Authors' response to reviewers: *NHESS-2020-244 Beachgoers' ability to identify rip currents at a beach in situ*

Dear Editor and Referees,

Thank you for your constructive comments on our manuscript entitled 'Beachgoers' ability to identify rip currents at a beach in situ'. We would like to thank you for your time, and feel that now having incorporated your comments that the manuscript is greatly improved as a result. In the response below we outline how we have engaged constructively with the referees' comments, and explicitly outline the revisions made to the manuscript.

Kind Regards,

Seb Pitman, on behalf of the co-authors.

Editor Comments (EC):

EC1: AR3 & AR4: You state that in response to these concerns, you have expanded Section 4.2, which discusses the implications for beach safety. Given the possible implication of the highlighted issue on your results, it seems useful to also acknowledge this issue in the results or limitation sections to ensure readers are aware of it.

We have expanded the second paragraph of the limitations to incorporate this explicitly. The text in bold italic below is new addition, whereas the normal text was existing but contributes towards this point also:

"Therefore, each respondent formulated their answer from slightly different viewpoints combined with different conditions. ***This study did not account for how viewing orientation, distance from the rip, or instantaneous hydrodynamic conditions impacted the ability to identify the rip.*** Any future in situ study should plan to incorporate some form of wave/tide measurement and a coastal imaging camera in order to make comparisons between identification rates and wave/tide heights and breaking wave patterns, ***as well as record observation locations relative to the rip***."

EC2: WS4: While I agree with WS that the t-test was not appropriate for your comparisons, I disagree with your choice to replace it with the Pearson chi-squared test. These are very different test that measure different things. While the former is a parametric test to examine differences in the means of an interval variable between two groups, the latter is used to examine differences between the expected and observed frequencies in a contingency table from categorical variables. However, your variables swimming competency, swimming distance, and swimming in the sea are all ordinal variables. Hence, a Wilcoxon rank-sum test would be able to indicate whether participants able to accurately identify the rip current were better or worse swimmers. This seems more in line with your original storyline and more insightful that just identifying differences in proportions without taking the ordinal character of the variable into account.

We have replaced these statistics with the Mann-Whitney U /Wilcoxon Rank Sum test, and amended the text as follows:

"A Mann-Whitney U-test indicated maximum pool swim distance was significantly higher (median = 5, "200+ metres") among those that could identify a rip current compared to those that could not (median = 3, "51 - 100 m") (p = 0.006). Across all classes, self-reported

confidence about swimming that same distance at sea was significantly greater among males (median = 4, "Confident") than females (median = 3, "Unsure") (p = 0.004)."

EC3: Presentation of statistical results (Section 3.1): I find your way of presenting proportions in the results section slightly confusion. For example, on line 157, you state "… higher proportions of males (33%, n = 15) that females (16%, n = 14) …". It was initially unclear to me whether the 33% was 5 of 15 or 15 of 46. In some sentences, it is more clear what your reference class is (e.g., Line 189: "Of the 29 respondents able to spot the rip current, …"), but I recommend that you change your format to something like "(33%, 15 of 46)", which avoid any misunderstandings.

We have updated this throughout the document.

EC4: Section 3.2: I find this paragraph quite confusing to read as you seem to be jumping around between different questions that you either interpret as interval or categorical variables. For example, you provide the descriptive statistics for the competence question on line 169, but you only mention that the difference is not statistically significant (which is fairly obvious) on line 174. I am also unclear on the reference class in your analysis of the confidence question. Did you include the responses from all participants or only the ones reporting that they were able to swim more than 100 m? If you used the entire sample, my calculations indicate that 32% among females (28 of 86) is significantly different from 54% among males (25 of 46) (chi-squared test: p = 0.025). I believe this paragraph would benefit from some clarifications.

We have re-arranged this paragraph to explicitly take each question in turn, outlining gender differences and the impact on rip spotting ability for each question before moving to the next. We have removed reference to a 'positive' response and instead are explicit in saying 70% of respondents replied 'Good' or 'Very Good'. We have also clarified that all respondents were asked about swimming that same distance at sea. The revised paragraph reads as follows:

"Respondents were asked to self-rate their swimming competency through a series of questions (Table 4), with each response assigned a numerical value between 1 and 5, representing increasing competence. When asked to rate on a qualitative spectrum ('Poor', 'Fair', 'Good', 'Very Good'), 70% of respondents (n = 90 of 129) replied either 'Good' or 'Very Good' and there was no significant difference between genders. No significant difference was evident when ability to identify an in situ rip was analysed against self-reported estimates of swimming competence (Figure 4a). In order to qualify self reported competence, respondents were subsequently asked to estimate their maximum pool swimming distance. In response, 47% of females reported being able to swim in excess of 100 m, compared to 61% of males. A Mann-Whitney U-test indicated maximum pool swim distance was significantly higher (median = 5, "200+ metres") among those that could identify a rip current compared to those that could not (median = 3, "51 - 100 m") (p = 0.006). Across all classes, self-reported confidence about swimming that same distance at sea was significantly greater among males (median = 4, "Confident") than females (median = 3, "Unsure") (p = 0.004)."

EC5: Fig. 4 to 6: It is unclear to me why the format and styling of your stacked bar charts changes between Fig 4, 5 and 6. Fig. 4 shows % respondents by gender on the y-axis, in Fig. 5 it is number of respondents, and in Fig. 6 it is normalized percentages of respondents. In addition, the styling of Fig. 6 is different from the other two. However, as far as I can tell, there is no difference in how the three different graphs are interpreted. Hence, I recommend a consistent format and presentation of these charts.

We have made Figs 4 – 6 consistent in style, including the y axis scale (percentage), and the colour of bars.

Anonymous Referee (AR) 1:

This study builds on previous work examining whether beachgoers are able to identify a rip current, and includes a new twist of asking beachgoers if they can spot a rip that is either in front of them or adjacent to them. The authors conclude that photographs are not necessarily a useful means for teaching beachgoers about rip currents and how to identify them in situ. While I believe that this is an important contribution to a growing body of literature on rip safety, I have some questions and concerns that need to be addressed before final publication:

AR1: Is this phrase correct in the abstract: "only 34% were unable to translate this into a successful in situ rip identification,. . ..". If I understand this correctly, “unable" should be “able".

Thank you - we corrected this by changing “unable” to “able”.

AR2: The photographs used in the survey are from above and at an angle to the beach. This is very different from the photographs used in previous studies that were near perpendicular to the beach as if the beachgoer was standing along the back shore. How much of the lower accuracy in this study is associated with the orientation and perspective of the photograph versus ability to spot a rip? This builds on the perspective idea of Brannstrom et al. (2013) who noted that the NOAA rip current sign was designed with a perspective different from a beachgoer. This is noted in the discussion, but should be discussed further.

We corrected this by adding photograph results in Section 3.4 (Ln 218):

“In this study, 31% (n = 41) of respondents were able to identify a rip in both photographs in Figure 3, 26% (n = 34) could identify a rip in only one photograph, and 43% (n = 57) were unable to identify a rip in either photograph.”

Further, we have also expanded the discussion in Section 4.2 (Ln 299) as follows:

“This reinforces the findings of a study by Brannstrom et al. (2015) that showed a warning sign with a graphical representation of a rip current portrayed from an aerial view was useful in teaching people what to do if caught in a rip (swim parallel), but was not a useful means of helping people to identify a rip in situ. This goes someway to explain the disconnect outlined in this study between purely photograph based identifications (57% able to identify a rip in at least one image) and the translation of that ability into meaningful in situ identification at the beach, where only 22% of respondents could identify the rip.

[…..]

Ultimately, if photographs are to be used in further studies of rip identification, they should be site-specific and taken from a realistic beach perspective to ensure that beachgoers can situate themselves in place, rather than being asked to interpret a photograph taken from a viewpoint that bears no resemblance to the viewpoint afforded to them on the beach (Brannstrom et al., 2015; Ménard et al., 2018).”

AR3: Following from the above, the perspective of the photographs is different from those looking for the rip in situ, and each respondent would have had a different perspective of the rip based on their cross-shore and alongshore position. How would these differences affect the results? Can you provide some photographs of how the beach and surf would have appeared to the beachgoer taking the survey from the flagged area and from the area directly in front of the rip?

AR4: Again following from the above, what was the spatial distribution of surveys on the beach relative to the in situ rip? Was there a difference in the ability of the beach user to spot the rip and/or identify a rip in the photograph based on their position on the beach? Essentially, were those sitting at or close to the rip able to spot the rip compared to those at a distance?

This was beyond the scope our study so our investigation did not include collecting the information requested from these two related points. However, we acknowledge this is an important component of subsequent related studies involving rip identification. We have therefore included in Section 4.2 (Ln 310) the following recommendation:

"The next logical step is to understand how spatial distribution of people on the beach influences their ability to identify the in situ rip current. Future studies should aim to identify how factors such as distance, and orientation of viewpoint relative to the main channel direction impact upon beachgoers ability to identify the rip."

AR5: The survey was only administered during times when wave breaking made the rip current visible by the breaking wave pattern. It would have been interesting to continue the questioning through the period when the rip was not active, albeit with a modified question, to determine if the "wrong" answers were consistent. This raises additional questions:

AR6: Were the breaking wave patterns and intensity consistent throughout the question period? If not, was there a difference in the ability of beachgoers to identify the rip based on wave and tidal conditions, and also based on their relative position?

This comment was common from both reviewers (see comment WS3). The breaking wave heights over the study period (estimated from latest surf forecasts at the time) varied between 1.5 and 3 m (the average significant wave height at the site is 2.1m). Our analysis of lifeguard rescue data shows a disproportionate number of rip related rescues occurred when breaking wave heights were between 1.5 and 2.5 m. Therefore, the conditions during the study were representative of those which are of greatest concern to lifeguards in respect to rip current rescues. We unfortunately do not have the data to explicitly make comparisons based on wave/tide conditions related to individual responses. We have added this to Section 2.1 (Ln 104):

"The breaking wave heights over the study period (estimated from latest surf forecasts at the time) varied between 1.5 and 3 m. Our own analysis of lifeguard rescue data shows a disproportionate number of rip related rescues occurred when breaking wave heights were between 1.5 and 2.5 m. Therefore, the conditions during the study were representative of those which are of greatest concern to lifeguards in respect to rip current rescues."

AR7: Was the accuracy of the in situ questions worse at the start and end of the active rip period compared to at the peak? How did this vary by the distance of the respondent to the rip?

We unfortunately do not have the data to make these comparisons. In the limitations section 4.3 we discuss the dynamic nature of the surfzone, and how wave height and breaking conditions and tidal stage might influence the perspective. We have updated this section to incorporate the following recommendation for future work (Ln 347):

“Any future in situ study should plan to incorporate some form of wave/tide measurement and a coastal imaging camera in order to make comparisons between identification rates and wave/tide heights and breaking wave patterns.”

