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Discussions

Public Perceptions of a Rip Current Hazard Education Program: 'Break the Grip of the Rip!'

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Abstract

Rip currents pose a major global beach hazard; estimates of annual rip current related deaths in the United States alone range from 35 to 100 per year. Despite increased social research into beach-goer experience, little is known about levels of rip current knowledge within the general population. This study describes results of an online survey to determine the extent of rip current knowledge across the United States, with the aim of improving and enhancing existing beach safety education material. Results suggest that the "Break the Grip of the Rip"® campaign has been successful in educating the public about rip current safety directly or indirectly, with the majority of respondents able to provide an accurate description of how to escape a rip current. However, the success of the campaign is limited by discrepancies between personal observations at the beach and rip forecasts that are broadcasted for a large area and time. It was the infrequent beach user that identified the largest discrepancies between the forecast and their observations. Since infrequent beach users also do not seek out lifeguards or take the same precautions as frequent beach users, it is argued that they are also at greatest risk of being caught in a dangerous situation. Results of this study suggest a need for the national campaign to provide greater focus on locally specific and verified rip forecasts and signage in coordination with lifeguards, but not at the expense of the successful national awareness program.

KEYWORDS: Rip Current, Beach Safety, Survey, Perceived Risk

1 Introduction

Rip currents (often called "rips") are a global hazard that has received considerable attention in the USA, Australia, Costa Rica, and many other countries (Klein et al., 2003; Hartmann, 2006; Sabet and Barani, 2011; Woodward et al., 2013; Arun Kumar and Prasad, 2014). Rip currents in these countries are considered a major public health problem (Short and Hogan 1994; Sherker et al., 2008; Morgan et al. 2009; Arozarena et al., 2015). In Australia, rip currents are believed to be responsible for approximately 13,000 beach rescues per year (SLSA, 2016) and an average of 21 confirmed deaths per year (Brighton et al., 2013), which exceeds fatalities caused by most other natural hazards (Brander et al., 2013). While it has been estimated that 30–40 individuals die by drowning each year as a result of being caught in a rip current in the United States (Gensini and Ashley 2010), Lushine (1991) suggested that rips may account for up to 150 fatal drownings per year and the United States Lifesaving Association (USLA) estimate this number to be over 100 per year. Regardless, according to USLA's National Lifesaving Statistics Report (2012), over 82% of rescues at surf beaches in the US are necessitated by distress in rip currents. They therefore surmise that 82% of all fatal drownings at beaches are associated with rip currents.

Beach users' vulnerability to drowning in a rip current depends on a combination of beach hydrodynamic and bathymetric conditions, personal and group behaviors, and the beach safety and rip current knowledge of the individual (e.g. Houser et al., 2011; Brander et al., 2011; Caldwell et al., 2013). Morgan et al. (2009) identified that lacking rip current knowledge was associated with rip current drownings, as was gender, age, alcohol consumption, and overconfidence in swimming ability. Recent evidence suggests that while the majority of beach users are aware of rip currents and the hazard they pose, they are not able to identify a rip current

(Sherker et al., 2010; Caldwell et al., 2012; Brannstrom et al., 2014). Most beach users surveyed in Florida and Texas (>80%) failed to identify rip currents in photographs, usually by incorrectly indicating that the part of a photograph with the heaviest surf represented the most hazardous swimming conditions (Brannstrom et al., 2014). This is consistent with the results of Sherker et al. (2010) who argued that the majority of beach users are unable to identify a rip current and that “beachgoers clearly need to know what a rip looks like in order to actively avoid swimming in it” (pg. 1787). Given sufficient information, it is possible for beach users to identify a rip current with confidence (Hatfield et al., 2012). However, the ability to identify a rip current or to recognize posted warnings about the rip current danger is not a guarantee that a beach user will be safe, particularly because many will still choose to swim in unsafe and unpatrolled sections of the beach, away from the presence of lifeguards, for social or behavioral reasons or because of lack of awareness and/or complacency (Drozdzewski et al. 2012; 2014; Williamson et al. 2012).

Informing the public about the rip current hazard has become a national priority in a number of countries including the United States (e.g. Ashley and Black, 2008; Brannstrom et al., 2013), Australia (e.g. Sherker et al., 2008; Brighton et al., 2013), United Kingdom (e.g. Woodward et al., 2013), and Costa Rica (Aronzarena et al., 2015). The United States has arguably the longest running cooperative and coordinated public rip current education program operating across various organizational and political levels (Carey and Rogers, 2005). A Rip Current Task Force was convened in 2003 by the National Oceanic Atmospheric Administration (NOAA) and United States Lifesaving Association (USLA) to establish consistent rip current education efforts and improve data sharing about rip current rescue data across the United States. Subsequently, with the assistance of the National Weather Service (NWS) and Sea Grant, a national “Break the Grip of the Rip!” ® education campaign was initiated in 2004. The “Break the Grip of the Rip!" campaign aimed to educate the public about the rip current hazard by providing information about what rip currents are, why they are dangerous, how to identify them, what to do if caught in one, and how to help someone else if they are caught in a rip current. Aspects of this information have been disseminated through various means such as the NWS Rip Current Safety webpage (http://www.ripcurrents.noaa.gov/), brochures, beach signs, videos, newspaper articles, and public service announcements on television. While this campaign was the first of its kind globally, it was also particularly challenging given that the United States has four coastlines (West Coast, East Coast, Gulf Coast, Great Lakes) that differ in terms of wave climate and beach systems and a large inland non-coastal population who may only visit any of these coastlines infrequently.

The core visual image used in many of these interventions was a simple diagrammatic illustration of an idealized rip current from an oblique aerial perspective (Fig. 1). In this image, the rip current is characterized by relatively calm white water surrounded by more intensive wave breaking adjacent to the rip and close to the shoreline. An image template was created that could be accessed online and in hardcopy and duplicated freely to be posted along boardwalks, beachfronts and public beach access points throughout the United States. The image has also been more recently adopted in other countries such as Thailand, Costa Rica, Mexico, South Korea, and Japan. While the NOAA-USLA rip current sign was not intended to teach the general population to identify a rip, the prominent image of a rip current on the sign and attempts to post the sign on beaches indicate that its function and visual argument constitute an invitation to beach users to use the information to identify rip currents (Brannstrom et al., 2015). The sign shows an aerial and oblique view of a rip current, an abstract view from 'nowhere' (see Crang and Thrift, 2000)

Due to this conflict between its theoretical and practical use, the NOAA-USLA rip current sign has proven to be mostly successful in regards to educating beachgoers on “what to do” (e.g. swim parallel to the beach) when caught in a rip current, but has not been particularly successful in improving beach users’ ability to identify rip currents from the perspective of standing or sitting on the beach (Brannstrom et al., 2015). Consistent with results of Matthews et al. (2014), only a small percentage of beach users (<50%) recalled observing rip current warning signs on beaches in Florida and Texas (Caldwell et al., 2012; Brannstrom et al., 2014) despite their wide spread occurrence at beach access points. It is important to note, however, that despite observing and understanding a warning sign, it is well established that some people will not take the appropriate actions to prepare for or avoid the hazard (Sietgrest and Gutscher, 2006; Karanci et al., 2005; Hall and Slothower, 2009; Johannesdottir and Gisladottir, 2010).

