. The Monitor was required to record information about this process, including responses from the carnival.

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28 ASRL were already required by SLSA to collect all incident data on all surfboat races using similar incident data sheets prior to the trialling of the SHR model in Phase II.
referee and the Boat Panel members, using the Monitor’s Report Sheet (2015d, p. 34, Appendix 9).

5.5.3.3 Phase III – Model Operationalisation

The third and final phase of this methodology tested the effectiveness of the SHR model as an objective and reliable risk-management tool in real time. This model has been theorised to evaluate surf-danger more objectively, and provide more reliable quantitative information than those decision tools previously used by SLSA carnival officials. Those SLSA decision-management models were used during the surf lifesaving carnivals where Robert Gatenby, Saxon Bird, and Matthew Barclay died in 1996, 2010, and 2012 respectively. To assess this claim reliably, it was deemed necessary to test model-efficacy under similar circumstances and surf conditions (see Section 6.4) to that experienced during the aforementioned SLSA Australian Surf Lifesaving Championships. The effectiveness of the SHR model and associated decision framework were tested at the ASRL Open Titles at Shellharbour and Warilla beaches, NSW, between 19 February 2015 and 22 February 2015 (Australian Surf Rowers League 2018).

The ASRL Open is the Australian Surf Rowers League’s equivalent to the Australian Surf Lifesaving Championships, but is restricted to surfboat rowers only. In 2015, over 1,500 competitors from around Australia partook in these championships. The competition categories comprised those same groups, which are normally listed at the Australian Surf Lifesaving Championships and on the general surfboat carnival calendar throughout the year. These categories are also the same categories that were used to collect data in phases I and II of this case study. The ASRL applied the protocols from SLSA’s Australian Surf Sports Manual, 34th and 35th editions (Surf Life Saving Australia 2008, 2015b). The 2008 version (34th edition) was the same manual as that used by SLSA at Australian Surf
Lifesaving Championships up to that time. However, the carnival referee, who was a TSO with extensive experience and confidence in using the SHR, having qualified through the TSO training program (see Section 5.5.2 (iii) a.), agreed to participate in the Phase III trial using the SHR Decision Framework as described above, and using this author as consultant. The Surfboat Hazard Rating System Trial 2015 report (2015d, pp. 46-53, Appendix 9) documents the notes recorded by this author at the time, which describe the circumstances leading to the cancellation of the carnival at Shellharbour Beach on 20 February 2015, and transference of all events to Warilla Beach that same day. The significant outcomes from this operational trial are discussed in the next chapter (Section 6.4).

5.6 Limitations of the Study

Data collection, using observational methods associated with natural environments, is fraught with difficulty, as was demonstrated in the Chapter 4 review of the literature on Wave and Surf Zone Modelling. The empirical research in this study attempts to control for many of the complex surf-zone processes by observing the ‘effects’ of those processes on an exogenous variable, such as surfboat incidents, during SLSA-approved surfboat competitions. As detailed in Section 5.5.3, the incidents, which potentially could lead to various levels of personal injury and surf-craft damage, were easily observable and recordable, given the available resources. However, there were several factors that either could not be controlled, or were beyond the capacity of the resources available to the author during the study period. Those limitations to the data collection process, which potentially could affect the results of analysis are hereunder acknowledged and discussed.

As stated in the previous chapter, this research was made possible through a partnership with SLSA and the assistance of its volunteers. Surfboat incident-data was collected from
approximately two thousand separate events and fifty separate beaches across Australia during the study period. A condition of the partnership was that data was to be collected for surfboat events only. Therefore, the findings are restricted to surfboat incidents and not to all surf lifesaving competition types. However, sufficient information across all craft types, including surfboats, surfboards, and surf-skis, was collected during the 2012/13 Pilot Study (See Table 5.1 and Appendix I), to conclude that similar dangerous surf conditions would cause comparable surf-craft incidents, in terms of risks of serious injury or death, and that they would similarly correlate to SHR values.

5.6.1 Surfboat Crew Competencies

Although surfboat crews comprise the categories listed in Section 5.5.2 (i), they are ‘captained’ by surfboat sweeps, who are not restricted to the category type. They can, and often do, sweep several different crews (in different races) from any of the listed categories, most of whom have widely differing competencies. Sweeps must qualify under several different grading standards, as governed by the ASRL Sweeps Manual (Australian Surf Rovers League 2007). Unlike all other craft types (i.e., surfboards and surf-skis), where individual competitors make surf-decision choices for themselves, surfboat sweeps, acting as the responsible captains, make all surf-decision choices on behalf of the entire crew. By virtue of this responsibility, they generally consider the welfare of the crew based on the crew’s strength and expertise, relative to their own ability. Therefore, the data contains events such as male Under Twenty Three and Open grades, which may have the same sweep as captain. Given the same surf-conditions and same sweep, widely differing crew-competencies may necessitate dramatically different risk-choices by the sweep during a race. These risk-choices may affect incident-numbers, both positively and negatively. It is also possible, given the same surf-conditions, that crews from different
clubs, with similar expertise, could be captained by sweeps of markedly different competencies, again affecting incident-numbers.

As a first step, and given the time and resource constraints, validation of the SHR model compares SHR-values to surfboat incident-data from the entire surfboat group as a whole, rather than using a categorical separation of age, gender, and experience. Sufficient information was collected to enable the effective implementation of whole-of-group risk-mitigation measures for surfboat competitions. For example, from a risk-management perspective, a single SHR threshold-value has been determined to mandate reliably the wearing of safety helmets for all surfboat categories, including gender.

5.6.2 Competition Intensity and Competitor Decision Making

Ethical standards for research involving human and animal participation in sports are strictly controlled by law and moral standards (Harriss & Atkinson 2009). This research investigates surfboat incidents under the direction of SLSA through its protocols listed in the Australian Surf Sports Manual 35th edition (Surf Life Saving Australia 2008, 2015b), and from an observational perspective. As a result, the methodology does not control for the surfboat-personnel decision choices to compete or not compete in surf conditions of varying levels of perceived danger. These decision choices may affect sample-representativeness, as it is possible for crews of similar competency to withdraw or to continue to compete as surf conditions deteriorate. Forcing crews to participate in deteriorating conditions in order to maintain sample representativeness is ethically unacceptable. Crews were not forced to compete during this research in order to acquire data, nor were they aware that they were being observed when the data was recorded. There exists a limit where it could be expected that surf conditions become so dangerous that no surfboat crews would be able to compete safely, even if they chose to do so.
Therefore, there is an upper limit, beyond which it is not reasonable or ethically acceptable to collect surfboat incident data to correlate with these more extreme surf conditions. The maximum SHR reading from all carnivals over the study period was 22, which occurred at North Steyne (New South Wales) carnival on 24 January 2015 (see Table 6.10). The upper limit of SHR outcomes is restricted to this maximum value, corresponding to the limit where a race was conducted (see Section 5.6.4 – Range Restrictions).

It is reasonable to assume that surfboat crews, which are captained by a single person (the sweep), may be prepared to take more risk as the intensity of the competition, and value of the result increases. For example, given the same surf conditions, surfboat crews may be more prepared to risk having an incident as listed in Section 5.5.3, to achieve a podium position in a national surfboat title-event, compared with a podium position or non-placement in a minor competition at a general surf carnival. These risk-choices are evident in extreme sports as discussed in Section 1.5, and are associated with “athlete-related” (Bahr & Holme 2003, p. 384) internal risk factors affecting competitor performance (Fuller 2007; Fuller & Drawer 2004; Fuller, Junge & Dvorak 2012; Meeuwisse 1991). Even though the competition motive may be internalised as an athlete-versus-athlete interaction, the consequence of the decision choice may be greatly affected by an external, natural-environment factor. For example, greater risk is associated with attempting to continue into a large dumping wave in order to acquire a potentially superior race position, compared with a wait-and-hold-back approach.

Thus, given the same surf conditions and crew experience, the level of competition may also influence surfboat incident-numbers. It could be expected that more capable crews might experience more incidents at moderate to high SHR levels than they otherwise would have under less important competitive circumstances for the above reasons. As the
data was collected from all carnivals, including local and national events, this may lead to an overestimation of the number of incidents occurring at these SHR levels owing to the presence of this competitor-motivation factor. As this factor was not measured during the research period, it remains a limitation of the study.

5.6.3 Refereeing Risk-Mitigation Measures

The case study’s empirical design does not control for refereeing risk-mitigation decisions, as these are made independently of the researcher. SLSA’s Australian Surf Sports Manual, in an attempt to maintain “fairness and safety for all competitors” (Surf Life Saving Australia 2015b, Section 5), directs referees to select a course that purposely reduces competitor exposure to dangerous surf-zone hazards. This direction for referees to mitigate surf-zone risk could possibly affect the number of surfboats permitted to start in a race, the starting positions of surfboats within the arena, or the timing of the race start until a time of perceived less danger. In surf conditions, where large sets of waves are present, a referee may delay the start of a race to occur between the larger sets of waves in order to maintain “fairness and safety” for all surfboat crews. Given these circumstances, fewer incidents may occur ‘going out’ through the surf zone than would normally be expected if the race had commenced at some random time.

As a further example, consider the statistical significance of rip or longshore currents as a surf-zone hazard. As demonstrated in the literature, and detailed in Section 4.4, rip currents are regarded as the most significant worldwide surf-zone hazard. However, if in prioritising competitor safety, a referee selects a course, which purposefully excludes rip or longshore currents from surfboat competition lanes29 or the whole arena, little

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29 A surfboat competition-rowing course consists of a maximum of seven surfboats in separate competition lanes. These lanes are positioned shore-normal in order to separate competitors and in alignment with turning
opportunity exists to collect sufficient incident-related data to test the statistical
significance of these factors in the SHR model. Course or lane determination by referees,
in an attempt to mitigate risk, may similarly affect the statistical significance of the Wave
Type Rating (WTR) or other variables, because opportunity is lost to analyse this in the
data. It is proposed that it is better, in the first instance, to study the SHR as a whole rather
than attempt to account for subscale-significance, so that examination of the model
variance including only the SHR variable can provide the first step of a potentially
complex solution.

Further, carnival referees and the Boat Panel\textsuperscript{30} often encourage less-experienced crews to
cease competition as conditions deteriorate, even though the crew may be led by a very
experienced sweep. Thus, the observation of surfboat incidents during more dangerous surf
conditions, may only involve the more experienced crews, thus again affecting sample
representativeness. It is reasonable to assume that, if less-experienced crews continue to
compete in these more treacherous surf conditions, incident numbers and the degree of
seriousness could substantially increase, because of their possible limited experience in
these types of surf conditions.

5.6.4 Range Restrictions

The abovementioned refereeing and competitor-based restrictions limit the accuracy and
reliability of the data in terms of range restriction, and representativeness, which after
initial statistical analysis, may indicate apparent statistical non-significance of a variable or
a lesser degree of model explanation, by a reduction in explained variance. Loss of

\textsuperscript{30} As footnoted in Section 5.5.3.2, the Boat Panel consists of three to five experienced surfboat sweeps who
are nominated by their peers to represent to surfboat competitors at a pre-carnival briefing.
accuracy and reliability may manifest in terms of the precision of the data collected to account for variable factors contributing possible risk other than in a crude fashion. The data collection and analysis process must therefore account for these assumptions (Hunter, Schmidt & Le 2006; Sackett, P et al. 2007; Sackett, P & Yang 2000; Schmidt, Oh & Le 2006), which in this case study, may “strongly influence [sic] the estimation of response curves” (Thuiller et al. 2004, p. 165) involving the number and type of incidents. It could be expected that the risk-mitigation measures implemented by referees, and decisions by boat sweeps, could affect the correlations between individual subscales within the SHR and the number of surfboat incidents. Under-estimation of correlations could result from both groups erring on the side of safety when making risk decisions. Over-estimation of correlations may result from the intensity and importance of the competition. Schmidt, Oh and Le (2006) argue that range restriction has long been understood to lead to ‘undercorrection’ of important model parameters and should be accounted for when estimating those parameters of the unrestricted population. In this study, a range restriction of the data, which is caused by sweep and/or refereeing decisions as well as ethical considerations, may reduce the overall predictive power of the model.

For these reasons the predictive model is restricted in the first instance to the SHR variable rather than an investigation using the SHR subscales. The sample range is limited to a maximum observed SHR value of 22. The choice of a suitable statistical point estimator, which best represents the distribution of surfboat incidents, should account for the number of surfboats in each race, the competitors’ gender, and the experience of competitors, together with the observed number of races at each SHR level. A triangulation of methods promotes convergence towards a parsimonious model, which minimises the effects of this ‘undercorrection’.
5.7 Chapter Summary

This chapter has detailed the development of the *Surf Hazard Rating* model from its origins in 2012 as one of two components of the conceptual Competition Surf Safety Index model. The conceptual Competition Surf Safety Index model was theorised by this author and his colleague to describe the inherent danger to surf lifesaving competitors of varying ability-levels, resulting from their interactions with the surf environment. This author, based on the outcomes of a 2012/13 Pilot Study and a subsequent focus group of expert SLSA surf lifesavers and administrators, reformulated the conceptual variables in the original model and developed them into a workable model during the present case study for the empirical research. The chapter presents the updated rationale for each *Surf Hazard Rating* descriptor-variable, the need to exploit exogenous variables to test the SHR model, the path model describing its theorised variance, and the research design used to collect the required data.

The relevance of the research is demonstrated through the research aim to validate and evaluate the theoretical construct of the *Surf Hazard Rating* as a risk-management tool for surf lifesaving competitions in real time. The efficacy of the research process is assessed via the three related research questions, which provide a chronology of the significant issues, and which are addressed in the analysis of the data collected during Phases I, II, and III of the study. The third research question has been framed to assess the relevance of the SHR model as a practical real-time surf-risk decision tool.

The Action Research structure draws on the research projects conducted by this author, with the assistance of the not-for-profit sporting organisation SLSA, during the 2013/14 and 204/15 surf lifesaving seasons. The methodology required the author to design a TSO Training Manual and a series of related workshops. These instructional tools provided
opportunity for the author to train data collectors and decision makers in the theory underpinning the Surf Hazard Rating model. It also provided opportunity to conduct the workshops as focus groups, so that expert feedback could be utilised before the implementation of the data collection process. This chapter also provides evidence of those other materials, which were also created by this author alone, to guarantee data-collection integrity. Figure 5.3 above summarises the research methodology developed for this case study.

Through a process of multiple presentations in workshops, and receipt of ongoing feedback, including that from the ASRL Annual General Meeting in May 2014, the SHR model received endorsement from the SLSA as a valid and reliable risk-management tool to be used in upcoming surfboat carnivals in the following 2014/15 season. This endorsement provided the opportunity to implement Phases II and III of the research study, which contributed to the evaluation of the SHR model as a real-time operational risk-management tool. By the conclusion of the 2014/15 competition season, the author had acquired information regarding 2118 races and referee feedback from 68 separate carnivals, to be able to analyse the data in accordance with the study’s stated aim and research questions, with due consideration to the limitations listed in Sections 5.5.3.1 and 5.6. An analysis and discussion of that data is hereafter presented in Chapter 6.
Chapter 6  Results and Analysis

6.1 Overview

It has been argued in the previous chapters that there is a need for a valid quantitative model that assesses surf-danger in real-time, and that this research study provides a methodology and the empirical evidence to support this claim. The evidence is presented in chronologic order as Phases I, II, and III, consistent with the methodology, which is detailed in Chapter 5, using predominantly quantitative methods of analysis of observational data. The analysis investigates the relationship between the Surf Hazard Rating (SHR) and the number of surfboat incidents occurring during competitions in the surfing seasons 2013/14 and 2014/15, across Australian beaches (Surf Life Saving Australia 2015d, Appendices 8 and 9). The results of the analysis are supported by surveys of participant surf-risk managers, and a case study during the same period, to triangulate the research towards an acceptable and reliable surf-hazard assessment model. The chapter also describes several limitations of the data-collection process and their potential effect on the study’s results. Being an observational study, the analysis is restricted to the collection of data that is affected by ethical considerations, human motivations, and decisions regarding perceived risk when competing in varied surf conditions.

Initially, the relationship between the number of surfboat incidents (the ‘dependent variable’) and the Surf Hazard Rating (the ‘independent variable’) are explored using Phase I (2013/14) data, comprising 515 separate races from 22 surfboat carnivals at 17 separate Australian east-coast beaches. The investigation sought to analyse the nature of the underlying distributions, with the view of presenting a predictive model that accurately and reliably relates a statistically-typical estimator of the central tendency of surfboat
incidents with each of the observed race-specific *Surf Hazard Rating* levels. The investigation utilises SPSS Version 25 (IBM 2018) to assess the underlying model assumptions and determine suitable predictive models. Predictive techniques, especially regression analysis, and other techniques such as Inter Rater Reliability (IRR), Receiver Operating Characteristic (ROC) curve, and Binary Logistic Regression analysis, are also utilised to assess the reliability of the model.

The analysis of Phase II data employs the same techniques as in Phase I to confirm the predictive power of the SHR model in terms of accuracy and reliability. The data from 1,603 different surfboat races used during this phase (2014/15) of the study analyses the relationship between the same statistical point-estimator of central tendency of surfboat incidents, with the more generalised time-period recording of the *Prevailing Surf Hazard Rating* (*Prevailing SHR*) to confirm model validity. This phase also investigates the association between carnival risk-manager opinions of surf danger and the *Prevailing SHR* to support the decision framework, which was developed during Phase I of the study. This process is used to determine a decision threshold, at a specific SHR value, beyond which the wearing of safety helmets is mandated in surfboat competitions, in accordance with SLSA protocols (Surf Life Saving Australia 2017a).

Phase III of this research involved a case study, which provides documented evidence of how the SHR tool and associated decision framework performed in real time. The case study was undertaken during a major carnival of similar importance, and in similar surf conditions, in terms of the presence of wave height, wave type, wave period, surf zone width, surface turbulence, and longshore and rip currents (see Section 6.4) to those evident at the time when Saxon Bird died in 2010 (Queensland Office of the State Coroner 2011). The documentation provides multiple *Prevailing SHR* readings taken in association with
the carnival referee, which indicated the rapidly deteriorating surf conditions, in terms of those same variables, immediately preceding the first race of the ASRL Open Australian Surfboat Championships in February 2015. These readings indicate a disparity with the forecasts of the Australian Bureau of Meteorology, web-based surfing websites, and local lifeguards, in the days preceding these championships, which initially led surf-risk managers, being part of their preliminary assessment as set out in Section 1.6.2 of the SLSA Surf Sports Manual (Surf Life Saving Australia 2017a), to believe that surf conditions would be abating throughout the duration of the upcoming carnival.

Finally, the discussion draws together the significant elements of the three phases of this research to converge to a validated surf-hazard assessment model. This model is demonstrated to be generalisable, exhibits ease-of-use, and complements existing SLSA risk-management protocols and policies, as is required under its charter of good corporate governance. Therefore, this chapter provides the evidence to support the achievement of its research aim as defined through its Research Questions One, Two, and Three (Section 5.4.1).

### 6.2 Analysis of Phase I Data

As described in the Methodology chapter, quantitative information in Phase I (2013/14) was gathered predominantly on a per-race basis, consisting of the following surfboat incidents: broaching, back-shooting/nose-diving, swamping, overturning, collisions, and injuries, as they related to Race-Specific SHR values. For reasons just described, the analysis is initially simplified in this study by considering the relationship between surfboat incidents and the SHR composite index, rather than with its underlying constituent subscales of WHR, WTR, WPR, ZWR, STR, LDR, RCR, and OHR, thus reducing the need to account for multicollinearity between these covariates (see Table 6.2).
There were two carnival cancellations removed from the data because no surfboat races were conducted owing to extremely dangerous surf conditions. The data included race-specific SHR determinations by Trained Surf Observers (TSOs) and an independent Quality Control Officer (QCO), which facilitated the investigation of Inter Rater Reliability (IRR). Finally, overall model relevance to perceived surf danger by official risk-managers was assessed using a Prevailing SHR as it related to a referee’s overall perception of danger while conducting the carnival, using a five-point Likert scale (see Section 6.2.8). Analysis of the data is consistent with the methods recommended by Tabachnick and Fidell (2014), Lattin, Carroll and Green (2003), and Pallant (2005).

6.2.1 Data Inputs, Screening, and Cleaning

Carnival data from the 2013/14 season (i.e., Phase I) was coded and entered into SPSS Version 25 from the TSO/QCO event report sheets and post-carnival referee questionnaires (Surf Life Saving Australia 2015d, pp. 11, 45-6, Appendix 8). Input variables for each case included: Race ID, Carnival Number Tag, Date, Venue, Quality Control Officer (QCO), and Trained Surf Observer (TSO), Race Start Time and End Time, Competitor Gender, Event Category, and Number of Surfboats in the race. Prevailing SHR values and subscales were recorded for the QCO and TSO, and coded as Q_P_WHR, Q_P_WTR, Q_P_WPR, Q_P_ZWR, Q_P_STR, Q_P_LDR, Q_P_RCR, Q_P_OHR, and Q_P_SHR etc. Race-Specific SHRs and subscales, both ‘going out’ and ‘coming in’ for QCOs and TSOs were similarly coded and entered. Surfboat incidents for each race were recorded as Broaching (B), Back-shoot/Nose-dive (BS), Swamped (S), Overturning (OT), Collision (C) and Number of Injuries (I). Finally, referee opinions were recorded using a five-point scale along with any further referee, QCO, and TSO comments, which took the
form of open ended responses (SLSA Personal Protective Equipment (PPE) Project, 2015d pp. 22-5, Appendix 8).

Data was initially screened and cleaned following the methods suggested by Tabachnick and Fidell (2014), and Pallant (2005). Data (n = 515) was correctly categorised, checked for errors and missing cases. The cleaning process assured that the data had no errors, had no missing cases, and contained no outlier values using standard descriptive techniques as advised by Tabachnick and Fidell (2014, pp. 106-11) and Pallant (2005, pp. 63-5). Correlational and regression assumptions were assessed, and are recounted in the relevant analysis sections listed below. These include the determination of the nature of variable distributions (skewness and kurtosis), plots for non-linearity and heteroscedasticity, and the evaluation of multicollinearity of covariates.

6.2.2 Exploring the Underlying Surfboat-Incident and SHR Data

6.2.2.1 Race-Specific SHR

The Surf Hazard Rating is an interval scale because the differences between consecutive discrete points is theorised to be equal (Lattin, Carroll & Green 2003). The distribution of Race-Specific SHR values across all 515 races appears to be approximately normal with a mean of 11.56, standard deviation (SD) of 3.268, skewness of 0.059, and kurtosis of 0.082, with no significant outliers. This is supported by inspection of the Race-Specific SHR Frequency Histogram (Figure 6.1), and the Normal Probability Plot (Figure 6.2) of the observed Race-Specific SHR value against the expected value from the Normal distribution.
Figure 6.1  *Race-Specific* SHR Frequency Histogram

Figure 6.2  *Race-Specific* SHR Normal Probability Plot
6.2.2.2 Surfboat Incidents

Surfboat incidents are measured on a discrete interval scale. The distribution of the number of All Incidents\(^{31}\) (broaching, back-shooting/nose-diving, swamping, overturning, collisions, and injuries) across Race-Specific SHR values is listed in Table 6.1 below:

<table>
<thead>
<tr>
<th>Race-Specific SHR</th>
<th>Number of Races</th>
<th>Number of All Incidents</th>
<th>Race-Specific SHR</th>
<th>Number of Races</th>
<th>Number of All Incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>20</td>
<td>0</td>
<td>13</td>
<td>65</td>
<td>54</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>0</td>
<td>14</td>
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<td>84</td>
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<tr>
<td>7</td>
<td>19</td>
<td>0</td>
<td>15</td>
<td>24</td>
<td>46</td>
</tr>
<tr>
<td>8</td>
<td>33</td>
<td>5</td>
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<td>76</td>
<td>49</td>
<td>20</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>515</strong></td>
<td><strong>440</strong></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

The distribution\(^{32}\) of totals for the number of All Incidents for each Race-Specific SHR value, as presented in Table 6.1 above, is clearly non-uniform. As this is an empirical study, no attempt was made to control for the number of All Incidents and related surf conditions. Data was collected on a random basis as stated in the methodology. The distribution of the number of surfboats per race is also non-uniformly distributed for reasons given in Section 5.6. The relevant descriptive statistics include a mean of 4.895, SD of 0.97, median of 5, mode of 5, minimum number of surfboats per race of 3, and maximum number of surfboats per race of 7.

\(^{31}\) An initial investigation of all surfboat incidents, being the sum of broaching (B), back-shooting/nose-diving (BS), swamping (S), Overturning (OT) and injury, has been undertaken in the first instance, with the view of refining the model to specific significant incidents if later required.