AR8: What was the distribution of answers on the photographs and how is an “X” on the photograph identified as correct or incorrect- I would assume the center of the X, but that should be described in more detail. Also- how large were the photographs shown to the beachgoer?

We corrected this by clarifying in Section 2.2 (Ln 143) that the center of the ‘x’ was taken, as follows:

“Participants were asked to draw an 'x' on the photograph to denote the location of the rip current. In assessing whether the answer was correct, the investigator would check that the centre of the x-mark corresponded to the darker area of the rip channel.”

The photographs were half an A4 portrait page wide, and the exact layout of the survey (and photograph sizes) can be seen in the supplementary material to the article. We unfortunately did not record the distribution of answers across the photographs, and are unable to retrieve this now as the University ethics approval required us to destroy returns after data had been summarised.

AR9: When a respondent was asked to identify the rip in situ, how were their answers determined to be correct or incorrect? For example, could they have been pointing in the right direction but for the wrong reason? Some anecdotal examples would be helpful in assessing the accuracy and validity of this question.

Verification was sought verbally in addition to a gesture. We have corrected this in the text in Section 2.2 (Ln 150) as follows:

“In addition to pointing, in order to verify their answer and ensure accurate recording, participants were asked to describe the area in which they believed the rip to be located. Some participants responded by describing visual surfzone clues (e.g. the gap in the breaking waves) and some with landmarks (e.g. in front of the lifeguard tower) or distances (e.g. approximately 100 metres down the beach).”

AR10: What was the sampling strategy for beachgoers and what was the rejection rate? How and where were beachgoers selected over the 7 days and over the period that the rip was active?

This comment was common from both reviewers (see comment WS4). We employed convenience sampling as a result of the relatively confined area within which we were operating and the requirement to maintain proximity to the rip channel in order to ensure it was visible to respondents. We have updated the methods section to reflect the convenience nature of sampling used. Refusal rate was not recorded, but our investigator qualitatively noted that more young males refused to participate, which is reflected in the gender bias. We have updated the text in Section 3 (Ln 160) as follows:

“Although refusals were not recorded, our investigator qualitatively noted that a higher proportion of young males refused to participate.”

We subsequently expand upon the implications of this in our limitations in Section 4.3 (Ln 337) as follows:

“Perhaps more significant in this study was the higher proportion of refusals to participate from young males. This is particularly pertinent as this demographic has been identified as at

risk in the global drowning literature (Woodward et al., 2013), and identified as a group more likely to over-estimate ability and under-estimate risk (Moran, 2011). Therefore, more work needs to be done to understand whether the previously reported under-estimation of risk is at all linked to an (in)ability to identify rip currents."

AR11: Were people told if their answers to the photograph question was correct or incorrect before being asked to identify the rip in situ? How would correcting their responses or not affect the ability of them to spot the rip? For example, if they were corrected about the location of the rip in the photograph, were they then using the photograph as an interpretive tool to find the rip in situ? If they were not corrected, it can't be argued that photographs are not useful since they were not used as an education device in the survey.

We did not let people know if their photograph indications were correct or not prior to them attempting an in situ identification as we wanted to be sure that their knowledge base was the same as they attempted both tasks. We have clarified this in Section 2.2 (Ln 146) as follows:

"Participants were not told whether or not their on paper rip identification was correct or not prior to attempting in situ identification such that their knowledge base was the same for both sets of identifications."

With reference to education we were hoping to highlight that rip identification on paper does not equal an ability to do so in the real life, and therefore there remains a question over the utility of photos in education. We have replaced the following sentence in Section 4.2 (Ln 313):

"Finally, our findings also suggest that the use of still images may not be an effective method to use in public rip current education campaigns."

with

"Finally, our findings suggest that more work is required to investigate whether photographs are actually a useful medium for rip current education campaigns, given the disconnect between successful identifications in photographs and real life."

We have retained the following sentence in the conclusion (Ln 369):

"These results have major implications for the future use of photographs to assess beachgoers' ability to identify rip currents and for future rip current education strategies involving rip current identification."

as this does not imply that we tested this, purely that this study has implications for the use of photographs in education.

AR12: There is insufficient evidence to suggest a video or immersive experience is better for educating beachgoers since it was not directly tested. This statement should be qualified as needing further testing and not as a direct outcome of this study. Essentially, I don't think there is enough evidence to "advocate" at this time.

Thank you, instead we have highlighted other studies that focussed on education and advocated for videos to be used in place of images, in Section 4.3 (Ln 352) as follows:

"Indeed, other studies have advocated for the use of video (Hatfield et al., 2012; Wilks et al., 2017) as a more appropriate means of visualising a rip current, and this would perhaps also allow for a more controlled measure of rip identification ability."

We have amended the sentence in our conclusion (Ln 372) to highlight this as an area for research:

"Future work should consider whether employing immersive 3D/virtual reality technologies and videos of actual rip current footage to present people with a dynamic surf zone would be a better means of educating people to identify rip currents."

AR13: In addition to videos and immersive experiences, the authors should also consider whether there is a limit to education on spotting rips and whether other management strategies are more appropriate and impactful.

We acknowledge the current debate concerning the focus of rip current drowning prevention approaches, namely either preventative (teaching identification), or reactive (teaching escape strategies for those caught in a rip). We do not feel that we have yet exhausted education approaches, especially given the lack of investigation concerning video images. Much of the work on response to being caught highlights that people either tend to forget appropriate actions (Drozdzewski et al., 2012; 2015) or that there is significant variability in the success of various escape methods (McCarroll et al. 2014; van Leeuwen et al., 2016). This current lack of universally applicable escape strategies and the pre-disposition of those caught in a rip to panic and forget information highlights the importance of continued work in the education space, whilst other management strategies are developed and evaluated. As such we feel confident in the recommendation that this is presently an area requiring further work, albeit alongside other strategies which we already acknowledge in the introduction.

AR14: I think that more could be made about the results of Figure 5, which points to the disconnect between knowledge and behaviour. I am particularly surprised by the inability of those who "would not" swim beyond the flags to identify a rip. This is interesting and suggests a self-selection of beachgoers with limited knowledge to swim in the patrolled area, or was it just coincidence? If there was a difference in the number of people and respondents within the flagged area versus outside the flagged area, a Chi-square test would be useful to determine if the larger number is an indication of over- or underrepresentation by question.

In response to this suggestion we ran a chi square test grouping all those who would swim outside the flags and comparing it against those who would not, but it did not come back as significant ($X2 = 2.36$, $p = .125$). We have updated the text in Section 3.3 (Ln 211) to reflect that this test was done:

"here was no statistically significant difference in rip spotting ability between those who chose to swim outside the flags and those who would not, although it does appear that many of those with lower knowledge may choose to remain between the flags."

AR15: In short, I think this is an interesting and important contribution, but there are a number of questions and concerns that need to be addressed in the manuscript. By number the concerns may appear major, but they should be easily discussed or qualified in the manuscript.

Thank you for the constructive review and comments – we are pleased the manuscript has been recognised for the importance of the overall contribution, and are grateful for the improved the clarity as a result of this review.

Wayne Stephenson (WS) Comments [Referee 2]:

Overall this is a very useful study of beach hazard understanding by users. It highlights, rather worryingly, how poor people are at identifying rips on beaches, 78% is truly a worry. Also, the disjunct between ability to see rips in photographs used for education and what people see when they go to the beach is cause for concern. There are clearly important implications for beach safety, education and hazard mitigation that come from this work. I have relatively little to suggest in the way of improvements, other than these minor points:

WS1: Line 9 (abstract) unable – should be able.

Thank you - we corrected this by changing "unable" to "able".

WS1: Title of section 2.2 – I found "Beach Survey design" a little confusing, since you are not surveying the beach (in the cross shore profile sense), but beach user survey might be more accurate.

We have corrected this section heading as suggested to "beach user survey".

WS2: I think a little more comment on the timing of the beach user survey would be useful, and which days of the week, was this Monday to Sunday – or Tuesday to Monday, Wednesday to Tuesday? Also what week in January was the survey undertaken? Given New Year and summer holidays in New Zealand, the cohort of people visiting the beach might different in the first week of January compared to those in the last week. I can imagine less experienced beach users being at the beach in early January, compared to late January. A comment on the representation of your surveyed users and how this might be different if you surveyed users in late February for example is worth considering. The frequency of beach visit data might look quite different in the later case.

The study was conducted Tues-Monday in mid-January and based on our analysis of beach user numbers this was a representative period. Beach numbers are lower in early January, which we surmise is indicative of more local use, rising to a peak in the first two weeks of February indicative of visitors from further afield. In early January and over holiday periods beach visitation is more evenly spread throughout each day of the week, whereas away from these periods there are significant weekend spikes. Over the study period (mid-January), weekend spikes are prominent and therefore it was important to capture that period in the survey. We feel that given the beach user numbers for this period are representative of the average over the wider season we can infer the user demographic is representative, and have clarified the timing of the survey in the text in Section 2.2 (Ln 111) as follows:

"…conducted over a 7-day period between Tuesday 15th and Monday 21st January 2019 (Austral Summer). Beach visitor numbers in mid-January are representative of the wider season typically averaging around 100 people at any given time during the week and 800 during the weekend. Visitation numbers steadily increase towards the second week of February, peaking at around 2500 at any given point over the weekend."

WS3: Given that the survey was run over 7 days – what were the wave and rip conditions? Did they change significantly over this period? Might it have been easier on some days to see a rip compared to others? You say the rip was prominent – but that is to an expert eye. Did changing wave conditions make the rip more or less prominent for participants?

This comment was common from both reviewers (see comment AR5 and AR6). The breaking wave heights over the study period (estimated from latest surf forecasts at the time) varied between 1.5 and 3 m (the average significant wave height at the site is 2.1m). Our analysis of lifeguard rescue data shows a disproportionate number of rip related rescues occurred when breaking wave heights were between 1.5 and 2.5 m. Therefore, the conditions during the study were representative of those which are of greatest concern to lifeguards in respect to rip current rescues. We unfortunately do not have the data to explicitly make comparisons based on wave/tide conditions related to individual responses. We have added this to Section 2.1 (Ln 104):

"The breaking wave heights over the study period (estimated from latest surf forecasts at the time) varied between 1.5 and 3 m. Our own analysis of lifeguard rescue data shows a disproportionate number of rip related rescues occurred when breaking wave heights were between 1.5 and 2.5 m. Therefore, the conditions during the study were representative of those which are of greatest concern to lifeguards in respect to rip current rescues."