In a separate initiative, the NWS has endeavored to develop a public rip current forecasting system, although the methodology varies among Weather Forecast Offices (WFO). Some WFOs issue surf zone forecasts that include a 3-tiered (low, moderate, high) rip current outlook that is communicated to the public during television and radio news broadcasts (Carey and Rogers, 2005) and social media platforms. Some WFOs work with local lifeguards to update their outlooks based on real-time observations. However, as discussed in NOAA (2015), these forecasts are not necessarily communicated or disseminated in a consistent manner throughout all regions and therefore are not communicated seamlessly. Perception of the rip hazard depends in part on trust in experts and authorities, and trust in the protective measures they employ (Njome et al., 2010; Heitz et al., 2009; Terpstra, 2009, 2011; Barnes, 2002). Inaccuracies in the forecast or a discrepancy between the forecast and what is observed at a specific beach at a specific time can erode confidence in the forecast (Siegrist and Cvetkovich,

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Published: 30 January 2017

2000; Espluga et al., 2009), and could potentially condition beach users to downplay the hazard warning on future visits (Hall and Slothower, 2009; Scolobig et al., 2012; Green et al., 1991; Mileti and O'Brien, 1993). Furthermore, the general nature of the rip current outlooks can result in situations where, particularly on a variable coastline, the actual intensity of rips varies substantially from the outlook. Beachgoers could easily observe a discrepancy between their beach location and the rip forecast, caused by either the generalized nature of the forecast or their inability to identify a rip current (Caldwell et al., 2012; Brannstrom et al., 2014, 2015).

The national US rip current education program is clearly an impressive effort, yet despite all its associated interventions, a large number of rip current related fatalities and rescues on US beaches still occur (Gensini and Ashley 2010) and there is little quantitative evidence available to assess the overall effectiveness of the program. This is largely due to the fact that no 'pre-program' study was conducted on the public's or beachgoers' understanding, perception, or behavior in relation to the rip current hazard. Complications are also caused by the lack of hard data on rip current related fatalities, beach visitation numbers and how incident frequency and exposure rate may have changed over time. In this regard, a NOAA sponsored workshop was held in 2015 to review the "Break the Grip of the Rip" ® program and the NWS rip current forecasts to ensure that messaging is scientifically sound, as well as effective and clear in reaching all age groups and demographics (NOAA, 2015). Any effort to revise and improve rip forecasts, the rip current warning sign, and the "Break the Grip of the Rip" ® education campaign requires an understanding of existing beach user knowledge and behaviors in relation to the campaign itself.

While there have been a number of recent studies to describe the extent of rip current knowledge amongst beach users (or lack thereof) on specific beaches in the United States

(Caldwell et al., 2013; Brannstrom et al., 2014, 2015) there is insufficient understanding about beach user knowledge of rip currents and their behavior at the beach nationally. This study describes results of a national online survey focused on United States based beachgoers and their understanding of, and experience with, the "Break the Grip of the Rip" ® program and the rip current hazard in order to provide quantitative evidence to guide future improvements to beach safety education material and forecasting efforts.

2 Methodology

The research design for this study relied on an internet-based survey instrument using Qualtrics that was approved by the relevant human subject protection program from Texas A&M University. The survey consisted of questions re-phrased from Sherker et al. (2010), and photograph-based rip current identification protocols (Fig. 2) modified from Brannstrom et al. (2014, 2015), with questions grouped into six categories (Table 1). The survey had 75 questions and took approximately 20-30 minutes to complete. The survey remained open from May 2015 until August 2015, and all answers were recorded anonymously through Qualtrics Survey Software. A copy of the survey instrument is provided as an appendix to this manuscript.

The survey was distributed by email to cooperating organizations for distribution though listservs, on websites, and in advertisements. It was made accessible to potential respondents via secure Internet links on websites for: Texas A&M University, Sea Grant, Science of the Surf Facebook page, NWS, and the National Oceanic and Atmospheric Association (NOAA); these organizations also posted secure links through their social media platforms. It should be noted that compared to previous beach related surveys by Sherker et al. (2010), Caldwell et al. (2011), and Brannstrom et al. (2014, 2015), which were based on hardcopy and face to face surveys at specific beach locations, this internet-based recruitment process attempted to target a much wider

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demographic of the US population. However, it is also reasonable to assume that as the websites that hosted the survey were all beach and surf-related, survey respondents likely had greater interest in coastal environments and hazards and possibly a better understanding of rip currents. This potential bias was also experienced in a beach safety related study by Drozdzweski et al. (2012).

3 Results

Between May and August 2015 a total of 2084 respondents started the online survey, but only 1622 completed all questions (completion rate: 78%). Geographically, the largest number of respondents were from the state of Texas (n=368) where Texas Sea Grant and the local NWS office conducted significant advertisement for the survey. Large numbers of respondents also came from North Carolina (n=214), California (n=184), and Florida (n=130), with the majority of remaining states having <50 respondents. Of the 50 US states, only Nebraska did not have a respondent. Overall this cohort managed to capture respondents who use each of the coastlines in the continental US. Respondents were evenly distributed by age (>18 years); each 10-year range between 21 and 60 garnered about between 320 and 420 respondents. A slight majority of the respondents were female (55%).

3.1 Beach Preference

As presented in Fig. 3, the majority of respondents visited the beach either once per year on vacation (22%) or multiple times per year (42%). Visitation exhibits a statistically significant relationship with the age of respondents, with older respondents (>40) visiting the beach more often than younger respondents (χ^2=46.5, ρ<0.01). The perceived size of waves on beaches visited by respondents depends on age and frequency of beach visitation with older respondents

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who visit the beach frequently tending to report beaches they visited having strong waves, while younger respondents, who tended to visit the beach infrequently, identified the beach as having small waves (χ^2=84, ρ<0.01). In general, respondents who visit the beach infrequently tend to describe the beach as having small waves and that their primary beach activity is swimming and/or wading. All respondents who visit the beach frequently (weekly or daily) identified board riding as their main activity and tended to frequent beaches with strong wave activity (χ^2=111, ρ<0.01), suggesting a greater understanding of wave conditions. There was no statistically significant variation in the description of the waves based on home state, suggesting that the perception of wave activity is largely based on frequency of beach visitation and other personal characteristics. In terms of choice of beach visited, wave activity and the potential hazard posed by rip currents or the absence of lifeguards is less important than cleanliness and at the same level of importance as crowds (Fig. 4).

When determining which beach to visit, frequent beach users, who were mostly board riders, tended to prefer beaches with lots of waves, whereas infrequent users emphasized safety and cleanliness (χ^2=159, ρ<0.01). Frequent beach users also believed it was very important to swim near a lifeguard, while infrequent users did not (χ^2=51, ρ<0.01). Across both groups, however, respondents suggested that they would still enter the water even if a lifeguard was not present, suggesting that recognition about the importance of lifeguards is not consistent with behavior in selecting where and when to swim (Fig. 5). Frequent beach visitors were also more confident in their ability to 'always' spot a rip current, while infrequent beach visitors were not (χ^2=247, ρ<0.01). Those who visit the beach less often, such as several times per year or per month, believed they could spot a rip 'sometimes' or believed that it is not possible to see a rip current, consistent with the response from all respondents (Fig. 6).

3.2 Swimming Ability

The majority of respondents (~52%) self-identified as competent swimmers (Fig. 7); these same respondents reported in a separate question that they were capable of swimming between 25 and 100 yards (or more than 100 yards) without having to stop or pause in open water (χ^2=1391, ρ<0.01). Respondents who self-reported that they were *highly* competent swimmers in open water (n=213, 12%) primarily believed they could swim more than 500 yards in open water without resting, while those who self-reported as weak swimmers (n=566, 31%) believed that they were only capable of swimming 25 yards or less. Those who identified as highly competent or weak swimmers tended to have the narrowest range of self-reported ranges of swimming ability, while those who self-identified as competent swimmers had the widest range of self-reported swimming distances for both pools and open water.