\(^{32}\) This is supported by visual comparison of the relevant graph.
6.2.2.3 An Initial Assessment of the Relationship

Since the study contains data where the number of incidents occurring per race and the number of boats competing in each race is not uniform, it is to be expected that the relationship between the number of incidents occurring during each race at given SHR levels initially reveals little useful information. A Scatter Plot of the total number of surfboat incidents (All Incidents) versus the *Race-Specific* SHR in Figure 6.3 below indicates the seemingly chaotic nature of the relationship between these two variables across 515 separate races, thus indicating a degree of heteroscedasticity. The upward sloping relationship does, however, indicate that, for low *Race-Specific* SHR values (values of 4, 6, and 7), there are no incidents occurring. In contrast, for values closer to 20, the number of surfboat incidents increases dramatically.

![Figure 6.3 Number of All Incidents versus Race-Specific SHR](image)

For the data in this study, the variability in *Race-Specific* SHR scores does not appear to be the same as the variability in the number of All Incident surfboat scores. This outcome violates the assumption of homoscedasticity for a linear correlation between the two
variables. Yet Tabachnick and Fidell (2014) note that, while this is not necessarily fatal to the analysis of the ungrouped data, a greater predictability of the relationship may result from the analysis of the data using a statistical estimator, together with multivariate methods, including curvilinear modelling.

6.2.3 Statistical Estimators for Surfboat Incidents and the SHR

A suitable measure of statistical central tendency is required to further investigate the relationship between surfboat incidents and the SHR. As cited in Section 4.5.2.2, Sutherland, Peet and Soulsby (2004), in their evaluation of numeric coastal morphological models, recommend the mean (average) or median as the most representative measure of population central tendency, with preference given to the former measure. This is also supported in the statistical literature by authors such as Heiman (2001), Lattin, Carroll and Green (2003), Nardo, Saisana, Saltelli, Tarantola, et al. (2005), Beguería (2006), Tabachnick and Fidell (2014), and DeVellis (2016). Following on from these recommendations in the literature, this analysis utilises the mean (or average) as the most representative measure of the number of incidents occurring during a surfboat competition race. The analysis of Phase I data therefore explores the relationship between the Race-Specific SHR, and the average number of All Incidents per race, both of which are defined as follows.

6.2.3.1 An Estimator for the Race-Specific Surf Hazard Rating

Data that determined the Race-Specific SHR was recorded for the 515 races at the carnivals listed in Table 5.2 in the Methodology section, when craft were ‘going out’ and ‘coming in’ through the surf zone. Although two values for the Race-Specific SHR were recorded in the data as RS_SHR_OUT and RS_SHR_IN, only one representative value
was selected to measure against the total number of incidents in the race both ‘going out’ and ‘coming in’. The data recording sheets (Surf Life Saving Australia 2015d, pp. 45-6, Appendix 8; Appendix VI) provided insight into whether the incident occurred ‘going out’ or ‘coming in’ through input in the “Comments” section, which provided opportunity for open ended responses. Together with this information and a recording of the incident itself (for example broaching or nose-diving, being ‘coming in’ incidents, or back-shooting, being a ‘going out’ incident), a representative value of the most appropriate Race-Specific SHR was determined. For example, if more incidents occurred ‘coming in’ than ‘going out’, then the SHR corresponding with the ‘coming in’ incidents was recorded, and vice versa. Where available, data was selected using the Quality Control Officer (QCO) data, as this person was the most experienced TSO, and was most often this author.

6.2.3.2 An Initial Estimator for the Number of Surfboat Incidents

As indicated in Section 6.2.1.2, the mean (4.895), median (5) and mode (5) for the number of surfboats competing in each race, were all approximately equal. These statistics indicate a near-normal distribution across all races. Therefore, the most representative number of surfboats per race is standardised to five (5). Correspondingly, the number of incidents in each of the 515 races was standardised to reflect the number of incidents that would occur if the race contained five surfboats. This value provided a balance in the observed range around this central point. With all other variables being held constant, one might expect more incidents to occur in a seven-boat race than a five-boat race, and less in a three-boat race.

The method of analysis of the most appropriate Race-Specific SHR in this research study differed slightly from that in the 2013/14 Surf Hazard Rating and Surf Helmet (Surf Boats) Project (Surf Life Saving Australia 2015d, Appendix 8). The project used only ‘coming in’ SHR values for convenience, whereas this research study uses the more representative value form ‘going out’ or ‘coming in’ as described above.
For example, at the Tugun carnival (11/01/2014), the starting number of surfboats in three adjacent races were 5, 4, and 6, whereas the total number of All Incidents in each of these races was 2, 1, and 1 respectively. When the latter numbers are transposed to the equivalent number of All Incidents in a five-boat race, the numbers become 2.00, 1.25, and 0.83 respectively. These values better describe the number of incidents as might be expected while controlling for number of boats in each race. The standardisation process enables a comparison of surfboat incidents with the Race-Specific SHR, using the representative value of five surfboats per race (hereafter called Five-All-Incidents) across all 515 races.

6.2.4 Initial Investigations of Variates and Covariates

A table of Pearson’s Correlations (r) relating Five-All-Incidents to Race-Specific SHR values and its constituent Race-Specific subscales: RS_WHR, RS_WTR, RS_WPR, RS_ZWR, RS_STR, RS_LDR, RS_RCR, and RS_OHR are recorded in Table 6.2 below. As indicated in this table, compared with later relationships (see Table 6.6 below), there is a low positive linear correlation (r = 0.582) at the 0.01 one-tailed significance level between Five-All-Incidents and the Race-Specific SHR. According to Tabachnick and Fidell (2014, p. 124) “The statistical problems created by singularity and multicollinearity occur at much higher correlation (0.9 and higher)”. Therefore using the argument of Tabachnick and Fidell (2014), correlations less than 0.9, which occur in the table below, indicate acceptable covariation between these subscale variables of the SHR. However, as indicated in this table and argued elsewhere, more robust methods of analysis are available to account for the variability in the Race-Specific SHR and the number of surfboat incidents than using a linear model.
Table 6.2  Phase I Surfboat Incident and SHR Descriptor Correlations

<table>
<thead>
<tr>
<th>Five-All-Incidents</th>
<th>RS_SHR</th>
<th>RS_WHR</th>
<th>RS_WTR</th>
<th>RS_WPR</th>
<th>RS_ZWR</th>
<th>RS_STR</th>
<th>RS_LDR</th>
<th>RS_RCR</th>
<th>RS_OHR</th>
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<tr>
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<td>0.000</td>
<td>0.000</td>
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<td>RS_LDR</td>
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<td>0.000</td>
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<td>0.000</td>
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<tr>
<td>RS_RCR</td>
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</tr>
<tr>
<td>RS_OHR</td>
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<td></td>
</tr>
<tr>
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<td>0.013</td>
<td>0.000</td>
<td>0.000</td>
<td>0.337</td>
<td>0.000</td>
<td>0.000</td>
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</tr>
</tbody>
</table>

6.2.5  A Conclusive Estimator of Surfboat Incidents

The number of races conducted at each Race-Specific SHR level also can effect the most representative estimator of the number of surfboat incidents to be mapped against the SHR. Table 6.3 below extends Table 6.1 to apply to the number of incidents occurring in five-boat races, as was argued in the previous section. This data also indicates a non-uniform distribution of five-boat incidents across all SHR levels. The number of Five-All-Incidents at each SHR level is highly influenced by the number of races at that level, which could potentially confound the true relationship between these two variables.

For example, consider the number of incidents occurring at SHR levels of 14 and 15 in Table 6.3 below. The total numbers of Five-All-Incidents are 85 and 50 respectively. From these values, it would appear that the SHR level of 14 is more dangerous than that at 15
because there are more five-boat incidents occurring at this level compared with at a SHR of 15. However, when considering the number of races held at each of these levels, being 46 and 24 respectively, one finds that the number of five-boat incidents occurring on a per-race (i.e., average or mean) basis are 1.84 and 2.06 respectively. This indicates that more five-boat incidents per race occurred at the SHR level of 15 compared with that at the SHR level of 14, as might be expected. This suggests that the mean of Five-All-Incidents is a better estimator of surfboat incidents than the Five-All-Incidents variable when measured against the Race-Specific SHR. This new variable will be henceforth called the Mean Five-All-Incidents.

### Table 6.3 Phase I Five-boat Race and Incident Frequencies

<table>
<thead>
<tr>
<th>Race-Specific SHR</th>
<th>Number of Races</th>
<th>Number of Five-All-Incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>33</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>70</td>
<td>7</td>
</tr>
<tr>
<td>10</td>
<td>44</td>
<td>9</td>
</tr>
<tr>
<td>11</td>
<td>56</td>
<td>29</td>
</tr>
<tr>
<td>12</td>
<td>76</td>
<td>48</td>
</tr>
<tr>
<td>13</td>
<td>65</td>
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<td>15</td>
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<td>17</td>
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<td>18</td>
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<td>69</td>
</tr>
<tr>
<td>19</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td>20</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>515</td>
<td>472</td>
</tr>
</tbody>
</table>

The distribution of Mean Five-All-Incidents, at each level of the Race-Specific SHR, exhibit positive skewness of the data when comparing the Mean, Median, and Mode in Table 6.4 below. As indicated in the right-most columns of this table, the number of zero-
incidents occurring during races heavily influences the skewness of the distribution. This is especially evident at Race-Specific SHR values of 12 or less, where the number of zero-incidents occurring per race represents over half of the data at each level. As stated above, the Mean Five-All-Incidents will be used from this point forward to measure the relationship with the Race-Specific SHR.

Table 6.4  Phase I Five-boat Incident Means versus Race-Specific SHR

<table>
<thead>
<tr>
<th>Race-Specific SHR</th>
<th>Number of Races</th>
<th>Mean[^34] Five-All-Incidents</th>
<th>95% LCL[^35]</th>
<th>95% UCL[^37]</th>
<th>Median Five-All-Incidents</th>
<th>Mode Five-All-Incidents</th>
<th>Number of Zero Incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>20</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0</td>
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<td>20</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
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<td>5</td>
</tr>
<tr>
<td>7</td>
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<tr>
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<tr>
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<tr>
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<td>0.62</td>
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<td>0.83</td>
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<tr>
<td>14</td>
<td>46</td>
<td>1.84</td>
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<tr>
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<tr>
<td>17</td>
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<td>11.35</td>
<td>5.00</td>
<td>2.50</td>
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Part of the data in Table 6.4 above indicates the new relationship between the two variables (Mean Five-All-Incidents and Race-Specific SHR). It can be interpreted as follows. Based on the data collected from 515 surfboat races, it could be expected that, for example, approximately 2.67 incidents occur on average per five-boat race at a Surf

[^34]: The Mean (or Average) in this sense indicates the most representative statistic for the Number of All Incidents per five-boat race.

[^35]: 95% Lower and Upper Confidence Levels of the Mean Five-All-Incidents.
Hazard Rating of 16. Figure 6.4 shows a clear and rapidly increasing number of incidents per race occurring in an average five-boat surfboat race across all observed Race-Specific SHR levels above a value of 8 (approximately). The trend of this mean-based curve better reflects the uncertainty caused by the limitations in the data as discussed in Section 6.2, including the lack of competitor numbers in some races.

![Figure 6.4 Mean Five-All-Incidents versus Race-Specific SHR](image)

It would appear, based on the data and reflected in Figure 6.4 above, that incidents were relatively infrequent below a SHR of approximately 9. Of primary importance is the need to accurately describe the relationship between Mean Five-All-Incidents and the Race-Specific SHR, as indicated in Figure 6.4 and Table 6.4. Accordingly, a more detailed analysis of the 2013/14 data now follows.
6.2.6 Determination of an Accurate Predictive Model

6.2.6.1 Model Prediction using Regression Analysis

Regression analysis is the most widely accepted analysis technique to explore the relationship between an independent variable, such as the SHR, and a dependent variable, such as the number of surfboat incidents (Lattin, Carroll & Green 2003; Tabachnick & Fidell 2014). Pallant (2005) argues that data collected using an observational and non-experimental design, which is evident in this case study, is best interpreted using regression analysis. Therefore, the following analysis investigates possible linear and non-linear regression models.

Table 6.5 Phase I Regression Models and Equations

<table>
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<th>Regression Equation</th>
<th>Regression Model</th>
<th>Regression Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>( Y = b_0 + b_1X )</td>
<td>Compound</td>
<td>( Y = b_0b_1^X )</td>
</tr>
<tr>
<td>Logarithmic</td>
<td>( Y = b_0 + (b_1 \ln X) )</td>
<td>Power</td>
<td>( Y = b_0X^{b_1} )</td>
</tr>
<tr>
<td>Inverse</td>
<td>( Y = b_0 + (b_1 \frac{1}{X}) )</td>
<td>S</td>
<td>( Y = e^{(b_0 + b_1X)} )</td>
</tr>
<tr>
<td>Quadratic</td>
<td>( Y = b_0 + b_1X + b_2X^2 )</td>
<td>Growth</td>
<td>( Y = e^{(b_0 + b_1X)} )</td>
</tr>
<tr>
<td>Cubic</td>
<td>( Y = b_0 + b_1X + b_2X^2 + b_3X^3 )</td>
<td>Exponential</td>
<td>( Y = b_0e^{(b_1X)} )</td>
</tr>
<tr>
<td>Logistic</td>
<td>( Y = \frac{1}{1 + b_0(b_1X)} )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The equations of the regression models, available using SPSS Version 25 (IBM 2018), are listed in Table 6.5 above. In the relevant model, \( X \) is the independent variable, \( Y \) is the dependent variable, \( b_0, b_1, b_2, \ldots b_k \), are the independent-variable coefficients, and \( u \) is the upper boundary value of \( Y \) in the Logistic model, which is set at a value of 6.3, being just greater than the maximum mean number of all five-boat incidents in Table 6.4 above.
6.2.6.2 Assumptions of Regression Analysis

Regression analysis of this environmentally-based research data assumes that the independent variable (SHR) is measured without error, which, as Tabachnick and Fidell (2014) note, is clearly not possible in most social and behavioural science research. As was argued in previous sections of this chapter, multicollinearity between the covariates RS_WHR, RS_WTR, RS_WPR, RS_ZWR, RS_STR, RS_LDR, RS_RCR, and RS_OHR is not significant. That said, interactions between these covariates could significantly complicate the multiple regression process involving these variables in association with surfboat incidents. The study has therefore sought to investigate the bivariate relationship between the number of surfboat incidents and the SHR level, rather than a multivariate analysis involving the above covariates, to control for introduced measurement error as far as possible in the first instance.

As previously stated in Section 6.2.1, the process of initial data cleansing and descriptive analysis indicated normality of the SHR variable. Additionally, both the Race-Specific SHR and Mean Five-All-Incidents variables are to be regarded as interval data, the former being discrete, and the latter being continuous. The independent variable (Race-Specific SHR) is not time-series data, and there exists independence between the incident observations for each Race-Specific SHR data point. Hence, there is no significant correlation between the error terms in consecutive SHR values, and autocorrelation is not a significant factor in the relationship. It is assumed that the distribution of means using the Mean Five-All-Incidents variable is normally distributed since it satisfies the Central Limit Theorem with a large sample size (n = 515). This is qualified by noting (Table 6.4) that the sample sizes for higher Race-Specific SHR-related data is small.
However, as also stated previously, an inspection of the scatter plot in Figure 6.3 indicates that the linear regression assumption of homoscedasticity does not apply in this case. The following section reviews the possible curvilinear forms of the relationship between the *Race-Specific* SHR and the *Mean Five-All-Incidents*. For completeness of comparisons of regression models, the Linear model is also included.

### 6.2.6.3 Comparison of Regression Forms

The following table (Table 6.6) summarises the bivariate regression models where X represents the independent variable *Race-Specific* SHR, and Y represents the dependent variable *Mean Five-All-Incidents* for the given range of data values in the sample of size n = 515. The related graphical representations of these models using the observed data are displayed in Figure 6.5 below.

Most models are significant, with high F-statistics at $p < 0.0005$, with the exception of the Inverse model, which is significant to $p < 0.005$. The Logarithmic and Inverse functions indicate lower R-squares than all other models and are therefore eliminated from further consideration. From theory, it could be expected that higher *Race-Specific* SHR values above the maximum value of 22, indicative of more dangerous surf conditions, could result in an increased rate of ‘five-boat incidents’ per race than within the range of observation. It is also for this reason that the linear model is set aside at this stage. The S model has an R-square value (0.827) that is approximately the same as the Linear model, and possesses a growth relationship similar in appearance to that of the Logarithmic model. It too is set aside at this stage in preference to other curvilinear models with higher real and potential predictability.
Table 6.6  Phase I Curvilinear Regression Model Test Statistics

<table>
<thead>
<tr>
<th>Regression Model</th>
<th>R-square</th>
<th>Regression Coefficients</th>
<th>F-statistic</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>0.813</td>
<td>(b_0 = -2.608) (b_1 = 0.338)</td>
<td>61.024</td>
<td>0.000</td>
</tr>
<tr>
<td>Logarithmic</td>
<td>0.644</td>
<td>(b_0 = -6.186) (b_1 = 3.196)</td>
<td>25.317</td>
<td>0.000</td>
</tr>
<tr>
<td>Inverse</td>
<td>0.437</td>
<td>(b_0 = 3.816) (b_1 = -22.759)</td>
<td>10.877</td>
<td>0.005</td>
</tr>
<tr>
<td>Quadratic</td>
<td>0.962</td>
<td>(b_0 = 1.567) (b_1 = -0.462) (b_2 = 0.033)</td>
<td>166.517</td>
<td>0.000</td>
</tr>
<tr>
<td>Cubic</td>
<td>0.970</td>
<td>(b_0 = -0.487) (b_1 = 0.187) (b_2 = -0.027) (b_3 = 0.002)</td>
<td>128.774</td>
<td>0.000</td>
</tr>
<tr>
<td>Compound(^{36})</td>
<td>0.897</td>
<td>(b_0 = 0.002) (b_1 = 1.538)</td>
<td>122.398</td>
<td>0.000</td>
</tr>
<tr>
<td>Power(^{38})</td>
<td>0.924</td>
<td>(b_0 = 0.000) (b_1 = 4.650)</td>
<td>169.699</td>
<td>0.000</td>
</tr>
<tr>
<td>S(^{38})</td>
<td>0.827</td>
<td>(b_0 = 2.931) (b_1 = -3.015)</td>
<td>66.801</td>
<td>0.000</td>
</tr>
<tr>
<td>Growth(^{38})</td>
<td>0.897</td>
<td>(b_0 = -6.143) (b_1 = 0.431)</td>
<td>122.398</td>
<td>0.000</td>
</tr>
<tr>
<td>Exponential(^{38})</td>
<td>0.897</td>
<td>(b_0 = 0.002) (b_1 = 0.431)</td>
<td>122.398</td>
<td>0.000</td>
</tr>
<tr>
<td>Logistic(^{38})</td>
<td>0.897</td>
<td>(b_0 = 465.256) (b_1 = 0.650)</td>
<td>122.398</td>
<td>0.000</td>
</tr>
</tbody>
</table>

The graphs displayed in Figure 6.5 are determined by substituting the regression coefficients listed in Table 6.6 into the equations from Table 6.5. Based on R-square values in Table 6.6, these curvilinear groups, which potentially best model the relationship in this investigation, are the Polynomial functions (Quadratic and Cubic), the Power function, and Exponential forms, given by the Growth, Compound, Exponential, and Logistic models.

\(^{36}\) The creation regression equations for the Compound, S, Growth, Exponential, Power, and Logistic models, X assumes the data-set contains non-zero values because otherwise the appropriate log transformations will not apply (IBM Knowledge Center 2018). Therefore, the Mean-Five-All- Incidents values for corresponding to Race-Specific scores of 4, 6, and 7 were transposed to 0.01 before curve estimations were calculated.
Reference to Figure 6.5 indicates a rapid increase in the average number of five-boat incidents per race as the Race-Specific SHR increases. Even though the linear regression relationship is reasonably good, as indicated by an R-square of 0.813, this relationship does not adequately explain the variance in the observed dependent variable for higher values of the independent variable.

The Growth and Exponential equations simplify to the same basic form. Along with the Compound and Logistic models, these all have same R-square = 0.897. For these models, approximately 90% of the variance in Mean Five-All-Incidents can be explained through the model, by variance in the Race-Specific SHR. The Logistic model, by definition, does not remain monotonically increasing for all values of the independent variable, as would be expected for this case study, so it is eliminated at this stage. The Power, Quadratic and Cubic models have the highest R-square values, being 0.924, 0.962, and 0.970 respectively. These three models have higher Coefficients of Determination (R-Squares).
than the previous group when applied to the recorded data. Given the uncertainty in the data, owing to the limitations listed above, it could be argued at this stage that the relationship between the Race-Specific SHR and the Mean Five-All-Incidents could best be explained by the Polynomial, Power or Exponential models with a high level of predictability.

6.2.7 Model Reliability

A valid quantitative environmental risk-management model, especially one associated with human participation, firstly requires high-variable association-accuracy when “comparing model predictions with a real-world dataset” (Beguería 2006, p. 315). The previous section established that the SHR is a very good predictor of those dangerous surf conditions that could lead to competitor injuries when they are exposed to incidents, similar to those recorded during this study. For surf-risk managers to gain confidence in the model, it is also necessary for the model to provide positive and negative signals that can consistently be interpreted by them. The following section evaluates the model in terms of inter-rater reliability and its adequacy in meeting the needs of carnival referees for an efficient predictive surf-hazard model.

6.2.7.1 Inter-Rater Reliability

Consistency in rating dangerous surf conditions by experts is assessed on a per-race basis using independent Race-Specific SHR evaluations by TSOs. Their recordings are subsequently compared with those of the QCOs from all carnivals within the scope of study in 2013/14. Data was coded to maintain participant anonymity and filtered before analysis to remove cases where both TSOs and QCOs were not simultaneously available to
record race-specific values. The data was analysed using SPSS Version 25 by splitting the file by carnival venue prior to analysis.

Table 6.7 Phase I Measures of Inter-Rater Reliability

<table>
<thead>
<tr>
<th>Carnival Venue</th>
<th>Date</th>
<th>Mean SHR</th>
<th>Number of Races</th>
<th>Cronbach’s Alpha (‘Going Out’)</th>
<th>Cronbach’s Alpha (‘Coming In’)</th>
<th>Intra Class Correlations (‘Going Out’)</th>
<th>Intra Class Correlations (‘Coming In’)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anglesea</td>
<td>5/1/14</td>
<td>9</td>
<td>25</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Tugun</td>
<td>11/1/14</td>
<td>10</td>
<td>28</td>
<td>0.944</td>
<td>0.944</td>
<td>0.893</td>
<td>0.893</td>
</tr>
<tr>
<td>Collaroy</td>
<td>12/1/14</td>
<td>8</td>
<td>30</td>
<td>0.959</td>
<td>1.000</td>
<td>0.921</td>
<td>1.000</td>
</tr>
<tr>
<td>Jan Juc</td>
<td>12/1/14</td>
<td>12</td>
<td>28</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Coolum</td>
<td>18/1/14</td>
<td>18</td>
<td>24</td>
<td>0.948</td>
<td>0.893</td>
<td>0.901</td>
<td>0.806</td>
</tr>
<tr>
<td>Queenscliff</td>
<td>18/1/14</td>
<td>13</td>
<td>22</td>
<td>0.879</td>
<td>0.926</td>
<td>0.785</td>
<td>0.863</td>
</tr>
<tr>
<td>Manly</td>
<td>25/1/14</td>
<td>16</td>
<td>29</td>
<td>0.854</td>
<td>0.760</td>
<td>0.745</td>
<td>0.613</td>
</tr>
<tr>
<td>North Steyne</td>
<td>26/1/14</td>
<td>14</td>
<td>19</td>
<td>0.895</td>
<td>0.897</td>
<td>0.809</td>
<td>0.814</td>
</tr>
<tr>
<td>Freshwater</td>
<td>27/1/14</td>
<td>17</td>
<td>32</td>
<td>0.940</td>
<td>0.921</td>
<td>0.887</td>
<td>0.853</td>
</tr>
<tr>
<td>Broadbeach</td>
<td>1/2/14</td>
<td>16</td>
<td>12</td>
<td>0.712</td>
<td>0.756</td>
<td>0.552</td>
<td>0.607</td>
</tr>
<tr>
<td>Point Leo</td>
<td>2/2/14</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Stockton</td>
<td>8/2/14</td>
<td>9</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Stockton</td>
<td>9/2/14</td>
<td>14</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Tallebudgera</td>
<td>15/2/14</td>
<td>12</td>
<td>32</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Mooloolaba</td>
<td>1/3/14</td>
<td>12</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Fairhaven</td>
<td>2/3/14</td>
<td>20</td>
<td>8</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>North Kirra</td>
<td>7/3/14</td>
<td>10</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>North Kirra</td>
<td>8/3/14</td>
<td>12</td>
<td>40</td>
<td>0.977</td>
<td>0.959</td>
<td>0.955</td>
<td>0.922</td>
</tr>
<tr>
<td>North Kirra</td>
<td>9/3/14</td>
<td>13</td>
<td>28</td>
<td>0.988</td>
<td>0.947</td>
<td>0.976</td>
<td>0.899</td>
</tr>
<tr>
<td>Broadbeach</td>
<td>1/3/14</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Ocean Grove</td>
<td>15/3/14</td>
<td>10</td>
<td>22</td>
<td>0.835</td>
<td>0.778</td>
<td>0.717</td>
<td>0.637</td>
</tr>
<tr>
<td>Ocean Grove</td>
<td>16/3/14</td>
<td>13</td>
<td>17</td>
<td>0.972</td>
<td>0.927</td>
<td>0.972</td>
<td>0.865</td>
</tr>
</tbody>
</table>

The results of that analysis are displayed in Table 6.7 above. Data entries of ‘N/A’ in the table indicate that insufficient data was available for analysis. This was either because both TSOs and QCOs were not simultaneously present, or it was eliminated during the analysis because of insufficient races conducted to make comparisons. Rater reliability was assessed using Cronbach’s Alpha and the Intra Class Correlation coefficient (ICC)
separately, for the ‘going out’ and ‘coming in’ readings. In general, measures of inter-rater reliability were high to very high (on average 0.88 and 0.93 respectively), thereby indicating consistency and accuracy of the SHR as an effective measuring instrument for surf hazardousness.