We acknowledge that the variability in rip prominence is not something we have been able to quantify. In the limitations section 4.3 (Ln 342) of the study we address this explicitly as follows:

"The surf zone is inherently dynamic due to factors such as tidal stage, individual wave sets, or changes in wind strength/direction which all influence the degree to which the rip current was visible. As the surveys were conducted at different times across 7 different days, the appearance of the channel rip current may have changed, despite remaining in a persistent location during the study period. Therefore, it is possible that each respondent formulated their answer from slightly different viewpoints combined with different conditions. One potential solution to this problem is to make use of the increasing availability of 3D headsets and virtual reality, whereby each respondent could still interact with a 'live' and dynamic surf zone, but the experiment could be better controlled such that each participant was given the exact same stimulus from which to formulate a response. Nevertheless, this study replicates the real-world conditions that people face when making decisions on the beach, and demonstrate that the selection of a safe place to swim without prolonged observation could equally result in the inadvertent selection of the rip current."

WS4: Given the sampling method, approaching people on the beach – this is not a true random sample, so I think some caution with regard to the statistical testing worth noting. Can you also report the number of refusals to participate? This helps to understand the randomness (or lack of) and size of sample. Chi square and T-tests are used are used without reporting how it was decided to use parametric or nonparametric tests. I'd like to see better explanation and justification for the choice of tests.

This comment was common from both reviewers (see comment AR10). It is true that this is not a random sample representative of the entire population. We have reflected this in the title of the manuscript by referring to 'Beachgoers' ability to identify a rip current – acknowledging that this is a subset of the population. Within this subset, the main skew is towards females. Whilst refusals were not recorded, our investigator qualitatively noted that males were more likely to refuse to participate, and we have added this into our results (Section 3, Ln 159) as follows:

"The sample population is gender-imbalanced, with 65% of respondents being female. Although refusals were not recorded, our investigator qualitatively noted that a higher proportion of young males refused to participate."

We have also updated the limitations section 4.3 (Ln 337) to reflect this, as follows:

“Perhaps more significant in this study was the higher proportion of refusals to participate from young males. This is particularly pertinent as this demographic has been identified as at risk in the global drowning literature (Woodward et al., 2013), and identified as a group more likely to over-estimate ability and under-estimate risk (Moran, 2011). Therefore, more work needs to be done to understand whether the previously reported under-estimation of risk is at all linked to an (in)ability to identify rip currents.”

With regard to statistical tests we have opted to replace the t-tests with non-parametric Mann-Whitney U tests, given that they do not require assumptions about the population characteristics in the same way that parametric tests do. We have updated the results to reflect this, with the only difference being that there is no longer a statistically significant difference in rip spotting ability based on self-reported qualitative swimming ability. There remains statistical significance between rip spotting ability and quantitative swimming competence in the form of maximum pool swimming distance.

WS5: Replace photo with photograph throughout the manuscript. Replace didn’t with did not. “spot” is often used with regard to participants ability to identify rip currents. I consider that rather informal, I suggest spot be changed to identify.

We have implemented all of these corrections.

WS6: Line 227 “This compares with..” How does it compare? Compares well? Compares poorly?

We have corrected this to reflect that it is a “good comparison” to other studies.

Beachgoers’ ability to identify rip currents at a beach in situ

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Abstract. Rip currents (“rips”) are the leading cause of drowning on surf beaches worldwide. A major contributing factor is that many beachgoers are unable to identify rip currents. Previous research has attempted to quantify beachgoers’ rip ~~spotting~~ identification ability using photographs of rip currents, without identifying whether this usefully translates into an ability to ~~spot~~ identify a rip current in situ at the beach. This study is the first to compare beachgoers ability to ~~spot~~ identify rip currents in photographs and in situ at a beach in New Zealand (Muriwai Beach) where a channel rip current was present. Only 22% of respondents were able to identify the in situ rip current. The highest rates of success were for males (33%), New Zealand residents (25%), and local beach users (29%). Of all respondents who were successful at identifying the rip current in situ, 62% were active surfers/bodyboarders and 28% were active beach swimmers. Of the respondents who were able to identify a rip current in two photographs, only 34% were ~~unable~~ able to translate this into a successful in situ rip identification, which suggests that the ability to identify rip currents by beachgoers is worse than reported by previous studies involving photographs. This study highlights the difficulty of successfully identifying a rip current in reality and that photographs are not necessarily a useful means of teaching individuals to ~~spot~~ identify rip currents. It advocates for the use of more immersive and realistic education strategies, such as the use of virtual reality headsets showing moving imagery (videos) of rip currents in order to improve rip ~~spotting~~ identification ability.

1 Introduction

Rip currents (colloquially known as “rips”) are fast, narrow, seaward-directed flows of water that commonly exist on sandy beaches. Many different types of rip currents exist (Castelle et al., 2016), but one of the most common and best understood types are channel rips. Channel rips occupy morphologic depressions (channels) between adjacent sand bars and are generated by alongshore variability in wave breaking (Castelle et al., 2016), which provides a distinct visual signature (Figure 1). Rips originate near the shoreline and generally flow offshore, with typical mean flow velocities of 0.5 – 0.8 ms-1 and instantaneous velocities occasionally reaching 2 ms-1 (MacMahan et al., 2006). It is therefore not surprising that rip currents are regarded as the primary surf zone hazard for bathers and swimmers on beaches where they exist (Brander and Scott, 2016). The lack of

Figure 1. Channel rips typically present as darker corridors of water between the whiter patches of breaking waves, as shown here at Perranporth Beach, UK. The rips occur in deeper channels which reduces or prevents wave breaking, hence the darker visual signature. The rip channels often look like the calmest or safest place to swim to inexperienced observers. [Image credit: SP].

national reporting structures for drownings mean that the true extent of global rip related drowning is unknown (Brander and MacMahan, 2011), but some notable studies estimate in excess of 100 drownings per year in the United States (Brewster et al., 2019), and around 21 per year in Australia (SLSA, 2019b).

The degree of physical hazard that rip currents represent is controlled largely by the temporal and spatial variability in their occurrence, flow velocity and flow circulation patterns (Scott et al., 2014; Pitman et al., 2016; Gallop et al., 2018). However, the risk or likelihood of a rip current-related drowning or rescue occurring also depends on multiple social factors, such as the presence/absence of lifeguards, choice of swim location, the number of beachgoers and water users, water competency, beachgoer behaviour, and their knowledge of rip currents (Gilchrist and Branche, 2016; Ménard et al., 2018).

There are several initiatives and interventions employed around the world to mitigate the social aspects of rip current drowning risk. It is well established that lifeguards are the most effective method for drowning prevention on popular surf beaches (Gilchrist and Branche, 2016). However, the coverage of lifeguarding services varies spatially and temporally. Logistical and cost constraints, as well as seasonality of demand, mean it is not feasible for lifeguards to be present on all beaches and at all times. For example, in New Zealand there are 74 Surf Life Saving Clubs spread around 15,000 km of coastline, and their patrol season typically only runs from October to April surrounding the Austral summer. Furthermore, the lifeguard beach flag systems used globally are inconsistent, varying from the traffic light system approach of the United States to the ‘swim between the red and yellow flag’ system adopted by Australia, New Zealand, the UK and some other countries. Beach safety signage is another commonly adopted mitigation method used to educate people about the rip current hazard, but the type and messaging involved varies globally. There is also evidence that signage at entry points to beaches goes unnoticed by a large proportion of beach users (Matthews et al., 2014), and that signage is often ineffective in communicating key messages to beachgoers (Brannstrom et al., 2015).

More recently, a number of dedicated national education campaigns have focussed specifically on rip current hazard interventions. For example, the United States ‘Break the Grip of the Rip!’ campaign (www.ripcurrents.noaa.gov), which began in

2005 focussed on a wide range of factors, such as how rip currents operate, why they are dangerous, how to ~~spot~~ identify them, and how to escape them (Carey and Rogers, 2005), and this campaign has been shown to be somewhat effective (Houser et al., 2017). In Australia, several campaigns since 2009 have focussed on how to escape rip currents, how to ~~spot~~ identify them and more recently the 'Think Line' campaign has been adopted (www.beachsafe.org.au/surf-safety/ripcurrents), where beachgoers are urged to stop, observe, and think about what the hazards are when they got to a beach. Similarly, the UK has the 'Respect the Water' campaign (www.respectthewater.com/), which focuses more broadly on raising awareness of the wider dangers associated with coastal or ocean recreation. New Zealand has also recently released the 3Rs ('Relax, Raise, Ride') rip current campaign (www.findabeach.co.nz/besafe/hazards/rips/), aimed at reminding people to remain calm and conserve energy in order to remain afloat, whilst signalling for help, going with the current, and weighing up your options to get back to shore.

One of the key themes in many existing rip current safety campaigns has been attempting to teach people to identify a rip current. However, several studies have shown that even when people are aware of what rip currents are and why they are dangerous, they are largely unable to visually identify a rip current in a ~~photo~~photograph. Caldwell et al. (2013) reports successful identification of channel rips to be lower than 20%, with success rates of up to 40% reported by Willcox-Pidgeon et al. (2017), and a 48% success rate in selecting a safe place to swim reported by Sherker et al. (2010). A similar study by Surf Life Saving Australia (SLSA, 2019a) surveyed ocean swimmers who self-assessed as highly competent, and reported that only 27% were able to accurately identify rip currents in multiple photographs. Evidence suggests a similar trend in other rip current types, with a study by Brannstrom et al. (2014) reporting 31% success when beachgoers were asked to identify a boundary-controlled rip current running along the edge of a groyne.

Rip ~~spotting~~ identification is complicated by the fact that different rip current types or forcing conditions can create different visual signatures. For example, channel rips that form in deeper channels between sand bars (Castelle et al., 2016) generally present optically as an area of darker and calmer water due to a relative lack of wave breaking when compared to the shallow sandbars either side (Figure 1). Conversely, flash rips (Castelle et al., 2016) are not channelized, but instead generated by transient surf zone eddies resulting from vortical motions associated with short-crested breaking waves, are typically characterised by sediment-laden plumes of water extending offshore and a turbulent water surface. The wave-current interaction between incoming waves and the offshore rip current flow can also present visually as a rippled and bumpy water surface (Ménard et al., 2018).

The calm, smooth visual signature associated with channel rips is particularly important in terms of educating people about how to identify the hazard as inexperienced or uninformed beach users will often pick this calmer patch of water as the safest place to swim (Gallop et al., 2016) to avoid the breaking waves either side of the rip, which are perceived as being more dangerous (Caldwell et al., 2013). Rip current visual signatures also vary as morphology, tidal stage, or wave energy changes (Pitman et al., 2016), meaning an observer might have to rely on different visual signatures for the same rip channel at different times during the day.