3.3 Ability to Identify a Rip Current

When asked "Where on this photograph would you swim?", approximately 54% of respondents were able to correctly identify the spot furthest away from the rip current in Photograph 1 (Figs. 2a and 8a). However, 182 (11%) respondents incorrectly selected the rip current as the safest spot to enter the water, with the remaining respondents identifying other areas of the photograph (adjacent to the rip) as being the safest spot to enter the water. Results of a z-test suggest that respondents who selected the rip as the safest location are significantly younger than those who correctly identified the safest location in the photograph (z=12.1, ρ<0.01). Those who correctly identified the safest location in the photograph also visited beaches more frequently (z=6.1, ρ<0.01) and self-reported the beaches they visited as having strong waves (z=6.4, ρ<0.01). Most respondents who identified the rip as the safest location self-reported never having swimming lessons (z=2.8, ρ<0.01), and described themselves as weak swimmers in both pools (z=3.7, ρ<0.01) and open water (z=6.2, ρ<0.01). Those same respondents also self-reported that it was important to swim near a lifeguard (z=5.8, ρ<0.01), but they tended to not consider hazards before going to the beach, unlike respondents who were able to correctly identify the safest spot to enter the water (z=14.1, ρ<0.01).

When asked about what features of a beach they believed to be the most dangerous, respondents who correctly identified the safest swimming location away from the rip were more likely to report alongshore currents and rip currents as dangerous features, while those who selected the rip as the safest location tended to identify jellyfish, sharks, and big waves as the most dangerous beach hazard. Respondents who incorrectly selected the rip current as the safest location were also the least familiar with the common US beach safety flag system (z=11.5, ρ<0.01), and tended to have not heard of rip currents (z=17.3, ρ<0.01). Respondents who selected the rip as the safest location did not understand what was meant by a "high risk" (z=3.2, ρ<0.01) or a "low risk" (z=7.5, ρ<0.01) of rip current development as broadcast by some NWS services. The same respondents also noted that rip forecasts are apt to be inconsistent with the conditions they encountered on the beach, in contrast to the respondents who correctly identified the safest location in the photograph and noted that the forecasts tended to be consistent with their experience (z=3.3, ρ<0.01).

Approximately 25% of respondents (n=630) incorrectly identified the left side of the groin (with an active rip) as the safest spot to enter the water in Photograph 2 (Figs. 2b and 8b). Similar to the responses to Photograph 1, those respondents tended to be younger (z=5.2, ρ<0.01), go to the beach infrequently (z=7.8, ρ<0.01), and self-report the waves being relatively small (z=7.3, ρ<0.01) and their swimming ability in open water to be relatively poor (z=2.2,

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$\rho<0.01$). These respondents are also unlikely to consider hazards before going to the beach ($z=10.9$, $\rho<0.01$), are unfamiliar with the common beach flag system in the United States ($z=12.5$, $\rho<0.01$), do not understand the definition of a "high-risk" of rip current development ($z=4.2$, $\rho<0.01$), and believe that rip forecasts are not consistent with their personal beach experiences ($z=2.8$, $\rho<0.01$). Unlike responses for Photograph 1, those respondents who incorrectly identified the rip as the safest location were not significantly different (at the 95% confidence level) from those who correctly identified the safest location (right side of the groin) with respect to: pool swimming, swimming near a lifeguard, type of water activity at the beach, knowledge of the "*Break the Grip of the Rip*" campaign, or their perceived ability to use the sign to identify a rip current.

A similar pattern was observed in respondent ability to identify the safest location to enter the water in Photograph 3 (Figs. 2c and 8c), with 26% of respondents incorrectly identifying the rip current as the safest location. Similar to responses for the other photographs, respondents who identified the rip as the safest location to enter the water did not visit beaches as often ($z=4.5$, $\rho<0.01$), self-reported having relatively limited swimming ability in pools ($z=3.1$, $\rho<0.01$) and open water ($z=2.8$, $\rho<0.01$), and did not believe that it was important to swim near a lifeguard ($z=3.0$, $\rho<0.01$), unlike those who correctly identified the safest location to enter the water in the photograph. Respondents who selected the rip current as safe for swimming were not as familiar with the flag system used in the United States ($z=5.6$, $\rho<0.01$), rip currents ($z=3.9$, $\rho<0.01$), or the "*Break the Grip of the Rip*" campaign ($z=4.4$, $\rho<0.01$). These respondents also did not understand what was meant by a "low risk" ($z=2.5$, $\rho<0.01$) and a "high risk" ($z=3.4$, $\rho<0.01$) of rips. However, unlike Photographs 1 and 2, no statistically significant difference was observed between those who correctly or incorrectly identified the safest spot to enter the water with respect to: age, self-reported wave activity, swimming lessons, behavior in the absence of lifeguards, importance of checking for hazards, or the ability to use the sign to identify a rip current.

3.4 Response to the Rip Current Warning Sign

Only 31% of all respondents believed that the NOAA rip current warning sign could be used to identify a rip current. Interestingly, those respondents who incorrectly identified the rip current as the safest spot on the beach to enter the water tended to believe that the NOAA rip current warning sign could *not* help a beach user identify a rip current. This was in contrast to those who correctly identified the safest location in any of the photographs ($z=5.2$, $\rho<0.01$). When asked to describe how the sign could be used to identify a rip current, some of the latter respondents were able to relate the rip in the picture to a real rip:

It shows that in a rip current, there appears to be a break in the water, with water moving in a different direction.

Shows the calmer, lighter colored water that indicates a rip current.

It lets the viewer know to look for a break in the waves

It shows you the "calm" area between the two areas of normal wave activity indicating the channel where the rip is located

Most of these responses focused on the pattern of wave breaking and the orientation of the 'calmer' water to the beach. There is evidence that some respondents believed the picture to be an accurate representation of a rip, but they could not provide specific detail about the real world features on the beach it depicted, for example "*Graphic depiction of what the tide looks like*." This suggests that some respondents believe the sign is accurate since it was designed and placed there by an authority.

As previously noted, the rip current warning sign was not designed to help beach users identify a rip current, but rather to inform them how to escape a rip. The majority of respondents were able to clearly state what the sign was informing them in regards to swimming parallel to the beach to escape a rip:

Let the current take you out and then swim parallel the shore to escape.

Swim parallel to the shore, or wait until the rip gets less strong further offshore.

If caught in a rip: swim parallel to the beach to get out before swimming into the beach

If you're not out too far, just swim parallel to the shore. If you're out farther than you're comfortable, swim parallel and then inland.

96% of respondents were able to provide a response to this question and virtually all responses indicated that the sign informed them to swim parallel to shore to escape the rip current, suggesting that the sign has been effective in communicating this message. When asked how seeing this sign would change their behavior of the beach, a majority (65%) of respondents suggested they would take precaution when entering the water:

Might avoid going in water if I see surface signs of rip activity and drive to another beach

Consider not going in. Look carefully for signs of rips. Look for flags and lifeguards

Be more proactive about where to enter the water

This suggests that while the majority of respondents understood that the sign provided them with information on how to escape a rip current, it also helped with prevention as most respondents also noted that they would take precaution or use it to spot (and presumably avoid) a rip, rather than focus on escape strategies.

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Natural Hazards and Earth System Sciences
Open Access
Discussions

Most respondents (86%) provided ideas on how to improve the rip current warning sign, with more than half suggesting the sign needed to provide a more accurate depiction and/or description of a rip current:

I don't think it clearly identifies it enough that the waves will not break where a rip current is. It is great because it shows how to get out of one but I think with another picture of an actual rip current people would identify them easier.