Results at several venues (i.e., Manly, Broadbeach and Ocean Grove) did not reflect this overall high rater consistency. The Manly and Ocean Grove carnivals experienced a change of TSO during the recording process. In the opinion of the author, the TSO at the Broadbeach carnival retained a biased assessment of wave heights throughout this recording period, by underestimating the wave height. This bias was noted on the QCO Comment sheet from this carnival, by this author. The official was later retrained to comply with SHR-variable definitions according to the TSO Training Manual (Appendix II) before the person was permitted to participate in any further data recordings. Variations of SHR readings between QCOs and TSOs of ±2 occurred in approximately 3% of nearly 800 rater comparisons (using ‘going out’ and ‘coming in’ data for each race), and a variation of ±1 occurred in approximately 15% of comparisons. Many of the rater discrepancies occurred during the early stages of the study, where TSO recorder-bias was noted,\(^{37}\) or where surf conditions became more treacherous. This resulted in very large surf-zones widths and rapid surf-condition changes (for example within 20 to 30 seconds) within the period of recording.

The above results indicate not only a high level of inter-rater reliability, as indicated in Table 6.7 by a high Cronbach’s Alpha and Intra Class Correlation values, but also that the

\(^{37}\) If a TSO recorder-bias was noted, only QCO SHR values were utilised for the study during that carnival. It could be argued that inter-rater reliability data at a carnival such as at Broadbeach could be removed from the data set. However, it has been retained to indicate the possible extent of measurement error owing to recorder bias. Further, it provides a mechanism for assuring rater reliability, as will be discussed in Chapter 7.
model is measuring what it is designed to measure (i.e., internal consistency), and is associated with excellent model predictability, as was detailed in the previous section.

6.2.7.2 Signal Detection

Risk-management decisions, based on any predictive model, require a demonstration that clear signals separate creditable risk-indicators from ineffective noise, which Streiner and Cairney (2007, p. 122) conclude “could be misinterpreted as a true signal”. This is especially relevant when making risk decisions involving participation in the natural environment, where incorrect choices related to complex-variable interactions may lead to life-endangering outcomes. The diagnostic performance of the SHR model to discriminate between true positive signals and ineffective noise is assessed by the Receiver Operator Characteristic (ROC) and Binary Logistic Regression, using the Odds Ratio. Both methods exploit a comparison of the SHR against the occurrence of any surfboat incident, which is treated as a dichotomous variable. Reliability to signal ‘true positives’, and ‘true negatives, are measured using the area under the ROC curve (AUC) and the Odds Ratio. A ‘true positive’ is the ability of the model to correctly signal when an incident has been observed, and a true negative is the model’s ability to correctly signal when an incident should not occur, as evidenced in the data.

Research by Pepe (2000), Qin and Zhou (2006) and Streiner and Cairney (2007) provide evidentiary support for the diagnostic accuracy of Receiver Operator Characteristic (ROC) curve analysis to discriminate between true and false positives when dealing with dichotomised variables. The ROC curve in Figure 6.6 below measures the prediction rate of true positives (Sensitivity) compared to the rate of false positives (1 – Specificity) for various cutoff levels of the RS_SHR variable. The area under this curve (AUC) is a measure of how well the predictive ability of the SHR model can distinguish between the
two groups. The AUC, when comparing the test variable (RS_SHR) to the number of surfboat incidents (treated as a dichotomous variable) occurring in each race is 0.848. Streiner and Cairney (2007) advise that this indicates a moderate to high level of model accuracy.

![ROC Curve](image)

**Figure 6.6  Receiver Operator Characteristic Curve**

Reliability analysis using Binary Logistic Regression similarly codes the number of surfboat incidents as a dichotomous dependent variable, which is measured against the RS_SHR variable to assess model performance. Binary Logistic Regression in this case estimates the probability of an incident occurring at a given SHR value, using a maximum
likelihood estimation function of the regression coefficients (Lattin, Carroll & Green 2003), where:

- \( Y \) is the binary response variable (\( Y_i = 1 \) if a surfboat incident is present in observation \( i \), and \( Y_i = 0 \) if an incident is not present).

- \( X \) is Race-Specific SHR, being the only independent (explanatory) variable.

- \( \pi \) is the conditional probability of \( Y \) occurring for a given value of \( X \), where

\[
\pi = \frac{e^{(\beta_0 + \beta_1 X)}}{1 + e^{(\beta_0 + \beta_1)}}
\]

- \( \beta_0 \) and \( \beta_1 \) are the coefficients \( b_0 \) and \( b_1 \) in the classification table below (Table 6.8).

- \( \ln(\pi) = \beta_0 + \beta_1 X \) ……………… (2)

The output from the analysis, when maximising the joint probability, or likelihood of observing the choice outcomes \( Y_i \) using SPSS, is summarised in Table 6.8 below.

<table>
<thead>
<tr>
<th>Omnibus Test</th>
<th>Hosmer &amp; Lemeshow Test</th>
<th>EXP(B)</th>
<th>( b_0 )</th>
<th>( b_1 )</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square = 212.488</td>
<td>Chi-square = 212.488</td>
<td>1.781</td>
<td>-5.77</td>
<td>0.430</td>
<td>76.5%</td>
</tr>
<tr>
<td>df = 1</td>
<td>df = 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sig. = 0.000</td>
<td>sig. = 0.240</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results from the Omnibus Test and Hosmer and Lemeshow Test when applied to the data both indicate a high level of model ‘Goodness-of-Fit’ (Chi-square of 212.488 for \( p < 0.0005 \)). The Odds Ratio (Tabachnick & Fidell 2014, p. 507), given by \( \text{EXP(B)} \), indicates that the odds of a surfboat incident occurring on a per-race basis increase by a factor of 1.78 for each one unit increase in the RS_SHR variable. The model correctly classifies approximately 76.5% of observed cases into either the ‘incident’ or ‘no incident’
categories. Using the coefficients $b_0$ and $b_1$, the binary logistic model in equation (2) is represented by the equation:

$$\ln(\pi) = -5.77 + 0.430*(RS_{\text{SHR}}) \quad \cdots \cdots (3)$$

Solving equation (3) for statistical certainty of an incident occurring results in an $X$-intercept value of $RS_{\text{SHR}} = 13.4$. This value will be referred to later (Section 6.3.6) in this analysis as the SHR Decision Threshold value, for the mandatory wearing of helmets.

Analysis using ROC curve or Binary Logistic Regression methods verifies that the SHR model is a good model fit for the observed data, and has a high level of consistency in distinguishing between true positive signals and ineffective noise. Using either method, it has been established that the SHR is a reliable model for surf-risk managers to predict the likelihood of a surfboat incident occurring in varying surf conditions. The following section triangulates the methodology to provide confirmation of the model as an effective risk-management tool.

6.2.8 Referee Opinions

Table 5.3 in Section 5.5.3.1 detailed referee responses to the survey question: “Overall, how much concern about the surf conditions and its effect on competitors did you have when you refereed the surfboat carnival at (beach/venue) on (date)?” (Surf Life Saving Australia 2015d, p. 11, Appendix 8). The responses were recorded using a five-point Likert scale. Referee opinions represented their overall assessment of the perceived level of surf danger, and the effect that this could have on competitors and surf-craft if competition continued in these circumstances. The data recorded semi-regular assessments of the prevailing surf conditions by the QCO and coded as QCO_P_SHR. The mean of the
QCO_P_SHR across all races at each carnival was compared with the summarised opinion of the referee using the Likert scale (see Table 6.9 below).

On two occasions, referees regarded surf conditions as being extremely dangerous (Likert scale-value = 5). This resulted in carnival cancellation. On the first occasion (Fairhaven 02/03/2014), competition was cancelled after eight events. The QCO Prevailing SHR was 21. The second occasion occurred at Broadbeach (15/03/2014), where the carnival was cancelled on the day before competition was to commence. No official Prevailing SHR was able to be recoded because of non-attendance. A QCO assessed the Prevailing SHR at an adjacent beach (North Burleigh) to be 24. This value has not been used in the analysis.

Table 6.9  Phase I Referee Opinion versus *Prevailing* SHR

<table>
<thead>
<tr>
<th>Venue</th>
<th>Date</th>
<th>Number of Races</th>
<th>Referee Opinion</th>
<th>Mean QCO_P_SHR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anglesea</td>
<td>5/01/2014</td>
<td>25</td>
<td>1</td>
<td>8.96</td>
</tr>
<tr>
<td>Tugun</td>
<td>11/01/2014</td>
<td>32</td>
<td>2</td>
<td>12.00</td>
</tr>
<tr>
<td>Collaroy</td>
<td>12/01/2014</td>
<td>29</td>
<td>1</td>
<td>8.63</td>
</tr>
<tr>
<td>Jan Juc</td>
<td>12/01/2014</td>
<td>27</td>
<td>2</td>
<td>13.25</td>
</tr>
<tr>
<td>Coolum</td>
<td>18/01/2014</td>
<td>24</td>
<td>4</td>
<td>19.38</td>
</tr>
<tr>
<td>Queenscliff</td>
<td>18/01/2014</td>
<td>32</td>
<td>2</td>
<td>12.22</td>
</tr>
<tr>
<td>Manly</td>
<td>25/01/2014</td>
<td>31</td>
<td>3</td>
<td>15.87</td>
</tr>
<tr>
<td>Nth Steyne</td>
<td>26/01/2014</td>
<td>20</td>
<td>3</td>
<td>15.30</td>
</tr>
<tr>
<td>Freshwater</td>
<td>27/01/2014</td>
<td>35</td>
<td>4</td>
<td>18.00</td>
</tr>
<tr>
<td>Broadbeach</td>
<td>1/02/2014</td>
<td>13</td>
<td>3</td>
<td>16.00</td>
</tr>
<tr>
<td>Pt. Leo</td>
<td>2/02/2014</td>
<td>20</td>
<td>1</td>
<td>4.00</td>
</tr>
<tr>
<td>Stockton</td>
<td>8/02/2014</td>
<td>6</td>
<td>1</td>
<td>9.00</td>
</tr>
<tr>
<td>Stockton</td>
<td>9/02/2014</td>
<td>18</td>
<td>2</td>
<td>14.17</td>
</tr>
<tr>
<td>Tallebudgera</td>
<td>15/02/2014</td>
<td>32</td>
<td>2</td>
<td>12.72</td>
</tr>
<tr>
<td>Mooloolaba</td>
<td>1/03/2014</td>
<td>44</td>
<td>1</td>
<td>12.66</td>
</tr>
<tr>
<td>Fairhaven</td>
<td>2/03/2014</td>
<td>8</td>
<td>4</td>
<td>20.13</td>
</tr>
<tr>
<td>Fairhaven</td>
<td>2/03/2014</td>
<td>1</td>
<td>5</td>
<td>21</td>
</tr>
<tr>
<td>Nth. Kirra</td>
<td>7/03/2014</td>
<td>12</td>
<td>1</td>
<td>10.42</td>
</tr>
<tr>
<td>Nth. Kirra</td>
<td>8/03/2014</td>
<td>40</td>
<td>2</td>
<td>11.65</td>
</tr>
<tr>
<td>Nth. Kirra</td>
<td>9/03/2014</td>
<td>28</td>
<td>2</td>
<td>13.46</td>
</tr>
<tr>
<td>Ocean Grove</td>
<td>15/03/2014</td>
<td>22</td>
<td>1</td>
<td>10.27</td>
</tr>
<tr>
<td>Ocean Grove</td>
<td>16/03/2014</td>
<td>17</td>
<td>1</td>
<td>12.41</td>
</tr>
</tbody>
</table>
A scatter plot of the mean of the QCO *Prevailing* SHR was measured against the Likert scale of referee responses and appears below as Figure 6.7. A strong positive linear correlation is indicated by the scatter diagram and confirmed with a Pearson’s $r$ of 0.91 (R-square of 0.83). The strong correspondence between referee opinions and the *Prevailing* SHR demonstrates the robustness of the SHR as reliable surf-risk management tool.

![Figure 6.7 Scatter Plot of Prevailing SHR versus Referee Opinions](image)

**Figure 6.7 Scatter Plot of *Prevailing* SHR versus Referee Opinions**

Previous sections have already provided evidence of the model’s predictive strength, and its internal consistency and accuracy as measured by inter-rater reliability. Combining these results with the opinions of carnival referees, it has been demonstrated that the SHR is a valid model to summarise surf-zone danger in real time, in terms of accuracy and reliability, as formulated in Research Question One (Section 5.4.1). The following section will provide out-of-sample testing of the model’s validity. The section also addresses the criteria of Research Question Two, this being to assess the extent to which the SHR provides an operationally effective risk-management tool throughout Australia.
6.3 Analysis of Phase II Data

Analysis of the data collected during this phase of the case study (season 2014/2015) provides further evidentiary support for the hypothesis that the SHR can be used as a reliable and accurate surf-risk management tool in real time. Phase I data \((n = 515)\) provided evidence that the SHR is an excellent predictive model, when considered in its curvilinear forms, with R-squares ranging from 0.9 to 0.97. These values were subject to Range Restriction, which influences model choice. As noted in Section 6.2.7.2, using the Binary Logistic Regression equation (3), a SHR intercept of 13.4, indicates the likelihood that at least one incident per five-boat race could be expected.

Phase II functions as an out-of-sample test of the validity of the SHR model, and its evaluation as a reliable, and easy-to-use surf-risk management tool. Data was collected from 1,603 races across Australian beaches from Perth (Western Australia), through South Australia and Victoria, and along the eastern coastline of Australia, including New South Wales and Queensland, from October 2014 to April 2015 (see Table 6.10 below).

As a confirmatory process, Phase II adopts the same methodology as in Phase I except that SHR data is collected at the more general management level using the \textit{Prevailing} SHR, instead of the \textit{Race-Specific} SHR in association with the per-race mean of five-boat all-incidents data. As a further demonstration of the SHR’s usefulness as a risk-management tool, the intercept value of 13.4, determined in Section 6.2.7.2 above, is employed as a SHR-threshold signal for the mandatory wearing of Personal Protection Equipment (PPEs) in the form of safety helmets during competition.\(^{38}\)

\(^{38}\) The partnership agreement with SLSA to this point only requires the determination of a SHR-threshold value for the mandatory wearing of safety helmets. Otherwise, the SHR model is used only as a tool to assist referees to make all other surf-risk mitigation choices.
<table>
<thead>
<tr>
<th>Date</th>
<th>Venue</th>
<th>Number of Races</th>
<th>Date</th>
<th>Venue</th>
<th>Number of Races</th>
</tr>
</thead>
<tbody>
<tr>
<td>25/10/14</td>
<td>Lancelin</td>
<td>15</td>
<td>26/1/15</td>
<td>Freshwater</td>
<td>49</td>
</tr>
<tr>
<td>8/11/14</td>
<td>Surfers Paradise</td>
<td>69</td>
<td>30/1/15</td>
<td>Nth Narrabeen</td>
<td>N/A^39</td>
</tr>
<tr>
<td>9/11/14</td>
<td>Surfers Paradise</td>
<td>16</td>
<td>14/2/15</td>
<td>South Maroubra</td>
<td>N/A^39</td>
</tr>
<tr>
<td>9/11/14</td>
<td>Terrigal</td>
<td>35</td>
<td>20/2/15</td>
<td>Shellharbour</td>
<td>1^39</td>
</tr>
<tr>
<td>16/11/14</td>
<td>Trigg Beach</td>
<td>16</td>
<td>20/2/15</td>
<td>Warilla South</td>
<td>45</td>
</tr>
<tr>
<td>22/11/14</td>
<td>Mollymook</td>
<td>41</td>
<td>20/2/15</td>
<td>Warilla North</td>
<td>25</td>
</tr>
<tr>
<td>22/11/14</td>
<td>Newport</td>
<td>30</td>
<td>21/2/15</td>
<td>Warilla South</td>
<td>48</td>
</tr>
<tr>
<td>23/11/14</td>
<td>Stockton</td>
<td>38</td>
<td>21/2/15</td>
<td>Warilla Nth</td>
<td>44</td>
</tr>
<tr>
<td>29/11/14</td>
<td>Coffs Harbour</td>
<td>60</td>
<td>22/2/15</td>
<td>Warilla South</td>
<td>12</td>
</tr>
<tr>
<td>30/11/14</td>
<td>Coffs Harbour</td>
<td>24</td>
<td>22/2/15</td>
<td>Warilla Nth</td>
<td>33</td>
</tr>
<tr>
<td>30/11/14</td>
<td>Mullaloo</td>
<td>28</td>
<td>28/2/15</td>
<td>Tallebudgera</td>
<td>42</td>
</tr>
<tr>
<td>6/12/14</td>
<td>Warriewood</td>
<td>48</td>
<td>8/3/15</td>
<td>Sorrento</td>
<td>34</td>
</tr>
<tr>
<td>7/12/14</td>
<td>Broadbeach</td>
<td>24</td>
<td>15/3/15</td>
<td>Middleton</td>
<td>11</td>
</tr>
<tr>
<td>14/12/14</td>
<td>Maroochydore</td>
<td>16</td>
<td>21/3/15</td>
<td>Scarborough</td>
<td>16</td>
</tr>
<tr>
<td>14/12/14</td>
<td>South Port</td>
<td>27</td>
<td>22/3/15</td>
<td>Scarborough</td>
<td>21</td>
</tr>
<tr>
<td>14/12/14</td>
<td>Scarborough</td>
<td>21</td>
<td>28/3/15</td>
<td>Alexandra Hds</td>
<td>39</td>
</tr>
<tr>
<td>14/12/14</td>
<td>Ocean Beach</td>
<td>34</td>
<td>29/3/15</td>
<td>Ocean Grove</td>
<td>45</td>
</tr>
<tr>
<td>20/12/14</td>
<td>Elouera</td>
<td>63</td>
<td>14/4/15</td>
<td>Tugun North</td>
<td>35</td>
</tr>
<tr>
<td>21/12/14</td>
<td>Elouera</td>
<td>31</td>
<td>16/4/15</td>
<td>Tugun North</td>
<td>41</td>
</tr>
<tr>
<td>4/1/15</td>
<td>Anglesea</td>
<td>34</td>
<td>16/4/15</td>
<td>Tugun South</td>
<td>42</td>
</tr>
<tr>
<td>10/1/15</td>
<td>Tugun</td>
<td>46</td>
<td>17/4/15</td>
<td>Tugun North</td>
<td>49</td>
</tr>
<tr>
<td>11/1/15</td>
<td>Fairhaven</td>
<td>12</td>
<td>17/4/15</td>
<td>Tugun South</td>
<td>48</td>
</tr>
<tr>
<td>18/1/15</td>
<td>Swansea</td>
<td>35</td>
<td>18/4/15</td>
<td>Tugun North</td>
<td>49</td>
</tr>
<tr>
<td>24/1/15</td>
<td>Coolum</td>
<td>N/A^39</td>
<td>18/4/15</td>
<td>Tugun South</td>
<td>23</td>
</tr>
<tr>
<td>24/1/15</td>
<td>North Steyne</td>
<td>34</td>
<td>19/4/15</td>
<td>Tugun North</td>
<td>37</td>
</tr>
<tr>
<td>25/1/15</td>
<td>Esperance</td>
<td>10</td>
<td></td>
<td>Total</td>
<td>1603</td>
</tr>
</tbody>
</table>

An initial analysis of the 2013/14 data, as recorded in the report to SLSA in July 2014 (Surf Life Saving Australia 2015d, p. 37, Appendix 8), recommended that the SHR-threshold value for the implementation of the mandatory wearing of safety helmets should occur when TSOs assessed the Prevailing SHR to be 13 or greater. The data presented in the Surf Hazard Rating and Surf Helmet (Surf Boats) Project report (Surf Life Saving Australia 2015d, Appendix 9) supported this decision because closer examination

^39 Carnival cancelled – no further race data was recorded.
indicated that the average number of surfboat rollovers\textsuperscript{40} significantly increased as the SHR increased from 13 to 14. As detailed in Section 5.5.3.2, the decision to implement the appropriate risk mitigation measures is based on a process of SHR calculation, together with ensuing communication between the carnival referee and the Boat Panel before the commencement of competition. Data was collected during Phase II to evaluate the effectiveness of the decision-making processes developed by this author to implement this aspect of the risk-management program, which is based on the Prevailing SHR.

The analysis of Phase II data indicates the same statistical nature of the underlying variables as in Phase I. As a consequence, this section compares the results of the analysis of Phase II data with the significant outcomes from the analysis of the Phase I data. The Prevailing SHR, being of a longer time period than the Race-Specific SHR, more closely aligns with referee opinions of their overall assessment of surf conditions across the whole carnival. Comparisons of model predictability are aligned with those curvilinear results determined in Phase I, as well as Inter Rater Reliability (IRR), and correlation between the Prevailing SHR and referee opinions, as was presented in Section 6.2.

6.3.1 Model Prediction using Regression Analysis

The Prevailing SHR, being a longer-time measure, is not as sensitive to possible variation in the surf conditions during each race as the Race-Specific SHR. The following analysis investigates the degree to which that loss of sensitivity affects the accuracy of the model with respect to predicting the Mean Five-All-Incidents.

Table 6.11 lists the Mean Five-All-Incidents, which in Phase II still remains a per-race average, as measured against the Prevailing SHR. Figure 6.8 below provides a plot of the

\textsuperscript{40} This type of incident is associated with potentially more competitor injuries.
Mean Five-All-Incidents data points versus the Prevailing SHR using the regression coefficients listed in Table 6.12. After comparing the Phase I and II outputs from Table 6.6 with Table 6.12, and Figure 6.5 with Figure 6.8, it would appear that the Exponential function is the most robust model to explain the change in the average number of five-boat incidents per race in terms of the Prevailing SHR.