The ability to ~~spot~~identify, and therefore avoid, a rip current is a critical skill for a beachgoer when making decisions about where and when to enter the water, particularly in the absence of lifeguards (Ménard et al., 2018). As demonstrated above, previous studies have shown that existing rip current identification abilities of beachgoers is poor. However, in these studies, rip current identification by beachgoers has either been based on participants self-reporting on how confident they would feel at being asked to identify a rip current (Morgan et al., 2009a), or by asking people to directly identify rip currents in photographs taken from various perspectives (Moran, 2008; Caldwell et al., 2013; Brannstrom et al., 2015; Clifford et al., 2018), or to identify the safest place to swim in a photograph of a beach (Sherker et al., 2010; Gallop et al., 2016; Houser et al., 2017; Willcox-Pidgeon et al., 2017; Clifford et al., 2018; Fallon et al., 2018). However, Ménard et al. (2018) noted that a fundamental problem is the lack of research investigating whether an individual's ability to identify a rip, or a safe swimming area in a photograph, translates to an equal ability to spot identify a rip current in situ at the beach. Therefore, the aims of this study are to use a survey instrument to investigate: (1) how an individual's demographic (e.g. gender, age, ethnicity) and beach competence (e.g. swimming ability and degree to which they are familiar with the surf zone) relates to their ability to identify a rip current in situ at a high energy beach; and (2) whether the ability to spot identify a rip in a photograph translates to an equal ability to locate a rip in situ at a beach.

2 Study site and methods

2.1 Study site

The study site was Muriwai Beach (Figure 2), a high-energy, dissipative, mesotidal beach on the exposed West Coast of New Zealand's North Island. An analysis of wave hindcast data shows average significant wave height at Muriwai to be 2.1 m, with mean wave period of 10 seconds. Waves during the summer months are typically calmer than in winter, but are interspersed with very high energy events associated with ex-tropical cyclone activity in the Tasman Sea. The surf zone typically exists in a double barred state, with a dissipative outer bar and intermediate inner bar (Brander and Short, 2000). This site was selected for this study as it is a high-risk site for rip current rescues according to Surf Life Saving New Zealand (SLSNZ), with 530 such events recorded in the period 2007 – 2018, representing 80% of beach lifeguard rescues at this site. Muriwai Beach is less than an hour's drive from New Zealand's largest city, Auckland (Figure 2a), making it a popular destination for both domestic visitors and foreign tourists. Analysis of lifeguard headcount data show that visitor numbers at Muriwai Beach typically exceed 80,000 per month in the peak summer period. During the study period, lifeguards patrolled a safe bathing area indicated by a pair of red and yellow flags, located between a headland at the southern end of the beach, and a prominent channel rip to the north of the bathing area, in front of the lifeguard tower (Figure 2b). This rip channel was static throughout the 7 day study period. The breaking wave heights over the study period (estimated from latest surf forecasts at the time) varied between 1.5 and 3 m. Our own analysis of lifeguard rescue data shows a disproportionate number of rip related rescues occurred when breaking wave heights were between 1.5 and 2.5 m. Therefore, the conditions during the study were representative of those which are of greatest concern to lifeguards in respect to rip current rescues.

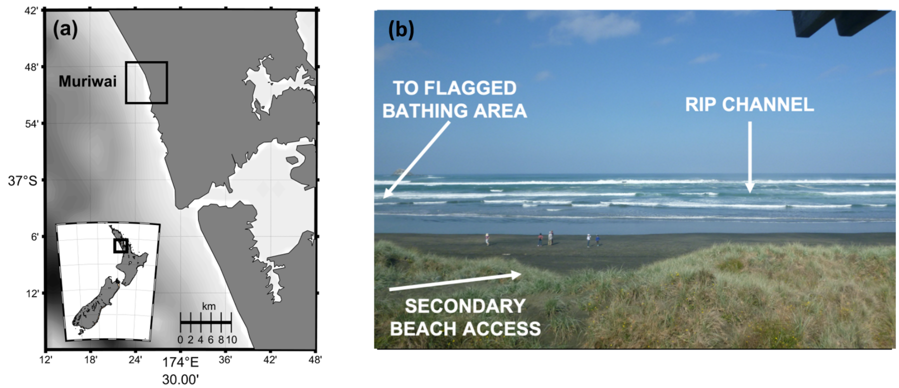

Figure 2. (a) Study site map and (b) ~~photo~~ photograph of main channel rip next to bathing area, used to test rip identification ability. ~~Photo~~ Photograph is taken by the lifeguard tower, next to a secondary access track linking the car park to the beach.

2.2 Beach user survey~~design~~

The research relied on a survey instrument completed by a convenience sample of various beach users who were either on the beach directly onshore from the channel rip evident in Figure 2b, or in the flagged bathing area adjacent to it. The survey was approved by the University of Canterbury human ethics committee (2018/97/LR), and conducted over a 7-day period ~~in~~ between Tuesday 15th and Monday 21st January 2019 (Austral Summer)~~incorporating both weekdays and~~ . Beach visitor numbers in mid-January are representative of the wider season typically averaging around 100 people at any given time during the week and 800 during the weekend. ~~Potential participants~~ Visitation numbers steadily increase towards the second week of February, peaking at around 2500 at any given point over the weekend. Potential participants for this study were approached by the investigator if they were settled on the beach (i.e., not if they had just got there, or were just leaving), and if they appeared to have no supervisory duties such as watching young children in the water. The survey took less than 10 minutes to complete, with participants self-completing their answers on a paper form (see supplementary material). Additionally, one follow up question was presented verbally by the investigator, where the participants were asked whether they could see any rip currents at this site, and if so, to point towards and describe the location. The survey consisted of 34 questions, grouped broadly into basic demographic questions (gender, age, ethnicity, and a question to identify whether the individuals were locals, wider New Zealand residents, or international visitors), as well as questions to ascertain how the participants spend their time at the beach, their swimming ability, and their understanding of rip current hazards. Answers fields in the survey made use of a combination of: (1) categorical tick boxes for questions about demographics, swimming ability or type of activity undertaken; (2) five-point Likert scales for questions addressing self-reported confidence in dealing with hazards; and (3) open text fields to understand the depth and breadth of knowledge of participants with respect to different hazards. A selection of example questions is outlined in Table 1 and the full questionnaire is included as supplementary material.

Table 1. Question groups and example questions used in the survey of beach users

Group	Focus of questions	Example question
1	Demographics	Do you live in New Zealand?
		How old are you?
2	Recreational use of the beach	Is this your local beach?
		How often do you visit beaches in the Summer?
		When you visit the beach which activities do you undertake?
3	Water competence	Can you swim?
		How far could you swim in a pool without stopping?
		When did you last swim this distance?
		How do you feel about swimming that same distance in the sea?
4	Beach hazards	What do the red/yellow flags mean on a New Zealand beach?
		When would you swim outside the patrolled area?
		Could you ~~spot~~ identify a rip current?
		If asked to identify a rip current, what would you look for?
5	Rip identification	Put a mark anywhere you think you can see a rip current in the images below
6	Education	Have you had the opportunity to learn about rip currents before?
		If yes, how did you learn about rip currents?

This survey used Protection Motivation Theory (PMT; Rogers, 1975) to investigate rip current hazard perception, in line with previous water-based studies of competency (McCool et al., 2008, 2009; Moran et al., 2011, 2018; Moran and Willcox, 2013; Willcox-Pidgeon et al., 2018). The use of PMT allowed us to quantify and compare the self-reported perceptions of water competence (including swimming and floating competency), versus the perceptions of risk in the surf zone. Water competence (as opposed to swimming ability) refers to a broad set of skills important in drowning prevention, with a full review of water competencies provided by Stallman et al. (2017). Participants were first asked if they could swim (yes/no), and if they answered yes, were then asked to rate their ability on a four-point scale from poor to very good. This was then quantified using questions asking how far they could swim in a pool, how confident they felt swimming that same distance at the beach, and when they last swam that distance. This was followed with basic competence questions identifying their perceived ability to float and/or swim effectively on both their front and back, and their ability to tread water for two minutes.

Respondents were then asked open questions about how they select safe areas to swim at the beach, when and why they might choose to swim outside of the flagged bathing area, what hazards may occur at the beach, and which hazards they have personally experienced (Table 1). They were then specifically asked about rip currents, such as what makes a rip current dangerous, how confident they feel about escaping a rip current, whether they have any experience of being caught in a rip, and the actions they would take to escape. Finally, we quantified their ability to ~~spot~~ identify rip currents using two photographs

Figure 3. Images from (a) Bronte Beach and (b) Coalcliff Beach in New South Wales, Australia were used for checking participants' ability to identify rip currents. These were chosen as they contained rip channels that presented visually as darker areas between breaking waves, which is similar to the rip current present at the study site during the surveys. Participants were asked to mark with an 'x' any area they thought there was a rip; an example identification is shown above. ~~Photo~~ Photograph credits: (a) Walkingmaps.com.au; (b) Rob Brander.

(shown in Figure 3), a method modified from that of Caldwell et al. (2013). Participants were asked to draw an 'x' on the photograph to denote the location of the rip current. In assessing whether the answer was correct, the investigator would check that the centre of the x-mark corresponded to the darker area of the rip channel. Participants were then asked to identify a rip current on the beach in front of them. Participants were not told whether or not their on paper rip identification was correct or not prior to attempting in situ identification such that their knowledge base was the same for both sets of identifications. The presence of an active in situ rip current was decided by consultation between a senior lifeguard, and the investigator who is experienced in surf zone dynamics, and provided both agreed that a channel rip was present and visible at the time of the survey, the question was asked of the participant. In addition to pointing, in order to verify their answer and ensure accurate recording, participants were asked to describe the area in which they believed the rip to be located. Some participants responded by describing visual surfzone clues (e.g. the gap in the breaking waves) and some with landmarks (e.g. in front of the lifeguard tower) or distances (e.g. approximately 100 metres down the beach). Examples of times when the question was not asked include mid- to high-tide, where there was insufficient wave breaking on the inner bar to establish rip current circulation, or if the participant refused. If the participant was unsure how to identify the rip, or incorrectly identified an area where no rip was present, the response was marked as incorrect.

3 Results

There were 132 surveys conducted whilst the rip current was active and displaying a visual signature that could be observed from the beach. Descriptive statistics for the sample are provided in Table 2. The sample population is gender-imbalanced, with 65% of respondents being female. Although refusals were not recorded, our investigator qualitatively noted that a higher proportion of young males refused to participate. Fifty four percent of the sample were New Zealand European, 17% were European, and 8% were Māori or Pacific Islander. Three percent of respondents were Chinese, 3% were Indian, and the remaining 15% were a combination of 'Other' nationalities. Eighty one percent of respondents were living in New Zealand, with 18% representing holidaymakers or short-term visitors, and 31% of respondents classified the survey site as their local beach. Seventy four percent of respondents indicated that they go to the beach at least once a week, with 13% indicating they usually visit every day. Respondent age was recorded in discrete groups, with the modal group being 20 – 29 years (30%). Twenty two percent were aged between 10 and 19 years, 18% were 30 – 39 years, and 11% were 40 – 49 years. Seventy five percent of the sample indicated that they could swim in excess of 50 m in a pool.