Pictures showing what actual rip currents look like would be useful. / Most casual beachgoers are not confident that they could identify a rip current from shore or predict where one might be forming.

[put a] picture of rip at actual beach [the sign] is placed on

There needs to be more info on how to detect, recognize and avoid a rip current. Information on conditions during which rip currents are most likely to form would also be useful.

A small number of respondents (<10%) suggested that the sign should either include step-by-step instructions on what to do and/or provide more information about the experience of being caught in a rip current:

Multiple steps: / 1. Know when you're in a rip / 2. Stay calm and tread water / 3. Wait until you've floated out to a slower moving water. / 4. Swim sideways

Specific instructions on what one should do if caught in a rip current - Should I swim left, right, straight? What if I'm not a strong swimmer? What are some other exit options?

To also put into words what it may look or feel like. The beach doesn't always give it away to easy

Another group of respondents (~15%) either did not provide suggestions on how the sign can be improved or noted that it only needed minor edits, including space for local emergency numbers and contacts. A small number of respondents (<5%) believed that the sign should include statements that elicit fear amongst beach users including statements such as "Rip currents can drown you."

3.5 Prevention

One in four (25%) respondents reported they had been previously caught in a rip current by accident, while 10% of respondents reported that they had purposely entered a rip for surfing. When asked how to escape a rip, those who had accidently been caught in a rip current provided relatively detailed responses that either described escape by swimming parallel or riding the current without panic:

Stay calm, keep afloat and wait for it to end then swim to sand bar. You can swim parallel to the shore if you have the energy

Let it flow. Don't fight it. Perhaps as long as you minimize tiring exertions try to flow towards the side of the current. Basically do the same thing you'd do if you fell in a strong river about to empty into a lake. You certainly wouldn't kill yourself trying to swim out upstream.

Roll over onto your back, and let the current pull you along, parallel to the beach. It will eventually peter out, and you can swim back to shore. DON'T FIGHT IT!!!

Depends, but don't swim against it unless you are catching a wave to body surf in. Mostly relax and it will peter out. If it's a bad one swim parallel to the shore, the general rule.

Don't panic!!! Either swim - without too much exertion - parallel to the beach for 25+ yards, OR tread water and allow yourself to be carried out until the rip loses power, then swim parallel to the beach. Once out of the rip, swim back towards shore (again in a relaxed manner, taking time to prevent exhaustion). When nearing the beach, take care not to get drawn back into the rip by water flow parallel to the shoreline.

Of those who had not been previously been in a rip 7% (n=36) did not provide a description of how to escape. The remaining respondents provided relatively short responses that described escape through swimming parallel and relaxation:

Swim parallel to the beach until out of the current and then swim ashore

Let it take you out then swim parallel to the coast.

Swim parallel to the beach until out of the current.

Yell and swim parallel to shore

Assuming no response is an indication of a lack of knowledge about rips, the number of respondents who did not provide an accurate description of how to escape a rip current is ~9%, suggesting that the campaign has been successful in informing beach users to: 1) not fight the current, 2) swim out of the current, then to shore, 3) if you can't escape, float or tread water, and 4) if you need help, call or wave for assistance.

3.6 Forecasts

About half of respondents (52%) reported seeking information about beach and surf conditions before going to a beach, with the majority using the internet to find that information (83%). A large majority (88%) of respondents stated that information about the beach and surf conditions affected their behavior, with many saying that they would either "not go" (to the beach), "not go in the water", or "look for rips". When asked whether the rip current forecast (either high or low) was consistent with conditions they experienced at the beach, approximately 67% of respondents stated that the forecasts were not necessarily consistent with their observations. For some, this inconsistency reflected the temporal broadness of the rip forecast compared to what they observed:

Because thing[s] change from time to time conditions etc.

Weather changed quickly and no beach flags were posted, advising of rip currents.

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as well as the spatial broadness of the forecast:

Usually, on the Texas coast there are very few well-defined rip currents.

Rip currents cannot be predicted for individual beaches, they are blanket warnings.

Other respondents noted that the forecast was inaccurate because other beach users had not adjusted their behavior:

I never noticed an[y] thing unusual and people in general don't seem to adjust their behavior.

No caution is shown by public toward water.

Others noted that it was not possible to determine if the forecast was accurate because they were not able to spot a rip on the beach at that specific time or in general:

Couldn't find any that looked like pictures.

Haven't really seen one when they caution against it.

There were no rip currents present.

I couldn't determine if/where rip tide activity might be in the water if the forecasts had warned beach-goers to be aware of a high risk on that day.

No rip currents observed.

In a number of cases (n=59) respondents noted they had not heard a forecast warning of the rip hazard on a given day or in general through responses such as "*I don't know if I've ever heard a rip current forecast?*"

Additional questions about high-risk rip conditions solicited written responses that suggest the majority of respondents understood the high-risk warning to mean that wind and wave activity are tantamount to the development of rips:

Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2017-16, 2017
Manuscript under review for journal Nat. Hazards Earth Syst. Sci.
Published: 30 January 2017

That there is a very good chance that rip currents will be forming.

Due to tides, weather, etc., there is a much greater risk for rip currents in the ocean.

That there will almost certainly be rip currents, and particularly strong.

I think it means rip current conditions are more powerful and prevalent than they normally are.

It means that conditions are right for a rip current to form.

High risk indicates this is an unusual situation and no one should enter the water.

There was a mix of responses in which respondents believed that 'high risk' meant that rips would form or that there was a greater chance of rip formation. Others (n=102) believed that the use of the terms high and low risk were misleading:

Whenever or wherever there are waves there can be rip currents, so I am not sure what 'high' or 'low' risk of rip currents means. All rips are potentially dangerous.

In response to the definition of low risk, respondents tended to suggest this implied that rips were unlikely or would not form:

There is a lower chance of rip currents occurring.

Rip currents may still exist but are weaker or fewer than normal.

Conditions are not conducive to rip currents.

The factors necessary for rip currents to form are absent- not likely to encounter rip.

Of note, whether a respondent described high and low risk of rips as a probability (likely, unlikely) or in absolute terms (is or is not present) is not related to whether the respondent noted that the rip forecast was consistent with their observations at the beach. For both high and low-risk, some respondents believed that the forecast (by radio, internet, etc.) was not based on the predicted weather, but rather on whether a rip had been sited on a particular beach or not with statements such as: "*Not Sighted*" or "*Strong rips observed.*" Others (n=129) believed that high and low risk was associated with the local bathymetry being conducive to the formation of rips: *"the topography/bathymetry is suited to rip currents."*

3.7 Trusted Sources of Information

Respondents were also asked to rank sources of information about rip currents from (1) most trusted to (5) least trusted. With the exception of social media (including Facebook, Twitter, etc.), all sources of information were nearly equally ranked from most to least trusted with no discernable pattern. Only social media exhibited a discernable pattern, with more than 35% of respondents identifying it as the least trusted source, although 18% of respondents also identified it as the most trusted. More respondents identified internet sources as the most trusted compared to other sources, while television and radio were identified as trusted (rank 2 and 3) but not the most trusted. No significant correlations were observed between trust in a source of information and respondent demographics, suggesting that a broad communication strategy is the most effective to reach the widest audience.