Table 6.11 Phase II Five-boat Incident Means versus Prevailing SHR

<table>
<thead>
<tr>
<th>Prevailing SHR</th>
<th>Number of Races</th>
<th>Mean Five-All-Incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>21</td>
<td>0.00</td>
</tr>
<tr>
<td>4</td>
<td>29</td>
<td>0.00</td>
</tr>
<tr>
<td>6</td>
<td>13</td>
<td>0.00</td>
</tr>
<tr>
<td>7</td>
<td>51</td>
<td>0.00</td>
</tr>
<tr>
<td>8</td>
<td>54</td>
<td>0.00</td>
</tr>
<tr>
<td>9</td>
<td>123</td>
<td>0.21</td>
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<tr>
<td>10</td>
<td>156</td>
<td>0.13</td>
</tr>
<tr>
<td>11</td>
<td>277</td>
<td>0.24</td>
</tr>
<tr>
<td>12</td>
<td>228</td>
<td>0.29</td>
</tr>
<tr>
<td>13</td>
<td>134</td>
<td>0.73</td>
</tr>
<tr>
<td>14</td>
<td>177</td>
<td>1.21</td>
</tr>
<tr>
<td>15</td>
<td>189</td>
<td>1.31</td>
</tr>
<tr>
<td>16</td>
<td>37</td>
<td>2.26</td>
</tr>
<tr>
<td>17</td>
<td>60</td>
<td>3.63</td>
</tr>
<tr>
<td>18</td>
<td>42</td>
<td>2.96</td>
</tr>
<tr>
<td>19</td>
<td>6</td>
<td>0.90</td>
</tr>
<tr>
<td>22</td>
<td>6</td>
<td>3.33</td>
</tr>
</tbody>
</table>

The R-square for the Exponential model using the Phase I Race-Specific SHR is 0.897. It has only decreased in Phase II to 0.856 as a result of using the more general Prevailing SHR over 1,603 races. All other model types have a considerable reduction in R-squares (see Table 6.12 below). When considering the graphs of the Phase II regression models in Figure 6.8 below, the coefficients of which are listed in Table 6.12 below, the effect on the relationship between the SHR and surfboat incidents using the Prevailing SHR instead of the Race-Specific SHR becomes evident.
<table>
<thead>
<tr>
<th>Regression Model</th>
<th>R-square</th>
<th>Regression Coefficients</th>
<th>F- statistic</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>0.673</td>
<td>$b_0 = -1.261$</td>
<td>30.895</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$b_1 = 0.189$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$b_0 = -0.167$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$b_1 = 0.034$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$b_2 = 0.009$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quadratic</td>
<td>0.721</td>
<td>$b_0 = 1.442$</td>
<td>18.09</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$b_1 = -0.585$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$b_2 = 0.060$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$b_3 = -0.001$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cubic</td>
<td>0.753</td>
<td>$b_0 = 0.000$</td>
<td>13.181</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$b_1 = 3.779$</td>
<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
<td>$b_2 = 0.002$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$b_1 = 0.391$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$b_0 = 1392.450$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$b_1 = 0.581$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>0.831</td>
<td>$b_0 = 0.000$</td>
<td>73.929</td>
<td>0.000</td>
</tr>
<tr>
<td>Exponential</td>
<td>0.856</td>
<td>$b_0 = 0.002$</td>
<td>89.411</td>
<td>0.000</td>
</tr>
<tr>
<td>Logistic</td>
<td>0.763</td>
<td>$b_0 = 1392.450$</td>
<td>48.274</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$b_1 = 0.581$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The generalisability of the SHR model using either the *Prevailing* scale or the *Race-Specific* scale is confirmed by the continued increase in the expected number of the average of five-boat surfboat incidents per race as the SHR rises from a maximum value of 20 in Phase I to a maximum value of 22 in the Phase II data. In contrast, the maximum number of the average of five-boat Surfboat incidents per race, being 11.25, occurred at a *Race-Specific* SHR of 20, while the maximum number of the average of five-boat surfboat incidents per race in Phase II, being 18.33, occurred at a *Prevailing* SHR of 22. The trend below in the *Mean Five-All-Incidents* for the *Prevailing* SHR retains a robust appearance to the curvilinear trend in the *Mean Five-All-Incidents* when measured against the *Race-Specific* SHR in Phase I (Figure 6.5).

A consideration of Figure 6.8, which is reflected in the data in Table 6.11, indicates a lower value for the *Mean Five-All-Incidents* at a *Prevailing* SHR of 19 than would be expected if the trend in the graph continued. The data related to this anomaly was obtained from one carnival at North Steyne, 24 January 2015 (n = 34). The *Prevailing* SHR decreased during the day from a starting value of 22 at 09:09 through to a value of 16 at
14:30. The *Prevailing* SHR remained at 19 for just over one hour (10:05 to 11:20) during this transition.

![Figure 6.8](image)

**Figure 6.8  Mean Five-All-Incidents versus Prevailing SHR**

A possible explanation for this anomaly, which also indicates the reduced sensitivity of the *Prevailing* SHR compared to the *Race-Specific* SHR, is that less dangerous surf conditions could have prevailed during each race during this time than indicated by the *Prevailing* SHR of 19. In addition, as explained previously (Section 5.6), referees are required to conduct races in surf conditions which are safe and fair to all competitors, as is reasonably practicable; that is, to mitigate risks where possible. Even though the *Prevailing* SHR may have been 19, it is quite possible that races were conducted in less dangerous surf conditions (perhaps in the form of a delayed race start), which would have been reflected in a lower *Race-Specific* SHR as opposed to the *Prevailing* SHR at the time. This loss of sensitivity of the *Prevailing* SHR compared with the *Race-Specific* SHR is possible across all SHR values.
From a risk-management perspective, a curvilinear regression model, which explains nearly 86% of the observations, is nonetheless a strong model to use as a robust risk-management tool. It is therefore argued that the most representative regression model to make risk-decisions relating to dangerous surf conditions is the Exponential function. As the prevailing and race-specific model coefficients are approximately equal (see Tables 6.6 and 6.12), it is further argued that, for a risk-management application, based on the coefficients from Phase II data, this equation becomes:

\[ Y = 0.002e^{(0.391X)} \]  

(4).

In this equation, \( Y \) is the Mean Five-All-Incidents (which is the average number of surfboat incidents per a five-boat race), and \( X \) is the Prevailing SHR at the time. The number of incidents includes all racing abilities, ages, and gender, and is subject to the study’s limitations, as was detailed in Section 5.6.

6.3.2 Model Reliability

Model reliability, as assessed using Binary Logistic Regression analysis of Phase II data, indicates that the model had approximately 75% ‘Goodness-of-Fit’ (Chi-square 391.78, \( p < 0.0005 \)), with an Odds Ratio of 1.559. This compares favourably with the results using the Phase I Race-Specific SHR data (Section 6.2.7.2), where the ‘Goodness-of-Fit’ was 76.5%, and Odds Ratio was 1.78. The area under the ROC curve (AUC) indicates a similar consistency of the data between Phase I and Phase II. This is indicated by an AUC of approximately 80% compared with Phase I data in Section 6.2.7.2 of 84.8%. Thus, the model remains robust when used to detect true positives (surfboat-incident occurrence) as surf conditions become more dangerous.
Consistency of measurement of the SHR was assessed by comparing the QCO’s Prevailing SHR values with Prevailing SHR values calculated by the nominated TSO\(^{41}\) (who was often the carnival referee) and carnival referee concerns. Cronbach’s Alpha and ICC for Phase II compare favourably with the results for the same measures of TSO and QCO Race-Specific SHR data in Phase I. From the venues at which carnivals were conducted throughout the 2014/15 season, this analysis is only able to compare 73 readings QCO’s Prevailing SHR readings with that calculated by the carnival referee’s nominated TSO, owing to carnival-referee safety-commitments throughout the carnivals’ operations. Cronbach’s Alpha and ICC on these occasions were 0.991 and 0.983 respectively. The consistency and accuracy of these measurements confirms the reliability of the SHR model and the versatility of the index over varying time-periods and arenas, which sometimes were adjoining. For example, Warilla Beach (between 20/02/2015 and 22/02/15) and Tugun (between 14/04/15 and 19/04/15) each had adjoining north and south arenas, both approximately 200 metres across, operating simultaneously – see Table 6.10.

The linear relationship between the mean Prevailing SHR at each carnival and referee concerns evident in the Phase II data indicates the same upward trend as indicated in Figure 6.7 for Phase I data. A Pearson’s r of 0.83 (R-square of 0.69) for the Phase II trend indicates a strong positive linear correlation between referee concerns and the SHR values for the Phase II data, given the limitations of the study. It is possible that a larger variation in the mean Prevailing SHR values for specific Likert values indicates referee recall bias (Coughlin 1990; Sackett, D 1979; Weinstock et al. 1991) of perceived danger after the

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\(^{41}\) Implementation of the SHR decision process required carnival referees to nominate a qualified TSO to record the Prevailing SHR before the Boat Panel meeting at each carnival and comply with the resulting consultation process as summarised in the Decision-Flowchart (Appendix II).
carnival had concluded, and their perception of danger as it applies to varying competitor ability-compositions across different carnivals.

6.3.3 An Evaluation of the SHR Decision Framework

As indicated earlier, the methodology used in Phase II differed from that employed in Phase I by focusing on model-confirmation and assessment of the effectiveness of the SHR as a surf-risk-decision-making tool. Specifically, the *Prevailing* SHR was used as a threshold-indicator of Heightened Risk,\(^{42}\) which, when determined, necessitated the mandatory wearing of surf helmets. The SHR Decision Framework,\(^ {43}\) which is now included in SLSA’s Australian Surf Sports Manual - 35th edition (Surf Life Saving Australia 2015b, p. 2, Section 5), required the carnival referees to communicate their *Prevailing* SHR value to the Boat Panel and competitors at briefing meetings before the commencement of competition. After consultation and agreement, competition would proceed using mitigation measures, including the mandatory wearing of helmets, if necessary. A survey of opinions from referees and Boat Panel members (Surf Life Saving Australia 2015d, p. 43, Appendix 9) assessed the efficacy of the decision-making process as formulated by this author in cooperation with the ASRL\(^ {44}\) and SLSA. This process was outlined in the SHR Decision Flowchart of the SHR trial report (2015d, p. 39, Appendix 9). Significant survey results, obtained by the project’s Quality Control Officers from that report (2015d, p. 12, Appendix 9), are listed in Table 6.13 below.

The results from Table 6.13 indicate that the SHR decision-making process, as it applied to Phase II data (n = 1603), was effective in its design, implementation, and acceptance by

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\(^{42}\) See SLSA Personal Protective Equipment (PPE) Project report (Surf Life Saving Australia 2015d, p. 21).


\(^{44}\) Australian Surf Rowers League.
carnival officials and competitor representatives. The following comments are related to the percentage agreement of each item. Variation in the data from the ideal (100%) predominantly occurred during the initial implementation of the process, when referees and competitors were unfamiliar with the new process.

Table 6.13 Phase III Participant Responses

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Survey Item</th>
<th>Percentage Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Was the Boat Panel Consulted?</td>
<td>94%</td>
</tr>
<tr>
<td>2</td>
<td>Was the “Decision-Making Flowchart” review process followed?</td>
<td>96%</td>
</tr>
<tr>
<td>3</td>
<td>Was Consensus reached about the dangerous nature of nature of Surf conditions?</td>
<td>96%</td>
</tr>
<tr>
<td>4</td>
<td>Did the Boat Panel agree with the Referee’s Decision?</td>
<td>96%</td>
</tr>
<tr>
<td>5</td>
<td>Did Prevailing SHR remain the same after consultation?</td>
<td>100%</td>
</tr>
<tr>
<td>6</td>
<td>Were helmets mandated at the SHR threshold of 13?</td>
<td>96%</td>
</tr>
<tr>
<td>7</td>
<td>How helpful was the SHR methodology in making a decision?</td>
<td>98%</td>
</tr>
</tbody>
</table>

SLSA permitted carnivals to be conducted during the 2014/15 season by referees who did not necessarily have TSO training. They were advised of the Prevailing SHR by a referee-appointed TSO. Before general acceptance of the ability of the SHR to provide objective assessment of the surf-condition-threshold at which to mandate the wearing of helmets, some referees continued to adopt their own subjective assessment of the surf conditions, because they were as yet not Trained Surf Observers. Several carnival referees attempted to ignore the objective assessment of surf hazardousness using the Prevailing SHR, especially at those surf-condition danger levels where the wearing of helmets was mandated to be worn. The data sheets record several disagreements at the initial phase of implementation between the carnival referee and the Boat Panel. Many of the Boat Panel representatives were themselves TSOs, and wished to comply fully with the SHR decision-process. After a cycle of consultation and mentoring by the QCO, the differences in each case were resolved, generally defaulting towards the viewpoint of the Boat Panel. By the
completion of the trial period in 2015, carnival referees and the Boat Panel were fully conversant and supportive of the SHR decision-making process (2015d, pp. 25-6, Appendix 9).

The Surfboat Hazard Rating Trial 2015 Report (2015d, pp. 18-21, Appendix 9) cited several cases that demonstrated the placement accuracy of the SHR threshold value (of 13) when mandating the wearing of safety helmets. These examples provide evidence of post-audit model validation, which Anderson and Woessner (1992) argued was the strongest form of model validation in being able to forecast model outcomes accurately. Although the predicted model-injury rate was low (on average at 0.017 injuries per five-boat race), injuries did occur throughout the 2014/15 competition season. It was reported (2015d, p. 18, Appendix 9) that, notwithstanding the fact that helmets were being worn on direction from the referee when the *Prevailing* SHR had reached 13, surf conditions often continued to deteriorate throughout some carnivals to a point where the *Prevailing* SHR had reached 15. This had occurred in several cases where the time-interval was as little as fifty minutes. The referees recorded three occasions, i.e., at Coffs Harbour 29/11/2014, Surfers Paradise 09/11/2014, and Tallebudgera 28/02/2015 (see Table 6.10 above), where they had been informed by paramedics and attending medical officers that the mandatory wearing of helmets had saved competitors from possible serious head trauma.

This report (2015d, Appendix 9) went on to add that officials and competitors found confidence in the efficacy of the SHR model as they became accustomed to the scales and the ensuing referee determinations as to when to mandate the wearing of helmets (as the *Prevailing* SHR had reached a value of 13 or above). A summary of comments by referees and competitors (2015, pp. 21-22, Appendix 9), which took the form of open ended responses, attested to the satisfaction of these stakeholders with the policy of mandating...
the wearing of safety helmets (Appendix III), when based on the objective assessments using the SHR. Some particular comments from that document include (2015, p22, Appendix 9):

(x) “The SHR provides a process which is OBJECTIVE to make a decision. Gives US (ie. referees) more confidence & support that our decision is based on evidence and is similar to other decision makers’ appraisals around Australia. Takes away some of the BURDEN of responsibility by being less subjective.”

(xi) “Puts a methodology to decision-making.”

(xii) “I like the process as it gets the respect of all involved.”

(xiii) “Why haven't we had a system in place like this for years before now?”

(xiv) A comment was obtained from “Surf Boats Australia” who prior to the Trial, had many testing discussions with SLSA regarding their concerns about the introduction of the helmet policy. A representative of the group stated at the latter stages of the Trial that he “was comforted to know that a realistic, equitable and objective system was now going to be used to make decisions regarding the mandated wearing of helmets”.

(xv) Of particular relevance is the comment from the president of ASRL, Mr. Bert Hunt, that summarised the general feeling of the boating fraternity including officials and competitors: “The Surf Hazard Rating system has been one of the biggest shifts in how we look at the safety in surfboat competition for many years. More work (has) to be done as we all continue to learn from the data but this has been an exercise well worth the time, cost and effort and we can see it being developed further into all aspects of surf lifesaving competition in the future.”

At first, some of these stakeholders had been sceptical of the success of this policy because, in general, SLSA tended to implement competition-based policy from a ‘Top Down’ approach, without considering their (i.e., the competitors’) input. However, the trial
helmet policy, when accompanied by the SHR decision framework, was interpreted by them as an informed ‘Grass Roots’ initiative, based on evidence, and with due consideration to their input. Consequently, as summarised in Table 6.13 above, there was overwhelming support from stakeholders for the actual helmet policy (Appendix III) and its method of implementation using the SHR framework.

In summary, Phase II analysis has demonstrated that the data confirms the robustness of the SHR model as an accurate and reliable surf-risk assessment tool. It has also demonstrated that the SHR model is an efficient and easy-to-use tool to make critical surf-related decisions on Australian beaches, in an objective manner, thereby providing a suitable response to Research Question Two.

6.4 Phase III – A Study of Real Time Model Operationalisation

The final phase of this case study requires assessment of the operational efficacy of the SHR as a real-time tool. This incorporates the SHR decision framework as a complementary set of protocols within existing of SLSA’s surf-sports risk-management practices. As a valid risk-management tool, it should be able to identify dangerous surf conditions, and provide an accurate and reliable quantitative scale to make real-time objective risk-management decisions within a time-period that is reasonably practicable. The purpose of this phase is to demonstrate the real-time application of the SHR model and associated decision framework as it addresses the criteria in Research Question Three. This final confirmation of the tool’s validity is in the form of an application of the decision framework at a major surfboat carnival.

The carnival, which took place at Shellharbour, New South Wales, in 2015, was the equivalent, in terms of surfboat-competitor-participation, surf conditions, and event
organisation, to SLSA’s Australian Surf Lifesaving Championships in 2010 and 2012, where two competitors died. A ratified documentation of the event proceedings by the carnival referee as recorded by this author, detailed the application of the SHR to real-time carnival decision-making between 19 February 2015 and 22 February 2015. This documentation was presented to SLSA in the Surfboat Hazard Rating System Trial 2015 report (Surf Life Saving Australia 2015d, pp. 46-53, Appendix 9). This document records the varying surf conditions within a short period of time that were critical to the decision to conduct the carnival. These observed conditions were counter-intuitive to prior information available through the Bureau of Meteorology (Australian Government Bureau of Meteorology 2017b), together with information from recognised wave-forecasting websites (Coastalwatch 2018; Willy Weather 2018), and Shellharbour lifeguards.

The author was invited by the carnival referee before the commencement of the carnival on 19 February to act as the SHR consultant throughout the event because of the importance of carnival, number of attending competitors (approximately 2,000), and the expected prevailing surf conditions. Table 6.14 and discussion below detail the relevant Prevailing SHR values, and actions recorded by this author prior, and subsequent to, the first carnival race.

The carnival was due to commence at 08:30 on Friday 20 February 2015. On the Monday and Tuesday in the week before the carnival commenced, the surf conditions were quite dangerous. The referees responsible for conducting the carnival had agreed that the surf conditions had abated somewhat by the afternoon of Thursday 19 February. Table 6.14 details the relevant Prevailing SHR values recorded by this author before and including the first carnival race.
Table 6.14  Phase III Shellharbour *Prevailing* SHR Values

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>WTR</th>
<th>WTR</th>
<th>WPR</th>
<th>ZWR</th>
<th>STR</th>
<th>LDR</th>
<th>RCR</th>
<th>OHR</th>
<th>SHR</th>
</tr>
</thead>
<tbody>
<tr>
<td>19/02/2015</td>
<td>15:00</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>20/02/2015</td>
<td>06:00</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>06:40</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>07:50</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>08:10</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>09:10</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>19</td>
</tr>
</tbody>
</table>

These values assisted the carnival referee to make a considered, real-time, and objective response that led to the immediate carnival cancellation at Shellharbour, and the transfer of events to Warilla Beach, located some five to six kilometres further north. The reference to the SHR values was an unsolicited initiative on behalf of the referee, as he was confident that this reflected an objective measure of the surf conditions at the time, based on his own personal experience in using the SHR model at other carnivals. However, as the process was only part of the trial program, no official reliance on this SHR value was used by this referee to mitigate the apparent risk by transferring the carnival. The surf conditions were far less dangerous at the new venue, as indicated in the discussion below.

With reference to Tables 5.3, 6.3 and 6.11, and Figure 6.7, a *Prevailing* SHR of 15 was regarded by most referees as displaying surf conditions in which they “had some concern if/when I [they] conducted the competition in these conditions”. However, as other data in Phase I and II indicates, these values were normally not sufficient to cancel or transfer events at a general surfboat carnival. However, referees tended to become more conservative when assessing those same surf conditions at a carnival of national importance. They are aware that a carnival of national importance attracts a wider data pool of competitor abilities, and make their decisions accordingly. Competitors travel large distances to attend these types of important carnivals. Their expenses are generally substantial, as is their preparation. They compete to challenge themselves against the surf
and their fellow competitors. Their motivations may cloud their judgement and incline such competitors to participate rather than miss a possible once-in-a-lifetime opportunity for success. The carnival referee must balance this competitive urge against the safety of all.

At 15:00 on Thursday 19 February, carnival referees were quite satisfied that the surf conditions were safe, and that it would be safe to conduct the carnival on the following day (Friday). Surf conditions at this time, as described in Table 6.14 using the Surf Hazard Descriptors, consisted of a wave height less than or equal to 2 metres, dumping waves, about 60 metres of surf-zone, with a moderate longshore drift, but no rips in the competition arena, all resulting in a SHR reading of 15. As can be seen in Table 6.14, on Friday 20 February, from 06:00 to 09:05, the surf conditions rapidly deteriorated from relatively calm, 2.5 metre wave-conditions, with a slight longshore drift (SHR=14), into conditions with a windy 3.5 metre wave, with strong longshore drift. Interestingly, the wave type was more dangerous at 06:00 than it was at 09:10, but nonetheless overall conditions became more hazardous, owing to the complex interactions of the other variables. This was indicated by the 09:10 SHR reading of 19.

Being part of the Surfboat Surf Hazard Rating Trial 2015 (2015d), the carnival was conducted under the provisions as set out using the SHR Decision Flowchart, which required the referee to consult with the Boat Panel, and implement appropriate SLSA policy, such as the mandatory wearing of helmets when the SHR was observed to be 13 or more. At this point, under advisement from the carnival referee, a race composed of four surfboats of experienced crews, all wearing safety helmets, competed at 09:10. This author calculated a SHR value while this race took place. There were three back-shoots and three overturns in the four-boat race, as crews attempted to negotiate the break. After
consultation between the carnival referee, the Boat Panel, and this author, the carnival was immediately cancelled and transferred to Warilla Beach, where surf conditions were much calmer. The carnival referee felt comfortable in quoting the objective measure of surf hazardousness using the SHR to dispel further argument.

The disparity in surf hazardousness between Shellharbour and Warilla beaches was reflected in differing SHR values. The 11:10 Prevailing SHR value of 15 at the Warilla South arena, and 12 at the Warilla North arena, compared dramatically with the last SHR reading taken earlier at Shellharbour (SHR = 19). Warilla Beach was sheltered from the northerly swell by a northern peninsula reef, compared to the open-facing Shellharbour Beach. Warilla Beach remained the site of the carnival, and displayed continually less dangerous surf conditions, which were reflected in SHR values recorded by this author, through to carnival completion on Sunday 22 February. The continual variation in potential surf danger between beaches was reinforced by the Prevailing SHR readings at both beaches on Saturday 21 February. The Prevailing SHR value at Shellharbour at 07:30 was 17 compared to Warilla South arena (13), and Warilla North arena (11) at 09:00.\textsuperscript{45}

The Shellharbour case study was able to demonstrate in real time the efficiency of the SHR model, and its associated decision framework, to act as an objective and reliable tool in real time, thereby providing a suitable answer to Research Question Three [Section 5.4.1 (iii)]. This component of the case study was able to demonstrate that such a tool could provide the basis on which to make sport risk-management decisions within five-minute periods if so required. This compares favourably with the time periods of more than two hours, in which it took SLSA officials to cancel events when Saxon Bird and Matthew

\textsuperscript{45} Time difference due to travelling time between venues.
Barclay were killed in 2010 and 2012 respectively (Queensland Office of the State Coroner 2011, 2016).

6.5 Chapter Summary

The evidence presented in this chapter demonstrates the achievement of the aim of this research, as detailed in the three research questions (Section 5.4), that being the creation and evaluation of a reliable and accurate surf-hazard-assessment tool for real-time application throughout Australia. The analysis of the data over the time period from December 2013 to April 2015 is sufficient to allow the development of an accurate curvilinear predictive model, and to verify a high level of rater consistency in calculating the SHR using thoroughly trained TSOs. Furthermore, the results of the research demonstrate the model’s ability to provide high-quality true-positive and true-negative signals for incident occurrence, and a high correspondence of the model’s SHR values with referee opinions of surf hazardousness.

The analysis included an acknowledgement of the limitations to the collection of data, thereby leading to a restriction of range in which the model should be applied.46 It also detailed the necessary statistical processes to screen, cleanse, and present the underlying distributions that are used to measure predictive accuracy and model reliability. The analysis of Phase I data (n = 515) described the reasons, the methods, and the assumptions required to create a representative statistic of surfboat incidents (Mean Five-All-Incidents), which was able to be correlated with the Race-Specific SHR using several curvilinear forms, given the presence of range restrictions when competing in the natural environment. These methods are consistent with multivariate techniques, which are recommended in the

46 The upper limit of the SHR range of model applicability is restricted to a value of 22, being that maximum value recorded during the collection of the Phase I and Phase II data.
composite index and statistical literature, including Nardo et al. (2005), Lattin, Carroll and Green (2003), Pallant (2005), Beguería (2006), and Tabachnick and Fidell (2014).

The most appropriate models based on Phase I data that describe the relationship between the Race-Specific SHR and the average number of five-boat incidents per race, are the Exponential form (R-square of 0.897), the Quadratic form (R-square of 0.962), and the Cubic form (R-square of 0.970). A triangulation of methods provided confirmation of model convergence using a survey of referees, which demonstrated a strong positive linear trend (R-square of 0.83) between the Race-Specific SHR and a five-point Likert scale of referee opinions. ROC curve and Binary Logistic Regression analysis indicated strong signal identification. This was demonstrated by the area under the ROC curve being 0.848, while the Omnibus ‘Goodness-of-Fit’ test used in Binary Logistic Regression to provide value of 0.765 for model Overall Classification. The Odds Ratio calculated in the Binary Logistic Regression analysis in Phase I predicted that the ‘odds’ of a surfboat incident occurring in an average five-boat race increased by a factor of 1.781 for each one unit increase in SHR.