3.1 Demographic trends in rip ~~spotting~~ identification ability

Seventy eight percent of respondents (n = 103 of 132) were unable to ~~spot~~ identify the in-situ rip current. Table 3 shows how reported demographics influence the ability to ~~spot~~ identify the in situ rip. A significantly higher proportion of males (33%, n = 15 of 46) than females (16%, n = 14 of 86) were able to ~~spot~~ identify the rip ($\chi 2 = 4.66$, p = 0.03). New Zealand Europeans had the highest successful rip identification rate (31%, n = 22 of 72). Chinese and Indian respondents both had a 25% success rate, but the sample size for each ethnicity was only 4. Māori and Pacific Islanders had a 20% (n = 2 of 10) success rate. Success rate was higher in New Zealand residents (25%, n = 27 of 107) than visitors (8%, n = 2 of 24). No specific trends were evident with regard to respondent's age and ability to identify the rip current. Most drowning literature identifies those under 30 as most likely to be involved in a rip current rescue. When grouped here, those 29 and under had a success rate of 21% (n = 15 of 71), and those 30 and over had a success rate of 25% (n = 14 of 56), again showing no significant difference.

3.2 Self-reported swimming competence

Respondents were asked to self-rate their swimming competency through a series of questions (Table 4), with each response assigned a numerical value between 1 and 5, representing increasing competence. When asked to rate on a qualitative spectrum ('Poor', 'Fair', 'Good', 'Very Good'), ~~most respondents replied positively~~ 70% of respondents (n = 90 of 129) replied either 'Good' or 'Very Good' and there was ~~little~~ no significant difference between genders~~with 68% of females and 69% of males indicating their swimming competence to be either good or very good. PMT requires this assertion to be qualified, and so they~~ . No significant difference was evident when ability to identify an in situ rip was analysed against self-reported estimates of swimming competence (Figure 4a). In order to qualify self reported competence, respondents were subsequently asked to ~~translate this into their pool swimming competence~~estimate their maximum pool swimming distance. In response, 47% of females reported being able to swim in excess of 100 m, compared to 61% of males. ~~When subsequently asked how confident they would feel about swimming that same distance in the sea, only 32% of females responded positively (confident, or very confident) , compared to 54% of males. No statistical difference was evident in self-reported estimates of swimming competence and confidence by gender. There was a significant difference between female ($\bar{x}$~~ A Mann-Whitney U-test indicated maximum pool swim distance was significantly higher (median = ~~3.06; σ~~ 5, "200+ metres") among those that could identify a rip current compared to those that could not (median = ~~1.11) and male ($\bar{x}$~~ 3, "51 - 100 m") (p = ~~3.67; σ = 0.86)responses to the question about swimming the~~ 0.006). Across all classes, self-reported confidence about swimming that same distance at sea ~~(p~~

Table 2. Sample characteristics in terms of demographics, frequency of beach visits, and self-rated pool swimming ~~ability~~ competency (*n* = 132).

Question	Response	n	%
Gender	Female	86	65
	Male	46	35
Ethnicity	New Zealand European	71	54
	European	25	19
	Other	18	14
	Maori or Pacific Islander	10	8
	Chinese	4	3
	Indian	4	3
Do you live in New Zealand?	No	24	18
	Yes	107	81
Age	0 - 10 yrs	2	2
	10 - 19 yrs	29	22
	20 - 29 yrs	40	30
	30 - 39 yrs	24	18
	40 - 49 yrs	15	11
	50 - 59 yrs	10	8
	60 - 69 yrs	5	4
	>70 yrs	2	2
Frequency of beach visit	Daily	17	13
	2 - 3 times per week	42	32
	Once per week	39	30
	Once per month	13	10
	Infrequently	20	15
Pool swimming ability	<25 m	9	7
	25 - 50	22	17
	51 - 100	30	23
	101 - 200	22	17
	200 +	47	36

was significantly greater among males (median = ~~0.001), with males reporting a value 0.61 higher than females , 95% CI 0.26 – 0.96~~4, "Confident") than females (median = 3, "Unsure") (p = 0.004).

Table 3. Respondents ability to ~~spot~~ identify an in situ rip based on their demographic (n = 132).

Question	Response	Unable to identify rip		Able to identify rip	
		n	%	n	%
Gender	Female	72	83.7	14	16.3
	Male	31	67.4	15	32.6
Ethnicity	New Zealand European	49	69.0	22	31.0
	European	24	96.0	1	4.0
	Other	16	88.9	2	11.1
	Maori or Pacific Islander	8	80.0	2	20.0
	Chinese	3	75.0	1	25.0
	Indian	3	75.0	1	25.0
Do you live in New Zealand?	No	22	91.7	2	8.3
	Yes	80	74.8	27	25.2
Age	0 - 10 yrs	2	100.0	0	0.0
	10 - 19 yrs	21	72.4	8	27.6
	20 - 29 yrs	33	82.5	7	17.5
	30 - 39 yrs	20	83.3	4	16.7
	40 - 49 yrs	10	66.7	5	33.3
	50 - 59 yrs	8	80.0	2	20.0
	60 - 69 yrs	3	60.0	2	40.0
	>70 yrs	1	50.0	1	50.0

~~Significant differences were evident when ability to identify an in situ rip were analysed against self-reported estimates of swimming competence (Figure 4a) and maximum pool swim distance (Figure 4b). A two sample t-test showed that the ability to identify an in situ rip current was higher among those that reported higher competence. The mean values were 0.34 (95% CI 0.02 – 0.67, p = 0.04) and 0.76 (95% CI 0.23 – 1.28, p = 0.006) higher in the self-estimated swimming competence and max pool swim distance categories respectively, for participants that successfully identified the rip current.~~

3.3 Familiarity, behaviour and experience

The questionnaire was able to ascertain how familiar people were with the study site, and what degree of interaction they had with the water. Of the 29 people able to ~~spot~~ identify the in situ rip current, 27 (93%) lived in New Zealand. Twenty two (92%) of the 24 people who lived overseas were unable to ~~spot~~ identify the rip. Twelve (41%) of the 29 people able to ~~spot~~ identify the rip classed Muriwai as their local beach, which equated to a 29% success rate among locals (n = 12 of 41).

Table 4. Self-reported swimming competency, broken down by the percentage of male and female respondents. The value in brackets was an assigned numerical value to aid statistical analysis of responses.

Question	Response (Value)	% Female respondents	% Male respondents
Rate your swimming competency	Poor (1)	2	4
	Fair (2)	28	24
	Good (3)	47	41
	Very good (4)	21	28
How far could you swim in a pool?	<25 m (1)	8	4
	25 – 50 m (2)	19	13
	51 – 100 m (3)	23	22
	101 – 200 m (4)	17	15
	200 m + (5)	30	46
How do you feel about swimming that same distance in the sea?	Very anxious (1)	8	-
	Anxious (2)	21	7
	Unsure (3)	34	37
	Confident (4)	22	37
	Very Confident (5)	10	17

NB. Totals may not equal 100% due to non responses.

Respondents were asked to state all activities they participate in at the beach, and these were ranked according to increasing interaction with the surf zone, from those that remain on the beach, those that enter the water, but remain in water shallow enough that they can stand, those that swim beyond their depth, to those that surf or body board (Figure 5a). Of the 29 respondents able to ~~spot~~ identify the rip current, the largest proportion (62%, n = 18 of 29) were in the surfing and body boarding group, followed by swimmers (28%, n = 8 of 29), and those that remain within their depth in the water (10%, n = 3 of 29). Of the 5 respondents who reported never entering the water at the beach, none were able to ~~spot~~ identify the rip current, although 4 out of the 5 did rate themselves as fair or good swimmers, so their decision to not enter the water did not appear to be a reflection of their perceived low swimming competence. In the swimming group, 85% (n = 46 of 54) of respondents were unable to identify the rip, as were 67% (n = 37 of 55) of the surfers and body boarders.

When questioned on whether they would swim outside of the flagged bathing area, 35% (n = 36 of 102) of respondents indicated that they would at times swim outside of the patrolled area at the beach. Of these respondents, 72% (n = 26 of 36) were also unable to ~~spot~~ identify the rip current (Figure 5b). The reasons given for swimming outside the patrolled area were that the flags were too crowded (61%, n = 22 of 36), they felt able to choose a safe place to swim (31%, n = 11 of 36), or they ~~didn't~~ did not have a specific reason and would do so at any time (8%, n = 3 of 36). The most competent subgroup in terms of rip ~~spotting~~ identification ability were those that felt they could identify a safe place to swim, in which 6 of the 11 (55%) were able to identify the rip. There was no statistically significant difference in rip spotting ability between those who chose

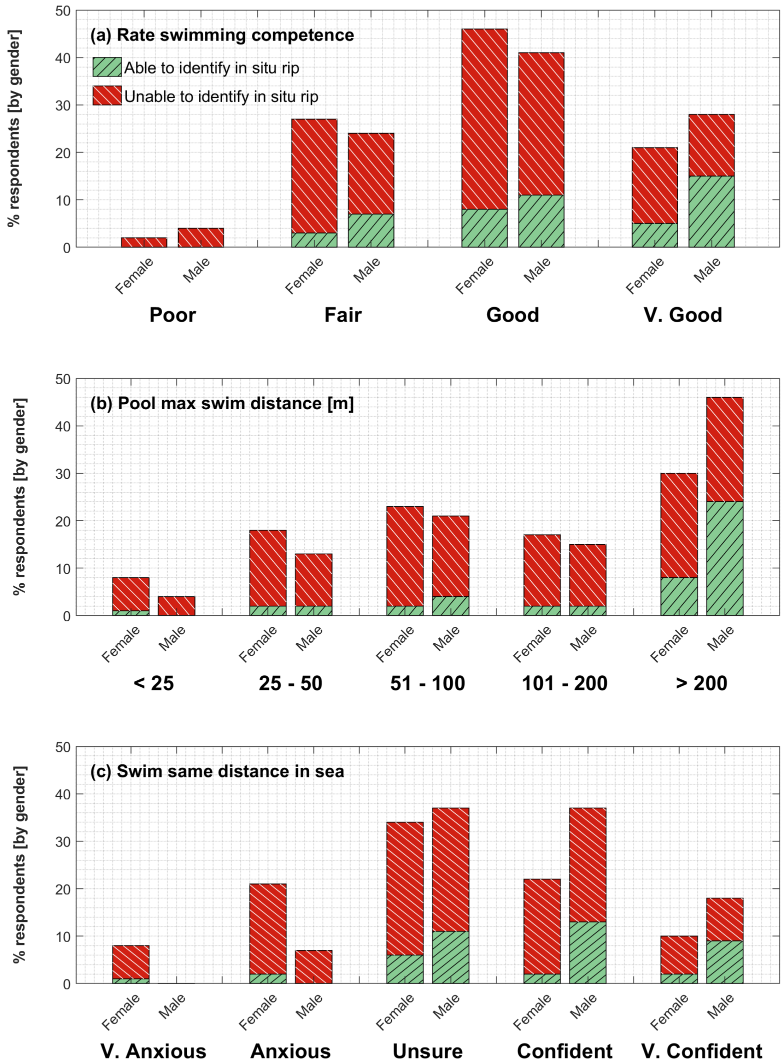

Figure 4. Respondent's ability to ~~spot~~ identify the in situ rip current as a function of: (a) their self-reported swimming competence; (b) the maximum distance they reported being able to swim in a pool non-stop; and (c) their feeling at being asked to swim the same distance in the sea. Responses are broken down by gender, with green bars indicative of the percentage of respondents able to ~~spot~~ identify the in situ rip, and red bars indicative of those that cannot.