4 Discussion

Results of this US-based rip current survey suggest that in general, the US beachgoing public is informed about rip current safety. While this is an encouraging result, it needs to be placed in context. The goal of this study was to examine United States based beachgoers understanding of, and experience with the national "Break the Grip of the Rip" ® program and the rip current hazard in order to provide quantitative evidence to guide future improvements to beach safety education material. While an online survey approach is a cost effective means to

Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2017-16, 2017
Manuscript under review for journal Nat. Hazards Earth Syst. Sci.
Published: 30 January 2017

collect information across a large area and increase sample size (Bird, 2009), it is not guaranteed to be representative of the general public. This was the case with this study. The survey was largely disseminated through websites and social media associated with the NWS, NOAA, and Sea Grant and the majority of respondents likely had prior knowledge of, or interest in, marine and coastal issues and hazards, including rip currents. This is evident from the cohort being dominated by relatively frequent beachgoers who self rated as competent swimmers with a large number of respondents (n=1248, 59%) being able to successfully identify the safest location to enter the water in all three of the photographs in the survey. These results are far better than those from studies involving face to face surveys of beach users in Florida (Caldwell et al., 2013) and Texas (Brannstrom et al., 2014; 2015).

Nevertheless, despite this potential bias, about 10% of survey respondents were infrequent beachgoers, poor swimmers and largely ignorant of the rip current hazard and more liable to make poor swim location choices. This cohort still represents a significant population of potential ‘at risk’ beachgoers when taking the entire US beachgoing population into account and is likely significantly underestimated due to the potential sampling bias of the study. It is this ‘at risk’ beachgoer population that was a key target of the Break the Grip of the Rip campaign. It is therefore of considerable concern that this cohort tended to select the rip as the safest location to enter the water on each of the survey photographs, tended not to consider hazards before going to the beach, were not familiar with the beach flag system in the United States, and did not seek out lifeguards when visiting a beach. These results clearly highlight how at risk infrequent beach users are, consistent with previous studies demonstrating how difficult it can be for people without first-hand knowledge to conceptualize danger posed by a hazard.

In contrast, survey respondents who tended to visit the beach often and had previous experience with rip currents demonstrated a better understanding of the danger of rip currents and were able to provide more accurate descriptions of rips and escape strategies than those who have not experienced a rip. As described by Brannstrom and Houser (2015), those who get caught in a rip current "*understand the dangers of rips first hand and…. realize [they] never want to be caught in that situation or accident [again]*." Similar results were found in studies involving surveys of people who had been caught in rip currents in Australia (Drozdzewski et al., 2012; 2015). Those with indirect or no experience tend to underestimate the danger compared to those with direct experience (Ruin et al., 2007).

It is also interesting to note that while a majority of survey respondents were not familiar with the "*Break the Grip of the Rip*" campaign itself, a vast majority of respondents (~91%) were familiar with the primary message of the campaign and able to provide an accurate description of how to escape a rip current (i.e. "break the grip") by swimming parallel and/or floating until the current weakened. This also indicates that respondents may also have gained this knowledge from other sources. It is also worth noting that several recent studies have found that no single rip current escape strategy is suitable for all scenarios (McCarroll et al., 2014; 2016; Castelle et al., 2016; Van Leeuwen et al., 2016) resulting in some debate within the greater global beach safety community (Bradstreet et al., 2014).

It is also important to note that having prior experience and knowledge of rip currents does not mean people will take appropriate actions to prepare for, or avoid, a hazard (Sietgrest and Gutscher, 2006; Karanci et al., 2005; Hall and Slothower, 2009; Johannesdottir and Gisladottir, 2010). As noted by Haynes et al. (2008, p. 260), "*it is now understood that there is not necessarily a direct link between awareness, perceived risk, and desired (by risk managers)* *preparations or behavioral responses*" (see also Miceli et al., 2008). As noted by several survey respondents, if everyone else at the beach is entering the water and not heeding an existing rip current warning (out of ignorance or purposeful neglect) there is a chance that the beach user is complacent when entering the water despite understanding the risk, for example: "*I never noticed anything unusual and people in general don't seem to adjust their behavior*," suggesting that decisions can be made based on what other beach users are doing rather than rip forecasts (Lapinski et al., 2014). The tendency to follow the behavior of others may be enhanced when someone goes together as part of a group and enters the water because everyone is willfully ignoring the risk or is ignorant to the severity of the risk (see Mollen et al., 2012; Aronzarena et al., 2015). A regional forecast or global warning will not necessarily deter beach user behavior as much as direct intervention by lifeguards.

In regards to the existing rip current forecasts issued by the NWS, this study has also revealed some important issues with the methods used to forecast rips and the resultant warnings. Approximately 67% of all respondents stated that rip current forecasts are not necessarily consistent with what they observe on the beach. Consistent with previous studies on natural hazards, those who have not experienced a predicted hazard or did not experience personal damage during a visit to the beach are more likely to downplay the danger the next time they visit (Hall and Slothower, 2009; Scolobig et al., 2012; Green et al., 1991; Mileti and O'Brien, 1993). Any inconsistency between a rip forecast and the observations of a beach user, either in general or specific to a place and time, can lead to some beach users downplaying the risk of rip currents on future visits to the beach. While forecast methodology varies by WFO, most rip forecasts do not take into account bathymetry, local topography, or hard structures that may force

Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2017-16, 2017
Manuscript under review for journal Nat. Hazards Earth Syst. Sci.
Published: 30 January 2017

rips over a range of wind wave conditions. It is not clear how many forecasts are based on the actual presence of rips observed by lifeguards.

The problem lies in the fact that rip forecasts tend to be overly general to a larger region and time period, whereas rip development does not necessarily occur at all times or places within a given region and rip flow behavior is spatially and temporally variable (Castelle et al., 2016). A regional rip warning may lead to differing experiences on the same day (see Brilly and Polic, 2005), and therefore a different interpretation of the forecast accuracy in the future and downplay of the risk. Mileti and O'Brien (1993, p 40) describe the reasoning as "*The first impact did not affect me negatively, therefore, subsequent impacts will also avoid me.*" At the same time, beach users will not be able to conceptualize events that have never occurred or to see future trips to the beach as anything more than a mirror of past visits or experiences (Kates, 1962; Tversky and Kahneman, 1973). If the rip forecast and warnings are inaccurate or are perceived to be inaccurate, there is a loss of trust in that authority (Espluga et al., 2009).

Since many beach users are unable to identify rips (Caldwell et al., 2012; Brannstrom et al., 2014, 2015), those who rely heavily on the rip forecast or assume it is locally accurate might use it to calibrate their observations and experience, or future interpretations of the forecast. If a low rip risk forecast is issued and actual rips are quite strong and/or more prevalent, , then beach users may (inappropriately) associate the flow strength of rip currents as being weak or may lose faith in forecast accuracy. Similarly, if a high rip risk forecast exists and no rips are observed with relatively calm conditions, then beach users may become complacent about the hazard and discount or ignore future forecasts in the future However, results of this study suggest that given time and experience at the beach over a range of conditions, beach users can develop a nuanced understanding of the forecast and gain greater confidence that it is appropriate. Rip forecast

Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2017-16, 2017
Manuscript under review for journal Nat. Hazards Earth Syst. Sci.
Published: 30 January 2017

Natural Hazards and Earth System Sciences
Open Access
Discussions

inaccuracies appear to be most problematic for infrequent beach users who also do not appear to seek out lifeguards and are unable to spot rips correctly. Results from this survey suggest that at least 10% of beach visitors in the United States are at risk of being caught in a rip due to ignorance and/or poor swimming choices. This conservative and likely significant underestimate (given the study sampling bias) means that more than 30 million potential beach users in the United States remain at risk and there is a need to continue to support the Break the Grip of the Rip"® campaign.