These model data summaries are presented, along with the strongly favourable measures of inter rater reliability, being Cronbach’s Alpha (0.93), and Intra Class Correlation (0.88), in Table 6.15 below. This table also includes where available, the appropriate comparative Phase II analysis-summaries of the data collected during the 2014/15 season.

Analysis of Phase II data used a similar methodology to confirm the results determined in Phase I, but used the Prevailing SHR and a larger sample size (n = 1603). This longer time-period measure of surf hazardousness provides a more realistic model for on-beach decision-making in surfboat competitions. According to this approach, the optimum suggested curvilinear model was the Exponential form: \( Y = 0.002e^{(0.391X)} \), where \( Y \) is the
average number of five-boat incidents occurring per race, and $X$ is the SHR. Given Phase II data, this form is able to describe approximately 86% of the variation in the number of five-boat incidents per race using the *Prevailing* SHR.

### Table 6.15  Phase I and Phase II Analysis Summaries

<table>
<thead>
<tr>
<th>Output Name</th>
<th>Phase I - 2013/14 Output Value (n=515)</th>
<th>Phase II - 2014/15 Output Value (n=1603)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exponential model $Y = b_0 e^{(b_1 X)}$</td>
<td>$R^2 = 0.897$ (Race-Specific SHR)</td>
<td>$R^2 = 0.856$ (Prevailing SHR)</td>
</tr>
<tr>
<td>$b_0$</td>
<td>0.002</td>
<td>0.002</td>
</tr>
<tr>
<td>$b_1$</td>
<td>0.431</td>
<td>0.391</td>
</tr>
<tr>
<td>Linear Regression (SHR v’s Referee Opinions)</td>
<td>$R^2 = 0.83$</td>
<td>0.69</td>
</tr>
<tr>
<td>Omnibus Test (‘Goodness-of Fit’)</td>
<td>$\chi^2 = 212.488$ ($p &lt; 0.0005$)</td>
<td>$\chi^2 = 391.78$ ($p &lt; 0.0005$)</td>
</tr>
<tr>
<td>$b_{00}$</td>
<td>-5.77</td>
<td>N/A</td>
</tr>
<tr>
<td>$b_{11}$</td>
<td>0.430</td>
<td>N/A</td>
</tr>
<tr>
<td>SHR Decision Threshold value using the equation: $\ln(\pi) = \beta_{00} + \beta_{11} X$</td>
<td>13.4</td>
<td>N/A</td>
</tr>
<tr>
<td>Odds Ratio $[= \exp(B)]$</td>
<td>1.78</td>
<td>1.559</td>
</tr>
<tr>
<td>Overall Classification</td>
<td>76.5%</td>
<td>75%</td>
</tr>
<tr>
<td>Area Under ROC curve</td>
<td>0.848</td>
<td>0.80</td>
</tr>
<tr>
<td>Cronbach’s Alpha</td>
<td>0.93 ($p &lt; 0.0005$)</td>
<td>0.99</td>
</tr>
<tr>
<td>Intra Class Correlation</td>
<td>0.88 ($p &lt; 0.0005$)</td>
<td>0.98</td>
</tr>
</tbody>
</table>

Model reliability was again confirmed and only slightly degraded using the longer time-period measure. ‘Goodness-of-Fit’ and the area under the ROC curve were still favourably comparable between Phase I and Phase II data. These values in Phase II were 0.75 and 0.80 respectively, with an Odds Ratio similarly comparable at 1.559. The Phase II data provided the opportunity to assess the effectiveness of the mitigation threshold SHR value of 13, which required the mandatory wearing of helmets. The application met with highly favourable competitor and referee agreement as to the model’s efficacy in being able to
predict reliably and accurately when surf conditions warranted the mandatory wearing of safety helmets.

The ASRL Open at Shellharbour in 2015 provided the final confirmatory evidence that the SHR was an accurate and reliable model on which to base surf-related decisions in real time. This evidence, unlike the models presented elsewhere by other scholars and in the literature review, is presented here with a multiplicity of accepted confirmatory quantitative and qualitative methods using large sample-size data. These methods provide evidence, using a triangulation of techniques, including standard regression modelling, Inter-Rater Reliability, and qualitative referee and competitor input. Given the format of the clearly defined SHR variables, checklist-styled recording sheets, and the evidence that trained TSOs can rapidly record Race-Specific SHR and Prevailing SHR values, the model has been shown to be easy-to-use, and represents an objective generalisable model to accurately and reliably quantify surf hazards for use in on-beach risk-management in real-time. It is also robust, given that “the correct conclusions are being achieved the correct number of times at the given alpha level” (Tabachnick & Fidell 2014, p. 112).

As a final confirmation of the SHR model’s efficacy, and validity, the SHR has been included as SLSA’s 2015 PPE report (Surf Life Saving Australia 2015d), which was presented in the 2016 Matthew Barclay coronial report (Queensland Office of the State Coroner 2016). Based on the information provided in this empirical study, and the SLSA 2015 PPE report, the SHR has recently been included in SLSA’s 35th edition of the Australian Surf Sports Manual (Surf Life Saving Australia 2017a, Sections 1.4 and 5.1) as recommended method of surf-condition assessment when making risk-based decisions in surfboat competitions.
Chapter 7  Conclusion

7.1  Introduction

This research, focussing on Not-for-Profit sporting organisations, details the evidence that supports the development of a quantitative hazard-assessment model, the Surf Hazard Rating (SHR), to assist risk managers in their efforts to make surf-related decisions in real time. The study contextualises the justification for this model by examining the pressures placed upon the governance and risk-management policies and practices of Surf Life Saving Australia (SLSA) when crisis events occur in the course of conducting large-scale sporting events involving natural environments.

The study highlights the threats to SLSA’s corporate legitimacy and public confidence following the deaths of three young surf lifesavers during national surf lifesaving competitions in 1996, 2010, and 2012. The consequent manner in which SLSA addressed these issues (see Sections 3.7 to 3.10) provides an example of stakeholders’ potential to influence decisions through attributes such power, legitimacy, and urgency (Mitchell, Agle & Wood 1997). This is particularly relevant to NFP organisations, such as SLSA, whose mission is to provide public benefit (Australian Charities and Not-for-profits Commission 2019; Australian Government 2012b). When that benefit, in terms of participant health and wellbeing, comes under threat, it is logical to bring to question those governance and risk-management structures at the core of the organisation.

The central objective of this research is the development of a new and more effective risk-model that quantifies surf hazards in terms of observable and measurable ‘effect-based’ parameters, rather than the hitherto ‘process-driven’ models. The subsequent research aim
was to validate and evaluate the theoretical construct of the *Surf Hazard Rating* (SHR) as a real-time risk-management tool for surf lifesaving competitions. This was achieved by answering three research questions addressing model accuracy, reliability, and operationalisation in real time, using an empirical design.

In order to collect a comprehensive data set across diverse Australian beach types, the methodology also took the form of a study using an Action Research design in partnership with SLSA. This focussed primarily on the real-time measurement of the *Surf Hazard Rating* against competition surfboat incidents, acting as external validators, and supported by participant surveys. A partnership outcome, which was consistent with the aims of this research, required the determination of a quantitative threshold SHR value, at which the wearing of safety helmets would become mandatory in surfboat competitions. The evidence to support model efficacy comprises the recording of data from over 2,100 surfboat races from 73 individual surfboat carnivals, occurring on 47 different Australian beaches throughout the study period from December 2013 to April 2015. To collect this data set, the author trained personnel, known as Trained Surf Observers (TSOs) throughout Australia using a series of workshops and author-created training manual (Appendix II).

As a means to maintain data integrity, the author designed, supervised, and participated in a hierarchical data-collection system, which consisted of multiple supervisory layers using TSOs, Quality Control Officers (QCOs), and data Monitors.

The study was divided into three phases (I, II, and III). These phases primarily consisted of the measurement of a *Race-Specific* SHR (Phase I) in 2013/14 and a *Prevailing* SHR (Phase II) in 2014/15, against defined surfboat incidents that might occur during each race. The validation and evaluation process also included the triangulation of surfboat incident data with confirmatory surveys of Trained Surf Observers (TSOs) and carnival surf-risk
managers (referees) regarding their perceptions of surf hazardousness and model efficacy during the period of observation. This was followed by the operationalisation of the SHR to on-beach decision making at a national surf lifesaving event (Phase III) in February 2015.

The analysis of Phase I Race-Specific SHR and surfboat incident data (n = 515) concluded (at $p < 0.0005$) that approximately 90% of the variation in the average number of incidents per five-boat surfboat race could be explained through several curvilinear regression models by the variation in the Race-Specific SHR variable. The best explanatory models comprised Exponential, Quadratic and Cubic forms. The reliability of the SHR to provide correct signals for when surfboat incidents might or might not occur was tested using Receiver Operator Characteristics (ROC) curve and Binary Linear Regression analysis. This resulted in approximately 80% model effectiveness ($p < 0.001$) and Odds Ratio of 1.78. Inter Rater Reliability (IRR) was assessed using Cronbach’s Alpha and Intra Class Correlations (ICC). These measures rated the model’s capacity to yield consistent rater determinations at 0.93 and 0.88 ($p < 0.0005$) respectively on average across the critical ‘going out’ and ‘coming in’ components of each surfboat race within the surf zone.

Although Phase II data (n = 1603) recorded the Prevailing SHR, instead of the Race-Specific SHR, against the average number of five-boat surfboat incidents per race, the findings produced similar results to those of Phase I data. Analysis using the longer time-measure (Prevailing SHR), which is better suited to on-beach decision making (see Sections 6.2, 6.3, and 6.4), determined that the most suitable curvilinear regression model was the Exponential function, with an R-square of 0.856 ($p < 0.0005$). Analysis of the data using Cronbach’s Alpha, ICC, ROC and Binary Linear Regression found similar results to
that in Phase I for decision making signal detection and inter-rater reliability, being 0.99, 0.98, 0.80, and 0.75 respectively ($p < 0.001$), and with an Odds Ratio of 1.56.

Throughout Phases I and II, model convergence was strongly supported by participant surveys and the successful application of a SHR threshold-value to signal when the wearing of safety helmets would become compulsory at 51 separate carnival venues (see Section 6.3.3). Reports by carnival referees at Coffs Harbour (29/11/2014), Surfers Paradise (09/11/2014), and Tallebudgera (28/02/2015) were particularly noteworthy. The referees at these carnivals reported they were informed by attending paramedics and medical personnel that competitors who were involved in serious surfboat accidents during these carnivals had likely avoided permanent head traumas because they were wearing safety helmets at the time, as initiated by the SHR threshold-value of 13 (Surf Life Saving Australia 2015d, p. 18, Appendix 9).

The successful operationalisation of the SHR model was demonstrated in Phase III of the case study during the Australian Surf Rowers League (ASRL) Open carnival at Shellharbour (NSW) in February 2015. This event was affected by local hazardous surf conditions, which were not forecast by traditional weather authorities, lifeguards, or surfing websites (Surf Life Saving Australia 2015d, pp. 46-53, Appendix 9). According to SLSA’s Beachsafe website (Surf Life Saving Australia 1990b), this beach has one of the lowest medium to long-term beach hazard levels of all Australian beaches using the Short and Hogan (1994) Beach Hazard Rating model (see Section 4.5).

However, these longer-term average models proved inadequate to predict the severity of the deteriorating surf conditions experienced on 20 February 2015 with the same accuracy as occurred in real time using the SHR model presented in this empirical study. Using the
SHR’s objective and quantitative assessment of surf hazardousness, referees were able to make critical risk-management decisions within a very short time-period, in the order of tens on minutes, to transfer this carnival to a safer beach (determined by referees and supported by relevant SHR determinations). This was in contrast to the decision processes associated with competitor deaths in 2010 and 2012, which took up to two-and-a-half hours to finalise (Queensland Office of the State Coroner 2011, 2016).

The research findings therefore strongly support the stated aim of this study, which was to develop a validated surf-hazard-assessment model. The confirmatory outcomes from the investigation of the research questions assured that this model is accurate, reliable, generalisable, and easy-to-use in real time.

### 7.2 Comparison with Previous Research

#### 7.2.1 Surf Hazard Assessment Models

Although research focussing on wave and/or surf zone theories and modelling abound in the literature (Cavaleri et al. 2007; Craik 2004), these scholarly works predominately investigate the process-driven dynamics within the coastal environment, with singular outcomes over medium- to long-term timeframes. A majority of the previous wave and surf-zone research focuses on sediment transport effects, coastal erosion, storm surges, and flooding, or the exploitation of the physical wave and wind processes to predict the occurrence of rip-current events. Until recently, these studies paid limited attention to beach safety and risk management involving human participants (Klein et al. 2003; Short & Hogan 1994; Short & Weir 2016). The development of the *Surf Hazard Rating* (McCoy & de Mestre 2014) during this study provides an alternative assessment-model that challenges coastal scholars to include all possible surf-zone hazards. These hazards often
result from the interaction of multiple factors, and are measured in this study, in terms of the ‘effect’ they have on surf-zone participant safety in real time.

Modern scholarly research into surf-zone risk-management comprises mainly rip-current forecast models or overall beach hazardousness using morphologic beach states. For example, the LURCs model and its derivatives (Dusek & Seim 2013; Lascody 1998; Reinhart & Pfaff 2016) provide medium-term forecasts of rip current occurrence based on the measurement of physical variables such as shoreline orientation, Significant Wave Height and direction, the speed and direction of onshore winds and tidal flows. An alternative medium- to long-term forecast model of beach hazardousness, as determined by the potential for rip current occurrence, is the Beach Hazard Rating (Short & Weir 2016). Based on Wright and Short’s 1984 Beach Safety Rating (Short & Hogan 1994; Wright & Short 1984), the Beach Hazard Rating measures beach hazardousness associated with medium- to long-term morphologic changes to beach state and average wave height. The Wright and Short model forms the underlying theory for the creation and development of SLSA’s comprehensive database called the Australian Beach Management Program (Surf Life Saving Australia 1990a).

The previously mentioned models are predicated upon the questionable accuracy of historical rip-rescue data, drawn from samples with limited temporal and spatial variance. In contrast, the Surf Hazard Rating presented herein draws on a sample with extensive temporal and spatial variance. It models surf hazardousness in terms of seven primary observable, and measureable, effect-based variables, which account for possible interaction effects, in real time. A significant distinguishing design-approach associated with this research is the reliance upon Construct Theory in the development of a composite index of surf hazardousness (Nardo, Saisana, Saltelli & Tarantola 2005). As a construct of
surf danger, the *Surf Hazard Rating* uses external validators such as surfboat incidents in competition and surf risk-manager assessment of surf danger during these times to assess model validity.

7.2.2 Crisis Management

Serious injury, especially death, during organised sport is notionally rare (Gabbe et al. 2005; McIntosh et al. 2017; Mitchell, Brighton & Sherker 2013). The data contained in this case study supports this notion. Indeed, it was found that there were less than four serious injuries and no deaths per one thousand races conducted during the study period. When one considers all surf lifesaving competitions, there have only been three deaths during competition at the Australian Surf Lifesaving Championships since 1996, and as the president of Surf Life Saving Queensland stated in 2012, overall there have been only a “‘handful’ of fatalities since surf lifesaving carnivals began in 1915” (Stoltz & Pierce 2012). This number is statistically non-significant compared with the 71,164 Australian road fatalities over a similar period between 1915 and 2013 (New South Wales Government 2013), although there are, of course, tragic ramifications and likely ongoing distress for the family, friends and acquaintances of the teenagers involved in the three surf lifesaving incidents that have occurred in more recent times.

Slovic and Weber (2002) argue that an individual death can elicit a much stronger community reaction than occurs with a large statistical loss of life, such as road deaths, a behaviour which Fetherstonhaugh et al. (1997, p. 283) classify as “psychological numbing”. Such individual events as the death of a young lifesaver during competition could therefore be seen as a crisis event for an organisation such as SLSA, as community concerns focus on their risk-management practices and overall governance structure. Boin
and Hart (2003) argue that, in times of crisis, people experience episodes of threat and uncertainty, and look to leaders from the relevant authority to display positive signs of leadership to encourage stakeholder trustworthiness. This includes putting public safety first, planning for worst-case scenarios, providing direction to crisis-management operations, and learning their lessons after a crisis has occurred (2003, pp. 547-50). Jones, Felts and Bigley (2007, p. 146) referred to this same expectation as a normative perspective of “moral stewardship”. This case study of surfboat races provides the opportunity to examine the governance and risk-management responses of a particular NFP to such crises, and the risk-management solutions available to such an organisation that can better enable it to make informed risk decisions.

The findings of the Australian Charities and Not-for-profits Commission’s Chantlink Report (Australian Charities and Not-for-profits Commission 2013b) into public trust and confidence in Australian charities found that public trustworthiness is a legitimising influence on authorities’ entitlement to receive government and public funding. It argued that a mission-focused not-for-profit entity, such as SLSA, is expected by an implied contract to provide services for the public good in return for receiving public funding. This case study documents the governance responses by SLSA during the study period to supply those services as part of its contract to maintain its high level of community trust and confidence as Australia’s foremost authority on coastal safety.

Furneaux and Wymer (2015) classified this mission-focused attribute as good stewardship of resources for the public benefit. This is echoed in research from the United Kingdom by Tonkiss and Passey (1999, p. 257), who refer to this public expectation as being mediated by “institutional and contractual forms”. An inappropriate response to major internal or external crisis events reflects poorly on community confidence in an organisation.
Furneaux and Wymer (2015) argue that charitable entities, such as SLSA, influence public trust and confidence when their management behaviour, including their response to crisis events, is perceived to achieve acceptable ethical standards, and levels of transparency and accountability. Yet, if responses are of a more strategic nature (Deegan, Rankin & Voght 2000), NFPs could evolve into what Seibel (1996, p. 1019) refers to as “successful failure[s]”, by exhibiting low corporate performance, and executive-to-board ignorance, while still remaining a viable entity.

This case study provides an opportunity to examine a particular NFP’s response to crisis events, with the view of providing a long-term normative approach to risk-management rather than one of short-term strategic purpose. As argued elsewhere in this research, SLSA could do well to consider alternative and well-researched surf-risk models that are consistent with its governance guidelines. This view is supported by SLSA’s 2020 Strategic Intent to seek “evidence-based research to determine community water safety requirements”, and to “utilise evidence-based research to inform [the] development and implementation of safe practices” (Surf Life Saving Australia 2018a, pp. 12, 6). It has been demonstrated that the Beach Hazard Rating model (Short & Hogan 1994) adopted by SLSA in 1990, which underscores its current beach management programs and surf-sports management policies, continues to focus on an assessment of surf conditions, using a predominantly morphologic, wave-height and tidal-flow approach. Although it is presented in checklist format, the surf-feature criteria it uses are not fully objective and quantifiable. Significantly, the model is not explained through a regression analysis using external validators, using a large and varied sample size as an appropriate research vehicle. These decision-making practices of on-beach risk-assessment (Short & Weir 2016) were in place before Saxon Bird died in 2010. They remained in place at the time of Matthew Barclay’s
death in 2012, and still form the core of SLSA’s existing surf carnival and public bathing risk-management practices.

The advancement of Stakeholder Theory (Boesso & Kumar 2009; Bryson 2004; Clarkson et al. 1994; Corfield 1998; Donaldson & Preston 1995; Fassin 2009; Freeman 2010), including stakeholder rights, power, and legitimacy to influence the ongoing success of organisations, has developed beyond Freeman’s original 1984 treatise on strategic management of ‘for-profit’ organisations (Freeman 1984). Indeed, these influences now apply equally to the long-term performance and survival of NFPs such as SLSA. As stakeholders in a charity and/or major sporting organisation, such as SLSA, competitors, their families, the membership, and the organisation’s sponsors, together with the public, expect the organisation’s board of directors to set the strategic tone by advancing the policies, systems and processes necessary to maintain its corporate legitimacy (Australian Institute of Company Directors 2017a, 2017b). As argued throughout this research, the pressures exerted by SLSA’s primary and secondary stakeholders on its governing board, which is responsible for the public wellbeing, are substantial. It has been demonstrated that SLSA’s management have striven to legitimise the organisation’s risk-management practices as a response to the crisis events in 1996, 2010 and 2012 to maintain or improve community trust and confidence, which is, of course, consistent with those theorised dimensions as expressed in the literature (Donaldson & Preston 1995; Friedman, A & Miles 2006; Furneaux & Wymer 2015; Laplume, Sonpar & Litz 2008).

It would appear that the crisis events of 2010 and 2012 particularly, and the ensuing coronial enquiries and resignations of SLSA’s CEO and board members (Surf Life Saving Australia 2014a, p. 21), and Surf Life Saving Foundation’s board members in 2013 (Australian Broadcasting Corporation 2013), created the conditions for formal
mobilisation of stakeholder influence and power (Walters & Tacon 2010). This encouraged a receptive atmosphere to trial the SHR model in SLSA surfboat competition.

7.3 Implications of Methodology

Benbasat, Goldstein and Mead (1987) argue that case-research is especially appropriate to research where theoretical problems are being explored at the formative stage or where the nature of the problem is complex and/or practice-based. It is also appropriate where participant experiences are important and the context of any actions is “critical” (1987, p. 369). The case study for this thesis research, which focused on the development of the SHR for SLSA surf lifesaving competitions, encapsulates the intent of Benbasat, Golstein and Mead’s (1987) argument by investigating, in detail, the effect of the application of an empirically derived surf-risk model on an organisation’s governance and risk-management practices, and the social benefit provided, as a consequence, to its primary stakeholders. It is logical to conclude that, for a well-informed and publicly funded NFP organisation such as SLSA, it should be incumbent upon management to seek and to operationalise a valid and functional risk-assessment model where possible. Such a model should be based on the best available scientific evidence, and be consistent with the organisation’s mission, which for SLSA is to save lives on Australian coastal beaches.

The premise underlying this research is that a legitimate surf-risk model should comprehensively and accurately assess those surf hazards that may lead to participant injury or death. The test of model-validity benefits from a triangulation of quantitative and qualitative methods using an empirical design to define and answer the research questions associated with the study’s aim of developing a real-time surf-risk management tool. It has achieved this by adhering to an accepted scientific method and by analysing the data of a
large sample size, using multiple statistical techniques. The methodology focuses on deriving a risk-management model that quantifies the external risk-factors for a sport (Fuller & Drawer 2004) that not only values the motivation of competition, but also the opportunity for competitors to test their skills against the challenges presented by the natural environment. As a result, this case study involving surf lifesaving competitions is a valuable contribution to both the sporting and risk-management literature.

As was previously established, few empirical studies exist that examine and develop risk-management models for the NFP and sporting sectors, especially to the depth and robustness of this research. It has also been argued elsewhere in this study that existing surf-risk models, which attempt to forecast or quantify the hazards associated with participation in the surf environment, have been limited in scope, both temporally and spatially. These models are also sub-optimal in terms of real-time risk-management outcomes for the surf, being predicated as they are on the assumption that historical reports of rip rescues is the most appropriate, and often only, causal-factor on which to base surf-hazard assessment.

By way of comparison, the methodology employed in this case study uses a more rigorous measure of surf-hazardousness, which is supported by the evidence collected during Phases I, II, and III of this study. The real-time data records the number of surf-related incidents, which is correlated against a composite of multiple surf-zone features, and is supported by the successful testing of significant model signal-strength, thereby reducing the possibility of statistical noise. It has been shown that previous studies are subject to measurement error in the form of recall bias (Coughlin 1990; Hassan 2006; Sackett, D 1979; Weinstock et al. 1991) as a result of relying on historical records. In addition, it has been demonstrated that the effectiveness of these previous studies is diminished by
definitional misunderstandings of a limited set of surf-zone variables. The present novel research undertaken by this author has overcome this difficulty by strictly defining the Surf Hazard Rating variables, their measurement using the Trained Surf Observer Training Manual (Appendix II), and by emphasising strict adherence to a systematic process to obtain an accurate and unbiased estimator of surf-zone danger for comprehensive risk-management purposes.