225 to swim outside the flags and those who would not, although it does appear that many of those with lower knowledge may choose to remain between the flags. Across the entire dataset, the majority of respondents (55%, n = 68 of 124) indicated that they had not been caught in a rip before, and of these, 87% (n = 59 of 68) were unable to identify the rip (Figure 5c). Of the 49 respondents who had experienced being caught in a rip, only 37% (n = 18) were able to identify the in situ rip.

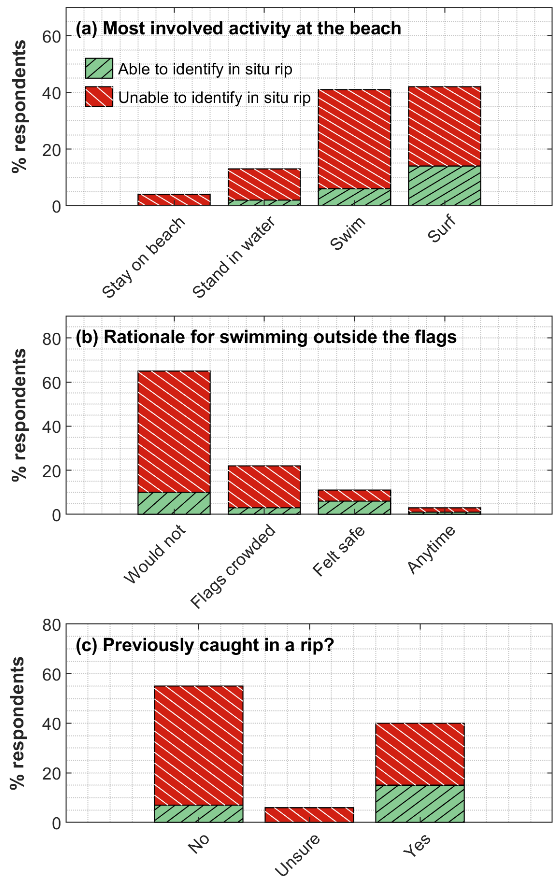

Figure 5. (a) Respondent's activity at the beach; (b) rationale for swimming outside of the flagged bathing are; and (c) indication of those who have experience of being caught in a rip. Green bars are indicative of the number of respondents able to ~~spot~~ identify the in situ rip, and red bars indicative of those that cannot.

3.4 ~~Photo~~ Photograph versus in situ identification

An implicit assumption of previous studies relating to rip identification is that the ability to ~~spot~~ identify a rip current in a ~~photo~~ photograph translates to an ability to identify rip currents in situ. ~~Figure~~ In this study, 31% (n = 41 of 132) of respondents were able to identify a rip in both photographs in Figure 3, 26% (n = 34 of 132) could identify a rip in only one photograph, and 43% (n = 57 of 132) were unable to identify a rip in either photograph. Figure 6 identifies the success rate of in situ rip identification as a function of participant's ability to identify rips ~~on paper~~in the photographs. Of the participants that were unable to identify a rip current in either of the images presented in Figure 3, 89% (n = 51 of 57) were unable to identify the in situ rip. Of those able to identify the rip in only one of the images in Figure 3, 74% (n = 25 of 34) were unable to identify the rip in situ, and of those able to identify rips in both images in Figure 3, only 34% (n = 14 of 41) were able to identify rip currents in situ (Figure

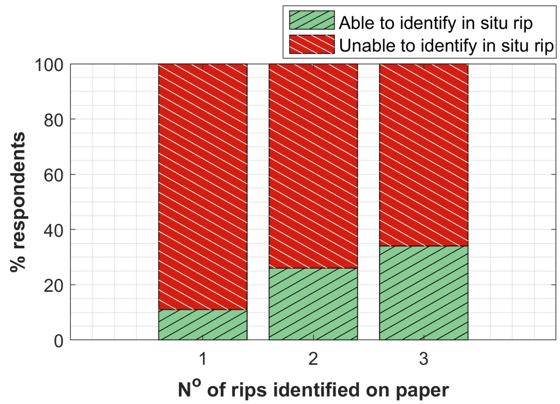

Figure 6. The percentage of respondents able to identify the in situ rip (green bars) versus those unable to identify the in situ rip (red), presented as a function of their ability to identify rips on paper.

6). The significance of the relationship between in situ and ~~photo-based~~ photograph-based ability was tested using a linear regression, where the ability to ~~spot~~ identify a rip in situ was coded as a binary outcome, and the number of rips identified on paper was used as a continuous predictor. The number of rips identified in ~~photos~~ photographs was a statistically significant ($p = 0.004$) coefficient in the prediction of a participant's ability to identify in situ rips. Despite this statistical significance, it is important to acknowledge that approximately two thirds of respondents who were able to identify both rip currents in photographs, were unable to do so in situ at the beach (Figure 6).

4 Discussion

This study, to our knowledge, represents the first attempt to quantitatively evaluate the ability of beachgoers to visually identify an actual rip current on a beach. Only 22% of surveyed beachgoers were able to successfully ~~spot~~ identify a channel rip at a high energy beach at Muriwai, New Zealand. Here we discuss the results of our study in the context of existing literature in regards to both beachgoer demographics and implications towards beach safety.

4.1 Demographic trends in rip ~~spotting~~ identification ability

Males are generally over-represented in rip-related rescue statistics (Woodward et al., 2013) and global drowning epidemiology more generally (Peden and McGee, 2003), and PMT shows them to be more likely to overestimate their ability and underestimate the risk they are in with regard to water-related recreation (Moran, 2011). In the current study, males generally self-reported higher competence, with men significantly more likely to report feeling confident at the prospect of swimming their maximum pool distance at sea. This compares ~~with previous studies identifying~~ well to previous studies that have identified higher self-reported confidence ~~in~~ among males, which ~~is likely to increase~~ likely increases drowning risk exposure through reduced inhibitions ~~around swimming in deep water~~ about deep water swimming or challenging conditions (Morgan et al., 2009a). Males were better able to identify the rip current, but this result was not controlled for other factors such as experience or familiarity with the beach in question. It is possible that the correlation with gender is linked to the fact that males are more likely to use surf equipment and swim further from the shore (Morgan et al., 2009b), and therefore are more likely to have frequently interacted with rip currents. A previous New Zealand study reported 53% of males felt confident identifying rip currents compared to 39% of females, but it did not report on their actual success rate (Moran and Ferner, 2016). Other studies addressing the impact of gender on the ability to identify a rip have had contrasting outcomes. For example, males at Miami Beach, USA, were more successful in identifying a safe ~~spot~~ location to swim (Fallon et al., 2018), whereas females were more successful in an Australian study (Williamson et al., 2012). Higher self-reported competence across both genders was linked to increased ability to ~~spot~~ identify the rip current in our study.

Respondents who undertook beach activities where they physically interacted more with the surf zone, such as swimming and surfing, were more likely to be able to ~~spot~~ identify the rip current. Surfing as an activity is associated with the type of coastline where many hazards may exist, such as larger waves and stronger rips. Therefore, surfers likely have a much higher understanding of rip currents (Attard et al., 2015), especially as surfing is often prohibited in the flagged bathing area which increases the likelihood of interacting with a rip current. Moreover, many surfers actively use rip currents to get out beyond the breakers with minimal effort, and are therefore more adept at identifying them. Prior experience of being involuntarily caught in a rip (as opposed to choosing to use one) was also a factor in whether a person could identify the rips in this study. This was consistent with an Australian study of rip current survivors showing that 84% of those people that had previously been caught in a rip current were now able to identify rips in ~~photos~~ photographs (Drozdzewski et al., 2012). In our study, only 37% of rip current survivors were able to identify the in situ rip, which highlights the additional complexity and skill required when considering an active and fluid surf zone, rather than a static ~~photo~~photograph. This was evidenced in the study by Sherker et al. (2010), where 93% of respondents indicated they could identify a rip when in reality less than two thirds of the respondents could actually identify the channel rip in a ~~photo~~photograph.

4.2 Implications for beach safety

As mentioned previously, only 22% of surveyed beachgoers in this study were able to identify a real rip current. Furthermore, 66% (n = 27 of 41) of the surveyed beachgoers that were able to successfully identify rip currents in two ~~photos~~ photographs (Figure 3) were unable to identify the channel rip present at Muriwai Beach. These findings have significant implications for beach safety practitioners on several levels. First, the ability to correctly identify rip currents on paper (i.e. still images) may result in overconfidence of actual rip identification ability, and therefore may lead to more risk taking behaviour, such as swimming away from lifeguards or in unpatrolled locations. Anecdotal evidence from Surf Life Saving Australia (Daw, 2019) showed an increase proportion of rescues of people who were considered educated and informed about rip currents following recent education campaigns, who, armed with this information, were now over predicting their ability to ~~spot~~identify, avoid and escape rip currents, and under predicting the risk.

Second, it suggests that the ability of beachgoers to identify rip currents may be worse than previously shown in the literature. The main methodological approach in previous studies has been either to directly ask surveyed participant to identify a rip current in an image (e.g. Brannstrom et al., 2014; Clifford et al., 2018) or to ask them to identify the safest place to swim (e.g. Sherker et al., 2010; Gallop et al., 2016; Warton and Brander, 2017) in an image that contained a rip current. The ability of beachgoers to specifically identify rip currents has generally resulted in successful identification rates less than 30%. Caldwell et al. (2013) reported that less than 20% of participants were able to identify the channel rip in a series of images of Pensacola Beach, Florida, under green, amber and red flag conditions, with many instead thinking the rip current was present in the heavy surf which was instead indicative of shallower depths and wave breaking. Brannstrom et al. (2014) showed multiple images of a groyne at Galveston Beach, Texas, under different wave conditions and asked participants to identify the most hazardous conditions to swim in. Only 13% of respondents identified the image with the boundary rip current, with the majority instead also opting for images of wave breaking. Similar results have been obtained from studies asking participants to identify safe swimming ~~spots~~locations. Sherker et al. (2010) showed that 52% of primarily Australian respondents chose a rip current as the safest place to swim in an image, while 40% did so in the UK based study of Gallop et al. (2016), and 73% chose a rip current as the safest place in at least one of the two images they were shown in a study at Miami Beach, Florida, by Fallon et al. (2018). While our finding that only 22% of respondents could identify the in situ rip is therefore at the lower end of values previously reported using photographs, the the fact that 66% of respondents who could identify rip currents in photographs (Figure 3), but could not identify the actual rip current is of significant concern.