A majority of respondents were able to clearly state what the standardized rip current sign was informing them to do in terms of swimming parallel to the beach to escape the rip (if caught in one), but a large number of respondents identified a need to provide information that would allow beach users to identify a rip current in general (e.g. "*Pictures showing what actual rip currents look like would be useful*") or specific to the local beach (e.g. "*Picture of rip at actual beach [the sign] is placed on*"). However, evidence from beach surveys in Florida and Texas suggest that beach users are not able to accurately identify a rip current (Caldwell et al., 2012; Brannstrom et al., 2014), although there may be ways in which the sign can be made more accurate through small revisions to the perspective, colors, and beach morphology (Brannstrom et al., 2015). While local information may improve the accuracy and interpretation of the sign, there is the potential for different signs and messaging being used (of varying quality and detail), leading to confusion and misinterpretation by beach users. A more appropriate strategy may be to take a more local-approach to risk and emergency management including local emergency contact information. This approach places greater authority in local managers and emergency responders, without resulting in different signs.

A local approach also includes putting greater emphasis on the expertise of lifeguards to prevent accidents and respond to emergencies promptly and properly. This would also partially take into account the fact that there are different rip currents and associated behavior in different geographic locations and regions (Castelle et al., 2016). Of note, Surf Life Saving Australia has recently adopted a 'combined approach' to promoting how to escape a rip current (Bradstreet et al., 2014). This decision was largely based on field tests of rip escape strategies (McCarroll et al., 2014; Van Leeuwen et al., 2016), which clearly showed that natural variance in the rip flow behavior influences effectiveness of different rip escape strategy strategies. However, communicating such a complex and mixed message is problematic. In contrast, concepts of rip avoidance instruction are consistent and simpler to explain, making them more suitable for advertising campaigns and signage (Bradstreet et al. 2014). While there is still insufficient evidence to suggest that present warning systems help people avoid and escape rip currents (see also Lapinski et al., 2014), there is evidence that lifeguards are effective at preventing drowning death through preventive actions and rescues. With proper training and experience a lifeguard can provide invaluable local understanding of the rip hazard to provide effective mitigation. Unfortunately, there is no consensus amongst beach users that it is safe (or not) to swim in the surf after lifeguards are off duty (Petrass and Blitvich, 2014), despite evidence that it is safer to swim in the presence of a lifeguard. In this respect, greater focus should be placed on reminding beach users to swim near lifeguards and only at times that lifeguards are present because "the chances of drowning at a beach protected by lifeguards trained under USLA standards is less than one in 18 million" (Branche et al. 2001).

5 Conclusions

Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2017-16, 2017
Manuscript under review for journal Nat. Hazards Earth Syst. Sci.
Published: 30 January 2017

A survey about the extent of public rip current knowledge in the United States was conducted with the aim of establishing a dataset that provides guidance for the improvement and enhancement of existing beach safety education material. Results suggest that the "Break the Grip of the Rip" ® campaign has been successful in helping inform the public about rip current safety. Although few respondents were familiar with the "Break the Grip of the Rip" ® campaign itself, the majority of respondents were able to provide an accurate description of how to escape a rip current by swimming parallel and/or floating until the current weakened. Results suggest that the most at-risk population are infrequent beach users because they do not seek out lifeguards, do not take the same precautions as frequent beach users, and believe there are large discrepancies between rip forecasts and their own observations at the beach. Survey results provide a conservative estimate of 10% of beach visitors being at risk of being caught in a rip due to ignorance and/or poor swimming choices. Future education efforts should attempt to target this beachgoing demographic group. Respondent knowledge of rips, ability to accurately identify a safe swimming location in a photograph (which is representative of the ability to avoid a rip), and ability to interpret rip forecasts are each dependent on prior experience with rips and the frequency that subjects visited the beach. In addition to concerns about the local (in time and space) accuracy of the NWS public rip forecast, many respondents identified a lack of local detail in the rip current warning sign as a concern, with more than half of respondents suggesting the sign needed to provide a more accurate depiction and/or description of a rip current and local emergency information. This suggests a need for greater focus on locally specific and verified rip forecasts and signage in coordination with lifeguards, but not at the expense of the successful "Break the Grip of the Rip" ® campaign.

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Natural Hazards and Earth System Sciences
Open Access
Discussions

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Tables

Table 1. Question groups used to elicit responses from respondents notified about the survey by various agencies in the United States.

Group	Focus of Questions	Example topics
1	Informed Consent	
2	Non-identifying personal information	ZIP code, age, ethnicity, and beach use
3	Swimming behavior	Self-assessed swimming ability
4	Beach behavior and beach safety information	Frequency of visits; perceived risks at the beach
5	Rip identification and knowledge	Description of a rip current; ability to identify rip current in a photograph
6	Memorability, conspicuity, comprehension, priming	Source of rip information; memory of observing rip safety warnings
7	Rip current sign knowledge and understanding	Understanding rip current warning sign and warnings

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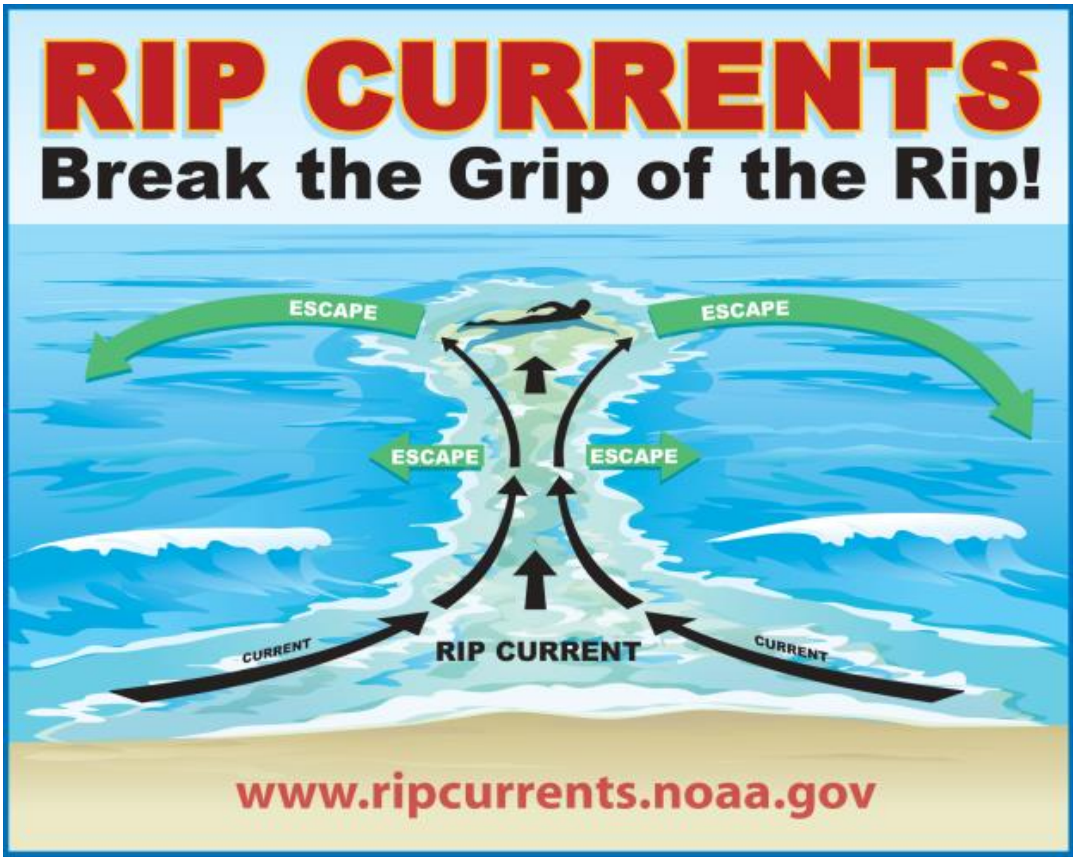

Fig. 1. Rip current warning sign developed by the United States Rip Current Task Force as part of the “Break the Grip of the Rip!” ® education campaign.