Procedural lapses, such as cognitive bias, pre-emptive and subjective estimation of a SHR value, may contribute to model inaccuracy, which, in turn, could lead to reduced participant safety-management. For example, consider the consequences if carnival referees had made such procedural lapses, and returned incorrect and lower SHR readings at the Coffs Harbour (29/11/2014), Surfers Paradise (09/11/2014), and Tallebudgera (28/02/2015) surfboat carnivals mentioned above. If referees had accepted a lower recorded SHR value than 13, this would have resulted in the non-enforcement of safety helmets according to policy guidelines (Surf Life Saving Australia 2014b). The serious incidents referred to in Section 6.3.3 occurred irrespective of whether any subjective or objective assessment of surf conditions had been carried out. However, it is reasonable to expect that, ultimately, incorrect decisions based on incorrect valuations of the SHR, owing to procedural lapses, could have increased the likelihood of serious head trauma to those competitors involved.

Event stakeholders, including competitors and their families, together with referees, place their trust in corporate entities such as SLSA to develop management strategies that reduce the risk of injury during competition. Referees, being organisational stakeholders, alluded to their trust and confidence in the SHR as an accurate and reliable surf-hazard assessment tool, together with associated risk-management procedures, in their comments during the
Surfboat Hazard Rating System Trial 2015 (Surf Life Saving Australia 2015d, Appendix 9). A selection of their comments stated that the SHR gave them “more confidence and support that [our] decision is based on evidence” and that it “takes away some of the burden of responsibility by being less subjective” (2015d, p. 22, Appendix 9). These comments, together with others listed in the report, confirm that the methodology used in this empirical research study achieves the research aim to develop a surf-assessment-model that is objective, decisive, and easy-to-use in real time. As recommended in the Surfboat Hazard Rating System Trial 2015 report, procedural lapses may be overcome by certification using the standards developed throughout this research, which are detailed in the TSO Training Manual, and are continually assured by annual proficiency testing.

A distinctive quality of this study’s methodology is its capacity to develop a model that has high predictability, reliability and signal strength in real time. Future inclusion or reduction in the number of SHR model-variables or co-efficient weightings (currently set at unity) should be reasoned using a similar methodology. By doing so, future researchers, who might consider model adjustment could compare any apparent change in model predictability and reliability using these robust measures, which Lattin, Carroll and Green (2003, p. 478) argue is based on model “utility”. For example, consider the inclusion of a new variable to the SHR model, which accounts for the proximity of low tide, when making a reading for surf hazardousness. Such a factor, which influences surf participant danger, is included in the updated LURCS model (Reinhart & Pfaff 2016), and Short and Hogan model (Short & Weir 2016). The addition of such a variable would need to demonstrate significant statistical model improvement using a similar methodology to merit SHR-model inclusion, based on the ‘utility’ argument of Lattin, Carroll and Green (2003).
7.4 Limitations of the Study

The nature of an investigation that examines participant risk when interacting with natural environments understandably incurs limitations such as ethical and operational challenges, as detailed in Section 5.6. The methodology employed in this case study, including the use of a large and representative sample size, across an extensive range of coastal beaches and conditions, has been shown to be capable of overcoming many of the limitations generally associated with empirical studies of this type. Silvertown (2009, p. 468), for example, suggests that any study seeking to collect large volumes of environmentally-based data, across wide geographical zones, can only overcome the limitations by employing the assistance of volunteers, which he labels “citizen scientists”. This case study has adopted a similar approach, in utilising the expertise of Trained Surf Observers (TSOs).

7.4.1 Simplifying Model Complexity

According to Fuller, Junge and Dvorak (2012), risk in sport is composed of two factors: intrinsic factors, which are associated with participant physiology and competency, and extrinsic factors, which are related to sporting equipment, facilities and the environment within which the sport is conducted. The SHR identifies and rates the environmental component of the external risk factors associated with conducting a surf-sports event. However, a comprehensive surf-sports risk model should also include the intrinsic risk associated with participant competency, at a group and/or individual level. A limitation of this case study has been that participant competency was not explored to a sufficiently detailed level to provide an overall determinant of surf-sports risk, inclusive of this intrinsic risk factor. This limitation was recognised in the planning of this study’s research design (Section 5.2.1), owing to partnership commitments, time limitations, and the
comprehensive breadth and diversity of an alternative research design required to achieve such an outcome. It has been argued in this case study, in the interests of model parsimony that the validation of the SHR forms an essential precursor to the development of a comprehensive surf-risk model, defined herein as the Competitor Surf Safety Index, which considers both intrinsic and extrinsic risk factors. In quantitative terms, it is only when a scale of danger has been validated can a group’s and/or an individual’s competency be measured against it and a final determinant of surf-sports-risk be calculated, as summarised using the Australian Sports Commission’s Sports Risk-Management model in Figure 2.2. Therefore, throughout this research involving the development of the SHR, participant competency was pooled to a crude measure by grouping all surfboat competitors together when formulating the Mean Five-All-Incidents variable (Section 6.2.5).

This research has been limited to the validation of the SHR against one external regressor-type that is inclusive of all surfboat competitions by collapsing all age and gender categories into one representative group. It might be possible that, if sufficient data\textsuperscript{47} was collected for each of these sub-categories, and analysed separately using similar techniques to those detailed in Chapter 6, each of these sub-groups could yield a more accurate family of curvilinear models and signal detection outcomes. The hazardousness of prevailing surf conditions, however, effects all participant-types in surf lifesaving competitions. Other relevant categories listed in the Australian Surf Sports Manual – 35\textsuperscript{th} edition (Surf Life Saving Australia 2017a) include the surf board, and the surf ski craft-categories, and

\textsuperscript{47} A study of alternative regressors using differing craft types and/or age and gender sub-categories should chose a sufficiently large sample size if one is to expect similar results to this study, although it is important to be mindful of the arguments of Tversky and Kahneman (1971) when it comes to using small sample sizes to replicate a previous study’s significant results.
swimming events. Similarly, within each craft and swimming type, there are also age and
gender sub-categories. These sub-groupings have also not been explored in this research
owing to time, partnership limitations, and model parsimony. It could be expected, based
on the data obtained in the 2012/13 Pilot Study, that any of these groupings could also act
as external validators for the SHR model, given the identification of similar incident
categories to those of surfboats.

7.4.2 Statistical Limitations

This research study limits investigation of the relationships within the data to regression
analysis, for the reasons reported in Chapter 6. It is recognised that the study is limited to
investigating the relationship between the Mean Five-All-Incidents variable and the SHR
variable without modelling against the SHR sub-scales consisting of the WHR, WTR,
WPR, ZWR, STR, LDR, RCR, and OHR variables. Review of the scholarly works by
Lattin, Carroll and Green (2003), Nardo, Saisana, Saltelli, Tarantola, et al. (2005), and
Tabachnick and Fidell (2014) suggest that further analysis of the data in this case study is
possible using higher order, multivariate statistical techniques (see Section 7.5.1). As
mentioned in the Methodology chapter (Sections 5.3.1 ), these advanced techniques of
statistical inference often reweigh model coefficients, recommend variable non-inclusion,
or variable-collapse into larger groupings, in order to satisfy model-significance criteria.
These techniques rely on representative data samples that are assumed to be little-effected
by range restriction. As noted in Section 5.6, Range Restriction (Sackett, P et al. 2007) is
evident in the data collected during this case study and would impact on tests of sub-scale
significance. The author has considered these techniques, but believes that such detailed
analyses is not justified at this stage of model development as they would detract from the
primary aim of this research, this being to develop a valid but simple decision tool to be
used by surf-risk practitioners in real time. It should be recalled that at the time of publication of this document, decision makers relied on the SHR calculation sheet as supplied in Appendix II. These carnival officials were only able to make simple additions, using unitary coefficients for SHR subscales, to calculate the SHR on the beach at the time of decision making. The use of non-unitary coefficients would have been counter-productive, in practical terms, at this stage of the development of the SHR as an on-beach decision tool.

7.5 Future Research and Applications

7.5.1 Statistics-based Research

Given the validation of the SHR model across multiple beach types and beach conditions throughout Australia, as demonstrated in this research, it becomes possible to extend the model towards greater risk-model accuracy and the inclusion of wider groupings of surf-sports participants. Model accuracy may be improved, albeit at the cost of model parsimony, using the existing data, through the exploitation of higher-order statistical techniques such as Factor Analysis, Principal Component Analysis, or Structural Equation Modelling (Bollen & Lennox 1991; Grace & Bollen 2005; Nardo, Saisana, Saltelli & Tarantola 2005; Tabachnick & Fidell 2014). However, as mentioned in the previous section, one should be mindful of the impact of coefficient-rescaling on ease-of-use and variable omission, through data non-representativeness, and the possible deletion of important theorised surf features such as rip currents, owing to possible statistical non-significance (see Section 5.6.3).
A logical extension of this hazard-assessment model is the creation of a participant-competency scale, the Competitor Surf Competency Rating (CSCR), which would moderate the SHR scale to yield a determinant of individual- or group-risk associated with participation in the surf environment. The resultant index would be known as the Competitor Surf Safety Index (CSSI), (see Figure 7.1 below).

**Figure 7.1  Proposed Competitor Surf Safety Index Path Model**

SLSA’s 2015 Personal Protective Equipment (PPE) project (Surf Life Saving Australia 2015d, p. 21), mistakenly interpret “heightened risk” in terms of the *Surf Hazard Rating* instead of the more correct Competitor Surf Safety Index, which is inclusive of surf-hazard assessment and participant-skill interaction. Heightened risk for competitors occurs when the surf conditions exhibit elevated risk (for them), which Surf Life Saving Australia (2015d, p. 21) regards as being below the “intolerable risk level where [surf lifesaving] carnivals should be cancelled or moved”. This suggests the concept of a threshold, beyond which an individual or group could be exposed to unacceptable risk of serious injury, if they continue to participate in the prevailing surf conditions.
The CSCR and the CSSI are also theorised to be latent variables. This is because both are measured in terms of the SHR, which itself is the latent variable for surf danger. The evaluation of the theorised CSSI can be quantified using the formula:

\[
CSSI = \text{CSCR} - \text{SHR} \quad (3)
\]

If one were to extend SLSA’s general concept of heightened risk to apply to any group or individual, according to equation (3), a significant risk-threshold would therefore occur when the difference between the CSCR and SHR approaches a critical value of zero. Increasingly negative CSSI values would thus suggest continued participation in a state of an increasing likelihood of serious injury, beyond that which is reasonably practicable. A more negative CSSI value infers that the level of hazardousness of prevailing surf conditions is beyond that in which the individual or group could safely negotiate, given their current skill levels.

Various methodologies are available to determine these participant skill levels. For example, a Quality Function Deployment (QFD) matrix (Akao 1990; Wang, Lin & Huang 2010) is a strategic risk management tool that matches stakeholder needs with the technical skills required to meet those needs. In the context of the Competitor Surf Competency Rating, a surf competency scale is mapped against required surf-participant skills, in this case for surfboat competitors (see Figure 7.2 below). These are general descriptors only and are intended to be determined by ASRL as part of their coaching program, which is detailed in their Coaching Manual (Australian Surf Rowers League 2007). Modelling of transient factors such as fatigue, overconfidence, and rescue capacity of safety authorities is outside the intended scope of this research.
Figure 7.2 Proposed Surfboat Competencies QFD Matrix

The QFD matrix could be extended to other surf lifesaving competitions such as surf skis, surfboards, and surf swimmers, surfboard riding competitions, and ultimately to the “Beach-going community” (Surf Life Saving Australia 2018a, p. 8), using a similar skill-mapping methodology.

7.5.3 Technology-based Research

Being a quantitative model, the SHR has operational potential for smartphone and drone technology applications. Technology-based platforms, such as smartphones, exploit algorithms to enhance the end-user experience. Future research using this type of technology, together with a more diverse data sample and higher-order statistical analysis as suggested above, may improve the SHR model’s accuracy, all the while maintaining the model’s ‘ease-of-use’ properties. Direct application of the SHR algorithm already forms the basis of a new smartphone application being designed by the author in partnership with
the Australian Surf Rowers League (ASRL) (Australian Surf Rowers League 2018). The SHR smartphone application will record, store, and communicate prevailing surf conditions before training sessions and during competition events.

The SHR model is also adaptable to other platforms and applications that may be suitable to civil and governmental agencies responsible for coastal safety, security, and engineering practices, and where real-time determinations of surf-zone hazards have a critical impact on operational performance. Recent advances in multi-spectral and hyper-spectral imaging and Unmanned Aerial Systems (UAS or ‘drone’) technology provide the opportunity to reduce the gap between field-based observational models, such as those used to determine the SHR, and more automated air-borne remote systems. Manfreda et al. (2018) and Green et al. (2019) argue that use of UAS technology provides a cost-effective pathway for remote sensing and spatial detail-enhancement, which is “key to improving our understanding of environmental systems” (Manfreda et al. 2018, p. 2). The inclusion of imaging and drone technologies with the existing SHR algorithm, or next-generation modifications, could assist tactical decision making by government agencies such as the Royal Australian Navy and/or the Australian Border Force, in successfully transitioning the surf zone using rigid hulled inflatable boats (RHIBs) or amphibious landing craft (LCMs) between sea and land-based operations (Love 2011).

7.6 Governance and Policy Implications

7.6.1 SHR and CSSI Implications

The outcomes of this research, focussing on the risk-management practices of sports organisations such as SLSA using the SHR, facilitate the exploration of alternative risk-control solutions involving participation in what can be regarded as competitive organised
sports involving natural environments, which can abbreviated using the acronym ‘COSINE’. This research has demonstrated through these chapters to have made a significant contribution to the corporate-governance and sports-management literature, where stakeholder safety is a primary responsibility. In particular, Phase III of the research demonstrated that the model can be operationalised to assist SLSA sports risk-managers to make rapid, accurate, and reliable decisions relating to a seemingly volatile and often dangerous surf environment, and positively contribute to competitor safety. The extension to the Competitor Surf Safety Index (CSSI) would enhance this capacity by quantifying surf-related risk as it applied to individual or group competency.

7.6.2 Governance Structure and Policy Implementation

Leading NFP corporates, such as SLSA, identify and actuate their community responsibilities and their commitments to relevant stakeholders through their policies, as is published in their annual and special reports. These reports articulate the governance structures and policy-implementation processes, all of which need to be consistent with the stated aims and mission statements of the organisation. SLSA’s continued commitments and responsibilities are evidenced in its most recent annual report (Surf Life Saving Australia 2017e, p. 51), which is to save lives on Australian beaches by developing a “safety framework and guidelines to ensure the protection and benefit of our [sic] members”.

In terms of surf lifesaving competition, this research presented a successful policy solution by determining a SHR threshold value of 13, at which safety helmets were mandated to be worn by all surfboat competitors to protect them during competition in dangerous surf conditions. As reasoned in Section 7.5.2, the application of this model can be extended to
include a wide variety of risk-solutions for other surf-sport categories, which ultimately could include lifesaver/lifeguard competency qualifications, and rescues involving the bathing and surfing public. The implication of the capacity of this mechanism to the management of risk, whether applicable to competition or to beach patrolling activities, could be profound. Consider the following two examples:

(i) If a SLSA safety policy for competitions existed in 2010, which included the CSSI or equivalent, the decision to compete or not, would have become objectified and rapidly determined. External and perhaps coercive factors would be removed because the approval to compete would be based on a quantifiable score (the CSCR), which could be determined by the governing authority before the acceptance of carnival entries. The CSCR or its equivalent would be based on a definable objective and quantifiable criterion, such as demonstrated with the Quality Function Deployment matrix. If such a system existed at the time Saxon Bird and his fellow athletes were permitted by SLSA to compete at the Australian Surf Lifesaving Championships in 2010, those competitors who were unsure of their competency to compete in such dangerous surf conditions (Queensland Office of the State Coroner 2011, pp. 19-22) could have referred to tools such as the SHR and CSCR to assist in making the decision to compete more objective. An objective mechanism that might trigger non-approval to compete could be, for example, the surpassing of the zero-threshold, as indicated by a negative CSSI. This would have been complementary to existing (2010) and current (2018) SLSA competition policy, as expressed in its Surf Sports Manuals (Surf Life Saving Australia 2008, p. i; 2017a, p. i).
Given the advances in imaging technology, the methodology adopted to determine surf hazardousness using the SHR could be applied to other constructs that explain the surf environment. For example, in the scholarly work “The Science of Surfing Waves and Surfing Breaks”, Scarfe, Healy and Rennie (2009, pp. 3-4) extended the research by Mead and Black (2001) to identify the major surfing-wave parameters as wave height, wave peel angle, wave breaking intensity, and wave section length (2009, pp. 3-4). Synergies exist between the development of CSSI and research by Hutt, Black and Mead (2001), which attempts to classify surfable breaks in relation to surfer skill levels. The management of surfing breaks to safely accommodate the growing demand of surfing tourism has become a major concern for local coastal authorities and communities (Ponting & O’Brien 2015; Usher, Goff & Gómez 2016), as ‘tourists’, locals, and organised surfing events, compete for access to this natural resource. As a result, the “recreational carrying capacity” (2015, p. 99) of such surf breaks becomes a governance responsibility of those coastal authorities. Once surf breaks are quantitatively evaluated for wave quality, and potential danger (using the SHR), which Hutt, Black and Mead (2001, p. 66) refer to as “wave difficulty”, coastal authorities will be able to more confidently develop safety policy to make risk-based decisions to adequately manage this niche economic market, especially as improved technologies make these determinations more readily available.

It is incumbent upon sports organisations that implement the SHR model and its associated decision framework in any capacity or application to: a) ensure that SHR-model-users are suitably qualified, trained, and attain yearly proficiency in the skills required to assess the constituent Surf Hazard Descriptors; and b) be able to record a value for the applicable
scale to the level of accuracy attained in this research. It is logical to assume that the efficiency of any surf-risk-management policy undertaken by SLSA, or other coastal safety authority, is reliant on the robustness of the underlying assessment tools, and adherence to the protocols developed throughout this research. For example, an entity that utilises the SHR model either singularly, or in conjunction with the future smartphone application, should assure that end-users, such as carnival referees, coaches, and/or professional lifeguards and lifesavers, attain this abovementioned level of proficiency.

7.6.3 Safety and other Stakeholder Expectations

Management of risk at sporting events entails internal and external risk factors, as has been previously described. However, these events involve other dimensions, such as stakeholder needs and expectations, which add another layer of complexity to the decision making process, especially when these events are conducted in potentially dangerous natural environments. Competitor-stakeholders often travel large distances to attend major events, such as the Australian Surf Lifesaving Championships or the Australian Surf Rowers League Australian Open. These events are generally held at the end of a competitive season after competitors have made substantial commitments of time, effort, and expense to training regimens and travel. These competitors expect sports organisers to provide a venue that is capable of permitting competitors of all competency levels to participate safely.

The management of the risk associated with a large number of competitors in the order of several thousands, which are present at the abovementioned events, may contrast dramatically with the management options available at a local carnival, where competitor numbers may approximate to a maximum of perhaps one hundred, even though both
events may be subject to the same dangerous surf conditions. Competitors attending local carnivals generally do not travel the same large distances as they do to attend championship events, nor do they generally spend as much money on this travel, or spend as much time in their training preparation. Therefore, their expectations to compete may be commensurately lower than that at major events. Surf-risk managers may be more inclined to postpone or cancel individual events at local carnivals on account of surf conditions deemed too dangerous for some, all the while permitting more competent competitors to continue to compete. Given the same dangerous surf conditions, as expressed, say, by a SHR rating of 19, lower competency groupings may be excluded from competition at a local carnival, whereas the presence of that same cohort at national championship events may necessitate whole-of-carnival transference to a safer venue, a circumstance which, for this case study, would be in line with SLSA’s Surf Sports Manual (Surf Life Saving Australia 2017a). In both circumstances, an objective and quantifiable level of ‘heightened risk’ would facilitate efficient decision making.

The data recorded during this case study noted circumstances where the assiduous use of the SHR, employed in conjunction with the risk-management protocols set out in SLSA’s Surf Sports Manual, facilitated different risk-management decisions to be made under similar circumstances at a local Queensland carnival at Coolum Beach on 18 January 2014, and at the ASRL Open at Shellharbour on 20 February 2015 (refer to Phase III data – Section 6.4). The surf conditions at each carnival were recorded at one point with a SHR of 19. At the local carnival, the Under Twenty Three Female surfboat event was postponed until surf conditions abated. The Open Male surfboat races were permitted to continue with surf conditions reaching a SHR of 20 at times. In contrast, at the major event at the Shellharbour carnival, where the SHR was also 19, all events were transferred to Warilla
Beach (where the SHR was between 11 and 14 at all times), thus providing all competitors with the opportunity to compete. The management of competitor-risk at both of these carnivals proceeded smoothly, without incident, and occurred quickly, and with the support of all stakeholders involved, with the added benefit of referral to the SHR scales. The SHR has therefore been demonstrated in practice to support SLSA risk-management policy applicable to event-importance under a variety of surf conditions.

7.7 Final Statement

The arguments and evidence presented within this dissertation have demonstrated the capacity of the SHR model to act as an effective tool to assist surf-risk managers to make reliable decisions in real time. It has been reasoned that the management of external risk factors in sports involving the natural environment have not only become essential elements of responsible corporate governance and policy development, but also requires guidance, possibly in the form of case studies such as those presented in this research document. The purpose of this research was to develop a model that assists in the management of the inherent risk associated with participating in surf-sport, which, by its very nature, involves interaction with the natural environment (Diehm & Armatas 2004), to a level that is reasonably practicable. This case study therefore provides a contribution to the corporate governance literature, especially involving NFP sporting organisations, by providing an objective mechanism by which external risk may be assessed and mitigated, all the while being complementary to the existing risk-management policies an organisation, such as SLSA.

Responsible corporate leadership prioritises stakeholder safety. The development of the SHR model evolved in response to the perceived deficiency in this aspect of SLSA’s
corporate governance structure. Specifically, it was community criticism of SLSA’s capacity to manage adequately surf-assessment-related risk during the aforementioned surf lifesaving competitions in 1996, 2010 and 2012 – all three of which were marred by tragedy – that provided the catalyst for this research. The data collected during this case study provides the evidence that validates the SHR as an accurate and reliable model that is capable of assessing the prevailing surf hazards across multiple Australian beach-environments. This model differs from other beach-hazard and rip-current predictive-models because its underlying variables are determined by considering the hazardous ‘effects’ of observable surf features in real time. The empirical research has demonstrated that surf-risk practitioners are able to make critical and objective decisions related to stakeholder-safety quickly and efficiently while adhering to a robust systematic checklist of TSO protocols.

It is proposed that the SHR model is easily adapted to user-friendly platforms such as smartphones and Unmanned Aerial Systems (i.e., ‘drones’) because of its quantifiable format, especially with further advances in multi-spectral and hyper-spectral imaging. Accurate and reliable decision making in ‘heightened-risk’ situations for individuals or selected participant groupings would be further enhanced by the inclusion of a moderating factor of participant competency in such natural environments, which, in this instance, would lead to an overall determinant of surf risk, generically known as the ‘Surf Safety Index’. In its existing form, it is proposed that SHR determinations could also apply to surf-risk control for the surfboard riding (‘surfing’) and bathing communities, which would assist in the management of the recreational risk-carrying capacity of general surfing areas.
This research provides opportunities for those that wish to build on this study to adapt this methodology for the creation of other quantitative models that assist risk-managers involved in sporting events in natural environments to make decisions. It thereby provides an opportunity for sports event-managers to conduct events with a priority on safety, and for participants to compete against each other while challenging themselves against a potentially dangerous natural environment.
References


2013, *Charities Act 2013*, by ——,


—— 2017c, *Australian Sports Commission*, viewed 29 December 2017,

2017d, *Federal Register of Legislation*, by ——, viewed 07 May 2018,


—— 2017f, *Workplace Gender Equality Agency*, viewed August 2016,


Australian Government Bureau of Meteorology 2012, *Ruling the Waves: How a Simple Wave Height Concept can help you judge the Size of the Sea*, viewed 29 November 2017,

—— 2017a, *Marine & Ocean*, viewed 16 April 2017,

—— 2017b, *Marine & Ocean*, viewed 14 August 2017,

—— 2018, *Beaufort Wind Scale*, viewed 31 July 2018,


Aven, T & Renn, O 2009, ‘On risk defined as an event where the outcome is uncertain’, *Journal of risk research*, vol. 12, no. 1, pp. 1-11.


—— 1872, ‘Théorie des ondes et des remous qui se propagent le long d’un canal rectangulaire horizontal, en communiquant au liquide contenu dans ce canal des vitesses sensiblement pareilles de la surface au fond’, *Journal de Mathématiques Pures et Appliquées*, pp. 55-108.


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Curby, P 2007, Freshie - Freshwater Surf Life Saving Club - The First 100 Years, University of New South Wales Press, Sydney.


Freeman, R 1984, Strategic management, a stakeholder approach, Pitman, Boston.