Third, our results suggest that the use of still images may not be an effective method to utilise in future research related to rip current identification. The selection of rip current images to use research surveys ultimately relies on subjectivity (Ménard et al., 2018). Often the rip current is centred in these images, and thus clearly the focal point of the image, perhaps leading to increased identification bias. The survey design may also lead to participants trying to figure out the "correct" answer, perhaps based on text in previous questions or by obvious visual cues in the image, rather than providing an accurate overview of their perception of the hazard (Ménard et al., 2018). Researchers will often provide static images in which the rip current is obvious based on these visual cues, or taken from an elevated position to enhance the visualisation of the rip (e.g. Figure 3), instead of from the beach or shoreline level, which is a more realistic viewpoint for someone making a decision on where to enter the water. This reinforces the findings of a study by Brannstrom et al. (2015) that showed a warning sign with a graphical representation of a rip current portrayed from an aerial view was useful in teaching people what to do if caught in a rip (swim parallel), but was not a useful means of helping people to identify a rip in situ. This goes someway to explain the disconnect outlined in this study between purely photograph based identifications (57% able to identify a rip in at least one image) and the translation of that ability into meaningful in situ identification at the beach, where only 22% of respondents could identify the rip. The reality is that the surf zone is spatially and temporally dynamic and it often takes a prolonged period of observation to successfully identify rip currents. Identifying a rip current in a well-defined snapshot image versus in situ requires different skills and timeframes, and rarely do beachgoers seek an elevated position from which to observe rips prior to entering the water. Ultimately, if photographs are to be used in further studies of rip identification, they should be site-specific and taken from a realistic beach perspective to ensure that beachgoers can situate themselves in place, rather than being asked to interpret a photograph taken from a viewpoint that bears no resemblance to the viewpoint afforded to them on the beach (Brannstrom et al., 2015; Ménard et al., 2018). The next logical step is to understand how ability to identify an in situ rip current is affected by spatial variations in perspective on the beach. Therefore, future studies should aim to identify how factors such as distance, and orientation of viewpoint relative to the main channel direction impact upon beachgoers' ability to identify the rip.

Finally, our findings ~~also suggest that the use of still images may not be an effective method to use in public~~ suggest that more work is required to investigate whether photographs are actually a useful medium for rip current education campaigns, given the disconnect between successful identifications in photographs and real life. One potential solution to this problem is to make use of the increasing availability of video footage of rip currents on social media, such as YouTube (Mackellar et al., 2015) and the rapidly increasing development and availability of 3D headsets and virtual reality, whereby people (e.g. school children) could interact with a 'live' and dynamic surf zone, including rip currents. These approaches are already being taken for water safety education in New Zealand (DPA, 2018), but are yet to be used for quantitative analysis of surf zone hazard perception. Additionally, one approach gaining traction as a successful way of allowing people to visualise the rip current is the release of harmless dyes as a tracer (Brander et al., 2014) either in person or in video footage. The benefit here is that people have the opportunity to try and ~~spot~~ identify the rip current before, during, and after the dye release. As the dye fades, onlookers can try to look for the natural rip channel signature (i.e. darker gaps between breaking waves), and learn to associate this with the presence of a rip current.

4.3 Limitations

One of the limitations of this study is that it was conducted at a lifeguarded beach during guarded hours, and therefore there was a flagged bathing area, which was signposted as a safe place to swim. ~~Therefore~~Thus, respondents may automatically have associated the area outside of the flags to be dangerous, which potentially aided them in ~~spotting~~ identification the rip. ~~Because~~ As this study was conducted in situ, familiarity with the beach may also have played a role in rip identification, with 31% of respondents identifying Muriwai as their local beach. These individuals may have been reliant on previous knowledge of the beach to identify the likely rip location, which does not necessarily mean they would be able to identify a rip at an unfamiliar site. This may go some way towards explaining how some people who ~~spotted no rip curents~~ identified no rip currents in photographs were able to identify the in situ rip. In the current study, 93% (n = 27) of the successful in situ identifications were made by people who lived in New Zealand, and 41% (n = 12) of the successful identifications were made by individuals who classed Muriwai as their local beach. This study still represents an accurate depiction of a given beach population's ability to identify the rip, as beaches typically have a mix of visitors and locals with varying site-specific knowledge. Previous studies have shown that 40% of international visitors to New Zealand identified swimming at the beach as their most popular recreational activity whilst on holiday (Moran and Ferner, 2016). Perhaps more significant in this study was the higher proportion of refusals to participate from young males. This is particularly pertinent as this demographic has been identified as at risk in the global drowning literature (Woodward et al., 2013), and identified as a group more likely to over-estimate ability and under-estimate risk (Moran, 2011). Therefore, more work needs to be done to understand whether the previously reported under-estimation of risk is at all linked to an (in)ability to identify rip currents.

The surf zone is inherently dynamic due to factors such as tidal stage, individual wave sets, or changes in wind strength/direction which all influence the degree to which the rip current was visible. As the surveys were conducted at different times across 7 different days, the appearance of the channel rip current may have changed, despite remaining in a persistent location during the study period. Therefore, ~~it is possible that~~ each respondent formulated their answer from slightly different viewpoints combined with different conditions. ~~One potential~~ This study did not account for how viewing orientation, distance from the rip, or instantaneous hydrodynamic conditions impacted the ability to identify the rip. Any future in situ study should plan to incorporate some form of wave/tide measurement and a coastal imaging camera in order to make comparisons between identification rates and wave/tide heights and breaking wave patterns, as well as record observation locations relative to the rip. One potential alternate solution to this problem is to make use of the increasing availability of 3D headsets and virtual reality, whereby each respondent could still interact with a 'live' and dynamic surf zone, but the experiment could be better controlled such that each participant was given the exact same stimulus from which to formulate a response. Indeed, other studies have advocated for the use of video (Hatfield et al., 2012; Wilks et al., 2017) as a more appropriate means of visualising a rip current, and this would perhaps also allow for a more controlled measure of rip identification ability. Nevertheless, this study replicates the real-world conditions that people face when making decisions on the beach, and demonstrate that the selection of a safe place to swim without prolonged observation could equally result in the inadvertent selection of the rip current. This further highlights the difficulty in educational approaches where the main aim is to teach people to identify the rip currents, given that conditions (and the visibility of the rip) change dramatically within a site during the course of a day, let alone between sites.

5 Conclusions

Previous studies have reported rip identification rates based on respondents looking at photographs of rip currents, rather than rip currents in situ. This study represents the first attempt to examine relationships between an individual's beach experience, their ability to ~~spot~~ identify a rip in a photograph, and if this translated to an equal ability to locate a rip in situ at the beach. Overall, 78% of people were unable to identify a rip current at Muriwai, a high energy beach in New Zealand known for its pronounced channel rip currents. Respondents that were able to identify rip currents in ~~photos~~ photographs were better able to identify the in situ rip current, but the majority of that group (66%) were still unable to translate this into meaningful identification of the in situ rip. Individuals that actively swim or surf at the beach were better able to identify rips when compared to those that never entered the water, or those that only waded in shallow water depths. Likewise, those that self-reported an increased water competence, or those that had previously been caught in a rip current, were also more likely to be able to ~~spot~~ identify the in situ rip.

These results have major implications for the future use of photographs to assess beachgoers' ability to identify rip currents and for future rip current education strategies involving rip current identification. Many education programs use static imagery to ‘teach’ people to identify rip currents, but this study presents clear evidence that this skill does not translate usefully into in situ rip identification. ~~Education either needs to make use of more~~ Future work should consider whether employing immersive 3D/virtual reality ~~strategies,~~ technologies and videos of actual rip current footage ~~or dye releases to try and show people~~ to present people with a dynamic surf zone ~~, or continue to focus efforts on teaching people how to escape and cope with a rip current, given the knowledge that very few people are able to accurately spot one in situ~~would be a better means of educating people to identify rip currents.

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References

Attard, A., Brander, R. W., and Shaw, W. S.: Rescues conducted by surfers on Australian beaches, Accident Analysis and Prevention, 82, 70–78, https://doi.org/10.1016/j.aap.2015.05.017, 2015.

Brander, R. and MacMahan, J.: Future challenges for rip current research and outreach, in: Rip Currents: Beach safety, physical oceanography, and wave modelling, edited by Leatherman, S. and Fletemeyer, J., pp. 1–26, CRC Press, Florida, USA, 2011.

Brander, R. and Scott, T.: Science of the rip current hazard, in: The Science of Beach Lifeguarding, edited by Tipton, M. J. and Wooler, A., pp. 67–84, CRC Press, Boca Raton, Florida, 2016.

Brander, R. and Short, A.: Morphodynamics of a large-scale rip current system at Muriwai Beach, New Zealand, Marine Geology, 165, 27–39, 2000.

Brander, R. W., Drozdzewski, D., and Dominey-Howes, D.: “Dye in the Water”: A Visual Approach to Communicating the Rip Current Hazard, Science Communication, 36, 802–810, https://doi.org/10.1177/1075547014543026, http://journals.sagepub.com/doi/10.1177/1075547014543026, 2014.

Brannstrom, C., Trimble, S., Santos, A., Brown, H. L., and Houser, C.: Perception of the rip current hazard on Galveston Island and North Padre Island, Texas, USA, Natural Hazards, 72, 1123–1138, https://doi.org/10.1007/s11069-014-1061-3, 2014.

Brannstrom, C., Lee Brown, H., Houser, C., Trimble, S., and Santos, A.: "You can’t see them from sitting here": Evaluating beach user understanding of a rip current warning sign, Applied Geography, 56, 61–70, https://doi.org/10.1016/j.apgeog.2014.10.011, 2015.

Brewster, B. C., Gould, R. E., and Brander, R. W.: Estimations of rip current rescues and drowning in the United States, Natural Hazards and Earth System Sciences, 19, 389–397, https://doi.org/10.5194/nhess-19-389-2019, https://nhess.copernicus.org/articles/19/389/2019/, 2019.

Caldwell, N., Houser, C., and Meyer-Arendt, K.: Ability of beach users to identify rip currents at Pensacola Beach, Florida, Natural Hazards, 68, 1041–1056, https://doi.org/10.1007/s11069-013-0673-3, 2013.

Carey, W. and Rogers, S.: Rip Currents — Coordinating Coastal Research, Outreach and Forecast Methodologies to Improve Public Safety, in: Solutions to Coastal Disasters 2005, pp. 285–296, American Society of Civil Engineers, Reston, VA, https://doi.org/10.1061/40774(176)29, http://ascelibrary.org/doi/10.1061/40774{%}28176{%}2929, 2005.