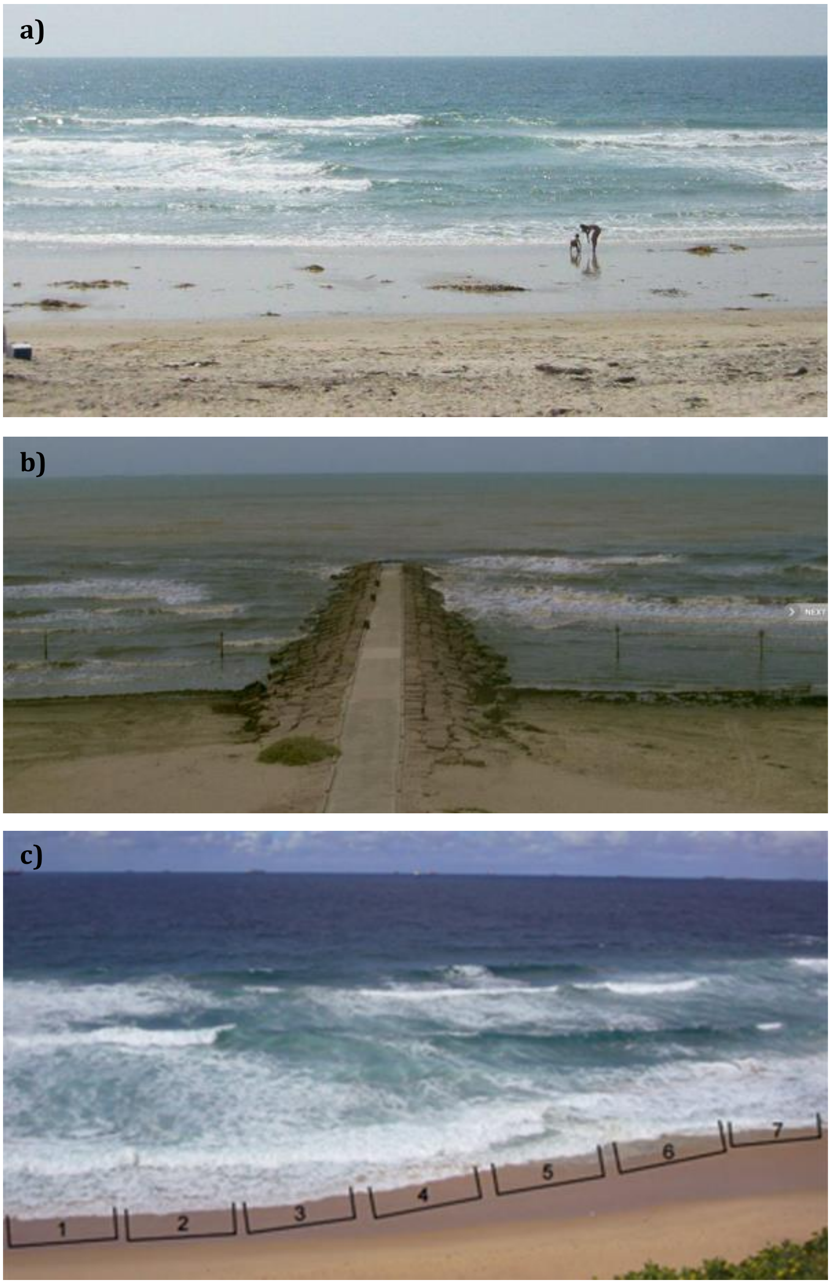

Fig. 2. Photographs used in Questions 42 through 44 of the survey to ask respondents "Where on this photograph would you swim?".

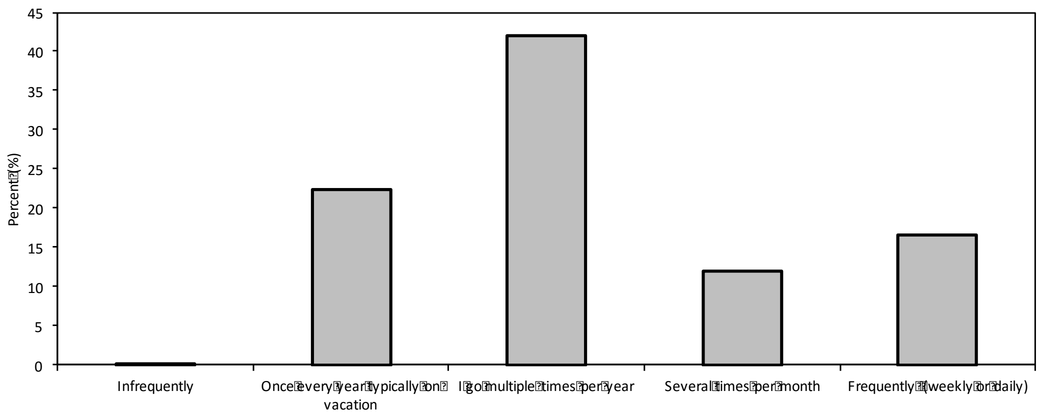

Fig. 3. Percent of self-reported beach visitation by respondents.

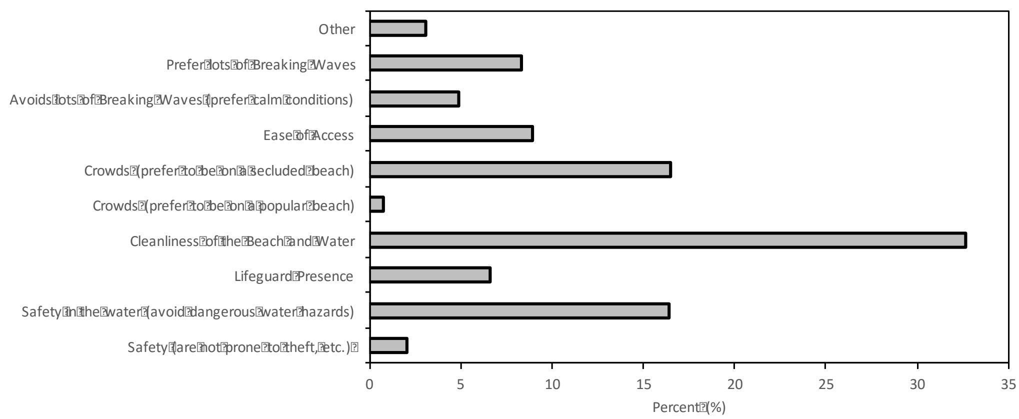

Fig. 4. Relative importance of beach and surf factors to respondents when selecting a beach. Note that respondents were asked to identify all factors that applied.