—— 2017, Currumbin surfer Robert Henderson died four months after breaking his neck in the surf, viewed 5 January 2018, <www.goldcoastbulletin.com.au/.../surf...surfer...died...breaking...neck...surf/.../bf9a6c30.. >.


Huschke, R 1959, Glossary of meteorology, American Meteorological Society, Boston.


Klein, A, Santana, G, Diehl, F & De Menezes, J 2003, ‘Analysis of hazards associated with sea bathing: results of five years work in oceanic beaches of Santa Catarina State,


Lam, J 2014, Enterprise risk management: from incentives to controls, 2nd edn, John Wiley & Sons, Hoboken, NJ.


Matthew, B 2017, Financial management in the sport industry, 2nd edn, Holocom Hathaway, Scottsdale, AZ.


Power, J 1992, ‘Beach hazard analysis and bather safety – an investigation using a geographical information system’, *Bachelor of Science Honours Thesis*, Department of Geography, University of Sydney.


—— 2000, Beaches of the Queensland Coast, Cooktown to Coolangatta: a guide to their nature, characteristics, surf and safety, Sydney University Press, Sydney.


—— 2007, Between the Flags - One Hundred summers of Australian surf lifesaving, University of New South Wales Press, Sydney.


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—— 2015, Corporate governance: principles, policies, and practices, Oxford University Press, Oxford.


Appendix I  Report to SLSA - Findings of 2012/13 Pilot Study

Report to SLSA on Findings of 2012/13 Pilot Study

Gary McCoy
26th July, 2013

1 Introduction

The following are details of the methodology, findings and recommendations based on a pilot study to develop a Surf Safety Index (see Project Outline version 3.3) for Surf Lifesaving Competitions. It relates to data collected (with SLSA approval) at boat- and craft-related surf lifesaving carnivals in South East Queensland and Metropolitan Sydney from 18th January to 18th April, 2013.

This model complements the ‘Beach Hazard Rating System’ in use by SLSA. However, the Surf Safety Index is different, in that it is a temporal-based model that can be adapted to all-of-beach or arena-specific venues.

2 Aim

The purpose of this study was:

(i) To assess the consistency and accuracy of the measure of the prevailing surf conditions at any time during a competition (known as the Surf Hazard Rating (SHR)).
(ii) To assess the accuracy of the baseline or lowest level of the Competitor Surf Experience Rating (CSER) for various boat and craft events.
(iii) To compare the CSER with poorly-performed competitors’ perceptions of those surf conditions.
(iv) To note any incident in those same heat and craft events with the appropriate CSER and SHR.

A Surf Hazard Rating was independently calculated as early as possible before the start of each carnival (approx. 8:00 – 8:30 am) by the Trained Surf Observer using definitions found in Appendix A of the Project Outline. The value was calculated after observing the surf conditions for a minimum of 20 minutes prior to recording. The value represents the Maximum Hazard Rating (and reflecting the ‘worst’ observed surf conditions) over that given time period. The frequency with which this value is reached over the given time period may vary considerably from very infrequent to very often. Consequently some events may be conducted when the surf conditions are considerably lower than this prevailing SHR (for example 95515/4/2013 North Kirra). Data may be collected during a ‘full’ in the waves (or any other Surf Hazard Descriptor variable). This might affect competitor perceptions and the number of incidents that might be expected at these prevailing SHR levels (see later comments re ‘Perceptions’ and ‘Incidents’). The SHR was recalculated when conditions changed. A minimum of 30 minutes was required before the SHR could be decreased. It was immediately changed however, if conditions worsened.

Baseline competitors were those identified in the ‘Limited’ ability column of the Competitor Surf Experience Rating Guidelines in Appendix B of the Project Outline. Specifically Boat-related competitions were those last or near-to-last placed in the Male Under 19 Boat and the Female Under 23 Boat, the Masters Boat events above 200 yrs (Male) and above 120 yrs (Female) and craft-related competitors were those last or near-to-last placed competitors in the Female Under 15 yrs Board, Male Under 15 yrs Board, the Female Under 17 yrs Ski and Masters 60+ yrs categories.

Although other related data (such as age, on-pence etc.) were also obtained, the primary objective was to record the competitor’s response after she had competed in the surf conditions just experienced. The question asked was: “On a scale of zero (least difficult/dangerous) to six (most difficult/dangerous), how would you rate the surf conditions you have just competed in?”

Further, any incident that occurred during that event was also noted. Incidents ranged from falling off craft during the race to over-toppling and/or out of control boat or craft. Any injury sustained by any competitor during the relevant event was also recorded. Various methods of establishing rater consistency were trialled including:

(i) Individual SHR cross-checking,
(ii) A consensus approach, and
(iii) Qualitative post hoc cross-referencing with long term and elite competitors, coaches and carnival officials.

3 Methodology

3.1 Phase I & II

3.1.1 The initial SHR model was enhanced via interview and survey techniques with more than 30 experts in surf lifesaving, including elite and long-term surf lifesavers, coaches, and professional lifeguards and SLS officials. The open-ended interviews were conducted in persons and also using telephone and email to confirm, prioritize and scale the observable and recordable factors that contribute to variable surf zone conditions (known as ‘Surf Hazard Descriptors’). Baseline CSER’s were also confirmed during these interviews.

The resultant factors (WHIR, WT, WR, WZR, STR, LDR, RR and OHR) are included in the enhanced model (version 3.3). These factors are distinctly identifiable and measurable. The ability to correctly identify and record these factors with accuracy, reliability and according to the authors’ definitions (Project Outline, Appendix D) require additional training above that already possessed by experienced Surf Bronze Medallion holders and experienced surfers. Presently only Gary McCoy and two assistants are fully qualified to record SHR values that are consistent with the specifications of the author.

3.1.2 Once a consensus from these experts was reached regarding the surf features and associated scales, a short survey was conducted with volunteer experts to assess the reliability of the Surf Descriptor scales across different surf condition-scenarios. The resultant enhanced model relating the SHR and CSER was then trialled at the surf lifesaving carnivals mentioned above as Phase III of the project.

3.2 Phase III

3.2.1 Carnival Data

Data was collected by Gary McCoy and his assistants in Queensland and New South Wales.

4 Findings

4.1 Phase I & II

4.1.1 Consistency in SHR rating across experts was very high in the written form for the scenarios mentioned section 3.1.2 above. Only one minor comprehension error occurred.

4.1.2 Most experts believed that 7 or 8 Surf Hazard Descriptors were sufficient to adequately describe prevailing surf conditions. They generally agreed that other variables such as wind speed, wind direction, depth of water in the surf zone of a competitive arena, tides etc could all be adequately reflected in the existing Surf Hazard Descriptors comprising the SHR.

4.1.3 Some long-term elite athletes and coaches commented that as a result of reading and following the SHR structure, they could more systematically and objectively identify and assess contributing surf conditions regarding overall safety, both in competition and at training sessions. The final value for the SHR was consistent with their overall assessment of the prevailing surf conditions and safety considerations. Some experts commented that they had begun to assess surf conditions in terms of this more systematic approach.

4.2 Phase III

4.2.1 General Description of Carnival Data

(i) Data was collected from 19 Carnivals –12 in QLD and 7 in NSW.
(ii) This comprised: 7 Boat carnivals (27%) and 12 Craft carnivals (63%).
(iii) 160 individual carnivals races were observed. However data for only 161 subjects was collected. Inability to collect data during some races occurred because of non-response by interviewees or due to injuries occurring in the particular event.
4.2.4 Competitor Perceptions (Boat and Craft)

A significant relationship appears to exist between the prevailing SHR value and the perceived level of danger by the competitors in the race in which they had just completed.

(i) Competitor perceptions of danger (and/or difficulty) associated with prevailing conditions did increase as the SHR increased. This was more noticeable as SHR values increased above 14. However, the limited amount of data collected at these SHR values restricts further accurate analysis to be undertaken at this stage.

(ii) Competitor perceptions of danger also increased as the number of incidents in each event increased.

(iii) Non-alignment between existing surf conditions that were perceived by competitors and the prevailing SHR, periodically occurred due to factors, as mentioned above. The correlation of a SHR between 13 and 14 is significant. Further, at these SHR values, the probability of a competitor receiving a score is less. However, there is a flaw in the current perception system as it does not take into account the actual conditions existing at the time.

(iv) As mentioned in 4.2.3 (ii), many of the subjects who were questioned at SHR values equal to or greater than 14 were competing at decreasing SHR, because the low-ability competitor at the title level may be of a higher standard than those at the regular level. For example, 20/23/2013 0810 and 0055 U19 Male and U13 Female Boat crews at Old State Boat Tittles were multiple incidents including: boat back, sitting, floating, not fishing, and even members being seriously hurt. However, competitor perceptions of danger recorded in the ‘Questionnaire’ remained at 1 or 2 out of 6. The SHR’s at the time were 14 and 13. There appears to be a discrepancy here. When these perceptions were cross-checked against the number of incidents occurring during these events, it appears that these perceptions were wrong.

The overall accuracy of competitor-perceived danger and the perceived level of danger by the competitors in the race in which they had just completed.

(v) The overall accuracy of competitor-perceived danger may be adversely affected (biased) by factors including:

a. Inability of the competitor to accurately judge the prevailing conditions, even in reading the surf accurately.

b. Social pressure or herd instinct. The competitor may be unwilling to admit that the conditions were more or less dangerous than they actually felt they were. The “testosterone” factor is a good example of this factor. For example, 15/4/2013 0930 Muraccioli State, Female U21 Surf Boat title. A boat back, one out of the four, got the severity. The boat’s boat fell out. The boat subsequently remained out of control. This boat then recorded a Danger Rating of 1 on the ‘Questionnaire’.

c. Competitor and/or Goal-set (commitment) factor. The competitor may be highly motivated towards competing or achieving a given goal (e.g. “winning”). They possess a bias towards admission to one’s ability limitations. They may incorrectly blame the conditions for their poor performance in this particular event when in fact there may be some other contributing factor.

d. Familiarity factor. The competitor may have had similar conditions and as a consequence under rated the ‘true’ danger level of danger present. Alternatively, they may have had a bad experience in similar conditions at some previous time before their ability level had risen to its present level. They might have a cognitive bias related to this past experience and not to their present ability level. A further question concerning a competitor’s perception of their own ability may be required in future Competitor Questions.

e. Restricted Range Effect. It is anticipated that competitor perceptions of surf danger/skill will increase as the level of hazardousness of the surf increases. However, as evidenced by the ‘Tugun’ (20/23/2013), Point Danger Branch Championships (15/4/2013) and Australian Surf Lifesaving (Mawson’s) Championships (15/4/2013 – 17/4/2013) SLSA risk-management protocols already in place will often prevent or restrict the conditions in which potential will be able to compete. This has the effect of restricting the collection of valuable data within the window of most interest to the project (i.e. SHR 14 to 22).

4.2.5 Incidents (Boat and Craft)

A significant relationship appears to exist between the prevailing SHR and the number and severity of incidents occurring per race in both boat and craft events.

(i) The number and severity of incidents tended to increase substantially as the SHR approached and exceeded 14.

(ii) Perceptions of danger levels tend to increase as the number and severity of incidents increased (see Section 4.2.4 (ii)).

(iii) The level of surf difficulty in which competition is allowed to be conducted is restricted according to existing SLSA protocols (see sections 4.2.24 (v) ‘Restricted Range Effect’). Consequently, the data collected within this window (SHR 14 to 22) is limited. This does have consequent implications upon prediction within this range.

(iv) The data record all incidents and comments related to those incidents. As yet, there is no differentiation between the severities of those incidents. Also, a definitive scale for the severity of incidents is used by SLSA others, or has been agreed upon at this point in the study. However, it has become apparent that a minor incident such as an emotional outburst or finishing a long way back in a race is not as serious as, say, a competitor being struck on the head by a craft, car or boat. There is a need to scale the level of seriousness of these incidents so that further analysis may improve the accuracy of the model. A scale, created by the author has been included here to initiate discussion only (see Table 2 below).

<table>
<thead>
<tr>
<th>Scale</th>
<th>Craft Description</th>
<th>Boat Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Incidents</td>
<td>No Incidents</td>
</tr>
<tr>
<td>1</td>
<td>Emotional, Appear or finish long way behind</td>
<td>Emotional, Appear or finish long way behind</td>
</tr>
<tr>
<td>2</td>
<td>Overtake - HELD Craft</td>
<td>Competitors a long way outside of their area</td>
</tr>
<tr>
<td>3</td>
<td>Overtake - HELD Craft - Minor collision</td>
<td>Minor Collision</td>
</tr>
<tr>
<td>4</td>
<td>Overtake - Lost Craft and/or Overtake - Broken Craft &amp; DNF</td>
<td>Swap Boat or Back-shoot</td>
</tr>
<tr>
<td>5</td>
<td>DNF - HELD Boat</td>
<td>DNF - HELD Boat</td>
</tr>
<tr>
<td>6</td>
<td>Rear or Back-shoot and/or Lost or Broken Boat</td>
<td>Rear or Back-shoot</td>
</tr>
<tr>
<td>7</td>
<td>Injury or Serious Collision</td>
<td>Injury or Serious Collision</td>
</tr>
<tr>
<td>8</td>
<td>Serious Injury</td>
<td>Serious Injury</td>
</tr>
</tbody>
</table>

Table 3

(v) As mentioned in Section 3.2.1 (i), the prevailing SHR is the ‘event case’ value existing over a time period of approximately 20-30 minutes. ‘Lifes’ in wave groups (sets) or any other Surf Hazard Descriptor variable often occur during that time.

Timing of individual race events most often is independent of the wave height etc. Consequently, if a full does occur during a particular race event, no incident might occur even though the prevailing SHR was sufficiently high to indicate that incidents may be likely. To the competitor this is just the lack of the draw. In terms of data reining and analysis, this impacts the level of error, accuracy and predictability of the resultant model. For Example: 15/4/2013 0945 Australian Titans North Reef Masters over 200 years Boat event. There were regular and sometimes potentially quite severe incidents occurring both before and after this event. However during this event there were much smaller waves going out and no waves coming in. This resulted in NO incidents occurring during this race only, even though the prevailing SHR remained at 16 over the 20-30 min surrounding this event. In future, for data collection purposes only, all event data will be recorded as existing on those conditions existing at the start (i.e. ‘race-specific’ SHR) even though the prevailing SHR may be higher.
4.2.6 Concomitant Surf Decisions

There were three surf carnivals at which restricted or no data was collected because of the decisions made by carnival organisers due to dangerous surf conditions existing at the time. These carnivals did however provide evidence that those decisions made by carnival risk managers were consistent with outcomes suggested by the Surf Safety Index. These surf carnivals had SHR values of 16 or 17 which, as supported by the model, would indicate that these were conditions in which the chance of serious injury was more likely to occur. The decisions made by carnival officials reflected this heightened level of risk and so are supportive of this model.

(i) 2/2/2013 Saturday Tugan Croft carnival 09:00 SHR = 16

<table>
<thead>
<tr>
<th>9/8/16</th>
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</thead>
<tbody>
<tr>
<td>WTR</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>

Comment:

a. The SHR was calculated by Gary at 0800 before he found out that the surf carnivals had been cancelled the previous day by SLSQ. It was 16. The Surf Safety Index model recommends that U15 Male, U15 Female and U17 Female ski races should not proceed.
b. It should be noted that the SHR equaled zero at this time, indicating no wind or chop. Later in the day the wind was predicted to increase (see part c below), this would most likely impact the surf conditions and therefore increase the SHR and hence, SHR values.
c. Re discussion with a Qld SLS official (Monday 4/2/2013). The official had discussed the surf conditions with several other officials and eastern surf directors on Thursday (31/1/2013) and Friday (1/2/2013). Comments made by them included:
   - The surf on Friday was 8 feet and hammering. It was definitely not suitable for under 15’s and under 17’s and possibly under 19 year olds.
   - The water quality was poor.
   - Most Gold Coast beaches were closed Thursday and Friday.
   - Weather reports for Saturday were not favourable (see point b above).
   - Many cells and emails had been received from concerned parents, coaches and competitors requesting cancellation.
   - Boat events had already been cancelled at Broadbeach.
   - SLSQ decided, based on all of the above factors, to cancel the carnival in the interests of safety.

d. Points to note:
   - The SHR taken by Gary was on the Saturday, when conditions had eased somewhat from the Thursday and Friday.
   - Friday’s surf conditions contained greater wind strength and littoral drift. These would have increased the SHR for Friday to a level consistent with an expert coach’s comment regarding the level of safety of the Under 19 year old ski as well.

(ii) 9/3/2013 Saturday North Kirra (Point Danger Branch Championships) 09:30 SHR = 17

<table>
<thead>
<tr>
<th>9/3/16</th>
</tr>
</thead>
<tbody>
<tr>
<td>WTR</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

Comment:

a. This carnival had been transferred from Currumbin Beach because of rough surf and beach conditions.
b. The carnival operated for some time using the buoys beyond the outer break (where SHR = 17).c. Multiple incidents occurred in (the only) Masters’ events, with 2 to 4 incidents per event.
d. Numerous coaches complained that the conditions were too dangerous for the U15 boards races that were scheduled to be run after the Masters’ events.
e. After multiple incidents in the Under 15’s, the officials changed the competitive area:
   - Buoys were relocated to between inner and outer surf zones. Competitors were subject to less dangerous conditions (SHR = 12 approx.).
   - Competitors completed the course from Right to Left to take into account the littoral drift.

(iii) 15/4/2013 Australian Surf Lifesaving Masters Championships.

Saturday 13/4/2013 - Pre-carnival rating:

<table>
<thead>
<tr>
<th>15/4/13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beach</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Tugan</td>
</tr>
<tr>
<td>Kurrawa</td>
</tr>
</tbody>
</table>

Sunday 14/4/215 - Pre-carnival rating:

<table>
<thead>
<tr>
<th>14/4/15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beach</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Tugan</td>
</tr>
<tr>
<td>Kurrawa</td>
</tr>
</tbody>
</table>

Monday 15/4/215: Boat areas (Bilinga South) – further north than North Kirra

<table>
<thead>
<tr>
<th>15/4/15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beach</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Tugan</td>
</tr>
<tr>
<td>Kurrawa:</td>
</tr>
</tbody>
</table>

a. The North Kirra readings for Saturday and Sunday were taken south of the North Kirra SLSQ where the surf conditions were less dangerous.
b. On Saturday and Sunday the SHR was considerably higher at Tugan and Kurrawa than at North Kirra.
c. The surf conditions at North Kirra were considerably lower on Sunday compared to Saturday.
d. The surf conditions at Bilinga South were considerably higher than at North Kirra SLSQ on Monday.
e. It appears from this data that the SHR value was probably considerably higher on Monday at Tugan and Kurrawa than at Bilinga South and North Kirra. No data was recorded at Tugan or Kurrawa on Monday.
f. On Monday, Gary recorded data at Bilinga (Masters’ Boat) events only.
g. Boat events continued with only 4 boats per event.

b. Multiple incidents occurred in each of the Over 180 years, over 200 years and over 240 years Boat events. These included multiple boat overturns, back shots, DNF’s, bordereers and one serious injury (Yamba boat swamped with neck injury).

i. Croft event areas (further South and with less dangerous surf conditions) were changed to a similar set up to 9/2/2013 P. Danger Branch Championships where competitors raced around the inside buoys from right to left because of the strong swamp northwards and because of the dangerous nature of the surf.

The adjusted SHR for this inside course was about 18 (approximation as Gary took reading from the Boat Areas some distance away to the north). In Summary: These three carnivals show a significant positive relationship between the SHR and the number of incidents that occurred and actual decisions that were made by carnival officials.

5 Special Note:

A comment by a carnival official during the running of U17 Female Ski heats at the Australian Titles on Thursday 17/4/2013 (SHR = 8) after some competitors had finished up to 2 mile behind pack and sometimes falling off several times was: “Don’t worry. It’s amazing how they self-regulate when the surf gets bigger”.

6 Summary of Findings

(i) The Surf Safety Index appears to be a reliable and accurate model for assessing surf safety and can be easily adopted to beach- or area-specific variants at any time.

(ii) The Prevailing SHR value should represent the ‘worst’ surf conditions within (approximately) a 20 to 30 minute timeframe. It should be calculated before the commencement of surf carnivals activities and recalculated as surf conditions change.

(iii) The SHR value appears to be positively correlated to competitor perceptions, race incidents and official’s surf safety-related decisions.

(iv) Evidence suggests that as surf conditions begin to reach the ‘critical’ level where the SHR is 14 or above, these groupings mentioned in the CSER tables as the ‘baseline, low-ability level competitors’, appear to:

a. Exhibit a greater tendency to perceive the level of danger of those surf conditions as being higher.

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b. Experience as increasing number of incidents per event.
   (v) The “Competitor Perceptions Questionnaire” requires refinement in order to eliminate statistical “Noise”.
   (vi) The method for recasting surf-related incidents requires refinement.
   (vii) The numerical rating system of the Surf Safety Index provides useful information for risk management in surf carnivals by establishing empirical ‘Thresholds’ at which participants could be restricted from competing for safety reasons.

7 Recommendations

(i) Be data-collected at carnivals:
   a. Further carnival data is required from each state, especially at SHR levels of 14 and above, in order to improve the accuracy and reliability of the model over a minimum of three (3) competitive seasons. This for example, may include data from elite carnivals such as the Kelly’s Ironman Series.
   b. There should be a minimum of 2 ‘Trained Surf Observers’/records per carnival. These people should record data independently of all carnival officials on the day and should initially be trained by Gary. See Project Outline for criteria for potential candidates.
   c. A prevailing SHR value and a race-specific SHR value will be recorded at future surf carnivals in order to improve the accuracy of data collection.
   d. More qualitative data is required from coaches, sweeps and experienced competitors to enrich the data pool.
   e. All incidents need to be recorded using comments and a scale similar to that suggested by the author in Section 4.2.5.
   f. There is a need to collect further data in order to differentiate between different ability levels within each of the CSER groupings (i.e., Low ability, Average ability and Elite ability). There is also a need to differentiate between categories within each age group (e.g., Board versus ski versus swim etc).
   g. Methods to confirm faster consistency and accuracy need to be continued at surf carnivals.
   (ii) The SHR should be co-ordinated with the newly developed SLSA ‘Risk Assessor Matrix’.
   (iii) Eventually, and after this model has been fully validated:

   b. Provides a systematic process to rate prevailing surf conditions against participant experience levels.
   c. Can be implemented as an easy-to-use, area-specific, decision-making tool for SLSA officials, competitors and coaches.
   d. Is an objective measure of surf safety, and consequently:
      - This model may assist in the reduction of the level of subjectivity by officials when making surf carnivals risk management decisions by officials.
      - Removes competitor subjectivity when the decision to enter an event is based on the difficulty level of the prevailing surf conditions. This would remove circumstances in which the “Self Regulate” mindset can develop.
   e. Can distinguish between those surf conditions that would be suitable to conduct “Regular Open”, “Limited Open” or “Elite/Professional” carnivals.
   (iii) Club coaches could determine individual CSER’s within the designated CSER window. Thus:
      - Age competitors with an Average or Elite CSER could compete in age groups above their own if the prevailing coastal SHR is equal to or below their own CSER.
      - Coaches might also be able to implement specific programs designed to improve a competitor’s experience level and thus raise his/her individual CSER.
   (iv) Enhancement of future beach-related safety research. The empirical nature of this model facilitates the enrichment of data collected at surf lifesaving carnivals, and later, at all beach environments involving the general beachgoer. Incidents may be analysed against a quantitative measure of the prevailing surf conditions. Thus, beach risk-management practices may further be supported by richer empirical evidence.
   (v) Opportunities exist to include this model in the education of SLS members and the general public. For SLS members, this may be in the form of more formal qualification in the assessment of surf conditions via the SHR. For the SLS members and general public, this may be in the form of the practising of a “Code of

a. A prevailing SHR value should be calculated by a panel of experts prior to the commencement of competition. This panel should consist of a minimum of 3 and maximum of 5 people comprising one from each of the following groups:
   (i) a panel official representative
   (ii) a professional lifesaving representative
   (iii) a coach representative
   (iv) a surf competitor representative
   (v) A sweep representative where applicable.
   b. The CSER for each competitor or boat crew should be set by Coaches/Sweeps at least 1 month prior to any carnival based on the appropriate category “Window”. If no rating is supplied then the appropriate default “Low Ability” rating is used for the designated competition category for competition purposes.
   c. SLSA should develop a campaign of ‘Participant Responsibility’ based around the SSR.
   d. The CSER’s are an average of the lowest ability levels over all competitors. If a competitor is not in line with the lowest ability reading of CSER for their category (that is SSR Low ability), then they are NOT allowed to compete until they improve to the lowest ability rating for that category.
   e. For Example: the Under 17 Female Ski race currently has a CSER (Low ability) of 15. However during the Australian Titles (17/4/2013) there were competitors who were obviously well below the minimum level, finishing at times 2 minutes behind the pack in conditions where the SHR = 8. Their club should be prevented from allowing them to compete in this event until their CSER is 15 or better. See related comment in Section 5.
   c. There is a need to account in the Surf Hazard Description and consequent SHR values for dangerous shore-breaks only, where there is no surf zone.