Castelle, B., Scott, T., Brander, R. W., and McCarroll, R. J.: Rip current types, circulation and hazard, Earth-Science Reviews, 163, 1–21, https://doi.org/http://dx.doi.org/10.1016/j.earscirev.2016.09.008, http://www.sciencedirect.com/science/article/pii/S0012825216303117, 2016.

Clifford, K. M., Brander, R. W., Trimble, S., and Houser, C.: Beach safety knowledge of visiting international study abroad students to Australia, Tourism Management, 69, 487–497, https://doi.org/10.1016/j.tourman.2018.06.032, 2018.

Daw, S.: Personal communication, 2019.

DPA: Drowning Prevention Auckland: Water Safety for Youth and Young Adults, https://www.watersafe.org.nz/courses/youth-and-young-adults/, 2018.

Drozdzewski, D., Shaw, W., Dominey-Howes, D., Brander, R., Walton, T., Gero, A., Sherker, S., Goff, J., and Edwick, B.: Surveying rip current survivors: preliminary insights into the experiences of being caught in rip currents, Natural Hazards and Earth System Sciences, 12, 1201–1211, https://doi.org/10.5194/nhess-12-1201-2012, http://www.nat-hazards-earth-syst-sci.net/12/1201/2012/, 2012.

Fallon, K. M., Lai, Q., and Leatherman, S. P.: Beachgoer's recognition of rip current hazard at Miami Beach, Florida, Ocean & Coastal Management, 165, 63–70, https://doi.org/10.1016/J.OCECOAMAN.2018.08.011, https://www.sciencedirect.com/science/article/pii/S0964569117301291?via{%}3Dihub, 2018.

Gallop, S., Woodward, E., Brander, R., and Pitman, S.: Perceptions of rip current myths from the central south coast of England, Ocean and Coastal Management, 119, https://doi.org/10.1016/j.ocecoaman.2015.09.010, 2016.

Gallop, S. L., Bryan, K. R., Pitman, S. J., Ranasinghe, R., Sandwell, D. R., and Harrison, S. R.: Rip current circulation and surf zone retention on a double barred beach, Marine Geology, 405, 12 – 22, https://doi.org/https://doi.org/10.1016/j.margeo.2018.07.015, http://www.sciencedirect.com/science/article/pii/S0025322718302196, 2018.

Gilchrist, J. and Branche, C.: Lifeguard effectiveness, in: The Science of Beach Lifeguarding, edited by Tipton, M. J. and Wooler, A., pp. 29–35, CRC Press, Boca Raton, FL, USA, 2016.

Hatfield, J., Williamson, A., Sherker, S., Brander, R., and Hayen, A.: Development and evaluation of an intervention to reduce rip current related beach drowning, Accident Analysis Prevention, 46, 45 – 51, https://doi.org/https://doi.org/10.1016/j.aap.2011.10.003, http://www.sciencedirect.com/science/article/pii/S0001457511003009, 2012.

Houser, C., Trimble, S., Brander, R., Brewster, B. C., Dusek, G., Jones, D., and Kuhn, J.: Public perceptions of a rip current hazard education program: "Break the Grip of the Rip!", Natural Hazards and Earth System Sciences, 17, 1003–1024, https://doi.org/10.5194/nhess-17-1003-2017, https://www.nat-hazards-earth-syst-sci.net/17/1003/2017/, 2017.

Mackellar, K. M., Brander, R. W., and Shaw, W. S.: YouTube Videos and the Rip Current Hazard: Swimming in a Sea of (Mis)information, International Journal of Aquatic Research and Education, 9, 10, https://doi.org/10.25035/ijare.09.03.10, https://scholarworks.bgsu.edu/ijare/vol9/iss3/10, 2015.

MacMahan, J. H., Thornton, E., and Reniers, A.: Rip current review, Coastal Engineering, 53, 191–208, https://doi.org/10.1016/j.coastaleng.2005.10.009, http://linkinghub.elsevier.com/retrieve/pii/S0378383905001353, 2006.

Matthews, B., Andronaco, R., and Adams, A.: Warning signs at beaches: Do they work?, Safety Science, 62, 312–318, https://doi.org/10.1016/j.ssci.2013.09.003, 2014.

McCool, J., Ameratunga, S., Moran, K., and Robinson, E.: Taking a risk perception approach to improving beach swimming safety, International Journal of Behavioral Medicine, 16, 360–366, https://doi.org/10.1007/s12529-009-9042-8, https://link.springer.com/article/10.1007/s12529-009-9042-8, 2009.

McCool, J. P., Moran, K., Ameratunga, S., and Robinson, E.: New Zealand beachgoers' swimming behaviours, swimming abilities, and perception of drowning risk, International Journal of Aquatic Research and Education, 2, 7–15, https://doi.org/10.25035/ijare.02.01.02, https://scholarworks.bgsu.edu/ijare/vol2/iss1/2, 2008.

Ménard, A. D., Houser, C., Brander, R. W., Trimble, S., and Scaman, A.: The psychology of beach users: importance of confirmation bias, action, and intention to improving rip current safety, https://doi.org/10.1007/s11069-018-3424-7, 2018.

Moran, K.: Will They Sink or Swim? New Zealand Youth Water Safety Knowledge and Skills, International Journal of Aquatic Research and Education, 2, 4, https://doi.org/10.25035/ijare.02.02.04, https://scholarworks.bgsu.edu/ijare, 2008.

Moran, K.: (Young) Men behaving badly: dangerous masculinities and risk of drowning in aquatic leisure activities, Annals of Leisure Research, 14, 260–272, https://doi.org/10.1080/11745398.2011.615719, http://www.tandfonline.com/doi/abs/10.1080/11745398.2011.615719, 2011.

Moran, K. and Ferner, D.: Water Safety and Aquatic Recreation among International Tourists in New Zealand, International Journal of Aquatic Research and Education, 10, https://doi.org/10.25035/ijare.10.01.05, 2016.

Moran, K. and Willcox, S.: Water Safety Practices and Perceptions of "New" New Zealanders, International Journal of Aquatic Research and Education, 7, https://doi.org/10.25035/ijare.07.02.05, https://scholarworks.bgsu.edu/ijare/vol7/iss2/5, 2013.

Moran, K., Quan, L., Franklin, R., and Bennett, E.: Where the Evidence and Expert Opinion Meet: A Review of Open-Water Recreational Safety Messages, International Journal of Aquatic Research and Education, 5, 5, https://doi.org/10.25035/ijare.05.03.05, 2011.

Moran, K., Webber, J., and Stanley, T.: Protection Motivation Theory (PMT), Risk of Drowning, and Water Safety Perceptions of Adult Caregivers/Parents, The Open Sports Sciences Journal, 11, 50–59, https://doi.org/10.2174/1875399x01811010050, 2018.

Morgan, D., Ozanne-Smith, J., and Triggs, T.: Self-reported water and drowning risk exposure at surf beaches, Australian and New Zealand Journal of Public Health, 33, 180–188, https://doi.org/10.1111/j.1753-6405.2009.00367.x, http://doi.wiley.com/10.1111/j.1753-6405.2009.00367.x, 2009a.

Morgan, D., Ozanne-Smith, J., and Triggs, T.: Direct observation measurement of drowning risk exposure for surf beach bathers, Journal of Science and Medicine in Sport, 12, 457–462, https://doi.org/10.1016/j.jsams.2008.04.003, 2009b.

Peden, M. M. and McGee, K.: The epidemiology of drowning worldwide., Injury control and safety promotion, 10, 195–199, https://doi.org/10.1076/icsp.10.4.195.16772, 2003.

Pitman, S., Gallop, S. L., Haigh, I. D., Masselink, G., and Ranasinghe, R.: Wave breaking patterns control rip current flow regimes and surf-zone retention, Marine Geology, 382, 176–190, https://doi.org/10.1016/j.margeo.2016.10.016, https://linkinghub.elsevier.com/retrieve/pii/S0025322716302821, 2016.

Rogers, R. W.: A Protection Motivation Theory of Fear Appeals and Attitude Change1, The Journal of Psychology, 91, 93–114, https://doi.org/10.1080/00223980.1975.9915803, 1975.

Scott, T., Masselink, G., Austin, M., and Russell, P.: Controls on macrotidal rip current circulation, Geomorphology, 214, 198–215, 2014.

Sherker, S., Williamson, A., Hatfield, J., Brander, R., and Hayen, A.: Beachgoers' beliefs and behaviours in relation to beach flags and rip currents, Accident Analysis and Prevention, 42, 1785–1804, https://doi.org/10.1016/j.aap.2010.04.020, http://www.ncbi.nlm.nih.gov/pubmed/20728630, 2010.

SLSA: National Coastal Safety Report, Tech. rep., Surf Life Saving Australia, Sydney, Australia, 2019a.

SLSA: Coastal Safety Brief: Rip Currents, Tech. rep., SLSA, Sydney, Australia, 2019b.

Stallman, R. K., Moran, K., Quan, L., and Langendorfer, S.: From Swimming Skill to Water Competence: Towards a More Inclusive Drowning Prevention Future, International Journal of Aquatic Research and Education, 10, https://doi.org/10.25035/ijare.10.02.03, 2017.

Warton, N. M. and Brander, R. W.: Improving tourist beach safety awareness: The benefits of watching Bondi Rescue, Tourism Management, 63, 187–200, https://doi.org/10.1016/j.tourman.2017.06.017, 2017.

Wilks, J., Kanasa, H., Pendergast, D., and Clark, K.: Beach safety education for primary school children, International journal of injury control and safety promotion, 24, 283–292, 2017.

Willcox-Pidgeon, S., Kool, B., and Moran, K.: Perceptions of the risk of drowning at surf beaches among New Zealand youth, International Journal of Injury Control and Safety Promotion, pp. 1–7, https://doi.org/10.1080/17457300.2018.1431939, https://www.tandfonline.com/doi/full/10.1080/17457300.2018.1431939, 2018.

Willcox-Pidgeon, S. M., Kool, B., and Moran, K.: Knowledge, Attitudes, and Behaviours of New Zealand Youth in Surf Beach Environments, International Journal of Aquatic Research and Education, 10, 10–16, https://doi.org/10.25035/ijare.10.02.06, https://scholarworks.bgsu.edu/ijare/vol10/iss2/6, 2017.

Williamson, A., Hatfield, J., Sherker, S., Brander, R., and Hayen, A.: A comparison of attitudes and knowledge of beach safety in Australia for beachgoers, rural residents and international tourists, Australian and New Zealand Journal of Public Health, 36, 385–391, https://doi.org/10.1111/j.1753-6405.2012.00888.x, http://doi.wiley.com/10.1111/j.1753-6405.2012.00888.x, 2012.

Woodward, E., Beaumont, E., Russell, P., Wooler, A., and Macleod, R.: Analysis of rip current incidents and victim demographics in the UK, Journal of Coastal Research, 65, 850–855, 2013.