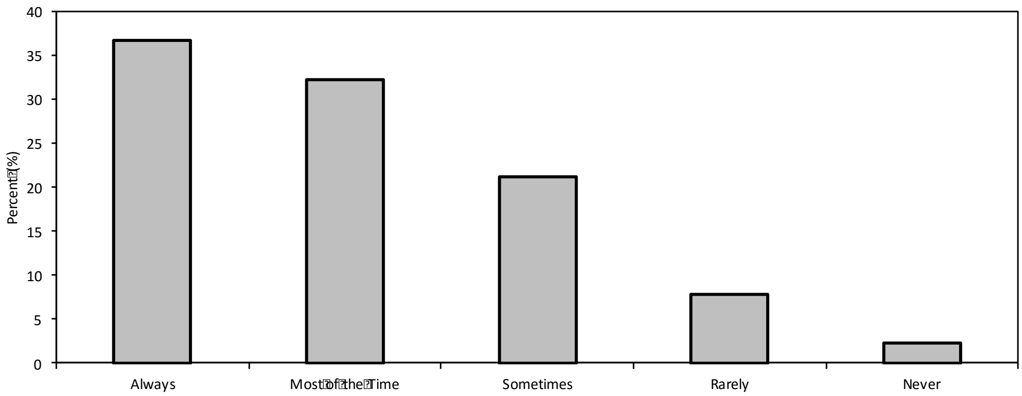

Fig. 5. Self-reported tendency to enter the water in the absence of a lifeguard on a beach.

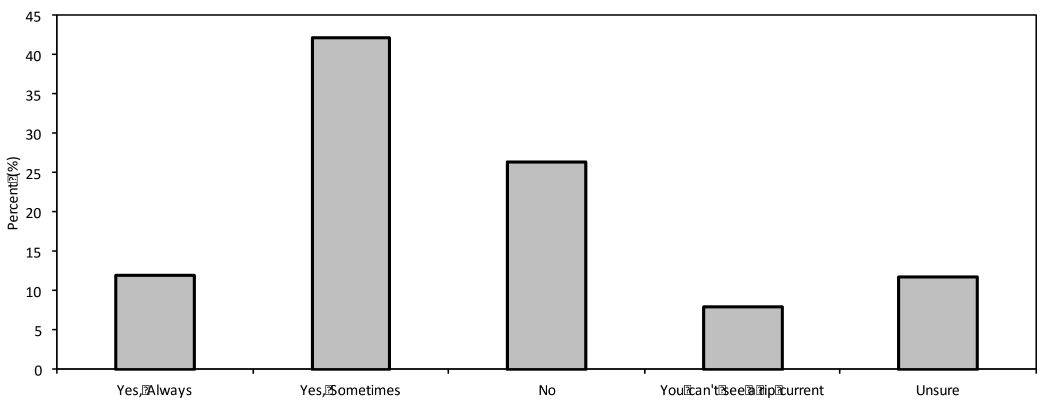

Fig. 6. Percent of respondents' belief that rip currents can be seen by beach users.

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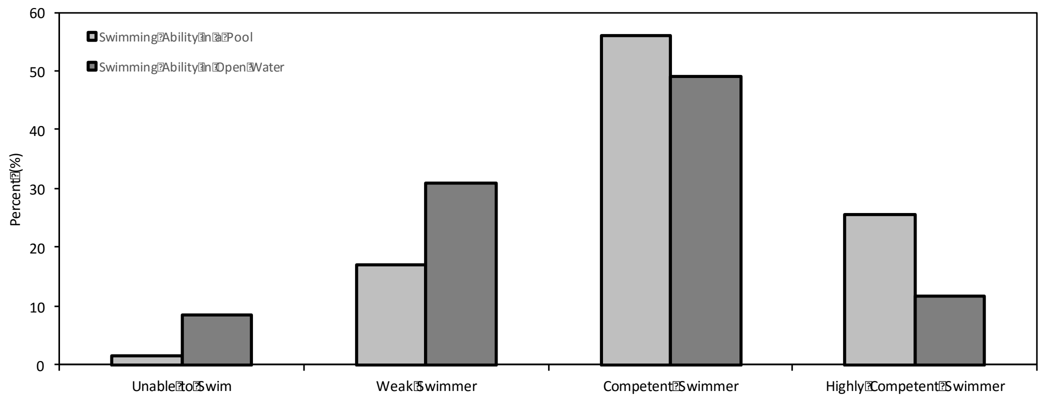

Fig. 7. Percent of self-reported swimming ability in a pool and in open water with waves.

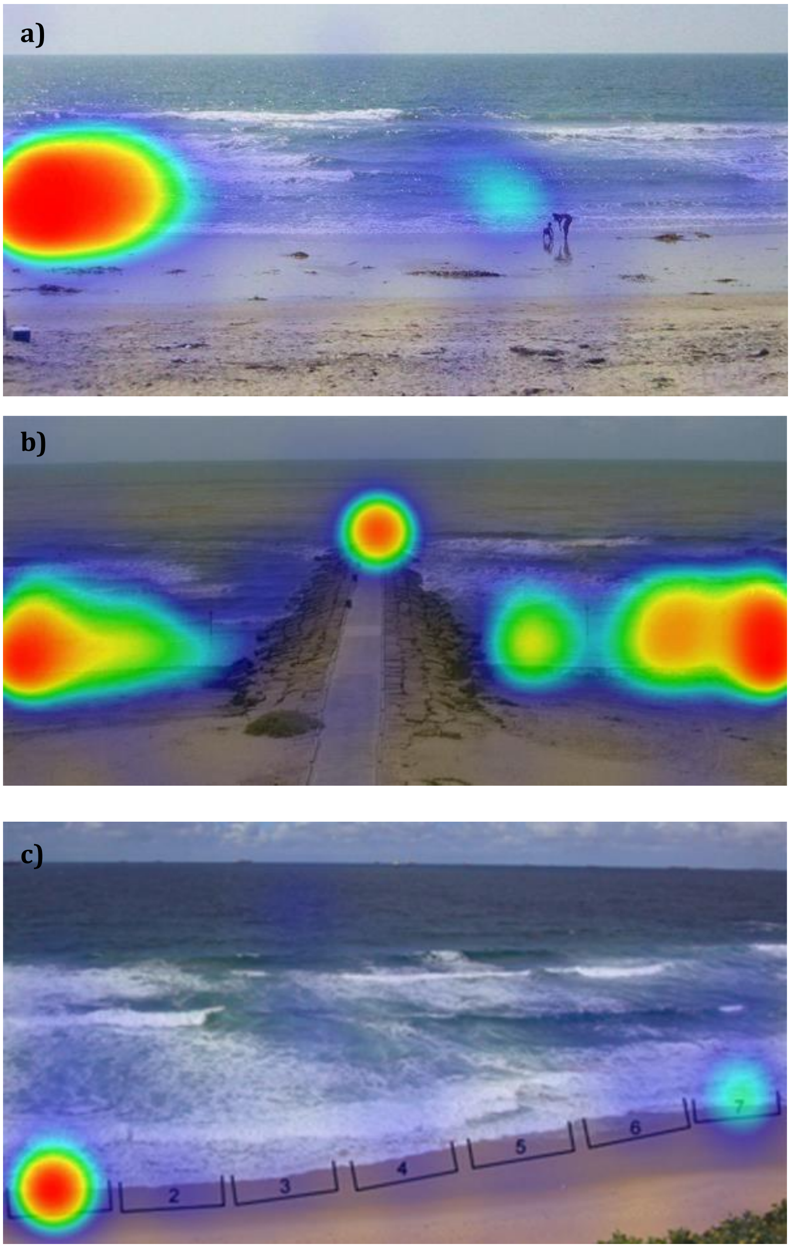

Fig. 8. Identified location of safest location to enter the water in the photographs presented in Question 42 through 44 and also presented in Figure 2. Warm (red) colors indicate large number of responses, while cold (blue) colors indicate few responses. No color (background picture) represents areas that received no responses.