8 Benefits to SLSA and State Centres and Associated Bodies

(i) The Surf Safety Index:
   a. Is an empirical model that complements the existing Beach Hazard Rating system used by SLSA. Further to this model, it possesses measurable components that are temporal - and versus-specific.
   (iii) Provides a systematic process to rate prevailing surf conditions against participant experience levels.
   (iv) Can be implemented as an easy-to-use, area-specific, decision-making tool for SLSA officials, competitors and coaches.

9 In Conclusion

Based on the evidence from this Pilot Study, the authors believe that the Surf Safety Index model should be able to:
   (i) Summarise the dangerous nature of prevailing surf conditions,
   (ii) Assess a surf competitor’s level of safety in those same surf conditions, both within a range of reasonable practicality.

10 Proposal to SLSA and associated State and Australian Bodies:

“That we enter into a partnership with SLSA and associated State and Australian bodies to further develop the Surf Safety Index model”

We do this by:
   (i) Promoting and supporting this project, both inside and outside of Surf Lifesaving circuits, as a worthwhile and achievable community endeavor.
   (ii) Establishing a ‘Trained Surf Observer’ training program.
   (iii) Assisting with data collection, especially at surf carnivals with SHR ≥ 13 and including Elite surf carnivals.
   (iv) Co-operatively developing a timeline for future research, education and possible implementation into SLSA beach-related safety protocols.
Appendix II   Trained Surf Observer Training Manual and Workshop

Surf Hazard Rating Project

Trained Surf Observer Workshop

Gary McCoy

Workshop Agenda

- Session One: Surf Hazard Rating Model - Components, Definitions and Scales
- Session Two: Administration - Data Collection Requirements
- Session Three: Surf Hazard Rating (Theoretical) - Example and Practice Scenarios
- Session Four: Surf Hazard Rating (Practical) - On-the-job exercises

Training Manual

Contents

1. Agenda
2. Session One: Surf Hazard Rating Model - Components, Definitions and Scales
3. Session Two: Administration - Data Collection Requirements
4. Session Three: Surf Hazard Rating - Theoretical Example and Practice Scenarios
5. Session Four: On-beach practical calculation of SHR
6. Appendix A: Surf Hazard Descriptors
7. Appendix B: Beaufort Scale

Project Overview

- SHR:
  1. Is a Tool to assist Referees make decisions
  2. Measures the Dangerous Nature of Surf Conditions in a Systematic Manner
  3. Complements SLIA policies on Surf Helmets
- Threshold is SHR >?. AT, and Above which ...
- At selected carnivals

- Project also to collect data on:
  1. Incidents
  2. Injuries
  3. Referees' and others' opinions

Trained Surf Observer Workshop

Session One:

Surf Hazard Rating Model:
- Components
- Definitions
- Scales
Surf Hazard Rating (SHR)

- Is a single-value measure to summarise:
  - The dangerous nature of surf conditions.
- It is Observation and Measurement-based.
- It can be specific to:
  - Any Beach or Coastal Areas
  - Any Time
- It is the subject of this research project.

Surf Hazard Rating - Helmet Model

<table>
<thead>
<tr>
<th>Surf Hazard Rating (SHR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12345678910</td>
</tr>
<tr>
<td>Mandatory Helmet Worn</td>
</tr>
<tr>
<td>Helmet Worn</td>
</tr>
<tr>
<td>Wake Determined</td>
</tr>
<tr>
<td>Wake Determined</td>
</tr>
</tbody>
</table>

Fig 1

Surf Hazard Characteristics:

The surf conditions at any beach and anytime are known to be caused by:
- The weather
  - Wind speed and easterly topography
  - Sun exposure

The effects of these fundamental causes are reflected in the characteristics of:
- The breaking wave
- The breaking surf face
- The residual water movement.

Surf Hazard Rating Descriptors:

- Wave Height (WH) (in metres)
- Wave Period (WP) (in seconds)
- Surf Zone Width (in meters)
- Surface Turbulence (STR)
- Littoral Drift (LDR)
- Rip Current (RRC)
- Other Hazards (OHR)

<table>
<thead>
<tr>
<th>Descriptors</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wave Height</td>
<td>(0 to 5)</td>
</tr>
<tr>
<td>Wave Type</td>
<td>(0 to 4)</td>
</tr>
<tr>
<td>Wave Period</td>
<td>(0 to 3)</td>
</tr>
<tr>
<td>Surf Zone</td>
<td>(0 to 5)</td>
</tr>
<tr>
<td>Surface Turbulence</td>
<td>(0 to 5)</td>
</tr>
<tr>
<td>Littoral Drift</td>
<td>(0 to 4)</td>
</tr>
<tr>
<td>Rip Currents</td>
<td>(0 to 3)</td>
</tr>
<tr>
<td>Other Hazards</td>
<td>(1 for each)</td>
</tr>
</tbody>
</table>
**Other Hazard Rating (OHR)**

1. Man-made or Natural Obstructions:
   - Significant: Leaders of Rocks, Reefs, or Seaweed.

2. Uncontrolled Surf Craft
   - Most Hazardous Rating: 6
   - Hazard: 5
   - Warning: 4

3. Skis/Skis and other Floatation Devices

4. Water Temperature (1-4 Rating: 4; 4-10 Rating: 3)

5. Visual Impairment (Sun Effects)

6. Life Threatening Marine Creatures

---

**Surf Hazard Descriptors**

**Definitions**

Surf Hazard Descriptors are:

- A reflection of the most hazardous observations of surf characteristics

- Measured over a given time period (e.g., 20 minutes)

Note: To err on the side of safety, be cautious of a serious underestimation of a hazard's potential.

**Always defer to the higher rating if unsure.**

---

**Wave Height Rating (WHR)**

The accepted definition through the use of the term "Wave Height" is the area of the underwater section of a wave and the preceding wave. It is measured as:

- Height

**Wave Height Rating (WHR)**

<table>
<thead>
<tr>
<th>Wave Height Rating</th>
<th>WHR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
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<td>9</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

---

**To estimate measuring the breaker height:**

- Observe conditions along the shoreline
- Observe breaking on a well-defined line (approximate 1.5m)
- Observe breaking on a submerged surfboard or oceanic jet
- Observe surf, regardless of the breaking trend the breaking depends on the breaking characteristics.**
### Wave Height Rating (WHR)

<table>
<thead>
<tr>
<th>Wave Height</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>1</td>
</tr>
<tr>
<td>Medium</td>
<td>2</td>
</tr>
<tr>
<td>High</td>
<td>3</td>
</tr>
<tr>
<td>Very High</td>
<td>4</td>
</tr>
</tbody>
</table>

**WHR = 3**

### Wave Type Rating (WTR)

<table>
<thead>
<tr>
<th>Wave Type</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolling</td>
<td>1</td>
</tr>
<tr>
<td>Plunging</td>
<td>2</td>
</tr>
<tr>
<td>Breaking</td>
<td>3</td>
</tr>
<tr>
<td>Rolling</td>
<td>4</td>
</tr>
</tbody>
</table>

**WTR = 1**

### Wave Period Rating (WPR)

<table>
<thead>
<tr>
<th>Wave Period</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short</td>
<td>1</td>
</tr>
<tr>
<td>Medium</td>
<td>2</td>
</tr>
<tr>
<td>Long</td>
<td>3</td>
</tr>
<tr>
<td>Very Long</td>
<td>4</td>
</tr>
</tbody>
</table>

**WPR = 2**

### Zone Width Rating (ZWR)

<table>
<thead>
<tr>
<th>Zone Width</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narrow</td>
<td>1</td>
</tr>
<tr>
<td>Medium</td>
<td>2</td>
</tr>
<tr>
<td>Wide</td>
<td>3</td>
</tr>
<tr>
<td>Very Wide</td>
<td>4</td>
</tr>
</tbody>
</table>

**ZWR = 2**

### Surface Turbulence Rating (STR)

<table>
<thead>
<tr>
<th>Surface Turbulence</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calm</td>
<td>1</td>
</tr>
<tr>
<td>Moderate</td>
<td>2</td>
</tr>
<tr>
<td>Rough</td>
<td>3</td>
</tr>
<tr>
<td>Very Rough</td>
<td>4</td>
</tr>
</tbody>
</table>

**STR = 3**
Tips when taking SHR readings:

1. Thoroughly know the definitions.
2. Observe the surf for at least 20 minutes before recording.
3. Refer to SHR Tables when determining SHR values—especially at the start.
4. Make several practice runs allowing survivalWinner when there is no pressure.
5. Practice with another TSO to help develop skill level.
6. Accuracy and Reliability are ESSENTIAL.
Surfboat Hazard Rating Project

Sections Two

Administration

- TSP Minimum Qualifications
- Recording SHR Values
- Decision Flowchart
- Recording Incidents related to SHR Values
- Debt Collection
- Extra Tips

Trained Surf Observer Qualifications

Trained Surf Observers (TSOs) - minimum qualifications:
1. Must be at least the age of eighteen 18th.
2. Must be a member of a surf lifesaving club.
3. Must be a Surf Bronze Medal holder.
4. Should have the equivalent of about 10 hours Surf Experience.
   i. As a general surfer, patrol member and/or competitor.
   ii. If you are comfortable to be able to ACCURATELY
      "read" the surf, this applies to the Surf Hazard
      Descriptions provided in Appendix A.

Recording Prevailing SHR values

When Collecting Prevailing SHR Data:

1. It is RECOMMENDED that you rate the surf conditions in a manner that is:
   i. Accurate
   ii. Unbiased - Do NOT prejudge the SHR value then try to fudge the number to suit
   iii. In accordance with your knowledge and our tables ONLY!

2. Task and Hewat's methods:
   i. Over a 200m Exclusive period
   ii. Independently
   iii. Interdependently

3. At the same beach - position for each and NOT on the Promenade

Referent’s Decision Flowchart - Using the SHR menu

[Diagram showing decision flowchart]

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**Boat Referees:**

1. **MUST** be a Trained Surf Observer (TSO)
2. Calculate the Prevailing SHR.
3. Consult with Boat Panel.
4. Document the Prevailing SHR value and the decision related to the surf conditions.
5. Comment on the usefulness of the SHR model. (a) To determine related surf conditions and (b) Your decisions based upon these conditions.
6. Coordinate Data Collection.

---

**Incident Report Sheets**

1. Record all incidents and numbers on the appropriate sheet.
2. Know the Incident Definitions.
3. Indicate if surf time has multiple incidents in the event of a break and a return. Each number will represent different sheets.
4. Incident Recorder – Designated by Carnival Referee
5. Incident Recording:
   - Option I: Modified Incident Report Sheet
   - Option II: Event Specific Incident Report Sheet

---

**Basic Incident Report Sheet**

1. **Prevailing SHR by Boat Referee**
   - Assume to inform the others when the prevailing SHR changes.
2. **If No Incident:**
   - One event per number.
   - No need to record anything else.
3. **When Incident Occurs:**
   - Record incident(s) against relevant Event Number.
   - Note the using SHF from Referee.
   - Also record Time, Category, Number from start.

---

**Option I: Modified Incident Report Sheet**

1. **One Extra TSO available (not Referee):**
2. **If Incident Occurs**
   - SHR taken (adjusting or increasing) by extra TSO.
   - Record Incident(s).
   - By either TSO or Incident Recorder.
   - Also record Time, Category, Number from start.
3. **If No Incident:**
   - Then new SHR taken by extra TSO.
   - Record Time.
   - No other details required.
4. **See Curly if considering this method.
Option II:
Event-Specific SHR & Incident Report Sheets

1. This is the event-specific process. Needs a lot of coordination.
2. Send current and incident reports to the SHR.
3. Always record the time and event details of each event on the SHR sheet.
4. Record a new Event-Specific SHR.
5. Category (LIGO) score.
6. Important: Only when the SHR event goes beyond a different category, change the SHR category.
7. If an event changes to SHR, the SHR cannot be reopened.
8. Details not to be added in DA9.
9. See Data Integrity for further details.

Data Integrity

A Research Monitor will be in attendance.
He/she will be responsible for:

1. Distribution of any required report sheets (where necessary).
2. Collection of all used report sheets (where possible, in most cases).
3. Making sure the Data Integrity Manual is followed.
4. Monitoring and ensuring proper:
   a. Quality control and security of patient data.
   b. Anonymity and accuracy will be ensured.
   c. Any problems phone Gary or 062 340 008.

Extra Tips:

- Always know the Prevailing SHR.
- Choose the report sheet appropriate to your circumstances.
- Make sure Incident Recorders know Prevailing SHR.
- Hand in all Report sheets.
- Collect some data later in the day if conditions look like changing significantly.

The Surf Hazard Rating

Session 3:

- Theoretical Example
- SHR Practice Scenarios

SHR Practice Scenarios

Example Scenario
- Surfing at a certain beach under specific conditions and temperatures.
- The wind blows from the south:
  a. Shelf depth: 9.0 meters
  b. Shelf width: 150 meters
  c. Shoreline: 200 meters
  d. Water temperature: 15°C
  e. Water depth: 30 meters
  f. Water temperature: 15°C
  g. Water depth: 30 meters

SHR Categories

1. Low hazard
2. Moderate hazard
3. High hazard
4. Extreme hazard
5. Hazardous conditions

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SHR Practice Scenario

Scenario A

- There is an unexpected outflow of surfers due to a change in the weather.
- The beach areas are crowded due to the increased number of surfers.
- The lifeguards are busy managing the situation and ensuring safety.

Calculations:

- [Numbers and calculations]

---

SHR Practice Scenario

Scenario B

- There is a sudden drop in temperature that affects the surfing conditions.
- The waves become more inconsistent, making it challenging for surfers to navigate.
- The beach patrol has to monitor the conditions closely.

Calculations:

- [Numbers and calculations]

---

SHR Practice Scenario

Scenario C

- A large group of surfers gather, causing a traffic jam on the beach.
- The beach patrol must ensure that the surfer's rights are respected.
- The cleanup crew is on standby in case any issues arise.

Calculations:

- [Numbers and calculations]

---

Where to from here?

- Read and understand ALL Surf Hazards Descriptions and their definitions thoroughly.
- Practice written scenarios first.
- Do not practice at a beach before attempting actual readings be recorded.
Appendix A

Table A1: Wave Height Rating (WHR)

<table>
<thead>
<tr>
<th>Wave Height Rating (WHR)</th>
<th>Wave Height</th>
<th>Bargain</th>
<th>Steeply</th>
<th>Troubled</th>
<th>Very Rough</th>
<th>Rough</th>
<th>Choppy</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

Appendix B

Table B1: Beaufort scale

<table>
<thead>
<tr>
<th>Beaufort Scale</th>
</tr>
</thead>
<tbody>
<tr>
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Source: Bureau of Meteorology
Appendix III  Implementation of Mandatory Surf Helmets in Surf Boats

Source: SLSA Bulletin 5/14-15
Appendix IV   TSO/Data Collector Information Sheet

Trained Surf Observer/Data Collector

Information Sheet

Dear potential Trained Surf Observer (TSO) and Data Collector,

Thank you for assisting me with this important section of the project. The information that you collect will be used to validate a model to assess how dangerous the surf conditions are at a given venue and any given time.

It is necessary that you have sufficient surf-related experience to be able to observe and accurately record the surf conditions as you see them and in line with the definitions presented in the accompanying manual. I therefore ask that you have the following minimum qualifications:

- You must be over the age of eighteen.
- You must be a member of a surf lifesaving club.
- You must be a Surf Bronze Medalion holder.
- You should have the equivalent of about 10 years surf-related experience. This may be as a general surfer, patrol member and/or competitor. With this level of experience, you should feel comfortable to be able to ACCURATELY "read" the surf, with regards to the Surf Hazard Descriptors provided as a separate document.
- You cannot be actively involved as a competitor, coach or official at the time of recording.

I am very interested in your opinions re these definitions. However, for this season the definitions have to remain unchanged for the accuracy of data collection. Therefore, you MUST enter the values as per the definitions ONLY.

In order to be accurately and reliably able to collect data, you will need to be a Trained Surf Observer (TSO). There is a scheduled Training Workshop on 6th December (1pm to 5pm) at Torquay SLSC. Other Training Workshops may have to be arranged for NSW and Qld before the start of the 2013/14 competitive season for those who cannot make this date.

As part of this project you will be required to collect data at targeted surf/hurricanes in two forms, and on two separate sheets: (i) A Prevailing Surf Hazard Rating (SIR) sheet, and (ii) A TSO Event-Specific Report sheet.

1. Carnival Report:
   a. You should not be actively involved as a competitor, coach, or official at the time of recording. You will need to take readings independently of carnival officials.
   b. The PREVAILING SURF HAZARD SHEET:
      - The Prevailing Surf Hazard Rating needs to be taken in approximately a 20 minute period just prior to the carnival commencing and at times during the carnival to reflect changing surf conditions.
      - The initial data includes your name, time, beach etc.
      - The important data comes from reading the surf according to the scales that I have developed. The skills necessary to record this data need to be taught in a workshop prior to data collection.
      - A minimum of two Trained Surf Observers (TSOs) are required to record the Prevailing Surf Hazard rating simultaneously and independently.
   c. The TSO EVENT REPORT:
      - This sheet is filled out for each of about 30 boat races during the day.
      - The sheet will record the event start and finish times, event category etc.
      - It will also record an Event-Specific Surf Hazard Rating only when it is significantly different to the Prevailing Surf Hazard Rating.
      - Any incidents occurring during this event will also be recorded on this sheet.
Appendix V  Research Assistant/QCO Information Sheets

Research Assistant/Quality Control Officer

Duties:

1. Take sufficient data sheets (Prevailing SHR $\approx 10$ and TSO Event Reports $\approx 80$) to each carnival – Gary to supply.
2. Arrive at the carnival approximately 7:30 – 7:45 am for an 8:30 am start.
3. Know who you are supposed to meet at the carnival (including TSO’s and Carnival Referee).
4. Notify them where you will be collecting the data. A good spot is near the starter’s tower.
5. Distribute Prevailing and TSO Event Report data sheets to TSO’s:
   a. Thoroughly know all definitions. Contact Gary if uncertain at any time.
   b. Clarify how they should be filled out – answer any related questions.
   c. Plan which events will be targeted for data collection during the day.
6. Assurance of Quality:
   a. Prevailing SHR sheets:
      i. Make sure all 3 of you fill out the Prevailing SHR simultaneously over a 20 min timeframe prior to commencement of the carnival.
      ii. (If Possible) Take a 2 min video of the Max surf conditions. Later email this back to Gary.
      iii. Review after completion:
         A. Make sure all details are filled out.
         B. Ask for clarification if SHR’s are different (if any or both different from you). It is OK if their results are different from yours. Just make a note of the differences on your sheet.
         C. TSO’s to keep Prevailing SHR sheet secure for the whole of carnival for later reference. Know the Prevailing SHR and Descriptor ratings at all times.
   b. TSO Event Report sheets:
      i. Review planned events to target during the carnival.
      ii. Simultaneously (at least two) monitor the Event-Specific SHR throughout the race. Discuss the SHR after you have recorded it on your sheet – The aim is also to gain consistency of the readings as well as independent recordings.
      iii. Record any NEW Event-Specific SHR ONLY if significantly different from the Prevailing SHR (especially WHR & WTR).
         A. If the Event SHR is LESS than the Prevailing SHR:
            (i) Record it on the sheet.
            (ii) Leave the Prevailing SHR UNCHANGED until these new conditions prevail for AT LEAST 20 minutes. This takes into account “lulls” in wave sets where the event overall had easier conditions than are prevailing at the time.
         B. If the Event SHR is GREATER than the Prevailing SHR:
            (i) Record it on the sheet.
            (ii) This new Event SHR - value becomes the NEW Prevailing SHR for the carnival.
            (iii) Comment that this is the NEW Prevailing SHR.
      C. Comment as to which Surf Hazard Descriptor(s) were different at this time
   iii. Only one TSO need record Incidents for each event. However the Research Assistant must keep a record of the incidents for their records so that we can verify the accuracy etc of the TSOs Observations. If you like you may collect the Incident information in communication with the TSOs.
iv. After each evaluation of a SHR, get a consensus and agree from that point onwards as to the value of the Prevailing SHR. Don’t go forward with differing Prevailing SHR’s.

v. Collect TSO Event report sheets after each event. Assure relevant information is filled out. Comment on differences if need be.

c. Maintain security of all data sheets throughout the carnival.

7. Collect all data sheets. Secure and return to Gary as soon as convenient. Assure privacy and anonymity of data recorders at all times. Names will be removed from the data as data is coded into the system.

8. Contact Gary on 0467 348 068 for clarification or assistance before, during or after the carnival.

9. I will organise payment for the relevant carnival work as soon as practical after the relevant carnival.

Thank you once again for your assistance. I would appreciate any comments or input as to how to make this system more efficient.

With thanks

Gary
### Race-Specific SHR Data Sheet

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<th>Race No.</th>
<th>Time (Eg 9:00am or 14:32)</th>
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Appendix VII  Author Presentation: ASRL General Meeting May 2014

Surf Hazard Rating and Surf Helmet (Surf Boat) Project
Gary McCoy
May 2014

Report on Data Collected
Boat Competition Season 2013/14

Acknowledgements
We wish to thank the following ASRL members for their assistance and cooperation in the collection of data relevant to this project:
- Queensland: Craig Williams, Charlie Melbye, Mark Inaway and Jonathan Collins
- NSW: Mark Lang, Ben Fawcett, Kim Mathis and Nathan Perry
- Victoria: Peter van Dossen, Tomas Brons, Steven Brown, Doug Sally and Paul Coles
- South Australia: Dan Henderson and John Graham
- Western Australia: Richard Hume and Ian McHugh

Boat Carnival Data Summary
January to March 2014

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Boat Carnival Event Statistics

1.3.7 Carnival Events
- Gender:
  - Male: 30
  - Female: 5
  - Combined: 2
- Age Group Categories
  - Under 20: 16
  - Under 30: 15
  - Under 40: 14
  - Over 40: 1
- Open Men: 33
- Open Women: 11

Distribution of the Total Number of Data-Events versus SHR

Total Events: 107
Boat Event Incidents

- 26 Sunk
- 34 Late-Start
- 14 Misses
- 237 Injuries
- 46 DNFs
- 38 Collisions
- 12 Minor Collisions
- 21 Minor Injuries
- 9 Serious Injuries
- 44 DNFs (21 due to engine failure)

- 413 Events from 2013 (data on 227 events 2015, data from cancelled race).

- 244 Events DNF/No-Start.
- Distribution of 244 events (2013) vs. 2015.

Note: Some incidents (e.g., engine failure) may not have been recorded accurately.

Distribution of Incident Type per Event versus SHR

Distribution of the Number of Events per Hour versus SHR

Distribution of Average Number of Incidents per Event versus SHR
Data Analysis for Reliability

How accurately did raters rate the surf conditions for each event (ASK) using the definitions and scales supplied?

Analysis Software:
- SPSS (version 9.0 software)

Results (Providing sufficient data to perform tests):
- Inter-Observer Correlation (IOC):
  - Single Measure: r (between 0.75 & 0.90)
  - Average Measure: r (between 0.80 & 0.97)
- Cronbach’s Alpha: r (between 0.71 & 0.73)
- Pearson’s Correlation Coefficient: r (between 0.70 & 0.93)
- Spearman’s Correlation Coefficient: r (between 0.78 & 0.95)

Conclusions (Reliability)

- Results are affected by:
  - Small sample sizes (in some cases)
  - Only two cases per event (in some cases)
  - Range restriction (data to self-regulation & mitigation measures etc.)

- When sufficient data available:
  - Very good to excellent agreement between cases:
    - Both assessments were highly related
    - Low measurement error when using scales to rate surf conditions

- The average of raters’ calculations increases the reliability of the SHR value
  - More stars improves reliability

Accuracy of Model

- Very high statistically significant correlation = 0.886 (between refiner’s opinion and the prevailing SHR [p<0.01])

- (Basic) Linear Regression Model:
  - Total Number Incidents per Event v. SHR: R² = 0.80

- Logit (Prediction) Model:
  - SHR is statistically significant predictor of all types of incidents (p<0.01)
  - Residual threshold: Cutoff = X

- Other Non-parametric Models:
  - p-value of between Y and Z

Distribution of Average Number Incidents per Event versus SHR

Distribution of Incident Type per Event versus SHR